Investigating musculoskeletal disorders in New Zealand meat processing using an industry-level participative ergonomics approach

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Abstract

In New Zealand, the highest incidence of musculoskeletal disorders (MSD) is found in meat processing, accounting for over half the injury compensation costs for the sector. This thesis reports on a two-year study of MSD in the New Zealand meat processing industry, with the aims of identifying MSD risk factors and interventions using an industry-level participative ergonomics approach.

A review of the literature on occupational musculoskeletal disorders and participatory ergonomics identified gaps in knowledge, notably contextual factors for MSD and a limited scope for participatory ergonomics. The studies described in this thesis contribute to addressing these knowledge gaps.

The first stage of the study established a profile of MSD injury data in the industry. Data were collected from four injury data sources for meat processing. A number of priority tasks were identified for beef and sheep processing, based on triangulation of these data, and findings were approved by the industry stakeholders, the Meat Industry Health and Safety Forum (MIHSF).

The second stage of the study was the assessment of these tasks in a representative sample of processing plants, with the purpose of identifying risk factors that contribute to the occurrence of MSD, implementation barriers and MSD interventions. The study involved interviews with 237 workers, management, union and safety personnel in 28 meat processing sites. MSD risk factor data were separated into those concerning the high MSD-risk tasks (task-specific), and the wider work system (task-independent). From these data a list of contextual factors was developed which it is proposed may create conditions under which greater exposure to physical and psychosocial factors can occur in meat processing. Some 276 interventions were also identified.

The third and final stage of the study involved working with the MIHSF in developing the interventions for use by the industry in reducing MSD risk. MSD intervention ideas were collated, summarised and prioritised. A document containing interventions, implementation barriers and risk factors was developed with the MIHSF and distributed to all levels of the industry. The thesis reflects on the effectiveness of an industry-level participative ergonomics approach to the achievement of the study aims, notably the identification of contextual risk factors and interventions for MSD.

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Chapter 1. Introduction

1.1 Introduction

This thesis investigates musculoskeletal disorders (MSD) in New Zealand meat processing, and the involvement of industry stakeholders in the development of MSD interventions. In so doing, it provides an insight into the scope of MSD risk factors affecting the industry and in particular, the role of contextual risk factors that impact on meat workers' exposure to physical and psychosocial MSD risk factors.

The longstanding nature of MSD in meat processing and an inability by the industry and government agencies to reduce the high incidence rates invites a new approach to addressing the issue. A history of adversarial industrial relations and scepticism towards people who are external to the industry also necessitates a careful and measured approach. Thus, the thesis endeavours to contribute to knowledge on MSD risk factors, and follows a participative ergonomics approach that engages with the industry in overcoming barriers and developing meaningful MSD interventions.

The first major issue considered is the role of organisational and contextual factors for MSD in the development of physical and psychosocial risk factors in meat processing. The second issue considered is the development of interventions to address MSD risk factors using an industry-level participative ergonomics approach.

This chapter begins by providing an overview of the research problem and the New Zealand meat processing industry. It then outlines the approach of the research before presenting the research aims and objectives of the thesis. The next section describes the ethics process, while the final part of the chapter provides an overview of the thesis structure.

1.2 Problem statement

Within New Zealand meat processing, musculoskeletal disorders result in more earnings compensation claims than any other area of health and safety. Direct costs of MSD are high, industry incidence rates are the highest nationally, and there is a long history of this problem in the industry. Figure 1.1 illustrates this in a comparison of MSD incidence rates for high-risk New Zealand industries over five years, based on new compensation claims from the Accident Compensation Corporation (ACC) and business demographic data from Statistics New Zealand (ACC, 2007).

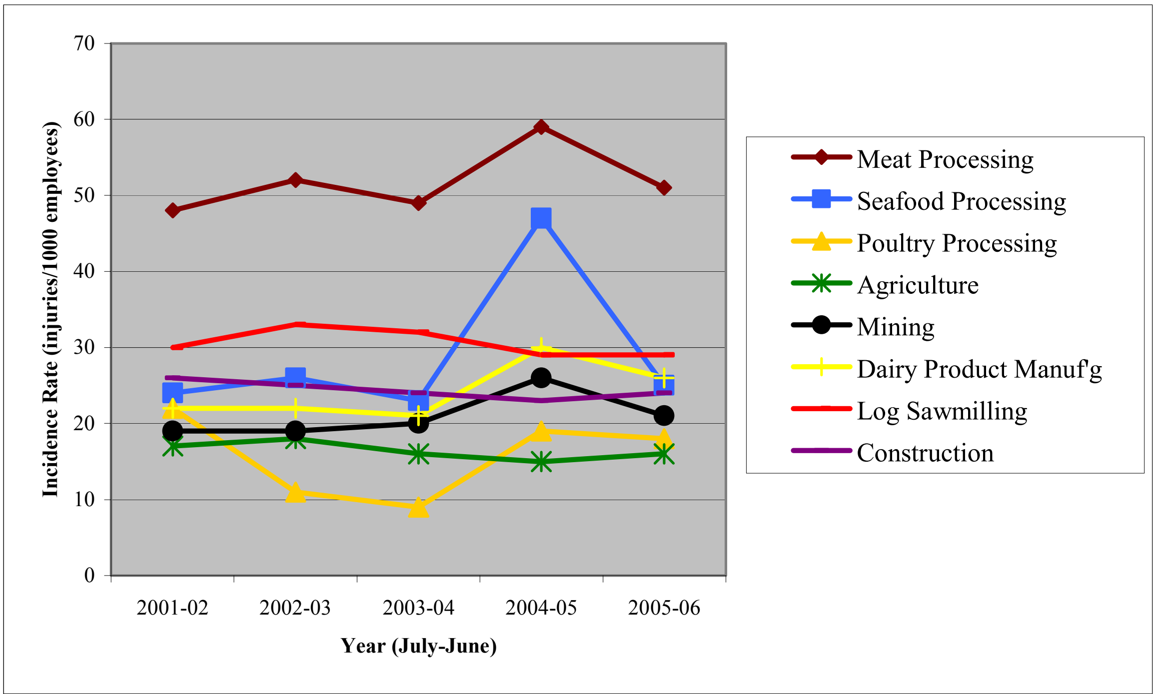

Figure 1.1. MSD incidence rates for industries targeted by the Department of Labour and ACC (2001-06)[1]

Despite the existence of many MSD interventions applicable to the meat processing industry, these are not always adopted. One reason for this may be that employees and employers do not perceive that they have had a say in their development and therefore feel no ownership of them. A second reason could be that where MSD interventions have been unsuccessful, other interventions may not then be considered. This lack of success could be as a result of MSD interventions not addressing root causes, not accounting for implementation barriers, or requiring an industry-level response.

[1] Incidence rate = number of ACC accepted MSD compensation claims / 1000 employees.

The present study emerges from the recognition by New Zealand funding agencies that MSD are a significant cause of injury and compensation costs in many industry sectors in New Zealand (ACC & OSH, 2003). Three government bodies, the Health Research Council, the Accident Compensation Corporation (ACC), and the Department of Labour established a Partnership Programme (PP) for generating a targeted programme of research in occupational health and safety. Funding was provided by the PP for a two year research programme into MSD incidence in both the meat and seafood processing industries as benefits from knowledge transfer between the industries were envisaged. This thesis reports on the study conducted in the meat processing industry.

Some of the benefits of the study, as perceived by the researcher, were that it would involve fresh pairs of eyes looking at an old problem, conducted by people with more knowledge of MSD than of meat processing. Additionally, remaining financially independent of industry would help to retain some control over the research processes, given that the power would rest with the industry concerning access to plants and data.

1.3 Meat processing in New Zealand

1.3.1 A brief history of the industry

Over half the land area of New Zealand is pastoral and correspondingly, the largest two merchandise export earners are dairy produce (21%) and meat (13%) (Statistics NZ, 2007a). Around 85% of the meat processed in New Zealand is exported to 100 overseas markets (Market New Zealand, 2007). The industry has always had an export focus, with an abundant supply quickly outpacing the requirements of a small population. The first frozen sheep carcasses were sent to London by sailing ship in 1882, an initiative which resulted in rapid expansion of both farming and processing facilities around the country (Robinson, 2006). Over the years the processing industry continued to expand as farming became more widespread and the number of species increased, particularly beef and venison. The ‘tyranny of distance’ however has contributed to significant troughs in the industry as export markets have been lost to geographically closer competitors or alliances (e.g. the United Kingdom’s entry into the European Economic Community in 1973). Countering this has been the desirability of New Zealand meat products due in part to geographical isolation (e.g. disease-free status of animals).

A significant factor in the development of the meat processing industry in New Zealand was the desire of farmers to protect their interests by building ownership of the processing and influence over the conditions of supply (Curtis, 1992). Thus, many of the meat processing companies were farmer-owned cooperatives and indeed the two largest meat processing companies still operate this way. This contrasted with countries such as Argentina, where the industry adopted the US model where the farmers responded to the requirements of the processors and the markets, and where "everything but the moo was converted into meat and by-products" (Curtis, p. 68).

Figure 1.2. Workers at a freezing works in Wellington, circa 1900.

Some of the implications of the farmer-owner cooperatives in New Zealand were that plants were located close to farms rather than ports and markets. Moreover, plants were rudimentary as they were only required to slaughter and dress animals, and their operation was sporadic to match the flow of stock from farms and the seasonality created by pasture-grazing (Curtis, 1992). These inefficiencies became increasingly problematic, coming to a head during the depression. Economic events at that time enabled processing companies to introduce the chain system (a dis-assembly processing line). The changes introduced brought about greater efficiencies but also drawbacks. The chain "removed understanding of the total process from the butcher and located it exclusively with management", and "provided managerial/technological control over the pace of work" (Inkson & Cammock 1984, p. 152).

This deskilling and wresting of control away from the workers and on to management created enormous animosity between the two groups. Unions were able to re-establish a position of strength within meat processing initially through the benevolent policies of Labour governments in the 1930's and 1950's and later the economic prosperity of the post-war years increasing their bargaining power as well as their resilience (Inkson & Cammock, 1988). Greater than 98% of the current workforce belongs to the Meat Workers Union, despite membership being voluntary, and contrasting with much lower rates of unionisation in other New Zealand industries (Amanda Stephens, personal communication, August 2, 2008). Relations have generally remained adversarial between unions and employers throughout this time, giving rise to such practices as seniority to establish job security between processing seasons.

A second cataclysmic change in the industry occurred during the 1980's. The drivers for change were economic deregulation and removal of farmer subsidies combined with a mismatch between processing capabilities of old facilities and market demands (Inkson & Cammock, 1988), along with reduced returns from meat production and new meat inspection standards (Tomoana, Keefe, & Ormsby, 2001). This mismatch had been identified earlier (Butcher, Gentry, & Wakeling, 1978) but little had changed prior to the emergence of these other factors. As a result of these circumstances, some large plants were closed down, and many others rebuilt to better match clients' needs (e.g. enabling Halal slaughter for Muslim markets) and to incorporate new further-processing technology. Between 1981-1993 the number of smaller single-species plants increased from 43 to 65, while the workforce reduced from 34,000 down to 22,000 (Mills, 1993). The most obvious results of this process were large numbers of staff redundancies through downsizing of the industry and the introduction of task automation and mechanisation (e.g. pelt/hide removal in slaughter). Some meat companies disappeared entirely, with their facilities bought out by other companies, thus increasing the level of monopoly control.

The meat processing industry is currently going through another significant upheaval as meat companies again respond to major changes in the supply chain. Many sheep and beef farmers have converted to dairy due in part to the lure of much higher returns, resulting in processing overcapacity (MIA, 2007; Gaynor 2008). Trade barriers (e.g. tariffs), government and client requirements (e.g. compulsory superannuation, new product specifications), and economic factors (e.g. high exchange rates, low unemployment) have all reduced the profitability of the industry (MIA, 2007). As a result, plant closures have begun to occur and further rationalisation appears likely (Hembry, 2008).

Currently, the meat processing industry is a large employer in many regions of New Zealand, involving approximately 1.8% (24,000 people) of the total workforce. There are approximately 80 meat processing plants situated around New Zealand, servicing 32,000 farms producing sheep, beef, veal, venison and pork for slaughter and further processing (MAF, 2005). Sheep and beef processing account for over 80% of the number of plants and more than 90% of the total workforce. For this reason the study mostly focuses on these two species. Venison and pork processing generally face less MSD risk due to factors such as a more consistent supply of stock. However, most of the task-independent interventions developed in this study apply equally to all species. Plant sizes range from small operations processing single species (30-50 employees) up to very large plants employing more than 2000 staff. Many of the plants are located in rural towns and are often the main source of employment in the area.

1.3.2 An outline of the main tasks in meat processing plants

In England in the Middle Ages, animals were slaughtered and sold on the street in areas known as The Shambles. Retail butchers today are descendants of this practice, albeit with greater attention given to animal welfare and food hygiene practices. However, as demand increased so too did the scale of meat processing, helped by the introduction of production lines involving the dis-assembly of the animal into components for sale or further processing. Originally, such large plants were referred to as freezing works, where the edible parts were frozen after slaughter to preserve them during transport to markets (Butcher et al., 1978). However the term “meat processing” more accurately reflects the main functions that now occur in plants.

The main functions of the processing plant are: the organisation of stock in the yards, slaughter and dressing, boning and packing, further processing, chilling/freezing, and despatching. The staff involved in stock organisation are responsible for ensuring a continuous flow of calm animals into the plant during its operation. This includes consideration of logistics (moving stock within the yards to ensure a steady in-flow to the plant in the order required), humane treatment of stock (ensuring they are not left for long periods without food or water or treated harshly), and duty of care (to minimise loss of value for the farmer).

The first part of the slaughter floor is the knocking pen where animals are stunned unconscious before having their throats cut by a Halal slaughterman. Tasks in the first part of the processing chain are preparatory to pelt removal and evisceration. Figure 1.3 illustrates the Y cutting task in sheep, involving removal of the fleece on the front legs and chest. Once the pelt and abdominal contents are removed, the carcass and gut are both inspected for disease. Further dressing of the carcass may occur to clean and trim the carcass prior to boning. Because of hygiene requirements there is a time limit for the entire slaughter process, which is one determinant of chain speed. Approximately 25% of plant staff are involved in slaughter and dressing.

Figure 1.3. The Y cutting task

The boning room employs the greatest proportion of staff, often more than 50% of the total plant staff. Boners break the carcass down into the main cuts of meat. Trimmers improve the presentation of cuts, or carry out further processing (e.g. removal of fat caps). Packers bag, wrap and weigh meat, usually assisted in this by a range of packing machines and conveyor systems. Like the slaughter floor, the boning room operates a processing chain with the pace of work usually determined by the boners. Carcasses can be boned immediately after slaughter or following a period of chilling. Figures 1.4 and 1.5 are examples of boning and packing operations.

Further processing refers to activities carried out on edible and inedible parts of the carcass derived from both slaughtering and boning (e.g. blood, fat, pelts, offal), as well as processing / re-assembling meat into consumer products (e.g. meals, dehydrated meat). Chillers, freezers and despatch functions involve the transfer and loading of carcasses and cartons manually and by forklift.

Figure 1.4. A beef boning room floor

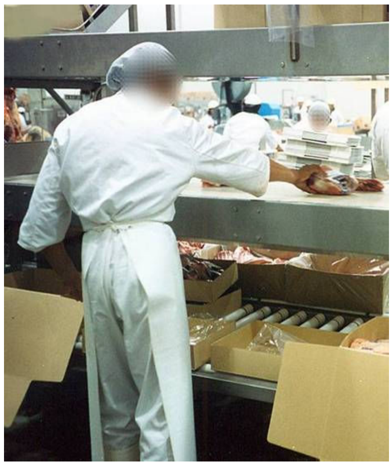

Figure 1.5. A packing floor task

1.3.3 Defining the meat processing industry

In this research, the primary activities described in the Australia and New Zealand Standard Industry Classification descriptions (C211100) were used as the basis for defining the meat processing industry (ANZSIC96, 2002). Additional criteria were established to further delineate which activities to include or exclude from the study. Criteria for including plants were that they processed red meat (slaughter, dressing, boning, or cutting) which was for human consumption, either through export or the local market (abattoir). Excluded, therefore, were meat processors involved in: processing for animal consumption (pet food); processing animal remains for fertiliser, further processing tasks (e.g. pharmaceuticals), or companies only involved in the storage, refrigeration, or transportation of meat products. Also excluded from the study were retail meat processing and home-kill operations as they were significantly different in nature to meat processing plants (e.g. processing whole carcases, no chain) and were also too numerous to include.

1.4 Approach of the research

1.4.1 Systems approach

Ergonomics is defined by the International Ergonomics Association (IEA) as 'the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to optimise human well-being and overall system performance' (IEA, 2000). A systems approach involves considering all elements of the work system, recognising the inter-relationships between system elements, and understanding that these interactions and influences do not occur in isolation from each other. This approach is commonly illustrated in a diagram showing the elements of a system. Figure 1.6 is a hybrid of several such diagrams, drawing on two in particular (Shackel, 1974; Moray, 2000), and combining the other central tenet of ergonomics: a person-centred approach, with a systems model.

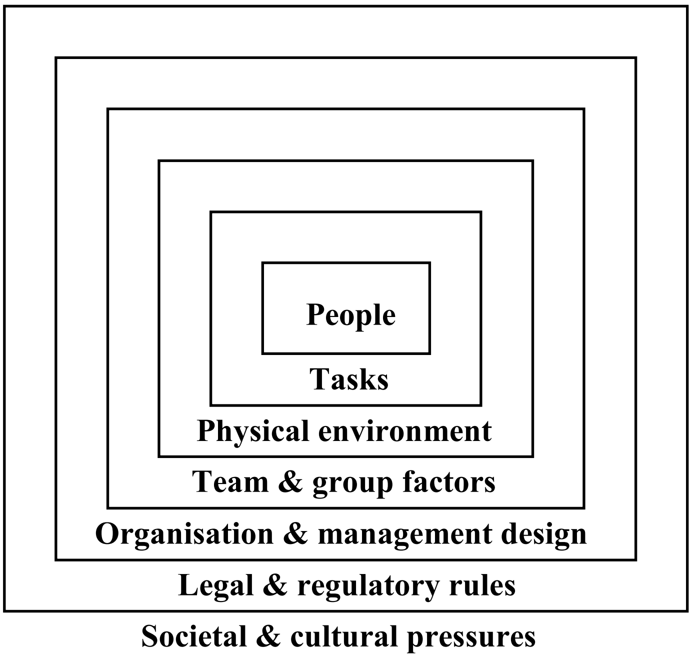

Figure 1.6. A model of a systems approach in ergonomics

MSD are complex events occurring within complex work systems. The nature of MSD, therefore, required the investigation to adopt a systems approach to identify the wide range of MSD risk factors and their interactions in meat processing, and in particular root causes of MSD rather than just symptoms. An ergonomics approach is therefore well suited to addressing system failures and mismatches between interacting risk factors, from which MSD can result (Buckle, 2005).

1.4.2 A participative ergonomics approach

Participatory ergonomics (PE) is described as a complex and diverse concept (Haines & Wilson, 1998), and is seen as an umbrella term for a range of different ideas and practices. This same breadth is apparent in the literature defining PE, or describing the tools and methods used in PE research. Reflecting this diversity and the evolving nature of the field, the literature about PE place greater importance on considering why it is used than on defining it (Wilson, 2005), or on being prescriptive about the approach taken (Morris, Wilson, & Koukoulaki, 2003). Participation therefore, is often viewed by ergonomists as a means to achieve a goal and not a goal in itself (de Jong, 2001; Haines & Wilson, 1998; Wilson, 2005). The participative elements of this study complimented the overall ergonomics approach that was used to investigate MSD at an industry level – a participative, ergonomics approach in other words.

The main reasons for adopting a participative approach arose from previous involvement in the industry. This provided the researcher with insights into how entrenched MSD were, how they were commonly perceived, and what strategies had been employed to address them (Slappendel, Moore, & Tappin, 1996; Blewden & Wyllie, 1998). The embattled history of the industry has also contributed to a general distrust of people and advice from outside the industry, including information on such a longstanding issue as MSD (Inkson & Cammock, 1984; Slappendel, 1996). The intention of the research was that a participative approach would help to allay such concerns, through involving a wide cross-section of plants and processing staff in a study driven by the health and safety body for the industry – the Meat Industry Health and Safety Forum (MIHSF). For the interventions to have any impact, it was important that the process from which they were derived was accepted by the industry.

An important requirement of the study was to identify and understand task variations within different companies, regions or sectors, and account for these in the development of interventions. Such information could only be derived from widespread industry involvement.

Data collection primarily occurred through both formal and informal participation with the industry. The MIHSF, became the primary vehicle for formal participation during the study (their role is further discussed in the following section). The MIHSF represented all the key stakeholders of the industry and had a mandate to address MSD at an industry level (members were not however elected representatives). While participation with the MIHSF occurred throughout the study, the greatest involvement was during the iterative development of MSD interventions. Informal but regular contact was also established with subject matter experts at both plant and industry levels, within and outside the MIHSF throughout the duration of the study.

An unforeseen benefit derived from the participative processes was the flow of information back and forth between the researchers and people in industry over the course of the study. This enabled important points to be repeated and questions to be answered as they came to light or became relevant. This assisted with the identification of a wide range of contextually relevant MSD risk factors and potential interventions that had a realistic chance of being accepted by those in the industry. Importantly, this industry-level involvement also led to the identification and subsequent development of relevant industry-level interventions. These interventions and the risks they were intended to address had not previously been identified for meat processing. A more localised initiative, involving individual plants or companies rather than the entire industry, would be less likely to develop the same outputs.

Engagement also occurred at an individual level through the involvement of people responsible for health and safety in each processing plant, and through face to face interaction with 237 staff (processors, managers, union delegates) in a national sample of plants. This however was simply ergonomics in action (Wilson, 2005) and is not described as participative. It was initially hoped that this engagement, or elements of it, would also be participative. However, the required size of the sample to achieve industry representativeness made this impossible within the finite resources of the study (both costs this would incur and the timeframe it would require). Two further potential barriers to participation at plant level were also foreseen. These were; involving processing staff without creating resentment (e.g. staff losing income, or plants their productivity); and resolving differences that might arise between disparate groups (e.g. occupation, plant, company, region, or species processed).

It is unknown whether industry-level participation with the MIHSF and engagement with a sample of industry staff and plants resulted in less useful outcomes than would the same industry-level MIHSF participation, but also with plant-level staff participation. Certainly there is support in the PE literature for combining expert-guided and participatory processes (Eason, 1995; Wilson, 2005), particularly when concerning work organisation issues (Haims & Carayon, 1998).

Taking these factors into account, and recognising potential limitations, the most effective way of meeting the study aims was determined to be with an industry-wide ergonomics approach, and with industry-level participation through the MIHSF.

1.4.3 The role of the MIHSF in the study

The MIHSF was formed in 2002 by the Accident Compensation Corporation (ACC) as part of a national 'Safer Industries' injury prevention initiative, based in part on recommendations from an earlier injury prevention initiative in the industry (Blewden & Wyllie, 1997). Meat processing had been deemed a high priority industry by both the Department of Labour (the enforcement agency) and ACC (the state insurer) on the basis of the number of serious harm injuries and the cost of ACC claims. A key stakeholder group was established which included representatives of the main processing companies, unions and employer groups, and relevant government agencies. This group received funding from ACC and the Meat Industry Association and became known as the Meat Industry Health and Safety Forum. Their objectives are to identify common causes of injury and find ways to reduce these through: developing industry-relevant initiatives, encouraging industry-level ownership of safety issues, sharing knowledge and experience in injury prevention, and reviewing the effectiveness of interventions (ACC, 2002).

The MIHSF is self-administered by industry personnel (most with health and safety roles), and appears well respected by those involved in health and safety at a plant level. This is possibly due to its tripartite structure, improving the acceptability by industry partners of outputs of the MIHSF and their level of influence with plants. Anecdotally, there is recognition within the industry that the MIHSF is a positive way for the ACC to invest in injury prevention, as well as recognition of the need for a consistent approach to addressing the industry's high injury statistics. Additionally, the MIHSF is difficult for meat companies to ignore, given its backing by government agencies concerned with injury prevention and prosecution.

The existence of the MIHSF was one of the main reasons for targeting meat processing in the research application. Without the support of the MIHSF, or some similar industry body, the feasibility of an industry-level study would have been greatly reduced. The intention was that the MIHSF would help overcome barriers for which the industry is known (Slappendel et al, 1996) such as industry secrecy, restricted access to plants and data, and 'acceptable' levels of injury. To a large extent this proved to be the case, with the MIHSF playing a pivotal role in many stages of the study, from supporting the research application through to initiating the implementation of MSD interventions at an industry level. One of their earliest tasks was to facilitate access to the industry. The MIHSF were able to disseminate information about the study, encourage support for it within their sphere of influence, and provide contact details for the majority of the processing plants. As the study was but one item on the agenda of their triannual meetings, contact was also established with forum members individually. This less formal communication enabled information to pass between the researcher and forum members about MSD, the study, as well as collecting both company and industry information.

The roles of the MIHSF in the study were therefore to act as: conduits into the industry, champions of the study, information providers and decision-makers at stages throughout the study, and champions of the subsequent MSD interventions beyond the study timeframe. These roles closely matched the founding objectives of the MIHSF.

1.5 Research Aims and Objectives

The major aims of the research were to identify risk factors and wider contextual factors, and interventions for MSD in New Zealand meat processing, using an industry-level, participative ergonomics approach.

Specific objectives of the research that contributed to achieving these aims were:

a. Critically review the literatures on models of MSD causation and participatory ergonomics;
b. Identify a participative process that represents the entire New Zealand meat processing industry, and reflect on its effectiveness in achieving the research aims;
c. Establish a profile of patterns and trends in MSD injury data in New Zealand meat processing, and determine which tasks are most commonly associated with reported MSD;
d. Identify the range of task-specific and task-independent MSD risk factors and implementation barriers;
e. Identify interventions that address task-specific and task-independent MSD risk factors and implementation barriers;
f. Develop these interventions for use by the industry, in participation with key industry stakeholders.

1.6 Research team roles and contribution

A team of seven people were involved in the study, with David Tappin leading all stages of the research. Four researchers from COHFE and two from Massey University assisted in a number of stages. The roles of contributors on each stage of the study are described in Table 1.1.

Table 1.1. Research roles in the study

Stage	**Lead role**	**Collaborators**
Development of the research proposal and study plan	Tappin	Bentley, Parker, Moore, Vitalis, Ashby, Trevelyan
Initial literature review for industry	Tappin	Moore, Trevelyan
MSD and participatory ergonomics literature reviews	Tappin	
MIHSF and processing plant contact	Tappin	
Development of MSD injury data profile for meat processing	Tappin	Bentley, Vitalis
Development of task and data analysis methods	Tappin	Bentley, Vitalis, Moore, Ashby
Plant-based data collection	Tappin	Moore, Bentley (assistants)
Analysis of MSD data	Tappin	Bentley, Moore (assistants)
Facilitating intervention development with the MIHSF	Tappin	
Dissemination to industry and reporting to funders	Tappin	

1.7 Ethical approval

An ethical application for the study was submitted to the Human Ethics Committee of Massey University's Albany Campus (MUAHEC) in August 2004. Elements of the research where ethical approval was required were: access to ACC claims data, survey of the health and safety staff at plants, access to accident register data from processing plants, and interaction with industry staff. Ethics approval was granted in September 2004 (MUAHEC 04/080) after minor revisions were made to some documents. Copies of the information sheets and consent forms are included as Appendices 1 and 2.

1.7.1 ACC Claims Data

MSD claims data for a two year period were provided to the researcher by the ACC. These data were without personal identifiers (name, date of birth, address, injury cost) but included all other variables recorded by ACC. Apart from protecting the identification of claimants, the main requirements of ACC were that the data only be used for the purposes of the study, that they were securely stored and would be destroyed five years after completion of the study.

1.7.2 Health and Safety Staff Questionnaire and Accident Register Survey

Assurances were made to questionnaire respondents that the data would remain confidential and only be used in aggregated form for the purposes of the study. This also applied to the accident register records provided by plants, with the additional requirement that no unique identifiers were included with the data to ensure the confidentiality of all records. For both data sources, ethical requirements were that data were securely stored and would be destroyed five years after completion of the study.

1.7.3 Interaction with industry staff

The same ethical process was applied to the staff interviews and task assessments. Minor modifications to the information sheet were approved by the ethics committee in September 2005 to better suit the conditions found at the plants including reducing the length of the information sheet, and being able to collect verbal consent where staff were unwilling to sign consent forms. The forms in Appendix 2 include these later changes.

1.8 Structure of the thesis

Figure 1.7 shows the various stages of the study and the chapters in which this work is reported.

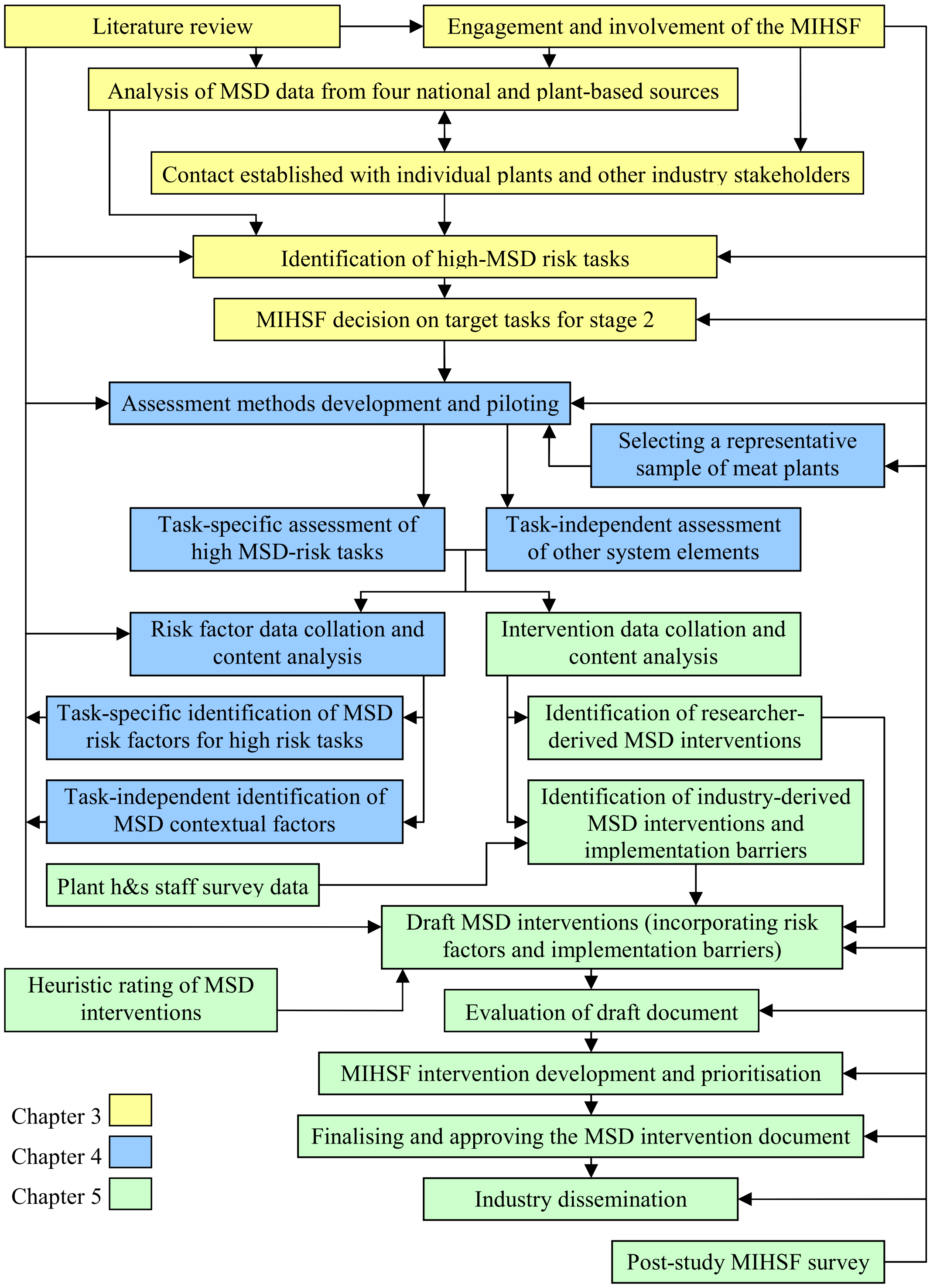

Figure 1.7. Stages of the study

Chapter Two is a critical review of the literatures on occupational musculoskeletal disorders and participatory ergonomics. Literature on MSD data, assessment, risk factors and interventions helped inform various stages of the study. Theoretical models on MSD development are reviewed and an extension to these is proposed. The history of employee involvement is briefly outlined and participative methods used by ergonomists are discussed. A framework for applying participatory ergonomics is reviewed from the perspective of industry-level approaches used in this study.

The objective of Chapter Three was to establish a profile of archival/secondary MSD injury data in New Zealand meat processing, and determine which tasks were most commonly associated with reported MSD. Key to this chapter was the engagement of industry stakeholders at both an industry level (MIHSF) as well as plant level (plant health and safety staff), gaining their support for the study as well as collecting information on the industry. Identifying high risk tasks involved the triangulation of data from four separate sources: accepted MSD injury claims made with ACC, records from an industry based injury database, accident register entries from individual processing plants, and questionnaire responses from health and safety personnel within each of these plants.

Chapter Four reports the identification of a range of task-specific and task-independent MSD risk factors. These data were derived from semi-structured interviews and task assessments conducted in one third of the processing plants across the country. The focus of this analysis was the role of contextual factors that created conditions under which greater exposure to physical and psychosocial factors could occur. A conceptual model for the development of MSD in meat processing was also proposed.

Chapter Five reports the development of industry-derived MSD interventions in participation with the MIHSF. Interventions were combined with other data from the study into a single document for use by the industry. A heuristic evaluation of the intervention priorities was also undertaken.

Chapter Six reviews the key findings from the study, evaluates the effectiveness of the approach used, and discusses the unique contributions of the thesis. Directions for further research are also outlined.

Chapter 2. Literature Review

2.1 Introduction

The objective of this review is to map and critically analyse the existing body of literature on theories of occupational MSD causation and participatory ergonomics for addressing MSD, as these inform the main elements of the thesis. These two topics are part of much larger bodies of the literature as they relate to musculoskeletal disorders and employee involvement. The review outlines each of these areas in turn, starting broadly before focusing in on the two topics that are of most relevance to the study. The review is broadly divided between MSD (2.3) and participatory ergonomics (2.4)

The review begins by establishing what MSD are, and outlines their prevalence in those countries where such data are collected. This is followed by a discussion of the literature concerning theories of MSD causation, before discussing MSD in meat processing. MSD interventions and those found in the meat processing literature are also discussed. A critique of the literature completes the first part of the review, discussing gaps and weaknesses in the theory and knowledge around MSD causation and MSD in meat processing. The literature on assessment methods, dose-response relationships and medical management are not relevant to the thesis and are therefore not included in the review.

The second part of the review briefly outlines the history of employee involvement, and describes the emergence and development of participatory ergonomics. This section includes the application of participatory ergonomics in addressing MSD, its application in multiple organisations, and the development of the Participatory Ergonomics Framework. The next section discusses participatory ergonomics research that has taken place in meat processing. Conclusions from the second part of the literature review are then outlined, highlighting gaps and weaknesses in the participatory ergonomics literature. The final section discusses the implications of the literature review on the approach taken in the study.

2.2 Literature Search and Review methods

An initial exploratory search of the literature was conducted to establish the scope of the literature and help to define keywords. Sources included: electronic databases, commonly cited publications and authors, Massey University library and the researcher's own library of material. A list of keywords was developed from this process (Table 2.1).

Table 2.1. Keywords used in the literature search

Participation	*MSD*	*MSD causation*	*Industry*
particip*[2]	musculo*	physical	meat
"particip* ergon*"	MSD	psychosocial	"meat proc*"
"particip* approach"	"upper limb disorder$"	organisation*[3]	slaughter*
"particip* management"	"cumulative trauma disorder$"	social	abattoir
"ergonomic$ program*"	"overuse syndrome"	cultural	butcher$
"work* engagement"	"gradual process"	behavioural	
"work* involvement"	RSI		
"work group$"			
"employee involvement"			

These keywords were applied as separate terms and in combinations to search the literature in electronic databases, identifying references where the keywords were present in any of the data fields. They were also used to assist librarians in the organisations visited. All references were considered for inclusion in the review, irrespective of publication date, including those in peer-reviewed sources as well as grey literature. Non-English publications were excluded where no accessible translation existed. Two main searches were conducted, in October 2004 and again in October 2007. Throughout the course of the study further references were also identified through electronic alerting, peer discussion, and conference proceedings.

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[2] * = any combination of letters, $ = spelt either with or without 's'.

[3] Both English and American spelling variations were included in the search.

Data sources that were used in the literature search are listed below:

1. Science citation index (via Web of Science)
2. Ergonomics Abstracts
3. Google Scholar
4. Business Source Premier
5. Personal communication with: researchers, meat processors, health and safety service providers to the industry, industry regulators, employee and employer advocates, and plant manufacturers, both nationally and internationally.
6. Emerald Full Text
7. Academic Search Elite
8. On line searches of international information sources, including: Health and Safety Executive, UK: NIOSH, USA: CCOHS, Canada: European Agency for Safety and Health at Work: MLA, Australia
9. Meat Industry Research Institute of New Zealand (MIRINZ)
10. New Zealand Meat Workers Union library (personal visit)
11. New Zealand Government websites: MAF, Statistics NZ, Asure, ACC, OSH
12. Newztext (New Zealand and Pacific media)
13. Index New Zealand (popular press)
14. FOODnetBase
15. ACM Digital Library
16. IEEE Xplore
17. Google Books
18. ACC Head Office library (personal visit)
19. OSH Head Office library (personal visit)
20. Scirus
21. Food Science and Technology abstracts

The abstract of each reference was read to establish its relevance to the study. Those included were then reviewed in full in compiling this chapter. Where relevant, additional literature in support of the arguments made, but not sourced during the literature search, have also been included.

2.3 Musculoskeletal Disorders

2.3.1 Defining MSD

Musculoskeletal disorders (MSD) is a term commonly used to describe a wide range of conditions that involve the nerves, tendons, muscles, and supporting structures of the body (Bernard, 1997; ACC, 2001). These can occur when physical and psychosocial demands are too great, resulting in discomfort, pain, or functional impairment (National Research Council-Institute of Medicine (NRC-IOM) 2001; Devereux, Rydstedt, Kelly, Weston, & Buckle, 2004).

There are many similar definitions in the literature. Buckle & Devereux (2002) for example, refer to MSD as a wide range of inflammatory and degenerative diseases and disorders affecting neck and upper limbs. Others describe MSD as health problems in the locomotor apparatus (Luttman et al., 2003), or "stemming from a wide range of factors that together result in an inadequate margin between people's work demands and the coping resources available to them" (MacDonald & Evans, 2006). Ergonomists however, do not always take such a broad approach to MSD. For example, Winnemuller, Spielholz, Daniell, & Kaufman (2004) restricted their analysis of tasks in four different industries to physical MSD risk factors only. In interviews with 14 ergonomics consultants, Whysall, Haslam, & Haslam (2004) also found that "ergonomics practice with respect to MSDs …focused heavily on the physical aspects of work" (p. 349), with some ergonomists considering psychosocial factors as outside their remit.

The term MSD is often prefaced by the phrase 'work-related' and referred to as work-related musculoskeletal disorders (WMSD or WRMSD). MSD are recognised by the World Health Organisation (WHO) as work-related conditions, where both work exposures and non-work factors contribute to their occurrence (NRC-IOM, 2001). A range of other names are used to describe MSD. Some of these have fallen (mercifully) into less common usage due to the narrow range of conditions they encompass or describe (e.g. occupational cervicobrachial disease; repetitive strain injury (RSI)). Others however, remain in use (e.g. occupational overuse syndrome (OOS); cumulative trauma disorders), while new terms are also emerging such as Discomfort, Pain and Injury (DPI) now used by government agencies in New Zealand (ACC, 2006).

In a review of OOS prevention literature, Boocock et al. (2005) outlined terms most commonly used to describe such conditions in fifteen western countries. Six of these use 'MSD' or similar derivatives, while 'upper limb disorders' and 'overuse syndrome' were the next most prevalent. The term MSD or WMSD therefore continues to be most widely used in the literature, possibly because of the better fit with the WHO and International Labour Organisation's definitions of work-related disease and the avoidance of implying both cause (e.g. repetition) and effect (e.g. injury) in the same term (Hagberg et al., 1995). Dodwell (2003) also refers to this last point in an article discussing the confusion and 'unnecessary obscurity' created in New Zealand by the term OOS.

Work related upper limb disorders (WRULD, ULD) or upper extremity disorders (UED) are other phrases widely used in the literature, narrowing the focus to MSD involving that part of the body (Aptel, Aublet-Cuvelier, & Cnockaert, 2002; Health and Safety Executive, 2002) and deliberately excluding low back disorders for which the body of research is very large (Hagberg et al, 1995). However, in a comprehensive review of the scientific literature on MSD and the workplace, NRC-IOM (2001) included disorders of the back as well as the upper extremities.

A classification system is necessary for identifying disorders/syndromes and the criteria required for each condition. Being able to classify which conditions are work-related MSD improves the consistency of the treatment that is provided, builds a database from which to develop prevention strategies, and is essential for achieving the appropriate levels of compensation. However there are many different and conflicting classification systems for MSD (Sluiter, Rest, & Frings-Dresen, 2001). Van Eerd et al. (2003) reviewed 27 such systems, concluding that the lack of a universally accepted classification system for MSD has limited both research and resulting efforts to reduce their burden (p. 935). Boocock et al. (2006) reported similar problems and proposed a model for classifying upper extremity disorders to help harmonise the recognition of conditions internationally. Broberg (1996) suggested that in Scandinavia, variations in systems of diagnosis and compensation can influence reporting behaviour. For example, in Norway 16% of neck and upper limb MSD are considered to be work-related, 40% in Denmark and Finland, and 70% in Sweden, with Broberg suggesting that this variance may be attributable to claim 'migration' between categories.

In New Zealand, occupational overse syndrome is currently the umbrella term used by the state insurer (ACC, 1997) to describe the heterogenous group of work-related and non-work related symptoms and disorders (Boocock et al., 2006), and which are defined above as MSD. The National Occupational Health and Safety Advisory Committee (NOHSAC) in New Zealand also categorise MSD as an occupational disease rather than injury (Driscoll et al., 2004). Therefore the range of conditions that are considered as MSD includes both gradual and sudden onset diagnoses which can share the same initiating events and contributory factors, but result in different injury outcomes. Within ACC data, gradual onset conditions have their own defined list of diagnoses, while sudden onset conditions can also include soft tissue injuries.

The approach used in the study on which this thesis is based included MSD occurring anywhere in the body (NRC-IOM, 2001), although it is recognised that disorders will be clustered around those body parts most involved in the work tasks (i.e. spine and upper limb). Like Hagberg et al (1995), acute musculoskeletal injuries, such as fractures and contusions were excluded from the study.

2.3.2 MSD incidence and prevalence

A lack of reporting on MSD and differences in classification of MSD means that much of the information on MSD in the public domain is derived from national surveys and reports. Echoing the sentiments of van Eerd et al. (2003) reported in section 2.3.1, Buckle & Devereux (2002) referred to a lack of standardised measures as a difficulty in determining WRULD prevalence in the European Union. NRC-IOM (2001) also state that there are no comprehensive national data sources in the United States which capture medically determined MSD, while distinctions are not drawn between work and non-work MSD. However, in those countries where national data on occupational injuries and illnesses are reported, either from national databases or surveys, MSD are invariably near the top of the list for both prevalence and costs.

The US Bureau of Labor Statistics (US BLS), which annually collects OSHA 200 log records from a random sample of private sector companies, showed that in 2006 MSD accounted for 30.2% of all non-fatal occupational illnesses and injuries, with an incidence rate of 38.6 per 10,000 workers (US BLS, 2006). The spine (neck and back) was the body part most affected. Although the number of MSD has declined over time, their proportion of the total number of occupational illnesses and injuries remains at similar levels, while incidence rates have dropped slightly (US BLS, 2005). Bernard (1997) also reported data from the BLS stating that in 1994, 32% of the cases were the result of overexertion or repetitive motion, with incidence rates in 1995 of 41.1 (in lifting) and 10.1 per 10,000 workers respectively. The back was again the body part most affected. In summarising data from six national surveys, NRC-IOM (2001) stated that MSD were "very prevalent among adults in the United States, especially after the age of 50, and are a source of an extraordinary burden of disability" (p. 39).

In a recent survey of self-reported work-related illnesses in Great Britain (Health and Safety Executive, 2007) the estimated incidence rate of MSD for twelve months in 2005/06 was 580 per 100,000 employees. The average time off work for each person reporting an MSD was 17.3 days. While estimated prevalence rates are lower than in seven previous surveys since 1990, MSD were still the most commonly reported type of work-related illness on each occasion. WRULD data from national surveys in the Netherlands, Belgium and Denmark were summarised by Buckle & Devereux (2002). Average twelve month prevalence of self-reported symptoms were 28% in the neck, 25% in the shoulder, 14% in the wrists/hands and 7.5% in the elbows.

Miller, McAtamney, Hogan, & Mallet (2006) reported on WMSD from two data sources: a 1998/9 survey by the Australian Institute of Health and Welfare (AIHW), and the National Data Set (NDS) from which compensation statistics are compiled. Data from AIHW reported that 45% of work-related cases were for musculoskeletal problems. For the NDS, 'body stressing' is the incident classification most applicable to WMSD, and accounted for 41% of all workers' compensation cases in 2002-3. The percentage of new cases of body stressing relative to total cases has remained relatively unchanged from 1996-2002. WMSD incidence rates have however decreased over this time, apart from an increase for cases attributed to repetitive movement and low muscle loading. MacDonald & Evans (2006) also referred to difficulties encountered when interpreting WMSD epidemiological data.

According to ACC data, MSD are the leading cause of non-fatal occupational injury and lost-time in New Zealand workplaces (ACC, 2005). Indeed, MSD are responsible for the highest number of claims and the highest total cost of claims for ACC over recent years. In 2006, MSD accounted for 42% of all work-related claims to ACC, and 35% of all 'serious' work-related claims (also known as compensation claims and are those resulting in more than seven days off work) (Statistics New Zealand, 2007b). However, these sprain and strain data encompass a narrower range of diagnoses than would normally be considered MSD, by omitting OOS claims for example. Table 2.2 provides more comprehensive summary data on MSD, drawing from ACC injury statistics (2001-2006) and including work-related MSD claims based on the definition used for the study in meat processing as defined in Chapter 3, section 3.2.2 (ACC, 2007). This shows MSD consistently accounted for greater than half the number of compensation claims and costs over the five year period. Unfortunately, more specific data on body part involved and incidence by injury/illness category are not readily available.

Table 2.2. MSD claims and costs as a percentage of total ACC compensation claims

Year	*2001/02*	*2002/03*	*2003/04*	*2004/05*	*2005/06*
MSD claims	54.3%	54.6%	52.7%	53.6%	54.5%
MSD costs	54.2%	52.8%	48.9%	51.7%	53.6%

2.3.3 MSD causation

The large percentage of people affected by MSD and the total costs attributed to their occurrence are two powerful drivers of research into MSD causation (Armstrong et al., 1993; Hagberg et al., 1995). Bernard (1997) notes that it was not until the 1970's that the work-relatedness of MSD became a regular topic in the scientific literature, despite the recognition of occupational risk factors more than a century prior (e.g. Anonymous, 1875). NRC-IOM (2001) referred to a generally held, but so far incorrect, assumption in the early 1980's that the number of repetitive jobs would decline in the future, and with them many of the known MSD risk factors.

Much research effort has since been expended trying to establish a theory of MSD causation that encompasses an ever-increasing range of risk factors and can therefore provide the basis from which to develop successful interventions. Early research emphasis was on physical and individual factors, with psychosocial, organisational and wider contextual factors receiving less attention and scientific validation until more recently (NRC-IOM, 2001; Buckle, 2005; Howard, Spielholz, Bao, Silverstein, & Fan, 2008; Marras, Cutlip, Burt, & Waters, 2009). For example, Bernard (1997) reviewed epidemiological data to establish levels of evidence of work-relatedness for specific risk factors. The strongest evidence was found for physical risk factors, which possibly indicates the proportions of research being undertaken, or the efficacy of the risk assessment methods, as much as it does the causal relationships between MSD and other types of risk factors (Aptel et al., 2002; Boocock et al., 2007). Keyserling (2000a, 2000b) conducted a thorough but narrow review of workplace risk factors for MSD, looking only at laboratory-based biomechanical and psychophysical research. In New Zealand, a review of the OOS (and MSD) literature by Boocock et al. (2005) was also considered; however stringent inclusion criteria meant that only 11 risk factor articles were included in the critical review. Those that were included predominantly reported on physical risk factors. This section describes the main findings of several international panels of researchers, as well as other prominent researchers in the field, as it traces the development of MSD causation theory over the past fifteen years.

Armstrong et al. (1993) proposed a conceptual model for the development of neck and upper limb MSD, having the ultimate aim of specifying individual limits on work design through informing further research as well as preventive programs. It included four interacting variables: exposure (work requirements, e.g. line speed), dose (factors that disturb the internal state of the individual, e.g. psychological stress), capacity (the ability to resist the effects of doses) and response (changes to the internal state as a result of the dose, e.g. tissue shape). The basis of the model, shown in Figure 2.1, was to show the cascading relationship between the variables, where the response of an exposure could become a dose for another tissue, producing another response. This remains particularly appropriate for the wide range of MSD risk factors that can contribute and interact with each other, as well as the insidious and gradual nature of many MSD. A further strength of the model was that exposure and responses were not limited by rigid definitions, enabling the range of contributory factors and possible responses to evolve with the findings from research. Indeed, the authors referred to the model as a beginning, and expected it to be modified to accommodate further research findings, such as the interactions between psychosocial exposures and tissue responses.

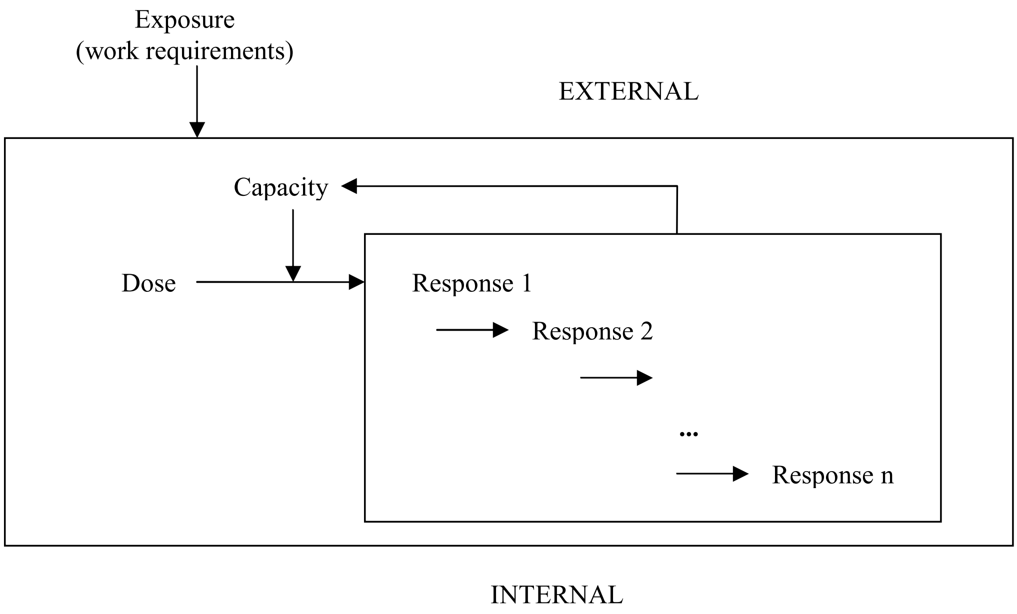

Figure 2.1. Dose-response model (Armstrong et al., 1993)

Hagberg et al. (1995) synthesised several models in arriving at their generic model of prevention (Figure 2.2). The model has three layers: generic risk factors, workplace features, and patho-physiological factors from which different outcomes may result. The authors stated that the patho-physiological process is only triggered if the risk factor(s) exceed individual levels of tolerance, however this is not evident from the model alone. The risk factors were thought to interact and form cascading cycles between the different layers.

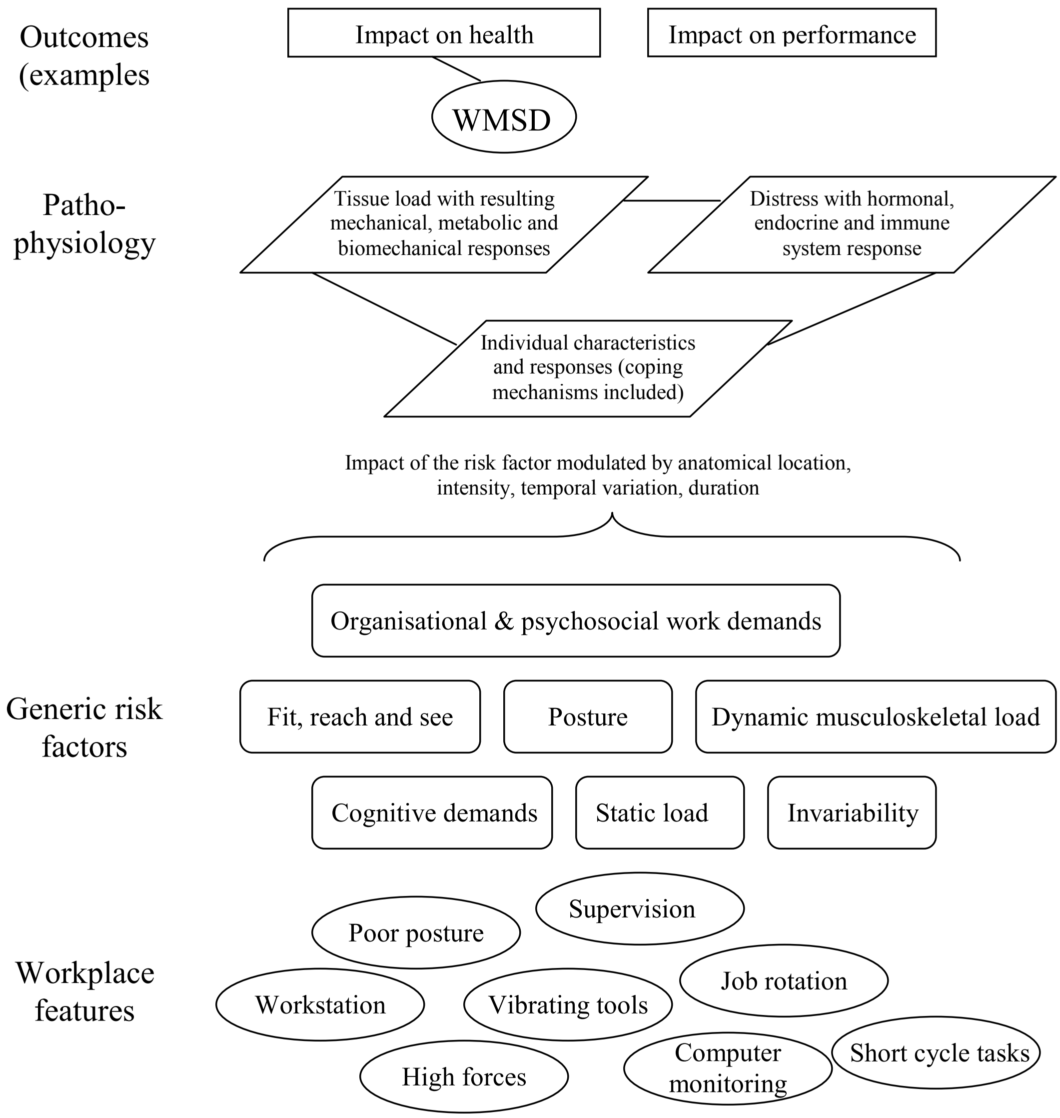

Figure 2.2. A generic model of prevention (Hagberg et al., 1995)

A unique element of this model at the time was the grouping of different contributory factors, and the division between individual factors and those involving the workplace. Also of significance is the recognition that outcomes may impact on performance as well as health, with MSD as one potential result. Two shortcomings of this model that have become apparent over time are that the lists of risk factors and workplace features are few in number, and limited in scope – particularly the under-emphasis of psychosocial factors, and that factors external to the workplace are not included, although reference is made to these in a later chapter of the text from which it is drawn.

The term 'psychosocial' in the context of MSD has evolved over the past fifteen years as the body of knowledge has grown. Carayon (2006a) refers to psychosocial work factors as perceived characteristics of the work environment that have an emotional connotation for workers and managers, and that can result in stress and strain (e.g. overload, lack of control), while work organisation is defined as the way work is structured, distributed, processed and supervised. Work organisation characteristics therefore determine to a large extent the type and degree of psychosocial work factors experienced by workers. Work organisation was defined by NIOSH (2002) as: external factors that contribute to new organisational practices (e.g. regulations, trade policies); organisational factors such as management structures and supervision practices; and work factors including task complexity and physical demands.

Bongers, de Winter, Kompier, & Hildebrandt (1993) conducted an extensive literature review of psychosocial factors and MSD. They postulated a model in which musculoskeletal symptoms arose as a result of an enhanced perception of symptoms and/or a reduced ability to cope with these symptoms in the presence of stressful working conditions (Huang, Feuerstein, & Sauter, 2002). An update of this review focusing on psychosocial factors for upper limb MSD was conducted by Bongers, Kremer, & ter Laak (2002). Karasek & Theorell (1990) developed the Demand-Control model, and derivatives of it, to illustrate the psychosocial work environment and the interrelationship between decision latitude and psychological demands. This concept has been commonly referred to in psychosocial studies including those concerned with MSD (Bongers et al., 1993; Hoogendoorn et al., 2001; Warren, 2001; Huang et al., 2002). The lower right quadrant (see Figure 2.3), representing high psychological demands with low control, is common in many routine jobs including meat processing tasks. A third dimension of the model, concerning social support, theorises that low levels exacerbate job strain and high levels can help protect against it. This aspect has also been considered in relation to MSD and found to be an indicator of risk (Hoogendoorn et al., 2001; Warren, 2001; Woods, 2005).

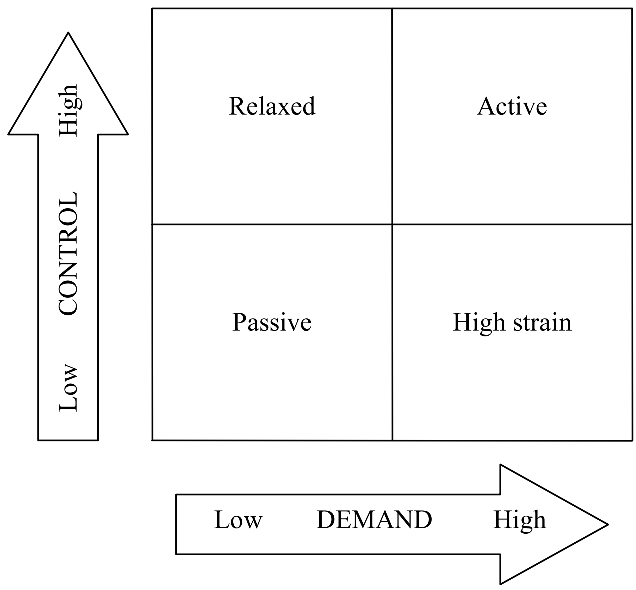

Figure 2.3. Demand-control model (after Karasek & Theorell, 1990)

Psychosocial aspects of MSD in office work were the subject of a 1996 edited book (Moon & Sauter, 1996) which reflected the amount of research being conducted at the time on non-biomechanical influences on MSD. Sauter & Swanson (1996) proposed their ecological model of MSD in VDT (visual display terminal) work, which had psychosocial, biomechanical, and cognitive components. The model shows VDT/office technology impacting directly on work organisation and physical demands. Work organisation is also prominent as it directly affects physical demands and psychological strain, and indirectly affects biomechanical strain. The connection between biomechanical strain and MSD is seen to be influenced by psychological strain, individual and work organisation factors, including the social context. Another new element that distinguished it from earlier models was that musculoskeletal outcomes did not have to include tissue damage, as this was not necessary for the development of symptoms. This factor helps to establish a difference between MSD research concerned with establishing work-relatedness of specific diagnoses for compensation, and that which simply seeks to understand MSD causation and address risk factors independently of any medical labelling.

Another model from the Moon & Sauter (1996) book was put forward by Feuerstein (1996) concerning upper extremity MSD. In this model, workplace psychosocial stressors, work demands and ergonomic stressors all impact on what was described as work-style factors. These describe the type of reactions that could occur as a result of the stressors and are divided into behavioural (e.g. increased force), cognitive (e.g. increased fear of losing job), and physiological (e.g. increased muscle tension). These reactions in turn can lead to symptoms or disorders and ultimately, work disability. A weakness of this model is that workplace psychosocial stressors and work demands are not defined or described, and a narrow view of ergonomics is adopted. The emphasis is instead on the response of the individual through their ‘workstyle’. While this concept helps to explain why under identical work conditions only some people develop MSD, it could also potentially be abused by those seeking reasons to look no further for cause than the individual.

The link between work stress and MSD has been the aim of several studies. Huang et al. (2002) reviewed models of occupational stress and health, highlighting the role that work organisation factors may play in contributing to occupational stress. The authors also made reference to the influence of work organisation on musculoskeletal outcomes through directly affecting exposures and biomechanical loads. Carayon, Smith & Haims (1999) presented a model of job stress in which work organisation factors can lead to stress reactions and strain outcomes, of which upper extremity MSD are one. Individual characteristics could also impact on each of these elements and act as a moderating influence between exposures and outcomes. The model follows earlier work by two of the same authors (Smith & Carayon-Sainfort, 1989; Smith & Carayon, 1996) designed to illustrate mechanisms of job stress. Their emphasis on work organisational factors is greater than the previous two models of Sauter & Swanson and Feuerstein, and was further developed in a paper by Carayon & Smith (2000) which examined the potential effects of sociotechnical and business trends (e.g. restructuring, downsizing, workforce diversity) on work organisation design. The role of stress and psychological factors on MSD development and reporting was the subject of a comprehensive study in the United Kingdom by Devereux et al. (2004). Significant results showed that high exposure to physical and psychosocial risk factors resulted in a greater likelihood of MSD being reported, and that individual stress reactions increased the likelihood of developing self-reported MSD. However, individual demographics, traits and attitudes were not implicated in the causation of self-reported MSD. In a review of MSD risk factors from epidemiological studies, Malchaire, Cock, & Vergracht (2001) also found only a weak association between MSD and individual characteristics, extra-occupational factors and medical history.

Consideration of the physical effects of MSD led Kumar (2001) to propose four theories of musculoskeletal injury causation. Based on the assumption that all occupational MSD are biomechanical in nature, these theories focus on the mechanical properties of the anatomical structures involved. The names of the theories are somewhat self-explanatory: multivariate interaction theory, differential fatigue theory, cumulative load theory and overexertion theory. Collectively they are useful in explaining what happens to the tissues and structures within the body, but do not help to advance understanding of MSD beyond biomechanics.

A model of MSD causation (Figure 2.4) was presented by the National Research Council and Institute of Occupational Medicine in a book on MSD and the workplace (NRC-IOM, 2001). The authors stated that MSD analysis must take place on two levels: the first addressing the individual, and the second addressing populations at risk.

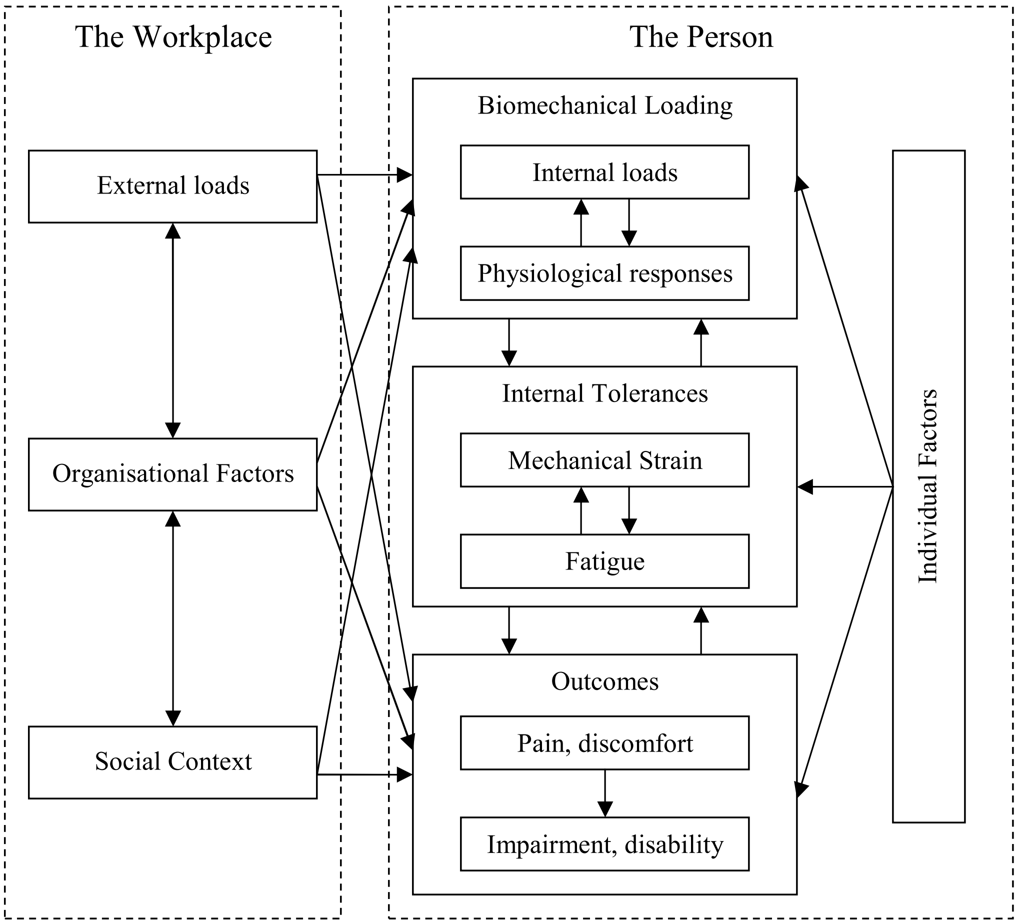

Figure 2.4. A conceptual model of the development of MSD (NRC-IOM, 2001)

Aggregate or population approaches provide a useful structure to consider a range of strategies for reducing MSD risk factors. In this model the social context is identified as a separate factor that interacts with external loads and organisational factors, to directly impact on biomechanical loading as well as outcomes (e.g. pain, disability). These three factors are included under 'the workplace', although the main emphasis still resides with the person and individual factors. The nature of interactive effects between these factors is not well understood however (NRC-IOM, 2001; Huang, Feuerstein, Kop, Schor, & Arroyo, 2003).

NRC-IOM (2001) described the association between physical exposure and the development of MSD as occurring "…in a broad context of economic and cultural factors and reflects the interaction of elements intrinsic to, as well as extrinsic to, the individual." (p. 28). Thus the authors recognised that most MSD research has focused on physical and psychosocial factors, while highlighting the potential role that economic incentives, organisational policies and cultural differences can play in MSD. These factors were included in a conceptual model for the development of MSD and the term 'contextual factors' is used to refer to the social, economic, cultural, political and organisational factors that are seen as creating the conditions under which physical and psychosocial risk factors can occur, through affecting the external demands of work and the individual's response to these demands. These factors are illustrated in Figure 2.5.

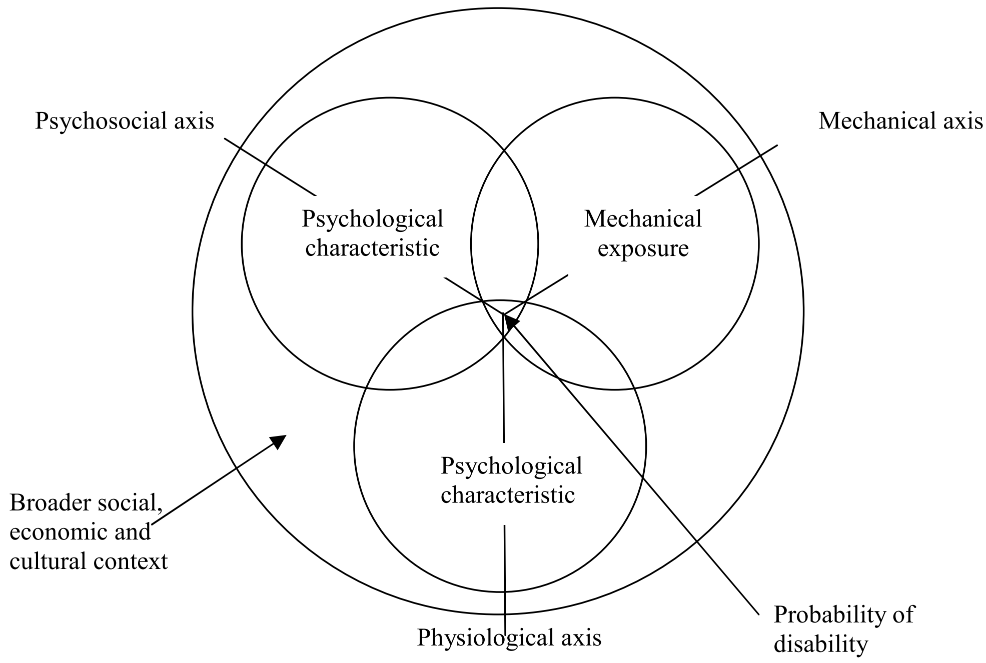

Figure 2.5. Risk factors for the injury, impairment, and disability attributed to MSD in the individual (NRC-IOM, 2001)

In a review of work-related MSD causation theories, Karsh (2006) developed an integrated model from nine existing models including several discussed above. Karsh noted a number of considerations that were not specified in these models, including information on the latency period between exposure and response, suggesting that this reflected the state of empirical evidence. A significant aspect of the integrated model is the incorporation of social and cultural contextual factors derived from NRC-IOM (2001). In the model, the social and cultural context of the organisation is shown to directly influence both the organisation of work and the psychological work demands. Work organisation factors directly affect both psychological and physical work demands, which in turn can influence each other. Karsh also reminded us that "many different exposures may be acting simultaneously to impact doses and responses", highlighting the necessity of considering a wide range of contributory factors as well as the research challenges of doing so. Figure 2.6 is a shortened version of the complex integrated model by Karsh. It was modified for this chapter, emphasising the range of contributory factors and their interactions and excluding the links between these factors and the development of MSD conditions.

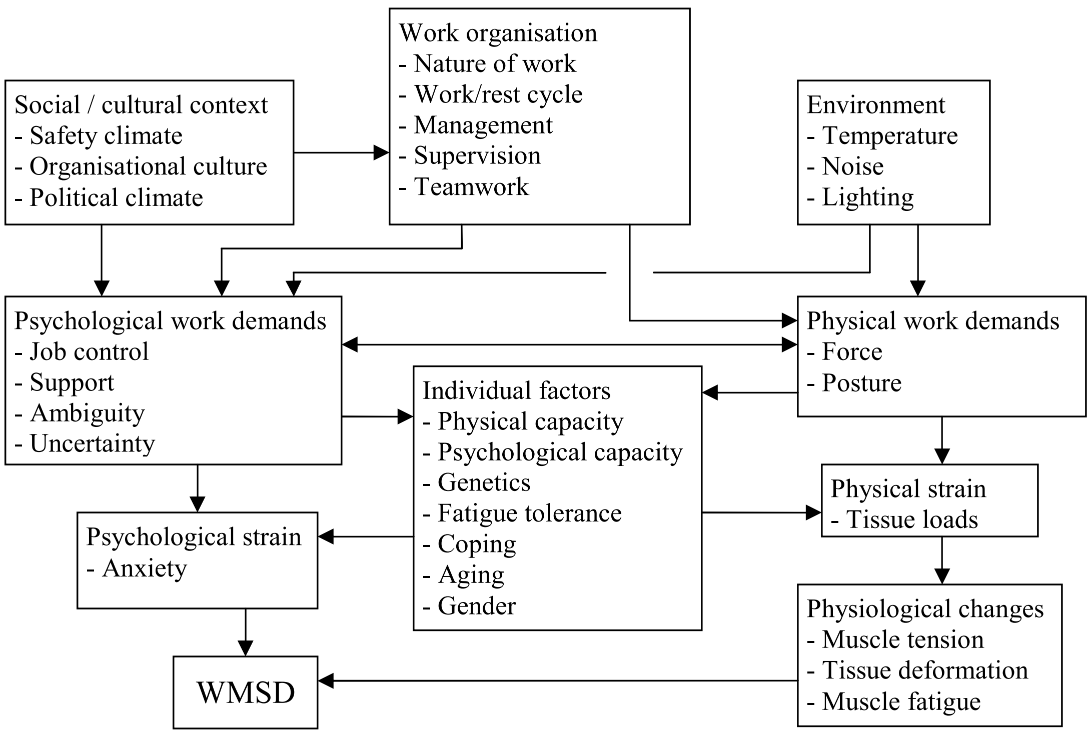

Figure 2.6. A shortened version of Karsh's integrated model (2006)

The role of wider contextual factors has also been asserted by other researchers. MacDonald, Karasek, Punnett, & Scharf (2001) for example, also referred to task-level physical and psychological job stressors arising from higher-level work organisational factors. Meyer & Turpin-Legendre (2001) discussed demographic and social changes which have created occupational MSD risk in France. Faucett (2005) used existing theoretical models to develop an integrated model of MSD incorporating psychological and social factors. The author argued that the complexity of MSD requires theoretical development to guide investigation and generation of interventions, and in particular, the 'organisational, social and physical attributes of contemporary jobs'. The link between psychosocial factors and MSD was explored, highlighting the roles that increased muscle tension/reactivity, altered states of the autonomic nervous system and changes in the cognitive state, may play in MSD development. Faucett raised several challenges for developing a theory on MSD causation including conceptual clarity, recognising the dynamic nature of work, and their relevance to practice. Emphasis was also placed on the role that management systems can play in introducing MSD risks and latent failures through organisational policies aimed at improving worker productivity. Although external conditions are included in the model, they are grouped under management systems and work environment rather than considered separately as in models by Karsh (2006) and NRC-IOM (2001).

Faucett (2005) also mentioned methodological approaches to minimise threats to validity encountered in real world MSD research, through such measures as multi-method approaches, data collection at multiple time points, qualitative as well as quantitative methods, and multidisciplinary research teams. The broad range of system elements and interactions between them, illustrated in Karsh's (2006) integrated model in particular, emphasised that MSD research must be based in 'real' work systems if the causes of MSD are to be fully understood. The very definition of ergonomics (e.g. IEA, 2000) implicitly supports this, and it is exhibited by many diagrams of the systems model for ergonomics (e.g. Moray, 2000, Wilson, 2000; Warren, 2001).

Sinclair (2007) discussed the need to understand complexity in future systems and refers to emergent behaviour - or symptoms of a system behaving differently, often unexpectedly and not necessarily in desirable ways. MSD are one such symptom of dysfunction in a complex system. Sinclair cited Rasmussen's (1997) 'drift to disaster' diagram to illustrate various forces acting on an organisation causing it to migrate toward the boundary of acceptable performance, while others work to keep it in balance. Rasmussen explained that normal changes in local work conditions lead to the adoption of system modifications and that as part of the adaptation to these changes, employees identify an 'effort gradient' and management determine an effective 'cost gradient'. Migration toward the boundary of functionally acceptable performance is likely and if the boundary is crossed may result in an error or an accident. Rasmussen went on to state that systems with functionally redundant protective defenses may not notice violations, and that such defenses are likely to "degenerate systematically through time, when pressure toward cost-effectiveness is dominating" (p. 190), which presumably applies equally to systems with no formal protective defences. A modified version of Rasmussen's original model is included as Figure 2.7. Although developed with severe, large-scale accidents in mind, this model would seem no less relevant to the occurrence of MSD and the influence of contextual factors (NRC-IOM, 2001) in creating MSD risk. Some parallels can be drawn with the effects of business rationalisation strategies and their role in MSD causation and prevention as discussed by Winkel & Westgaard (1996).

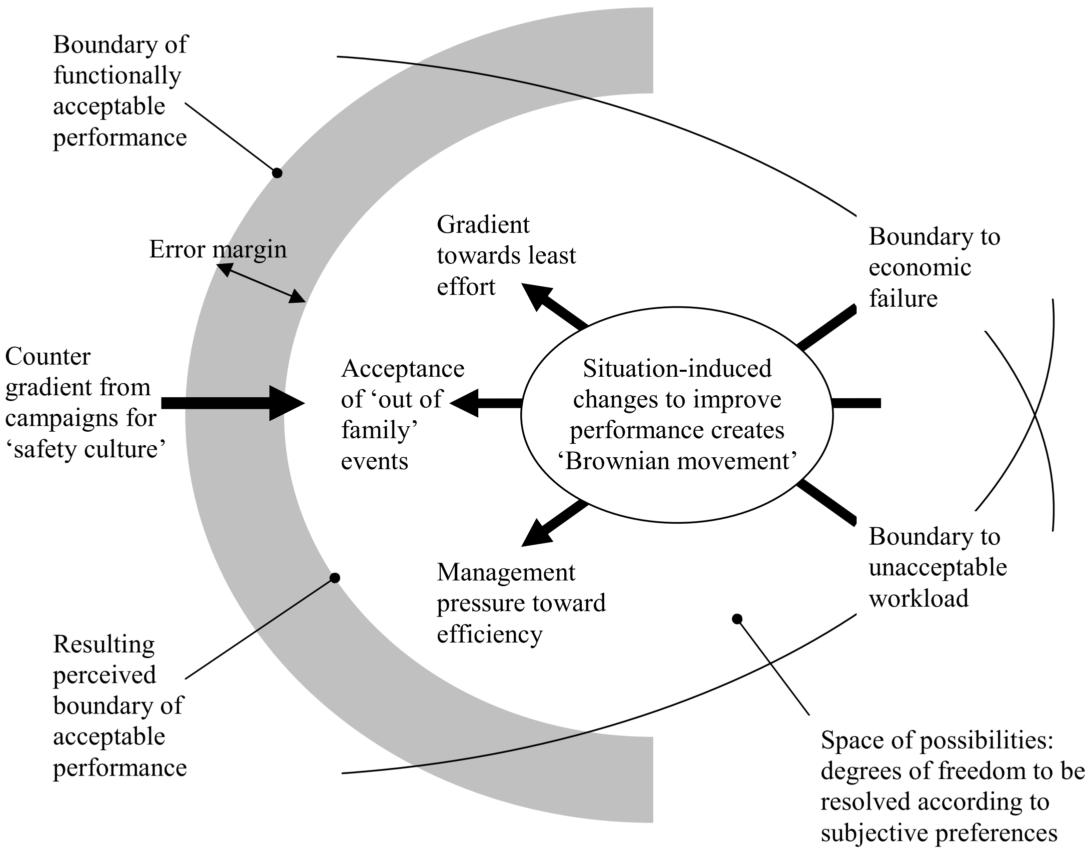

Figure 2.7. Adapted from Rasmussen (1997) and Sinclair (2007)

Looking to the future, regarding how MSD causation is characterised by influential bodies, Marras et al. (2009) discussed future research directions in MSD as part of the National Occupational Research Agenda (NORA) in the United States. Included in these is the suggestion to quantitatively link epidemiological, biomechanical loading, soft tissue tolerance, and psychosocial factors in order to better understand causation and the prevention strategies that develop from this. While many of the other suggestions are biomechanically focused (e.g. responses of tissues to loading, quantifying physical risk factors) the authors indicate an acceptance of a wider range of risk factors and recognition of the need for collaborative approaches to MSD research.

This discussion of MSD risks and the prominent MSD causation models has highlighted the gradual expansion of risk factors that are associated with MSD from individual and physical factors to psychosocial and work organisation factors. However, less attention has been given to industry-level and wider economic and societal influences on MSD risk. This suggests that mainstream thinking on MSD causation is still developing, and further research is required to better understand the role of wider contextual risk factors in MSD causation. Indeed, the consideration of factors outside the immediate work environment in relation to systems design as well as MSD injury prevention, including those of concern from an industrial sociology perspective, has growing support in the literature (Dwyer, 1995; Moray, 2000; Aptel et al., 2002; Woods, 2005; Sinclair, 2007).

2.3.4 MSD in meat processing

2.3.4.1 Extent and cost of MSD in meat processing

Internationally, MSD feature prominently in injury statistics for the meat processing industry. In North America for example, MSD were highlighted during the 1980s (Conroy, 1989) when a reported general increase in output was followed by a series of legal actions from OSHA. This resulted in two large companies being fined for high injury incidence rates and record keeping violations, requiring them to instigate long term ergonomics programmes (OSHA, 1991). Despite these initiatives, the US meat industry has remained a poor performer in addressing MSD (Gjessing, Schoenborn & Cohen, 1994). Piedrahita, Punnett, & Shahnavaz (2004) report from the US Bureau of Labour Statistics that in 2000, meatpacking had the highest incidence rates of repeated trauma disorders of all private industries, with 812 cases per 10,000 full-time workers. Previously, Bureau of Labour Statistics (1982-1990) showed that meatpacking plants had the highest occupational injury and illness rates in the US for seven consecutive years (Genaidy, Delgado, & Bustos, 1995). In Canada, meat and poultry processing were the highest risk industries for work related MSD among workers' compensation board claims (Yassi, Sprout, & Tate, 1996).

While MSD are recognised as one of the main health problems in European meat processing industries, publicly available MSD data are scarce. In a literature review on MSD in meat deboning, Riley (1998) also noted the paucity of data and the difficulties in drawing comparisons between general data that are available. Nossent, de Groot, & Verschuren (1995) provided an overview of occupational health and safety in the meat processing industries of ten European countries but only reported MSD data for three countries (Denmark, Germany, Spain) between 1988-1993. In these three countries MSD are ranked first, second and fourth respectively based on the incidence of notified occupational diseases. Loppinet and Aptel (1997) reported that MSD in the French meat processing industry more than doubled between 1992-1995.

The Australian meat processing industry was described as one of high risk for MSD, with estimated direct cost of injuries of $300 million per year (Caple, 1992). Caple (2003) reported that from 1998-2001, the rate of injury claims for meat processing was four times higher than for the manufacturing industry, and that manual handling claims accounted for 54% of these claims. The costs of these claims were almost 50% more than other injuries.

Meat processing in New Zealand has the highest annual incidence of MSD compensation claims of all major industries[4] nationally with the average incidence rate of 52 claims/1000 employees between 2001-2006 (ACC, 2007). In direct costs alone, the amount paid by the meat processing industry in 2005/6 for all MSD compensation claims exceeded NZ$12 million annually and accounted for 64% of the total cost of compensation claims (ACC, 2007). Earlier data for compensation claims show a similar

[4] Based on a list of industries identified as high priorities by ACC and the Department of Labour (ACC & OSH, 2003).

pattern. In 1994/95 the incidence rate was 45 claims/1000 employees and 58% of the total direct costs (ACC, 1996), while in 2002/03 MSD incidence rate for meat processing was 59 claims/1000 employees compared to 20 for forestry and logging and 16 for construction (ACC, 2003). Similar trends are also evident for the number and cost of MSD compensation claims lasting more than one year (ACC, 2003) and for less serious MSD claims, where such data are available (ACC, 2004a). Although previous attempts to address MSD risk have met with only limited success (Slappendel et al., 1996; OSH, 1997), improvements in injury management (return-to-work) have helped to reduce the 'tail' or costs of ongoing injuries from 82% of total MSD compensation claims costs (1994/5) to 64% in 2005/6 (ACC, 2007).

Estimates of indirect costs of occupational MSD to those injured, their families, and their employer vary, although they are clearly considerable. ACC suggest a figure of between 3-12 times that of the direct costs, while the UK Health and Safety Executive, cited in Tomoda (1997), suggest that the cost of accidents could be as much as 37% of profits, 5% of operating costs, and 36 times the insured cost. Riley, Cochran, May, Schwoerer, & Stentz (1994) estimated the full costs to meat processing companies for a carpal tunnel syndrome case to be US$40,000 typically, and up to as much as US$100,000.

2.3.4.2 Body areas involved

From the data that are available, MSD in meat processing are most commonly located at the upper limb, shoulder and neck. Most cited conditions include epicondylitis and tenosynovitis (Kurppa, Viikari-Juntura, Kuosma, Huuskonen, & Kivi,, 1991; Viikari-Juntura et al., 1991), carpal tunnel syndrome (CTS) (Yassi et al., 1996; Frost, Andersen, & Nielsen, 1998; Gorsche et al., 1999; Isolani, Bonfiglioli, Raffi, & Violante, 2002), tendonitis (Yassi et al., 1996), and trigger finger (Gorsche et al., 1999). The neck and low back are recognised as further sites of MSD among meat processing workers (Roto & Kivi, 1984). Magnusson, Ortengren, Andersson, Petersen, & Sabel (1987) surveyed 73 butchers in Sweden to determine frequency of physical symptoms, finding that 92% of those surveyed had experienced pain in some part of the body in the last three months. Most commonly reported was pain from the hands and wrists (≈ 60%) and from the shoulders and low back (55%).

2.3.4.3 Reported risk factors and approaches for meat processing

The literature on MSD risk factors for meat processing work follows a similar pattern to that of the wider literature, with the primary focus on physical risk factors. Awkward or static work postures, forceful movements, repetition and lack of recovery are therefore the risk factors most commonly linked to meat de-boning work (Magnusson et al., 1987; OSH, 1997; Riley, 1998). Marklin & Monroe (1998) suggest that few studies have been undertaken that quantify the biomechanics of the upper extremity among red-meat packing workers. However, there have been considerably more papers published on biomechanics in meat processing than on broader issues such as psychosocial issues and work organisation. The remainder of this section outlines the literature on risk factors in meat processing as it relates to biomechanical factors, knife and glove design, and the ambient environment. Finally, research that has adopted a broader approach to MSD in meat processing is discussed.

Biomechanical factors

In an Australian study involving worksite inspections of 29 abattoirs, Waniganayake and Steele (1990) identified high frequency handling, awkward grips, forward reaching, stooping and twisting, workstation design and handling of heavy loads as the most common manual handling risk factors. Oxenburgh (1991) observed the involvement of both arms during meat processing; one arm and wrist adopting a static posture to hold the meat steady, while the other arm cut the meat with the wrist positioned away from its strongest midline position. Falck & Aarnio (1983) assessed forearm force requirements during de-boning in two slaughterhouses over a period of six hours work, observing that muscles on the non-knife side were exposed to a higher level than on the side holding the knife. In a study by Christensen & Larsen (1995), mean force requirements on the forearm flexors muscles were assessed by EMG during deboning work and found to be at peak activity more than 60% of the time.

Following a similar theme of upper limb forces and exposure to risk, Van der Doelen & Barsky (1990) recommended using a variety of knives to allow neutral wrist postures, as well as work surface height and slope adjustability to improve wrist/hand alignment. Further observations were that cutting forces depended on wrist position, the distance from the wrist to the point of force application, knife sharpness and product density. A link was also suggested between MSD and performing cutting tasks on an overhead line. Riley (2001) also referred to a paper by Frost and Andersen (1999) that linked shoulder MSD and working with the arms elevated, as occurs in rail boning.

The high prevalence of Carpal Tunnel Syndrome (CTS) in meat processing has led researchers to investigate this issue specifically. In interviews and examinations of workers from meat plants, Frost et al. (1998) and Gorsche et al. (1999) both found that CTS risks to both hands (particularly boning) are higher in the industry compared with the general population. Frost & Andersen (1999) also considered daily high-velocity and high-force manual work to be a risk factor for CTS, and found an elevated risk of CTS in the non-dominant hand among workers involved in de-boning tasks.

Kurppa et al. (1991) carried out a 31 month follow-up of 377 workers in strenuous manual jobs and 338 workers in manually non-strenuous work in a meat processing factory. The annual incidence for tenosynovitis or peritendinitis was less than 1% for employees in non-strenuous jobs, 23.5% for female packers, and 12.5% for male meat cutters. The annual incidence of epicondylitis was 1% for employees in non-strenuous jobs, 11.3% for female packers and 6.4% for male meat cutters.

Knives and gloves

Aspects of knife and glove design and use are common topics in the meat processing literature, though again with little consideration of the wider work systems involved. Grant & Habes (1997) measured surface EMG studies with subjects performing simulated meat cutting tasks under laboratory conditions, concluding that musculoskeletal stresses can be reduced through tool and workstation redesign. Van der Doelen & Barsky (1990) noted some aspects of hand tools that were contributory to MSD development including: longer knives increasing wrist torsion forces, knife shape and stiffness also influencing the force generated, and the effects of vibration and weight of automated hand tools. Claudon (2006) discusses the need to improve knife design and cites Buchholz, Frederick, & Armstrong (1988) who stated that low handle friction causes the operators to grip more firmly, increasing the risk of MSD. Marklin & Monroe (1998) investigated wrist motion of nine workers using Whizzard-type knives for bone-trimming in one plant, finding they were in the high-risk group of MSD compared with the manufacturing industry benchmarks and that both the knife and non-knife hands were likely to sustain nerve and soft tissue damage. Although aspects of this research add to the body of knowledge on MSD in meat processing, this article is otherwise another example of a biomechanical approach that omits information that cannot be easily measured and applies complex measures to single elements of the work system.

Claudon (2000) noted that of 196 butchers from 12 plants interviewed in their study in France, only 16% reported having been trained in knife sharpening and maintenance, and 42% complained of the blade not being sharp enough. Marsot, Claudon, & Jacqmin (2007) described how use of a dull knife edge results in a higher force applied by the operator, and an increase in cutting time. Cutting forces were also found to vary according to blade inclination. McGorry, Dowd, & Dempsey (2003) measured muscle activity using strain gauges within knife handles and found that grip forces, cutting moments and cutting time were lower with a sharp knife. In a similar study, Claudon and Marsot (2006) measured muscle activity using EMG and a quantifiable method of determining blade sharpness. The sharper blade reduced EMG activity levels in most muscle groups measured, but very high activity was recorded for one forearm muscle (extensor digitorum communis), even when the knife sharpness was excellent. In a study investigating factors related to force and posture during a simulated meat cutting task, McGorry, Dempsey, & O'Brien (2004) found grip force and cutting moments were highest when working at a pace based on piece rate payment. This brings into consideration the effects of line speed on MSD risk for people unfamiliar with the tasks, and for tasks with low autonomy.

Gloves are worn to reduce knife cuts and bone scratches to both non-knife and knife hands as well as provide an impervious barrier to zoonotic diseases. Glove design may affect grip force by changing the sensory feedback from a tool or object (Fleming, Jansen, & Hasson, 1997). Claudon (2006) found that use of Kevlar fibre gloves increased friction between the hand and knife handle, but with no significant differences in EMG values of forearm and shoulder muscles.

In New Zealand, the potential benefits and risks associated with the use of protective gloves was examined during the meat industry 1993-6 study (Slappendel et al., 1996). Greenslade, Moore, & Tappin (1998) had also noted that the surgical gloves used over the cut resistant gloves could improve hygiene performance but became slippery with blood and fat and increased the grip forces needed to maintain the same 'feel' and control.

Ambient environment

One of the hygiene compliance requirements for boning operations in meat processing plants is ambient temperature limits, which can conflict with comfortable working conditions. Coldness, high humidity, draught and temperature fluctuations are identified as problematic factors by Nossent et al. (1995), OSH (1997) and Ilmarinen, Tammela, & Korhonen (1990). In similar studies, Drewczynski & Bertolini (1995) point to the cold environment as one contributory factor for MSD. Piedrahita et al. (2004) explored the relationship between MSD and cold exposure in a large meat processing plant and found that workers in very cold areas (+2degC) had a higher prevalence of MSD than those in less severely exposed areas (+8 to +12degC).

Loppinet & Aptel (1997) stated that apart from harmful effects on hearing, noise can also stress the operator, influence balance, and bring on fatigue as well as diminishing performance. Caple (1994) reported that a high proportion of work areas in Australian abattoirs have noise levels in excess of 85 decibels (dB(A)). Peak levels of 111 – 140 dB(A) from metal on metal contact were a common feature in many work areas. Noise was also identified by Nossent et al. (1995) as a risk factor in MSD and communication problems. The Australian National Guidelines for Health and Safety in the Meat Industry also identified that poor control of noise can create stress leading to fatigue and may affect balance and concentration (AMIEU, 1995). The wearing of hearing protection also reduces interpersonal communication thus impacting on hazard management and teamwork (AMIEU, 1995).

2.3.4.4 Adopting a broader approach to MSD

A number of studies and reviews have taken a broader, systems approach to MSD analysis than evidenced in the previous section, and some of these have pointed to the importance of contextual factors for MSD in meat processing. Many have also been conducted in the industry itself, or reflect on data from the industry. In New Zealand, the Department of Labour (OSH, 1997) categorized the risk factors for MSD in meat, poultry and seafood processing under twelve headings covering: work organisation, postural and workplace considerations, psychosocial factors, and individual behavioural characteristics. This list and the information contained within them, while not completely balanced, at least included a bigger range of factors than previously considered by the industry.

Waniganayake and Steel (1990) discussed some of the reasons behind the physical risk factors they observed in their study. These recognised issues such as; the tally system leading to high work pace and compression, the work pace being set by experienced staff, haphazard rotation due to lack of training in tasks; and forward reaches required with larger carcasses or to ensure hygiene compliance. In a study of the Canadian meat packing industry, Novek, Yassi, & Spiegel (1990) argued that changes in technology, labour relations, and work organisation were largely responsible for increased frequency and severity of physical injury, particularly upper limb repetitive strains and inflammation. This is supported by a further study in two meatpacking plants (Novek, 1992) which highlights aspects of the labour process (e.g. tiered wage systems and lower relative wages leading to higher staff turnover), along with the consequences of restructuring and mechanisation (e.g. task fragmentation, machine pacing), all contributing to the presence of MSD risk factors in the work tasks (e.g. rapid, repetitive movements).

Nossent et al. (1995) provided an illustration of the role of contextual factors on MSD risk, noting that the predominantly Tayloristic production line work and hierarchical organisational structure result in hazards such as lack of autonomy and control over one’s work, strenuous work rhythms and time constraints, short-cycled repetitive work, and highly divided work with low job content. They also found deficiencies in training at management level and state that this is likely to affect all levels of the industry operations including: physical hazards, work organisation, work relations and company health and safety policies. They identify four high risk groups on the European plants: slaughter workers, boners, production line (packing) and women generally; and nine overall risk factors. Of these nine, five relate to the physical work environment, one to organisational constraints and three to the social work environment. The specific risks identified in their study are shown in Table 2.3.

Table 2.3. Main risk groups, risk factors and health problems
(from Nossent et al., 1995)

Main risk groups	*Main risk factors*	*Main health problems*
Slaughter house workers: ▪ slaughterers ▪ butchers ▪ cutters	Biological agents Musculoskeletal loads Noise Climate factors Unsafe conditions Lack of autonomy/control High work pace Time constraints Repetitive work Low job content	Accidents and injuries Skin diseases Infectious diseases Hearing impairment Musculoskeletal disorders
Production line workers	Biological agents Musculoskeletal loads Noise Climate factors Unsafe conditions	No data, but likely: Accidents and injuries Skin diseases Infectious diseases Musculoskeletal disorders Hearing impairment Respiratory diseases
Boners	Biological agents Musculoskeletal loads Noise Climate factors Unsafe conditions Repetitive work Time constraints Payment on production basis	Serious accidents Cut and stab injuries Repetitive strain injuries

Malchaire et al. (2001) reviewed industry-based epidemiological studies of neck/shoulder and hand/wrist MSD in the previous 15 years, concluding that the evidence was not strong enough to link specific situations in industry generally with specific disorders, and that questions relating to a person's weight and hobbies outside work could be abandoned as irrelevant for future studies. However, their findings provided justification for interventions targeting biomechanical and organisational factors.

Loppinet and Aptel (1997) concluded from their literature review that the main risk factors for MSD in meat plants are understood, but that their interactions and methods of assessing relative importance are less well established. They conclude that a broad and systematic approach must be taken that targets all risk factors. Riley (1998), from a review of the literature on MSD in boning work, also included work organisation, along with repetition, force, static posture, low temperature, and lack of recovery, as an important MSD risk factor for meat processing work.

Habes described in Gjessing et al. (1994), some of the factors that resulted in increased injuries, illnesses and staff turnover in the American meat processing industry during the 1980's. These included an industry recession followed by restructuring, technological changes, increased production rates and reduced wages, machine pacing and division of labour. A further example of a study that has identified contextual factors (Caple, 1992) involved the development of interventions to address MSD in Australian meat processing plants. Risk factors identified included; the paced work demand of production lines; the existence of seniority systems reducing task rotation options; and the effects of piece rate payment systems on work pace and individual sustainability.

Nossent et al. (1995) reported that in seven of the ten countries considered in their analysis, pay was linked directly to productivity. Also of note was that the meat industry across Europe had a higher than average labour turnover and was considered unattractive to workers. Tight profit margins reduced investment in the industry and made survival in the market difficult. In the USA, meat processing plants paid 110% of the national average for manufacturing workers in 1963, but by 1990 it was down to 71% due to recessionary pressures on companies to cut costs and increase production (Gjessing et al., 1994). OSH (1997) stated that pay structures with bonus systems can lead to people working beyond their capacity and risking the occurrence of MSD. Pay incentives are also suspected to be a factor in grip forces used. McGorry et al. (2004) found that in their laboratory-based study of non-meat workers on a simulated meat cutting task, the variable of asking subjects to work as though they were getting paid by the amount of cutting they did produced the biggest increase in cutting force applied.

Temmyo & Sakai (1985) noted that inherent rest pauses in the work cycle seen in traditional autonomous butchering 'work teams' still in operation at that time in Japan were largely missing from tasks in plants in Japan and New Zealand which were using a chain system. Christensen, Sogaard, Pilegaard, & Olsen (2000) explored the effect of different work/rest patterns as risk factors for developing MSD. The study used self-selected "slow" and "fast" groups of meat cutters and found no difference existed in the mean muscle activity levels. The comparative experience of the two groups or the amount of rest time achieved by the slower group between task cycles is not described, however.

While many of the studies mentioned above have acknowledged the role of work organisation and other contextual factors in MSD risk, this has had little impact on the New Zealand meat processing sector. Historical events have shaped both the development of MSD risk in the industry and how this risk is managed. As the first link in the supply chain, farmers exert significant influence over processors which has affected plant design and layout over time (Curtis, 1992). The move in the 1930's from solo butchering to mass production saw scientific management principles widely implemented, unionisation of the workforce and deterioration in labour relations as workers tried to regain some control in the workplace (Inkson & Cammock, 1988). This control did not always extend to health and safety issues, however, which were seen as the responsibility of the Department of Labour, and could be traded in negotiations for increased earnings (Jeffrey, 1995).

The year-round pasture-grazing of stock leads to seasonal fluctuations in processing volumes and corresponding fluctuations in employment as processors try to manage these peaks and troughs. A seniority system has evolved to provide some job security as well as a hierarchy for engaging and relinquishing staff as required by seasonal production. This system of seniority is extremely strong in the industry and has resulted in exclusionary practices of work organisation (Curtis, 1992) Such factors have resulted in many MSD risks being firmly embedded in the industry, through work practices, cultural norms, and physical design (Blewden & Wyllie, 1997). A further historical factor of relevance is that meat companies generally attempt to conduct major building modifications during the annual shutdown period. This affords little opportunity for the trialing of new structural arrangements to workplaces and workstations (Slappendel et al., 1996). The design work preceding this work is also often completed in haste, and with inadequate consultation with those on the floor (Hanara, 1981).

An earlier study to consider MSD in the industry was a government-funded pilot programme undertaken in three meat processing plants between 1993-96 in response to the high incidence of ACC compensation claims and costs, particularly strains and sprains (Blewden & Wyllie, 1997). MSD were the most common and costly injuries in all three plants and MSD contributory factors identified included: work compression, variations in workload and workflow, the implications of limited task training and job seniority, and poor workspace design.

Findings from the programme highlighted the need for better understanding of MSD risk factors, particularly those related to work organisation, and suggested that risk factors be considered in the scheduling of work, task training and plant design (Slappendel et al., 1996). Competition between plants, even within the same company, had restricted the movement of good ideas on both risk assessment and interventions (Caple & Hodgson,1992; Slappendel et al., 1996).

This account of research on MSD risk factors in meat processing has highlighted the narrow approach adopted in many studies, where the emphasis has been on quantifying individual elements of the risk under controlled conditions. However, these studies often neglect to account for many of the realities of work in the industry, as well as the principle that it is the combination of risk factors that result in MSD rather than one element of risk (Silverstein & Clark, 2004). Some studies have considered the broader picture, conducting research in industry and measuring more than just physical risk factors, and further MSD research in meat processing needs to continue with this approach. Research on injury causation (e.g. Mullen, 2004) also helps to inform this viewpoint.

2.3.5 MSD interventions

2.3.5.1 An overview of MSD intervention research

There are several obstacles mentioned in the literature which can affect the validity of MSD intervention research. Firstly, it is accepted that MSD require combinations of measures to most effectively address them (Hagberg et al., 1995; Westgaard & Winkel, 1997, Silverstein & Clark, 2004). This makes their evaluation commensurately more difficult (Karsh, Moro, & Smith, 2001), particularly as this is likely to involve actual workplaces with the accompanying management and employee-imposed barriers and other threats to internal validity that this poses (Westgaard & Winkel, 1997; Karsh, 2006). Secondly, while randomised experimental designs are preferred as they provide the most powerful data, there are often ethical and logistic issues that prevent this from happening (Karsh et al., 2001; Boocock et al., 2007). Thirdly, evaluating the effectiveness of interventions requires an extended period to allow the change(s) to become fully embedded and to enable them to have any measurable effect on risks and/or incidence, during which other changes within the workplace are likely to have confounded results (NRC-IOM, 2001; van der Molen, Sluiter, Hulshof, Vink, & Frings-Dresen, 2005; Dempsey, 2007). Moreover, the method of implementation itself may also have a significant impact on the success of the intervention(s), possibly explaining why there are different responses to seemingly identical interventions (Karsh, 2006). Fourthly, MSD research may not be sufficiently funded to allow for comprehensive studies and may not include objectives for long-term intervention implementation and evaluation (Karsh, 2006).

Despite these difficulties there have been several reviews which have collectively identified successful MSD interventions. NRC-IOM (2001) summarised MSD intervention literature from the 1990's, reaching several conclusions about the methodology for MSD intervention studies (p. 328-9). They also state that no single strategy will be effective across industries and that instead they must be tailored to each situation. Westgaard & Winkel (1997) reviewed 92 studies, reporting that intervention strategies with the best chance of success were multiple work organisation interventions (e.g. job enlargement, participatory ergonomics) to reduce identified risk factors, and interventions that focused on and involved workers at risk (e.g. medical management, physical training). Similar conclusions were made by Boocock et al. (2007) in a review of 44 articles on neck and upper limb interventions.

Karsh et al. (2001) peer reviewed 101 articles on workplace-based studies of MSD interventions, including studies with less methodological rigour than in other MSD intervention reviews. They found that the most effective studies were those with multiple interventions, namely a combination of training, new tools, new workstations, and/or work organisation changes. Some 97% of these led to at least some improvement in outcomes. Other interventions with high reported effectiveness were tool/technology interventions (90%), exercise interventions (86%), and training interventions (67%). When only considering studies with randomised experimental designs, effectiveness increased for multiple component interventions and exercise interventions but reduced for the others. Karsh et al. also discussed difficulties associated with MSD intervention studies and provided guidelines to help improve the quality of future research.

Silverstein & Clark (2004) included both methodologically rigorous studies along with less robust designs in their review of 73 peer reviewed articles published from 1990-2002. The findings support Karsh et al. (2001) that interventions with multiple components have a greater chance of success than single interventions. Exercise appeared to reduce some of the consequences of MSD, and in workplace studies participatory approaches were often found to be successful. The authors also referred to difficulties that can be encountered in workplace-based studies but concluded by stating that "there is sufficient information to act now without the perfect being the enemy of the good" (p. 150).

van der Molen et al. (2005) considered the effectiveness of measures to reduce physical work demands and MSD symptoms as well as the effectiveness of implementation strategies in 44 studies. They found that when lifting devices were part of an intervention this helped to reduce work demands and low back disorders. The most successful implementations strategies used a participatory ergonomics approach, an education programme, or both of these. Two recent reviews by Denis, St-Vincent, Imbeau, Jette, & Nastasia (2008) and Durand, Veizina, Loisel, Baril, Richard & Diallo (2007) also evaluated MSD intervention processes and interventions for workers with MSD, respectively. Denis et al. (2008) found that the range and suitability of interventions is directly related to the extent of the intervention process, and also refer to the complexity inherent in MSD prevention.

In a provocative article discussing MSD interventions, Dempsey (2007) referred to the growing popularity of intervention effectiveness and opined that this is due to the politicising of MSD in some countries and the promotion of ergonomics as a cost-effective method of addressing MSD. Consequently, individual research findings may be amplified by people arguing different viewpoints, while negative or inconclusive findings can be used to attack the scientific basis of ergonomics. Dempsey also referred to some of the stumbling blocks raised at the beginning of this section, emphasising that the insidious onset of MSD and their fluctuating recovery may cloud the benefits of any intervention, particularly when answers are required "sooner than good research practices permit". Some important questions are discussed: whether interventions that address one problem but create others are acceptable, or the research questions asked are sometimes too broad to provide useful answers, and finally whether intervention research is always beneficial to the field of ergonomics. In considering the last question, Dempsey outlines the difficulties in measuring effectiveness in real world situations among the many uncontrollable influences that may be present, and the 'ergonomic pitfall' possible with productivity interventions. It could be argued, however, that asking broader research questions and expanding the systems being considered would mean that the wider effects of interventions could be included, along with contextual factors which are only 'uncontrollable' when they are not part of the research. While such an approach may not identify individual quantifiable interventions, resolving MSD requires a raft of interventions rather than single planks, as has already been stated. This is in part supported by Dempsey's final point which reiterates Silverstein & Clark (2004) in stating that there is sufficient research evidence available to begin making changes rather than researchers suggesting that yet more research is required.

2.3.5.2 MSD interventions in meat processing.

While much research attention has been on knife design and other physical design issues, organisation design and training design are also mentioned in the literature. The most relevant literature from overseas and New Zealand is included although the methodological rigour is variable across those studies cited.

Riley (2001) summarised risk reduction measures from the meat de-boning literature, identifying a range of generic interventions centred around improved training, task modifications and physical design. Nossent et al. (1995) suggested in their review that the dissemination of knowledge and experience in implementing interventions in meat processing across the ten European countries should be encouraged and organised to avoid duplication. Loppinet and Aptel (1997) stressed the need for accepting a multi-factorial aetiology, and cite Toulouse et al. (1991) in looking for interventions in other areas of the supply chain. Patry et al. (1993), cited in Loppinet & Aptel (1997), recommended optimising the balance between hygiene standards and minimising human discomfort.

Dababaneh, Swanson, & Shell (2001) studied the impact of frequent short breaks on the productivity of 30 workers in a meat processing plant, comparing twelve 3-minute breaks with four 9-minute breaks over the shift. The results showed that workers preferred the 9 minute break and reported less leg discomfort, while production was not negatively affected. However it was not stated whether there were changes to line speed, shift length or payment to accommodate the study. It is also not clear whether subjects had a choice to participate, and whether their low task autonomy had any effect on the findings. Genaidy et al. (1995) introduced active (stretching) micro-breaks into a plant for four weeks. Staff could select their own micro-break times in spells of two minutes for up to 24 minutes over the 8 hour shift. While significant reductions in levels of perceived discomfort were recorded, it was not explained how the self-determined breaks were made possible for staff working on the chain.

As the primary work tool for many tasks in the industry, knives have attracted much research attention. However, the applicability of findings to industry has been limited by studies being conducted in laboratories or off-line with no subsequent live testing, or by subjects unfamiliar with the task (e.g. Marsot et al., 2007). Studies that have taken place in meat plants have not always measured other aspects of the work system (e.g. work pace, yield) or canvassed the views of the workers themselves (McGorry, Dowd, & Dempsey, 2005). Many studies have employed simulated meat cutting tasks (Hsiang, McGorry, & Bezverkhny, 1997) and have used artificial substances rather than meat as the cutting medium for reasons of cost and uniformity (McGorry, 2001; McGorry et al., 2004). However, this does not account for factors such as the three-dimensional nature of the work, the effects of the process line on work pace and social interactions, and the variability of tissue type and density within and between carcasses.

A number of authors have reported on attempts to quantify knife sharpness and effectiveness in meat cutting tasks. One such study by Cochrane & Riley (1986) concluded that both MSD and lacerations could be reduced by improved knife designs. Another, by Szabo, Radwin, & Henderson (1998), found the blade edge angle to be significant. McGorry et al. (2005), in a plant-based study, conversely found that blade edge angle made no significant difference to cutting time, mean grip force or cutting moment, but that a highly polished blade did.

The angle of the blade in relation to the handle has also been studied. Bobjer (1989) supported a 15^{o} blade inclination with respect to the knife handle axis. Fogleman, Freivalds, & Goldberg (1993) evaluated wrist angle and grip force of six knives on two simulated poultry boning tasks. Angled blades performed best, while a straight knife performed worst. Marsot et al. (2007) also found that cutting forces decreased in knives with a curved and/or angled blades while also limiting wrist constraint. Occhipinti, Columbini, Bulgheroni, & Grieco (1993) compared three different knife handle designs using experienced boning staff to cut meat in a laboratory setting. Findings confirmed that the upper arms were overworked, but were inconclusive on the role of handle design.

Other interventions have focused on elements of the physical workspace. Juul-Kristensen et al. (2002), for example, compared the physical workload before and after the introduction of new technology in poultry processing, finding that it only had a marginal effect on the physical risk factors associated with MSD. Caple and Hodgson (1992) collated information on low-cost micro level solutions for workstation and tool design, while Caple (1994) also compiled a catalogue of practical measures to reduce the noise at source in plants. The effect of these on MSD risk was not assessed. Touzart (1986), cited in Loppinet & Aptel (1999) reported that raising ambient temperatures by as little as one degree had been found to be beneficial in reducing MSD risk. The advantages of the cradle system for beef slaughter were discussed by Waniganayake & Steele (1990), and inverted dressing of sheep for stabilizing the task to reduce reach and applied forces. Brasington & Hammonds (1971) objectively compared table boning to rail boning, finding a higher yield for the on-rail system through trimming meat from bones. Finally, Magnusson & Ortengren (1987) studied table height and work surface angle on boning, using meatworkers in plant and laboratory locations. They recommended separate height adjustable tables for each person to meet postural as well as task needs.

The earliest reference to injury prevention in New Zealand meat processing is in 1967 when the Gear Meat Company reported reductions of lost time accidents from 20 per 100,000 work hours in 1962 down to 8 in 1967 (Gazette, 1967). The national incidence rate for the meat industry in 1962 was 14.7. This improvement was attributed to a safety programme that reduced manual handling, improved knife sharpness for new staff, and introduced an additional five minute break every hour. The cost of the safety programme was reported to be outweighed by the savings in lost production time, recruiting, equipping, clothing and training new staff. The issue of rest break design remains a priority for the union (New Zealand Meatworkers Union, 2008).

Slappendel, Moore, & Tappin (1996b), reporting on the 1993-6 New Zealand Meat Industry Injury Prevention Project, noted the importance of work organisation changes to reduce injury risk. In one boning room, modifications were made over the course of the programme and the modified injury severity rate (lost days and time on alternative duties) was measured. Results showed a 90% decrease over the three processing seasons, with stakeholders stating that a 'large' effect was through: greater worker/union and management commitment to reducing injuries, reduced work compression rates, and better training for learners (Blewden & Wyllie, 1998). Other recommendations to the industry from this pilot programme included strengthening the industry's health and safety infrastructure for the benefit of all stakeholders, improving information sharing on injury prevention, and planning for anticipated demographic changes in the workforce. Also recognised was the need to change the culture regarding an acceptable level of injury (Slappendel et al., 1996), effectively avoiding the 'ergonomic pitfall' of Winkel & Westgaard (1996). The Injury Prevention Programme provided the evidence base for subsequent industry intervention strategies (Slappendel, Moore, Tappin, 1996a, b, c; Greenslade et al., 1998; Moore, Tappin, & Vitalis, 2004).

In a discussion paper of the New Zealand meat processing industry, Slappendel (1996) also noted the need to increase understanding of MSD risk factors, particularly those related to work organisation. The intention was to get this information included into task training, management decisions on work scheduling and line balancing, and plant design. Unfortunately, few of these suggestions have been adopted by the industry. An earlier comment by Farlow (1990) sheds light on one potential reason for this, stating that a wider approach to injury prevention can "run hard into the brick wall of entrenched industrial relations attitudes and practices" (p. 317).

An industry awareness publication, OSH (1997) emphasised the role of work organisation and task scheduling more strongly than in the international literature on meat processing and included consideration of supervisory structures, chain speed, task description clarity, monotony, and the effects of seasonality on workload and shift work.

Greenslade et al. (1998) called for systematic studies on optimising knife design and edge maintenance for specific tasks in New Zealand meat plants, an initiative that has recently occurred through the Meat Industry Health and Safety Forum (MIHSF). Greenslade et al. also report on plant-based trialing of a prototype knife design, matching a preferred blade with a preferred handle. Publications on knife sharpening and use were also developed in this period (Rata, 1995; Dowd, 2001).

Given the slender range of MSD interventions applied by industry, it is therefore unsurprising that reported MSD cases in meat processing have remained at high levels, and have proven highly resistant over time to micro-level interventions. Indeed, the wider literature would suggest that multifactorial solution approaches that address the range of contributory factors are likely to have the greatest effect in reducing MSD (Hagberg et al., 1995; NRC-IOM 2001; Silverstein & Clark, 2004). Additionally, micro-level interventions have commonly targeted specific system elements or risk factors rather than all elements of the broader work system as advocated by Hagberg et al. (1995), Moray (2000), and Buckle (2005).

2.3.6 Critique of the MSD literature

MSD have proven to be highly resistant to attempts by ergonomists to control them. Incidence rates remain high, despite predictions of their decline with changes in the nature of work. The range of potential risk factors has subsequently increased over time, as researchers have continued to theorise on causation and have identified a complex array of associations between physical, psychosocial and contextual factors. This has naturally affected MSD intervention research, which has struggled at times with determining which intervention(s) to implement, how to implement them, and how to measure their effectiveness. This situation is not made easier by the narrow approach adopted by many people involved in MSD research and prevention, in continuing to focus on only a few (usually physical) elements of work systems.

Although Karsh (2006) warns against a proliferation of MSD causation theories without testing and developing existing ones, there is arguably a need to better define the extent and the role of what NRC-IOM (2001) label as contextual factors for MSD. The scope of these factors (e.g. legislation, behavioural norms) will require looking outside single work systems to consider the involvement of multiple work systems and their interactions, at a company, industry, community and societal levels. Clearly this approach also concerns the development and implementation of MSD interventions and will require research to accept that the complexity of MSD (both causes and interventions) will not fit neatly into existing methodological designs.

Nowhere are these developments more challenging to apply than in the New Zealand meat processing industry. The primary focus of MSD prevention in meat processing is on secondary and tertiary prevention, with primary level initiatives mostly targeting physical risk factors. Much of this research only considers a small number of elements and minimises threats to validity by conducting research in the lab or off-line, thereby failing to consider the effects of psychosocial and contextual factors. The limited amount of input by meat processing staff is also evident, making MSD interventions less relevant to the industry, and less likely to be put into practice.

2.4 Participatory Ergonomics

2.4.1 Employee Involvement

This section introduces the concept of people participating in the decision making processes of systems, and briefly outlines some of the literature on the topic. The attention is on employees working within an organisation, rather than on product or systems design. The intention is to provide some context for the emergence of participatory ergonomics, which is the focus of this discussion.

Cotton (1993) describes Kurt Lewin as the father of employee involvement, through focusing on the individual within a social environment, and encouraging the practical application of theories. Cotton also refers to the contribution and influence of Trist and Emery’s idea of sociotechnical systems and their promotion of self-directed work teams. In an overview of participation program research, Glew, O’Leary-Kelly, Griffin, & van Fleet (1995) stated that employee participation is one of the oldest areas of inquiry within organisational behaviour, and list research to support this statement. Frei, Hugentobler, Schurman, Duell, & Alioth (1993) refer to the importance of employees’ right to participate in industrial governance and note that this was central to legislation passed in America during the great depression, quoting the Senator who sponsored the act as saying "…one must have democracy in industry as well as in government; that democracy in industry means fair participation by those who work in the decisions vitally affecting their lives and livelihood" (p. 261).

Wilson (2005) referred to several separate movements in participation, which have arisen for different reasons, in different domains, and therefore have different philosophies and methods. In addition to participatory ergonomics these include, user-centred design (HCI), product design, industrial democracy, and approaches from management and sociology such as action research. Haines (2003) also lists other fields involved in participation as including participative management, change management, and systems design. In his text on employee involvement, Cotton (1993) discusses many of these disciplines and the models they use. He also describes participation as a 'slippery concept' and cites Schregle (1970) who said "Worker's participation has become a magic word in many countries. Yet almost everyone who employs the term thinks of something different" (p.22).

Consequently there are many different definitions of participation, ranging from narrow to broad perspectives (Frei et al, 1993), and weak to strong definitions (Wilson, 2005). Cotton (1993) defined employee involvement as "a participative process to use the entire capacity of workers, designed to encourage employee commitment to organisational success" (p. 3), and argued that it is not a unitary phenomenon but a label for a range of techniques. Wagner (1994) defined participation as a process in which influence is shared among individuals who are otherwise hierarchical unequals. Markey (2001) defines employee involvement or participation as any workplace process that allow employees to exert some influence over their work and the conditions under which they work. Wilson (2005), states that participation can mean different things to different people with definitions focusing on such aspects as tools or techniques, processes, an approach, or a philosophy. Illustrating this further, Glew et al. (1995) conceived of employee participation more as a gift to bestow on people rather than as an inalienable right, by defining it "as a conscious and intended effort by individuals at a higher level in an organisation to provide visible extra-role or role-expanding opportunities for individuals or groups at a lower level in the organisation to have a greater voice in one or more areas of organisational performance" (p. 402).

However, Wilson (2005) adds to this debate by noting that it is perhaps more important to consider why participation is used than it is to define it. Some of the reasons mentioned include: deriving a better solution, creating ownership, improving the design process, developing a culture of involvement in the organisation, and providing an opportunity to learn and disseminate knowledge. Furthermore, Karasek & Theorell (1990) highlighted participatory work processes to enhance worker health and productivity. Markey (2001) refers to three reasons for participation; to satisfy peoples' non-pecuniary needs for creativity, achievement and social approval; as a democratic form of power sharing; and as a contribution to organisational efficiency, with this being the most dominant reason since the 1980's. The effects of participation, particularly on work performance and job satisfaction, have been summarised in a number of reviews (Dachler & Wilpert, 1978; Cotton, Vollrath, Froggatt, Lengnick-Hall & Jennings, 1988; Wagner, 1994), as well as in non-peer reviewed reports (Shearn, 2004; Shearn, 2005; Cameron, Hare, Duff, & Maloney, 2006).

Contextual variables which can influence the impact of participation include: individual differences, participation processes such as its breadth and setting, methodology, and the form that employee involvement takes (Cotton, 1993). Marchington, Wilkinson, Ackers, & Goodman (1994) also concluded that employee involvement approaches need to be adapted for different contexts. On a similar note, Cohen (1996) mentioned shaping factors for participation, such as the nature of the issues to be considered, whether the matters are broad-based or local, whether it is a single action or requires continued efforts, the abilities of the group most affected, and the prevailing practices for resolving issues. Damodaran (1996) stated that empowering the user is demanding and complex and requires careful structuring of the organisational context. Other researchers have considered similar issues (e.g. Batt & Appelbaum, 1995; Eason, 1995; Ingelgard & Norrgren, 2001).

Neumann (1989) reviewed participative case studies to provide ideas on what influences employees' willingness to participate in decision-making or organisational change. She estimated that two thirds of the workforce were non-participators, which included those who exclude themselves, refuse jobs/tasks, or are passively involved. Neumann outlined several structural, relational, and societal explanations for non-participation, and stated that "significant aspects of organisational structure, relationships and culture must be integrated with any participative effort" (p.8). Among the conclusions is the view that blame for poor performance often belongs to the design of the participative effort itself, as participation is rarely introduced into a workplace in such a way that contradictions and mixed messages are absent.

Literature on employee involvement in New Zealand is scarce. However, two booklets were produced within a year of each other when the concept started to become more popular in New Zealand (Oram, 1977; McClennan, 1978). The publication by Oram was a guidance document sponsored by the Employers Federation, and made the point that "Participation must be planned but not packaged. Each company is different. Each employee is different. The form which participation takes must be tailored to suit all these facets of the organisation…" (p. 48). Interestingly, Oram also asserted that at the time unions showed limited interest in the concept in case it became an alternative to union involvement. These views were later reversed when provisions for employee participation were being considered as part of the the Health and Safety in Employment Amendment Act 2002[5]. The provisions that were passed into law included the requirement to involve employees in health and safety matters, develop an employee participation system for health, and train health and safety representatives (Health and Safety in Employment Amendment Act, Part 2a, Schedule 1a, 2002).

2.4.2 Participatory Ergonomics: Background

The term participatory ergonomics (PE) first arose in the mid-1980's and quickly became a topic for papers at conferences and meetings of researchers around that time (Noro & Imada, 1991). A round-table session on PE was held at the International Ergonomics Association congress in 1991, where PE was described as an ergonomics strategy which can be applied in different ways to different fields of ergonomics (Vink, Lourusen, Wortel & Dul, 1992). Reasons given for its emergence vary. Imada (1991) explained that participatory ergonomics provides one perspective in macro-ergonomics, which is itself described as the 'third generation' of ergonomics after physical and cognitive considerations. A more global view was offered by Haines & Wilson (1998)

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[5] *Submissions of the New Zealand Council of Trade Unions and the Employers and Manufacturers Association to the Transport and Industrial Relations Select Committee on the Health and Safety in Employment Amendment Bill*, New Zealand Government (March, 2002).

who refer to the gradual changes in management practices in recent decades away from scientific management and toward those that embrace workforce participation. de Jong (2001) echoes this with reference to forces that are making management more participative including legislation, competition, and service orientation where traditional management styles are no longer relevant. As well as asserting that people-centred approaches are central to ergonomics work, Wilson (1991) also referred to the antipathy that many ergonomists have towards Taylorism and the subsequent attraction that a participative approach provides. However, it is also arguable that the concept has only developed to the extent that it has through the projects and publication efforts of a few researchers (e.g. Imada, Kogi, Wilson, and Vink) and research organisations (e.g. TNO in the Netherlands, Institute for Work & Health in Toronto, and the Swedish Working Life Fund).

Descriptions of what constitutes PE and how it is best defined are prevalent in the literature. Wilson (2005) asks whether it really matters, and suggests that there can be different levels of involvement within PE, perhaps depending on the aims of its application. de Jong (2001) stated that participation is "merely a means to achieve a goal and not a goal in itself. (p. 1273), and that the most important factor in determining effectiveness is the way the change process is organised. Laing et al. (2007) addressed a common theme when stating that "workers who regularly perform the tasks in question be involved in the process of change in concert with all stakeholders who have the potential to be affected by the ergonomics intervention" (p. 1093). Wilson (1991) discusses types of participation and summarises Arnstein's (1969) Scale:

- user control
- delegation; some decision-making authority, following bargaining
- partnership; decisions by users and 'owners'
- placating; allowing a (powerless) few to participate
- consultation
- information (one way)
- user therapy; 'curing' user pathological ideas
- user manipulation; public relations exercises

This scale ranges from initiatives controlled by the users, down to those that use participation deceptively. It is only the top three categories on this scale where meaningful participation can occur, with the second and third categories of most relevance to the study on which this thesis is based.

Perhaps the most widely referenced definition of PE states that it concerns “the involvement of people in planning and controlling a significant amount of their own work activities, with sufficient knowledge and power to influence both processes and outcomes in order to achieve desirable goals” (Wilson, Haines, & Morris, 2005, p.933). Haines (2003) refined this slightly in her PhD thesis in stating that “PE concerns the various processes through which end users are enabled to have the knowledge and power necessary to make a meaningful contribution towards improving ergonomics within their organisation” (p.208). Both these definitions appear to be based on direct rather than representative participation. Vink et al. (1992) cite from Cotton (1993) who noted that representatives will not lead to successful participation, a point reiterated by Vink, Koningsveld, & Molenbroek (2006). However, direct participation is not always possible (e.g. with large work populations or multiple work sites), or may not be wanted (e.g. it may affect an individuals’ earnings or increase their time at work). Many of the studies reported in the literature are based on teams of labour and management representatives.

Contextual factors, in relation to the use of PE, are also mentioned in the literature. Imada & Robertson (1987) postulated whether PE is appropriate across cultures, and suggested that culture (both organisational and national) is considered as part of the system. Liker, Nagamachi, & Lifshitz (1989) compared PE programs in US and Japanese manufacturing plants and found that effective programs can take many forms, with the best taking into consideration relevant history, structure and culture. Vink, Imada, & Zink (2008) conducted a questionnaire of health and safety experts in three European countries on involvement during a step-wise participative project. One of the requirements for success was to develop an understanding of a group’s norms, languages and concerns. Morris, Wilson, & Koukoulaki (2003) referred to the value of addressing the context and organisational requirements in PE and state that “It is therefore difficult to be prescriptive about the approach that should be taken and how the various tools and methods should be used” (p. 48). This is clearly illustrated in a randomised controlled trial of four physical interventions in ten companies (van der Molen et al., 2005) when the authors found that not all companies followed the programme structure suggested to them. While they assumed that the companies in the study were late adopters or precontemplative, they also questioned whether the steps of the programme all needed to be applied or followed sequentially. Wilson and Haines (1997) also outlined the difficulties of separating "the impact of particular programs of participatory ergonomics from that of general participative-based management" (p. 493). The authors noted that while the latter may not permit any real knowledge or power to users, ergonomists should seek to take advantage of such initiatives.

The most appropriate level of involvement by ergonomists has been a topic of discussion for some in the ergonomics literature. Devereux, Buckle, & Haisman (1998) suggested that professional ergonomics input is necessary at all stages of the participation process. Some support for this was provided by Hasle, Limborg, Hvenegaard, & Bruvik-Hansen (1997), who referred to the difficulty for employees in low qualified work with low levels of control to participate in decisions about changing their work. This is particularly the case if the decisions reach much further than daily operation, or involve overall company strategy. However, Haims and Carayon (1998) argued that a combination of expert-guided processes and participatory processes is required in the implementation of work organisation interventions. Eason (1995) also discussed this issue in relation to design of products and services. Wilson (1994) refers to the need for organisational and individual level participation in devolving ergonomics, while also advising that workforce motivation and competence cannot be imposed but grow slowly through learning and involvement (Wilson, 1991). In a small study at a chemical plant, Maciel (1998) similarly found that people needed time to become accustomed to participation as it was not part of the company culture.

Wilson (2005) uses a diagram to illustrate the participation cycle and the advantages that can accrue as the process builds on itself (Figure 2.8). The potential advantages of a PE approach are outlined in numerous articles and studies (e.g. Nagamachi, 1995; Haims & Carayon, 1998; Haines & Wilson, 1998; Wilson, 2005; Wilson et al., 2005). Advantages most commonly mentioned include: greater ownership of the process, greater acceptance of changes, better solutions, improved industrial relationships, and opportunities for personal development. Several studies have measured the effects of

PE. In a project involving production line changes, van Rhijn, de Looze, Tuinzaad, Groenesteijn, de Groot, & Vink (2005) found that productivity increased while order lead time and overall fatigue decreased. Lewis, Imada, & Robertson (1988) conducted a quality improvement case study in an organisation and mention increased trust and respect among team members as well as a growth in self-confidence as a result of this initiative. Kogi (2008) reported on the merits of building upon local good practices, applying basic principles and low cost improvements in a review of workplace improvement programs in small workplaces. There is also some evidence that small-scale PE projects build good experience in ergonomics use and can show positive cost benefits, generate interest, and raise awareness of ergonomics benefits and uses (Morris & Wilson, 2003). Large scale projects on the other hand require greater resources to ensure their effectiveness and can experience a wide range of problems. Indeed, the authors stated that “an informal approach may be a useful first step to developing a more systematic approach within an organisation.” (p. 307).

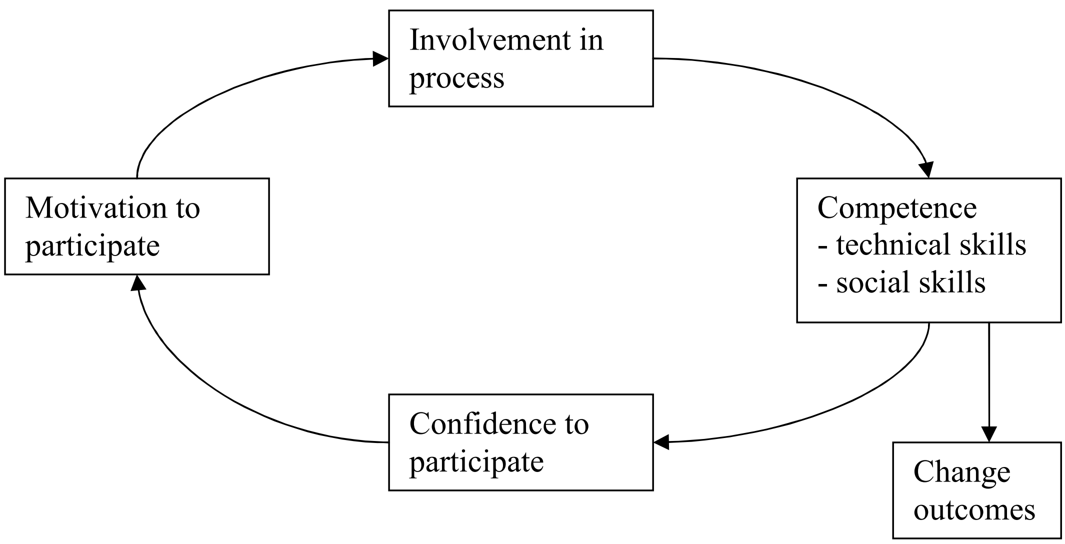

Figure 2.8. The participatory ergonomics cycle (Wilson, 2005)

There are also many potential difficulties associated with a PE approach mentioned in the literature (e.g. Kuorinka, 1997; Wilson & Haines, 1997; Wilson et al., 2005; Bohr, Evanoff, & Wolf, 1997; Vink & Kompier, 1997). Examples include: resistance to participation, unwillingness or lack of motivation to participate, finding the necessary time and resources, instigating and supporting participation, extracting useful information from participants, raising unrealistic expectations among employees.

Wilson (1995), states that participation in domains such as job design can be more difficult to establish and harder to show success in, than in physical domains.

Key factors for success of PE programs are outlined by Morris et al. (2003), Haines & Wilson (1998), Wilson (2005), and Vink et al. (2006). A summary of the success factors from the last two authors is shown in Table 2.4. While Wilson's keys to participation provide more detail, there are many points in common between the two lists. Vink emphasises direct participation and a stepped approach, whereas Wilson stresses greater flexibility and continuity of the participative processes that are established.

Table 2.4. Keys to participation (adapted from Wilson, 2005 & Vink et al.,2006)

Keys to participation (Wilson, 2005)	*PE success factors (Vink et al., 2006)*
Establish partnerships of all stakeholders	Arrange direct workers' participation
Establish commitment by senior managers and stakeholders	Arrange strong management support
Arrange a capable champion for the process	Arrange participation of other stakeholders
Climate and an open communicative organisation are important	Carry out a good inventory (needs of target group and feasibility of changes)
The most successful projects are simple and well-defined, with a structure to match the organisation, and with actors and their roles clearly defined at the outset	Use a step-by-step approach
There should be clear identification of what resources are available and when, with rich information coming from real users, and equal recognition of time and people as well as money	Arrange a steering group with responsibilities
Agreement reached on budget at an early stage	Check the effects, including side effects, at an early stage
Procedures established for departure of the change agent (both unplanned and planned) to ensure project continuity	Focus on health and productivity goals
Plans in place to follow with continual improvements, broadened and embedded in a participatory management system where possible	Describe the cost benefit ratio in monetary and non-quantitative terms
Find a means to enable those who are represented and not directly involved feel part of the process and can make their feelings known at an early stage	
Be prepared for what to do in a situation where the solution from the process is one with which they are not fully happy.	

A comprehensive account of the PE literature, including tools and methods, is found in Haines & Wilson (1998). Further information on methods used in case studies, along with other aspects of PE is included in Noro & Imada (1991); Cohen (1994); Rivilis et al. (2008); Cole et al. (2005); Hignett, Wilson, & Morris (2005); and OHSAH (2006).

Kogi (2006) also reviewed participative methods, particularly those based around action training, including training workshops (WIND), action training for home workers (WISH/WISE), and action training of trade union members (POSITIVE). Moreover, Hanse & Forsman (2001) reported on the use of video-based tools, finding that they work best for consistent work practices, but less well with task variation, movement, or where extraordinary events are what create significant risk. Kuorinka (1997) described some of the techniques and approaches in PE and advised that the methodology used depends on the social, organisational and industrial context. Design Decision Groups (DDG) is a PE method that was used successfully in a crane control room (Wilson, 1995). In this redesign project the solutions needed to be acceptable to everyone concerned, as well as meet cost and technical feasibility criteria. DDG achieved this, with participants going on to apply their new knowledge to other changes. The method however is less applicable to large numbers of participants. Vink et al. (1995) refers to an 'ideal' participatory approach of five steps including: preparation, analysis of work and health, choice of solutions, implementation, and evaluation. In this small-scale study of one department this approach was deemed successful, although time-consuming. This step-wise approach has been applied by the Vink and others in many other studies (e.g. Vink, Urlings, & van der Molen, 1997; de Jong & Vink, 2000; de Looze, van Rhijn, van Deursen, Tuinzaad, & Reijneveld, 2003). Vink et al. (2008) broke the original five steps into nine, while Moore & Garg (1997a, b) also referred to a similar approach in their problem-solving method.

2.4.3 Participatory ergonomics and MSD

A significant proportion of the PE literature is concerned with addressing MSD (Wilson, 2005). Hignett et al. (2005) reviewed this literature and found it it difficult to evaluate real world changes from PE to address MSD, due to organisational restructuring that can accompany a participative project. The authors saw this, however, as a challenge for evaluation design in PE projects. St-Vincent, Bellemare, Toulouse, & Tellier (2006) also conducted a critical review of 11 PE studies conducted by the IRSST in Canada, highlighting several difficulties encountered in the studies such as: sufficient time to participate and collaborate (especially on production lines), limited involvement of middle management, and senior management commitment.

A number of MSD prevention studies have adopted a narrow perspective of either participation or ergonomics. Many of the latter were from the North America, perhaps highlighting differences in how ergonomics is defined on either side of the Atlantic. For example, Hess, Hecker, Weinstein, & Lunger (2004) studied the use of lumbar motion monitors on four construction labourers carrying out one task, arguably failing on both counts of participation and ergonomics. Cynical use of PE appears evident in Halpern & Dawson (1997), where a steering committee of management was formed and staff were trained on physical ergonomics with the stated purpose of making them aware of their responsibilities, their posture, and from which it was hoped they would accept changes. Other examples of studies with a narrow perspective of MSD and ergonomics include: Zalk et al. (2000), Bohr et al. (1997), and Sundin & Medbo (2003). Examples of studies with only a limited level of participation include Pohjonen, Punakallio, & Louhevaara (1998), and Saleem, Kleiner, & Nussbaum (2003). Typically, these studies involved the evaluation of training material or postural assessment methods in a specific application.

For some studies, there is significant emphasis on the training provided to participants. The scope of this training is therefore a factor in how successful a PE study will be in preventing MSD. However, focusing on training and specifically on physical risk factors and physical interventions is unlikely to significantly reduce MSD in the long-term. Some studies appear to have adopted this narrow approach, achieving a limited effect on MSD (e.g. Keyserling & Hankins, 1994; Mansfield & Armstrong, 1997).

Theberge, Granzow, Cole, & Laing (2006) recognised some of the complexities of conducting a participatory process in industry to address MSD, such as generating commitment to the process, juggling time pressures, and tensions between production and team processes. They cite Kuorinka & Patry (1995) who stated that there is no single best way to run a PE program. Straker, Burgess-Limerick, Pollock, & Egeskov (2004) also recognised the limitations of using a single standardised risk assessment tool in a randomized controlled trial in 31 workplaces to measure effects on MSD of a

PE intervention. de Looze et al. (2001) discussed seven case studies aimed at reducing physical stress. Success factors were similar to those in Table 2.4 and included: direct worker participation and management commitment, initial analysis of the tasks and the potential health problems, installation of a multi-disciplinary steering group at the beginning of the process, awareness of negative side effects that may occur, and taking a step-wise approach to the project even though risks and solutions may appear obvious at first glance.

Despite the shortcomings of PE studies that emphasise physical MSD risk factors and solutions, there are some benefits which can accrue from this approach. St-Vincent, Kuorinka, Chicoine, Beaugrand, & Fernandez (1997) recognised the importance of company culture, management support, and worker attitude on knowledge transfer. In their study involving two assembly plants, the operators saw ergonomics and their participation as a ‘noble cause’, and one worth supporting. In a study in a metal workshop, Laitinen, Saari, Kivisto, & Rasa (1998) found that targeting physical factors also positively affected other aspects of work such as cooperation between management and workers, and industrial relations. They conclude that this approach may provide the management a more controllable and acceptable tool than measures focusing directly on psychosocial factors. In PE programmes that focused on physical risk factors in five companies, Dale (2005) found that the programmes facilitated a change in company culture towards ergonomics, and was affected by other business changes.

St-Vincent et al. (2006) reported on the need to consider a wider range of MSD risk factors in PE studies, including psychosocial, organisational, and contextual, although the ability to achieve this depends on how ergonomics and participation are perceived by the researchers. In line with this view, Rosencrance & Cook (2000) adopted a participatory action research approach to control MSD in a metropolitan newspaper company in a six-year project, and adopted the goal of developing interventions that were both contextually grounded (knowledge from workers) and based on accumulated theoretical knowledge (theory from the researchers). In a study conducted in a courier depot, Rivilis et al. (2006) found that PE had a greater impact on changing work organisation factors than reported physical demands and suggested that studies should measure both physical and work organisation stressors to understand interventions and what aspects of work might be good targets. Contextual factors identified by the authors included: the organisations' commitment to change, the organisational climate, and the resources available to the project. The study demonstrated that a PE approach can be useful for improving aspects of work organisation.

As well as taking into account a broader range of MSD risk factors, other influences which impact on effectiveness have been identified in a number of PE studies. de Jong & Vink (2002) reported on a step-wise PE approach to reduce MSD in construction installation work for 7000 workers where they encountered some resistance to change despite the PE approach and the focus on employee level solutions. The authors also referred to the difficulties of measuring effectiveness in naturalistic settings. Laing et al. (2005) found few changes in perceived effort or pain severity in their manufacturing plant study. Possible reasons given were: the confounding effects of fluctuating production rates, a short intervention period, plant/team ambivalence towards the process, and low impact on exposure of the implemented changes, and staffing changes – also mentioned by Rivilis et al (2006) and Carrivick, Lee, Yau, & Stevenson (2005). The importance of a site champion, preferably with ergonomics expertise, was also mentioned by the authors. This point is also made by others (Wilson, 2005; Burgess-Limerick, Straker, Pollock, Dennis, Leveritt, & Johnson, 2007). St Vincent et al. (1997) recognised that the initial training for participants was too short to adequately learn an ergonomics approach and did not overcome the barrier of status among specialists involved in the team. Rosencrance & Cook (2000) also found that PE can create role-related tensions among team members and researchers. Loisel, Gosselin, Durand, Lemaire, Poitras, & Abenhaim (2001), reporting on an injury management study found that lack of involvement of middle management, competing priorities in the workplace, and mistrust between employees were barriers to change.

The effectiveness of PE studies on preventing MSD is the final topic of this section of the review. The effects of both PE programmes and MSD interventions can take some time to become apparent, and as reported earlier, can be confounded by other changes in the organisation over this time. Despite this there are several PE studies that have reported some positive change about MSD. In their review of the literature, Cole et al (2005) found partial evidence that PE interventions can have a positive impact on MSD symptoms. Moore (1994) provides a thorough account of a well-resourced case study on flywheel truing in a manufacturing plant, and reported a reduction in MSD incidence and severity following a participative approach to redesigning work equipment. Reporting on a three-year study of hospital cleaners, Carrivick et al. (2005) found that MSD severity (duration and cost) reduced following the introduction of a risk assessment approach, although very high staff turnover confounded results. A case study evaluation by Kogi, Kawakami, Itani, & Batino (2003) of a program to achieve work improvements in small enterprises showed improvements in heart rates, posture and EMG. Evanoff, Bohr & Wolf (1999) also found that reported injuries and lost days reduced following a PE programme involving orderlies, and impetus was created for establishing further PE groups. Less formally, Glaxosmithkline (2008) estimated significant savings and reduction in injury incidence were made over three years from an ergonomics improvement team looking at manual handling.

2.4.4 Participatory ergonomics involving multiple organisations

Relatively few studies reported in the literature have applied a participative approach across multiple organisations or an entire industry. We can only speculate on why this might be, however the potential benefits of doing so are significant as such an approach enables industry or sector-level factors to be identified and addressed (MSD contextual factors for example), and for changes to occur on a large, industry-level scale.

Acting at this level does, however, bring additional factors into consideration which may rule out the feasibility of such an approach or affect the efficacy of a PE initiative that does occur. Most obviously, there are potential barriers to participation such as agreeing a structure that enables companies to work together, determining representation, determining funding, establishing communication between representatives, overcoming concerns about competition and confidentiality, and the logistics of meeting together and facilitating the group of representatives involved. With studies that are conducted, it is likely to be harder to create momentum for involvement and change across multiple organisations, particularly as the evidence of participation may be less visible to many. It also requires that the industry is considered as a work system, comprised of smaller systems operating within individual companies, and yet smaller work systems operating at plant and department level. This perspective may be difficult to portray to the stakeholder representatives involved, who are likely to be more familiar with working at the lower levels. The abilities of the change agent and the influence of personnel as well as process on success, as discussed by Wilson (2005), are equally relevant here. This section outlines the literature that has considered working at this level, focusing on the reported benefits and drawbacks.

In an insightful and highly relevant article, Carayon (2006) considers complex sociotechnical systems, drawing on research from health care and computer security. The article discusses two trends which can increase work system complexity, one of which is relevant here and concerns the occurrence of interactions among people who work across organisational, geographical, cultural and temporal boundaries. The author cites Vicente (1999) and dimensions of work system complexity that can have an effect such as social system variations between organisations, heterogenous perspectives, people located in different places, highly coupled interacting systems, automation, and uncertain data. Presumably writing for a North American audience, Carayon strongly states the need to integrate the various dimensions of human factors and ergonomics (physical, cognitive, psychosocial) and to interact with other disciplines to design 'whole' systems, also citing Rasmussen (2000). Carayon asks questions about applying PE to the design and implementation of complex systems, including: "How can a PE program be created when the participants belong to various organisations?" How can we apply PE in work environments with heavy workload and time pressure…? How can sociotechnical systems be more efficiently and effectively implemented, while further involving customers?" (p.532). These three questions are directly applicable to the present study of MSD in the meat processing industry, and have informed considerations in developing a participative approach in this sector.

Commissaris, Schoenmaker, Beune, & Eikhout (2006) describe the modification of a change management model to suit the ergonomists' role in large multiclient projects. This is recognised as a new experience for most ergonomists who normally work at company rather than sector level. It describes the difficulties of conflicting interests when dealing with unions, organisations and government, and working with multiple projects simultaneously. These considerations are also applied to the present study. de Jong & Vink (2000) also worked at an industry level in developing mechanical aids to reduce musculoskeletal loading for glaziers. The project involved development and trialing of mechanical aids by glaziers in three companies, overseen and prioritised by an industry steering group, before an industry-wide campaign was conducted to promote their use. Success factors included the involvement of employees in defining the needs and testing solutions, and sector level involvement. However, the researchers questioned whether the large effort involved was the best use of resources. In another study by the same authors (de Jong, Vink, & de Kroon, 2003), the involvement of different companies in identifying and developing solutions was highlighted as a difficulty. Moreover, Koningsveld (2005) referred to covenants between the Netherlands government, employers' organisations and unions to facilitate them working together to reduce health and safety hazards. However, the extent to which there was inter-organisational collaboration was not discussed.

Other studies have involved a number of different companies in PE research and initiatives, but not an entire sector. In a longitudinal case study, Kardborn (1998) looked at hand-tool development across six manufacturing companies. Success factors included: allowing additional time for changes and unforeseen events, establishing and maintaining good communication, and harnessing enthusiasts to keep the project running. Kardborn also mentioned hesitancy by stakeholders to get involved due to concerns over intellectual property rights and patents. Further to this, Jensen & Friche (2007) mention scepticism of academic advice compared with experienced tradespeople as one reason for the low uptake of new work methods among floor layers in 120 companies. Pehkonen et al. (2009) evaluated a PE study to reduce musculoskeletal load in 59 municipal kitchens and found that holding workshops in different kitchens facilitated sharing of ideas and skills between people. Difficulties were experienced in gaining the support of management across the kitchens, and sustaining the study despite unexpected changes in some of the participating companies. In a manual handling study in four underground coal mines, Burgess-Limerick et al. (2007) described how staff turnover affected momentum and the need for an on-site champion. They also referred to the refinement stage as having the greatest potential to break down, and that expertise required to identify risks may be different to that needed to design and implement controls. Axtell, Waterson, & Clegg (1995) looked at IT depts in one company over multiple sites and found that the organisational context can impact on outcome, with "thousands of users working nation-wide, in different offices with local characteristics and demands" (p. 33). Moir & Buchholz (1996) identified specific barriers within construction that a participative approach can help to overcome, such as: mobility of the workforce, resistance to change, existing labour – management relationships, and the number of small employers. Other examples of multi-organisation studies include

Enerke Oy (2008); Gadbois, Villate, Bourne, & Visier (1995); Kogi, Kawakami, Ujita, & Khai (2005), and several case studies outlined in Morris et al. (2003).

2.4.5 The Participatory Ergonomics Framework

The desire to have a theoretical framework for better understanding participation has been held by ergonomists for some time (Wilson, 1991; Vink et al., 1992; Haims & Carayon, 1998). Haines & Wilson (1998) reviewed the literature on PE, identifying a lack of theoretical understanding and limited guidance for companies on setting up and operating a PE programme. They presented eight dimensions illustrating variations that might occur in PE initiatives. This is a later version of the dimensions described in Wilson & Haines (1997). The first dimension is the extent/level that PE is applied, from an organisational level through to an individual workplace or product. Next is the purpose of PE and whether it "is being used to implement a particular change or to be *the* method of work organisation (whether under conditions of change or not)" (p. 44). Continuity and whether the process has a continuous or discrete timeline is the next dimension. Involvement is described, from direct participation through to representative. The formality of PE is the fifth dimension, while the sixth is the requirement to participate (voluntary-compulsory). The seventh dimension considers who makes the decisions, and the last dimension describes the degree of coupling between participants' views and final recommendations. Haines & Wilson (1998) included a general framework which identified some of the motivating factors for initiating PE (shown in Figure 2.9).

Further development by Haines & Wilson took place before Haines, Wilson, Vink, & Koningsveld (2002) tested and refined the conceptual participatory ergonomics framework (PEF) using seven independently conducted case studies and peer review. The authors view was that reported successes of PE programs were often only partial reports which may be difficult to transfer to other settings, that one-off cases of participation were not usually translated into company-wide programmes, and that better guidance on PE process and methods was required to motivate and support companies as well as ergonomics practitioners. The PEF aimed to "provide clarity and organisation for the field of participatory ergonomics" (p. 310), as well as help in developing guidance for implementing PE initiatives.

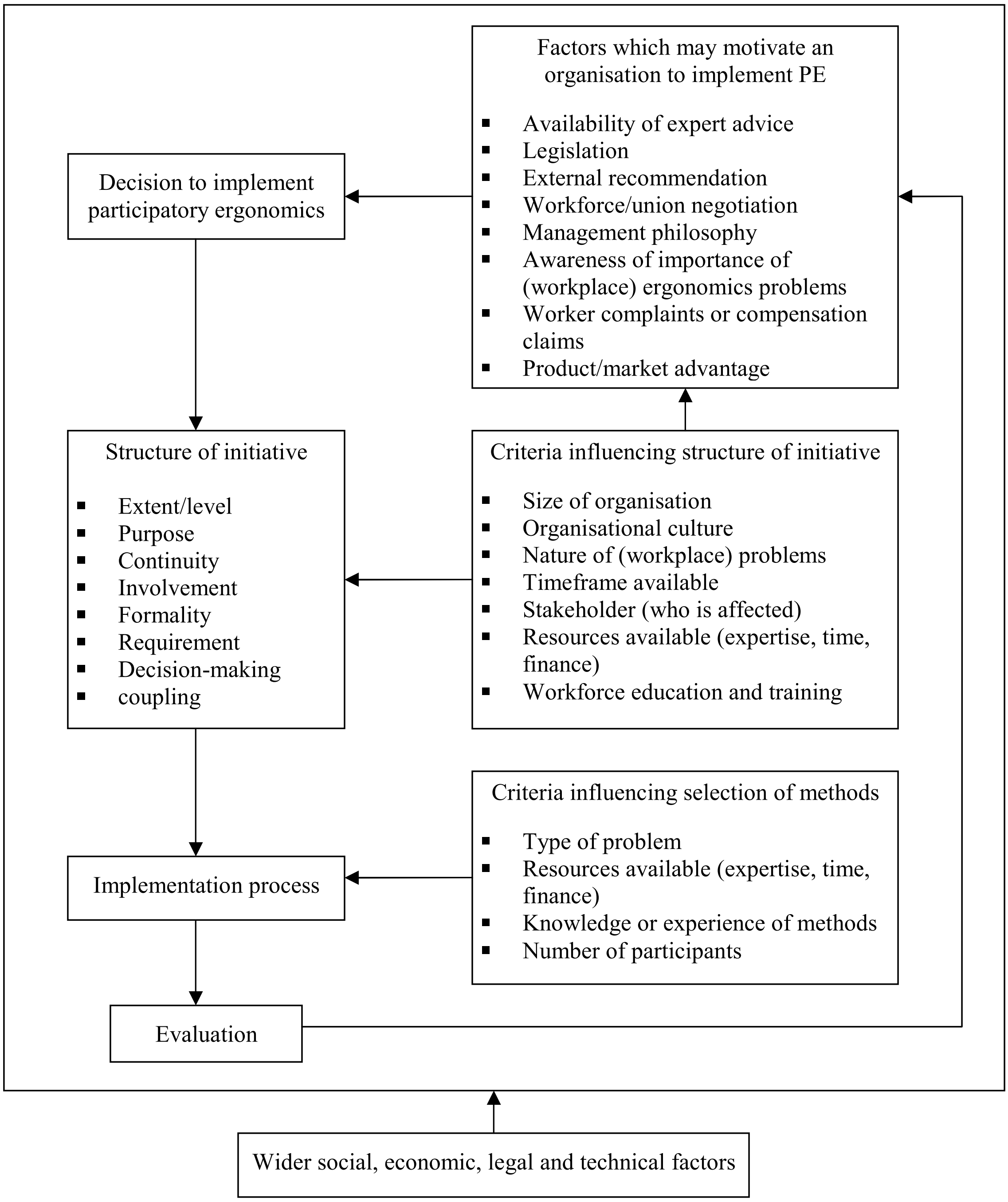

Figure 2.9. A first general framework illustrating PE initiatives
(from Haines & Wilson, 2008)

Changes to dimensions from Haines & Wilson (1998) included the removal of three dimensions (purpose, formality, coupling) and the addition of four dimensions concerning the mix of participants involved, the focus of PE (designing, specifying, strategising), remit or activities involved, and the role of the ergonomics specialist. Further changes were made to the PEF following the validation exercise. These included changing some of the terminology and extending the range of some categories including the addition of 'group of organisations', a point that is significant to the study on which this thesis is based. The resulting framework following these changes is shown in Table 2.5. The authors recognise that the PEF will continue to develop over time. Although the number of dimensions in Table 2.5 remained the same as before the peer review, two possible additions to the framework were mentioned. The first is 'embedded participatory structure' which refers to the number of layers of participation such as working groups and steering groups. The second possible dimension is 'project boundary' with possible categories ranging from no boundaries through to tight/defined boundaries. Both of these dimensions appear to be relevant to multiple organisation initiatives.

Hignett et al. (2005) presented the nine dimensions in the order that they were ranked by the project managers during the peer review, noting that the top two dimensions (decision-making and mix of participants) highlight the importance of worker involvement.

Table 2.5. The participatory ergonomics framework (Haines, Wilson,Vink, & Koningsveld, 2002)

Dimension	*Category*
Permanence	Ongoing – Temporary
Involvement	Full direct participation – Direct representative participation – Delegated participation
Level of influence	Group of organisations - Entire organisation – Department - Work group/team
Decision-making	Group delegation – Group consultation – Individual consultatioin
Mix of participants	Operators – Line management – Senior management – Internal specialist/technical staff – Union – External advisor – Supplier/purchaser – Cross-industry organisation
Requirement to participate	Compulsory – Voluntary
Topics addressed	Physical design/specification of equipment/workplaces/work tasks – Designing of job teams or work organisation – Formulation of policies or strategies
Brief	Problems identification – Solution development – Implementation of change – Set-up/structure process – Monitor/oversee process
Role of ergonomics specialist	Initiates and guides process – Acts as expert – Trains participants – Available for consultation – Not involved

Conclusions from the validation exercise showed the PEF to be an appropriate and valid tool, able to understood by the project managers, and a useful way to conceptualise PE. The PEF was also seen as a valuable tool for establishing and agreeing an agenda in the planning of a PE initiative (outlining issues and options to all parties at all levels from the start), and to enable comparison across PE projects.

Others have subsequently applied the PEF. Morris et al. (2003), for example, categorised the 38 case studies using the PEF, noting that it does not consider the methods used, or provide the dimension of 'outcome' by which the effect of the project may be evaluated. Other difficulties include were that the categorisation of a study may vary depending on the perspective taken (e.g. end users, senior manager), and that there may be a number of different participatory groups working within an organisation. Some categories (e.g. decision-making, brief) may also be hard to define. However, a strength of the PEF is that, as participatory projects evolve during their life cycle to adapt to external factors, it could be used to review the project at different points in its history. The authors also proposed the addition of category 'designer/manufacturer' to the 'mix of participants' dimension. Morris & Wilson (2003) also described the value of the PEF in planning the process of participation and not just the content, thus reducing the chances of failure.

It should be noted that two other models appear in the literature. Wells, Norman, Frazer, Laing, Cole, Kerr (2003) developed the Participatory Ergonomics Blueprint to help organisations 'start and sustain' a PE program. The change management in ergonomics model developed by Commissaris et al. (2006) is another recent approach. However, both models are quite prescriptive and tightly defined, lacking the flexibility of the PEF.

2.4.6 Participatory ergonomics and MSD in meat processing

In New Zealand, the earliest reports of formalised worker participation in the meat processing literature are from Hanara, an industrial designer at the Meat Industry Research Institute of New Zealand (MIRINZ). Hanara (1980) developed a method called Committee Design, whose aim was to enable the design of new and refurbished meat plants to meet the needs of the workforce, as well those of the company and union. Reflecting the difficult industrial relations of the time, Hanara refers to the method as involving both workers and management without damaging the loyalty of workers to their union or of management to the company. While the process had many restrictions it did enable the formal involvement of workers in the design process for the first time. Hanara reported that many jobs had never been analysed, and additionally the ideas for improvements of experienced workers had never been tapped, "There is always a better way. This is especially true for repetitive jobs and the people who actually work on those tasks are the best ones to find a better way." (p. 7). The Committee Design team, which was active from concept to evaluation of the project, consisted of one representative each from management, the workforce (chosen by the workers) and the design team. There were boundaries on what was discussed, with remuneration, production, and administrative issues off-limits to the team. Roles were also restricted, with the manager responsible for total plant layout, the worker responsible for workstation design, and the designer responsible for the feasibility of the design. The worker and the designer collect anthropometric data, task-relevant dimensions and ideas from the workers doing the tasks. Prototypes were used extensively to test workstations until workers and management agreed on the design.

Hanara (1981) reported on the application of the method in the redesign of one plant. Some of the difficulties encountered included management reticence to delegate authority to the committee, union suspicion about the committee's motives, and workers who derive job satisfaction from the sense of a good days hard work being concerned about making the job too physically easy. Some of the advantages found included workers generating a commitment to making their ideas work, and people identifying other relevant issues through the data collection and trialing process. Hanara also referred to the history of industrial unrest and introduction of automation as reasons why a method that is acceptable to the workforce and their unions is important. Unfortunately, the Committee Design method or any of the principles it contained are not reported in the New Zealand literature since this time.

The high incidence of MSD in the USA and the resulting fines by OSHA, referred to earlier in this review, provided the impetus for the development of guidelines for managing ergonomics programmes in meat packing plants (OSHA, 1991). Commitment by top management and employee involvement are seen as essential elements of the programme, although guidance on how to achieve these aims is limited.

Also limiting the scope of the document is the definition for 'ergonomic hazards' as "workplace conditions that pose a biomechanical stress on the worker" (p. 20), possibly an indicator of how ergonomics and MSD were perceived in the USA at the time. This lack of guidance on involving employees was rectified somewhat by a National Institute for Occupational Safety and Health (NIOSH) document on participatory ergonomics in meatpacking plants (Gjessing, Schoenborn, & Cohen, 1994), funded as part of the settlement agreement for the meat companies fined by OSHA.

The document includes a review of the literature on worker participation and three case studies of one-year PE programmes which are then reviewed in a final section. Despite weaknesses in the case studies and the lack of control measures, they demonstrate the value of worker contributions to hazard control. The main conclusions include the necessity of senior management commitment and support, training in teamwork skills and problem analysis, a team that represents all workforce groups and with thought given to team composition, accessible company data, and good communication with the plant without overselling the programme. Similar conclusions were made by Jones (1997) and Smith (1994) following the introduction of OSHA-based ergonomics programmes in processing plants. The importance of management commitment was also illustrated by Jorgensen (1990), in a plant redevelopment project with the combined thoughts of unions, worker representatives and researchers being ignored by management in the final design. Further, Loppinet & Aptel (1997) gave four principles for successful ergonomics actions in a plant, stating they should be: participatory, multidisciplinary, global and systematic, and embedded in time.

Gjessing et al. (1994) reported a number of PE case studies, the first of which took place in a unionised pork processing plant (Riley, Cochran, Stentz, May, & Schwoerer, 1994) and involved labour/management representative teams who reviewed all work tasks in their area and implemented mostly physical design changes. The authors reported reductions in MSD incidence, severity, and staff turnover. Moore & Garg (1994) in the second case study found that the attitude of team leaders made a difference to the success of two teams in a pork processing plant. The third case study (Schoenmarklin & Monroe, 1994) took place in a non-unionised plant and experienced difficulties with securing commitment throughout the plant, achieving a united team, and also experienced organisational barriers to implementation.

Moore & Garg expanded on various aspects of their case study, and the six-year project that it was part of, in a series of subsequent publications. Moore & Garg (1996) explained that the participatory process was based on quality management principles, with the five stages and the structured approach they recommend being very similar to the step-wise approach mentioned by Vink and others. The ergonomics programme was intended to help improve productivity as well as reduce MSD exposure. The only opportunity for direct involvement of workers affected by changes was during interviews of staff by team members. They noted that the study was limited by the lack of control groups, and the absence of a pre versus post-intervention comparison. Moore & Garg (1997a) evaluated the MSD data and found that over the six-year period the crude incidence rates and lost-time incidence rates increased in the first few years and then dipped to pre-intervention levels, with a shift from lost-time to restricted time. There was also a progressive and consistent decrease in inflation-adjusted annual workers compensation costs. The authors stated that increased awareness of MSD and early reporting of symptoms were the most likely reason for the initial increased incidence but decreased costs overall. Moore & Garg (1997b) presented three of the tasks that were assessed as case studies, providing risk assessment results and MSD morbidity data. Moore & Garg (1998) largely restated earlier findings, with decreases in MSD varying between plants in the company, with manual tasks experiencing greater reductions than more automated ones.

In Australia, Caple (1992) reported on an injury prevention study that was conducted in a sample of beef and sheep processing plants nationally. From previous involvement in the industry, Caple had identified that companies who had successfully reduced injuries used a systems approach and had senior management commitment, while injury prevention initiatives had typically focused on personal protective equipment and upgraded technology. Caple also identified that a common implementation barrier was limited internal industry communication on good injury prevention initiatives.
Data on injury prevention interventions was gathered from discussions with union and government officials, visits to 30 processing plants and a questionnaire survey of further plants, and a series of workshops for industry members to discuss intervention ideas. Evaluation trials of selected interventions were conducted in 30 plants from which a document was developed and distributed throughout the industry. These interventions concerned all injury types and mostly addressed physical task demands; an issue which

Caple recognised but thought was a good start point for building committed and trained management from which broader and more complex issues could then be addressed.

An industry inquiry in Australia led to the development of a best practice programme which was linked with industry benchmarking. This is described in a document by Meat & Livestock Australia (1994) where the results from 19 plants were rated against: management commitment, participation, skill development, work environment design, integration of health and safety, and continuous improvement. A more recent document (Meat & Livestock Australia, 2005) provided a structure for assessing and improving health and safety management systems, and encourages participation of all groups.

Shaw & Blewett (2001) reported on a pilot study in the meat industry in three Australian states that considered the role of participation at all levels in Continuous Improvement Programmes in Occupational Health and Safety (CIP OHS). The most positive outcomes of the study were in enterprises with substantial management commitment and workforce participation, those with realistic goals, and robust occupational health and safety (OHS) management systems. Indeed, the project's success was influenced by the role of the OHS professional and their knowledge of OHS and facilitation. They concluded that in plants where participative action was excluded from the exercise, little improvement was achieved in the working environment and an increase in cynicism towards OHS professionals was noted among both workers and management. Industrial relations were also a factor with the authors commenting that "where manager-worker relations are less than cordial, a top-down approach to organisational change is not likely to succeed in the long term..." (p. 254). Participative programmes, they suggest, not only produce better working environments through joint problem-solving, but also improved industrial relations generally. The authors also emphasised the need for health and safety training plans to include all levels of the organisation, as analysis and interventions must extend system-wide to be fully effective.

Caple (2005) reported on a project aimed at addressing MSD in a large abattoir in Australia, which was supported by management and unions and funded by government. Previous initiatives in the plant had been limited by the difficulties of removing workers from the production line; an issue that is relevant to most meat processing plants.

Briefing meetings were held with key stakeholders, followed by collection of data from task assessments, a discomfort survey and injury data review. Data sheets were compiled for each task, which included a traffic light rating (green, orange, red) based on the physical risk factors present. Unfortunately, staff were concerned that reporting discomfort could be used against them for future employment opportunities within the company, resulting in a low survey response rate. Individual consultations with workers on potential modifications to reduce MSD risk occurred - enabling workers to provide frank feedback. The traffic light system helped focus both management and workers on body areas and tasks at risk, and provided priority to these. Participation evolved from initial strong reluctance to be involved, to open discussion and contribution to risk control plans. The investment of significant capital in engineering changes to reduce risk has further assisted in improving trust. This study reflects some of the unique elements of the meat processing industry and illustrates the importance of both management and union participation. While Caple outlines some merits of the traffic light system, there would also appear to be significant limitations, such as the lack of consideration of psychosocial and contextual factors and not accounting for variations between individuals or temporally within the task.

2.4.7 Critique of the participatory ergonomics literature

The numbers of studies involving a PE approach that are reported in the literature have increased significantly since the mid-1990's (Cole et al., 2005). Among the influences contributing to the range of different approaches to PE, the researchers' level of understanding of ergonomics and cultural expectations (organisational and societal) seem to predominate. Many adopt (or at least report on) a narrow perspective of ergonomics, either limiting their attention to physical elements of the system (e.g. North American interpretation of ergonomics), or to the implementation of a limited number of interventions (e.g. an alternative design of a piece of work equipment). Cultural mores in some cases are also understated, or would limit the transferrability of the approach to other cultures (e.g. the level of acceptance of ergonomics and PE in the Netherlands). Some studies also represent the less desirable end of Arnstein's scale of participation, cited in Wilson, 1991. There is, therefore, an argument for referring to a participative approach and explaining what this entails (Cotton, 1993), rather than using the term participatory ergonomics and suffering the preconceptions that can be associated with it.

Case studies of PE programmes applied at a department or plant level are often limited to interventions that can be implemented at this same level. In the case of MSD, this means that the wider contextual factors, which are usually not evident when only considering one work area, may not be identified or are likely to be outside the control of those involved. This constraint may be a condition of the brief, but may also be limited by the researcher's understanding of ergonomics, or that which is taught to participants. Indeed, the training that PE group members receive will influence what they recommend, and arguably it is this training that needs greater attention, rather than the form or function of the group itself.

Hignett et al. (2005) point to a lack of quality evaluations in PE, with both successful and unsuccessful outcomes acting as disincentives for the company to allow or fund project evaluation. Complex changes within the work systems increase the difficulty of evaluation, as has been discovered in recent randomised controlled trials in PE. The long-term nature of achieving organisational and cultural change, particularly when combined with the gradual and insidious nature of MSD, poses further difficulties for PE evaluation. However, a PE approach is an essential part of identifying subtle MSD risk factors, including those referred to in this study as contextual factors.

There has been comparatively little reported on PE programmes at an industry level, or spanning several separate organisational structures (Carayon, 2006), as evidenced in the discussion earlier. Where such studies have occurred, little has been mentioned on the challenges that this may create, such as creating the desire for such a group and funding it, overcoming confidentiality and competition concerns, resolving conflicting interests, and implementing industry-level changes. Studies involving multiple organisations have often involved the implementation of a specified work tool or work method; a relatively low-threat intervention that is not reliant on industry agreement for its success.

Other areas which receive little mention in the literature include methods for overcoming the lack of direct worker participation in large-scale participative programmes - such as in projects with multiple layers of participation (Haines et al., 2002), and how to increase worker involvement in situations where production or income is adversely affected – such as production lines or where there is high staff turnover (Laing et al., 2007). The steps required to establish a PE group and the lessons learnt from this process are also rarely mentioned.

2.5 Implications for the present study

MSD is a complex concept, with many different definitions offered. For the purpose of this research, MSD is taken to mean sudden or gradual onset conditions, excluding trauma, and occurring anywhere in the body. The literature on MSD causation helped to determine the assessment methods used in this study, which needed to be able to identify contextual factors along with physical and psychosocial risk factors. An industry-level approach provided the opportunity to consider these broader contextual factors, while also meeting stakeholders needs and expectations. Research support for the implementation of multiple MSD interventions provided further support for this broader approach, as a means of identifying a wide range of potential interventions.

Previous studies in meat processing indicated the advantages of a participative approach, while the literature on PE provided a framework for considering these elements of the study. Furthermore, the literature also indicated that there were many participative techniques that could be successfully applied. While direct representation was preferred, other methods of engagement were possible. Consideration in the literature to the complexities of achieving participation at multiple sites or organisations also helped to inform the study process.

Chapter 3. Analysis of MSD injury data in meat processing

3.1 Introduction

3.1.1 Background

Despite the high overall incidence of reported MSD in meat processing in New Zealand (ACC, 2007), there is very little publicly available information on MSD injuries that occur in the industry. While individual companies have their own data, this level of information is not shared between companies or plants. Similarly, the state insurer (ACC) can only provide summary figures on industry claims or discuss individual company claims data, in isolation from the rest of the industry. While benchmarking of gross indicators (e.g. LTI, severity) has occurred through the Meat Industry Association and through privately owned injury databases, this limited information is either no longer available or has only limited coverage of the industry. In the absence of better data sources, information about MSD injuries in meat processing has been largely derived from anecdotal experiences of individual plants or companies, and sporadic analyses of ACC claims data (ACC, 1996).

The overall goal of this initial stage of the study was to establish a profile of MSD injury data in the industry, from which tasks most commonly associated with reported MSD could be identified and targeted for the next stage of the study. A secondary goal was to establish contacts and dialogue throughout the industry as part of the participative approach to the study. The starting point was to attempt to substantiate industry beliefs in relation to MSD, examine in greater detail the industry-level data available through ACC, and determine if other data were available that would assist in these goals.

Four injury data sources for meat processing were identified, and data were collected from each of them. The data sources were: accepted MSD injury claims made with ACC, records from an industry-based injury database, accident register entries from individual processing plants, and questionnaire responses from health and safety personnel within each of these plants. This chapter describes each of the four sources, outlining the methods used to collect data and the nature of the researcher's involvement in the industry. Findings are presented from analysis of data from these four data sources, and results are discussed as they relate to the aims[6].

3.1.2 Aims of this chapter

1. To examine patterns and trends in MSD injury data.
2. To determine which activities or tasks (by species) are most commonly associated with MSD, and using this evidence base to determine which tasks to focus on in the next stage of the study (through the Meat Industry Health and Safety Forum (MIHSF)).
3. To contact people responsible for health and safety at each processing plant to: more accurately define the industry; identify industry injury data sources; promote awareness of the study; and build relationships for further stages of the study with both plant personnel as well as with members of the key stakeholder group (MIHSF).
4. To identify any issues for consideration in further research.

3.2 Methods

3.2.1 Overview of methods used

At the outset of the study, little was known about what information sources were available on MSD from within the industry. It became apparent through the MIHSF that apart from ACC data there was only one other data source (National Injury Database - NID), following the discontinuation of the Meat Industry Association's survey of injury severity and injury frequency rates for its member plants. Two further data sources were also collected - accident register records and a questionnaire to plant health and safety staff. While these two methods were not as robust, they were necessary to enable some triangulation of findings across all four data sources and to provide a profile of MSD in the industry including work tasks/areas where they were

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[6] Some of the main findings of this stage have also been presented in Tappin et al. (2005b), and published in the journal *Ergonomics* (Tappin, Bentley, Vitalis, & Macky, 2008).

most likely to occur. These were aims which the more rigorous data sources could not meet on their own.

Therefore, four sources of data concerning MSD were collected, two of these from national injury databases and a further two through collaboration with key personnel in each processing plant. A full list of meat processing plants and key contacts within each plant was derived from the MIHSF, and also from a list of registered processors issued by the Ministry of Agriculture and Forestry (MAF) for identifying plants not involved in the MIHSF. Figure 3.1 presents an overview of the methods used in this stage of the study.

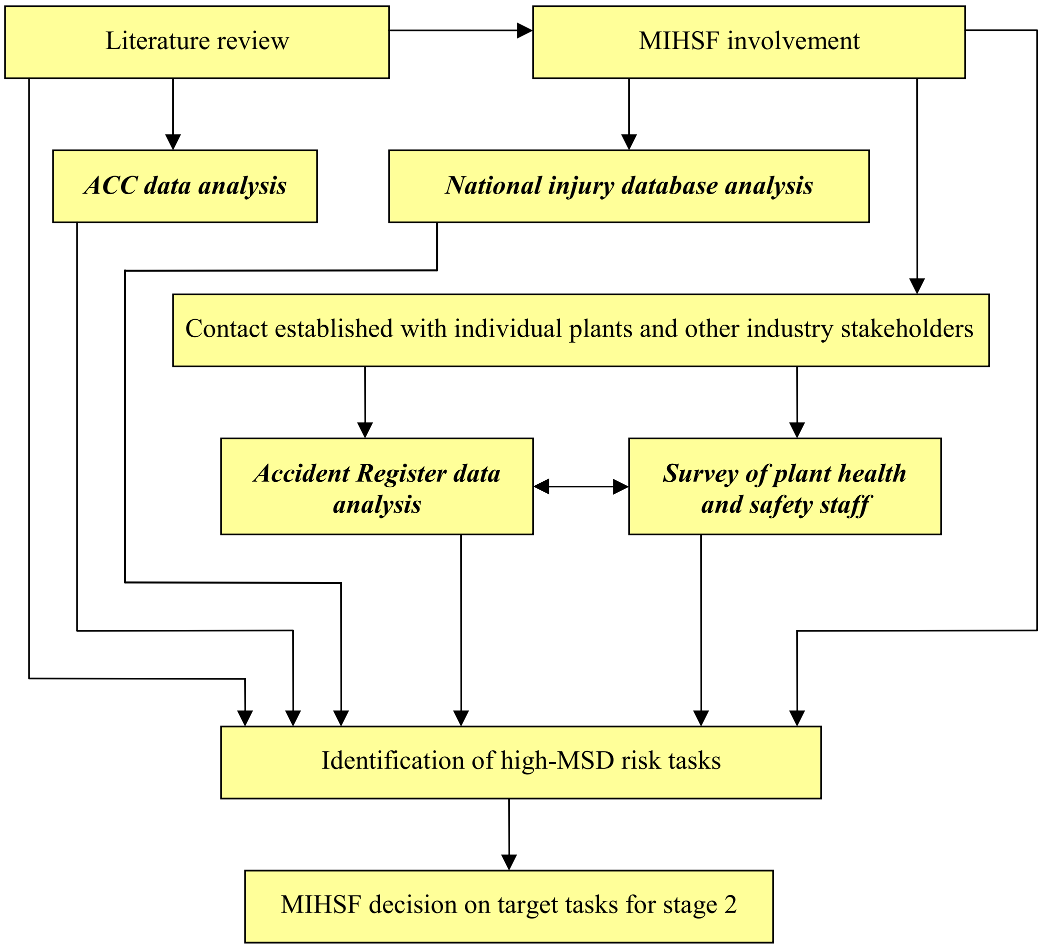

Figure 3.1. Methods used in stage 1 of the study

3.2.2 Accident Compensation Corporation (ACC) data

ACC administers New Zealand's accident compensation scheme which provides 24 hour, no-fault personal accident insurance cover for all New Zealand citizens, residents and temporary visitors to New Zealand. In return people do not have the right to sue for personal injury, other than for exemplary damages. All health providers collect personal and injury information from every patient. This information is then collated by ACC and analysed to provide the priorities for injury prevention strategies by ACC.

A descriptive epidemiological analysis was undertaken for all claims accepted by ACC during the period July 2002-June 2004 that were associated with MSD-related injuries in the meat processing industry (ANZSIC code C21110) (ACC, 2004a). ACC diagnosis categories that encompass both sudden and gradual onset MSD conditions were included in the analysis to maintain some consistency between ACC data and industry data, where MSD are referred to as 'sprains and strains' and include all conditions that affect the muscles, tendons, bones and joints (excluding fractures/dislocations, contusions/bruises, and lacerations/wounds). Data for accepted claims were extracted from ACC's main claims database for specific diagnosis categories (Soft Tissue Injury, Occupational Overuse Syndrome, Gradual Process [localised inflammation], Gradual Process [compression syndrome], and Pain Syndrome), as well as specific codes from the READ clinical coding system (Gradual Process, Sprain/Strain, Tendon Injury, and Unspecified Conditions). Including READ clinical codes increased the total number of accepted claims for consideration by 14%, and the total of 'cleaned' claims by 5.6%.

There were three types of accepted claims, including treatment claims (usually a visit to a health professional), compensation claims (usually to claim for lost earnings incurred if away from the workplace for more than seven work days) and other claims (usually claims made through bulk-funded organisations such as hospitals). In line with ACC's and Massey University's ethical guidelines, no information that might identify a claimant was made available to the researchers. The data were cleaned by removing cases that were either not MSD-related (n=1801), had insufficient information within the various data fields to be able to determine the nature of the injury (n=1229) or were erroneously included in the dataset (n=174). This left a useable dataset of 9180 accepted ACC claims cases (from an original 12,384). A descriptive analysis of these data was undertaken to determine the distribution of the variables presented in Table 3.1 among the meat processing MSD claims cases. This involved simply frequency distribution and cross tabulations.

A multivariate analysis, using logistic regression, was conducted to determine the relative predictive ability of the independent variables listed in Table 3.1 in relation to the dichotomous dependent variable (treatment versus compensation claim). Logistic regression was used for the multivariate analysis, as most variables were categorical in nature and the dependent variable was dichotomous.

Finally, a content analysis was undertaken of cases for which narrative text descriptions of the injury circumstances were recorded (n=1,153; 12.6%). Narrative text data are not collected by ACC for companies that have been accredited (assessed and approved) by ACC and are responsible for their own injury management. Thus, the cases with narrative data represented claims for individuals working in non-ACC accredited organisations, the majority of which are smaller companies with domestic markets. Narrative fields were content-analysed and coded to produce two new variables (Table 3.1): 'activity at time of MSD injury' and 'injury agency'. Inter-coder reliability (between the researcher and a co-investigator) was conducted on a random sample of 231 cases with narrative text data (20%). The rate of agreement for each of the variables coded was > 80%. Further variables were considered (initiating event, species, department) however the information was insufficient for the findings to be of use. All data were analysed using the Statistical Package for the Social Sciences – version 12.0.

Table 3.1. A typical example of an ACC Meat Processing MSD dataset

Variable name	*Variable description or example*
Year of MSD	2002-2004
Month of MSD	January-December
Gender of claimant	M/F
Age of claimant	15-70
Ethnicity of claimant	*e.g.* NZ European
Region of claimant's workplace	*e.g.* Waikato
Medical fee versus Entitlement	M/E
Sudden versus gradual onset of MSD	Soft tissue injury/gradual process
Diagnosis	*e.g.* Carpal Tunnel Syndrome; Lumbar sprain
Body part injured	*e.g.* Back; wrist; ankle
Activity at time of MSD*	*e.g.* 'Boning mutton. Pain in both wrists when working and doing hand movement.'
Injury agency*	*e.g.* Box or crate; slippery underfoot surface; live animal

(* from content analysis of free-text narrative fields)

3.2.3 National Injury Database for Meat Processing (NID)

The NID was established in 1997 following a survey of accident register records across the industry, on which it was based (Moore, Tappin, & Vitalis, 2004). It is operated by a private company with the support of the meat processing industry, to provide more detailed injury incident information than can be obtained from ACC data alone. Thus data fields are included which are specific to meat processing (e.g. species, knife hand), along with those which help in identifying injury trends (e.g. task, job title, department).

As all incidents are recorded, irrespective of severity, this provides a larger pool of data than only those injuries which incur direct costs through ACC. MSD are recorded in the NID as strains and sprains, and include both gradual and sudden onset conditions involving all body areas. The NID enables companies to enter and access their own information on all injury incidents, while data summaries can be produced for the industry as a whole. Not all companies have contributed data to the scheme. Estimated FTE coverage for 2004 data is 27% of the industry workforce and coverage of the two main sectors is approximately 40% for sheep processing and 10-15% for beef processing (Peter Dowd [NID developer], personal communication, February 15, 2005). Results therefore have to be considered carefully, as they are not representative of the industry as a whole, with many processing companies and some species not included.

A descriptive epidemiological analysis was undertaken for all MSD-related NID records during 2004, a dataset of 3257. These data were from nine meat processing plants in three companies. In line with Massey University's ethical guidelines, no information from which the claimant or the meat processing company could be identified was provided to the researchers. Analysis of these data, using frequency analysis and cross tabulations, determined the distribution of the variables presented in Table 3.2. NID data fields for department, task and injury details provided better indication of high-risk tasks and processes than the accident details field, which in most cases did not provide further useful information. A content analysis of the accident details narrative was therefore not conducted.

The NID and ACC databases were highly complementary in meeting the aims of the study. NID data provided information specific to species, work area, task and knife hand, all of which were absent from ACC data, but provided no data regarding age, gender, ethnicity and geographical region, all fields which were present in ACC data. Thus, while they did not collectively provide comprehensive information on MSD injuries in meat processing, there were certainly benefits to be gained by considering both data sources.

Table 3.2. NID MSD dataset: relevant variables available for analysis

Variable name	*Variable description or example*
Date of MSD	Day/month/year
Species involved	*e.g.* Beef; sheep; veal
Department	*e.g.* Slaughter floor; boning room; freezers
Specific task	*e.g.* Boning-table; packing-offal; kidney removal
Job title	*e.g.* Butcher; boner; labourer
Injury type	*e.g.* Strain/sprain, knife cut, other
Body part involved	*e.g.* Back; wrist; ankle
Accident details	Brief outline of event (one line)
Body side	Left; right; not specified
Knife side	Knife; non-knife; not specified
Lost time	Light duties; time off work
Severity	1-4 scale, negligible – fatality
Frequency	1-4 scale, remotely possible – happens all the time
Injury cost	Average cost of injury

3.2.4 Accident Register Data Summary

Among the obligations of the Health and Safety in Employment Act (1992) is the requirement for all places of employment to possess and maintain accident registers and for all employees to report accidents (whether or not involving injury) and cases of serious harm when they occur. The term 'accident' also includes discomfort and situations where first aid is sought. Levels of reporting are generally high as accidents or cases of discomfort which are not reported and progress to become more serious can result in disputes over who is responsible and therefore who bears the costs not covered by ACC. Accident register records therefore offer a source of injury data at a level below ACC data, and which is universally accessible (in principle) as the law requires it to be consistently collected by every meat processing plant.

Accident register data were sought from each processing plant, to supplement the ACC and NID data and enable corroboration between data sets. While the amount of detail that is recorded may vary between plants, accident registers legally require personal and employment details of the person involved. Further obligatory information that is relevant to the study includes: job title, time and date of the accident, and a description of what happened. To improve the consistency of data provided and to meet ethical requirements regarding anonymity of register entries, a form was developed for the collection of accident register data. The lessons learnt from conducting two previous national accident register surveys, in meat processing and timber processing, helped inform this process (Moore et al., 2004). The survey form was evaluated by four people involved in the meat processing industry before being piloted with two plants. All meat processing plants (excluding plants whose data were already provided through the NID) were contacted and the person holding responsibility for health and safety management in the plant (or their designate) was invited to participate in the accident register data collection process. Sixty-nine plants (from a total of 81) agreed to participate and were sent survey forms (Appendix 3) along with an information sheet and consent form covering both the accident register survey and the questionnaire in 3.2.5 (Appendix 1). Variables requested from the companies' accident registers are shown in Table 3.3.

Twenty nine plants (response rate = 42%) provided their accident register records from 2004, with a total of 4028 entries. Analysis of these data, using frequency analysis and cross tabulations, was undertaken to determine the distribution of the variables presented in Table 3.3. Accident register data provided some information on MSD in plants not contributing to the NID, thus helping to further build a profile of MSD in meat processing.

Table 3.3. Accident register MSD dataset: relevant variables available for analysis

Variable name	*Variable description or example*
Department	*e.g.* Slaughter floor; boning room; freezers
Job title	*e.g.* Legger; boner; packer
Task (at the time of injury)	*e.g.* Rail boning; degambrelling; halving saw
Species (at the time of injury)	*e.g.* Beef; veal; sheep
Body part involved	*e.g.* Back; wrist; ankle
Severity	Days off work; alternative duties; GP visit
Month of injury	Jan-Dec

3.2.5 Questionnaire for Health and Safety Staff

The fourth source of MSD data was derived from a questionnaire which accompanied the accident register survey for health and safety staff. The questionnaire covered four main topics: processing plant details (e.g. FTE processing staff), respondent details (e.g. industry experience), MSD management practices at the plant, and respondent opinions on the tasks most likely to lead to MSD in the meat processing industry and reasons why. A copy of the questionnaire is included as part of Appendix 3. The procedure for summarising staff opinions on tasks most likely to lead to MSD in meat processing was to assign points to each task that was mentioned (5 points for the first task (most likely to lead to MSD), down to 1 point for the fifth task (least likely to lead to MSD) listed on the questionnaire). Points were totalled for each task across all respondents.

The purpose of this questionnaire was twofold: to collect further information about the industry not available elsewhere; and to provide people with an opportunity to give their opinions on MSD problem areas both in their plant and in the industry. Data on both are reported on in this chapter, with some findings on MSD risk factors, implementation barriers and interventions (questions 12, 13, 14, 16) discussed in chapters 4 and 5.

As with the accident register survey, the questionnaire was evaluated by four people involved in the meat processing industry before being piloted with two plants. All 81 meat processing plants were contacted and the person holding responsibility for health and safety management in the plant (or their designate) was invited to participate in the questionnaire. The questionnaire was sent to the 77 plants who agreed to participate, along with the information sheet and consent form (Appendix 1). Questionnaires were completed and returned by 44 plants (response rate = 57%). Responses to the question regarding their opinions on the five tasks most likely to lead to musculoskeletal disorders were summarised by species, department and task.

3.2.6 MIHSF Involvement

The MIHSF were involved from the outset of this stage through disseminating information on the study, and providing industry and plant information to the research team. Their role was also to discuss the main findings from this stage, before agreeing on the areas of focus for the next stage of the study.

3.3 Results

3.3.1 ACC Data

3.3.1.1 Claim Status and Sample Demographics

A total of 9,180 MSD-related accepted ACC claims cases were included in the analysis following data cleaning, with 4692 occurring in 2002-03 and 4488 in 2003-04. These cases were comprised of treatment claims (health professional treatment costs) (n=5462; 59.5%), compensation claims (lost earnings) (n=2319; 25%) and other claims (hospital treatment) (n=1399; 15.2%). This distribution was very similar for each year (differences of less than 1% of the total). For the purpose of this analysis, the variable 'treatment versus compensation' was considered the best available proxy for severity, in the absence of a more accurate measure of severity, such as a severity rating or actual cost of claim. The rationale for this decision was that compensation claims involved time away from work (more than seven days before compensation for lost earnings is paid by ACC), and were therefore likely to be of greater severity. Conversely, treatment claims were relatively minor, requiring visit(s) to health professionals without significant time away from work.

Male claimants (n=7383; 80.4%) dominated the sample. Females accounted for 22.8% of claims in Waikato, 25.3% of claims in Hawkes Bay, 24.3% of claims in Southland, but only 11.4% of claims in Canterbury and 15.2% of claims in Otago. However, it was not possible to generate claim incidence rate data for gender as no reliable industry demographic data (from which to determine exposure) was available to the researchers. Claimants' ages ranged between 15-70 with a mean claimant age of 37.9 years (sd 11.7). No significant difference for gender by age or by year of claim was observed (mean age males: 38.1 years; females: 36.8 years). Claimants were predominantly New Zealand European (n=5264; 57.3%) or New Zealand Maori (n=2565; 27.9%), with 6.9% being of Pacific Island or other ethnicity. In 7.9% of cases the ethnicity of the claimant was not recorded or unknown. The proportion of claims for New Zealand Maori is higher than would be expected, based on the numbers of Maori employed in meat processing (approximately 20%, from 2001 census data).

3.3.1.2 Geographic and Temporal Distribution of Claimants

Meat processing MSD occur in highest proportions in the Canterbury (19.1%), Southland (16.6%), Gisborne/Hawkes Bay (13.1%), Otago (12.7%) and Waikato (11.3%) regions. This distribution is consistent with the main sheep and beef farming regions of New Zealand and the accompanying location of processing plants (based on available employment data for plants).

Figure 3.2 shows the monthly distribution of claims over the two-year period of the analysis. The data represent the month in which the MSD was incurred. The majority of MSD were incurred during the January-May period, with 58.6% of MSD occurring during this five-month period (59.2% in 2002/03 and 57.8% in 2003/4). This is consistent with the workload peak for most processing plants which falls somewhere between December and June to accommodate seasonal fluctuations in stock numbers and reduced availability of stock feed going into winter. Many plants have an off-season and are either closed or on reduced hours during the winter months, while some plants processing other species (e.g. veal) have workload peaks at different times of the year.

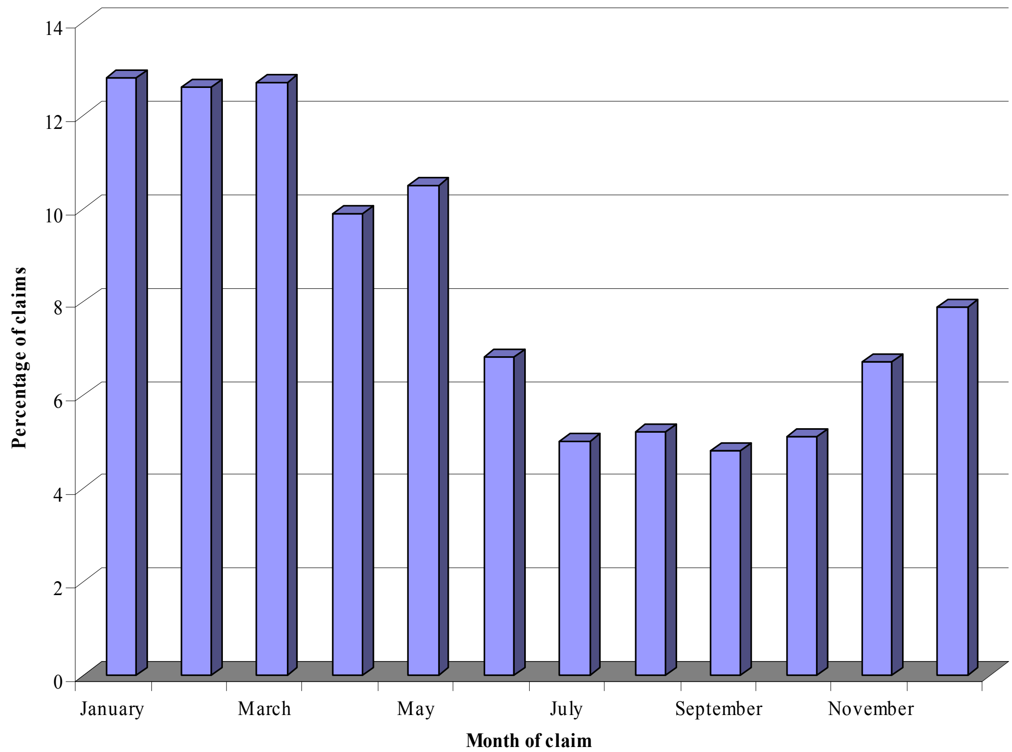

Figure 3.2. Monthly distribution of MSD claims

3.3.1.3 Diagnosis and Body Part Injured

Most MSD (81%) were categorised in the database as 'soft tissue' or 'sudden onset' MSD injuries, while the remaining 19% were 'gradual onset' injuries. However, the diffuse nature of many MSD-related conditions, variations in their clinical presentation and categorisation within the ACC dataset reduce the usefulness of these figures. For instance, 'rotator cuff sprain', of which there are 492 (5.3%), could be either gradual or sudden onset. For actual diagnosis, lumbar spine-related MSD were the major injury type (n=1942, 21.2%), followed by wrist sprains other than carpal tunnel injuries (n=851, 9.3%), upper arm injuries (n=843, 9.2%), and shoulder tendon/joint damage (n=807, 8.8%). Table 3.4 shows the distribution of claims by READ clinical code diagnoses grouped together by body region.

Table 3.4. Distribution of claims by READ clinical code diagnoses for each body region

Injury diagnosis by body region	*2002-03*		*2003-04*		*Total*	
	n	*%*	*n*	*%*	*n*	*%*
Lumbar sprain / disc disorder	942	20.1	1000	22.3	1942	21.2
Wrist tendon / ligament damage	452	9.6	399	8.9	851	9.3
Upper arm muscle tear	426	9.1	417	9.3	843	9.2
Shoulder tendon / joint damage	376	8.0	431	9.6	807	8.8
Elbow tendon / joint damage	326	6.9	338	7.5	664	7.2
Cervical sprain / disc disorder	299	6.4	352	7.8	651	7.1
Carpal tunnel syndrome	290	6.2	306	6.8	596	6.5
Hand tendon / ligament damage	252	5.4	241	5.4	493	5.4
Thoracic sprain / disc disorder	237	5.1	251	5.6	488	5.3
Knee ligament / joint damage	185	3.9	181	4.0	366	4.0
Forearm muscle tear	161	3.4	184	4.1	345	3.8
Ankle sprain	134	2.9	137	3.1	271	3.0
Thigh muscle tear	68	1.4	88	2.0	156	1.7
Rib-chest sprain / muscle tear	67	1.4	62	1.4	129	1.4
Sacrum / pelvis / hip sprain	43	0.9	39	0.9	82	0.9
Foot sprain	25	0.5	37	0.8	62	0.7
Lower leg muscle tear	29	0.6	16	0.4	45	0.5
Unobtained body part or diagnosis	378	8.1	10	0.2	388	4.5

Of significance in these figures are the very similar percentages for injuries between the two years, possibly indicating the consistent presence over time of injury risks across the industry. Unfortunately the diagnoses provide very little information other than which body parts are usually involved.

Grouping the data by body part rather than diagnosis tells a similar story however, but does increase the dataset by being able to include records with major body part but no diagnosis. As a result a total of 53.8% of cases over both years were injuries to the upper limb, 27.8% to the upper/lower back, and 10% to the lower limb (Figure 3.3), with a large proportion of MSD located at the hand/wrist (23%) and shoulder (16.5%). Variations between percentages for diagnosis and body part involved (e.g. neck/head) occur as a result of referred pain and accompanying dysfunction.

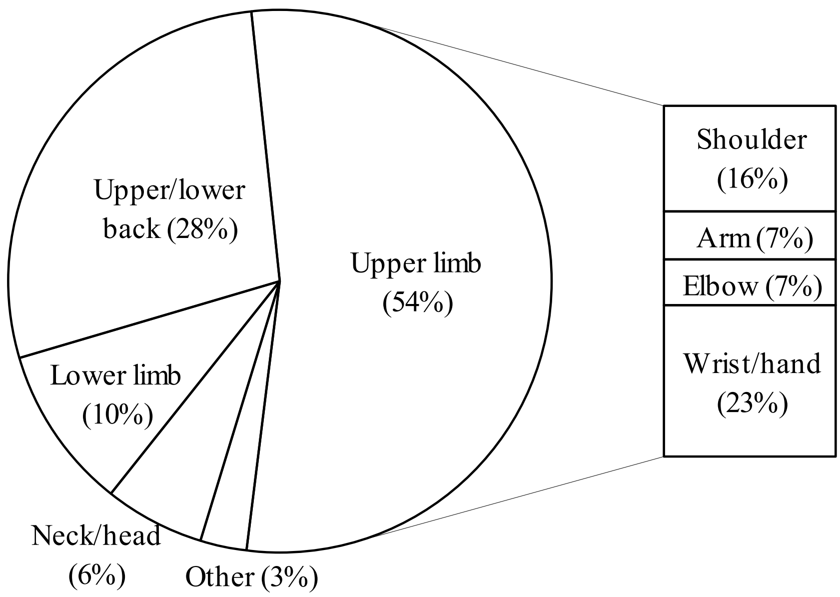

Figure 3.3. Distribution of MSD injuries by body part injured

3.3.1.4 Logistic Regression Analysis

Logistic regression was used to explore the predictors of MSD injury severity using the dichotomous dependent variable of whether someone received either medical treatment for their injury or a compensation payment for lost earnings. The independent predictor variables included in the model were: age, month of reporting, gender, ethnicity, whether the injury was caused by an animal as an external agency, whether the employer was ACC accredited, the geographic region in which the injury occurred, the body part injured, whether the injury was classified as soft tissue or gradual process, and the injury diagnosis by body region.

Each of the variables was recoded to create a new variable for each category with the values of 1 and 0. All variables were forced into the regression analysis. The final regression model meets the Hosmer-Lemshow test for goodness of fit (χ^2 (8) = 6.85, p = .552) and improves the correct classification rate from an initial 70.8% to 73.0%. While this difference is not large, the change from the initial -2 log likelihood of 7624.85 to the final value of 7008.50 is statistically significant (χ^2 (45) = 616.35, p = .000). The final logistic regression model does, therefore, significantly reduce the amount of unexplained variance, although the obtained Nagelkerke pseudo R^2 of 0.13 also indicates that considerable variation in severity remains unexplained by the model.

Table 3.5. Logistic regression for treatment versus compensation claims (N = 6316)

Variable	*B*	*Wald*	*P*	*Exp(B)*
Age	<.001	1.62	.203	1.00
Month	-0.03	15.19	<.001	0.97
Gender	-0.02	0.08	.780	0.98
Ethnicity		29.11	<.001	
NZ Maori	0.52	8.79	.003	1.68
NZ European	0.17	1.02	.313	1.19
Pacific Island	0.04	0.03	.867	1.04
Accredited employer status	0.10	1.15	.284	1.11
Animal as external agency	0.59	0.72	.397	1.06
Region		164.46	<.001	
Northland	0.54	10.89	.001	1.71
Auckland	-0.30	2.23	.136	0.74
Bay of Plenty	0.57	13.63	.000	1.78
Waikato	-0.09	0.59	.443	0.91
Gisborne / Hawkes Bay	-0.69	31.84	<.001	0.50
Manawatu / Wanganui	<.001	<.001	.993	1.00
Taranaki	0.93	27.23	<.001	2.53
Wellington	-1.04	9.44	.002	0.35
Nelson / Marlborough	0.10	0.11	.741	1.11
Canterbury	0.01	0.01	.944	1.01
West Coast	1.35	5.70	.017	3.85
Otago / Southland	0.38	9.83	.002	1.40
Body part injured		4.82	.681	
Soft tissue or gradual process	1.05	35.09	<.001	2.86
Injury diagnosis by body region		82.22	<.001	
Thoracic sprain / disc disorder	-1.83	13.29	<.001	0.16
Knee ligament / joint damage	-0.79	1.81	.179	0.45
Ankle sprain	-1.12	3.44	.064	0.33
Lumbar sprain / disc disorder	-1.52	9.53	.002	0.22
Carpal tunnel syndrome	-0.01	<.001	.984	0.99
Cervical sprain / disc disorder	-2.05	16.93	<.001	0.13
Sacrum / pelvis / hip sprain	-1.79	9.95	.002	0.17
Foot sprain	-2.12	7.95	.005	0.12
Shoulder tendon / joint damage	-0.85	3.00	.083	0.43
Elbow tendon / joint damage	-0.84	2.35	.125	0.43
Rib-chest sprain / muscle tear	-2.15	14.59	<.001	0.12
Hand tendon / ligament damage	-1.19	4.78	.029	0.30
Forearm muscle tear	-0.79	2.37	.124	0.45
Upper arm muscle tear	-1.29	6.93	.008	0.28
Wrist tendon / ligament damage	-0.80	2.26	.133	0.45
Thigh muscle tear	-1.33	5.12	.024	0.26
Lower leg muscle tear	-1.27	3.18	.074	0.28

As Table 3.5 shows, the month in which the injury was recorded, the ethnicity of the employee, the geographic region in which the injury occurred, whether or not the injury was sudden or gradual onset, and the injury diagnosis were all predictive of injury severity. The finding for injury month is consistent with the distribution shown in Figure 3.2. With regard to ethnicity, an examination of the regression coefficients and change in the odds ratio (e*xp(B)*) indicates that Maori are more likely to be in the entitlement MSD category than non-Maori. ACC claims data from 2000/01 and 2001/02 show a similar pattern with work-related injury incidence rates for Maori being significantly higher than other ethnic groups (OSH, 2001; Statistics New Zealand, 2002; ACC, 2004b). Analysis of new claims data for 2003 and 2004 indicate a continuation of this trend.

Regions where the odds of receiving compensation payments were higher were Northland, Bay of Plenty, Gisborne / Hawkes Bay, Taranaki, Wellington, and Otago / Southland. Employee age, gender, and whether or not they worked for an accredited employer were found to be independent of the measure of MSD severity used in this study.

In considering MSD severity predictor variables pertinent to injury type, Table 3.5 shows that employees with gradual onset MSD injuries were more likely to receive compensation payments than those with sudden onset MSD injuries. However, the actual body part injured was independent of injury severity. This said, injury diagnoses pertinent to thoracic spine, lumbar spine, cervical spine, sacrum / pelvis, foot, ribs / chest, hand, and upper arm were associated with a greater likelihood of being treatment rather than compensation claims. The most significant of these is the lumbar spine which accounts for 21.2% of cases in the ACC data sample. Thoracic and cervical spine injuries comprise 12%, with upper arm (9%) and hand (5%) also having significant numbers of injury claims. Overall, predictor variables most strongly associated with more severe injuries were geographic region, the injury being a gradual onset MSD, and being Maori in ethnicity.

3.3.1.5 Activity at Time of MSD

Activity or task at time of MSD was identified from the narrative description of injury circumstances for non-accredited cases (n=1153, 12.6%), for which narrative text is recorded by ACC. Figure 3.4 shows the distribution of activity at the time of the MSD injury. Lifting tasks (n=409; 35% of non-accredited cases) were most commonly associated with MSD injury, with knife work the only other significant activity. Knife work (n=149; 13%) included the sub-categories of boning (n=72; 6%); trimming (n=30; 3%) and unspecified knife use (n=36; 3%). Other common activities/tasks included: walking or running (n=78; 7%), skinning/pelting (n=60; 5%), pushing (n=50; 4%) or pulling (n=61; 5%), ascending/descending (n=42; (4%) and handling live animals (n=42; 4%).

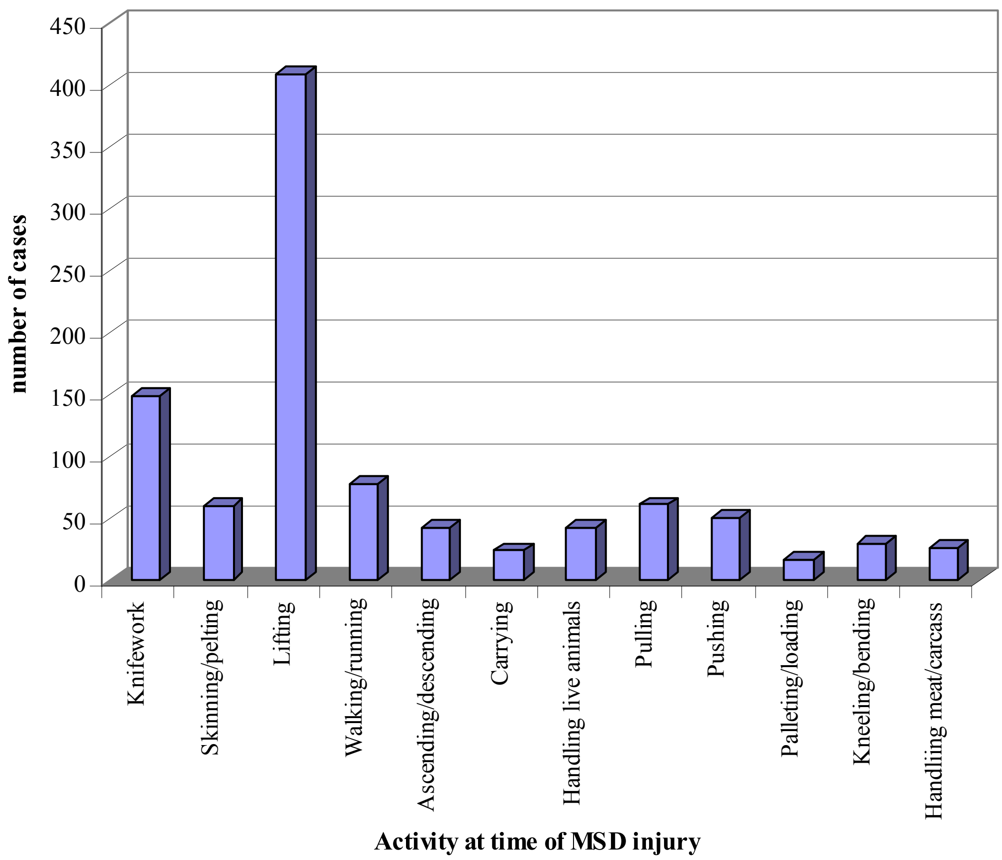

Figure 3.4. Activity at time of MSD injury

3.3.1.6 Agency for MSD injuries

Further analysis of the narrative description of injury was conducted to determine the injury agency for MSD involving lifting tasks. A large proportion of MSD cases involved lifting boxes (n=115; 28% of lifting-related MSD) or animal carcasses/meat (n=151; 37%) (Figure 3.5). Due to lack of detail in the accident descriptions, the extent to which these injury agencies relate to similar tasks is unknown. However, it is likely that claims involving the more prevalent injury agencies occurred in slaughter and boning/packing as these work areas are where there is greatest contact with the carcass, meat and boxes.

Lifting-related MSD injuries were most frequently located at the back/spine (n=207; 51% of lifting cases), shoulder (n=77; 19%), hand/wrist (n=43; 11%) and neck (n=33; 8%). Just 19% of lifting-related MSD resulted in entitlement claims (n=77), compared to a figure of 25% for the larger MSD database – a finding consistent with the logistic regression results, suggesting other MSD not involving lifting are of a greater severity. Figure 3.5 shows the distribution of injury agency for MSD injuries involving lifting tasks.

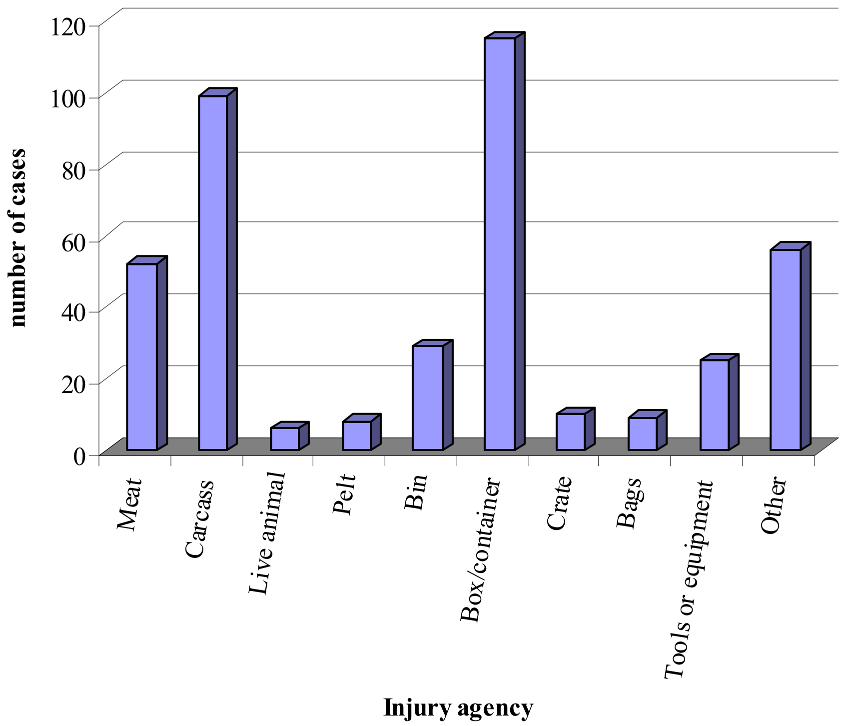

Figure 3.5. Distribution of injury agency for MSD injuries involving lifting tasks

3.3.2 NID Data

3.3.2.1 Sample Demographics

MSD-related cases from 2004 included in the analysis totalled 3257 following cleaning. These cases included 3208 recorded as 'Strain/Sprain' and a further 49 gradual onset cases recorded under 'Other'. MSD cases make up approximately one third of the entries, with most of the remaining two thirds comprising cuts, abrasions, bruises, zoonoses (animal-borne infections) and foreign body injuries. Age, gender and ethnicity were absent from this database. Sheep were the predominant species involved (n=2861; 88%) which is consistent with the companies contributing to the database. Other species were beef (n=322; 10%), venison and pork.

3.3.2.2 Temporal Distribution

Month of injury showed a pattern of higher numbers of incidents occurring in the first six months of the year (81%) than in the second six months, with incidents in January to May accounting for 77% (n=2569) of the total for 2004. This pattern is also apparent in the previous two years data where incidents for the first five months were 74% (n=3515) in 2002 and 70% (n=2775) in 2003. These findings are consistent with those for ACC data, and reflect the seasonality of the industry. The higher percentages for NID is likely to be due to sheep being the main species involved as they have a greater peak for processing in these months than do other species.

3.3.2.3 Body Part Injured

The most common body parts injured were: wrist/hand (31.3%), back/spine (24%), shoulder (16%), arm/elbow (14.4%) and lower limb (11.1%). These percentages are closely aligned with those of the ACC data and reflect the high-risk tasks for MSD identified below.

3.3.2.4 Department and Task by Species

Analysis of MSD cases by department and task was undertaken for adult beef (therefore excluding veal and hereafter referred to as beef) and lamb, ewes, hogget, mutton and sheep (hereafter referred to collectively as sheep). This provided the most useful level of information for achieving the study objectives from the fields available for analysis as job title details were too generic to be of use, and accident details did not provide any additional information already present in department and task. The frequency of incidents was the main measure used, since severity data was incomplete as not all contributors provided complete cost-related information. Most injuries occurred in the slaughter and boning departments, (74% for sheep and 84% for beef), which is consistent with the number of staff usually employed in these two areas. Table 3.6 lists tasks with the highest number of MSD incidents in 2004 for the two main species. In those cases where cost data were provided by companies, average cost estimates for these injuries were among the highest for all strains and sprains. Analysis of knife-work tasks indicated that, contrary to industry opinion, MSD injuries involving the upper limb are evenly distributed between knife and non-knife arms through both handling the knife and gripping / handling the meat that is being cut.

Table 3.6. Most Common Incidents Listed in NID by Department and Task For Sheep and Beef

Department	*Task*	*Sheep (% of total for sheep)*	*Beef (% of total for beef)*
Boning		1424 (50.6%)	185 (57.4%)
	Knifework	814 (28.9%)	90 (28%)
	Packing	204 (7.3%)	42 (13%)
	Saw operation	104 (3.7%)	-
Slaughter		667 (23.7%)	86 (26.7%)
	Knifework	398 (14.2%)	52 (16%)
	Gutting	71 (2.5%)	7 (2.2%)
	Y cutting	58 (2.1%)	-

These findings are similar to those from the analysis of non-accredited ACC claims where lifting (in this case, packing, saw operation and gutting) and knife-work were the two main activities involved, bearing in mind the small size of the sample of ACC claims with narrative text. More task information can be derived from the NID data than from ACC narrative. However inconsistencies in the information provided for each entry, particularly the amount of detail, make it difficult to reach strong conclusions about specific tasks involved.

3.3.3 Accident Register Survey Data

3.3.3.1 Sample Demographics

Of the 69 plants who agreed to participate in the survey, 29 submitted accident register data for 2004 (42% response rate) for a total of 4028 MSD incidents. This sample of plants represents approximately 39% of the industry workforce (Statistics New Zealand, 2004). The 29 plants (from 13 companies) appear as representative of the industry for plant size and species processed, although the Southland region was under-represented owing mainly to a cluster of one company's plants that contributed their accident data through the NID.

3.3.3.2 Temporal Distribution

The number of incidents occurring in the first five months of the year was 59.7% (n=2404). This is consistent with the figures for both the ACC and NID data and is due to the higher levels of work exposure at this time of the year (longer shifts, less downtime) and the plant shutdowns that occur through the off-season in the second half of the year. Information on severity was provided in only 19% of cases.

3.3.3.3 Body Part Injured

The most common body parts injured were wrist/hand (26.4%), back/spine (22.1%), shoulder (17.1%), arm/elbow (15.5%) and lower limb (8%). In a further 8.9% of cases, the affected body part was not specified. These figures are very similar to the ACC and NID results for body part injured.

3.3.3.4 Department and Task by Species

Beef and sheep were again the two main species involved in the accident register data with sheep providing 44.4% (n=1789) of cases and beef 36% (n=1451). In 16.4% of cases, the species was not specified while veal, venison and pork made up the remaining 3.2%. All of the 4028 entries had information on department, while task data was present in more than 77% of cases. Job title information was only provided in 56% of cases, and of these many used company or plant specific terminology making comparisons difficult. In some instances, job title information was able to be used to clarify the work task. Table 3.7 provides a breakdown of department and the main tasks mentioned for the two major species.

Table 3.7. Accident Register Data by Department and Task for Sheep and Beef

Department	*Tasks*	*Sheep (% of total for species)*	*Beef (% of total for species)*
Boning room		992 (55.5%)	840 (57.9%)
	Boning – knifework & handling meat	300 (16.8%)	291 (20.1%)
	Packing	139 (7.8%)	145 (10%)
	Trimming	-	95 (6.5%)
	Lifting/handling meat & equipment	54 (3%)	73 (5%)
	Saw operation	53 (3%)	-
	Quarter boning	-	29 (2%)
Slaughter floor		546 (30.5%)	496 (34.2%)
	Pelting	46 (2.6%)	-
	Gutting	49 (2.7%)	25 (1.7%)
	Legging	-	31 (2.1%)
	Y cutting	38 (2.1%)	-

Work within the boning and slaughter departments is broken down into a large number of tasks. Most of these do not appear as significant in the accident register data because of the small numbers of injuries involved. Without further information on task prevalence it is not possible to determine how significant they might be. However, some tasks that may be relevant include: cleaning tasks (across a number of departments for both beef and sheep), aitch boning (sheep boning), kidney removal (sheep slaughter), chiller/freezer tasks (all species), offal tasks (sheep and beef slaughter) and maintenance tasks (all species).

Differences in the level of detail provided by plants limited the level of analysis. In addition to the shortcomings already mentioned, 44% of entries had no job title while 23% were without task information. Variations in terminology used by plants to describe department, job title and task also contribute to data analysis constraints.

3.3.4 Health and Safety Staff Questionnaire Data

3.3.4.1 Sample Demographics

The response rate for the questionnaire was higher than for the accident register data, despite it being sent to the same person at each plant. Some plant staff indicated that this was because the questionnaire took less time to complete than preparing accident register records. Of the 77 plants sent the questionnaire, 44 responded (57% response rate), and these represented 19 companies. This included all plants that contributed accident register data, all but one of the plants that contributed NID data and responses from health and safety staff at an additional 7 processing plants. The number of staff that the 44 plants represent is 72% of the total industry workforce. Positions held by the questionnaire respondents included: 17 health and safety managers/officers, 11 production or compliance managers/coordinators, 8 occupational health professionals, 4 plant managers, and 4 personnel managers.

These plants represented the main species processed in New Zealand in rough proportion as follows: 28 involved in processing sheep, 23 involved in processing beef, veal processed by 16 plants, venison 7 and pork 4 plants. Twenty one plants processed single species, the remainder processed between 2 and 4 species. All geographical regions were represented, with most plants located in the main processing regions of Waikato, Hawkes Bay, Canterbury and Otago/Southland. Plant size ranged from employing 16 staff to 2,200 staff in peak season, with an average of 408. A breakdown of staff numbers by gender (for 42 plants who provided data) gave an average of 78% male and 22% female, and approximately matched the ACC data for gender proportions by geographical region. Staff had been involved in the meat industry for an average of 13.8 years (range 6 months - 40 years), with experience in health and safety in meat processing averaging 5.1 years (range 1 month – 10.9 years). Twelve people (27%) had health and safety work experience in other industries.

3.3.4.2 Staff Perceptions of High MSD-risk Tasks

The results most relevant to this study came from the questionnaire respondents' perceptions on tasks most likely to lead to MSD within the industry. Table 3.8 provides a summary of the data for beef, sheep and where multiple species were involved.

Table 3.8. Staff Opinions on Tasks Most Likely to Lead to MSD in Meat Processing

Sheep	*Ranking points*	*Beef*	*Ranking points*	*Multi-species*	*Ranking points*
Boning – knifework	36	Boning – knifework	41	Boning – knifework	33
Boning – handling meat	36	Boning – handling meat	35	Boning – packing	23
Boning – packing	16	Boning – packing	20	Chillers/Freezers	14
Aitch boning	15	Boning quarters	16	Slaughter	30
Slaughter – manual handling	23	Slaughter	15		
Slaughter – knifework	19	Chillers/Freezers	12		

A breakdown of the 173 lines of data by species shows that; 36% (n=62) specified sheep, 27% (n=47) specified beef, 12% (n=21) specified venison, with the remaining 25% comprising more than one species (often beef/veal, sheep/veal or beef/sheep). The boning room was the most commonly mentioned department (51% of responses), with slaughter accounting for a further 26%. The range of tasks was much larger, however many respondents simply mentioned aspects of the work conducted rather than specific work tasks.

Of further interest were the reasons given to explain the inclusion of a task. While aspects of knife use were expected (force, repetition, awkward postures, etc), there were an equal number of statements regarding non-knife hand use and the risks created through gripping, restraining, holding and carrying elements of both knife-related and general handling tasks. This occurred across all species, but particular tasks that were mentioned included: beef boning (gripping, pulling, carrying large cuts), aitch boning in sheep (awkward grip, pulling and carrying meat), sheep gutting (breaking ligaments, lifting and carrying offal), packing (lifting meat cuts). Also of interest were the reasons why the task received the rating. Most of these were less concerned with physical design issues (e.g. heavy lifting, over-reaching, dull knife) than with work organisation issues. This could be a function of the questionnaire sample, in that only people who perceived MSD as a problem worth investigating returned the questionnaire, or the findings may provide an insight into the level of awareness of MSD prevention within the industry as a whole.

3.3.5 MIHSF involvement

A summary of findings from all four data sources was presented at a meeting of the MIHSF. Following discussion and clarification, agreement was then reached among MIHSF members on the tasks that would provide the focus for the next stage of the study. Crucially, the continued support of the MIHSF for the study was also confirmed at the same time.

3.4 Discussion

3.4.1 Key findings

3.4.1.1 ACC claim type and claimant demographics

The majority of MSD compensation cases for the New Zealand meat processing industry for the period of the analysis were of relatively low severity, with about 60% of cases requiring medical visits to the doctor only. Interestingly, just one in five MSD cases for this sector were reported as gradual process injuries, with the majority recorded as sudden onset or soft tissue injuries. This was a lower proportion than expected, given the relentless and repetitive nature of many production line tasks in the industry. However, as many sudden and gradual onset cases share the same risk factors, it is possible that gradual onset cases presented acutely for treatment and were diagnosed and categorised accordingly.

ACC MSD injuries were predominantly incurred by European male or Maori male employees, although this finding is of limited importance as no reliable industry demographic information was available from which to determine the relative exposure of these population groups.

3.4.1.2 Geographical and temporal trends from MSD data

ACC MSD injuries occurred most frequently in the lower South Island region (Canterbury, Otago and Southland) and during first five months of each year. NID and

Accident Register data followed a similar pattern. This is consistent with the proportion of the industry workforce located in these regions (approximately 40%) and the workload peak for sheep which is the predominant species processed at this time.

3.4.1.3 Diagnosis and body part involvement

Diagnosis for the ACC data was less useful than body part, due to the large number of potential diagnoses and a number of cases without any diagnosis at all. With regard to the body part affected, injuries were located in the upper limb in approximately 60% of cases for ACC injury data, with a similar pattern for the NID injury data (62%) and the Accident Register data (59%). The next body part most involved was the spine, however a breakdown by spinal region was not possible within the data. These figures are predictable given the heavy workload on the upper limbs and trunk that occurs in this industry where both arms are used in many tasks for lifting, gripping, pulling or restraining. Additionally, tasks are often knife-based, repetitive, slippery, cold, and the pace of work is usually fixed. An interesting finding from the three data sources where more specific information was available indicated that injuries were as likely to occur in the non-knife hand in knife related tasks. While this has been identified elsewhere (Falck & Aarnio, 1983; Gorsche et al., 1999: Riley, 2001) the assumption made in the industry here is that a sharp knife would reduce MSD risk for both hands. This would appear not to be the case for many non-knife hand injuries where MSD risks are independent of knife activity (e.g. restraining the carcass or meat, handling meat products after the completion of knife activity).

3.4.1.4 Injury severity indicators

A number of variables in the ACC data were found to be significant predictors of greater MSD injury severity, based on compensation claims as opposed to medical fees only as a proxy for severity. Unsurprisingly, gradual process injuries were more likely to be compensation claims, as were being of Maori ethnicity and working in certain geographical regions. According to ACC injury statistics (ACC, 2004b), Maori have historically had a higher injury incidence for entitlement claims compared to other ethnic groups, as is the case with meat processing MSD. It is hypothesised by ACC that a partial reason for this higher incidence rate could be that a larger proportion of Maori work in occupations in which the incidence rate is higher than the average. The number of Maori employed in meat processing is approximately 20%, significantly higher than the number of Maori as a percentage of the total workforce (11%). However, it remains unclear why Maori meat processing workers were over-represented in MSD compensation claims. While it was beyond the scope of the available data, further insight might arise through considering ethnicity employment figures and MSD incidence, by region and by high MSD-risk tasks. It is also unclear why geographical region might be a significant predictor of MSD injury severity.

3.4.1.5 Activity or tasks (by species) most commonly associated with MSD

As ACC data were collected from the entire industry, the two-year dataset provides a good overview of industry demographics and is unlike the other data in this regard. Unfortunately, the lack of task or species detail limits the ability to draw further conclusions from it. The opportunity for useful data from the accident descriptions is wasted, with only 12.6% (and all from smaller plants) providing this information. Its existence is useful, however, as smaller plants were not well represented in the NID data. The Accident Register survey and Health and Safety staff questionnaire provided a more representative sample for the industry overall, including plant size, species processed and geographical region. While the tasks identified from the accident descriptions were only low numbers, there are similarities between these two sources and the NID data. It is also significant to note that these two sources accounted for approximately 72% of the industry workforce.

Among the relatively small number of ACC claims possessing accident descriptions, the most common activity or task at the time of the MSD was reported to be lifting, although lifting injuries were less likely to lead to entitlement claims than non-lifting injuries. Boxes of meat were the most common agency involved in lifting MSD, with other common agencies being meat and animal carcasses.

NID data fields enabled a more specific analysis of where injuries occur. Injury frequency by task provided the most complete and useful information and highlighted a small number of task locations where MSD injuries were more likely to occur. These tasks occurred in the boning and slaughter areas for both beef and sheep, and involved either knife use in the handling of carcasses or meat in both boning and slaughter areas, or simply handling meat products (packing and saw operation in boning, Y-cutting and gutting in slaughter). These findings closely matched those for the Accident Register

Survey, where some tasks were also more prevalent than others in both beef and sheep slaughter departments. The results from the Health and Safety staff questionnaire provided further evidence to support the findings from the national and plant accident data. While inconsistent data fields made it difficult to aggregate findings, the same departments and broad task types were indicated for both sheep and beef.

Triangulation between the four data sources helped to strengthen their merit overall, and highlighted the tasks that are most commonly mentioned in the data. Although there are weaknesses in all four data sources, such as missing or inconsistent data fields and the inability to determine severity or incidence rates, it was known from the outset that this was a likely outcome and the MIHSF were content to focus on the tasks most commonly associated with MSD. It is evident from the MSD data and the industry profile attained during this stage of the study that sheep and beef are the two obvious species to consider, and that within plants processing these, boning and slaughter are the two departments to target. Specific tasks that were most commonly mentioned are stated in Table 3.9.

Table 3.9. Tasks most commonly associated with MSD as presented to the MIHSF

Sheep	*Beef*
Boning - Aitch boning - Packing	Boning - Quarter boning - Packing
Slaughter - Y cutting - Gutting	Slaughter - Gutting

Additional factors which had some bearing on this list of tasks included how many staff were likely to be involved, and whether it was in common practice throughout the industry. Tasks involving fewer staff (e.g. saw operation) or only occurring in some plants (e.g. manual versus machine pelting) were not included. The final number of tasks also reflected the research resources available for the study. A summary of the results from each data source were presented to the MIHSF along with Table 3.9 for their consideration and provided the focus for the next stage of research, involving task assessments on site. Once approval was gained from the MIHSF, a summary of results from this stage of the study was disseminated to contacts at all processing plants and other industry stakeholders (Tappin, Ashby, Bentley, Vitalis, 2005a).

3.4.1.6 Industry liaison

The two main mechanisms for liaison with people in the industry were through the MIHSF and from contacting staff in each of the 81 processing plants. The MIHSF served several purposes during this stage of the study. Firstly, they assisted in disseminating information about the study to the industry – through a press release, providing time at meetings and industry workshops for presentation and discussion, and through their individual network of contacts. Secondly, they were able to provide information on the industry otherwise not publicly available (company and plant specific information) which assisted in creating an accurate and current profile of the industry. Thirdly, they facilitated contact with processing plants under their jurisdiction encouraging their support of the study. Finally, they considered and approved the tasks to be assessed in the next stage of the study. Based on previous experience in the meat processing industry it is considered unlikely that the level of industry access, information and support for the study could have been achieved without their involvement.

Contact with each of the processing plants was also established for several purposes. Initially it served to inform them of the study and invite their participation in it. Secondly, information about each of the processing plants (species processed, FTE, shift/season details, etc) and about sources of injury data other than ACC were able to be gathered. Thirdly, once relationships were built these channels of communication were used to pilot data collection methods and then to collect Accident Register data and questionnaire responses. These relationships supplemented the MIHSF, particularly as smaller plants, geographically isolated plants, or some plants of multi-site companies were not involved directly with the forum and may otherwise not know about the study.

3.4.1.7 Issues for consideration in further research

Issues that were highlighted for further consideration included the need to consider other species processed and which feature in the MSD data. These include venison, which involve less than 10% of the workforce but appear in both the Accident Register data and Questionnaire, veal (bobby calves) which are processed over a short season in 18 beef or sheep plants, and to a lesser extent, pork (processed in only 4 plants). Similarly, tasks other than those highlighted in the study may become prominent as the next stage progresses.

Feedback from the union representative in the MIHSF was to use their contacts and networks more in subsequent stages of the study, for gathering and disseminating information and enabling the involvement of workers on process lines. This was a welcome development as the union is a national body representing all unionised meat workers (more than 98% of the workforce), and holds the power to allow or deny access to workers on the floor. Thus there are two gatekeepers to the industry: the company and plant management, and the Meatworkers Union. The support of both groups was achieved through involvement of the MIHSF.

3.4.2 Limitations of the study

Although the findings of this study provide a rich insight into the incidence and causes of MSD in New Zealand, a more comprehensive insight was constrained by the incompleteness of the data available to the researchers and by some weaknesses in the methodology applied.

3.4.2.1 Weaknesses in the data

A major limitation of using the ACC data, which also applies to the other data sources, is that incidence rates cannot be determined without workforce and exposure information. Thus, tasks with high incidence of injury cannot be identified. Furthermore, the absence of actual injury cost creates a risk of focusing on the wrong tasks. Other limitations of the ACC dataset include: not having narrative text descriptions for a larger sample of ACC claims from which to draw stronger conclusions and the risk of bias as claims with narrative were predominantly from smaller companies, and finally, inconsistencies in the coding by ACC of diagnoses and body parts leading to a larger number of unusable claims. Potential confounding factors of ACC data may include: incomplete or inaccurate injury data (through the injured person, the health professional or the data entry operator); the effect of treatment claims that continue on to also become entitlement claims; and targeting diagnoses/symptoms that are difficult to refute or will increase the chance of the claim being accepted by

ACC. Finally, the sample of claims for the logistic regression analysis was only 69% of the total dataset. What effect this had on the findings from it is unknown.

The most significant limitations of the NID dataset, other than the inability to determine incidence, were the lack of data fields for age, gender, and ethnicity, and the number of unspecified entries for task, department and species. Differences in data field interpretation by the plants also resulted in ambiguity and repetition of information, leading to many records being left out of any analysis. Data from the NID is also not an accurate representation of the industry, either by company, species or region.

Similar issues affected the accident register data, with variations between plants in both terminology and the type of data collected making data comparison difficult. Some fields were also missing (e.g. species, task) from otherwise complete data sets. Both of these factors limited the analysis that could be conducted with the data. For both the NID and accident register records, the stated task is no guarantee that this had anything to do with the injury given the gradual onset of many MSD and variations in data capture practice between plants.

For the health and safety staff questionnaire, limitations related to the unknown nature of any biases affecting which high MSD-risk tasks are listed and in which order. This bias was further amplified because a small amount of aggregation was necessary to make use of the data.

3.4.2.2 Methodological weaknesses

The main weakness of this stage of the study was its standing start and short timeframe, a problem common to many research projects in New Zealand. This lack of momentum quickly became apparent, and was exacerbated by being an industry that has 'MSD fatigue' and is cautious about allowing access to outsiders. Thus, there was initial reliance on the MIHSF and the goodwill of people to be involved, with no tangible incentive for their efforts. Ideally a more collaborative and pre-emptive approach between funders, industry and researchers would have helped to create support and raise understanding of study before asking for any data. This may have improved response rates for the accident register survey and questionnaire. A further barrier to progressing with the study was the limited availability of people in industry through seasonal workload peaks, infrequent industry meetings, and large distances between plants in different regions.

Despite thorough evaluation and piloting of the questionnaire, there were modifications which may have improved the usefulness of some responses such as: better clarification of what was meant by the term ‘task’, and better distinguishing between what was happening in their plant, and their opinions on MSD in the industry.

3.5 Conclusions

The two main objectives of this stage were to identify patterns and trends in MSD in the meat processing industry, and to identify high MSD-risk tasks and processes on which to focus attention in further stages of the study.

The use of the four data sources, including primary and secondary data, provided a better overview of the industry than previously available. Each data source complemented the other, providing qualitative and quantitative information at national and plant levels. ACC injury data claims indicated factors for further assessment, including consideration of claimants’ gender, ethnicity and geographical region. NID industry data claims helped to identify specific tasks in which MSD are more likely to occur for the main animal species processed. Accident register data and questionnaire responses provided species, department and task data from a wider range of companies and plants.

Predictably, there were weaknesses and inconsistencies in all four data sources, which made it more difficult to draw conclusions from them. There were also limitations in the methodology, which affected the validity of results. However, these are also the only injury data sources available concerning the New Zealand meat processing industry, and this is the only study that has drawn on all these converging sources.

An important part of this study was to establish contacts and dialogue throughout the industry to inform them of the study and encourage their participation. The MIHSF was the primary means of achieving this. The approval of the MIHSF for the priority tasks is also an endorsement of the process followed in the study.

Based on the triangulated findings of this study, a number of priority areas for more focused ergonomics research were identified for beef and sheep processing. These included specific tasks in boning and slaughter departments that featured prominently in data sources and involved significant musculoskeletal stress to the back, arm and wrist areas; and involved lifting/handling activities, particularly meat and packed boxes. These high risk tasks provided a consistent focus for the site visits (see Chapter 4), and their evaluation was achievable within the available resources of both the researcher and the host plants.

The following chapter reports on task-centred and task-independent data on MSD risk factors arising from a representative sample of meat processing plants, and proposes a conceptual model for the development of MSD in this industry.

Chapter 4. Industry-based assessment of MSD risk factors

4.1 Introduction

4.1.1 Background

Stage one of the study established a profile of MSD injury across the industry, identified high MSD-risk tasks in beef and sheep processing, and engaged industry stakeholders in the research process. This chapter reports findings from the second stage of the study. It describes the steps followed in assessing these tasks in a representative sample of processing plants, with the purpose of identifying risk factors that contribute to the occurrence of MSD. These are separated into those concerning the high MSD-risk tasks (task-specific), and the wider work system (task-independent).

The assessment of high MSD-risk tasks was initially seen as a means of providing a consistent focus for the site visits, for engaging widely with industry staff and plants, and for managing the allocation of study resources across the sample of plants. Targeting these tasks also made sense to the MIHSF and others from industry. While some MSD risk factors arose that were task-specific, a far larger number of task-independent factors were identified concerning both high-risk tasks and the wider work system (e.g. task training, shift design). In addition, many task-independent MSD risk factors involving industry-level issues were found to be present across the sample of plants (e.g. staff retention and replacement).

Although the range of risk factors for work-related MSD is well recognised (Bernard, 1997; NRC-IOM, 2001; Bongers, de Winter, Kompier, Hildebrandt, 1993), much of the emphasis of epidemiological, medical and ergonomics research has highlighted the role of physical, psychosocial and individual factors, while the organisational and contextual factors that underlie them have not received the same level of attention (NRC-IOM, 2001; Warren, 2001; Buckle, 2005). NRC-IOM (2001) describe the association between physical exposure and the development of MSD as occurring "…in a broad context of economic and cultural factors and reflects the interaction of elements intrinsic to, as well as extrinsic to, the individual." (p.28). The authors included these factors in a conceptual model for the development of MSD and used the term ‘contextual factors’ to refer to the social, economic, cultural, political and organisational factors that are seen as creating the conditions under which physical and psychosocial risk factors can occur. These contextual factors include forces that are external to the industry but which act on it (e.g. the effects of drought or low national unemployment), and which in turn may influence the structure or management of the industry and organisations within it (e.g. systems of payment or length of the working week). These may then result in the occurrence of commonly accepted risk factors for individual workers on the production line (e.g. static postures, repetition, monotony, low autonomy, etc).

In this chapter it is argued that a broader range of MSD risk factors can be identified within meat processing than has been thus far considered, that these contextual factors are latent conditions for MSD in the industry, and that this approach is consistent with existing theoretical frameworks for MSD causation (NRC-IOM, 2001; Karsh, 2006).[7] The causal mechanisms that linked contextual, physical and psychosocial factors to the onset of injury were not a concern for the study, although the inter-relationships between contributory factors was important.

4.1.2 Aims of this chapter

1. To identify risk factors for the high MSD-risk tasks identified in chapter 3.
2. To identify contextual factors leading to MSD risk in the industry.
3. To identify any issues for consideration in further research.

Despite the reduced involvement with the MIHSF in this part of the study, the intention was to continue to provide information on MSD and the study, as well as to build relationships with the MIHSF, its individual members, and staff at the sample of plants.

[7] The findings from this chapter relating to contextual factors for MSD in meat processing have been published in Ergonomics (Tappin, Bentley, & Vitalis, 2008).

4.2 Methods

4.2.1 Introduction

This qualitative study followed an exploratory approach, as no previous research had fully examined MSD risks using a systems approach across a representative sample of meat processing plants. Further, the role of contextual MSD risk factors in this industry had not been considered, and only anecdotal information on these risk factors was available to researchers prior to the study.

As with the initial engagement of the industry, credibility was an important factor in determining sample size and methodology. For the industry to consider implementing findings from this research, it required that the study was considered to be representative of the industry, and that there was ownership of the interventions by the industry. The first of these requirements is covered in this chapter. It was achieved through discussion with the MIHSF that indicated that the sample of plants needed to be representative of: geographical region, company, species processed and plant size. A further essential element was the support of the national union who, as part of the MIHSF, ensured that plant delegates also provided support for the researchers during the data collection process.

Assessment methods applied during the plant visits were chosen to provide the most useful information on MSD risk factors and interventions, taking into account the constraints of time and accessibility to processing line staff and management. The primary emphasis was therefore on collecting information and opinions from as many staff as possible about the nature of their work and the MSD risks inherent in it, including any variations that occurred throughout the processing season and under different operating conditions. Data collection was divided between task-specific (focused on high MSD-risk tasks in chapter 3) and task-independent (focusing on risk factors affecting a wider range of tasks). While postural and physical measurements were also collected, it was recognised that these findings were likely to be less useful as they only measured physical presentation of risk on one element of the tasks at that moment in time.

Data from the task assessments, along with relevant findings from the health and safety staff questionnaire conducted in stage 1 (refer to Appendix 3), were sorted into themes and collated. Information from the literature also contributed to this content analysis process. Figure 4.1 presents an overview of the methods used in this stage of the study.

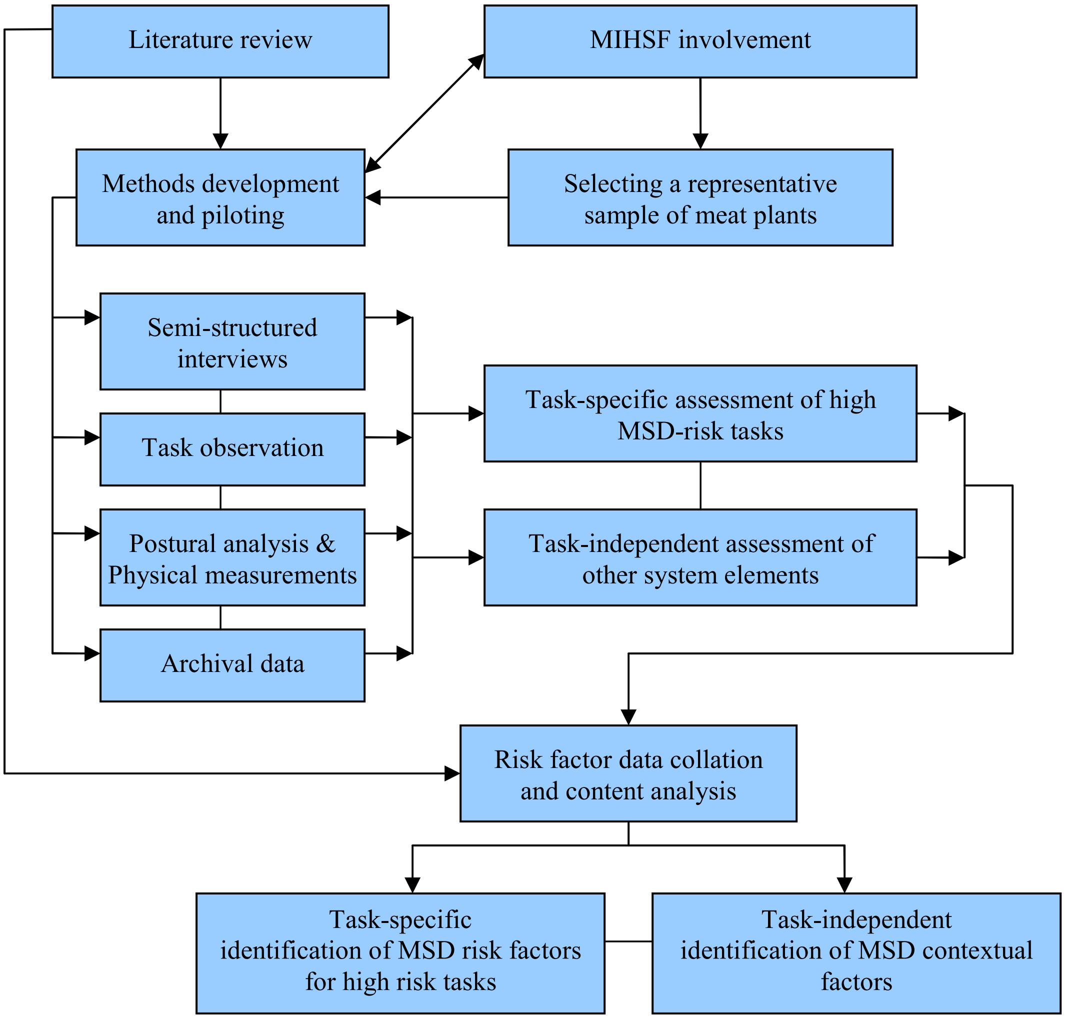

Figure 4.1. Methods used in identifying meat processing MSD risk factors

4.2.2 Meat Industry Health and Safety Forum Involvement

While the collection and summary of data on MSD risk factors did not directly involve them as a group, the MIHSF continued to provide support to the study through facilitating plant and union support for the site visits. The researcher also provided presentations to MIHSF national workshops and regional meetings on findings from the study and on preventing MSD. Individual MIHSF members also continued to be involved in piloting assessment methods.

4.2.3 Selecting the sample of plants

The decision was made to include one third of all 77[8] processing plants in this stage of the study. This was based on feedback from MIHSF members and other stakeholders in the industry regarding representation and perceived credibility of the process by the industry. Calculation of the number of plants required to adequately account for region, company, species processed and plant size, while also working within time and cost constraints of the study also indicated that a sample of this size would be required. Consultation with a statistician also supported this approach, given the large number of variables affecting the sample. Additionally, the existence of any contextual factors for MSD would become more evident with a larger sample size. The sample was therefore selected to include plants processing beef (10), sheep (10), veal (3), venison (2) and pork (1).

To achieve the required representation while also ensuring a quasi-random selection process, beef and sheep plants were first grouped by region and ranked according to the number of plants, FTE, and percentage of ACC claims per region. Adjoining regions with fewer than three plants were combined. The number of plants to be involved per region was then based on the overall ranking of regions from the total of these three criteria as illustrated in Table 4.1. The decision to first group plants by region as opposed to company or plant size was made because this would more adequately account for national variations in species processed and was seen by industry stakeholders as a preferred method of achieving a representative sample.

Plants were then randomly selected from a list for each region. At this point a check was made to ensure that the sample provided a sufficient spread of plant sizes (i.e. not all very small or very large), companies (i.e. not all from one organisation), included a mix of plants that processed both single and multiple species, and was logistically feasible. These plants were then contacted to establish their willingness to be involved. Where plants declined involvement or the plant had closed, another plant was randomly selected from that region (or from the next ranked region if no further plants existed) until the sample was filled (n=3). This was essentially a convenience sample that

[8] At the end of stage one the number of plants processing meat was revised from 81 to 77, excluding four plants involved exclusively in hide and fleece treatment (tanning, scouring).

reflected logistic and cost considerations associated with extensive travel to distant parts of the country, and in some cases, willingness of companies and individual plants to be involved in the study.

Table 4.1. Criteria for selecting the sample of beef and sheep plants

Region	*Species*	*Plants by region**		*FTE by region**		*ACC MSD claims by region*		*Total ranking points*	*Overall ranking by region*	*Number of plants in the sample*
		n	*ranking*	*n*	*ranking*	*%*	*ranking*			
Northland/Auckland	All	4		1025		6.1				
	Beef	4	4=	1025	7		7	18	7th	1
	Sheep	3	6=	795	6		7	19	7th	1
Waikato	All	13		2674		11.3				
	Beef	8	1	2081	3		5	8	2nd	2
	Sheep	6	3=	771	7		5	15	5th	1
Bay of Plenty		3		665		4.2				
	Beef	1	10	570	9		9	28	10th	-
	Sheep	1	10	570	8		9	27	9th=	-
Gisborne/ Hawkes Bay	All	11		4228		13.1				
	Beef	2	7=	1220	6		3	16	6th	1
	Sheep	9	2	3608	2		3	7	3rd	1
Manawatu/Wanganui/ Wellington	All	8		3116		9.5				
	Beef	6	3	2245	1		6	10	3rd	1
	Sheep	4	5	1886	5		6	16	6th	1
Taranaki	All	5	5	1373		4.3				
	Beef	2	7=	962	8		8	23	8th	1
	Sheep	2	8=	305	10		8	26	8th	1
Nelson/Marlborough/ West Coast	All	4		534		2.9				
	Beef	2	7=	282	10		10	27	9th	-
	Sheep	2	8=	350	9		10	27	9th=	-
Canterbury	All	14		3678		19.1				
	Beef	7	2	2185	2		1	5	1st	2
	Sheep	10	1	3254	3		1	5	1st	2
Otago	All	6		2782		12.7				
	Beef	4	4=	2032	4		4	12	4th	1
	Sheep	3	6=	1992	4		4	14	4th	1
Southland	All	9		4786		16.6				
	Beef	3	6	1983	5		2	13	5th	1
	Sheep	6	3=	4652	1		2	6	2nd	2
Totals	All	77		24861		99.8				20

(* These columns include figures for plants processing beef or sheep. Totals for all plants per region are different from the total for beef and sheep as many plants process more than one species, and exact FTE numbers by species processed for each plant are not available.)

A different process was used for selecting the veal, venison and pork plants as there were fewer plants available to choose from, involving fewer regions. In many cases, processing of these species is a secondary activity, with the exception of venison where nine of the fifteen plants involved process deer exclusively. Approximately 15% of plants processing these three species were included in the study, equating to three veal, two venison and one pork processing plant. Two of the veal processing plants were chosen for the pilot process, while the remaining four plants were randomly selected from a list of plants with the requirement that they represented different regions and different companies and both the North and South Islands to counter concerns of bias (refer to Table 4.2). No reselection of plants declining to be involved was required. Veal processing was included in the study as it is generally considered a high MSD-risk event, mainly due to the difficulties in staffing, training and scheduling of work over the intensive 6-8 week annual season when all juvenile veal is processed. Venison and pork are the two other most commonly processed species after sheep, beef and veal. Some plants also process other species (e.g. goats, horses, ostriches, and emu), however these are only very small volumes not warranting inclusion in the plant sample. Site visits were arranged through the company health and safety manager and the person on site responsible for managing health and safety (the job title of this person varied depending on plant/company size). High-risk tasks for the species being processed, identified in chapter 3, provided a consistent initial focus for each visit.

Table 4.2. Selection of sample veal, venison and pork processing plants

Region	*Plants processing veal*		*Sample plants*	*Plants processing venison*		*Sample plants*	*Plants processing pork*		*Sample plant*
	n	*FTE*		*n*	*FTE*		*n*	*FTE*	
Northland/Auckland	1	374		-	-		-	-	
Waikato	5	1275	1	1	43		2	575	
Bay of Plenty	1	570	1	2	104	1	-	-	
Gisborne/Hawkes Bay	3	1337		2	330		2	90	
Manawatu/Wanganui/Wellington	2	1577		2	241		1	165	1
Taranaki	2	661		1	8		1	25	
Nelson/Marlborough/West Coast	2	248	1	1	50		-	-	
Canterbury	4	1860		2	338	1	2	338	
Otago	1	1003		2	235		-	-	
Southland	2	400		2	84		-	-	
Totals	23	9305	3	15	1433	2	8	1193	1

4.2.4 Selecting and piloting assessment methods

The selection of assessment methods for the task assessments on plants was a compromise between what would yield the most useful data on MSD, what would be practical in the challenging work environment, and what would be acceptable to those involved. Most importantly, the assessment of the high MSD-risk tasks needed to encompass all elements of the work system within which they occurred for identifying the presence of physical, psychosocial, organisational and other contextual factors. There is support from the literature for such an approach in the quest for addressing MSD with a range of interventions aimed at addressing this broad scope of risk factors (NRC-IOM, 2001; Silverstein & Clark, 2004; Buckle, 2005; Marras et al., 2009).

Prior knowledge of the meat processing work environments gave some insight into what methods would be appropriate to use on the plants. The most significant restriction was that of time, as the processing line continues relentlessly and trained replacement staff that enable participants to step off-line are often limited. A further constraint was the effect of high noise levels, and accompanying hearing protection, both limiting conversation and privacy, particularly in situations where participants are unable to leave the processing line. Limited space available for observing and recording data or interviewing staff (without getting in the way or risking accidental injury from other staff, machinery or carcasses) can also impact negatively on privacy and therefore on data quality as well. Hygiene compliance requirements can also affect what data are collected. Most plants do not allow any equipment into the processing areas for fear of product contamination; reflected in the fact that the protective clothing provided often has no pockets. For the same reason, task participation opportunities are minimal. Protective clothing worn in the processing areas serve as barriers against injury and zoonotic disease, but also verbal communication (ear plugs, face and beard masks). Hygiene standards can also affect the location and length of the semi-structured interviews as people in most tasks are unable to move out of the work area without first undergoing a decontamination and washing process.

Task analyses of the high MSD-risk tasks were considered, but not conducted due to variations in the high MSD-risk tasks between plants. Task descriptions were developed instead which included the most common task variations (section 4.3.2).

Acceptability of assessment methods by the MIHSF and other industry stakeholders centred around four requirements. Firstly, that our presence did not adversely affect productivity on the processing line or personal earnings in the case of piece rate payment. Secondly, that confidentiality of both of the plant and the participants was maintained. Thirdly, that hygiene compliance requirements were not compromised, and finally, that our involvement did not set unrealistic expectations for the participants or the plants.

The combination of all these factors resulted in several iterations of site schedules and data collection forms. Deciding on the site schedules was more straightforward given the finite resources available and the known locations of the plants. Importantly, the methods needed to be achievable by one researcher. Once the researcher was at the plant, the amount of time required to collect the data was less of an issue than being able to collect it single-handedly. A structured interview schedule was initially considered for the interviews, as this would enable easier comparison of the responses. However this was changed in favour of a semi-structured interview format due to: the complexity of the information involved, the predicted levels of emotion attached to MSD, and the wide range of views on the topic (Sinclair, 2005). Additionally, a less formal interview process would be consistent with the manner and expectations of most participants and would better match the environmental conditions in which they were to take place (wet, contaminants, restricted space, high noise levels). Using interviews also removed the barrier of literacy, an issue raised by some industry stakeholders and known to be a significant issue in many companies. For the same reasons approval was sought and gained from the ethics committee to reduce the information sheet from two pages down to one page in length (Appendix 2).

Simple forms were used for collecting archival and establishment data from each plant, as well as recording raw events and task cycle times during periods of observation. Established postural analysis tools were also available when required. These data sources were collected to help triangulate findings from the semi-structured interviews. Initial intentions to collect photos and video footage were abandoned due to plant concerns over confidentiality and hygiene. As outlined by David (2005), the methods chosen provided the best match between the requirements of the study, the preferences of the host plants and the finite resources of the study.

Members of the research team along with two members of the MIHSF evaluated draft assessment forms and interview schedules. Once changes were made, the forms and the assessment process were piloted at three meat processing plants. The three plants were selected based on the support of the plant health and safety staff and geographical convenience. The pilot process included evaluation of the forms, the order and timing of events on site and the collation of the data collected. Minor changes were made to the forms and the data collection process to make the most efficient use of the time on plant as well as time spent collating and analysing data. A checklist was developed for organising plant visits and ensuring a consistent process was applied (Appendix 4). As part of the ethical approval process, information sheets and consent forms were available for all plant staff involved in the assessment process (Appendix 1). A total of 250 hours of on-site analysis was undertaken across the study sample. Additional visits were made to a further six processing plants prior to and during the early stages of the task assessments to increase understanding of the industry, and to discuss and test assessment methods.

4.2.5 Semi-structured interviews

Semi-structured interviews were conducted with plant staff including: those engaged on high MSD-risk tasks, other staff working in related tasks (e.g. up and down stream, or part of the same task rotation group), supervisors, health and safety staff, union officials, and managers. Interviews lasted between ten and ninety minutes, and were conducted in a range of settings, including the production floor, 'smoko' (lunch) room, and offices alongside the processing areas. Principles of exploratory interviews from Oppenheim (1992) informed the development process.

The semi-structured interview schedule consisted of nine questions, related to their current place of employment, covering: high MSD-risk tasks, MSD risk factors, MSD interventions, their success and implementation barriers. When asked about MSD risk, no prompts were provided to elicit specific MSD risk factors. Follow up questions about risk factors helped establish links between contextual and physical risk factors. For example, high levels of task repetition were due to job specialization, which was contributed to by barriers to job rotation or enlargement. The nine semi-structured interview questions are included in Appendix 5.

4.2.6 Observation data

Observation data were recorded for each high MSD-risk task at the 22 beef and sheep processing plants and involved as many staff as possible in the time available. Recorded data included the grade of animal observed, average task cycle/recovery time, rotation positions and duration, as well as any observed MSD risk factors. The length of time spent observing varied between plants, depending on production, product variations, the number of staff involved, and plant accessibility. Further questions were also asked of staff during this time to clarify task variations and techniques and establish the significance of potential risk MSD risk factors observed. In some plants researchers were also able to participate in packing tasks for brief periods to provide some understanding of task requirements and team dynamics.

4.2.7 Postural analysis and physical measurements of high MSD-risk tasks

Selection of the postural analysis methods was informed by the specific requirements for method suitability outlined in section 4.2.4, as well as the literature on assessing physical exposure to MSD. In a critical review on the topic, Li and Buckle (1999) noted some shortcomings of these techniques. For example, there can be difficulties in determining the weighting of risk variables, safe exposure levels, and the effects of interactions between risk factors. This can make the score systems of some postural analysis methods hard to apply to tasks outside the system for which they were designed. As Li and Buckle (1999) state, "It is difficult (or even impossible) to determine whether these score systems are 'true' or 'correct', and equally difficult to determine whether they are 'untrue' or 'incorrect' (p. 687). Hagberg et al. (1995) also state that the size of the risk factor and interactions among risk factors may influence the level of exposure in a task, and that these aspects may not be visible to the observer using observational methods. Corlett (1995) also referred to this in suggesting that as the interactions of seemingly disparate components become recognised as contributory then their measurement becomes necessary.

Two postural analysis tools were chosen. The Rapid Upper Limb Assessment (RULA) (McAtamney & Corlett, 1993) was selected as it includes consideration of fixed postures and repetitive movements; both common in the meat processing tasks concerned. It also has some validation through studies in manufacturing, VDU tasks, and office-based tasks (Hignett & McAtamney, 2006). The second tool was the Manual

Handling Risk Score from the NZ Manual Handling Code of Practice (ACC, 2001), which is the document used by government agencies in assessing and advising workplaces on MSD.

These two tools were applied to one person involved in each of the high MSD-risk tasks at the 22 beef and sheep processing plants. Only certain elements of the high MSD-risk tasks were assessed as measuring all elements of the high MSD-risk tasks, or involving more than one person, was not considered feasible within the time available and was seen as a lower priority than interviewing further people. Two factors determined which task elements were measured: whether they were likely to be common across the plant sample, and which task(s) were available on the day(s) of the plant visit.

The intended purpose of the postural analysis was to quantify the degree of MSD risk associated with each task and compare this across the sample of plants. Like observation data, however, postural analysis measurement does not account for many work system characteristics or variations that can occur among plants. Dempsey and Mathiassen (2006) also recognised this and argued that "the real issue may be that too much is expected of these tools." (p. 38). They are more a measurement of risk for the person involved in the task at that time, than a measure of actual task risk.

Although all plants carried out the high risk tasks, their method of doing so varied significantly. This rendered the findings little more than a snapshot of physical MSD risks that were present in one element of the tasks at that moment in time, and restricted any meaningful conclusions being drawn from the findings or comparison between plants. Indeed, the identification and prioritisation of subtasks is recognised as a limitation of observation-based postural analysis methods (Li & Buckle, 1999). Measurements of relevant workplace dimensions, weights or forces were also collected where possible.

4.2.8 Archival data collection

Archival data were collected from each plant and included factual information about the plant (e.g. shift structure, seniority) and management practices (e.g. training, staffing ratios, operating procedures). These data improved the accuracy of information on the sample of plants and the high risk tasks involved. It also helped with understanding of company and regional variations in such matters as employment conditions (e.g. season, shifts, recruitment, training, remuneration), work practices and production (e.g. specifications, tallies, compliance) as well as some information on more sensitive management practices such as succession planning, change management and injury prevention. Archival data also enabled corroboration of participants' comments, researchers' observed/measured findings and task descriptions.

4.2.9 Risk factor data collation and content analysis

Risk factor data were summarised and then collated into groups to make sense of the large amount collected. For contextual factors, qualititative thematic content analysis was conducted on the data collected. The interview notes, together with other data collected on site, were organised into various themes that gradually emerged from the data collected across the sample of processing plants. Internal validity was reinforced with direct quotes from a range of participants to support key points. This list of themes was revised and expanded based on new information derived as the study progressed, and as more site assessments were undertaken.

Once all site assessments were completed, the process of organising the responses on MSD risk factors was revisited. Two lists were created: the first including a list of risk factors under 28 headings, and the second a summary of the contextual factors under a list of nine themes. The criteria for establishing the list of contextual factors included the number of plants at which it was raised, and the number of staff who raised it. One exception to this was economic contextual factors. These were less often mentioned in the interviews but were documented in industry reports, are widely recognised by the industry as potential business threats (e.g. high exchange rates, low unemployment) and are therefore logically linked to increased MSD risk.

The findings were triangulated with the literature on MSD risk factors and expert opinion of the researcher based on knowledge of the industry, to ensure that each factor merited its inclusion. This information was combined with other findings from this stage of the study to produce a draft document on key risk factors, intervention strategies, and implementation barriers. This was developed with the MIHSF, who provided input to help interpret and contextualise the information gathered, thereby further adding to the validity of the findings.

The high-risk tasks provided a consistent focus for engaging with people at each of the plants, and acted as the vehicle through which work system and higher-level contextual factors could be identified. The data collection process highlighted that while there are some task-specific issues concerning physical design and layout, many of the MSD risks faced in the high-risk tasks are most likely to be common to all meat processing tasks. Therefore, it is with contextual factors that most emphasis in the analysis lies.

4.3 Results and Discussion

4.3.1 Characteristics of plants and respondents surveyed

Task-specific and task-independent data collection was conducted in 28 processing plants over an eight month period (August 2005 – April 2006), timed to coincide with peak season processing for veal (July-September) and sheep (December-March), while also avoiding long seasonal shutdowns that occur in many plants (from 2-6 months between May-November). As stated above, the decision to sample widely from processing plants was vindicated by the high level of industry acceptance, being exposed to a wide range of variations in some tasks (e.g. beef gutting, packing), and being able to identify MSD risk factors present across the industry.

Some variations occurred between the number and location of proposed and actual sample plants. In three cases this was due to plants not processing the target species at the time of the visit or because of plant industrial action and required a reselection of plants. The decision was also made to involve a further two sheep processing plants in Southland and Hawkes Bay to reflect the large numbers of people employed in sheep processing in these two regions. The final sample therefore comprised plants processing: sheep (12), beef (10), veal (3), venison (2), pork (1). This sample of plants represented 15 of the 31 companies working in the industry at the time, and just over one-third of the total number of processing plants nationally. Fourteen plants processed single species, the remaining 14 plants processed 2 or more species. Plant sizes ranged from the smallest with 30 processing staff up to 2200 staff (at peak season). The total number of processing staff in the plant sample was 13279 or approximately 53% of the total FTE involved in the industry. Table 4.3 provides further details on the sample of plants involved while Figure 4.2 illustrates where in New Zealand they are located.

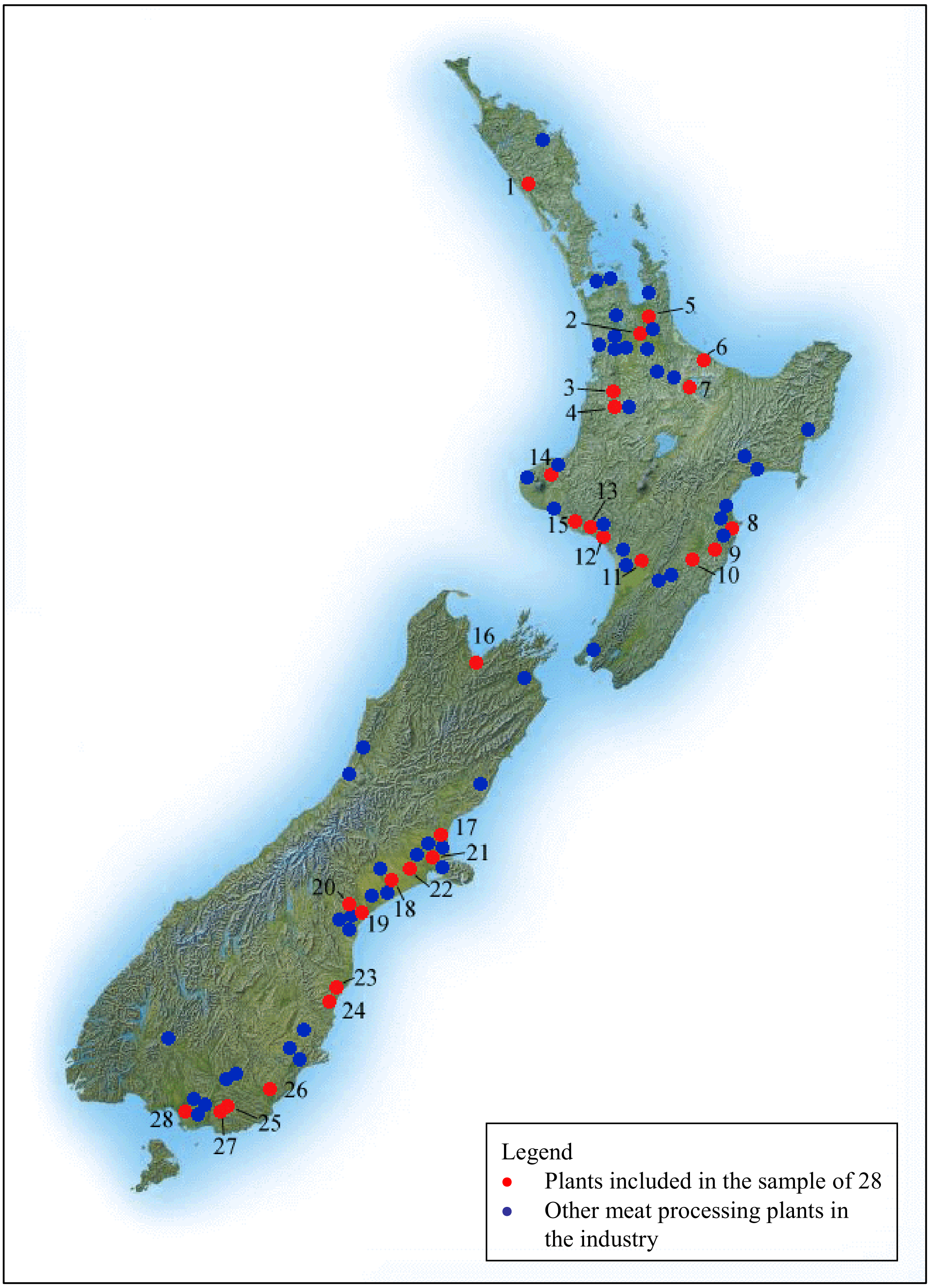

Figure 4.2. Location of meat processing plants

Having been made aware of the study and the visit to their plant through the union and company management, almost all staff approached were willing to be involved in the assessment process. There was some inconsistency between plants in the number and nature of staff interviews and physical risk factor assessments, due to plant and production variations across the sample, limited workspace in some work situations, and restricted availability of staff through leave, training or production pressures.

Table 4.3. Characteristics of the surveyed plants

Plants by region and species assessed	*Company*	*Other species processed at the plant*	*FTE (max)*	*Proposed plant sample*	*Actual plant sample*
Northland/Auckland				1 beef 1 sheep	1 beef
1 Beef	a	-	240		
Waikato				2 beef 1 sheep 1 veal	2 beef 1 sheep 1 veal
2 Beef	a	-	370		
3 Beef	l	-	220		
4 Sheep	m	veal	200		
5 Veal	a	-	300		
Bay of Plenty				1 veal 1 venison	1 veal 1 venison
6 Veal	b	beef, sheep	570		
7 Venison	e	-	47		
Gisborne/Hawkes Bay				1 beef 1 sheep	1 beef 2 sheep
8 Beef	a	-	620		
9 Sheep	g, h	-	550		
10 Sheep	a	-	1100		
Manawatu/Wanganui/ Wellington				1 beef 1 sheep 1 pork	1 beef 1 sheep 1 pork
11 Beef	b	-	280		
12 Sheep	b	veal	730		
13 Pork	f	beef, sheep	165		
Taranaki				1 beef 1 sheep	1 beef 1 sheep
14 Beef	n	veal	570		
15 Sheep	a	veal, goats	280		
Nelson/Marlb/W.Coast				1 veal	1 veal
16 Veal	c	sheep	200		
Canterbury				2 beef 2 sheep 1 venison	3 beef 2 sheep 1 venison
17 Beef	a	-	175		
18 Beef	d	sheep, veal	700		
19 Beef	j, k	sheep	96		
20 Sheep	a	-	520		
21 Sheep	d	beef, veal	700		
22 Venison	o	-	30		
Otago				1 beef 1 sheep	2 sheep
23 Sheep	c	beef, veal	880		
24 Sheep	i	-	86		
Southland				1 beef 2 sheep	1 beef 3 sheep
25 Beef	c	sheep	1100		
26 Sheep	a	beef	1050		
27 Sheep	c	beef	1100		
28 Sheep	c	-	2200		
Totals	a=9 of a total 23 plants b=3 of a total 7 plants c=5 of a total 8 plants d=2 of a total 6 plants e-o=9 of a total 33 plants		13279 (53%) of the industry FTE		

Some 237 staff across the 28 plants were interviewed, including 69 managers and supervisors, 134 process staff and union representatives (employed in slaughter, boning, packing) and 34 people employed in health and safety. This equates to approximately 1% of the total industry workforce. Table 4.4 provides a breakdown of staff designations by plant and species for the plants involved.

Table 4.4. Job titles of staff interviewed by region and species

Plants by region and species assessed	*Managers & Supervisors*			*Processing staff & union reps*			*Health & Safety staff*			*No. of staff interviewed*
	Beef	*Sheep*	*Other*	*Beef*	*Sheep*	*Other*	*Beef*	*Sheep*	*Other*	
Northland/Auckland										
1 Beef	2			3			1			6
Waikato										
2 Beef	1			4			1			6
3 Beef	1			2			-			3
4 Sheep		6			2			-		8
5 Veal			4			-			3	7
Bay of Plenty										
6 Veal			4			3			1	8
7 Venison			1			4			-	5
Gisborne/Hawkes Bay										
8 Beef	4			7			1			12
9 Sheep		6			9			1		16
10 Sheep		5			10			1		16
Manaw./Wang./Well.										
11 Beef	2			2			1			5
12 Sheep		2			6			2		10
13 Pork			1			2			1	4
Taranaki										
14 Beef	-			3			1			4
15 Sheep		1			5			1		7
Nels./Marlb./W.Coast										
16 Veal			1			3			1	5
Canterbury										
17 Beef	2			9			1			12
18 Beef	1			8			1			10
19 Beef	2			1			1			4
20 Sheep		-			8			1		9
21 Sheep		3			6			1		10
22 Venison			3			-			-	3
Otago										
23 Sheep		3			12			2		17
24 Sheep		4			1			-		5
Southland										
25 Beef	2			4			2			8
26 Sheep		3			5			3		11
27 Sheep		3			4			2		9
28 Sheep		2			11			4		17
Totals	17	38	14	43	79	12	10	18	6	237

The number of staff interviewed for each species is included in Table 4.5 and shows that a greater number of staff were interviewed in sheep processing compared to beef processing and other species. The two extra sheep processing plants included in the sample and the additional high risk task account for most of this difference. Other significant reasons are that sheep processing plants generally have higher numbers of staff and shifts but a shorter processing season than beef, and the targeted tasks having larger numbers of staff involved compared with beef – a function of a smaller number of much larger carcasses. The average number of hours spent on plant shows a much smaller difference between the two main species.

Table 4.5. Staff interviewed and time on plant by species

Species	*Managers & Supervisors*	*Processing staff and union reps*	*Health & Safety staff*	*Total staff interviewed by species*	*Average number of staff interviewed*	*Average time spent on plant (hours)*
Beef	17	43	10	70	7	8.5
Sheep	38	79	18	135	11	10.5
Other	14	12	6	32	6	6
Total	69	134	34	237	8.5	9

4.3.2 Task descriptions for high MSD-risk tasks

These descriptions are derived primarily from archival data, semi-structured interviews and task observation data collected from the 22 sheep and beef processing plants. They are included to give context to the findings from this chapter as well as the interventions discussed in chapter 5.

Y cutting (sheep)

The Y cut occurs near the beginning of the slaughter chain and is the first step in removing the pelt from the carcass. With the carcass suspended by all four legs and presented head first, the butcher makes incisions from the brisket (sternum) up both front legs before flaying to dress the pelt around the brisket. Butchers must wash their hands and knife between carcasses. ‘Socking’ (cutting the fleece around the front feet), freeing the pelt from the brisket (manually or mechanically) and further flaying of the pelt around the shoulders are other elements that can be part of the Y cut task. There are many variations between plants in how this task is managed (e.g. each butcher taking one carcass and completing the task or each butcher conducting one element of the task) and which elements are performed by butchers or labourers. Y cutting is an exacting task and requires a high level of skill to avoid contamination from the pelt and knife damage of the carcass, while also keeping pace with the moving chain. The task pace is relentless, leaving no room for mistakes or for their correction.

Sheep gutting

Gutting occurs after removal of the pelt, head and hooves and is one of a number of tasks concerned with eviscerating the carcass prior to its inspection for disease. The carcass is suspended from the moving chain by its rear legs. The gutting task involves reaching in and detaching the ‘gut’ (viscera), and lifting it out into offal trays for further processing. This action is repeated for the ‘pluck’ (heart, lungs, trachea). Other related tasks include ringing (freeing the anus), opening the cavity and removing the bladder, removing the kidneys, cutting the brisket and trimming fat from the carcass. Gutting is surprisingly technical and warrants the skill of a butcher to perform it, as perforating the gut or pluck results in a loss of product (offal and contaminated parts of the carcass) and production time (sterilising and additional processing of the carcass). As with Y cutting, the relentless task pace leaves little time for recovery or correcting errors. Additionally, the gut and pluck are heavy, slippery, and not always in one piece.

Aitch boning (sheep)

This is the removal of the hind legs from the pelvic (aitch) bone, which requires a high level of skill to perform quickly and without damage or loss to the high value legs. The legs and pelvis arrive as a single piece from the bandsaw, and is then lifted by the boner and suspended by the gamcord of one leg on a hook at around eye height. The boner then holds the shank of the free leg and cuts the tissues holding this leg to the pelvis. The same action is repeated for the suspended leg with the boner on this occasion holding the aitch bone, which is discarded once removed. Both legs are placed back on the table/conveyor for further trimming or boning, which in some cases are also tasks for the aitch boner. As sheep are usually chilled before boning, room temperature is around 8-10° C.

Sheep and beef packing

Packing tasks for both sheep and beef are described together as there are relatively few differences between the processes that occur. However, across both species there are many variations in how these processes are performed – through differences in room layout, processing equipment, product specifications, and work conditions. In the more than 35 packing rooms observed in the 28 sample plants no two were the same, even within the same plant. The end result of the packing process is wrapped and strapped cartons of meat (up to the international standard of 27.2kg). The role of packers is to sort, bag, weigh and pack the meat, according to client specifications, as it arrives by conveyor(s) from the boners and trimmers. Packing areas are usually extensions or annexes of the boning room, having the same hygiene and temperature requirements as boning. One difference between beef and sheep is the size and weight of cuts with beef primal cuts being big and heavy, while sheep have smaller cuts but a higher work pace.

Beef gutting

The beef gutting task is similar in nature to sheep gutting but on a much larger scale. As with sheep, gutting occurs after removal of the pelt, head and hooves and is one of a number of tasks concerned with eviscerating the carcass prior to inspection for disease. However, beef gutting requires a lot more mechanical assistance than sheep, due to the much larger weight and size of the carcass. Either the rail or the platform on which the guttee stands must be height adjustable to span the length of the carcass and to account for animals of different size (e.g. 150kg heifer to 450kg+ prime steer). The gutting task can involve cutting the brisket first to allow the gut and pluck to drop through into offal trays underneath, opening the carcass and stripping the bladder, using a knife to detach the gut and then cutting out the pluck and kidneys before washing and sterilising themselves and their equipment. Like sheep, a skilled butcher is involved in gutting as perforating the gut or pluck results in a loss of product (offal and contaminated parts of the carcass) and production time (sterilising and additional processing of the carcass). The task is made more difficult by often having to work blind as the guttee's hands reach into the carcass. There are many variations between plants in the physical configuration and the number of butchers and labourers involved in gutting.

Quarter boning

Beef carcasses are either separated into fore and hind quarters before being boned, or the two quarters are boned from a complete side. In both cases, the meat is suspended from a rail with the boner removing cuts of meat and transferring them to tables for further processing and then packing. The fundamental task difference between quarter and side boning is cut orientation for forequarters, which are leg-down for side boning but suspended by their leg for quarter boning. Beef can be boned 'hot', coming straight from the slaughter floor, or it can be chilled before being boned (either 'chilled' or 'on the curve' as it warms up). The temperature at which meat is boned causes differences in room temperature and work pace to meet hygiene requirements, as well as task differences between cutting hot and chilled meat. There are three main categories of beef including; prime – the most common and largest carcass size (160-450kg); bull – less common and smaller carcasses (200-350kg); and manufacturing cow – comprising heifers, old calvers and milkers (140-220kg). The range of potential cuts of meat across these categories is very large.

4.3.3 Observation data

Tables 4.6 – 4.10 summarise the findings for five of the high MSD-risk tasks.

Table 4.6. Y Cutting (Sheep) task details

Plant No.	*Grade observed*	*Average cycle time (sec)*	*Average steel/sterilise/ recovery time (sec)*	*Rotation positions for Y cutters*	*Rotation time (min)*
4	Sheep	11	4	4 – 2x Y cut (1 leg each), 1x brisket roller, 1x flaying	15
9	Sheep	67	8	4x Y cutters doing 1 carcass each (Y cut, clear brisket, roll brisket, sock, flay)	-
10	Lamb	4	2	10 – 1x stun, 2x spreaders, 1x open up, 2x clip & rod, 3x Y cut (1 leg each & 1 socking), 1x brisket roller	15
12	Sheep	22	8	9 – 4x Y cut (Y cut, sock, clear brisket), 1x brisket roller, 2x flaying, 2x shoulder fleecing	15
15	Sheep	8	2	6 – 1x 1st leg Y cut, 1x neck break, 1x 2nd leg Y cut, 3x flaying	15
20	Lamb	5	2	5 – 1x hanging up, 1x 1st leg Y cut, 1x dress brisket, 1x 2nd leg Y cut, 1x brisket roller	15
21	Lamb	5	2	8 – 5x Y cut, 2x socking, 1x brisket roller	15
23	Sheep	26	7	5x Y cutters doing 1 carcass each (Y cut, clear brisket, sock, roll brisket)	-
24	Sheep	40	8	2x Y cutters doing 1 carcass each (Y cut, sock, clear and roll brisket)	-
26	Lamb	5	2	4 – 1x hang up & right leg, 1x sock right leg, 1x clear brisket, 1x left leg and sock	15
27	Lamb	5	2	6 – 1x hang up, 4x Y cut, 1x brisket roller	15
28	Lamb	5	2	6 – 1x hang up, 4x Y cut, 1x brisket roller	15

Table 4.6 illustrates the fast work pace and narrow range of tasks available in Y cutting. Tallies of up 10 carcasses per minute, common in larger plants during peak processing for lamb, result in very short task cycles and limited recovery time. As stated by Inkson et al. (1988) " a life's work might be to cut a fresh throat or trim another cut of lamb, every seven-and-a-half seconds, eight hours a day, for 40 years" (p. 69). In most cases, there are few opportunities for doing tasks that are significantly different from Y cutting, and even with these the same time pressures are present. These work arrangements remain the same for each day of the season. Many other tasks occur around Y cutting, but these are labouring positions and are not usually included in butchers' rotation cycles.

Table 4.7. Sheep gutting task details

Plant No.	*Grade observed*	*Average cycle time (sec)*	*Average steel/sterilise/ recovery time (sec)*	*Rotation positions*	*Rotation time (min)*
4	Sheep	9	3	5 – Ringing, open & strip, gut, brisket, pluck	30
9	Sheep	15	5	5 – Ringing, open & strip, 2x gut, pluck	informal
10	Lamb	4	2	10 – Clean tail, 2x ringing, 2x open & strip, 3xgut, brisket, pluck	15
12	Sheep	7	2	5 – Ringing, open & strip, gut, brisket, pluck	15
15	Sheep	7	3	5 – Ringing, open & strip, gut, brisket, pluck	15
20	Lamb	5	2	7 – Ringing, head removal, open & strip, gut, 2x pluck, brisket	15
21	Lamb	5	2	5 – Ringing, open & strip, gut, brisket, pluck	15
23	Sheep	9	6	7 – Ringing, open & strip, 2x gut, kidneys, pluck, brisket	10
24	Sheep	38	10	2 – 1 does ringing/open & strip/gut, 1 does pluck/ kidneys/ brisket	30
26	Lamb	5	2	10 – Gambrel, ringing, atlas cut, head removal, stub cut, open & strip, gut, brisket, 2x plucking	15
27	Lamb	5	2	6 – Ringing, open & strip, gut, brisket, 2x pluck	15
28	Lamb	5	2	4 – Ringing, open & strip, gut, pluck	15

As gutting occurs downstream from Y cutting, the work pace is equally fast. However, there is generally greater task variety and less time overall spent gutting. Variations in carcass size (age) greatly affect the difficulty of this task in most of the plants surveyed.

Table 4.8. Aitch Boning (sheep) task details

Plant No.	*Grade observed*	*Task elements*	*Average cycle time (sec)*	*Average steel/recovery time (sec)*	*Rotation positions*	*Rotation time (min)*
4	Sheep	Place on rail, remove legs & aitch, place on table, trim legs	35	8	2x breakdown, 3x aitch boning, 8x table boning	informal
9	Sheep	Place on rail, release legs & aitch, place on table, remove legs & aitch, trim legs	25	3	1x breakdown, 2x aitch boning	15
10	Lamb	Place on moving rail, remove legs & aitch, place on table	18	5	8x aitch boning, 15x table boning	per run
12	Sheep	Place on rail, remove legs & aitch, place on table, trim legs	47	9	2x aitch boning, 6x table boning	60
15	Sheep	Place on rail, remove legs and aitch, place on conveyor	15	6	2x breakdown, 3x aitch boning	30
20	Lamb	Place on rail, remove legs and aitch, place on conveyor	17	4	2x aitch boning, 6x table boning	15
21	Lamb	Place on rail, remove legs and aitch, place on table	12*	2*	8x aitch boning, 14x table boning	informal
23	Sheep	Place on rail, remove legs & aitch, place on conveyor, trim 2nd leg	30	6	2x breakdown, 3x aitch boning, 10x table boning	60
24	Sheep	Place on rail, remove legs and aitch, place on conveyor	20	8	1x breakdown, 2x table boning	informal
26	Lamb	Place on rail, remove legs and aitch, place on conveyor	18	5	1x breakdown, 2x aitch boning, 4x table boning	informal
27	Lamb	Place on adjustable height rail, remove legs and aitch, tunnel bone and trim	45	6	2x breakdown, 4x aitch boning, 12x table boning	15
28	Lamb	Remove legs and aitch, take chump off and trim leg on table	25	5	2x breakdown, 3x aitch boning, 6x tunnel boning	30

(Based on tally rate – mock up only observed)*

Table 4.8 shows a wide range of both task designs and work speeds. Although this is a highly skilled task, performing it off-line means there is more opportunity to work at a pace that suits individuals than many other processing line tasks.

Table 4.9. Beef gutting task details

Plant No.	*Grade observed*	*Configuration*	*Average cycle time (sec)*	*Steel/sterilise/ recovery time (sec)*	*Tasks elements*	*Staff involved*
1	Prime	Rise & fall rail, drop into buggy	130	10	Open, strip, gut, pluck, halving saw, sterilise	1 person full time
2	Prime	Rise & fall rail, drop into trays	67	6	Open, strip, gut, pluck, sterilise	1 person full time
3	Prime	Rise & fall rail, drop into buggy	90	8	Trim flap, open, strip, gut, pluck, sterilise	2 people (rotate daily)
8	Prime	Rise & fall platform, drop into conveyor trays	70	5	Open, strip, gut, pluck, brisket saw, sterilise	2 people full time (alternate carcasses)
11	Prime	Fixed rail, stand in trays	120	built into 2 minute cycle	Open, strip, gut, pluck, sterilise	1 person full time
14	Bull	Rise & fall rail, stand in conveyor trays	60	built into 1 minute cycle on indexed rail	Gut, pluck, sterilise	2 people full time (alternate carcasses)
17	Prime	Rise & fall carousel platform, drop into trays	105	10	Open, strip, brisket saw, gut, pluck, sterilise	1 full time (can rotate to legging)
18	Prime	Rise & fall platform, drop into trays	120	built into 2 minute cycle	Brisket saw, open, strip, gut, pluck, kidneys, sterilise	3 (1 guttee, 2 leggers)
19	Cow	Rise & fall rail, drop into buggy	180	built in to 3 minute cycle	Open, strip, gut, pluck, empty buggy, sterilise	1 person full time
25	Bull	Rise & fall rail, drop into buggy	108	built in to 1.6 minute cycle	Gut, pluck, sterilise	1 person full time

Each of the ten plants surveyed had a distinctly different workspace and task design, ranging from a mostly manual task (19) through to high levels of automation (17), and from a small range of task elements (25), through to many (18). Task cycles and staff involved are equally varied.

Table 4.10. Beef boning task details

Plant No.	*Grade observed*	*Quarter or side*	*Average cycle time (& cut)*	*Rotation positions*	*Rotation time (min)*	*Steel/clean/ recovery time (sec)*	*Staff involved*
1	Hot prime	side	20 (topside)	All cuts	60	3	10 boners
2	Hot prime	¼	15 (knuckle)	All cuts	10 (move along 1 position)	3	12 boners
3	Hot prime	side	14 (shoulder)	All cuts	-	2	8 boners
8	Chilled prime	¼	12 (shoulder)	Stay on 1-2 cuts	-	3	18 boners
11	Chilled prime	side	15 (shoulder)	All cuts	-	3	15 boners
14	Hot bull	side	18 (aitch)	All cuts	-	4	18 boners
17	Chilled prime	side	14 (topside)	All cuts	-	4	8 boners
18	On the curve prime	side	15 (brisket)	10	20	3	9 (rail) + 3 trainees
19	Chilled prime	¼	5.5 min/quarter	All cuts	-	built in	5 boners
25	Chilled bull	¼	18 (aitch)	8	30	3	8 boners

As with beef gutting, Table 4.10 illustrates a large range of task configurations for beef boning, based on carcass type, meat temperature, and which primal cuts were performed. This task, more than the others observed, requires high levels of strength and fitness due to the size and weight of cuts and total task exposure per shift.

For the remaining high MSD-risk task, beef and sheep packing, there were many different tasks observed as a result of the work being conducted by the host plant at the time the visit(s) occurred. However, the extent of both task and workplace variations precluded data being meaningfully recorded in table format. Observed tasks included: packing off a range of bulk lines and other product conveyors, a number of manual subtasks in moving meat products between work areas, a wide range of vacuum packing arrangements and carton packing areas, and a number of weigh scales and strapping stations. Other tasks observed during plant visits included: sheep legging, pelting, kidney popping, rail-in, breakdown saw, table boning, fatcap removal, beef shackling, rodding, scalping, legging, breakdown, and trimming.

Observing tasks and performing some of the task elements, helped to develop a better understanding of the task demands and the possible reasons for task variations, while also raising further questions for the semi-structured interviews. However, this same process also highlighted some well-recognised weaknesses with observation data such as the inability to know how typical the tasks were on the day(s) of the plant visit, and the possibility of Hawthorne effects. Two groups of work system variations relevant to MSD that observation data do not account for include: factors influencing work tallies, and factors influencing task exposure. For work tallies – which determines work pace, this can include: fluctuations in stock grade and procurement, product specifications, compliance requirements, time of season, additional work shifts, work compression and staff availability. For task exposure – by run or by season, this can include: task rotation, shift design, job grades, replacement staff, training systems, remuneration systems, seniority, line balancing, injury management equipment design and plant design.

Such work system variations between processing areas limit comparisons among the sample plants and prevent strong conclusions being drawn from the observation data without further corroboration from other data sources.

4.3.4 Postural analysis & physical measurements for high MSD-risk tasks

The task elements involved, and the scores across the sample of plants, are included in Tables 4.11 and 4.12. High scores occurred in all tasks, with a few exceptions where task and workplace design characteristics were better matched to the staff concerned. However, these scores added little useful information. They only repeat what was already known – that the tasks are high-risk (as chapter 3 informed us), and that certain physical factors can contribute to this risk.

Physical measurements were collected in many cases, but are only of relevance to the plant concerned and were used in this context when illustrating risk and discussing possible interventions.

Table 4.11. RULA Scores for high MSD-risk tasks

	Beef				*Sheep*			
	Gutting	*Quarter boning*	*Packing*		*Y cutting*	*Gutting – transfer*	*Aitch boning*	*Packing*
1	5	5 (topside)	5 (bagging conveyor)	4	3 (legs, sock)	7	5 (2nd leg)	5 (bulk packing)
2	5	6 (knuckle)	5 (bagging conveyor)	9	4 (legs, sock)	4	5 (release 1st leg)	5 (packing cartons)
3	7	6 (shoulder	6 (primal cuts line)	10	4 (1st leg)	7	5 (2nd leg)	7 (bulk packing)
8	7	7 (shoulder)	7 (bulk line)	12	7 (legs, sock, clear brisket)	7	7 (2nd leg)	7 (bulk conveyor)
11	5	6 (shoulder)	6 (circular conveyor)	15	5 (legs, sock, clear brisket)	7	7 (2nd leg)	5 (packing conveyor)
14	3	6 (aitch)	6 (individual wrap line)	20	5 (legs, sock, clear brisket)	7	5 (2nd leg)	6 (bagging legs)
17	3	7 (topside)	5 (bulk line)	21	5 (legs)	7	5 (based on mock up)	7 (loading vacuum packer)
18	3	6 (brisket)	3 (packing cartons)	23	5 (legs, sock, clear brisket)	7	6 (2nd leg)	7 (unloading vacuum packer)
19	4	6 (knuckle)	5 (bulk line)	24	6 (legs, sock, clear brisket)	5	4 (2nd leg)	5 (packing off table)
25	5	6 (aitch)	6 (loading vacuum packer)	26	5 (leg)	7	5 (1st leg)	5 (bulk conveyor)
				27	5 (legs, sock, clear brisket)	7	7 (tunnel boning)	5 (bagging)
				28	5 (legs)	7	5 (1st leg)	5 (packing from bagger)

Table 4.12. Manual Handling Risk Scores for high MSD-risk tasks

	Beef				*Sheep*			
	Gutting	*Quarter boning*	*Packing*		*Y cutting*	*Gutting*	*Aitch boning*	*Packing*
1	30	42 (topside)	42 (bagging conveyor)	4	24 (legs, sock)	40	24 (2^{nd} leg)	32 (bulk packing)
2	30	42 (knuckle)	32 (bagging conveyor)	9	24 (legs, sock)	24	32 (release 1^{st} leg)	40 (packing cartons)
3	56	42 (shoulder)	48 (primal cuts line)	10	24 (1^{st} leg)	56	32 (2^{nd} leg)	42 (bulk packing)
8	30	40 (shoulder)	56 (bulk line)	12	32 (legs, sock, clear brisket	42	24 (2^{nd} leg)	48 (bulk conveyor)
11	30	42 (shoulder)	42 (circular conveyor)	15	32 (legs, sock, clear brisket)	42	24 (2^{nd} leg)	42 (packing conveyor)
14	24	40 (aitch)	56 (individual wrap line)	20	32 (legs, sock, clear brisket)	56	32 (2^{nd} leg)	40 (bagging legs)
17	16	40 (chuck)	32 (bulk line)	21	32 (legs)	48	32 (based on mock up)	56 (loading vacuum packer)
18	12	30 (brisket)	32 (cartons)	23	32 (legs, sock, clear brisket)	42	32 (2^{nd} leg)	42 (unloading vacuum packer)
19	20	40 (knuckle)	32 (bulk line)	24	42 (legs, sock, clear brisket)	30	30 (2^{nd} leg)	42 (packing off table)
25	30	42 (aitch)	40 (loading vacuum packer)	26	32 (leg)	48	32 (1^{st} leg)	32 (bulk conveyor)
				27	32 (legs, sock, clear brisket)	48	48 (tunnel boning)	40 (bagging)
				28	32 (legs)	56	30 (1^{st} leg)	42 (packing from bagger)

4.3.5 Summary of MSD risk factors

The large number of MSD risk factors collected from the sources outlined in the Methods section, along with data from the health and safety staff questionnaire reported in Chapter 3, were collated and summarised by content under main headings (Table 4.13). The initial 36 headings were reduced down to 28 which best summarised the interventions, as these were the findings of most interest to the industry. Information on the relevant risk factors was included under each intervention heading, a step discussed in Chapter 5. Risk factors from the semi-structured interviews, the questionnaire and archival data concerned all aspects of the work system whereas observation and postural analysis data covered only the high MSD-risk tasks.

Table 4.13. MSD risk factor categories identified

Initial risk factor headings	*Final headings used for risk factors and interventions*
Work compression	Work pace
Task rotation	Task rotation
Job allocation	Job allocation
Task training	Task training
Injury management	Early reporting and injury management
Physical task requirements	Physical task requirements
Task design	-
Cleaning	-
Workspace design	Workspace and equipment design
Equipment design	-
Floor surface	-
Staff participation	Staff participation
Knife sharpness	Knife sharpness / training
Noise	Noise
Work flow	Work flow
Tally	-
Seasonality	-
Knife and glove design	Knife and glove design
Thermal environment	Thermal environment
Rest breaks	Rest / recovery breaks
Plant design	Plant design
Work hours / shift design	Shift design
Maintenance	Maintenance
Recruitment / retention	Recruitment / retention
Absenteeism	Attendance
Remuneration / job grades	Remuneration / job grades
Hazard management	Health and safety management
Beef gutting	Beef gutting
Beef boning	Beef boning
Beef packing	Sheep/beef packing
Sheep packing	-
Y cutting	Y cutting
Aitch boning	Aitch boning
Sheep gutting	Sheep gutting
Other	MSD awareness

Table 4.13 includes both task-specific and task-independent risk factors. However, all systemic risk factors identified in the table may also create risk in the high MSD-risk tasks. There is also a large amount of inter-relatedness between risk factor categories.

The following text provides brief examples of risk factors for each of the categories in the table. A summarised list of MSD risk factors is included in Appendix 6.

Work pace: This refers to risks associated with compressing shift length to finish earlier, peaks and troughs by working at a much faster pace than the chain to create a corresponding lull in work for resting, or being required to work at the pace of the fastest person on the chain and being unable to keep up.

Task rotation: examples of risks include being unable to rotate onto other tasks causing overexposure to high risk tasks, rotation around equally stressful tasks, or rotation periods that are not adequately matched to the task demands.

Job allocation: criteria for determining task suitability that is unrelated to skill (e.g. seniority) may result in exposure to MSD risk through limiting training, rotation, or being unsuited to the job being done.

Task training: examples of risk factors include an absence of task training, delayed training, inadequate training through buddying with staff ill-equipped to train others, or a difficult training environment (e.g. on line, noisy, restricted space).

Early reporting and injury management: MSD cases that do occur can be prolonged and more serious if not reported when first symptomatic, or are not well managed when they are reported.

Physical task requirements: common examples of mismatches between physical requirements and task demands include situations where older workers or less physically prepared new staff are exposed to tasks originally designed for physically fit, strong staff (traditionally male) in their 20's. Similar mismatches can occur through not accommodating people rehabilitating from injury.

Workspace and equipment design: factors such as fixed heights, weights and placements can create MSD risk through constrained work postures, overreaching, and large travel/transfer distances for example.

Staff participation: not involving staff affected by proposed changes can result in less suitable and efficient designs, or the introduction of new unforeseen risks. Other examples of creating MSD risk include involving staff and disregarding their suggestions, or ignoring known problems until the level of injury is sufficiently high.

Knife sharpness / training: cutting tasks require more effort and time with a blunt knife. Inadequacies in training can result in skills not being learnt or not properly applied.

Noise: the most significant risk factor with noise is that high levels affect communication and therefore training, but can also contribute to muscle tension and the onset of fatigue.

Work flow: some examples of MSD risk include imbalances between ratios of boners to packers, not allowing additional time for work involved in complex or physically difficult cuts, and the effects of seasonality and weather fluctuations on work flow.

Knife and glove design: MSD risks can result from poor fit, poor or mismatched design of equipment. Glove ensembles designed for protection from cuts and disease (both ways) can also create MSD risk in the trade-off between protection and performance.

Thermal environment: chilled work areas (e.g. boning room, chiller) with high air velocity, high humidity and the use of vibrating hand tools (e.g. flay knives) can impair manual dexterity and individually or collectively contribute to the occurrence of MSD.

Rest / recovery breaks: mismatches between work intensity and rest / recovery breaks increases MSD risk. Additional risks can occur on processing lines where there is limited opportunity for spontaneous breaks or pauses between task cycles.

Plant design: many plants are being used in ways for which they were not originally designed. Advances in mechanisation, increased hygiene compliance requirements, and increases in carcass size are some examples of factors that can create physical constraints which processing staff are required to accommodate.

Shift design: factors such as the timing of shifts, long shifts, or working double shifts during season peaks can all lead to MSD risk through overexposure and fatigue. *Maintenance*: lack of maintenance, or reactive rather than preventive maintenance, can contribute to MSD risk through requiring manual handling to fill the gap (e.g. frequency or force). This additional workload may also not be accounted for in task cycle time.

Recruitment / retention: examples of MSD risk that this can create include exposing staff to tasks for which they have inadequate training or experience, and a having insufficient numbers of replacement staff.

Attendance: as with staff retention, poor attendance can overload the remaining staff present or can adversely affect the ability to rotate between tasks.

Remuneration / job grades: piece rate and bonus payment systems can be a source of MSD risk through increased work pace, peer pressure to perform, and by acting a disincentive to training or task rotation.

Health and safety management: the likelihood of MSD increases if there are no systems that enable MSD risks to be identified and managed.

Beef gutting: there are many variations between plants in the physical configuration and the number of butchers and labourers involved in gutting. Significant task-specific MSD risks include when either the speed of the chain outstrips the capabilities of the staff involved, or in situations where the mechanical assistance is limited.

Quarter boning: common MSD risks in beef boning are the high levels of physical exertion required of both knife and non-knife hands to remove and handle the large cuts of meat, and mismatches between line speed, meat characteristics, skill levels and staffing ratios. Workplace layout and duration of task exposure can also contribute.

Sheep and beef packing: there are relatively few differences between the packing tasks for both sheep and beef, other than the size and weight of cuts with beef primal cuts being big and heavy, while sheep have smaller cuts but a higher work pace. Common

MSD risk factors are the relentless work pace, processing line imbalances and poor workspace geometry with packers being required to fill the gaps in the physical design.

Y cutting (sheep): the very fast pace of this task and its unchanging nature (up to 10 carcasses each minute, for up to 10 hours per day, every day) introduces risk through repetition, task invariability, and having no task control. Manual brisket rolling introduces a further risk through requiring high levels of force. Other factors such as carcass variations, skill levels and total task exposure may also be relevant.

Aitch boning (sheep): the main observable MSD risks arising in this paced task appear to occur through the speed of the processing line, the skills of the boner, and mismatches between these two elements. Limited opportunities for task variety and total task exposure also contribute to the risk. Physical elements such as hook height, transfer distances and knife sharpness can also have a bearing on the level of MSD risk.

Sheep gutting: the most obvious MSD risk factors are its very physical and repetitive nature, which occur under paced conditions. As with Y cutting, the relentless pace also leaves little time for recovery or correcting errors. Poor workplace design can markedly increase risk, as can variations in gut weight, chain speed, and length of exposure.

MSD awareness: being unaware of the potential MSD risks present in their tasks means people are unaware of how to avoid them. Other factors such as health and safety management and early reporting can also have a bearing here.

4.3.6 An overview of contextual factors identified

Task-specific and task-independent data collection highlighted a number of risk factors that transcended tasks and plants, and concerned the entire industry. While some of these factors were known by the researcher to exist prior to the study (e.g. effects of seniority on job allocation and task rotation), the extent of their influence on MSD risk across the industry was not known. These risk factors were raised, unprompted, by staff during the semi-structured interviews and have been summarised into a list of contextual factors which, it is postulated, may create conditions under which greater exposure to physical and psychosocial factors can occur in meat processing. Some of the contextual factors are recognised as problematic by the industry, but have not previously been associated with MSD risk.

Figure 4.3 provides an overview of the postulated relationship between the various contextual factors identified in the study. The conceptual model is based on a systems approach with arrows indicating the direction of influence for contextual factors and their role in increasing exposure to physical and psychosocial risk factors.

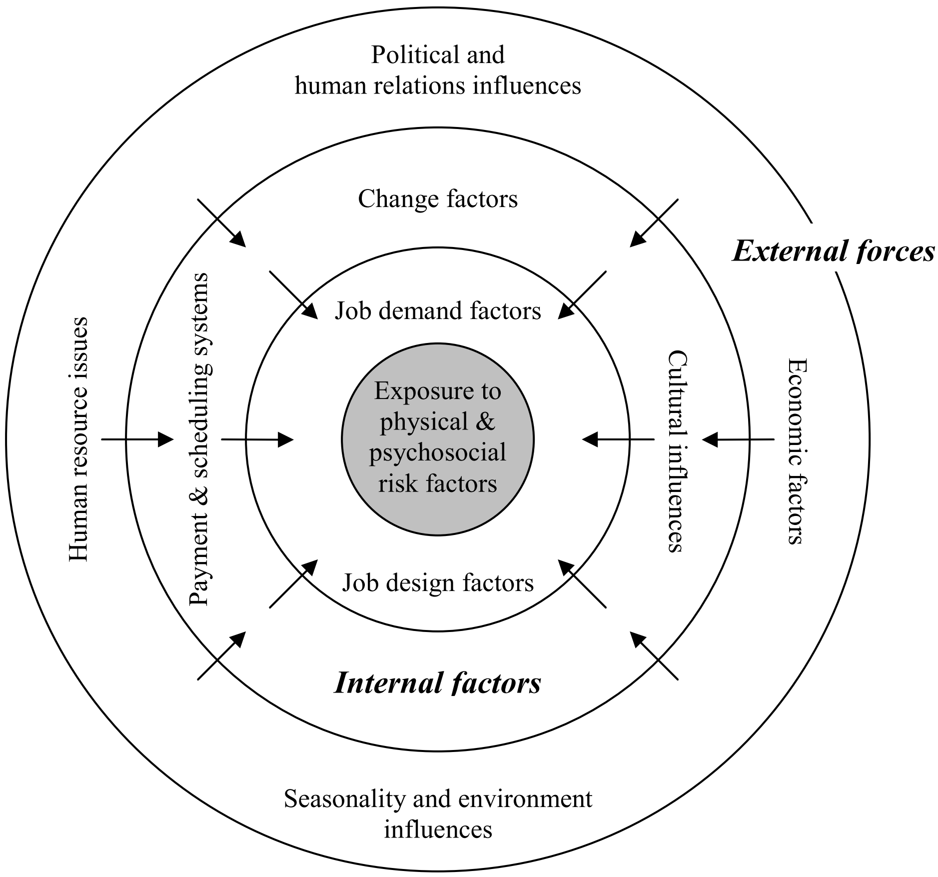

Figure 4.3. Conceptual model for the role of contextual factors in meat processing MSD

Table 4.14 outlines each of the theme groups shown in Figure 4.3, together with key contextual factors within each group, and the basis for its inclusion. It should be noted that factors within these nine areas interact with each other, as well as contributing to the presence of physical and psychosocial risk factors, and that the list generated in Table 4.14 reflects contextual factors that were found to be present in the industry, but were not necessarily present in all plants examined. Table 4.14 also indicates whether the contextual factors were internal or external to the meat processing industry.

Table 4.14. Contextual factors for MSD in meat processing

Contextual factor group	*Contextual factor origin*	*Contextual factor*	*Plants identifying this factor (%)*	*Staff interviewed identifying this factor (%)*	*Industry data support*
Cultural influences	Internal	1. competitive and entrenched culture 2. 'blame the victim' culture 3. mono-causality belief 4. machoistic culture 5. culture of high work pace	68 43 50 68 89	14 7 7 12 24	
Political and human relations influences	External & internal	1. hygiene compliance requirements 2. adversarial relationship between management and workers 3. low level of workforce participation 4. seniority factors	46 64 64 75	11 13 13 16	
Economic factors	External	1. export focus 2. high exchange rates 3. low national unemployment 4. company mergers, plant closures	7 4 11 18	1 - 2 3	MIA Annual Report MIA Annual Report Statistics NZ Rural News NZ
Human resource issues	External & internal	1. labour resourcing 2. ageing workforce 3. preparedness of new recruits 4. staff and skill retention issues 5. limited career path 6. training factors	93 64 71 89 39 89	30 14 20 38 5 38	MIA Annual Report
Seasonality and environment influences	External & internal	1. off-season issues – recruitment, retention 2. workload variability 3. weather impacts on workflow	71 68 46	19 19 14	MIA Annual Report Meat & Wool NZ
Job demand factors	Internal	1. production pressures 2. increases in carcass weights 3. work compression and scheduling 4. variability in workflow 5. low control of work planning and method 6. task complexity	100 39 82 71 82 46	39 9 27 19 26 14	 NZ Meat Statistics
Job design factors	Internal	1. high job specialisation 2. barriers to job rotation and enlargement	54 96	14 29	
Payment and scheduling systems	Internal	1. work compression 2. piece-rate work 3. bonus systems	50 36 43	7 5 5	
Change factors	Internal	1. entrenched industry resistant to change 2. competitive nature of industry 3. low participation of workforce 4. pre-contemplative management 5. industry scepticism about MSD	86 71 64 39 71	19 14 12 8 11	

Factors that were most commonly mentioned in relation to MSD risk were job demands and human resource issues, matters that most directly affect the staff involved. The least mentioned factors were those relating to external forces about which the staff interviewed generally have little involvement with and influence over. Payment and scheduling systems were also less mentioned, possibly because they are considered as favourable by staff as they allowed some control over work hours and earnings.

The responses in Table 4.14 may also reflect the level of awareness about MSD among the staff interviewed. Many of the MSD risks raised by staff concerned physical factors within their own work environment; however, the proportion of contextual factors mentioned increased in the interviews with managers and increased again with health and safety staff interviews. Table 4.15 shows interview responses by staff grouping across all 28 plants. Unfortunately, data on age, experience and seniority of the staff interviewed was not consistently available, preventing consideration of these demographic factors in the analysis.

Table 4.15. Contextual factors for MSD in meat processing by staff grouping

Contextual factor group	*Contextual factor*	*Managers & Supervisors (%)*	*OHS staff (%)*	*Processing staff & union reps (%)*
Cultural influences	1. competitive and entrenched culture	12	47	6
	2. 'blame the victim' culture	3	26	4
	3. mono-causality belief	7	35	0
	4. machoistic culture	12	44	4
	5. culture of high work pace	26	50	17
Political and human relations influences	1. hygiene compliance requirements	16	18	7
	2. adversarial relationship between management and workers	9	29	11
	3. low level of workforce participation	14	21	10
	4. seniority factors	29	38	4
Economic factors	1. export focus	1	3	0
	2. high exchange rates	1	0	0
	3. low national unemployment	1	9	0
	4. company mergers, plant closures	3	9	1
Human resource issues	1. labour resourcing	54	76	6
	2. ageing workforce	23	41	2
	3. preparedness of new recruits	36	44	6
	4. staff and skill retention issues	70	74	13
	5. limited career path	6	18	1
	6. training factors	68	56	18
Seasonality and environment influences	1. off-season issues – recruitment, retention	29	53	4
	2. workload variability	26	24	15
	3. weather impacts on workflow	20	24	8
Job demand factors	1. production pressures	54	50	28
	2. increases in carcass weights	10	12	7
	3. work compression and scheduling	42	35	17
	4. variability in workflow	20	24	16
	5. low control of work planning and method	32	41	19
	6. task complexity	22	26	6
Job design factors	1. high job specialisation	20	26	7
	2. barriers to job rotation and enlargement	51	59	10
Payment and scheduling systems	1. work compression	16	15	0
	2. piece-rate work	10	9	0
	3. bonus systems	12	15	0
Change factors	1. entrenched industry resistant to change	22	47	10
	2. competitive nature of industry	20	44	3
	3. low participation of workforce	13	29	7
	4. pre-contemplative management	6	26	4
	5. industry scepticism about MSD	13	38	3

The figures show that a higher percentage of health and safety staff raised contextual factors when asked about MSD risks compared with managers and processing staff. This could be due to their greater awareness of MSD as well as their more frequent involvement in addressing risks and managing cases. They also mentioned cultural influences and change factors far more than the other two groups of staff, again possibly indicating a greater knowledge of MSD multicausality specific to meat processing. Managers and supervisors mentioned many of the same factors relating to human resourcing, job demands and job design factors, with smaller numbers also raising a wider range of contextual factors. By comparison, processing staff were more likely to raise risk factors that related to the aspects of work with which they were most familiar (job demands, human resource issues). A possible reason for lower reporting levels among processing staff was that in some cases access was more restricted compared to the other two groups of staff. In these instances, interviews took place within the hygiene-controlled area, often with the person working on the production line, affecting privacy and their ability to engage completely in the interview process. These interviews were generally shorter than those without such restrictions. These circumstances could be considered an unobtrusive measure of, among other things, management interest in MSD, the demands of the job, and level of staff participation in health and safety matters affecting their work.

A breakdown of interview responses by species is shown in Table 4.16. Beef and sheep had fewer variations than plants processing other species, perhaps predictably as they account for over 85% of the staff interviewed. It is also important to note that some of the staff interviewed worked on more than one species (refer to Table 4.3) with many of their comments more generic to the industry rather than a species. Staff involved in beef processing reported more human resource issues, namely finding, training and retaining staff. This is at odds with the perception that seasonality increases staff turnover as beef processing plants generally have a longer season of work. A higher proportion of people involved in sheep processing raised the issues of weather impacts on workflow and increases in carcass weights, which both affect sheep more than other species. Less people however raised the issue of barriers to rotation and enlargement. Possible reasons for this are unclear. The largest variations arose from the smaller total number of people interviewed in the six ‘other’ plants (veal, venison, pork). Some of these figures reflect that three of the six plants processed veal, which are processed over a short and highly intensive season. This is likely to explain the concerns over high work pace, low levels of participation, seasonality of work, production pressures and a low response for task complexity.

Table 4.16. Contextual factors for MSD in meat processing by species

Contextual factor group	*Contextual factor*	*All staff interviewed at beef plants (%)*	*All staff interviewed at sheep plants (%)*	*All staff interviewed at other plants (%)*
Cultural influences	1. competitive and entrenched culture	11	13	19
	2. 'blame the victim' culture	6	7	9
	3. mono-causality belief	10	6	6
	4. machoistic culture	9	13	16
	5. culture of high work pace	20	20	53
Political and human relations influences	1. hygiene compliance requirements	9	13	13
	2. adversarial relationship between management and workers	14	12	16
	3. low level of workforce participation	14	10	25
	4. seniority factors	19	13	25
Economic factors	1. export focus	0	1	3
	2. high exchange rates	0	0	3
	3. low national unemployment	0	2	3
	4. company mergers, plant closures	1	1	13
Human resource issues	1. labour resourcing	39	27	22
	2. ageing workforce	19	12	13
	3. preparedness of new recruits	21	21	16
	4. staff and skill retention issues	49	36	25
	5. limited career path	6	6	0
	6. training factors	43	36	34
Seasonality and environment influences	1. off-season issues – recruitment, retention	13	19	28
	2. workload variability	17	24	6
	3. weather impacts on workflow	4	20	9
Job demand factors	1. production pressures	41	33	56
	2. increases in carcass weights	1	14	3
	3. work compression and scheduling	39	26	6
	4. variability in workflow	29	15	13
	5. low control of work planning and method	30	25	19
	6. task complexity	21	12	3
Job design factors	1. high job specialisation	11	16	9
	2. barriers to job rotation and enlargement	37	23	38
Payment and scheduling systems	1. work compression	7	5	13
	2. piece-rate work	6	4	3
	3. bonus systems	7	4	6
Change factors	1. entrenched industry resistant to change	19	18	22
	2. competitive nature of industry	9	16	19
	3. low participation of workforce	11	11	19
	4. pre-contemplative management	7	8	6
	5. industry scepticism about MSD	6	10	25

Sections 4.4.6.1 to 4.4.6.9 discuss the interview findings in more detail for each of the contextual factor themes presented in Table 4.14.

4.3.6.1 Cultural influences on MSD risk

The industry has a highly competitive culture, where companies and plants compete for the same resource in a tight seasonal market (MAF, 2003). While there is sharing of health and safety information at an industry level through national fora, individual companies are less likely to share information that might result in other organisations improving productivity or reducing lost-time injuries. As one informant put it,

> *"In all my years, I haven't found any way to get around the argument from management that ultimately if we don't kill these animals another company will."*

Historically, information sharing between plants within the same company has also been restricted (Slappendel et al., 1996). This high level of competition combines with truncated processing seasons, increasingly complex processing requirements, and payment systems based on throughput, to create a strongly entrenched industry focus on production volumes. This in turn can result high work pace, long work hours and limited rest breaks. These entrenched industry work practices relating to production can become obstacles to addressing MSD risk. The two comments below reflect this situation,

> *"The culture in meat plants is to just go like hell."*

> *"Productivity is number one - everything else is a cost. If I suggest anything their first concern is whether it's going to bring in more money. If not, they're not interested."*

Secondly, a 'blame the victim' attitude pervades parts of the industry, where MSD injuries are attributed to factors such as individual technique, resilience, and false reporting. Such thinking is a major impediment to prevention efforts. Similarly, the assumption that MSD injuries have a single major cause is a view held by many people interviewed in the study. Not recognising that MSD are complex events with multiple risk factors has resulted in a flawed approach to previous MSD prevention efforts. This is illustrated by the following observations, *"People who get sprain and strain injuries are just not hard enough."*

"Sometimes it's a strain of the heart, not the body (small heart syndrome)."

Finally, the meat processing industry has a reputation as a highly machoistic culture, where speed and resilience to injury are widely respected and rewarded, and where pain is regarded as inevitable and something that needs to be worked through. Despite a growing culture of early reporting of symptoms and more comprehensive injury prevention, there is still the belief among many that MSD, like pain, are an unavoidable consequence of some processing tasks. These factors all act as barriers to implementing change, and reduce the likelihood of the industry adopting improved work organisation and job design measures to reduce MSD risk.

4.3.6.2 Political and human relations influences on MSD risk

Regulatory bodies and overseas buyers impose strict hygiene compliance requirements on each stage of meat processing. These requirements are referred to as the top business priority along with production, and ahead of health and safety issues. MSD risks may therefore not be addressed where they might affect hygiene compliance (e.g. physical design constraints to avoid contact with certain surfaces). As for example,

"We have to lift the runners up so they don't touch the rail – otherwise they get thrown out. It makes it much harder, especially on mutton as they're bigger and heavier."

Another important political factor is the often adversarial relationship between management and the workforce in the meat processing industry. This first emerged following the introduction of scientific management-based working arrangements in New Zealand around the 1930's, where butchers lost considerable control and earnings potential as the task of processing a carcass ceased to be the responsibility of individual butchers and their teams, being divided instead into many highly specialized, short task cycle jobs (Inkson & Cammock, 1984). Consequently, the industry has since become increasingly unionised, with relations between management and labour very divided at times. Clearly such a situation has serious implications for employee involvement in health and safety and other aspects of work planning and design, and stands as a barrier to reducing MSD risk across the industry.

This history of adversarial bargaining has led to scepticism about issues such as work-related injury, meaning management may be less responsive to reports of MSD. This attitude may become more entrenched with time, given the very high MSD incidence rates in the industry. Occasionally, health and safety issues are reportedly used to bargain for improved conditions of employment, but not always conditions related to the issues initially raised. Such practices only serve to increase scepticism, and under-emphasise the occurrence of MSD. Against this background, the opportunities for staff to participate in matters affecting their workplace is restricted in most plants by the nature of production line jobs with low autonomy, narrow task scope and social isolation.

Staff seniority is a potential MSD risk factor as it can act as a barrier to changes that reduce MSD risk. Seniority exists in most plants to provide both workers and employers with greater security through defining when staff will return after seasonal shutdowns, to which tasks and pay levels. Workers who have been in the plant the longest will have the highest 'seniority numbers' and have the greatest job security across the working year. The following two comments from two informants illustrate difficulties that can occur,

> *"Above position 160 you know you'll have a job all year round, guys below that number will take a job somewhere else if it's available."*

> *"Bringing people in out of seniority - even to train them, is not accepted by the union."*

While there are many different seniority systems in place, they can increase MSD risk through restricting training, rotation, staff transfers, and potentially contributing to staff turnover as advancement may depend on others retiring or leaving the plant. Advancement and remuneration across the industry is based on seniority along with skill and attendance, presenting a potential barrier to skill acquisition for meat processing workers. Moreover, workers with low seniority may be restricted from training for high seniority tasks, while senior workers may not rotate to low seniority tasks. Some seniority systems can also act as disincentives to transfer between departments or shifts as staff lose their seniority through such a move.

4.3.6.3 Economic factors for MSD risk

In recent years, fluctuations in exchange rates have been a significant factor in reducing profitability, which in turn has placed greater emphasis on increasing production, reducing production costs and increasing value-added production (MIA, 2007). Some of the changes made have consequently increased MSD risks, for example through reducing staffing levels, recovery time, and training time, along with increasing work pace and processing requirements for certain tasks.

Further business pressures are occurring as a result of record lows in national unemployment (Statistics New Zealand, 2006). The resultant scarcity of potential employees requires that some plants operate with less staff, potentially overloading existing staff and reducing opportunities for training as the emphasis is placed on throughput rather than skill development. Buyouts, mergers and plant closedowns have also been relatively common in the industry for the past two decades, as the industry has evolved to accommodate reduced profitability, new meat inspection standards, new technologies, industry deregulation and farmers converting to other land uses. Indeed, since completion of the study the number of processing plants has decreased by almost 10%. These actions have resulted in a lot of change and, undoubtedly, staff concern over the security of work conditions and ongoing employment, all of which add to the potential MSD risk.

4.3.6.4 Human resource issues for MSD risk

A significant worker and skill shortage in the industry has led to the over-exposure of existing workers to MSD risk. This shortage of competent workers is due to low unemployment, geographically isolated plants, comparatively low wages, a limited career structure, and the presence of more attractive job opportunities. Long off-seasons in some areas of meat processing, and the requirement to work night shifts and/or weekends during the busy season, further reduces the attraction of employment in this industry. As some managers put it, *"We're losing guys in their 40's too now to other jobs that pay more."*

"To be honest, we only get the ones who can't hold down a job elsewhere. Years ago you'd get a kick up the arse if you needed it. Now we can't even get rid of them if they are rubbish."

The occurrence of MSD among existing staff and retirement of highly skilled older staff further exacerbates these concerns as higher staff turnover has incrementally reduced the industry's skill base. An ageing workforce may also succumb more quickly to physical workload demands, despite their skills and experience. Older workers may also have a greater likelihood of pre-existing conditions, through wear and tear on their musculoskeletal systems over the years, making MSD more likely. As one person put it,

"The old guys have all the skills, but they're starting to get hurt. There's not many other jobs available in the plant that they can do."

New entrants to the industry and younger workers are reported by many in the industry as being less physically prepared for heavy work than has been the case in the past. Should this be the case then this may result in higher turnover of new staff who may not be able to cope with the physical demands of the job, and require a greater length of time to build necessary conditioning for the job, with increased risk of MSD until such conditioning is achieved. The industry has generally been slow to reduce physical task requirements to increase the pool of staff - including young and old, male and female - who are able to carry out the work sustainably.

A number of training factors also affect MSD risk across the industry. As mentioned earlier, tenure as well as skills determines advancement and remuneration, thus limiting training opportunities for workers. Seniority can be a barrier to training as senior workers may resist training of lower seniority employees for high seniority tasks. On the job training arrangements prevail across the industry, meaning issues such as production noise, divided attention and the passing of bad habits (e.g. poor technique) or incomplete information (e.g. through poor communication) reduce training effectiveness and increase MSD risk.

4.3.6.5 Seasonality and environmental influences on MSD risk

Work across the industry is highly seasonal, and many meat processing plants have an off-season ranging from several weeks to several months. Workloads during the season are often very high to keep up with the stock becoming available for slaughter and processing. A typical comment is,

> *"It's difficult to get good young staff because it's only a six month job." "The pay is not good enough to keep them going through the year – it was in the 90's but not now."*

The timing for starting up processing lines while recruiting and training the required staff based on predicted stock volumes can introduce further MSD risks through over-loading and under-training. Work pace and work duration concerns during the processing season arising from seasonality and line balancing factors can lead to extended hours, increased work pace, and reduced training time. These factors lead to an increased risk of MSD through greater exposure to physical and psychosocial risk factors, which may be coupled with lower physical conditioning after time away from the job. Weather fluctuations can further exacerbate the problems of seasonality and stock procurement (Meat & Wool New Zealand, 2008), creating workload peaks and troughs as farmers sell or withhold their stock (which is all pasture grazed), or choose to send them to companies with more attractive payment rates. The following comment reflects this uncertainty,

> *"A slow fattening season like this year can produce a big surge of stock later on – although it's hard to predict".*

4.3.6.6 Job demand factors for MSD risk

Increases in productivity and production have had a significant impact on the pace of work, and other physical risk factors in meat processing. This reported increase in productivity is provided through the New Zealand Meatworkers Union (2005) estimates of volumes of meat exported per person employed in meat processing, which rose significantly between 1980 (23 tonnes) and 2004 (37 tonnes). Increases in average carcass weight over a similar period are around 30% for sheep and 15% for beef (New Zealand Meat Statistics, 2007). While an increase in carcass weights over the years has played a part, there are other important influences on production pressure. Notable among these are competition within the industry, an overwhelming emphasis on productivity rather than yield, mechanisation that has involved further job specialisation and speeding up of the production chain, and seasonality and weather fluctuations that produce variations in work flow. As some processing staff commented,

> *"It was a really good job before they started chasing the yields too hard".*

> *"Health and safety is a low priority, management push for more productivity until we break".*

Workers who return to work too early following MSD face an increased risk of injury where the work pace is too great for the current level of rehabilitation, and plants may not have sufficient measures for enabling the graduated reintroduction to work. Similarly, new entrants may experience serious difficulties trying to keep up with their more seasoned colleagues while skills and physical preparedness are developed. Compounding these factors is the lack of control over work planning, work methods, and in many cases, work pace. This lack of control can also adversely affect social support at work, both of which are associated with increased MSD risk (Bongers et al., 1993; NRC-IOM, 2001; Woods, 2005).

Task complexity has also increased markedly in recent years due to hygiene compliance and a wider range of further processing requirements. This has added greatly to the range of skills meat processing workers need, while training has not always been well-enough resourced to ensure these new skills are present where needed. Modifications to plant, workspace, packaging and line balancing are also often required. Any lag between a change in product requirements and accompanying changes in the work system can lead to the occurrence of MSD risk as workers adapt to meet the shortfall. As many of these special requirements are either seasonal or sporadic, workers do not always get the opportunity to learn the required techniques well enough to avoid redundant energy wastage, leading to further MSD risk.

4.3.6.7 Job design factors for MSD risk

High levels of task specialisation dominate the meat processing industry, with many workers experiencing little or no variety in their work. The problems for such job design arrangements are well-understood, and involve low levels of challenge and job satisfaction, which may also have a bearing on the experience and reporting of musculoskeletal pain or discomfort. Although it is generally accepted that job specialisation increases exposure to both physical and psycho-social risk factors for MSD, the physical design of plant and production lines means that in the majority of cases job design alternatives are limited to possible task rotation. While task rotation, where used appropriately, can help spread the physical loading around the body and also counter boredom , the reality is that much of the rotation that does occur in meat processing plants tends to be to similar tasks, and may do little to relieve exposure to MSD risk factors.

Moreover, there are a number of barriers to task rotation. Notably, workers with high seniority numbers are unlikely to rotate to lower seniority tasks in many plants, while higher seniority tasks are fiercely protected by task incumbents. These arrangements are seen as over-riding any concerns about occupational health and safety, as seniority, with its associated higher pay and mana (respect), represents the main form of career path provided by the industry. Another barrier is illustrated by the following comment,

> *"Some staff don't want to rotate as they've been there for ages and don't want to go back to doing the boring jobs".*

Where seniority is not a barrier, then pay grades can be, where tasks in the rotation cycle involve more than one pay rate. Rotation may also be problematic when working at a high pace, as it can be seen by workers and management as potentially compromising output.

4.3.6.8 Payment and scheduling systems

The meat processing industry uses payment incentives to maximise output and work pace during the short production season and periods of high demand. Payment and scheduling systems commonly in use across the industry include piece rate working, compression of work hours, and bonus-driven working. Each of these systems can create high-paced work, and an accompanying increased exposure to MSD risk factors (Trevelyan & Haslam, 2001). Lacey, Lewis, and Sim (2007) also report that perceptions of low job control, little supervisor support and high physical demand were associated with increased areas of pain and poorer general physical health. Exacerbating the problem of increased work pace is the fact that the nature of the production line usually means that all workers must try and keep up with the fastest person, meaning many workers are working at a faster pace than they should, due to pressure from colleagues who are dependent upon them for their level of earnings. Again, payment systems that encourage fast paced work are a barrier to rotation and other measures designed to reduce exposure to MSD risk factors, including off-line training, or changes in rest break regimes to allow more recovery time.

4.3.6.9 Change factors for MSD risk

Change in attitudes towards worker health and the implementation of measures to reduce MSD are very difficult to achieve in New Zealand. The meat processing industry is highly entrenched and resistant to change. The competitive forces make productivity a constant priority and focus, even to the extent where quality may be negatively impacted and yield reduced due to production pressure. The low participation of the workforce in health and safety further acts as a barrier to change. As two of the interviewees put it,

> *"Too ingrained to change now, it's just how we've always done it here".*

> *"They just stick stuff in without consultation. There's no system for making changes, and if there was it would be ignored."*

With respect to change to reduce MSD risk, management have long been pre-contemplative about the industry having a major MSD problem, despite the evidence of national and company data to the contrary. Where the industry and individual managers are pre-contemplative about MSD, it is unsurprising that calls for improvements in working conditions to reduce exposure to MSD risk factors are ignored (Barrett et al., 2005). Industry scepticism about MSD is another barrier to change, and represents a further obstacle to tackling high levels of MSD across the industry. A typical comment is,

> *"Managers look at health and safety as a lost cause – they can't see any way through the mire. It's always been like that, and it's unlikely to change".*

As MSD often fails to present as a specifically diagnosed injury, sufferers of non-specific disorders that comprise a large proportion of reported MSD can be seen as malingerers by management and colleagues. The insidious nature of MSD discomfort and the lack of obvious visible signs and symptoms (compared with knife cuts for example) may contribute further to these perceptions. Colleagues may also apply pressure for MSD sufferers to keep up in order to achieve bonuses or finish early, further exacerbating the problem.

4.3.7 Contextual factors - implications for theory and prevention of MSD

MSD prevention practices across the New Zealand meat processing industry have focused almost exclusively on those which pose little threat to production, including those aimed at single risk factors (e.g. knife sharpening programmes), injury management (e.g. ACC's 'Back to Work' programme), or as additional benefits accrued from task automation or mechanisation. However, these initiatives have had little meaningful impact on the reported incidence of MSD in the meat processing industry (Slappendel et al., 1996; ACC, 2007), which has remained at the same high levels for more than a decade.

There are several possible reasons for this. Firstly, the MSD interventions have most commonly involved individual controls (e.g. lifting programmes, anti-fatigue mats), instead of combinations of measures which is the strategy recognised as having the greatest chance of reducing MSD (Warren, 2001; NRC-IOM, 2001; Silverstein, 2004). Secondly, these micro-level interventions have commonly targeted specific system elements or risk factors rather than all elements of the broader work system – a systems approach in other words (Hagberg et al., 1995; Buckle, 2005; Faucett, 2005). Thirdly, the interventions have not involved industry-level MSD risk factors, most likely because they are not perceived as being associated with MSD. Finally, increases in MSD risk have offset any positive effect of the interventions. This chapter is concerned with the second and third reasons, arguing that a broader range of MSD risk factors can be identified within meat processing than currently occurs, that these contextual factors are latent conditions for MSD in the industry, and that this approach is consistent with existing theoretical frameworks for MSD causation (NRC-IOM, 2001; Karsh, 2006).

In adopting contextual factors as the level of analysis for understanding MSD risk in the meat processing industry, this chapter has sought to understand and characterise the role or influence of these factors in maintaining the high incidence of MSD in this sector. In doing so the intention has not been to minimise or ignore the importance of physical risk factors in MSD aetiology. On the contrary, the study has sought to examine the role that contextual factors have in creating conditions under which physical and psychosocial factors can occur. While MSD research has increasingly focused on the role of organisational risk factors (Bongers et al., 1993; Carayon et al., 1999; Shannon et al., 2001; Devereux et al., 2004), this study examined a wider group of external and internal contextual factors, including cultural and social influences on MSD risk (NRC-IOM, 2001; Karsh, 2006). The attention to these factors reflects their important role in producing conditions of work that result in high MSD incidence. Cultural factors, for example, were found to impact on workplace issues such as flexibility in job design and training provision, while issues such as ‘blame the victim’ and ‘work through the pain’ values are significant barriers to effective prevention. Economic and political forces have produced change across the industry that has contributed to increased MSD risk, while payment systems used across much of the industry further encouraged an overwhelming productivity focus and culture of speed in the production line.

The study has theoretical implications for MSD analysis and prevention. Karsh’s (2006) integrated model highlights where contextual risk factors for meat processing fit in a causation model. This study provides support for Karsh’s model, where wider cultural, social and economic influences can be critical precursors to exposure to physical and psychosocial MSD risk factors in the industrial workplace. The contextual factors that became evident during the data analysis are an important finding for the overall study of which this chapter is one part. In many cases, they indicate the presence of industry-level MSD risks hitherto unrecognized by the industry and therefore unaddressed, necessitating their inclusion in the participative development of interventions that subsequently occurred. The method for determining contextual factors and themes was also robust.

The findings of the study also give rise to the issue of prevention. While changes to physical aspects of meat processing work, such as improvements in knife sharpness and maintenance may be relatively easy to implement, wider economic, political, social and cultural influences are often beyond the direct control and influence of the industry. However, the first step to addressing the problem associated with such contextual factors is to recognise their influence on what occurs in the workplace. In doing so, the industry can begin to adopt a change in mindset towards the problem and consider options for reducing the influence of external contextual factors such as seasonality, customer and regulatory requirements and human resource issues, while addressing more directly the internal contextual factors such as cultural influences and payment systems.

Lessons from this study for the prevention of MSD include the requirement for a long-term, multi-faceted approach. Industry ownership of the issue is required, from recognising the risks to developing solutions to them. There is a need to change industry attitudes from contemplative to preparing for change where possible (Haslam, 2002), with the rationale that the pre-contemplative will be dragged along by momentum of changes by others. It is also essential that the whole or majority of the industry is involved. While the scale of such an undertaking may make it harder to develop momentum, it means that external contextual risk factors will at least be recognized if not addressed. It also means that interventions become industry standards not just company standards. Support is necessary from larger companies and also from the employee advocates so that momentum for change can be created, particularly for more entrenched risk factors such as extending season length, reducing physical task requirements, and changes to payment systems.

4.3.8 Value of the participative ergonomics approach to study outcomes

Involvement of the MIHSF in this stage of the study was limited to providing input into the method for selecting sample plants, piloting assessment methods and collaborating on injury prevention workshops for meat processors. However, the adoption of a participative approach to this research played a vital part in industry acceptance and ownership of the findings of the study, and a commitment to addressing the issues at the heart of the MSD problem in meat processing. The industry is beginning to understand the implications of not addressing contextual risk factors for the future of an industry where human capital is increasingly scarce and the importance of employee retention, health and longevity of employment are crucial elements to their survival.

4.3.9 Limitations of the study

As with all such fieldwork, the study had limitations. Some of these have been noted in earlier sections (e.g. weaknesses of observer-based postural analysis), while reflection on the processes in this chapter has highlighted others. There was some variation in the data that could be collected for each site, although this was not thought to markedly impact on the quality of information gathered. Variations in levels of awareness about MSD among the staff interviewed affected their responses, as they received no prompts regarding MSD risk factors. Similarly, staff interviewed in work areas with genuinely lower MSD incidence had less to say about MSD and associated risk factors. Therefore, it is possible that with a different sample of plants there would also be differences in the summary of contextual factors. There was some conflict between the aim of achieving a non-directive approach (Oppenheim, 1992) and establishing rapport with the interviewees, which may have introduced bias into the interview. The researcher was also reliant on the support of the MIHSF members, and particularly the union, for encouraging plant participation. This may have affected the amount and nature of the data provided, as well as the composition of the plants involved.

The number of staff involved in processing each species is not known. Therefore the proportion of staff interviewed for each species cannot be determined. This is countered somewhat by many staff being involved in processing multiple species and reflecting on their general experiences in meat processing, rather than those related to a species.

While the threshold levels for contextual factors were low in some cases, it could be considered noteworthy they were mentioned as much as they were, as people received no cues on what MSD risk factors might be. An interesting exercise would be to interview meat processing staff under the same conditions, but using the list of contextual factors as an interview tool.

The sample of meat processing sites represented only one-third of the New Zealand industry, meaning a possible bias towards companies willing to participate and their perspectives on MSD. Time on plant collecting data was only a snapshot of the work system and could not account for task variations. Similarly, the extent of any observer bias was unknown.

The involvement of plant representatives, for example through plant health and safety committees, might have enabled more transfer of ideas and active involvement in making changes. However, there were insufficient resources to undertake this across a large enough sample, and would first require the establishment of committees in plants without them. Similarly, more involvement of the MIHSF in the data collection and analysis while desirable, would also have been beyond the scope of the resources available. Given that the MIHSF is voluntary and reduces their available time for their paid tasks, it may well have had the opposite effect.

4.4 Conclusions

This study has made an important contribution to the understanding of MSD causation and prevention in the New Zealand meat processing industry. Moreover, the implications for research in similar industry settings both in New Zealand and internationally are significant, where the aim is to understand the broader context for the presence of physical and psychosocial risk factors in the workplace, and to develop effective and sustainable solutions that address the underlying causes of exposure to physical risk factors for MSD. Such research may require an industry-level participative ergonomics approach, and a willingness to confront and break down prevailing attitudes across the industry that stand as solid barriers to the prevention of MSD. The first step to achieving such a change is to identify and analyse the role of external and internal contextual risk factors and help the industry to understand the implications of not addressing the MSD problem at this level.

The next chapter discusses the development of industry-derived MSD interventions with the MIHSF, and the combination of the interventions along with other data from the study into a single document for use by the industry. Chapter 5 also considers the level of success of the industry-level participative approach, including feedback from the MIHSF members involved.

Chapter 5. Participative development of MSD interventions

5.1 Introduction

5.1.1 Background

Stage two of the study concerned the collection of task-specific and task-independent data on MSD risk factors, interventions and implementation barriers from a representative sample of processing plants. Chapter 4 reported on the MSD risk factors identified from this process. This chapter completes stage two by reporting on the MSD interventions and implementation barriers collected at the same time as the risk factor data. The chapter also reports on the third and final stage of the study: the process of working participatively with the Meat Industry Health and Safety Forum (MIHSF) in developing the interventions for use by the industry in reducing MSD risk. A survey of MIHSF members regarding their involvement, eighteen months on from completion of the study, is also included in this chapter.

The task-specific approach provided a consistent focus for the site visits, as with identifying MSD risk factors, and was well accepted by industry staff involved. A number of the interventions and barriers identified were task-specific, but the majority were task-independent, concerning plant, company and industry-level issues. Some 276 interventions were identified and organised under 28 headings. The majority of the interventions were those raised by industry staff during the semi-structured interviews. Additional data were included from the Health & Safety Staff questionnaire (chapter 3) as well as from the literature on MSD interventions (chapter 2).

MSD intervention ideas were collated, summarised and prioritised. The methods for each of these steps were developed and evaluated with input from industry contacts and colleagues. A document containing interventions, implementation barriers and risk factors was developed with the MIHSF. The final version of this document was distributed widely to people at all levels of the industry.

The participative role played by the MIHSF in this stage of the study mostly involved determining the content of the intervention document and prioritising the interventions within it. This relationship, established during the study, was convenient for the MIHSF but less participative than was initially anticipated by the researcher. The pre-existence of the MIHSF, the many health and safety priorities in which it is involved, and the fact that MIHSF members only have a limited amount of time to give to the role, are some of the more significant reasons for this. The participative relationship with the MIHSF is discussed further in this chapter, including findings from the survey of MIHSF members.

5.1.2 Aims of this chapter

1. To identify task-specific and task-independent MSD interventions and implementation barriers, based on data collected from a nationally representative sample of processing plants.
2. To heuristically prioritise the MSD interventions.
3. To collect and evaluate feedback from MIHSF members on the participative processes of the study in which they were involved.
4. To identify any issues for consideration in further research.

5.2 Methods

5.2.1 Introduction

From the outset of the study, the ideal outcome was to develop one document for industry that prioritised interventions to address MSD, including MSD interventions currently in use or planning to be used by others in industry, and which included relevant information such as risk factors and barriers. A single document would be more usable than having several that covered different results or were written for different industry sectors. Interventions that were from the industry were also likely to have greater authenticity and relevance, as well as a higher likelihood of being accepted and adopted than those developed by someone from outside the industry.

It was also essential that the MIHSF, as representatives of the industry, were involved in the development of the document. One of the anticipated advantages was that this would improve the suitability and specificity of interventions included in the document.

Asking the MIHSF to assign priorities to the interventions would also assist industry users of the document to make decisions about which interventions were most worthwhile for them. Finally, involvement of the MIHSF was hoped to encourage a sense of ownership of the document so that they would use and promote it themselves beyond the life of the study.

With most of the MSD intervention data being collected from processing plants at the same time as MSD risk factor data, many of the methods from Chapter 4 are also relevant here. These are discussed in 5.2.3-5.2.5. Figure 5.1 outlines the steps followed in developing MSD interventions, from their collection and summarising through to MIHSF prioritising and dissemination

As stated in 4.3.1, credibility was an important factor in determining sample size and methodology. Chapter 4 provided details on ensuring industry representativeness, while this chapter will cover development of the interventions by the industry. Prior to this study, only a narrow range of MSD prevention strategies had been implemented in New Zealand meat processing. While Slappendel et al. (1996) applied a systems approach to the assessment of injury risks in three processing plants, findings were not seen by the industry as being representative and a lack of industry ownership resulted in MSD interventions languishing in a written report, unread by many in industry. The present study was therefore an opportunity to apply a systems approach across a representative sample of meat processing plants, to identify industry-derived MSD interventions, and encourage greater ownership and acceptance of their own ideas for reducing MSD. The methods described in this section reflect these intentions.

Intervention data collected from the sample of processing plants were collated and grouped under headings. Relevant data from the health and safety staff questionnaire conducted in stage 1 (refer to Appendix 3) and evidence from the literature were also considered in support of the interventions. The requirement of collecting information and opinions from as many staff as possible about the nature of their work applies equally to MSD interventions as it does to MSD risk. Similarly, data collection involved task-specific and task-independent approaches.

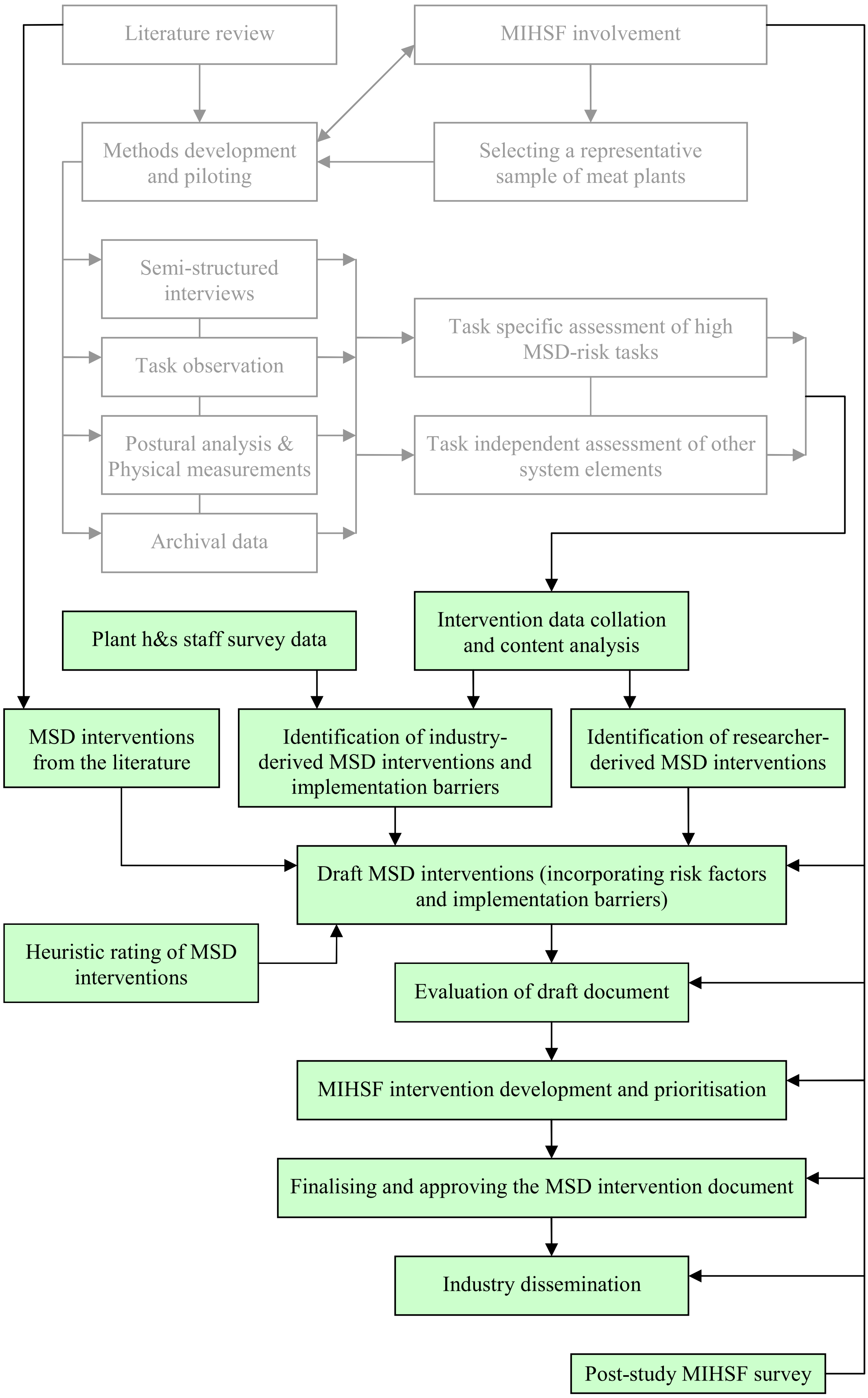

Figure 5.1. Methods used in identifying and developing interventions for addressing meat processing MSD

The process of collating intervention data through to disseminating the final intervention document to industry took more than a year and involved several stages. These stages and the timeline over which they occurred, are illustrated in Figure 5.2. This flowchart is an elaboration of parts of Figure 5.1, and refers to relevant sections of the chapter providing more detail. The central bold boxes depict the different versions of the document from raw data through to the final report for industry.

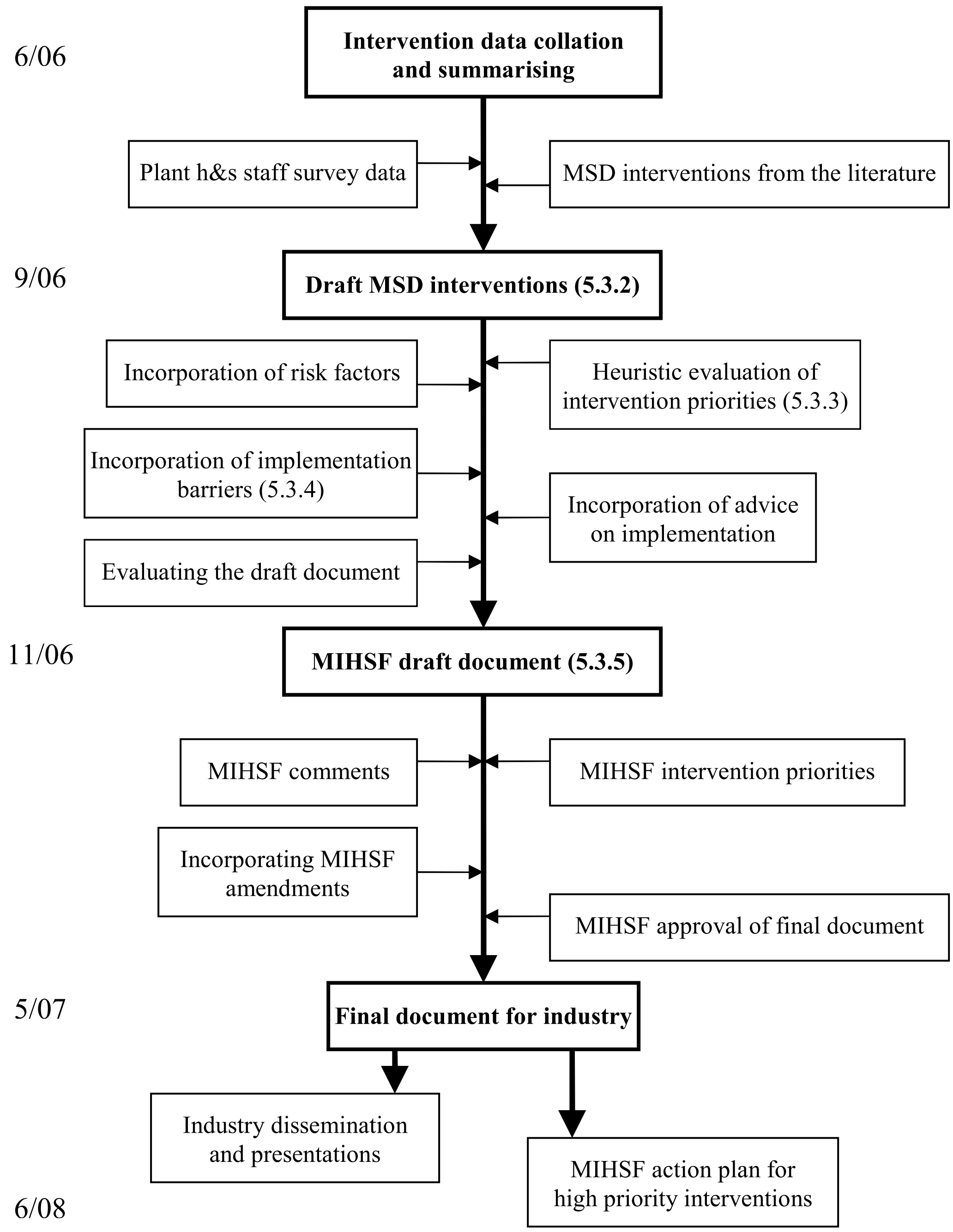

Figure 5.2. Data sources included in the development of a single document for industry

To provide some initial guidance to the MIHSF, and ultimately to the users of the final intervention document, each intervention was prioritised on its potential to reduce MSD and on its breadth of industry applicability (section 5.3.3). Information on risk factors, implementation barriers (section 5.3.4) and approaches to implementation were also included under each intervention heading. Piloting of the prioritising method and the draft intervention document was undertaken using members of the research team and industry stakeholders.

Participative development of the intervention document by the MIHSF was the final and most crucial stage of the intervention development process (section 5.3.5). MIHSF members were asked to rate each of the interventions against three criteria, as well as provide input and comment on the draft document. Members were invited to respond individually and as a group. A workshop was held to reach consensus on the interventions included and the priorities assigned to them, from which a final document was developed for dissemination to industry.

5.2.2 Meat Industry Health and Safety Forum Involvement

MIHSF were heavily involved in developing and finalising the document sent out to industry; a process which took several months to complete (refer to section 5.2.10). This involvement included prioritising each of the final intervention groups on their likely impact on reducing MSD and likelihood of implementation. Individual MIHSF members also continued to be involved in piloting assessment methods throughout the stages of intervention development.

5.2.3 Selecting the sample of plants & piloting task assessment methods

The steps involved in selecting which plants to involve and determining how to best utilise the time on site for collecting data on MSD are described in detail in sections 4.2.3 and 4.2.4 of Chapter 4.

5.2.4 Semi-structured interviews

As described in section 4.2.5 in Chapter 4, semi-structured interviews were conducted with plant staff including: those engaged on high MSD-risk tasks, other staff working in related tasks, supervisors, health and safety staff, union officials, and managers. Interviews lasted between ten and ninety minutes, and were conducted in a range of settings, including the production floor, 'smoko' (lunch) room, and offices alongside the processing areas. The semi-structured interview schedule consisted of nine questions, related to their current place of employment, covering: high MSD-risk tasks, MSD risk factors, MSD interventions, their success and implementation barriers. The semi-structured interviews were a way of reporting on how the sample of processing plants were managing MSD, including what they were doing, or wanted to do, and how barriers might be overcome. Predictably, responses for question 3 ('What have they done to address MSD?') was where most interventions arose. Prompting ('what else have they done') was required in most cases to elicit further interventions. Occasionally, people approached the researcher some time later as other interventions occurred to them after the interview. The nine semi-structured interview questions are included in Appendix 5.

The same interview schedule was used for all staff in all roles so that there was consistency in the data collected and to avoid the potential for delays in data collection (where time was often restricted). Additionally, there was not always a clear demarcation initially between processing staff and management (e.g. the roles of training officers, leading hands, and supervisors who also work on the line), particularly in smaller plants where staff have multiple roles.

Four of the nine questions concerned interventions, namely: identifying existing prevention methods, their level of success, factors that prevented MSD in situations with low incidence, and interventions that were planned or that respondents would like to try. No prompts were provided to elicit specific MSD interventions. Follow up questions were asked to clarify points concerning interventions (e.g. differences in terminology, the extent of changes that were made and how their effects were measured, and differentiating between planned interventions and individual ideas for change). The desire to extract MSD interventions wherever possible, including situations with no reported MSD, was the reason behind asking questions regarding actual, planned and desired interventions and potential barriers.

The main purpose of the questions was to create a list of interventions that were industry-derived, rather than a list compiled by someone external to the industry. Not only would the interventions be more specific to meat processing, but the fact they were actually from people in the industry would help to overcome the barrier of credibility. The type of sentiments expressed by plant staff included, “if other meat processors are already doing it then it must be feasible” and “if they’re considering doing it, then perhaps we should too”. This also applied to the identification of implementation barriers, which in many cases were an integral part of the final intervention (e.g. inability to rotate without further task training). Other potential implementation barriers were unlikely to have been identified without asking people in the industry (e.g. different cultures between departments or shifts).

5.2.5 Observation, postural analysis, measurements & archival data

Details on how these methods were applied at the plants are described in sections 4.2.6-4.2.8 in Chapter 4. While their main purpose was to help identify MSD risk, there were some potential interventions identified as well. These were discussed with staff to determine their feasibility, and relevant interventions were included in the draft document.

5.2.6 Developing draft MSD interventions

Making sense of the large number of interventions generated from the semi-structured interviews took place in two steps. The first step was to remove repetition by summarising interventions and record the evidence for their inclusion. Data were then sorted into themes that emerged throughout the data collection process. The second step was to draft the interventions into a format that would make sense to members of the MIHSF, and would be straightforward for them to provide comment on.

For the first step, an initial total of 587 interventions were collected during the semi-structured interviews, from which 254 different interventions resulted after collating and summarising the interventions. The summarising process involved combining identical interventions and rewording others slightly to incorporate very similar interventions. The purpose of this step was to reduce the total amount of information that would be included in the intervention document through repetition or redundancy. Data from questions 12-14 of the health and safety questionnaire conducted in stage one of the study (section 3.2.5; appendix 3) were added to the supporting evidence for interventions from the semi-structured interviews (all interventions from the questionnaire data had been mentioned in the plant interviews). Where relevant, supporting evidence from the literature on MSD interventions in meat processing was added to the interventions. While the emphasis was on interventions arising from within the industry, a small number of other interventions (n=22) were also added to the list, derived from the literature and task observations.

All the resulting interventions were then organised under 28 headings (themes), which included some amalgamation of related headings (e.g. workspace design and equipment design). The intervention headings were intended to provide a framework for considering interventions systematically, rather than simply as a long list of possible ideas. The headings also matched those used for the MSD risk factors.

The decision on what information to present to the MIHSF went through much iteration. For the MIHSF and the industry, the most important information was the interventions themselves. However, the rationale for their inclusion and the priority assigned to them were considered by the researcher to be equally important. Both of these factors would help people decide whether an intervention was worth considering for their particular situation. For example, how many plants have tried, or would like to try an intervention, is anecdotally considered by people in industry to be strong enough evidence to consider doing it themselves. Evidence from the literature of the success of interventions provides a further strand of support. Accordingly, this information was recorded for each of the 276 draft interventions. Table 5.1 lists the column headings used for the first and second drafts summarising the intervention data. Column headings were combined for the second draft to reflect the nature of the intervention data. The inclusion of species was found to be redundant as most interventions were independent of animal type, or would affect all species equally. The exceptions were the task-specific interventions, for which species was included in the intervention heading. As not all interventions had been tested for their level of success this was simplified to state whether plants tried the intervention, although the pragmatism of the industry would suggest that unsuccessful interventions would quickly be reversed. Evidence from the literature was scant compared to the number of interventions, therefore combining these two columns into one made sense from both the perspectives of content and readability.

Table 5.1. Possible sources of evidence for the draft interventions

Column headings for the first draft	*Column headings for the second draft*
Species	-
Interventions tried by plants (n)	Interventions tried by plants (n)
Interventions found successful for plants (n)	-
Interventions they are planning to implement (n)	Interventions they are planning to implement (n)
Interventions suggested in the literature	Interventions supported by the literature
Interventions tested in the literature	-
Interventions from the H&S staff questionnaire	Interventions from the H&S staff questionnaire
Interventions identified by the researcher	Interventions identified by the researcher

The second step of deciding on the format and content of a document for the MIHSF was also paramount. The volume of industry-derived interventions was already very large, and this would increase further with the addition of information on the study, MSD risk factors, barriers and approaches to implementation. Determining what to include became a compromise between completeness of information and its usability by the MIHSF, while also considering its eventual use by people in the industry. It was important that the information was accessible, understandable and concise. On this basis, the decision was made to tabulate the data under each of the intervention headings as this would reduce the overall volume of information. Tables were also perceived to be easier to comment on than free text. Other perceived advantages of using a table format included it being easier to compare evidence and priorities for interventions, and that they enabled the separation of risk factors and implementation barriers from the interventions.

5.2.7 Prioritising the draft interventions

As the intervention data were summarised, it became apparent some form of prioritising was needed to help users of the intervention document in industry make sense of the long lists of interventions and provide them with a tool to gauge their relative importance. While the plant-related evidence improved credibility, a rating assigned to each intervention would help people make decisions on which interventions to implement by adding to a sense of perspective between high and low ratings, and would enable comparisons between them. Prioritising the interventions would also assist, along with the intervention headings, in breaking up the large amount of information and would create another way for interventions to be sorted or categorised. Finally, as the interventions were industry-derived, the addition of priorities - particularly by the MIHSF, would provide further validation of the interventions for people using the document in industry. Initial intentions were to present the most highly rated interventions separately from the rest. However, after consideration it was felt that this would weaken the process by implying that the rating was more important than other sources of evidence, by effectively underemphasising the remaining interventions, and by making it more difficult for people to choose from the full range of interventions those ideas that best suited their needs (given the heterogeneity of the industry).

Having decided to add priorities to the interventions, the next task was to determine the criteria against which to prioritise the interventions. Different criteria were proposed to match the knowledge of the researchers and the MIHSF, as it was envisaged both groups would separately prioritise the interventions. The researcher priorities were planned to provide initial guidance to MIHSF members in differentiating between the interventions and to highlight interventions that the researchers saw as the most important. The addition of MIHSF priorities in developing the final document for industry were intended to improve credibility of the document, and help to illuminate those interventions seen as having most merit.

The evolution of the prioritising criteria for researchers' and the criteria proposed for the MIHSF evaluation went through a number of stages of iteration. Following various modifications, the final criteria used by the researchers' were: the predicted effect of the intervention on addressing key MSD risk factors (the extent to which they might be reduced), the breadth of industry applicability (at a task, department, species or industry level), and the opinion of the researchers' on the overall merits of the intervention. The third criterion drew from the researcher's experience in meat processing and MSD prevention, as well as from the data supporting the interventions (number of plants involved and any evidence from the literature). A combined priority was given for each intervention from 1-10 (with 1 being highest priority). Final criteria for the MIHSF prioritisation were unchanged (predicted industry acceptability, predicted ease of implementation, and the likelihood of implementation), but a combined priority of between 1-10 was suggested, so that the scale was consistent for both MIHSF and researchers.

The decisions to include the opinion of the researchers in the prioritising process, and to include these priorities in the draft document for the MIHSF, were made to provide MIHSF members with some guidance when commenting on the document themselves. This triangulation of information sources and synthesis into a priority drew heavily from experience in industry consultancy and research, where the expectation is to provide an expert opinion about the data presented (bearing in mind that the remainder of the draft intervention report was a summary of data from people in the industry, not the researchers). This mirrored the way the meat processing industry made decisions, providing them with the strongest information from which to generate discussion and then make an informed decision. This required a compromise between providing as much detail as possible but without detracting from the important elements.

Despite the preparation and evaluation of these final criteria, there were still limitations to them. Piloting of the criteria was limited by the timeframe of the study and the time that industry contacts had available. On reflection, the decision to rate interventions on their impact on MSD risk factors was flawed as there is rarely a direct link between MSD risk factors and interventions. Although significant interventions (e.g. reducing work compression) were more likely to reduce MSD risk than others (e.g. annually updating staff induction document), the priority was highly subjective.

However, as stated earlier, the main reasons for including these priorities were as a guide to help people make sense of the interventions, gauge their relative importance, and enable comparisons between them, while the most important component of the document were actually the interventions themselves. Different criteria may have produced different priorities, but the overall impact on the draft intervention document would have been minimal. The document sent to the MIHSF for their development is further discussed in 5.2.10.

5.2.8 Heuristic evaluation of intervention priorities

The aims of this process were to assign a priority to each of the draft interventions to guide MIHSF and other document users, and to carry out a final check on the wording and layout of the draft interventions and supporting material. At first, the intention was to involve four members of the researchers' work team in the evaluation. This was reduced to the two people (of whom the researcher was one) who had the most experience in meat processing and MSD prevention in industry, which was a requirement of the evaluation process.

Development of the three criteria used by the researchers is outlined in 5.2.7. Prior to the evaluation, the two researchers discussed the prioritising criteria to ensure that they shared the same understanding of the process and would be as consistent as possible in applying the criteria. The two researchers independently rated each intervention for each of the three criteria using a scale of 1-5, with 1 being highest priority and 5 the lowest priority. The scores were added together, divided by three, and rounded to create a combined rating of 1-10. The rounding process is shown in Table 5.2. Interventions were then ranked under each intervention heading from highest to lowest priority.

An obvious limitation to this process was the unequal weighting given to priorities, particularly 1 and 2 ratings. Rating interventions out of 10 and then averaging them would have been more appropriate.

Table 5.2. Determining raw scores and a combined researcher priority for interventions

Raw score sum out of 30 (a)	*Score out of 10 (a/3)*	*Rounding to 1-10*
6	2	1
7	2.33	2
8	2.67	3
9	3	3
10	3.33	3
11	3.67	4
12	4	4
13	4.33	4
14	4.67	5
15	5	5
16	5.33	5
17	5.67	6
18	6	6
19	6.33	6
20	6.67	7
21	7	7
22	7.33	7
23	7.67	8
24	8	8
25	8.33	8
26	8.67	9
27	9	9
28	9.33	9
29	9.67	10
30	10	10

5.2.9 Evaluation of intervention development methods

The completed version of the draft intervention document was sent to two people working in meat processing, two research ergonomists external to the study, and to members of the research team for their formal comment. They were asked to comment on document structure, length and layout, readability, and whether the MIHSF member instructions made sense. Feedback from this testing resulted in only minor changes to the document layout and readability.

5.2.10 MIHSF development of MSD interventions for the industry

Before the interventions could be given to the MIHSF for their input, three further steps were required. The first step was to add a preamble to each of the intervention headings, which included a brief outline of the MSD risk factors and implementation barriers relevant to that intervention. This was intended to increase the usefulness of the interventions to industry users without detracting from the main information, which were the interventions themselves. The second step was to add introductory information to the document which briefly summarised the study, explained the structure of the document and gave instructions on what was requested of them. Thirdly, and finally, the research team, colleagues not involved with the study, and two industry contacts piloted the completed draft intervention document. Minor changes to layout and wording were made before sending the document to the MIHSF secretary for distribution to members. A literature review of MSD in meat processing was also sent to the MIHSF a month after the draft intervention document (Tappin et al., 2006).

Figure 5.3 is a page from the draft intervention document sent to the MIHSF, and is included to illustrate what information was presented and what was requested of the MIHSF. The intervention heading is Maintenance, with the header indicating this is in the group of Organisational Design interventions. Evidence supporting the interventions were included, along with the priority assigned by the researchers (known as COHFE to the MIHSF). The bolded boxes are where the MIHSF members were asked for their specific input.

MIHSF members were given a month to make initial comments, with the intention that a second draft of the report would be compiled based on their feedback, before being returned to them for their further input. However, many of the members requested further time to comment on the report due to its length, some uncertainty about the feedback process, and the approaching seasonal peak in processing. As a result, a full day workshop dedicated to the intervention document was organised for a date three months later, after the peak in lamb processing. In the intervening time, queries by individual MIHSF members were answered clarifying what information they were being asked to provide, as well as aspects of the interventions. During this three-month period, ongoing contact between MIHSF members continued to occur concerning the intervention document as well as other MIHSF initiatives unrelated to MSD. This was seen as desirable as it ensured they maintained control over the intervention development process, and hopefully greater ownership of the outcomes.

Musculoskeletal Disorders in Meat Processing: draft interventions. ***Maintenance (Organisational Design)***

Maintenance

MSD key risk factors and implementation barriers
Poorly maintained equipment can increase MSD risk through the raising of force requirements, elevated noise, introducing unexpected forces and resistances, and imposing additional handling steps or complexities. Barriers include limited time available for preventive maintenance and lack of allocation of responsibility.

Recommended intervention approach
Pragmatic initial plant selection and design, well-functioning preventive maintenance program and prompt-response repair systems reduces these risks.

Current interventions in the 28 plants **- in order of potential to reduce MSD risk nationally, as judged by the research team**	Plants already doing it	Plants planning to do it	Support for it in the literature	COHFE priority rating 1=highest 10=lowest	***Your priority rating*** *1=highest 10=lowest*
1. Good preventive maintenance system (rollers, castors, rails, etc).	3	2		3	
2. Involvement of engineers in plant problems and redesign issues.	1			4	
3. Have separate contract cleaners - reduces total work hours for processing staff, especially important during season peak.	4			5	
4. Spare conveyor belts available on a trolley in case of breakdown.	1			5	
5. Want to train maintenance staff on: principles of MSD prevention relevant to their role, requirements of tasks on which they have an impact (e.g. sharpening flay knives), and to be more efficient/knowledgeable on machines (reduce repair time).		3		5	

Other intervention ideas you have, and potential barriers to these ...

33

Figure 5.3. An example page from the draft intervention document for the MIHSF

Discussion took place between the MIHSF secretary and the researcher on preparation of the workshop. Members were sent reminders of what they were required to do prior to the workshop, namely to rate each intervention, comment on them and add any material they felt was missing. It was proposed that at the meeting the discussion would be by intervention heading, dealing by exception with individual interventions where required. At the completion of the workshop, members would provide the researcher with the intervention document containing their priorities and comments, which would be summarised as a group and included in the next draft.

The workshop took place in the usual venue for MIHSF meetings. Thirteen of the 15 members were present. The remaining two were asked after the workshop to send their feedback directly to the researcher. The workshop commenced with a presentation by the researcher, which along with the agenda and desired outcomes for the day also included an update of ACC MSD claims incidence for meat processing and other primary processing industries, a recap of MSD causation in meat processing and further explanation of the grouping and prioritising of the draft interventions.

The first point of discussion by the MIHSF was on the prioritising process. The group agreed on four significant changes. Firstly, rather than provide one combined priority (as described in 5.2.7), the MIHSF wanted separate priorities for the likely impact of interventions on reducing MSD and the likelihood of their implementation in the industry. Secondly, the decision was made to express the priorities as high, medium and low rather than from 1-10. Thirdly, the priorities would be given to intervention headings rather than individual interventions, and finally, the MIHSF would agree on priorities as a group rather than as individual members. The rationale behind these changes was partly for expediency – making it feasible to cover all the material in one day and making it easier to reach agreement on priorities, and partly to improve the usefulness of the document for themselves by having priorities that were meaningful to them. While the inclusion of these priorities may have less meaning to other users of the document in industry, this was a welcome sign as it indicated a significant degree of ownership of the intervention report. The remainder of the workshop was spent discussing amending the interventions and assigning their priorities.

Once changes from the workshop were made the intervention document was sent back to the MIHSF for final checking and agreement to release it to industry. The final document (Tappin et al., 2007) was then distributed widely through the network of contacts established during the study along with a copy of a literature review on MSD in meat processing written for an industry audience (Tappin et al., 2006).

5.2.11 Post-study survey of MIHSF members

Eighteen months after completion and dissemination of the final report to industry, MIHSF members were asked to take part in a telephone survey, discussing their involvement in the study. The aims were to ascertain: how much control they feel they had in the study, their views on the level of involvement, what they would like to have changed and why, and their opinions on the usefulness of the final intervention document. The survey form is included as Appendix 7. The survey drew from Oppenheim (1992), Sinclair (2005), Moore (1994), Moore & Garg (1994), and Haines et al. (2002) for the initial design, and was piloted among members of the research team before being finalised. A telephone survey was chosen over a postal questionnaire as experience indicated that the response rate and amount of discussion was likely to be higher, possibly due to the lower priority given to MIHSF tasks compared with their main role and reluctance to commit their thoughts to paper. The researcher conducted the survey as it was felt that MIHSF members would be more likely to speak their mind to someone they knew rather than a third party, given the importance placed by them on industry credibility and relationships. This was a rare opportunity to provide an evaluation of a participatory ergonomics project – an identified shortcoming in the participatory ergonomics literature.

5.3 Results

5.3.1 Introduction

Results in this section are structured according to Figure 5.2, which is repeated here.

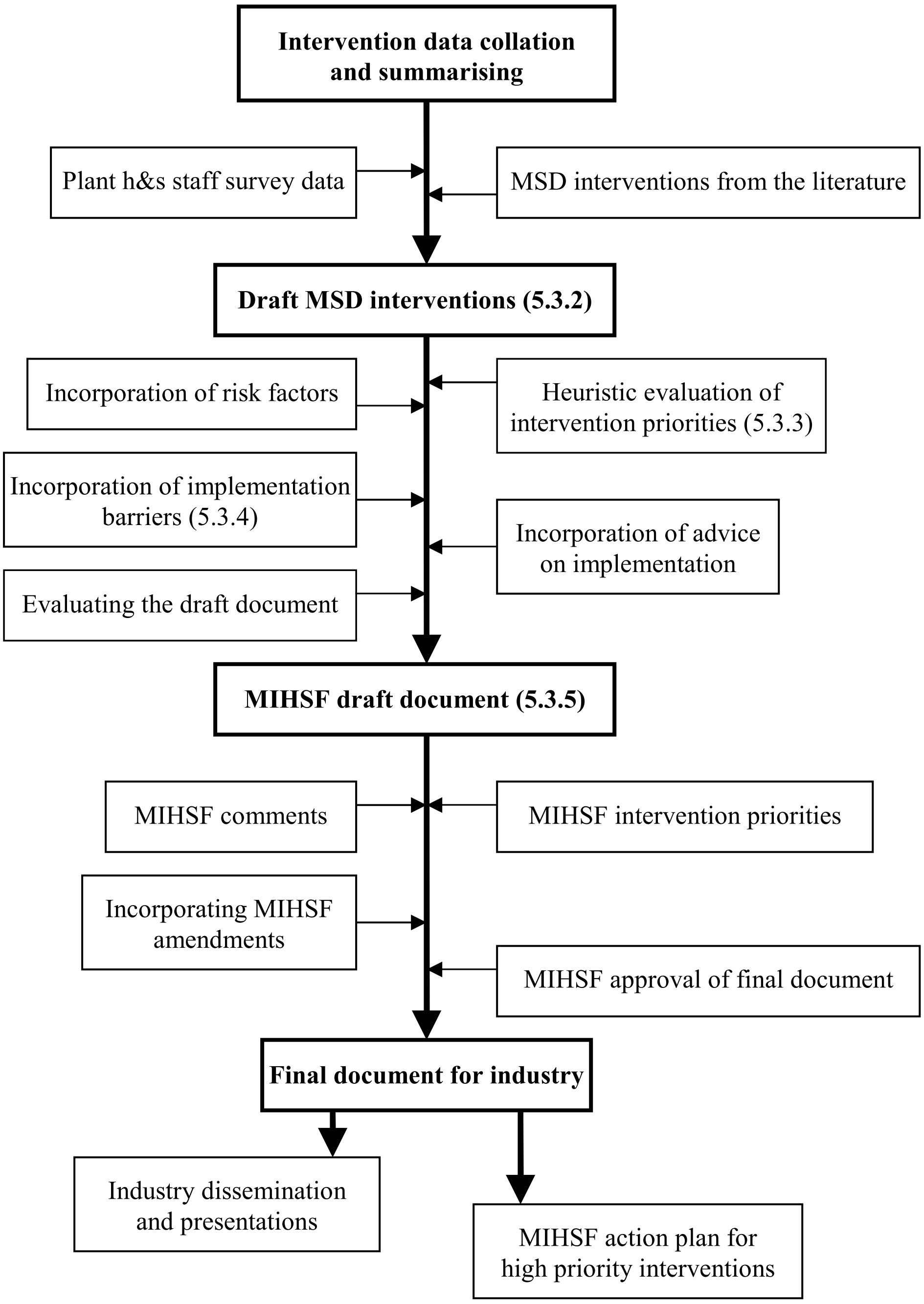

Figure 5.2. Data sources included in the development of a single document for industry

5.3.2 Draft MSD interventions

MSD intervention data were collated and summarised under the 28 intervention headings. Intervention headings were grouped into five categories (Job design, Organisational design, Physical Design, Training design and Task-specific design) to further assist users of the document in navigating their way around the document, and as a possible structure for deciding on changes in their own plant (Table 5.3).

Table 5.3. MSD intervention headings and categories

Job design	*Organisational design*	*Physical design*	*Training design*	*Task specific design*
Task rotation	Recruitment / retention	Plant design	Task training	Sheep/beef packing
Rest / recovery breaks	Work flow	Workspace and equipment design	Knife sharpness training	Aitch boning
Work pace	Remuneration / job grades	Knife and glove design	MSD awareness training	Sheep gutting
Physical task requirements	Job allocation	Thermal environment		Beef boning
	Attendance	Noise		Y cutting
	Staff participation			Beef gutting
	Shift design			
	Health & safety management			
	Early reporting and injury management			
	Maintenance			

The resulting 276 interventions therefore incorporate data from the semi-structured interviews of 237 meat processing staff (5.2.4), the questionnaire responses from 44 people responsible for health and safety at these processing plants, support from the MSD literature, and intervention ideas from the researchers derived from the task assessments (5.2.5) which did not arise from other data sources. Due to their length, the draft interventions and their supporting evidence are included as a table in Appendix 8.

The first two columns alongside the interventions in Appendix 8 contain data from the semi-structured interviews and indicate the number of plants at which the intervention was raised. This was considered the source of evidence most likely to be taken seriously and to convince other plants to change. It was also simple data to convey alongside each of the interventions. Consideration was given to including the number of people who mentioned each intervention, but this information was found to be possibly misleading without including the number of plants as well, while also adding unwanted complexity to the interventions. The numbers were not a count for all the plants assessed, but were simply those interventions mentioned by plants as steps they have used to address MSD.

Approximately 30% of the interventions concerned the seven high MSD-risk tasks (task specific) discussed in chapter 3. The remainder concerned broader work system issues (task independent). Data for question 4 of the semi-structured interview schedule ('How successful have these measures been?') were limited as none of the measures had been formally evaluated. As the responses were anecdotal, they were not recorded as a separate dataset.

Question 5 ('If there are no MSD, what do they do that prevents them?') proved extremely useful in deriving MSD interventions from plants with low reported MSD incidence or those who perceived that their MSD risk was low. More prompting was required to elicit interventions than with question 3. Some of the interventions were implemented for reasons other than injury prevention, but had the additional effect of reducing MSD risk (e.g. setting maximum daily tallies, actions taken to recruit and retain staff). Question 7 ('Are there any other interventions planned, or ones you would like to try?') gave people a chance to include their own ideas. While this question could record two separate sources of data, often they were synonymous with each other. For example, some people raised ideas that could be easily implemented and that involved issues that were under their control, but were just waiting for the right timing to implement them (the off-season or availability of funding). However, separating this question into two might have resulted in findings that were more specific.

The next two columns in Appendix 8 indicate where there was support from the health and safety staff questionnaire or the literature on MSD in meat processing. Information from the literature was also included in the preamble to each intervention heading added later in the development of the intervention document. This information included first principles or general guidance that did not sit neatly in the list of interventions (e.g. senior management commitment, job enrichment/enlargement considerations). An additional consideration was to avoid detracting too much from the list of industry-derived interventions. The final column includes intervention ideas raised by the researcher. These were limited to occasions where potentially useful interventions were not otherwise mentioned by the industry (e.g. maximum tallies by work period) or for successful interventions used in similar industries (e.g. carton design handles and sizes).

5.3.2.1 Examples of interventions

The following text provides brief examples of interventions for each of the 28 headings.

Work pace: the four interventions grouped under this heading all concerned the compression of work periods. While the number of plants mentioning compression was relatively low, there is support in the literature for reducing it.

Task rotation: many plants had implemented some changes in task rotation. Most involved some aspect of informal rotation such as training, timing, and consistency in pay rates.

Rest / recovery breaks: around half of the plants mentioned these interventions. Most concerned the frequency and length of breaks away from the processing line, ranging from periodic short pauses to longer breaks in the middle of runs. (The industry already has well-established protocols for tea and meal breaks.)

Physical task requirements: few plants raised these interventions, which included making jobs physically easier for both new staff and older staff moving towards retirement. A comment from one supervisor reiterates these points,

> *"Industry has to overcome the lack of skills in new staff and better cope with an ageing workforce by designing out heavy work".*

The potential loss of 'mana' (prestige) as well as the loss of an enjoyable physical activity through making the task easier was mentioned as a barrier to implementation (Dempsey & Mathiassen, 2006; Slappendel et al., 1996).

Recruitment and retention: many plants had something to say on this issue, with low national unemployment being one of the main difficulties in employing and retaining staff. Interventions include arranging employment in the off-season, retaining staff through lulls in work, and actively recruiting staff from outside their region.

Work flow: there were a large number of points on this topic, which were grouped into 23 interventions. Most were quite specific to species, task or work area (e.g. using spray chillers, boning temperature, order of animals processed). However, others applied to all plants, such as matching tally to grade and staff numbers, and flexibility in allocating jobs to staff.

Remuneration / Job grades: the small number of interventions mentioned here included: setting maximum work hours by shift/week, simplifying job grades and payment levels to reduce barriers to task rotation and covering for absent staff.

Job allocation: most of the seven interventions under this heading concern seniority, and the desire to use other measures as well in allocating jobs. This is a highly emotive issue for everyone involved, and is stated as being a barrier to many ideas for change. As one manager put it,

> *"Seniority gives you a position, it's a nonsense that seniority has been the only factor in promotion and allocation of tasks."*

Attendance: while many staff held concerns regarding absenteeism and the pressure this placed on the remaining staff, relatively few interventions were mentioned that addressed these concerns. Interventions focused on how to manage the work (i.e. ensuring continued production) with high levels of absenteeism, rather than addressing the absenteeism itself. This was reflected in the following comment from one plant,

> *"We man to cover our average absenteeism, so if six people are off normally we staff the chain to 81 not 75".*

Staff participation: approximately half of the plants in the sample stated that staff were involved in changes to the plant, from concept development through to some form of trialing. The extent of this involvement was unsubstantiated in all but two cases.

Shift design: most of the eight interventions concerned run and shift length. As with attendance, many of the interventions were initially made in response to absenteeism, staff turnover and practices such as double shifting.

Health and safety management: of the four interventions only one had been implemented (greater autonomy for the occupational health nurse), with several plants also making plans for increasing the priority of health and safety.

Early reporting and injury management: fourteen initiatives were mentioned, with most plants contributing. With the high incidence of MSD in the industry and the amount of time spent managing them, these strategies are what many people in industry view as MSD prevention. They included: alternative duties, early reporting, and the assistance of health professionals on site. In lieu of addressing risk factors, physical strength and fitness were instead emphasised, for example,

> *"People who do well at boning are those who are physically fit outside work."*

Maintenance: interventions in place include preventive maintenance and having contract cleaners rather than processing staff on overtime. Some plants also wanted to train maintenance staff on aspects of MSD prevention.

Plant design: these interventions were quite narrow in their perspective, including such issues as consistent floor levels and unobstructed circulation space. Two further interventions were added that considered likely additions and changes over the design life of the building as well as space for training on line.

Workspace and equipment design: two plants had put significant effort into redesigning their slaughter and boning work areas and important principles were included as interventions. Surprisingly, relatively few other interventions had been implemented, however there were a number of plants wanting to make changes such as height adjustable worksurfaces and mechanised conveyors.

Knife and glove design: five interventions were included under this heading, one concerning glove trialing, the remaining four relating to knife design and trialing.

Thermal environment: three interventions were raised concerning drafts and footwear. Intervention ideas were included on thermal clothing and localised cooling feasibility.

Noise: two interventions focused on hearing protection, making it possible to communicate more easily in noisy working/training environments. One further intervention referred to reducing noise levels to enable more effective communication.

Task training: As task training for both new and existing staff is an accepted business activity, almost all plants contributed an intervention that they felt was successful in reducing MSD risk. Many of these concerned training of new staff with initiatives such as off-line training facilities, full-time trainers, and modified task technique. Staff were generally quite passionate about the topic and typical comments included,

> *"Working well is about finding your seams (between muscles in the meat), getting your rhythm, with a good (knife) edge."*

> *"In the first three months you can do a lot of damage to people, so it's important that they learn the skills first before adding the speed."*

Knife sharpening training: The introduction of a knife sharpening programme by one large company and its dissemination by ACC made this another topic about which the majority of plants in the sample had something to say, mostly about the merits of knife sharpening systems and full-time trainers. A typical comment in regard to knife sharpness was,

> *"People with a sharp knife have a smile on their face."*

MSD awareness training: There were fewer interventions on this issue. Ones that had been implemented were aimed at reducing discomfort rather than preventing it such as micropauses and stretches. Some plants wanted more information about MSD, again mostly focusing on physical design and personal avoidance.

Sheep / beef packing: the majority of plants raised interventions on this issue, many of them on workspace and conveyor design principles. Other interventions covered shared tasks, control of work pace and rotation practices.

Aitch boning: All twelve plants contributed to the interventions. Workspace design principles were commonly mentioned, along with ways to vary the task and reduce exposure (e.g. rotation, product variation, provisions in tally for absenteeism).

Sheep gutting: Most plants had made some changes to reduce the physical difficulty of this task. However, in many cases this was to simply to spread exposure to the task around a group of people through short rotation periods. Some plants also altered chain speed or staffing for larger carcasses. Two plants had made significant changes to the workspace design to reduce the physical effort required, while a number of plants were also planning physical design modifications for the same purpose.

Beef boning: Interventions included workspace design changes (e.g. rail heights, chute placement), and providing task variety through rotation and boning whole quarters/sides. The inclusion of mechanical assistance was also mentioned by one plant.

Y cutting: In half of the 12 plants, a counter-balanced brisket roller was stated as an intervention to reduce MSD risk. Other interventions: were task rotation systems and the inclusion of easy / rest positions in the cycle, sheep cleaning systems to reduce damage to knife edge, steriliser design and placement, and knife design.

Beef gutting: Five of the ten plants performing this task mentioned a height adjustable rail as being an important intervention in reducing MSD risk. Other interventions included: task variations and rotation, reducing gut content of animals, and gut buggy design for smaller plants.

5.3.3 Heuristic evaluation of intervention priorities

The inclusion of a researcher priority for each of the interventions was intended to provide further guidance to users of the document along with evidence from plants and the MSD literature for meat processing. The order of the interventions was changed to match the priorities that were assigned to them by the two researchers. Some minor changes were also made to the wording and layout to reduce ambiguity without altering the intent or vernacular used. The researcher or 'COHFE' priorities were included in the final intervention document to industry (Tappin et al., 2007).

Differences in the totals for each researcher are shown in Table 5.4. In 77% of the interventions the difference was less than two out of five. Most of the difference occurred in the criteria that rated the breadth of industry applicability of the intervention, particularly for the task specific interventions, with almost half of the differences of three or more occurring within these 81 interventions.

Table 5.4. Differences in rating totals between researchers for each intervention

Difference in rating totals between researchers (out of 5)	Number of cases	Percent of total interventions
0	63	23%
1	76	28%
2	72	26%
3	40	14%
4	19	7%
5	6	2%
	276	100%

There were very few high ratings resulting from the prioritising process. Apart from the unequal weighting for 1 and 2 priorities, another possible reason was that this reflects findings from the MSD literature on the favoured approach for addressing MSD, with multiple interventions targeting a range of risk factors. While it was not the intention of the researchers to emphasise this point through the prioritising process, in hindsight it was considered to be a useful reminder to users of the document not to rely on a limited range of interventions. Accordingly, this was included in the preamble of the intervention document for industry.

5.3.4 Implementation barriers

Questions 6 and 8 of the semi-structured interview asked participants about implementation barriers encountered in relation to the interventions they had mentioned. Comparatively few implementation barriers were found in the literature on MSD in meat processing, possibly due to the nature of many implementation barriers which are often quite specific to an intervention. Implementation barriers from the semi-structured interviews and the literature were grouped under twelve headings and are listed in Table 5.5.

Table 5.5. Implementation barriers identified during the study

Implementation barriers	Plants (n)	Literature
Job allocation		
Seniority can be a barrier to task rotation (cannot rotate onto higher ranked jobs).	10	
Seniority is also a barrier to staff retention as people are less likely to want to stay (hard to get on to better pay rates, and poor job security if they are low seniority). Plants may let these staff go first when work decreases whereas more senior staff stay.	4	Y
Departmental seniority is a barrier if people want to move departments (e.g. slaughterman wanting to go onto a labourers position as a move towards retirement) as they lose their seniority rank.	3	
Job opportunities have to be offered to the next in line. Might not be a good match with task - increase injury risk and potentially reduced production.	3	
People brought in to the plant out of seniority even to train (and above full manning levels) is a practice not accepted by union.	3	
Reluctance by people high on the seniority list to work in another area or be involved in other tasks (as part of a rotation) as any change to their seniority number will affect earnings (higher seniority means a longer working season).	2	
Too many A graders and not enough A grade jobs. This impacts on task rotation, and is a factor in absenteeism. Try to maintain their dignity by having the assessment method for task placement clearly set out in the contract.	1	
Seniority can limit rehabilitation options - may not be able to work on another task (alternative duties) during their rehabilitation.	1	
Task rotation		
Different pay rates creates a barrier to task rotation. Higher paid staff won't rotate to lower grade jobs if they only get paid at the lower rate, lower paid staff won't rotate to higher grade jobs without an increase in their rates.	10	
Reluctance to rotate away from tasks they prefer / are familiar with, onto harder / less desirable tasks.	5	
Resistance to changes that break the 'tradition' of how work is done.	4	
Can't rotate onto tasks they have not been trained for.	4	
Aspects of workspace design that can't be adjusted to suit staff of all heights and sizes.	3	
Aspects of plant design may make task rotation changeover too time consuming (e.g. travel distances).	3	
Difficulties in recruiting, retaining and training sufficient numbers of people to achieve effective task rotation and cover for absenteeism.	3	
Informal rotation is hard to enforce and often leads to patch protection so limited task variation occurs.	3	
Status can be a barrier, if money is the same for all tasks in the rotation.	2	
Suspected drug users aren't permitted to work on tasks involving machinery (e.g. deskinner, bandsaw), therefore limiting rotation cycles.	1	
Organisational culture		
Health and safety is a lower priority than production and hygiene compliance.	8	

Some staff have a fatalistic acceptance of pain/discomfort and attempt to 'work through the pain barrier'. This affects early reporting, and their attitude towards any sort of injury prevention.	4	
Management and staff are sceptical of MSD - their causes, and whether injuries are genuine or not.	4	
Some management also perceive that staff need to 'work through the pain barrier', thereby underemphasising early reporting and addressing risks. Some staff share these opinions and expose themselves to greater risk as well as being less supportive of initiatives to reduce risk.	3	
Managers look at health and safety as a lost cause, and will not consider making changes unless there is a direct link to saving or making money. Many in management have only worked in the meat industry and do not understand how good health and safety ideas can make business sense.	3	
'Gungho' attitudes towards MSD risks by workers and management.	3	
Low level of priority given to health and safety may mean that interventions are not well supported or funded, placing them in jeopardy.	3	
Loyalty between management and senior workers - don't want to rock the boat and see them leave, therefore management may not support a change (e.g. rotation) if senior workers don't want it. (Could also be seen as blackmail.)	3	
Women on plant are still relatively few in number. Some resistance as their presence changes dynamics, and there is a perceived limited choice of tasks for them.	2	
Different cultures between departments and/or shifts. Makes introduction of plant-wide changes difficult to implement (along with strategies to introduce changes).	2	
There is a perception that older workers underreport injuries.	2	
Workers have increasingly lower work ethic and poorer attitude to work systems and reporting compared with the past. Poor work ethic can also create confusion as to whether reported risks/injuries are real and can make it difficult to achieve teamwork and workplace changes.	2	
School leavers difficult - no work ethic so are late, unfit, undisciplined.	2	
Thinks Maori staff have more of a fatalistic attitude towards health and safety than Europeans "if it happens it was supposed to". May affect their role in the prevention of workplace injuries.	1	
Embarrassment at doing warming up exercises publicly.	1	
Less experienced staff can struggle when the pace is set by senior workers (including compression).		Y
Resistance to change		
Resistance to change among workers for a number of reasons (breaking 'tradition' and fear of loss of job security the most common) (e.g. introduction of new technology – cut resistant gloves, pelt puller).	6	
Resistance to change by management who do not perceive MSD as a risk.	5	
There is resistance to working with new staff as they are slower and will affect piece rate earnings.	3	
Resistance to rotate due to losing face as they do not have skills for all the tasks involved.	3	
Resistance to MSD interventions by unions on other grounds (e.g. changes to seniority, resistance to putting liner gloves over cut resistant gloves.)	3	
Resistance to changes that adversely affect pay or hours of work (e.g. stopping compression)	3	Y
Management are reluctant to make changes that may reduce current performance levels, even temporarily, for later gains.	2	
Resistance from experienced staff to making tasks easier and losing their 'mana' (prestige) and the opportunity to have a physical workout, despite this improving their employability.	3	Y
Despite having the support of senior management and workers, resistance by line management may influence the implementation of changes.	2	
Aging workers slowly become less physically capable of doing the job. Have started to pull butchers (60+ years) off the line and offering them labouring positions. Problems arise if they don't want to move (status, reduced pay), and only works if they rotate with other tasks (not stay on the easy job).	2	
The supervisor is buried in administration so is not often on the chain to identify and manage risks.	1	
Very high family presence in the plant. So intergenerational advice gets passed on (good and bad) making change very hard to implement.	1	
Managers may feel threatened by interventions which cast a poor light on their existing management practices / past decisions.	1	
Some staff are harder to convince of the need to change, until they've had an injury themselves.	1	
Staff participation		
Lack of consultation by engineers/fitters on physical workplace changes. These changes often happen during shutdown when the staff that will be affected are not around to have their input. Can be ad hoc.	5	
Takes a lot of time to engage staff in proposed changes. Are reluctant to do so unless necessary. They aren't interested in MSD, or any changes to reduce injury risks.	4	
Don't readily accept the changes that have been made if staff are not involved in their design.	3	Y

Resistance (by maintenance, engineers, management) to involving staff in proposed changes as this takes them off production and may increase the length of development time. Little consideration given to potential benefits to product, reduced injury risk, and better staff/mgmt relations.	3	
New technology takes a lot of trialing to get it right and to be accepted by staff (scared of job losses).	1	
Night shift		
Night shift have no management around, including health and safety. Difficult to make changes and ensure they're followed through with as intended.	3	
More difficult to implement rotation in night shift - absenteeism makes it harder and night shift are the staff pool resource for day shift.	2	
First aiders are part of the crew on night shift so if they are working who does their job?	1	
Staff turnover / absenteeism		
Hard to retain staff with short seasons - resulting in high staff turnover year to year. (Especially veal, sheep). Therefore many staff lack training or task skills, making rotation more difficult and constantly exposing new staff to MSD risk as they learn each task.	8	
Absenteeism can affect the ability to rotate tasks (not enough staff to enable full rotation, or available staff are not fully trained to cover all tasks in rotation).	5	
Staff turnover is quite high with the seasonal shift. Have trouble getting staff since pre-employment drug screening introduced (people don't bother coming). Low staff numbers means any changes come second to meeting minimum production requirements. Also increased risk as people are working in jobs they're not trained for.	4	
More employment options available now with low unemployment. Staff will leave if there are better offers, resulting in low staff numbers and difficulties in organising work or making changes.	4	
A shortage of skills in the labour force, due to low unemployment rates and the need therefore to employ unskilled workers that previously would not have been employed.	3	Y
Holiday Act - no Doctors certificate is required for absences of 3 days or less. More staff now taking sick leave resulting in short notice of staff absences. This makes it difficult to get replacements, increases workload for remaining staff, and can reduce task rotation options and training.	3	
Injury data		
Can't always relate MSD to one incident, makes identifying and addressing problems more difficult.	3	
Potential bias in some plants data if they use on-hire staff to fill gaps, as any injuries don't then appear on meat companies stats. May make it more difficult to prioritise risk and gain support for changes.	2	
Inaccuracies in injury data - can't get full costs logged on at the plant as specialist costs that go to Head Office are not assigned to individuals.	1	
Plant design		
Changes only possible during the off-season.	9	
Limited ability to change physical design due to size of building. This is a barrier until the building is added to / built again.	2	
Insufficient time during design and build exercises - reluctance to lose production time on trialing or consultation, and limited time for making changes during shutdown/off-season.	1	Y
Old buildings - structural constraints, lots of changes in level, poor housekeeping, stf hazards		Y
Management at smaller plants usually have multiple roles, whereas larger plants have staff dedicated to particular roles (e.g. h&s, production, HR). Makes it harder to spend time on health & safety.	1	
Smaller plants are more geographically isolated, making it harder to attend meat industry meetings.	1	
Training		
Have a poor training system. This becomes a barrier to: training, rotation, recruiting/retaining staff.	4	
Noise in work areas can make it very difficult to get comments from workers - is a barrier to training and to redesign projects.	3	
Limited room available for training on line - having a trainer stand alongside but who can't always see what's happening or demonstrate without changing positions.	3	
Training is difficult to resource - finding the time, and the spare staff to replace those being trained.	2	
Frequent changes to product spec's make it harder to train staff and have effective task rotation.	2	
Compliance		
Pressures from compliance requirements of overseas clients. Can compromise changes that are proposed to reduce MSD risk, and the requirements themselves can introduce other MSD risks.	5	Y
Hygiene compliance makes training harder - scared of making a mistake. Vet used to give informal advice on the spot, now is formal and has wider implications on training and work practices.	2	
Intervention effectiveness		
Commercial sensitivity - reducing the likelihood of good ideas being shared around the industry.	6	Y

The cost of interventions may delay their implementation or mean that they may not be considered at all. Cost may also be time and production lost to implement them.	3	
Effects of MSD interventions are hard to measure (too many other variables), therefore hard to convince management of the need for further changes.	2	
Negative effects of poorly researched intervention ideas that then have to be changed/stopped (e.g. use of wrong gloves in boning – poor fit and wrong thickness, had to be returned).	1	
Two separate h&s committees on site as a hangover from the days of having two unions. Still some division on health and safety issues, and creates delays in implementation.	1	

Some of the people interviewed found it difficult to distinguish between risk factors and implementation barriers, and indeed many could be considered synonymous (e.g. those concerning seniority, hygiene compliance, or training). Often it is the context in which they arise that determine how they are categorised. For example, work compression is a potential MSD risk factor as it can increase work pace beyond sustainable levels, and it is also an implementation barrier as staff may be reluctant to change and suffer a loss of income.

5.3.5 MIHSF development of interventions

At this point the interventions had been summarised and tabulated with evidence from the plants and the literature, and a priority added by the researchers. The MIHSF were then given the draft intervention document. Appendix 9 is the first eight pages of this 64 page document and includes the contents page, introductory information, and the first intervention heading.

One of the expected outcomes of this process was that the MIHSF would either remove contentious or difficult interventions (e.g. seniority, payment systems), or de-emphasise them through applying a low priority. This assumption was based on negative responses to the intervention document from some MIHSF members soon after they received it. Typical comments were,

> *"The quicker we automate, the better."*

> *"There's nothing new here, we used to do some of these things years ago."*

However, countering these initial responses were a number of MIHSF members who were positive towards the interventions and were beginning to apply some of them in their own plants. More positive comments included, *"What's been done in the past hasn't worked, so we need to follow through with some of these ideas."*

"This is a helpful report,...we will need to work together to make some of the big changes, but a lot of things can be done by plants straight away."

Over the four-month period for considering the intervention document, MIHSF members who initially appeared negative moved to a position of reluctant acceptance. Although this was not formally assessed, it was clear that by the time the workshop took place there was too much support for the document to not proceed with its development (e.g. from the government agencies, unions, and supportive processors). Subsequently, very few interventions were deleted (n=3) and one idea was added by the MIHSF. Members had also begun to develop an understanding and an interest in the broader range of interventions, beyond the traditional focus of the worker and their workstation. The priorities assigned by the MIHSF to each group of interventions reflect this.

Other changes that were suggested for the document including changes to the wording to better explain some terms and reduce ambiguity, to change the COHFE priority from numbers to letters to avoid confusion with other data columns, and to soften language around sensitive interventions such as task rotation and seniority to lessen the chances of unintentionally raising concern among staff.

Following the workshop, amendments suggested by the MIHSF were made before sending the intervention document back to MIHSF members for their final approval. It was then disseminated to all processing plants as well as to other industry stakeholders, through the contacts established during the study. The literature review on MSD in meat processing was sent out at the same time. The final intervention document can be downloaded from:
http://www.scionresearch.com/portals/0/COHFE_MSDinNZMeatProcessing.pdf.

5.3.6 Post-study MIHSF member survey

Fourteen of the fifteen people involved with the MIHSF could be contacted and each agreed to take part in the survey, conducted in October 2008. Respondents included: eight staff representing six processing companies, three staff from government agencies, and one person each from the employers' association, the national union, and the national training organisation. The average length of time that the respondents had been involved in the meat processing industry was 12 years, and ranged from one to 41 years. A summary of responses to the first five questions are shown below in Table 5.6 (where 1=strongly disagree, 5=strongly agree).

Table 5.6. MIHSF member survey responses

	Question	Mean	SD	Range
1.	I felt involved in the study.	4.4	0.5	4-5
2.	I felt I had the right amount of control in the study.	3.7	0.5	3-4
3.	I am satisfied with the outcomes from the study.	4.4	0.7	3-5
4.	I find the intervention report from the study useful.	3.6	1.2	1-5
5	The MIHSF has a strong influence on the interventions being implemented in industry.	3.6	0.8	2-5

The high level of agreement with the first statement indicates strong support for the approach taken and the level of involvement of the MIHSF throughout the study. There was slightly less agreement about the amount of control they felt they had in the study. One person stated they would like to have had more control over which staff were interviewed and which work areas were visited at the sample plants. However with most of the power resting with the MIHSF and the processing companies, it was fortunate that this level of control did not extend to the plant visits as this would have significantly limited both access to participants and researcher independence. Another person wanted more time for development of the draft interventions by the MIHSF.

The results show that most respondents were satisfied with the outcomes from the study, with some choosing to reserve judgement to see whether momentum continued to build or began to wane. Opinions on the usefulness of the intervention document showed the widest variation in the survey. The most critical comment was that it was too long for many people in industry to want to use. Others commented that only parts of the document were relevant to the staff they represented (e.g. meat inspectors, less commonly processed species). Interestingly, the critical comments related to the format of the document rather than its contents. Opinions on the influence of the MIHSF were also varied. Some were undecided but also guarded as to reasons why. However others felt their influence was strong as they represented most of the industry, were well funded, and had the support of government injury prevention agencies.

Over half the respondents answered ‘no’ on whether there were aspects of the study they would like to have seen done differently. Other comments concerned the format of the intervention document and the desire to have had more time for developing the document. Two respondents commented that more information on industry contacts, industrial relations and protocols could have been provided by the MIHSF to the research team at the beginning of the study.

When asked about what changes in industry have occurred as a result of the study, most respondents referred to the development by the MIHSF of a resource guide on strains and sprains (further discussed in section 5.4.1.5) and the ACC funding of a coordinator for the MIHSF to implement some of the ideas from the study. Several respondents also felt that the MIHSF as a group now had a better understanding about MSD and their prevention, as did many people in industry as attention on MSD had increased. Other changes were mentioned that were occurring at an organisation level. Most were low cost or easy to implement and included: improved content of task training and structure of task rotation systems, changes in work procedures to reduce understaffing and workload peaks, the development of best practice examples based on material from the intervention document, and specifying more suitable products from manufacturers and suppliers.

Question 8 asked what changes they anticipate will occur as a result of the study. Many people referred to the difficulties of initiating and implementing change within traditional industry such as meat processing, and the effects of the current rationalisation of the industry and economic downturn on funds for injury prevention. However respondents felt that there would be gradual adoption of the interventions by companies as the ideas became more familiar and widespread. Other likely changes mentioned were mechanisation of certain tasks to reduce physical load, and better task training which incorporated MSD prevention principles. Several respondents also mentioned that many interventions may be adopted when restructuring (physically and/or organisationally) as this would incur the lowest implementation costs.

Several respondents mentioned independently that they thought the study was worthwhile as it provided direction and a plan for MSD prevention. The intervention document was also seen to carry weight as it was industry-based, and was thought likely to be used for some time by the industry. These same respondents also recognised the importance of the MIHSF in achieving any changes. They saw the strengths of the MIHSF as including: their present agreement on priority areas, their relative independence and representativeness, and the buy-in of the main meat processing companies.

5.4 Discussion

5.4.1 Key findings

5.4.1.1 MSD interventions and implementation barriers

The most important element of the MSD interventions was that they were a product of the industry, derived from what was perceived by the industry as an acceptably representative number of plants. The interventions from each plant helped to build a picture of what the industry as a whole was doing, or planned to do, about preventing MSD. While no one plant could boast a comprehensive MSD prevention and management system, the combined effect of intervention ideas from all plants, even those plants with poor injury prevention systems, made the data very powerful. This arguably produced a more comprehensive list of interventions than that which might have arisen from a more traditional approach, and one that is likely to be more readily accepted by industry.

As noted by some members of the MIHSF, although many interventions were not technologically advanced or novel, they were ideas that people within the industry had found that helped address MSD and were therefore more likely to be successful at encouraging change in other industry staff. In addition to reducing resistance to change, this factor may also help to overcome barriers to information sharing – a problem firmly embedded in industry culture (Tappin et al., 2008). Despite the fact that many interventions were summarised and combined, much of the language remained unchanged and is therefore familiar to people in industry. Seeing familiar interventions (those they have implemented) may also make them respond positively to other intervention ideas. Despite the predictability of some of the interventions, they still represent a fundamental departure from current business practices for many plants by challenging the way people in the industry perceive MSD and injury prevention (e.g. basing workload on existing staff, task training off-line, job enlargement).

It is important to note that the authenticity or effectiveness of the interventions included in the final document was not tested. However, corroboration by others in the workplace helped to verify claims. Although there would be little to gain by fabricating interventions, in at least one plant staff did use the MSD study as a vehicle to promote their agenda of obtaining radio earmuffs.

The decision on how to best present the interventions, first to the MIHSF and then to the wider industry, was only made once all the data had been collected. Criteria included making it as succinct as possible and easy to use. To help with succinctness, one document was developed which incorporated interventions, barriers and risk factors. Interventions themselves were also listed and information supporting the interventions was minimised. To improve ease of use the interventions were summarised to remove duplication and reduce the volume of information, and grouped together under intervention headings. These headings were chosen to best suit the intervention data but were also intended to help inform users of the document by highlighting important topics and providing risk factor information on them. Thus the interventions could be categorised either by topic or by the priorities assigned them by the researchers and the MIHSF. It was also felt that providing all the task-independent interventions together, rather than by the two main species, would expose the interventions to a wider industry audience. For the many plants processing both species, this would also avoid duplication of information. A disadvantage of developing one document for the entire industry is that it may not adequately accommodate the needs of all plants, particularly those who have yet to grapple with MSD in their own plant.

With the industry more focused on interventions than on what these address, it was important that information on risk factors and barriers did not dominate the document. Outlining this information for each intervention heading enabled its inclusion without detracting from the interventions. Barriers to implementation that arose ranged from those that were easy to avoid through to requiring industry level changes.

5.4.1.2 Heuristic prioritisation of MSD interventions

The large number of interventions meant that without some order the more significant interventions would be buried among other less important ones. In addition, as the lists of interventions implied some sort of an order, the researchers' priorities actually provided one. The priorities assigned by the researchers' were intended to direct users of the document toward interventions believed to be more successful in reducing MSD risk. In the first instance they gave guidance to the MIHSF during their own evaluation of the intervention document, and were also intended to inform industry users and assist them to make decisions on which interventions to consider. The inclusion of this additional column alongside the evidence from the plants and the literature enabled 'expert' opinion to be included in the report without detracting from the industry-derived interventions.

5.4.1.3 MIHSF involvement in intervention development

Involving the MIHSF in the development of the final interventions was intended to improve their relevance to the industry, while also giving credibility to the study and to the interventions themselves. It was also hoped that creating ownership of the intervention document would increase its application in industry and its longevity (Hagberg et al., 1995). This was one of the main lessons learnt from a previous experience in meat processing research where an industry report, written as part of the 1993-96 injury prevention study (Slappendel et al., 1996), was poorly received by the company to which it applied due to differences in expectations and levels of understanding about injury risk. The fact that people outside the industry compiled the report further reduced its perceived worth. The report was subsequently rewritten by the company, but lost many of the important findings and recommendations in translation, most of which were never implemented.

The tangible effects of industry involvement are numerous. The information in the document was made more industry-specific and clearer. Ownership of the intervention document was demonstrated by the MIHSF deciding to change their prioritising criteria and the way in which they were assigned. These changes were made so that the document better suited their own injury prevention objectives. Further evidence of this ownership is discussed in 5.4.1.5. More fundamentally, agreeing to comment on the interventions and add their priorities to the document endorses both the process and the final document. This endorsement greatly increases the status of the interventions to industry users, therefore increasing the likelihood that it will be used. Given this endorsement and support, and in the absence of an alternative, the intervention document is likely to become a good practice document for government agencies involved in meat processing as it is based on interventions already practiced by parts of the industry, and has the support of key stakeholders.

MIHSF members' initial reaction to the interventions ranged across the spectrum of opinion. The level of support, from begrudging to enthusiastic, grew over the months prior to the final workshop. Similarly, understanding of MSD increased for some members over the course of the study, including the realisation that a number of interventions are usually required to make a difference and that they need not be expensive.

The intervention document reflects what the industry is currently doing about MSD. It provides an industry perspective and therefore a much broader view than the plant or company standpoint held by many MISHF members. The document also enables plants to draw comparisons with how they are approaching MSD, and to use the prioritised interventions and accompanying information to augment their approach. Providing priorities for the interventions partly serves an education role as well as informing readers about what the researchers and the industry stakeholders see as important. Similarly, the document reminds the reader, both directly, and indirectly through the amount of material it contains, of the need to consider both the range of risk factors and potential interventions in addressing MSD. Ideally, the document will become a discussion point in plants and have a longer life than if a more prescriptive approach had been adopted for the study, and will serve as a blueprint for the MIHSF to help direct government and industry initiatives to address MSD.

5.4.1.4 Issues for consideration in further research

A follow-up evaluation of the intervention document and its application by the industry would help to inform further studies at an industry level. This would initially involve measuring how people perceive the MSD interventions and what changes they have made, or are likely to, in their own workplace. More specifically it would be worth knowing more about: whether the involvement of the MIHSF in prioritising and endorsing the interventions had any effect on understanding and accepting them, and similarly, whether the inclusion of the researchers' priorities had any effect on their understanding and acceptance the interventions.

5.4.1.5 Postscript – MIHSF progress on implementing MSD interventions

Following completion of the study and dissemination of the intervention document to industry, the Meat Industry Association and ACC (who are the funders and main supporters of the MIHSF) have made MSD the top injury prevention priority for the MIHSF. The implications of this is that funding is now available for the MIHSF to help the industry with implementing some of the interventions, and the MIHSF is now required to report to the board(s) on their progress with attending to this priority.

In response to this, the MIHSF have taken the highest rating interventions from the final document (those rated high by MIHSF as well as those rated between a - d by COHFE), along with the accompanying information on risk factors and implementation barriers and produced a resource guide entitled 'Reducing strains and sprains in the workplace'. These interventions include: workspace and equipment design, knife and glove design, staff participation, early reporting and injury management, task rotation, task training, and knife sharpening training. The MIHSF will be working with the plants represented by their members (more than 75% of plants) to put these interventions into practice. The intention is then to repeat this process with further interventions from the final document. While this initial list of interventions mostly concern physical design and are the easier targets to aim for, it is significant that staff participation and task training are also included, as these would require considerable changes to the management of work in many plants.

The significance of this initiative is that it indicates a degree of ownership of the MSD interventions by the MIHSF (a desired outcome of the study but never a certainty). The resource guide reproduces material from the final intervention document, and uses the COHFE and MIHSF priorities as the basis for selecting their target interventions.

5.5.2 Limitations of the study

The first weakness in the study concerned the involvement of the MIHSF. While they were unquestionably the right group to involve (the only group in fact) as they represented all key stakeholders, several aspects of their structure made their participation difficult. Firstly, members' involvement in the forum is part-time and comes on top of their existing workload, which means relying on their goodwill to devote time to the study and invoking resentment by requesting too much of their time, particularly if they have different opinions on addressing MSD. This also meant that progress was slowed by waiting for their response. Secondly, the forum has existed for several years and MSD is only one of many injury prevention priorities. The level of motivation to consider MSD varied accordingly, making contact and lobbying of individual MIHSF members necessary. Thirdly, as members were spread around the country and only met every four months, it was more difficult to engage with them 'face to face' on MSD. Finally, their modus operandi is to engage 'experts' and then make decisions accordingly. The participative approach of this study was therefore unfamiliar to many of them. There were difficulties in achieving the right balance between not pressuring MIHSF for their involvement and getting good levels of participation in the study. The threshold of time available for the study varied between individuals and within the same individual across time. This again points to a weakness of having an expectation to be involved, but no pressure to do so (i.e. not being one of their performance indicators).

The semi-structured interviews, as the primary source of interventions, also had some limitations. Question 7, regarding what they would like to do or were planning to do, created confusion for some participants. Ideally, this would have become two questions. Due to the limited availability of participants, the interviews were brief on some occasions. While there was sufficient time to gather the main points, the opportunity to discuss issues at length was limited. Data from the semi-structured interviews were also difficult to collate as people provided information in the order and format they wanted to, perhaps indicating its importance to them, rather than the order preferred by the researcher.

While it was most important to maintain the ongoing support of plants, the researcher could have been more insistent at some of the plants to gain access to more processing staff or achieve greater levels of privacy during interviews. This would have increased the number of participants and changed the ratios of staff groupings, as well as increased the pool of data. There was also some opportunity bias in the sample of plants and personnel spoken to on plants. However, this was unavoidable as data on individual plants was not available prior to the study, and the researcher had no influence on who was able to be interviewed on plant.
The process of summarising the intervention data may have reduced its initial intent or specificity. In the same way, the intervention categories that were chosen resulted in some interventions applying equally well to multiple headings while others barely fitted into one. Ideally, the understanding of interventions that summarised several points made by participants would have been evaluated by a sample of processing staff, however, there was not enough time or resources available in this study for this to occur.

There were also limitations in the selection of prioritising criteria for the researchers and the MIHSF. Clearer and fewer priorities would have made the task easier for both groups, as well as being easier to explain in the intervention document. In hindsight there was also a strong argument for simplifying the priorities as the MIHSF did and reducing the range from 10 down to 3 (high, med, low) for each intervention.

Finally, the study would be difficult to replicate or use as an approach in a non-funded study, as it was very time consuming and longitudinal in nature. This has implications for ergonomists and researchers working in the MSD or change areas.

5.6 Conclusions

The main output from the study was the production of an industry-generated list of prioritised interventions for addressing MSD. The interventions, which included information on risk factors and implementation barriers, were written for two audiences.

Firstly, the intention was that plant staff would be able to implement interventions within their own level of control, while also being made aware of the full scope of MSD risks and intervention ideas from within the industry. Secondly, it was intended that the MIHSF would be able to expedite changes at an industry level to address previously unaddressed contextual risk factors (Tappin et al., 2008) with industry-level interventions identified from the study. Similarly, the MIHSF would also become aware of other intervention ideas being applied at department and plant level. Since the completion of the study, the MIHSF have decided to make addressing MSD their top injury prevention priority.

Applying a participative approach to addressing MSD risk across the meat processing industry has highlighted both strengths of the approach as well as limitations. de Jong & Vink (2002) state that there is no single approach that can be effective in every case, while Haines et al (1998) state that "the most appropriate strategy should be chosen for each project". In this study that strategy was to engage with the industry as much as possible to facilitate a change in attitude toward addressing MSD, and create a shared responsibility to do so.

This need for engagement stems from a long history of high MSD incidence and widespread scepticism about their occurrence and causation. These attitudes are firmly embedded in the industry culture alongside Tayloristic work practices such as division of labour, repetitive and monotonous tasks and minimal task control. Industry competitiveness, a history of adversarial industrial relations and a common distrust of outsiders (particularly if they challenge long-held beliefs) all further point to the need to engage with the industry if intervention ideas are to be accepted and acted upon.

Identifying existing or potential MSD interventions from within the industry was achieved by engaging with the MIHSF and a sample of plant staff. As a collective, these industry-based task experts have often already identified and designed interventions that work best. The role of the researcher in this situation was to tease out important details and work with the task experts in refining the interventions to make sense across the industry. Encouraging people to consider these new ideas and to change existing practices is made easier if the information comes from the industry itself. In the case of MSD, many risk factors require intervention at an industry rather than local level which is made easier if they are already engaged and challenged, if not already prepared, for change.

The methods used were successful in meeting the aims of the chapter. The MIHSF, with a better understanding of MSD, have taken ownership of the interventions and have targeted high priorities to address as a group. Fundamental organisational design changes still required to reduce contextual factors of MSD have been introduced in a manner that is less threatening to those it most affects. Individually, plants are able to use the interventions as a way to reduce risk and increase competitiveness. Unions are also using the interventions in their negotiations, while government agencies are looking to the document as a guide on good work practice, which in turn has raised expectations in addressing MSD risks. Meat processing workers also have the intervention document and can use it to influence their own situation or as an education tool. Collectively therefore, the industry as a whole has it within their grasp to take some steps towards accepting and addressing MSD.

Chapter 6. Discussion

6.1 Introduction

This chapter reviews key findings from the study under each of the six research objectives (section 1.5). The contributions of the thesis to theory and knowledge are then discussed, and directions for further research outlined. The chapter ends with final conclusions of the thesis.

6.2 Review of key findings in relation to research objectives

The major aims of the research covered in this exploratory thesis were to identify risk factors, including wider contextual factors, and interventions for MSD in New Zealand meat processing, using an industry-level participative ergonomics approach. Within these aims, a number of specific research objectives were formulated. This section of the thesis reviews findings from the study in relation to these objectives, before briefly discussing the study as it addresses the research aims.

6.2.1 Review of MSD and participatory ergonomics literatures

The first research objective was to review the literature on models of MSD causation and participatory ergonomics. This was to help inform the research methods, and to provide insights into the range of contributory factors associated with MSD, and the approaches that were being used in participatory ergonomics. The review also included coverage of MSD in meat processing, MSD interventions, and employee involvement, as these were closely related to the main topics and the research aims.

One of the limitations of MSD research has been a lack of agreement on what constitutes MSD and what conditions are classified under it (van Eerd et al., 2003). The decision to include gradual and sudden onset conditions involving any area of the body for this study was pragmatic to match Accident Compensation Corporation (ACC) criteria (ACC, 2004a), and was also based on the literature (Bernard, 1997; NRC-IOM, 2001). The assumption that repetitive work and associated MSD would decline over time has not occurred (NRC-IOM, 2001), with MSD prevalence and costs remaining high based on the available data.

MSD causation theory has grown from consideration of physical and individual risk factors (e.g. Armstrong et al., 1993) to including organisational and psychosocial factors (e.g. Sauter & Swanson, 1996). More recently, wider system issues have been considered (e.g. NRC-IOM, 2001), with Karsh (2006) recognising the role that these contextual factors play in influencing work organisation and psychological work demands, and the interactions between these and other factors such as physical work demands. The evidence of work-relatedness is strong for physical MSD risk factors (Bernard, 1997), although less attention has been given to assessing other risk factor categories or to the interactions between them (Aptel et al., 2002). This is also the case for MSD research in meat processing (Slappendel et al., 1996).

Many obstacles affect the validity of MSD intervention research, such as: the evaluation of multiple interventions required to address MSD (Hagberg et al., 1995), difficulties with randomised experimental designs (Boocock et al., 2007), confounding effects of other changes during the evaluation period (van der Molen et al., 2005), and research that is too short to evaluate its effects (Karsh, 2006). Research findings support Karsh et al. (2001) that interventions with multiple components have a greater chance of success than single interventions, while Silverstein & Clark (2004) state that there is sufficient research evidence available to begin making changes.

Participatory ergonomics (PE) is one of several separate movements that have arisen within participation (Wilson, 2005). The participation of workers also carries different meaning between people, with many different definitions (Cotton, 1993). The reasons for adopting a participative approach are considered more important to define (Wilson, 2005), and can include: reaching a better solution, creating ownership, improving the design process, developing a culture of involvement, and facilitating knowledge dissemination. The importance of carefully considering system variables in structuring participation processes is emphasised by researchers (e.g. Cotton, 1993; Cohen, 1996).

There are several different levels of involvement within PE, depending on the aim of its application (Wilson, 2005). Many researchers also refer to the importance of contextual factors in structuring and implementing a PE program (e.g. Imada & Robertson, 1987; Liker et al, 1989; Morris et al, 2003). Key success factors are also listed by Wilson (2005) and Vink et al. (2006) to assist in developing a PE programme. Studies adopting a PE approach to MSD vary widely in quality, often only considering physical interventions. Hignett et al. (2005) referred to the difficulties of evaluating PE effectiveness on MSD due to organisational changes, a possible reason for adopting a limited approach. Studies involving multiple organisations are less common. Carayon (2006) discusses some of the unique aspects of such an approach, while Caple (1992) does the same for a study in meat processing.

A theoretical framework for establishing and operating a PE programme was gradually developed. This grew from a description of 'dimensions' to illustrate variations that might occur in PE initiatives (Wilson & Haines, 1997), into a peer reviewed framework (Haines et al., 2002), with the expectation by the authors that the framework would continue to develop over time. Possible uses of the framework include helping to develop guidance for implementing PE initiatives, and helping to establish and agree an agenda in the planning of a PE initiative.

In conclusion, MSD have a complex web of causation, requiring an approach that considers all potential risk factors. A participative approach provides the means for achieving this, and while there are both advantages and disadvantages, can occur at an industry level.

6.2.2 Identification of an industry-level participative process

The second research objective was to identify an effective participative process that represented the entire New Zealand meat processing industry, and reflect on its effectiveness in achieving the research aims. The Meat Industry Health and Safety Forum (MIHSF), whose members represented all of the key stakeholders for the industry, but not all of the processing companies, were the main vehicle for the study. The participative processes were therefore developed based on their existence and the level of assistance they could provide to the study.

The reasons for adopting a participative approach include many of the desired benefits outlined by Wilson (2005) and others. However, several characteristics of the meat processing industry also necessitated a participative approach. These include distrust of outsiders and experts, scepticism about MSD, limited access to plants, staff and data, a history of adversarial industrial relations, and company/regional parochialism affecting representation. Additionally, input from subject matter experts as well as industry level experts provides greater context to the MSD interventions that arose from the study.

While the ergonomists had most control over the research process in this study, all the power lay with an existing key stakeholder group (MIHSF) regarding industry access, intervention development, knowledge dissemination, and implementing industry-level change. Some rebalancing of power and control was helped by the study being externally funded, enabling researcher independence and ensuring that all findings were publicised, however unpopular. The key stakeholder group also had a mandate to address industry health and safety issues and agreed to provide their support. The establishment of an additional network of contacts who represented parts of the industry outside the influence of the stakeholder group helped ensure industry-level coverage.

The existence of the MIHSF and their use as a 'Trojan horse' (Cotton, 1993) made an industry-level participative approach possible as they represented all stakeholders, had authority within the industry, and were accepted by management and workers. While their use in the study had some drawbacks, such as MSD being only one of their priorities, the importance of the MIHSF acting as the champion of the study far outweighed these. Across-sector support for an initiative of this kind would otherwise have been unlikely to occur, given the large number of companies involved, the level of industry competitiveness, and competing concerns about injury prevention. The support of the MIHSF for the MSD study invigorated an issue that many in the industry have grown weary of. It is important to note that similarly structured stakeholder groups do not often exist, making replication of this approach in other studies difficult.

The role of the facilitator was important in this study (Wilson, 2005). The potential for role conflict was high in balancing the differing demands of MIHSF members, plant staff and management, government agencies and funders. The relationship with plants also differs as they did not directly fund or support the study and access was mostly reliant on the relationship with the MIHSF. There was a need to tread a line between research and industry pragmatism. Being too academic would have reduced the chances of fitting in with the industry and along with this, the likelihood that research outputs were taken seriously. Being too closely aligned with the industry would reduce the rigour of the research through their influencing decisions in their quest for favoured outcomes.

Involvement of plant staff through the first two stages of the study enriched the data collected but was simply ergonomics in action, rather than specifically participative. Despite potential shortcomings of the participative processes and the limited study objectives, the post-study survey indicated support for the approach as well as for the findings from it. The continued attention given to the MSD interventions by the MIHSF, while modest, indicates a tangible level of acceptance and ownership of study findings.

Industry-level studies are uncommon in the participatory ergonomics literature. Difficulties such as creating momentum, having sufficient resources, and overcoming barriers to industry-level changes are some of the likely reasons for this (Morris & Wilson, 2003). The serendipitous need for actively involving the industry, along with the existence of the MIHSF, and the requirement of a broad assessment process to unearth MSD risk factors and interventions, suited this approach. However, the feasibility of an industry-level approach should be considered, particularly in situations with no champion or body such as the MIHSF, or where there is little interest in the issue being considered. An industry-level participative approach requires a lot of time and money and therefore may not suit larger industries, or might be better spent in other ways.

Table 6.1 describes the study using the dimensions of the PEF (Haines et al., 2002), and includes the addition of the dimension ‘project boundary’ suggested by Haines et al., to help define the study. Two additional categories are also included, based on experiences from the study. Obligatory participation better describes the involvement of many MIHSF members, and injury prevention more accurately describes the topics addressed.

Table 6.1. A description of the study using the Participatory Ergonomics Framework (Haines et al., 2002)

Dimension	*Category*
Permanence	Temporary (two year study), MIHSF is ongoing however.
Involvement	Delegated participation – MIHSF members
Level of influence	Industry (group of organisations)
Decision making	Individual and group consultation
Mix of participants	Senior management, line management, internal specialists, union, external advisors, cross-industry organisations
Requirement to participate	Voluntary *(obligatory)*
Topics addressed	*Injury prevention*, involving: Formulation of policies/strategies, Design of work organisation, Physical design/specification
Brief	Problems identification, Solution development
Role of ergonomics specialist	Initiate and guide process
Project boundary	Tight/defined boundaries

When reflecting on the approach taken there are some modifications that would have been beneficial. Arranging more meetings with the MIHSF to raise their awareness and understanding of MSD may have improved the level of feedback during the process of intervention development and increased their motivation to tackle some of the more complex interventions. Providing more time and resources for the MIHSF to develop and trial the presentation of interventions may have resulted in a range of documents and formats for different audiences. Greater use could also have been made of the union member of the MIHSF to facilitate higher levels of participation by processing staff during some of the plant visits.

In conclusion, the industry-level participative process achieved through involvement of the MIHSF was effective in meeting the research goals, and, indeed, was necessary to gain access to the industry in the first place. Although the level of participation had limitations, it was sufficient to achieve the goal (de Jong, 2001).

6.2.3 Meat processing MSD injury data: patterns, trends and tasks

The third research objective was to establish a profile of patterns and trends in MSD injury data in New Zealand meat processing and determine which tasks are most commonly associated with reported MSD. The main purpose of this objective was to provide sharper focus for the subsequent stages of the study, through identifying specific regions, species and tasks for targeting.

Four injury data sources were collected from the industry. ACC data, while lacking specificity, provided coverage of the entire industry. An industry database (NID) provided greater task detail for part of the industry. A sample of plant accident register records and survey responses from health and safety staff also provided further detail.

One in five of the MSD cases for this sector were gradual process injuries, with the majority recorded as sudden onset or soft tissue injuries. MSD injuries from all sources occurred most frequently in the lower South Island region and during the first five months of each year, consistent with the proportion of the industry workforce located in these regions and the workload peak over these months. Approximately 60% of cases involved the upper limbs, with the spine being the body part next most involved. These findings are predictable based on the heavy involvement of the upper limbs and trunk, with MSD injuries just as likely to occur in the non-knife hand in knife related tasks (Gorsche et al., 1999).

Gradual process injuries were predictably more likely to be more severe claims, as were being of Maori ethnicity and working in certain geographical regions. Reasons for ethnicity and region being over-represented in more severe MSD claims remain unclear. Tasks commonly involved with MSD were mostly derived from the Accident Register survey and Health and Safety staff questionnaire, with ACC and NID data mostly lacking this information. Triangulation between the four data sources helped to highlight the tasks that are most commonly mentioned in the data, including four tasks in sheep processing (aitch boning, packing, Y cutting, gutting) and three tasks in beef processing (quarter boning, packing, gutting). These were subsequently agreed on by the MIHSF.

To conclude, analysis of patterns and trends in MSD data assisted in the design of the plant sample for the next stage of the study. Identifying the high-risk tasks also enabled the subsequent plant visits to be focused on a finite and consistent number of tasks in the two main work areas of the two main species processed. The secondary purpose was also met, through establishing a network of plant contacts and regular involvement with the MIHSF members.

6.2.4 Task-specific and task-independent MSD risk factors and implementation barriers

The fourth research objective was to identify the range of task-specific and task-independent MSD risk factors and implementation barriers in the meat processing industry. The main purpose of this objective was to develop an understanding of interactions occurring between risk factors and the contributory role of implementation barriers. This required that variations in task and work practices based on company, region or species processed were accounted for within the scope of the sample of 28 plants selected.

The assessment of high MSD-risk tasks provided a consistent focus for the plant visits and made sense to the industry. A range of task-specific MSD risk factors were identified. However, most of the risk factors were task-independent, concerning the wider work systems in place at the plant or company, as well as factors external to the workplace that impact on how the work is carried out on plant. One of the limitations of previous efforts to address MSD in the New Zealand meat processing industry has been a narrow perspective of what constitutes MSD risk, and little consideration of barriers to change. The collection of data from semi-structured interviews, plant records, observation, postural analysis and the literature was cognisant of this limitation.

A large number of risk factors were identified from all the data sources. Risk factors from the semi-structured interviews, the questionnaire and archival data concerned all aspects of the work system, whereas observation and postural analysis data covered only the high MSD-risk tasks. A number of implementation barriers were also identified, although some were indistinguishable from risk factors. The context in which they arose assisted in their categorisation. Many risk factors transcended tasks and plants and concerned the entire industry. These were summarised into a list of contextual factors, which, it is postulated, may create conditions under which greater exposure to physical and psychosocial factors can occur in meat processing. Some of the contextual factors are recognised as problematic by the industry, but have not previously been associated with MSD risk. Figure 6.1 provides an overview of the relationship between the various contextual factors identified in the study.

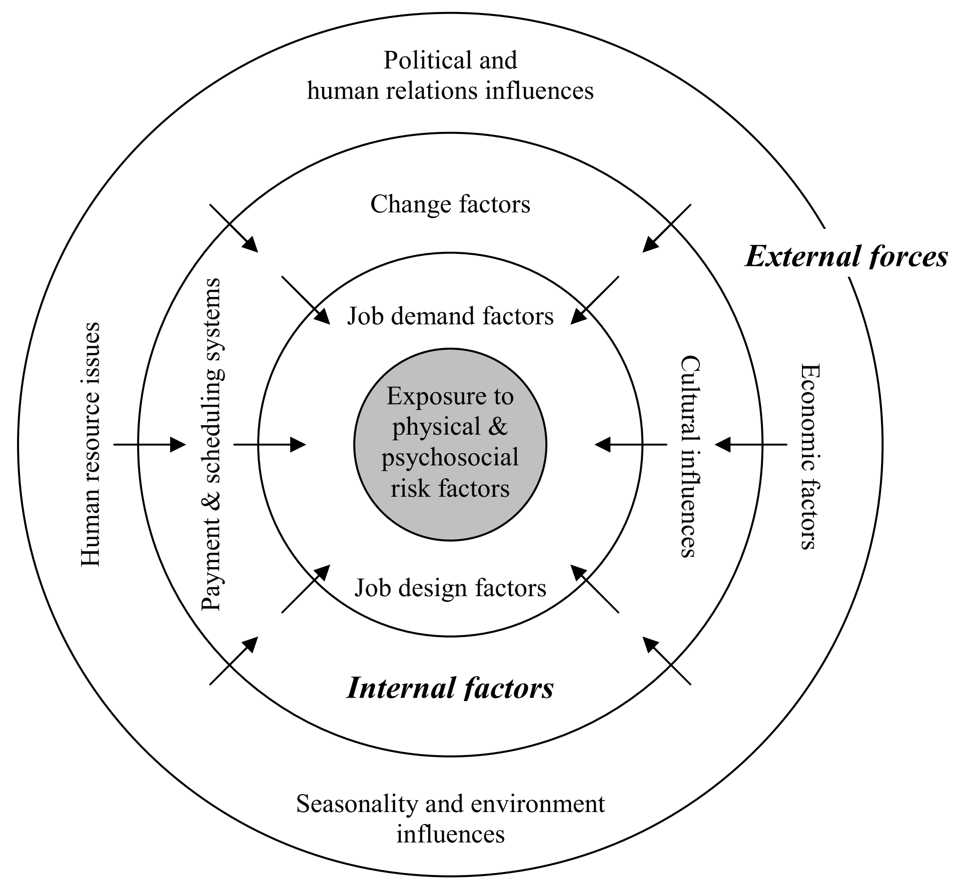

Figure 6.1. Conceptual model for the role of contextual factors in meat processing MSD

In conclusion, the assessment process was successful in identifying task-specific and task-independent MSD risk factors and implementation barriers. However, the extent to which they are definitive for the meat processing industry, or the validity of the role that contextual factors play in MSD causation, is unknown.

6.2.5 Task-specific and task-independent MSD interventions

The fifth research objective was to identify interventions that address task-specific and task-independent MSD risk factors and implementation barriers. The main purpose of this objective was to collect interventions from across the industry that either had been implemented or were to be implemented. Industry-derived interventions were likely to be better accepted by the industry, and were also likely to have considered, if not addressed, implementation barriers.

Interventions were mostly derived from semi-structured interviews with 237 plant staff. The remainder were from task assessment data and the meat processing literature. The final 274 interventions were grouped under 28 headings. Although many interventions were very straightforward, their industry origins and stated success in many cases were intended to encourage change in other plants. In addition to reducing resistance to change, this factor may also help to overcome barriers to information sharing (Tappin et al., 2008). Despite the fact that many interventions were summarised and combined, much of the language remained unchanged, and is therefore familiar to people in industry and understood by them.

The authenticity or effectiveness of the interventions included in the final document was not tested. However, corroboration by others in the workplace helped to verify claims. With further time available it would have been useful to verify effectiveness and to gather more information on the planning and implementation processes followed.

In conclusion, a wide range of industry-developed MSD interventions were identified. While the industry staff perceived that these interventions did address some of the MSD risks they faced, the extent to which they address all MSD risk factors and implementation barriers could not be determined during this study. It is important to note that there is not always a linear link between MSD risk factors and interventions and that a combination of intervention measures is most effective in addressing MSD (Silverstein & Clark, 2004).

6.2.6 Industry stakeholder development of interventions

The final research objective was to work with industry stakeholders in developing these MSD interventions for use by the industry. The main purpose of this objective was to contextualise and encourage ownership of the interventions by the MIHSF, so that they would continue to support and implement the interventions after completion of the study (Hagberg et al., 1995). Additional goals were that their involvement would help improve the veracity of the interventions for industry, and that their input would increase the credibility of the interventions in the eyes of industry personnel considering the interventions.

MIHSF input into the development of interventions included verbal and written feedback, group meetings and a one-day workshop with MIHSF members. Subsequent changes to the interventions improved their clarity for an industry audience. Priorities assigned to intervention groups served to assist industry users but were also used to determine the priorities for MIHSF initiatives on addressing MSD. The MIHSF endorsement of the interventions makes it likely that the document will become a good-practice resource for government agencies involved in meat processing, as it is based on interventions already practiced by parts of the industry, and has the support of key stakeholders.

With more resources available for the study, this stage would ideally have been more participative, involving a number of workshops to decide on content, priorities, and presentation. Further training on MSD causation and problem solving throughout the study may also have assisted in encouraging more feedback during the intervention development stage, as well as equipping them with skills to continue addressing MSD beyond the life of the study. Involvement of other industry groups less well represented by the MIHSF would also have been useful in this stage. Tempering these aspirations is the amount of time that the various stakeholders had available to commit to this participative development process. Generally, by this stage of the study MIHSF members had accepted the researcher and many had stated their preference to review and comment rather than be too heavily involved in the development process.

In conclusion, industry stakeholders did have input into the development of interventions for industry. However, the usefulness of the interventions to industry is not known. The subsequent development of a summary document containing just the interventions rated as high priorities by the MIHSF and the researcher, would seem to indicate acceptance of the information, but not its presentation.

6.2.7 Overall research aims

In this study, an industry-level approach provided the best fit with the nature of the industry, its expectations, and the objective of identifying a wide range of MSD risk factors. Moreover, a PE approach made best use of the existing stakeholder group, enabled industry cultural barriers to be broken down, and allowed the collection of industry-derived interventions that addressed both contextual and physical risk factors.

6.3 Contributions to theory and knowledge

While contextual factors for MSD have been considered recently in the literature on MSD causation (NRC-IOM, 2001), most of the research emphasis remains with the role of physical and psychosocial factors. The difficulties of measuring the effects of multiple risk factors and the interactions between them present challenges to MSD research (Karsh, 2006). The implicit requirement that this research is based in real work systems adds to this challenge. MSD research in meat processing has also been strongly slanted toward measurement of biomechanical risk factors, often in laboratory rather than field settings (e.g. Grant & Habes, 1997; Frost & Andersen, 1999) in an attempt to quantify individual elements of the risk under controlled conditions. Some wider contextual factors have been related to MSD causation in meat processing (e.g. Novek, 1992; Gjessing et al., 1994; Nossent et al., 1995), however these have hinted at relationships but they have not been systematically measured or related to MSD causation theory.

Therefore, the major contribution to knowledge provided by this thesis is the identification of the role of contextual factors in creating conditions under which psychosocial and physical risk factors can occur within meat processing. Moreover, the implications for research in similar industry settings both in New Zealand and internationally are significant, where the aim is to understand the broader context for the presence of physical and psychosocial risk factors in the workplace, and to develop effective and sustainable solutions that address the underlying causes of exposure to physical risk factors for MSD.

The thesis also contributes to theory by providing support for the few MSD models (NRC-IOM, 2001; Faucett, 2005; Karsh, 2006) that include wider system influences on exposure to MSD risk factors. Currently there is very little empirical support for such approaches.

Identifying contextual factors for MSD that are external to individual plants or companies and occur at an industry or national level requires an industry-level approach for their assessment. A participative model was adopted for its good fit with the meat processing industry (section 6.1.2). The challenges of conducting a participative approach at an industry level are not widely discussed in the literature (Carayon, 2006; Commissaris et al., 2006). Therefore, a secondary contribution to knowledge from the thesis is the development and adoption of the industry-level participative approach. The thesis also makes a contribution through supporting the addition of another dimension to the PEF, strengthening the industry-level participative aspects of the framework as suggested by Haines et al. (2002).

A further contribution to knowledge is the finding from the three industry-based data sources that in knife-related tasks, MSD were as likely to occur in the non-knife hand as the knife hand. Although previously reported in the literature (Gorsche et al., 1999), this unexpected finding runs contrary to industry expectations regarding MSD in knife tasks. The finding therefore has the potential to strongly influence MSD prevention initiatives regarding knife use.

6.4 Directions for future research

Many aspects of this study arguably deserve further research attention. As the study did not include the implementation and evaluation of interventions this is an obvious next step. Although many of the interventions concern changes that need to occur at an industry level, there are also task-specific interventions where staggered implementation would be possible, thereby enabling the use of a control group (Straker et al., 2004). The measurements of most relevance to the industry would be the impact on total cost, number of serious (compensated) claims, and overall MSD incidence rate. Additionally, evaluating task-specific interventions would allow the collection of production, quality, physical risk, and subjective data on the process and outcomes from it.

A further area of research in the current study could be to evaluate the efficacy of the current industry stakeholder group, the MIHSF, in achieving industry-level change. The group has been successful in implementing well-accepted injury prevention topics (e.g. leptospirosis, knife sharpening) involving change at plant level. This same mechanism should also work for many of the MSD interventions. However, some of the MSD interventions that challenge beliefs and traditions, and those that may affect income in the short term, will require consultation and education that are likely to be beyond the resources of the current group. Several structural changes could be discussed with the MIHSF, including the addition of a second tier participative group established specifically for implementing interventions, or establishing a taskforce for presenting industry-level interventions to those who can make changes (e.g. chief executives of processing companies, trade unions, Federated Farmers, government ministers).

The post-study survey of MIHSF members provided some insight into how the study and findings from it were perceived. This survey could be further developed and repeated over time. Evaluating the use of the intervention document by processing plants would also be useful, including for example: who is involved, how the document is being used, which interventions have been implemented and their effects.

A final research consideration for this study would be to investigate MSD in venison and veal plants separately. While these are much smaller sectors, they are arguably under-represented on the MIHSF and have enough points of difference from the two main species to warrant specific attention.

The feasibility of applying an industry-level or multi-organisation participative approach for addressing MSD in another industry would also be worth investigating. While this approach has been successful in identifying a wide range of MSD risks and interventions, the question of how well it works in addressing industry level issues that require the cooperation and commitment of all stakeholders, is still to be answered. However the growing complexity of work systems (Sinclair, 2007), relationships between organisations working for a common purpose (Moir & Buchholz, 1996), and even working within the same organisation (Carayon, 2006) make it sensible to consider a participative approach.

The further development of participative methods that can assist in identifying contextual factors and interventions that address them is also worth considering. Another issue to consider is at what level commitment is required in multi-level participative studies. Management commitment may not be essential if changes are at an industry level and occur without the managers necessarily recognising them (e.g. consistency in seniority rules, changes to hygiene compliance requirements, or an extension of the processing season). Instead, perhaps management commitment is required for supporting their representative to be involved in the participative programme. Possibly there are others whose commitment is more important for facilitating the process and making changes (e.g. legislators, government agencies, clients, or suppliers (farmers)). The use of the PEF for helping to conceptualise and plan complex participative studies (such as those involving multiple organisations / industries), and its further development as a planning and reviewing tool, could also be considered.

A final area for further research would be to investigate whether any relationship exists between the presence of MSD contextual factors and aspects of safety culture, ideally measured at an industry rather than organisational level. This is of relevance as several of the contextual factors identified in this study relate to cultural aspects of the industry, and in particular, the prioritisation of safety versus productivity issues.

6.5 Final conclusions

From research undertaken in this study it is concluded that a range of external and internal contextual factors contribute to the occurrence of MSD risk in the New Zealand meat processing industry.

An industry-level participative approach was undertaken which enabled the identification and development of industry-derived MSD interventions. The interventions also accounted for many of the potential barriers to their implementation. Engaging with the industry and involving them wherever possible raised awareness of MSD, and helped to transcend potential barriers such as competitiveness, adversarial industrial relations and distrust. Ownership of the interventions from the study occurred among members of the stakeholder group. Motivation to change was also created through the MSD interventions becoming default 'best practice' against which government agencies and trade unions are likely to measure performance.

References

ACC. (1996). *Analysis of work related injuries: meat processing industry 1992-1995*. Wellington, New Zealand: Accident Compensation Corporation.

ACC. (1997). *Occupational overuse syndrome: treatment & rehabilitiation – a practitioners' guide*. (2nd ed.). Wellington, New Zealand: ACC.

ACC. (2001). *Manual Handling Code of Practice*. Wellington, New Zealand: ACC.

ACC. (2002). *Safer Industries: Meat Industry Health and Safety Forum Objectives and Action Plan*. Wellington, New Zealand: ACC.

ACC. (2003). *Work related new and ongoing entitlement claims in selected industries by minor diagnosis*. Wellington, New Zealand: ACC.

ACC. (2004a). *All accepted new and ongoing claims data by selected minor diagnosis and READ code between July 2002 – July 2004*. Wellington, New Zealand: ACC.

ACC. (2004b). Section 3.1 Number and cost of new and ongoing paid entitlement claims by claimant ethnicity. *ACC Injury Statistics 2004* (3rd ed.) Wellington, New Zealand: ACC.

ACC. (2005). Section 3.1 Number and cost of new and ongoing work-related paid entitlement claims by diagnosis, *ACC Injury Statistics 2005*. Wellington, New Zealand: ACC.

ACC. (2006). *Preventing and managing discomfort, pain and injury*. Wellington, New Zealand: ACC.

ACC. (2007). *An analysis of work related new entitlement claims and costs in selected industries (2001-2006)*. Wellington, New Zealand: ACC.

ACC & OSH. (2003). *Joint Statement - OSH and ACC position on industry health and safety groups*. Wellington, New Zealand: ACC & OSH.

AMIEU. (1995). *National guidelines for health and safety in the meat industry*. Australian Meat Industry Employees Union and the Meat and Allied Trades Federation of Australia. Victoria: AMIEU.

Anonymous. (1875). A telegraphic malady. *Lancet, 1,* 585.

ANZSIC96. (2002). *Australia and New Zealand Standard Industry Classification (New Zealand use version),* version 4.1. Wellington: Statistics New Zealand.

Aptel, M., Aublet-Cuvelier, A., & Cnockaert, J. C. (2002). Work-related musculoskeletal disorders of the upper limb. *Joint Bone Spine*, 69, 546-555.

Armstrong, T. J., Buckle, P., Fine, L. J., Hagberg, M., Jonsson, B., Kilbom, A., et al. (1993). A conceptual model for work-related neck and upper-limb musculoskeletal disorders. *Scandinavian Journal of Work Environment & Health, 19*, 73-84.

Axtell, C. M., Waterson, P. E., & Clegg, C. W. (1995). *User participation in system development: the importance of organisational factors.* Paper presented at the Contemporary Ergonomics conference.

Barrett, J. H., Haslam, R. A., Lee, K. G., & Ellis, M. J. (2005). Assessing attitudes and beliefs using the stage of change paradigm – case study of health and safety appraisal within a manufacturing company. *International Journal of Industrial Ergonomics*, 35, 871-887.

Batt, R., & Appelbaum, E. (1995). Worker participation in diverse settings: does the form affect the outcome, and if so, who benefits? *British Journal of Industrial Relations, 33*, 353-378.

Bernard, B. (Ed.). (1997). *Musculoskeletal disorders and workplace factors: a critical review of epidemiologic evidence for work-related musculoskeletal disorders of the neck, upper extremity, and low back.* (NIOSH Publication No 97-141). Cincinnati: NIOSH.

Blewden, M., & Wyllie, A. (1997). *Council of Trade Unions Injury Prevention Programme: outcome evaluation report*. Auckland, New Zealand: Alcohol and Public Health Research Unit, University of Auckland.

Blewden, M., & Wyllie, A. (1998). Outcome evaluation findings from a pilot injury prevention project in the meat industry. *Journal of Occupational Health and Safety - Australia & NZ, 14*(4), 401-408.

Bobjer, O. (1989). Ergonomic knives. In A. Mital (Ed.), *Advances in industrial ergonomics and safety 1* (pp. 291-298). London: Taylor & Francis.

Bohr, P. C., Evanoff, B. A., & Wolf, L. D. (1997). Implementing participatory ergonomics teams among health care workers. *American Journal of Industrial Medicine, 32*(3), 190-196.

Bongers, P. M., de Winter, C. R., Kompier, M. A. J., & Hildebrandt, V. H. (1993). Psychosocial factors at work and musculoskeletal disease. *Scandinavian Journal of Work Environment & Health, 19*(5), 297-312.

Bongers, P. M., Kremer, A. M., & ter Laak, J. (2002). Are psychosocial factors, risk factors for symptoms and signs of the shoulder, elbow, or hand/wrist? A review of the epidemiologic literature. *American Journal of Industrial Medicine, 41*, 315-342.

Boocock, M., McNair, P., Larmer, P., Armstrong, B., Collier, J., Simmonds, M., et al. (2005). *OOS Prevention Literature Review: report to ACC.* (No. 040405). Auckland, New Zealand: Auckland University of Technology.

Boocock, M., McNair, P., Larmer, P., Armstrong, B., Collier, J., Simmonds, M., et al. (2006, 10-14 July 2006). *Terminology and definitions for upper extremity musculoskeletal conditions: a new framework.* Meeting diversity in ergonomics, Paper presented at the XVIth Congress of the International Ergonomics Association. Maastricht, The Netherlands.

Boocock, M. G., McNair, P. J., Larmer, P. J., Armstrong, B., Collier, J., Simmonds, M., et al. (2007). Interventions for the prevention and management of neck/upper extremity musculoskeletal conditions: a systematic review. *Occupational and Environmental Medicine, 64*(5), 291-303.

Brasington, C. F., & Hammonds, D. R. (1971). *Boning carcass beef on the rail: a feasibility study*: United States Department of Agriculture.

Broberg, E. (1996). *Anmalda arbetssjukdomar i Norden 1990-1992 (Reported occupational diseases in the Nordic countries 1900-1992).* Temanord, Norway: The Nordic Council of Ministers.

Buchholz, B., Frederick, L., & Armstrong, T. J. (1988). An investigation of human palmar skin friction and the effects of materials, pinch force and moisture. *Ergonomics, 31*(3), 317-325.

Buckle, P. W. (2005). Ergonomics and musculoskeletal disorders: overview. *Occupational Medicine-Oxford, 55*(3), 164-167.

Buckle, P. W., & Devereux, J. J. (2002). The nature of work-related neck and upper limb musculoskeletal disorders. *Applied Ergonomics, 33*, 207-217.

Burgess-Limerick, R., Straker, L., Pollock, C., Dennis, G., Leveritt, S., & Johnson, S. (2007). Implementation of the Participative Ergonomics for Manual Tasks (PErforM) programme at four Australian underground coal mines. *International Journal of Industrial Ergonomics, 37*(2), 145-155.

Butcher, G. W., Gentry, S. C., & Wakeling, B. J. (1978). *The design of freezing works for the 1970s*. Paper presented at the 20th Meat Industry Research Conference, Hamilton, New Zealand.

Cameron, I., Hare, B., Duff, R., & Maloney, B. (2006). *An investigation of approaches to worker engagement* (No. RR516). Norwich: Health and Safety Executive.

Caple, D. C. (1992, May). *Musculoskeletal injury prevention - meat industry intervention study.* Paper presented at the International Scientific Conference on Prevention of Work-related Musculoskeletal Disorders. Sweden.

Caple, D. C. (1994). *Noise control for abattoirs*. Unpublished report by David Caple Associates for the Meat Research Corporation, Sydney, Australia.

Caple, D. C. (2003). *The 45 Syndrome: Age and MSD Incidence amongst Meat Workers.* Ergonomics in the Digital Age, Paper presented at the XVth Triennial Congress of the International Ergonomics Association and the 7th Joint Conference of the Ergonomics Society of Korea and the Japan Ergonomics Society. Seoul, Korea.

Caple, D. C. (2005). *Participatory ergonomics in the meat industry.* Paper presented at the Proceedings of CybErg 2005 - The fourth international cyberspace conference on ergonomics.

Caple, D. C., & Hodgson, R. (1992). *Meat processing industry - 100 micro ergonomic solutions.* Paper presented at the Unlocking Potential for the Future Productivity and Quality of Life, Proceedings of the 28th Annual Conference of the Ergonomics Society of Australia Inc, Melbourne, Australia.

Carayon, P. (2006). Human factors of complex sociotechnical systems. *Applied Ergonomics, 37*, 525-535.

Carayon, P. (2006a). Psychosocial work factors. In W. S. Marras & W. Karwowski (Eds.), *Fundamentals and assessment tools for occupational ergonomics* (2nd ed., pp. 26.21 - 26.29). Boca Raton: CRC Press.

Carayon, P., & Smith, M. J. (2000). Work organization and ergonomics. *Applied Ergonomics, 31*, 649-662.

Carayon, P., Smith, M. J., & Haims, M. C. (1999). Work organization, job stress, and work-related musculoskeletal disorders. *Human Factors*, 644-663.

Carrivick, P. J. W., Lee, A. H., Yau, K. K. W., & Stevenson, M. R. (2005). Evaluating the effectiveness of a participatory ergonomics approach in reducing the risk and severity of injuries from manual handling. *Ergonomics, 48*(8), 907-914.

Christensen, H., & Larsen, J. (1995). Handgrip strength and forearm muscle activity during meat cutting. In: *PREMUS Book of Abstracts* (p. 72-74). Montreal, Canada.

Christensen, H., Sogaard, K., Pilegaard, M., & Olsen, H. (2000). The importance of the work/rest pattern as a risk factor in repetitive monotonous work. *International Journal of Industrial Ergonomics, 25*, 367 - 373.

Claudon, L. (2000, 19-21 May 2000). *Ergonomic hand tool design: interview of users.* Paper presented at the Ergonomics and Safety for Global Business Quality and Productivity: proceedings of the Second International Conference ERGON-AXIA 2000, Warsaw, Poland.

Claudon, L. (2006). Influence on grip of knife handle surface characteristics and wearing protective gloves. *Applied Ergonomics*, 37(6), 729-735.

Claudon, L., & Marsot, J. (2006). Effect of knife sharpness on upper limb biomechanical stresses - a laboratory study. *International Journal of Industrial Ergonomics, 36*, 239-246.

Cochrane, D. J., & Riley, M. W. (1986). An evaluation of knife handle guarding. *Human Factors, 28*(3), 295-301.

Cohen, A. (1994). Worker participation approaches and issues. In C. C. Gjessing, T. F. Schoenborn & A. Cohen (Eds.), *Participatory ergonomic interventions in meatpacking plants* (Vol. Publication No. 94-124, pp. 9-46). Cincinnati, OH: DHHS (NIOSH).

Cohen, A. (1996). Worker Participation. In A. Bhattacharya & J. McGlothin (Eds.), *Occupational Ergonomics: theory and applications* (pp. 235-258). New York: Marcel Dekker.

Cole, D., Rivilis, I., van Eerd, D., Cullen, K., Irvin, E., & Kramer, D. (2005). *Effectiveness of participatory ergonomic interventions: a systematic review*. Toronto: Institute for Work and Health.

Commissaris, D., Schoenmaker, N., Beune, E. A. T., & Eikhout, S. M. (2006). Applying principles of change management in ergonomic projects: A case study. *Human Factors and Ergonomics in Manufacturing, 16*(2), 195-223.

Conroy, C. (1989). Work-related injuries in the meatpacking industry. *Journal of Safety Research*, 20(2), 47-53.

Corlett, E. N. (1995). The evaluation of posture and its effects. In J. Wilson & E. N. Corlett (Eds.), *Evaluation of human work: a practical ergonomics methodology* (2nd ed., p. 662-713). London: Taylor & Francis.

Cotton, J. L. (1993). *Employee involvement: methods for improving performance and work attitudes*: Sage Publications.

Cotton, J. L., Vollrath, D. A., Froggatt, K. L., Lengnick-Hall, M. L., & Jennings, K. R. (1988). Employee participation: diverse forms and different outcomes. *The Academy of Management Review, 13*(1), 8-22.

Curtis, B. (1992, 12-13 November). *The export meat industry*. Paper presented at the Fifth Conference on Labour, Employment and Work in New Zealand. Wellington.

Dababaneh, A., Swanson, N., & Shell, R. (2001). Impact of added rest breaks on the productivity and well being of workers. *Ergonomics, 44*(2), 164 - 174.

Dachler, H. P., & Wilpert, B. (1978). Conceptual dimensions and boundaries of participation in organizations: a critical evaluation. *Administrative Science Quarterly, 23*(1), 1-39.

Dale, H. (2005). The implementation of a participatory ergonomics program in industrial workplaces. *Ergonomics Australia, 19*(2), 21-32.

Damodaran, L. (1996). User involvement in the systems design process - a practical guide for users. *Behaviour and Information Technology, 15*(6), 363-377.

David, G. C. (2005). Ergonomic methods for assessing exposure to risk factors for work related musculoskeletal disorders. *Occupational Medicine-Oxford, 55*, 190-199.

de Jong, A. M. (2001). Participation. In W. Karwowski (Ed.), *International Encyclopedia of Ergonomics and Human Factors* (Vol. 2, pp. 1271-1273).

de Jong, A. M., & Vink, P. (2000). The adoption of technological innovations for glaziers; evaluation of a participatory ergonomics approach. *International Journal of Industrial Ergonomics, 26*(1), 39-46.

de Jong, A. M., & Vink, P. (2002). Participatory ergonomics applied in installation work. *Applied Ergonomics, 33*, 439-448.

de Jong, A. M., Vink, P., & de Kroon, J. C. A. (2003). Reasons for adopting technological innovations reducing physical workload in bricklaying. *Ergonomics, 46*(11), 1091-1108.

de Looze, M. P., Urlings, I. J. M., Vink, P., van Rhijn, J. W., Miedema, M. C., Bronkhorst, R. E., et al. (2001). Towards successful physical stress reducing products: an evaluation of seven cases. *Applied Ergonomics, 32*(5), 525-534.

de Looze, M. P., Van Rhijn, G. W., van Deursen, J., Tuinzaad, G. H., & Reijneveld, C. N. (2003). A participatory and integrative approach to improve productivity and ergonomics in assembly. *Production planning and control, 14*(2), 174-181.

Dempsey, P. G. (2007). Effectiveness of ergonomics interventions to prevent musculoskeletal disorders: beware of what you ask. *International Journal of Industrial Ergonomics, 37*, 169-173.

Dempsey, P. G. & Mathiassen, S. E. (2006). On the evolution of task-based analysis of manual materials handling, and its applicability in contemporary ergonomics. *Applied Ergonomics 37*(1), 33-43.

Denis, D., St-Vincent, M., Imbeau, D., Jette, C., & Nastasia, I. (2008). Intervention practices in musculoskeletal disorder prevention: a critical literature review. *Applied Ergonomics, 39*(1), 1-14.

Devereux, J., Buckle, P., & Haisman, M. (1998). The evaluation of a hand-handle interface tool (HHIT) for reducing musculoskeletal discomfort associated with the manual handling of gas cylinders. *International Journal of Industrial Ergonomics, 21*(1), 23-34.

Devereux, J., Rydstedt, L., Kelly, V., Weston, P., & Buckle, P. (2004). *The role of work stress and psychological factors in the development of musculoskeletal disorders* (No. RR273). Norwich, England: Health and Safety Executive.

Dodwell, P. (2003). OOS or MUD? Time for a cleanup. *The New Zealand Medical Journal, 116*(1176), 480-486.

Dowd, P. (2001). *Improving average knife sharpness in the New Zealand meat industry: summary of results from MIRINZ Inc project*. Hamilton: MIRINZ.

Drewcynski, A., & Bertolini, R. (1995). Repetitive Motion Injuries: beefing up prevention. *Occupational Health and Safety Canada, Sep/Oct 11*(5), 137-142.

Driscoll, T., Mannetje, A., Dryson, E., Feyer, A., Gander, P., McCracken, et al. (2004). *The Burden of Occupational Disease and Injury in New Zealand* (Technical report): National Occupational Health and Safety Advisory Committee. Wellington: NOHSAC.

Durand, M. J., Vezina, N., Loisel, P., Baril, R., Richard, M. C., & Diallo, B. (2007). Workplace interventions for workers with musculoskeletal disabilities: A descriptive review of content. *Journal of Occupational Rehabilitation, 17*(1), 123-136.

Dwyer, T. (1995). Industrial Accidents: A sociological analysis. In C. Slappendel (Ed.), *Health and Safety in New Zealand Workplaces* (pp. 249-265). Palmerston North: Dunmore Press.

Eason, K. D. (1995). User-centred design: for users or by users? *Ergonomics, 38*(8), 1667-1673.

Enerke Oy. (2008). Participative development of work methods (SATKE, TASKE. In Z. Podniece (Ed.), *European Good Practice Awards 2007 - Prevention of work-related MSDs in practice* (pp. 27): European Agency for Safety and Health at Work.

Evanoff, B. A., Bohr, P. C., & Wolf, L. D. (1999). Effects of a participatory ergonomics team among hospital orderlies. *American Journal of Industrial Medicine, 35*(4), 358-365.

Falck, B., & Aarnio, P. (1983). Left-sided carpal tunnel syndrome in butchers. *Scandinavian Journal of Work, Environment & Health, 9*, 291 – 297.

Farlow, D. W. (1990). *Recent overseas research into plant safety and productivity.* Paper presented at the 26th Meat Industry Research Conference, Hamilton, New Zealand.

Faucett, J. (2005). Integrating 'psychosocial' factors into a theoretical model for work-related musculoskeletal disorders. *Theoretical Issues in Ergonomics Science, 6*(6), 531-550.

Feuerstein, M. (1996). Workstyle: definition, empirical support, and implications for prevention, evaluation, and rehabilitation of occupational upper-extremity disorders. In S. D. Moon & S. L. Sauter (Eds.), *Beyond biomechanics: psychological aspects of musculoskeletal disorders in office work.* (pp. 177-206). Bristol, PA: Taylor & Francis.

Fleming, S. L., Jansen, C. W., & Hasson, S. M. (1997). Effect of work glove and type of mucsle action on grip fatigue. *Ergonomics*, *40*(6), 601-612.

Fogleman, M. T., Freivalds, A., & Goldberg, J. H. (1993). An ergonomic evaluation of knives for two poultry cutting tasks. *International Journal of Industrial Ergonomics, 11*, 257-265.

Frei, F., Hugentobler, M., Schurman, S., Duell, W., & Alioth, A. (1993). Union participation in work design. In *Work design for the competent organization* (pp. 261-274). Westport: Quorum Books.

Frost, P., & Andersen, J.H. (1999). Shoulder impingement syndrome in relation to shoulder intensive work. *Journal of Occupational Environmental Medicine, 56,* 494-498.

Frost, P., Andersen, J. H., & Nielsen, V. K. (1998). Occurrence of carpal tunnel syndrome among slaughterhouse workers. *Scandinavian Journal of Work, Environment & Health, 24*(4), 285 - 292.

Gadbois, C., Villatte, R., Bourne, J. P., & Visier, L. (1995). Union Assimilation of the Ergonomic Approach and the Transformation of Social-Relations. *Relations Industrielles-Industrial Relations, 50*(4), 852-873.

Gaynor, B. (2008, May 24). Change would save meat processors. *New Zealand Herald.* Retrieved from http://www.nzherald.co.nz.

Gazette. (1967). Meat freezing company's safety campaign. *Labour and Employment Gazette,* pp. 28-30.

Genaidy, A. M., Delgado, E., & Bustos, T. (1995). Active Microbreak Effects on Musculoskeletal Comfort Ratings in Meatpacking Plants. *Ergonomics, 38*(5), 996-1010.

Gjessing, C. C., Schoenborn, T. F., & Cohen, A. (Eds.). (1994). *Participatory ergonomic interventions in meatpacking plants*. U.S. Department of Health and Human Services, National Institute for Occupational Safety and Health. Cincinnati: CDC & NIOSH.

Glaxosmithkline. (2008). Use of participatory ergonomics to identify and solve high-risk tasks. In Z. Podniece (Ed.), *European Good Practice Awards 2007 - Prevention of work-related MSDs in practice* (pp. 16): European Agency for Safety and Health at Work.

Glew, D. J., O'Leary-Kelly, A. M., Griffin, R. W., & van Fleet, D. D. (1995). Participation in organizations: a preview of the issues and proposed framework for future analysis. *Journal of Management, 21*(3), 395-421.

Gorsche, R. J., Wiley, J. P., Renger, R. F., Brant, R. F., Gemer, T. Y., & Sasyniuk, T. M. (1999). Prevalence and incidence of carpal tunnel syndrome in a meat packing plant. *Journal of Occupational and Environmental Medicine, 56*, 417-422.

Grant, K. A., & Habes, D. J. (1997). An Electromyographic Study of Strength and Upper Extremity Muscle Activity in Simulated Meat Cutting. *Applied Ergonomics, 28*(2), 129-137.

Greenslade, E., Moore, D. J., & Tappin, D. C. (1998). *Meat Industry Injury Prevention Project - Case study six: Improving the personal equipment of meat workers.* Wellington: New Zealand Council of Trade Unions.

Hagberg, M., Silverstein, B., Wells, R., Smith, M. J., Hendrick, H. W., Carayon, P., et al. (1995). *Work-related Musculoskeletal Disorders (WMSDs): a Reference Book for Prevention*. London: Taylor & Francis.

Haims, M. C., & Carayon, P. (1998). Theory and practice for the implementation of 'in-house' continuous improvement participatory ergonomic programs. *Applied Ergonomics, 29*(6), 461-472.

Haines, H. M. (2003). *Understanding participatory ergonomics: developing theory and practice.* Unpublished Doctoral Thesis, University of Nottingham, England.

Haines, H. M., & Wilson, J. R. (1998). Development of a Framework for Participatory Ergonomics. *Health and Safety Executive, HSE Books, Sudbury, Suffolk*, 1 - 72.

Haines, H., Wilson, J. R., Vink, P., & Koningsveld, E. (2002). Validating a framework for participatory ergonomics (the PEF). *Ergonomics, 45*(4), 309-327.

Halpern, C. A., & Dawson, K. D. (1997). Design and implementation of a participatory ergonomics program for machine sewing tasks. *International Journal of Industrial Ergonomics, 20*(6), 429-440.

Hanara, P. (1980, Spring 1980). Productivity through design. *Forequarter,* 6-7.

Hanara, P. (1981). Worker designers. *Designscape, 134*, 13-16.

Hanse, J. J., & Forsman, M. (2001). Identification and analysis of unsatisfactory psychosocial work situations: a participatory approach employing video-computer interaction. *Applied Ergonomics, 32*(1), 23-29.

Haslam, R. A. (2002). Targeting ergonomics interventions - learning from health promotion. *Applied Ergonomics, 33*, 241-249.

Hasle, P., Limborg, H. J., Hvenegaard, H., & Bruvik-Hansen, A. (1997). A critical evaluation of bottom up strategies in participatory ergonomics. *From Experience to Innovation - IEA97. Proceedings of the 13th Triennial Congress of the International Ergonomics Association, Tampere, Finland, June 29-July 4, 1997, Edited by P. Seppala, T. Luopajarvi, C.H. Nygard and M. Mattila.*, 364-366.

Health and Safety in Employment Amendment Act, Part 2a, Schedule 1a (2002).

Health and Safety Executive. (2002). *Upper limb disorders in the workplace.* (No. HSG60(rev)). Norwich: HMSO.

Health and Safety Executive. (2007). *Musculoskeletal Disorders*. Retrieved from http://www.hse.gov.uk/statistics/causdis/musc.htm.

Hembry, O. (2008, May 14). Oringi closure sign of things to come in meat industry. *New Zealand Herald*. Retrieved from http://www.nzherald.co.nz.

Hess, J. A., Hecker, S., Weinstein, M., & Lunger, M. (2004). A participatory ergonomics intervention to reduce risk factors for low-back disorders in concrete laborers. *Applied Ergonomics, 35*(5), 427-441.

Hignett, S., & McAtamney, L. (2006). REBA and RULA: whole body and upper limb rapid assessment tools. In W. S. Marras & W. Karwowski (Eds.), *The Occupational Ergonomics Handbook - Fundamentals and assessment tools for occupational ergonomics* (Second ed., pp. 42.01 - 42.12). Boca Raton: CRC Press.

Hignett, S., Wilson, J. R., & Morris, W. (2005). Finding ergonomic solutions - participatory approaches. *Occupational Medicine-Oxford, 55*(3), 200-207.

Hoogendoorn, W. E., Bongers, P. M., de Vet, H., Houtman, I., Ariens, G., van Mechelen, W., et al. (2001). Psychosocial work characteristics and psychological strain in relation to low-back pain. *Scandinavian Journal of Work Environment & Health, 27*(4), 258-267.

Howard, N., Spielholz, P., Bao, S., Silverstein, B., & Fan, J. (2008). Reliability of an observational tool to assess the organization of work. *International Journal of Industrial Ergonomics*.

Hsiang, S., McGorry, R., & Bezverkhny, I. (1997). The Use of Taguchi's Methods for the Evaluation of Industrial Knife Design. *Ergonomics, 40*(4), 476 - 490.

Huang, G. D., Feuerstein, M., & Sauter, S. L. (2002). Occupational stress and work-related upper extremity disorders: concepts and models. *American Journal of Industrial Medicine, 41*, 298-314.

Huang, G. D., Feuerstein, M., Kop, W. J., Schor, K., & Arroyo, F. (2003). Individual and combined impacts of biomechanical and work organization factors in work-related musculoskeletal symptoms. *American Journal of Industrial Medicine, 43*(5), 495-506.

IEA. (2000). [IEA definition of ergonomics]. Retrieved July 2, 2008, from http://www.iea.cc/browse.php?contID=what_is_ergonomics.

Imada, A. S. (1991). The rationale and tools of participatory ergonomics. In K. Noro & A. S. Imada (Eds.), *Participatory Ergonomics* (pp. 30-49). London: Taylor & Francis.

Imada, A. S., & Robertson, M. M. (1987). *Cultural perspectives in participatory ergonomics.* Paper presented at the Proceedings of the Human Factors and Ergonomics Society 31st Annual Meeting.

Ilmarinen, R., Tammela, E., & Korhonen, E. (1990). Design of functional work clothing for meat-cutters. *Applied Ergonomics, 21*(1), 2-6.

Ingelgard, A., & Norrgren, F. (2001). Effects of change strategy and top-management involvement on quality of working life and economic results. *International Journal of Industrial Ergonomics, 27*, 93-105.

Inkson, K., & Cammock, P. (1984). Labour process theory and the chain system in the New Zealand meatworks. *New Zealand Journal of Industrial Relations, 9*, 149-160.

Inkson, K., & Cammock, P. (1988). The meat freezing industry in New Zealand. In E. Willis (Ed.), *Technology and the Labour Process* (p. 68-81). Sydney, Australia: Allen & Unwin.

Isolani, L., Bonfiglioli, R., Raffi, G. B., & Violante, F. S. (2002). Different case definitions to describe the prevalence of occupational carpal tunnel syndrome in meat industry workers. *International Archives of Occupational Environmental Health, 75*, 229 - 234.

Jeffrey, G. (1995). The industrial relations context of workplace health and safety. In C. Slappendel (Ed.), *Health and Safety in New Zealand workplaces* (p. 157-180). Palmerston North: The Dunmore Press.

Jensen, L. K., & Friche, C. (2007). Effects of training to implement new tools and working methods to reduce knee load in floor layers. *Applied Ergonomics, 38*(5), 655-665.

Jones, R. J. (1997). Corporate Ergonomics program of a large poultry processor. *American Industrial Hygiene Association Journal, 58*, 132-137.

Jorgensen, M. (1990). Automation in the Danish meat industry - a case study on social shaping of technology. In W. Karwowski & M. Rahimi (Eds.), *Ergonomics of Hybrid Automated Systems II* (pp. 101-108). Amsterdam: Elsevier.

Juul-Kristensen, B., Fallentin, N., Hansson, G.-A., Madeleine, P., Andersen, J. H., & Ekdahl, C. (2002). Physical workload during manual and mechanical deboning of poultry. *International Journal of Industrial Ergonomics*(29), 107 - 115.

Karasek, R., & Theorell, T. (1990). *Healthy Work: stress, productivity and the reconstruction of working life*: Basic Books.

Kardborn, A. (1998). Inter-organisational participation and user focus in a large-scale product development programme: The Swedish hand tool project. *International Journal of Industrial Ergonomics, 21*, 369-381.

Karsh, B. T. (2006). Theories of Work-Related Musculoskeletal Disorders: Implications for Ergonomic Interventions. *Theoretical Issues in Ergonomics Science, 7*(1), 71-88.

Karsh, B. T., Moro, F. B. P., & Smith, M. J. (2001). The efficacy of workplace ergonomic interventions to control musculoskeletal disorders: a critical analysis of the peer-reviewed literature. *Theoretical issues in ergonomics science, 2*(1), 23-96.

Keyserling, W. M. (2000a). Workplace risk factors and occupational musculoskeletal disorders, part 1: a review of biomechanical and psychophysical research on risk factors associated with low-back pain. *American Industrial Hygiene Association Journal, 61*, 39-50.

Keyserling, W. M. (2000b). Workplace risk factors and occupational musculoskeletal disorders, part 2: a review of biomechanical and psychophysical research on risk factors associated with upper extremity disorders. *American Industrial Hygiene Association Journal, 61*, 231-243.

Keyserling, W. M., & Hankins, S. E. (1994). *Effectiveness of plant-based committees in recognizing and controlling ergonomic risk factors associated with musculoskeletal problems in the automotive industry.* Paper presented at the 12th triennial congress of the international ergonomics association, Toronto, Canada.

Kogi, K. (2006). Participatory Methods Effective for Ergonomic Workplace Improvement. *Applied Ergonomics, 37*(4), 547 - 554.

Kogi, K. (2008). Facilitating participatory steps for planning and implementing low-cost improvements in small workplaces. *Applied Ergonomics, 39*(4), 475-481.

Kogi, K., Kawakami, T., Itani, T., & Batino, J. M. (2003). Low-cost work improvements that can reduce the risk of musculoskeletal disorders. *International Journal of Industrial Ergonomics, 31*(3), 179-184.

Kogi, K., Kawakami, T., Ujita, Y., & Khai, T. T. (2005). *Roles of farmer trainers for participatory ergonomics in agriculture.* Paper presented at the CybErg 2005 conference.

Koningsveld, E. A. P. (2005). Participation for understanding: an interactive method. *Journal of Safety Research - ECON proceedings, 36*, 231-236.

Kumar, S. (2001). Theories of musculoskeletal injury causation. *Ergonomics, 44*(1), 17-47.

Kuorinka, I. (1997). Tools and means of implementing participatory ergonomics. *International Journal of Industrial Ergonomics, 19*(4), 267-270.

Kurppa, K., Viikari-Juntura, E., Kuosma, E., Huuskonen, M., & Kivi, P. (1991). Incidence of tenosynovitis and epicondylitis in a meat processing factory. *Scandinavian Journal of Work, Environment & Health, 17*, 32-37.

Lacey, R. J., Lewis, M., & Sim, J. (2007). Piecework, musculoskeletal pain and the impact of workplace psychosocial factors. *Occupational Medicine-Oxford, 57*, 430-437.

Laing, A. C., Frazer, M. B., Cole, D. C., Kerr, M. S., Wells, R. P., & Norman, R. P. (2005). Study of the effectiveness of a participatory ergonomics intervention in reducing worker pain severity through physical exposure pathways. *Ergonomics, 48*(2), 150-170.

Laing, A. C., Cole, D. S., Theberge, N., Wells, R. P., Kerr, M. S., & Frazer, M. B. (2007). Effectiveness of a participatory ergonomics intervention in improving communication and psychosocial exposures. *Ergonomics, 50*(2), 1092-1109.

Laitinen, H., Saari, J., Kivisto, M., & Rasa, P. L. (1998). Improving physical and psychosocial working conditions through a participatory ergonomic process - A before-after study at an engineering workshop. *International Journal of Industrial Ergonomics, 21*(1), 35-45.

Lewis, H. B., Imada, A. S., & Robertson, M. M. (1988). *Xerox leadership through quality: merging human factors and safety through employee participation.* Paper presented at the Proceedings of the Human Factors and Ergonomics Society 32nd Annual Meeting.

Liker, J. K., Nagamachi, M., & Lifshitz, Y. R. (1989). A comparative analysis of participatory ergonomics programs in U.S. and Japan manufacturing plants. *International Journal of Industrial Ergonomics, 3*, 185-199.

Li, G., & Buckle, P. (1999). Current techniques for assessing physical exposure to work-related musculoskeletal risks, with emphasis on posture-based methods. *Ergonomics 42*(5), 674-695.

Loisel, P., Gosselin, L., Durand, P., Lemaire, J., Poitras, S., & Abenhaim, L. (2001). Implementation of a participatory ergonomics program in the rehabilitation of workers suffering from subacute back pain. *Applied Ergonomics, 32*(1), 53-60.

Loppinet, M., & Aptel, M. (1997). *Musculosketal disorders in the meat industry (HSL translation from French).* Nancy, France: INRS.

Luttman, A., Jagar, M., Griefahn, B., Caffier, G., Liebers, F., & Steinberg, U. (2003). *Preventing musculoskeletal disorders in the workplace*. Geneva: World Health Organization.

MacDonald, L., Karasek, R., Punnett, L., & Scharf, T. (2001). Covariation between workplace physical and psychosocial stressors: evidence and implications for occupational health research and prevention. *Ergonomics, 44*(7), 696-718.

MacDonald, W., & Evans, O. (2006). *Research on the prevention of work-related musculoskeletal disorders. Stage 1 - Literature Review*. Canberra: Australian Safety and Compensation Council.

Maciel, R. (1998). Participatory ergonomics and organizational change. *International Journal of Industrial Ergonomics, 22*(4-5), 319-325.

MAF. (2003). *Report on the contribution of the land-based primary industries to New Zealand's economic growth.* Wellington: Ministry of Agriculture and Forestry.

MAF (2005). *Agricultural, Horticultural and Forestry industry statistics*. Retrieved July 5, 2007, from http://www.maf.govt.nz/statistics/index.htm.

Magnusson, M., & Ortengren, R. (1987). Investigation of optimal table height and surface angle in meatcutting. *Applied Ergonomics, 18*(2), 146-152.

Magnusson, M., Ortengren, R., Andersson, G. B. J., Petersen, I., & Sabel, B. (1987). An ergonomic study of work methods and physical disorders among professional butchers. *Applied Ergonomics, 18*(1), 43 - 50.

Malchaire, J. B., Cock, N., & Vergracht, S. (2001). Review of the factors associated with musculoskeletal problems in epidemiological studies. *International Archives of Occupational and Environmental Health, 74*, 79-90.

Malchaire, J. B., & Piette, A. (2002). Co-ordinated strategy of prevention and control of the biomechanical factors associated with the risk of musculoskeletal disorders. *International Archives of Occupational and Environmental Health, 75*, 459-467.

Mansfield, J. A., & Armstrong, T. J. (1997). Library of Congress workplace ergonomics program. *American Industrial Hygiene Association Journal, 58*, 138-144.

Marchington, M., Wilkinson, A., Ackers, P., & Goodman, J. (1994). Understanding the meaning of participation: views from the workplace. *Human Relations, 47*(8), 867-893.

Market New Zealand (2007). *New Zealand Meat Industry Profile, June 2007*. Retrieved August 12, 2008, from http://www.marketnewzealand.com/MNZ/ aboutNZ/ sectors/14408.aspx.

Markey, R. (2001). Introduction: global patterns of participation. In R. Markey, P. Gollan, A. Hodgkinson, A. Chouraqui & U. Veersma (Eds.), *Models of employee participation in a changing global environment* (pp. 3-22). Sydney: Ashgate.

Marklin, R. W., & Monroe, J. F. (1998). Quantitative biomechanical analysis of wrist motion in bone-trimming jobs in the meat packing industry. *Ergonomics, 41*(2), 227-237.

Marras, W. S., Cutlip, R. G., Burt, S. E., & Waters, T. R. (2009). National occupational research agenda (NORA) future directions in occupational musculoskeletal disorder health research. *Applied Ergonomics, 40*(1), 15-22.

Marsot, J., Claudon, L., & Jacqmin, M. (2007). Assessment of knife sharpness by means of a cutting force measuring system. *Applied Ergonomics, 38*(1), 83-89.

McAtamney, L., & Corlett, E. N. (1993). RULA: a survey method for the investigation of work-related upper limb disorders. *Applied Ergonomics, 24*, 91-99.

McGorry, R. (2001). A system for the measurement of grip forces and applied moments during hand tool use. *Applied Ergonomics, 32*(3), 271-279.

McGorry, R. W., Dempsey, P. G., & O'Brien, N. V. (2004). The effect of workstation and task variables on forces applied during simulated meat cutting. *Ergonomics, 47*(15), 1640 -1656.

McGorry, R., Dowd, P., & Dempsey, P. G. (2003). Cutting moments and grip forces in meat cutting operations and the effect of knife sharpness. *Applied Ergonomics, 34*(4), 375-382.

McGorry, R. W., Dowd, P., & Dempsey, P. G. (2005). The effect of blade finish and blade angle on forces used in meat cutting operations. *Applied Ergonomics, 36*, 71-77.

McLennan, R. (Ed.). (1978). *Participation and change in the New Zealand workplace*. Wellington: Fourth Estate Books.

Meat & Livestock Australia. (1994). *Toward OHS best practice in the Australian meat industry* (No. M.338C). Sydney: Meat & Livestock Australia.

Meat & Livestock Australia. (2005). *OH&S management systems benchmarking process*. Sydney: Meat & Livestock Australia.

Meat and Wool New Zealand (2008). *Sheep and Beef Mid-season Update* (Paper No. P08001). Wellington: Meat and Wool New Zealand.

Meyer, J. P., & Turpin-Legendre, E. (2001). Risk factors of musculoskeletal disorders: demographic, social and work change aspects in France. In W. Karwowski (Ed.), *International Encyclopedia of Ergonomics and Human Factors* (pp. 1582-1584).

MIA. (2007). *Annual Report 2007*. Wellington: Meat Industry Association.

Mills, R. A. (1993). *Beef and sheep operations - the future in New Zealand*. Paper presented at The Australian Meat Industry Research Conference. Gold Coast: CSIRO Australia.

Miller, P., McAtamney, L., Hogan, A., & Mallet, K. (2006). *Work-related musculoskeletal disease in Australia*. Canberra: Australian Safety and Compensation Council.

Moir, S., & Buchholz, B. (1996). Emerging participatory approaches to ergonomic interventions in the construction industry. *American Journal of Industrial Medicine, 29*, 425-430.

Moon, S. D., & Sauter, S. L. (Eds.). (1996). *Beyond biomechanics - psychosocial aspects of musculoskeletal disorders in office work*. London: Taylor & Francis.

Moore, J. S. (1994). Flywheel truing - a case study of an ergonomic intervention. *American Industrial Hygiene Association Journal, 55*(3), 236-244.

Moore, J. S., & Garg, A. (1994). Case Study #2. In C. C. Gjessing, T. F. Schoenborn & A. Cohen (Eds.), *Participatory ergonomic interventions in meatpacking plants* (Vol. Publication No. 94-124, pp. 93-163). Cincinnati, OH: DHHS (NIOSH).

Moore, J. S., & Garg, A. (1996). Use of participatory ergonomics teams to address musculoskeletal hazards in the red meat packing industry. *American Journal of Industrial Medicine, 29*(4), 402-408.

Moore, J. S., & Garg, A. (1997a). Participatory ergonomics in a red meat packing plant .1. Evidence of long term effectiveness. *American Industrial Hygiene Association Journal, 58*(2), 127-131.

Moore, J. S., & Garg, A. (1997b). Participatory ergonomics in a red meat packing plant .2. Case studies. *American Industrial Hygiene Association Journal, 58*(7), 498-508.

Moore, J. S., & Garg, A. (1998). The effectiveness of participatory ergonomics in the red meat packing industry: evaluation of a corporation. *International Journal of Industrial Ergonomics, 21*(1), 47-58.

Moore, D., Tappin, T., & Vitalis, A. (2004). *Accident register surveys: developing league tables of tasks linked to high incidences of musculoskeletal disorders.* Paper presented at the 12th Conference of the New Zealand Ergonomics Society, Taupo, New Zealand.

Moray, N. (2000). Culture, politics and ergonomics. *Ergonomics, 43*(7), 858-868.

Morris, W., & Wilson, J. (2003). *End user participation in design - an informal approach.* Paper presented at the Proceedings of the HFES Europe Chapter.

Morris, W., Wilson, J., & Koukoulaki, T. (Eds.). (2003). *Developing a participatory approach to the design of work equipment: assimilating lessons from workers' experience*. Brussels: TUTB & SALTSA.

Mullen, J. (2004). Investigating factors that influence individual safety behavior at work. *Journal of Safety Research, 35*, 275-285.

Nagamachi, M. (1995). Requisites and Practices of Participatory Ergonomics. *International Journal of Industrial Ergonomics, 15*(5), 371-377.

National Research Council and the Institute of Medicine (NRC-IOM). (2001). *Musculoskeletal Disorders and the Workplace: Low Back and Upper Extremities. Panel on Musculoskeletal Disorders and the Workplace. Commission on Behavioral and Social Sciences and Education.* Washington, DC: National Academy Press.

Neumann, P. (1989). Why people don't participate when given the chance. *Industrial Participation, 601*, 6-8.

New Zealand Meat Statistics (2007). *Meat and Wool Economic Service Statistics*. Retrieved February 4, 2008, from www.nzmeatstats.co.nz.

New Zealand Meatworkers Union. (2005). *Presentation to meatworker union delegates*. Unpublished presentation, New Zealand Meatworkers Union, Auckland.

New Zealand Meatworkers Union. (2008). *Submission on the Employment Relations Amendment Bill*. Unpublished document, New Zealand Meatworkers Union, Auckland.

NIOSH (National Institute for Occupational Safety and Health). (2002). *The changing organization of work and the safety and health of working people* (DHHS Publication No. 2002-116). Cincinnati, Oh: NIOSH.

Noro, K., & Imada, A. S. (Eds.). (1991). *Participatory Ergonomics*. London: Taylor & Francis.

Nossent, S., de Groot, B., & Verschuren, R. (1995). *Working Conditions in the European Meat Processing Industry*. Dublin, Ireland: European Foundation for the Improvement of Living and Working Life.

Novek, J. (1992). The labour process and workplace injuries in the Canadian meat packing industry. *Canadian Review of Sociology and Anthropology, 29*(1), 17-38.

Novek, J., Yassi, A., & Spiegel, J. (1990). Mechanisation, the labour process, and injury risks in the Canadian meat packing industry. *International Journal of Health Services, 20*(2), 281-296.

Occhipinti, E., Columbini, D., Bulgheroni, M., & Grieco, A. (1993). Evaluation of the strain in the upper limb muscles during different meat cutting tasks by means of vocational EMG. In W. S. Marras, W. Karwowski, J. L. Smith & L. Pacholski (Eds.), *The ergonomics of manual work*. London: Taylor and Francis.

OHSAH. (2006, December 22, 2006). *Participatory ergonomics literature review*. Retrieved 29 July, 2007, from http://www.ohsah.bc.ca/?section_copy_id=2052&section_id=462.

Oppenheim, A. N. (1992). The exploratory interview (chapter 5), *Questionnaire design, interviewing and attitude measurement* (3rd ed.). London: Pinter Publishers.

Oram, R. (Ed.). (1977). *Employee involvement in the New Zealand workplace*. Wellington: New Zealand Employers Federation.

OSH. (1997). *Muscle Minding: a guide for the prevention of OOS in the meat, poultry and fish processing industries*. Wellington: Occupational Health and Safety Service, Department of Labour.

OSH (2001). Part B2.3 Ethnic Group. *Workplace Accident Insurance Statistics Report 2000/01*. Wellington: Occupational Health and Safety Service, Department of Labour.

OSHA. (1991). *Ergonomics Program Management Guidelines for Meat Packing Plants* (No. OSHA 3123): United States Department of Labour, Occupational Safety and Health Administration.

Oxenburgh, M. (1991). Case 45 - Reduction of musculoskeletal hand injuries in meat processing. In *Increasing productivity and profit through health and safety* (pp. 239-242). North Ryde, NSW: CCH International.

Pehkonen, I., Takala, E. P., Ketola, R., Viikari-Juntura, E., Leino-Arjas, P., Hopsu, L., et al. (2009). Evaluation of a participatory ergonomic intervention process in kitchen work. *Applied Ergonomics*.

Piedrahita, H., Punnett, L., & Shahnavaz, H. (2004). Musculoskeletal symptoms in cold exposed and non-cold exposed workers. *International Journal of Industrial Ergonomics, 34*, 271-278.

Pohjonen, T., Punakallio, A., & Louhevaara, V. (1998). Participatory ergonomics for reducing load and strain in home care work. *International Journal of Industrial Ergonomics, 21*(5), 345-352.

Rasmussen, J. (1997). Risk management in a dynamic society: a modelling problem. *Safety Science, 27*(2/3), 183-213.

Rata, S. (1995). *Knife handling in the meat industry*: Meat Industry Training Board, New Zealand Fishing Industry Training Council, ACC.

Riley, D. (1998). *Musculoskeletal disorders in meat de-boning work: a review of the literature* (No. EWP/98/14). Sheffield, England: Health & Safety Laboratory.

Riley, D. (2001). Reducing the risks of musculoskeletal injury in meat boning work: Final report (b) for circulation to working group members. *(HSL Report No. ERG/01/05(b))*. Sheffield, England: Health & Safety Laboratory.

Riley, M. W., Cochran, D. J., Stentz, T. L., May, D. R., & Schwoerer, C. E. (1994). Case Study #1. In C. C. Gjessing, T. F. Schoenborn & A. Cohen (Eds.), *Participatory ergonomic interventions in meatpacking plants* (Vol. Publication No. 94-124, pp. 51-91). Cincinnati, OH: DHHS (NIOSH).

Rivilis, I., Cole, D. C., Frazer, M. B., Kerr, M. S., Wells, R. P., & Ibrahim, S. (2006). Evaluation of a participatory ergonomic intervention aimed at improving musculoskeletal health. *American Journal of Industrial Medicine, 49*(10), 801-810.

Rivilis, I., van Eerd, D., Cullen, K., Cole, D., Irvin, E., Tyson, J., et al. (2008). Effectiveness of participatory ergonomic interventions on health outcomes: a systematic review. *Applied Ergonomics, 39*(3), 342-358.

Robinson, D. (2006, November). The bad old days. *Food focus*, 16-18.

Rosencrance, J. C., & Cook, T. M. (2000). The use of participatory action research and ergonomics in the prevention of work-related musculoskeletal disorders in the newspaper industry. *Applied Occupational and Environmental Hygiene, 15*(3), 255-262.

Roto, P., & Kivi, P. (1984). Prevalence of epicondylitis and tenosynovitis among meatcutters. *Scandinavian Journal of Work Environment and Health, 10*, 203 - 205.

Saleem, J. J., Kleiner, B. M., & Nussbaum, M. A. (2003). Empirical evaluation of training and a work analysis tool for participatory ergonomics. *International Journal of Industrial Ergonomics, 31*(6), 387-396.

Sauter, S. L., & Swanson, N. (1996). An ecological model of musculoskeletal disorders in office work. In S. D. Moon & S. L. Sauter (Eds.), *Beyond Biomechanics - psychosocial aspects of musculoskeletal disorders in office work* (pp. 3-21). London: Taylor & Francis.

Schoenmarklin, R. W., & Monroe, J. F. (1994). *Case Study #3 - Demonstration of ergonomic intervention in the red-meat packing industry*: CDC & NIOSH.

Shackel, B. (1974). *Applied Ergonomics Handbook*. London: IPC Press.

Shaw, A., & Blewett, V. (2001). Having a Say Makes It Work - Participative Ergonomics in the Meat Industry. *Better Integration: Bringing Research and Practice Together. Proceedings of the 37th Annual Conference of the Ergonomics Society of Australia, Sydney, NSW, 27-30 November 2001, Edited by M. Stevenson and J. Talbot. Ergonomics Society of Australia, Downer*, 249 - 256.

Shearn, P. (2004). *Workforce participation in the management of occupational health and safety* (No. HSL/2005/09). Sheffield: Health and Safety Laboratory.

Shearn, P. (2005). *Workforce participation in occupational health and safety management in non-unionised workplaces* (No. HSL/2005/41). Sheffield: Health and Safety Laboratory.

Silverstein, B., & Clark, R. (2004). Interventions to reduce work-related musculoskeletal disorders. *Journal of Electromyography and Kinesiology, 14,* 135-152.

Sinclair, M. A. (2005). Participative Assessment. In J. R. Wilson & E. N. Corlett (Eds.), *Evaluation of human work: a practical ergonomics methodology* (3rd ed., p. 83-111). Boca Raton, Florida: CRC.

Sinclair, M. A. (2007). Ergonomics issues in future systems. *Ergonomics, 50*(12), 1957-1986.

Slappendel, C. (1996). *Strains/sprains injuries in the meat industry: work organisation as a factor in their prevention.* Unpublished discussion paper.

Slappendel, C., Moore, D., & Tappin, D. (1996). *Ergonomics in the meat processing industry.* Paper presented at the 7th conference of the New Zealand Ergonomics Society, Wellington.

Slappendel, C., Moore, D., & Tappin, D. (1996a). *Meat Industry Injury Prevention Project - Case Study One: problem-solving teams*. Wellington: New Zealand Council of Trade Unions.

Slappendel, C., Moore, D., & Tappin, D. (1996b). *Meat Industry Injury Prevention Project - Case Study Two: preventing injuries by reducing work compression*. Wellington: New Zealand Council of Trade Unions.

Slappendel, C., Moore, D. J., & Tappin, D. C. (1996c). *Meat Industry Injury Prevention Project - Case Study Three: finding better ways to measure plant safety*. Wellington: New Zealand Council of Trade Unions.

Sluiter, J. K., Rest, K. M., & Frings-Dresen, M. H. W. (2001). Criteria document for evaluating the work-relatedness of upper-extremity musculoskeletal disorders. *Scandinavian Journal of Work Environment & Health, 27*(supplement 1), 1-102.

Smith, M. J. (1994). *A Case Study of a Participatory Ergonomics and Safety Program in a Meat Processing Plant.* Paper presented at the 12th Triennial Congress of the International Ergonomics Association, Toronto, Canada, August 15-19, 1994.

Smith, M. J., & Carayon-Sainfort, P. (1989). A balance theory of job design for stress reduction. *International Journal of Industrial Ergonomics, 4*, 67-79.

Smith, M. J., & Carayon, P. (1996). Work organisation, stress, and cumulative trauma disorders. In S. D. Moon & S. L. Sauter (Eds.), *Beyond Biomechanics - psychosocial aspects of musculoskeletal disorders in office work* (pp. 23-42). London: Taylor & Francis.

Statistics New Zealand. (1996). *Australia and New Zealand Standard Industry Classification (New Zealand Use Version)* (Version 4.1). Wellington: Statistics New Zealand.

Statistics New Zealand. (2002). Appendix 2, Work related injuries. *Injury Statistics 2001/2002*. Wellington: Statistics New Zealand.

Statistics New Zealand. (2004). *Annual Business Enterprise Survey, February 2004*. Wellington: Statistics New Zealand.

Statistics New Zealand. (2006). *Labour Market Statistics 2006*. Wellington: Statistics New Zealand.

Statistics New Zealand. (2007a). *New Zealand External Trade Statistics, June 2007*. Wellington: Statistics New Zealand.

Statistics New Zealand. (2007b). *Injury Statistics – work related claims: 2006*. Wellington: Statistics New Zealand.

Straker, L., Burgess-Limerick, R., Pollock, C., & Egeskov, R. (2004). A randomized and controlled trial of a participative ergonomics intervention to reduce injuries associated with manual tasks: physical risk and legislative compliance. *Ergonomics, 47*(2), 166-188.

St-Vincent, M., Bellemare, M., Toulouse, G., & Tellier, C. (2006). Participatory ergonomic processes to reduce musculoskeletal disorders: summary of a Quebec experience. *Work, 27*, 123-135.

St-Vincent, M., Kuorinka, I., Chicoine, D., Beaugrand, S., & Fernandez, J. (1997). Assimilation and use of ergonomic knowledge by nonergonomists to improve jobs in two electrical product assembly plants. *Human Factors and Ergonomics in Manufacturing, 7*(4), 337-350.

Sundin, A., & Medbo, L. (2003). Computer visualization and participatory ergonomics as methods in workplace design. *Human Factors and Ergonomics in Manufacturing, 13*(1), 1-17.

Szabo, R. L., Radwin, R. G., & Henderson, C. J. (1998, October 5-9). *The Influence of Knife Sharpness on Poultry Processing Operator Exertions and the Effectiveness of Re-Sharpening.* Paper presented at the Human Factors and Ergonomics Society 42nd Annual Meeting, Chicago, Illinois.

Tappin, D. C., Ashby, L., Bentley, T. A., & Vitalis, A. (2005a). *Musculoskeletal disorders in the meat processing industry: summary of results from stage 1* (No. 6(3)). Rotorua: Centre for Human Factors and Ergonomics.

Tappin, D., Bentley, T. A., & Vitalis, A. (2008). The role of contextual factors for musculoskeletal disorders in the New Zealand meat processing industry. *Ergonomics, 51*(10), 1576-1593.

Tappin, D. C., Bentley, T. A., Vitalis, A., & Macky, K. (2008). An analysis of sprain and strain injury data for the New Zealand meat processing industry from national and industry injury surveillance databases. *Ergonomics, 51*(11), 1721-1734.

Tappin, D. C., Moore, D., Ashby, L., Riley, D., Bentley, T. A., & Trevelyan, F. (2006). *Musculoskeletal disorders in meat processing: a review of the literature for the New Zealand meat processing industry* (No. 7(1)). Rotorua: Centre for Human Factors and Ergonomics.

Tappin, D. C., Vitalis, A., Bentley, T. A., Ashby, L., Moore, D., Parker, R., et al. (2005b). *An ergonomics study of musculoskeletal disorders in meat processing in New Zealand.* Paper presented at the 3rd International Conference on Ergonomics and Safety for Global Business Quality and Productivity - Ergon-Axia 2005, San Diego.

Temmyo, Y., & Sakai, K. (1985). *An ergonomic study on workload in a slaughterhouse.* Paper presented at the International Symposium on Ergonomics in Developing Countries, Jakarta, Indonesia.

Theberge, N., Granzow, K., Cole, D., & Laing, A. (2006). Negotiating participation: understanding the "how" in an ergonomic change team. *Applied Ergonomics, 37*, 239-248.

Tomoana, N., Keefe, V., & Ormsby, C. (2001). *Mauri Mahi: Does being made unemployed affect health? The closures of Whakatu and Tomoana*. Hastings: Ngati Kahungunu Iwi Incorporated.

Tomoda, S. (1997). *Safety and health of meat, poultry and fish processing workers*. Geneva: International Labour Organization.

Trevelyan, F. C., & Haslam, R. A. (2001). Musculoskeletal disorders in a handmade brick manufacturing plant. *International Journal of Industrial Ergonomics, 27,* 43-55.

US BLS. (2005). *Occupational illness and injuries: counts, rates and characteristics, chart 36, MSDs 2002-05*. US Department of Labour. Retrieved from http://www.bls.gov/iif/oshwc/osh/os/osh05_36.pdf.

US BLS. (2006). *Table 10a: Number and incidence rate of non-fatal occupational injuries and illness involving days away from work by selected worker and case characteristics and musculoskeletal disorders, all United States, private industry*. US Department of Labour. Retrieved from http://www.bls.gov/iif/oshwc/osh/case/ostbl790.pdf.

van der Doelen, J. A., & Barsky, S. J. (1990). Repetitive strain injury within the meat-processing industry. *Occupational Health in Ontario, 11*(4), 154 - 167.

van der Molen, H. F., Sluiter, J. K., Hulshof, C. T. J., Vink, P., van Duivenbooden, C., & Frings-Dresen, M. H. W. (2005). Conceptual framework for the implementation of interventions in the construction industry. *Scandinavian Journal of Work Environment & Health, 31*, 96-103.

van der Molen, H. F., Sluiter, J. K., Hulshof, C. T. J., Vink, P., Van Duivenbooden, C., Holman, R., et al. (2005). Implementation of Participatory Ergonomics Intervention in Construction Companies. *Scandinavian Journal of Work, Environment & Health, 31*(3), 191 - 204.

van der Windt, D. A., Thomas, E., Pope, D. P., de Winter, A. F., MacFarlane, G. J., Bouter, L., et al. (2000). Occupational risk factors for shoulder pain: a systematic review. *Occupational and Environmental Medicine, 57*, 433-442.

van Eerd, D., Beaton, D., Cole, D., Lucas, J., Hogg-Johnson, S., & Bombardier, C. (2003). Classification systems for upper-limb musculoskeletal disorders in workers: a review of the literature. *Journal of Clinical Epidemiology, 56*(10), 925-936.

Van Rhijn, G. W., de Looze, M. P., Tuinzaad, G. H., Groenesteijn, L., de Groot, D. E., & Vink, P. (2005). Changing from batch to flow assembly in the production of emergency lighting devices. *International Journal of Production Research, 43*(17), 3687-3701.

Viikari-Juntura, E., Kurppa, K., Kuosma, E., Huuskonen, M., Kuorinka, I., & Ketola, R., et al. (1991). Prevalence of epicondylitis and elbow pain in the meat-processing industry. *Scandinavian Journal of Work, Environment & Health, 17*, 38 - 45.

Viikari-Juntura, E., & Riihimaki, H. (1999). New avenues in research on musculoskeletal disorders. *Scandinavian Journal of Work Environment & Health, 25*(6), 564-568.

Vink, P., Imada, A. S., & Zink, K. J. (2008). Defining stakeholder involvement in participatory design processes. *Applied Ergonomics, 39*(4), 519-526.

Vink, P., & Kompier, M. A. J. (1997). Improving office work: A participatory ergonomic experiment in a naturalistic setting. *Ergonomics, 40*(4), 435-449.

Vink, P., Koningsveld, E. A. P., & Molenbroek, J. F. (2006). Positive Outcomes of Participatory Ergonomics in Terms of Greater Comfort and Higher Productivity. *Applied Ergonomics, 37*(4), 537 - 546.

Vink, P., Lourijsen, E., Wortel, E., & Dul, J. (1992). Experiences in Participatory Ergonomics - Results of a Round-Table Session During the 11th IEA Congress, Paris, July 1991. *Ergonomics, 35*(2), 123-127.

Vink, P., Peeters, M., Grundemann, R. W. M., Smulders, P. G. W., Kompier, M. A. J., & Dul, J. (1995). A Participatory Ergonomics Approach to Reduce Mental and Physical Workload. *International Journal of Industrial Ergonomics, 15*(5), 389-396.

Vink, P., Urlings, I. J. M., & van der Molen, H. F. (1997). A participatory ergonomics approach to redesign work of scaffolders. *Safety Science, 26*(1-2), 75-85.

Wagner, J. A. (1994). Participation's effects on performance and satisfaction: a reconsideration of research evidence. *The Academy of Management Review, 19*(2), 312-330.

Waniganayake, A., & Steele, P. (1990). *Meat Industry Survey of Abattoirs.* Ergonomic Design of Products for the Consumer. Paper presented at the Proceedings of the 26th Annual Conference of the Ergonomics Society of Australia, Adelaide.

Warren, N. (2001). Work stress and musculoskeletal disorder etiology: the relative roles of psychosocial and physical risk factors. *Work, 17*, 221-234.

Wells, R. P., Norman, R. P., Frazer, M. B., Laing, A., Cole, D., & Kerr, M. S. (2003). *Participative ergonomic blueprint*. Toronto: Institute for Work and Health.

Westgaard, R. H., & Winkel, J. (1997). Ergonomic intervention research for improved musculoskeletal health: A critical review. *International Journal of Industrial Ergonomics, 20*, 463-500.

Whysall, Z., Haslam, R. A., & Haslam, C. (2004). Processes, barriers and outcomes described by ergonomics consultants in preventing work-related musculoskeletal disorders. *Applied Ergonomics, 35*, 343-351.

Wilson, J. R. (1991). Participation - a Framework and a Foundation for Ergonomics. *Journal of Occupational Psychology, 64*(1), 67-80.

Wilson, J. R. (1994). Devolving Ergonomics - the Key to Ergonomics Management Programs. *Ergonomics, 37*(4), 579-594.

Wilson, J. R. (1995). Solution Ownership in Participative Work Redesign - the Case of a Crane Control Room. *International Journal of Industrial Ergonomics, 15*(5), 329-344.

Wilson, J. R. (2000). Fundamentals of ergonomics in theory and practice. *Applied Ergonomics, 31*, 557-567.

Wilson, J. R. (2005). *Participation and its role in human factors.* Paper presented at the Human Factors in Organizational Design and Management Conference - VIII, Hawaii.

Wilson, J. R., & Haines, H. (1997). Participatory ergonomics. In G. Salvendy (Ed.), *Handbook of human factors and ergonomics* (2nd ed., pp. 490-513). New York: John Wiley & Sons, Inc.

Wilson, J., Haines, H., & Morris, W. (2005). Participatory Ergonomics. In J. R. Wilson & E. N. Corlett (Eds.), *The Evaluation of Human Work* (Third ed., pp. 933-962). Boca Raton, Florida: CRC Press.

Winkel, J., & Westgaard, R. H. (1996). A model for solving work related musculoskeletal problems in a profitable way. *Applied Ergonomics, 27*(2), 71-7.

Winnemuller, L. L., Spielholz, P. O., Daniell, W. E., & Kaufman, J. D. (2004). Comparison of ergonomist, supervisor, and worker assessments of work-related musculoskeletal risk factors. *Journal of Occupational and Environmental Hygiene, 1*, 414-422.

Woods, V. (2005). Work-related musculoskeletal health and social support. *Occupational Medicine-Oxford, 55*, 177-189.

Yassi, A., Sprout, J., & Tate, D. (1996). Upper limb repetitive strain injuries in Manitoba. *American Journal of Industrial Medicine, 30*, 461-472.

Zalk, D. M., Biggs, T. W., Perry, C. M., Tageson, R., Tittoranonda, P., Burastero, S., et al. (2000). *Participatory ergonomics approach to waste container handling utilizing a multidisciplinary team.* Paper presented at the 14th Triennial Congress of the International Ergonomics Association & 44th Annual meeting of the Human Factors and Ergonomics Society, San Diego, California.

Bibliography

Argyle, M. (1972). *The social psychology of work*. Harmondsworth: Penguin.

Aikin, C., Rollings, M., & Wilson, J. (1994). *Providing a foundation for ergonomics: systematic ergonomics in engineering design (SEED).* Paper presented at the Proceedings of the 12th Triennial Congress of the International Ergonomics Association, Toronto, Canada.

Anton, F. (1980). *Worker participation: prescription for industrial change*. Alberta: Detselig Enterprises.

Baber. C. (2006). Cognitive aspects of tool use. *Applied Ergonomics 37*, 3-15.

Balka, E. (2006). *Inside the belly of the beast: the challenges and successes of a reformist participatory agenda.* Paper presented at the Proceedings of the Participatory Design Conference, August 2006, Trento, Italy.

Bank, J., & Jones, K. (1977). *Worker directors speak*. Farnborough: Gower Press.

Berg Rice, V., Pekarek, D., Connolly, V., King, I., & Mickelson, S. (2002). Participatory ergonomics: determining injury control "buy-in" of US Army cadre. *Work, 18*, 191-203.

Bernoux, P. (1994). Participation: a review of the literature. *European Participation Monitor, 9*, 6-11.

Blewett, V. (2006, 10-14 July, 2006). *Navigating the Industrial Turf: Lost Leaders in Organizational Change.* Paper presented at the Meeting diversity in ergonomics, Proceedings of the IEA2006, Maastricht.

Blewett, V. & Shaw, A. (2008). *Future Inquiry: participatory ergonomics at work.* Paper presented at the Nordic Ergonomics Society Conference (11-13 August, 2008), Reykjavik, Iceland.

Boel, M., Daniellou, F., Desmores, E., & Teiger, C. (1985, 2-6 September 1985). *Real work analysis and workers involvement.* Paper presented at the Ergonomics International 85, Bournemouth, England.

Bolman, L. G., & Deal, T. E. (2003). *Reframing Organizations: artistry, choice and leadership* (3rd ed.). San Francisco: Wiley.

Brannen, P., Batstone, E., Fatchett, D., & White, P. (1976). *The worker directors: a sociology of participation*. London: Hutchinson.

Brenner, S., & Ostberg, O. (1995). Working conditions and environment after a participative office automation project. *International Journal of Industrial Ergonomics, 15*, 379-387.

Brown, O. (1990). Marketing Participatory Ergonomics - Current Trends and Methods to Enhance Organizational-Effectiveness. *Ergonomics, 33*(5), 601-604.

Buchanan, D., & Boddy, D. (1992). *The expertise of the change agent*. London: Prentice Hall.

Buckle, P. (1996). *Participatory ergonomics and risk management.* Paper presented at the Nordic satellite symposium under the auspices of ICOH '96, 13-14 September 1996, Copenhagen, Denmark.

Caccamise, D. J. (1995). Implementation of a Team-Approach to Nuclear Criticality Safety - the Use of Participatory Methods in Macroergonomics. *International Journal of Industrial Ergonomics, 15*(5), 397-409.

Carayon, P., Haims, M. C., Hoonakker, P. L. T., & Swanson, N. (2006). Teamwork and musculoskeletal health in the context of work organization interventions in office and computer work. *Theoretical issues in ergonomics science, 7*(1), 39-69.

Carrivick, P. J. W., Lee, A. H., & Yau, K. K. W. (2002). Effectiveness of a workplace risk assessment team in reducing the rate, cost, and duration of occupational injury. *Journal of Occupational and Environmental Medicine, 44*(2), 155-159.

Cassell, C., & Symon.G. (Eds.). (2004). *Essential guide to qualitative methods in organizational research*. London: Sage Publications.

Chaney, F. B. (1969). Employee participation in manufacturing job design. *Human Factors, 11*(2), 101-106.

Cherns, A. (1987). Principles of sociotechnical design revisited. *Human Relations, 40*(3), 153-162.

Clark, H. H., & Schober, M. F. (1992). Asking questions and influencing answers. In J.M. Tanur (Ed.), *Questions about questions: Inquiries into the cognitive bases of surveys* (pp. 15-47). New York: Russell Sage Foundation.

Coch, L., & French, J. R. P. (1948). Overcoming resistance to change. *Human Relations, 1*, 512-532.

Cooperrider, D. L., & Whitney, D. (2005). *Appreciative inquiry: a positive revolution in change*. San Francisco: Berrett-Koehler.

Corlett, E. N., & Manenica, I. (1980). The effects and measurement of working postures. *Applied Ergonomics, 11*(1), 7-16.

Coutarel, F., Daniellou, F., & Dugue, B. (2003). Examining Work Organization in Relation to Margins of Manoeuvre in Design and in Operation. Is Rotation a Solution to MSD? *PISTES, 5*(2), 24-.

Crotty, M. (2003). *The Foundations of Social Research: meaning and perspective in the research process*. London: Sage Publications.

Daniellou, F., Garrigou, A., Kerguelen, A., & Laville, A. (1990, 18-20 April, 1989). *Taking future activity into account at the design stage: participative design in the printing industry.* Paper presented at the Proceedings of the Third International Occupational Ergonomics Symposium, Zadar, Yugoslavia.

Davis, L. E. (1980). Individuals and the organization. *California Management Review, 22*(2), 5-14.

Davis, M. (1997). Repetitive strains still plague European meat industry. *Safety and Health, 155,* 78-85.

de Looze, M. P., Urlings, I. J. M., Vink, P., van Rhijn, J. W., Miedema, M. C., Bronkhorst, R. E., et al. (2001). Towards successful physical stress reducing products: an evaluation of seven cases. *Applied Ergonomics, 32*(5), 525-534.

Department of Labour. (1976). *Worker participation in New Zealand: a study of worker participation in 65 manufacturing firms*. Wellington: New Zealand Department of Labour, Research and Planning Division.

Devereux, J., & Buckle, P. (1998, August 19-22, 1998). *The impact of work organisation design and management practices upon work related musculoskeletal disorder symptomology.* Paper presented at the Human Factors in Organizational Design and Management - VI, The Hague, The Netherlands.

Descatha, A., Leclerc, A., Chastang, J. F., & Roquelaure, Y. (2003). Medial epicondylitis in occupational settings: prevalence, incidence and associated risk factors. *Journal of Occupational and Environmental Medicine, 45*(9), 993-1001.

DeJoy, D. M. (2005). Behavior change versus culture change: divergent approaches to managing workplace safety. *Safety Science, 43*, 105-129.

Eason, K. D., Harker, S., & Olphert, W. (1996). Representing socio-technical systems options in the development of new forms of work organization. *European Journal of Work and Organizational Psychology, 5*(3), 399-420.

Eason, K. D. (2005). Ergonomic interventions in the implementation of new technical systems. In J. Wilson & E. N. Corlett (Eds.), *Evaluation of Human Work: A practical ergonomics methodology* (3rd ed., pp. 919-931). Boca Raton, Florida: CRC Press.

Eklof, M., Ingelgard, A., & Hagberg, M. (2004). Is participative ergonomics associated with better working environment and health? A study among Swedish white-collar VDU users. *International Journal of Industrial Ergonomics, 34*, 355-366.

Entzel, P., Albers, J., & Welch, L. (2007). Best practices for preventing musculoskeletal disorders in masonry: stakeholder perspectives. *Applied Ergonomics, 38*, 557-566.

Farrington-Darby, T., Wilson, J., Norris, B., & Clarke, T. (2006). A naturalistic study of railway controllers. *Ergonomics, 49*(12-13), 1370-1394.

Forrester, K. (1986). *Involving workers: participatory ergonomics and the trade unions.* Paper presented at the Ergonomics for tomorrows world - Proceedings of the Ergonomics Society's 1986 Annual Conference, Durham, England.

Fraser, C., & Foster, D. (1984). Social groups, nonsense groups and group polarization. In H. Tajfel (Ed.), *The social dimension* (Vol. 2, pp. 473-497): Cambridge University Press.

Garmer, K., Ylven, J., & MariAnne Karlsson, I. C. (2004). User participation in requirements elicitation comparing focus group interviews and usability tests for eliciting usability requirements for medical equipment: a case study. *International Journal of Industrial Ergonomics, 33*(2), 85-98.

Garrigou, A. (2002). *Participatory ergonomics: a risky activity between commitments and reality*: The European Trade Union Technical Bureau for Health and Safety (TUTB).

Garrigou, A., Daniellou, F., Carballeda, G., & Ruaud, S. (1995). Activity Analysis in Participatory Design and Analysis of Participatory Design Activity. *International Journal of Industrial Ergonomics, 15*(5), 311-327.

Graves, R. J., Way, K., Riley, D., Lawton, C., & Morris, L. (2004). Development of risk filter and risk assessment worksheets for HSE guidance - 'Upper Limb Disorders in the Workplace' 2002. *Applied Ergonomics, 35*, 475-484.

Griffeth, R. W. (1985). Moderation of the effects of job enrichment by participation: a longitudinal field experiment. *Organizational Behavior and Human Decision Processes, 35*, 73-93.

Hagg, G. M. (2003). Corporate initiatives in ergonomics - an introduction. *Applied Ergonomics, 34*(1), 3-15.

Haines, H., & Wilson, J. R. (1997). Towards a Framework for Participatory Ergonomics. *From Experience to Innovation - IEA97. Proceedings of the 13th Triennial Congress of the International Ergonomics Association, Tampere, Finland, June 29-July 4, 1997, Edited by P. Seppala, T. Luopajarvi, C.H. Nygard and M. Mattila. Finnish Institu*, 361 - 363.

Haines, H. M., & Wilson, J. R. (1998). *Practical Constraints on Employee Involvement in Workplace Redesign: Fundamental Issues and a Case Study.* Paper presented at the Human Factors in Organizational Design and Management - VI, Edited by P. Vink, E.A.P. Koningsveld and S. Dhondt. Elsevier, Amsterdam.

Hale, A. R., & Hovden, J. (1998). Management and culture: the third age of safety. A review of approaches to organizational aspects of safety, health and environment. In A. Feyer & A. Williamson (Eds.), *Occupational injury: risk, prevention and intervention* (p. 129-165). London: Taylor & Francis.

Hanara, P., & Allpress, L. J. (1978). *Plant Layout.* Paper presented at the Twentieth Meat Industry Research Conference, Hamilton.

Haro, E., & Kleiner, B. M. (2008). Macroergonomics as an organizing process for systems safety. *Applied Ergonomics, 39*(4), 450-458.

Hartmann, M., & Ryom, P. (2006, 10-14 July 2006). *Reducing repetitive work by organizational changes and job development.* Paper presented at the Meeting diversity in ergonomics, Proceedings of the IEA2006, Maastricht.

Hendrick, H. W. (1996). *The fallibility of focus group results in identifying critical job skills.* Paper presented at the Human Factors in Organizational Design and Management V (181-185). Elsevier, Amsterdam.

Hignett, S., & Wilson, J. R. (2004). The role for qualitative methodology in ergonomics: a case study to explore theoretical issues. *Theoretical issues in ergonomics science, 5*(6), 473-493.

Hignett, S., & Wilson, J. R. (2004). Horses for courses - but no favourites. A reply to three commentaries. *Theoretical issues in ergonomics science, 5*(6), 517-525.

Holmboe, K. (1995, 24-28 September). *Daily weight lifted during meat cutting as a risk factor for musculoskeletal disorders.* Paper presented at the 2nd International Scientific Conference on Prevention of Work-Related Musculoskeletal Disorders, PREMUS 95, Montreal, Canada.

Hornby, P., & Clegg, C. W. (1992). User participation in context: a case study in a UK bank. *Behaviour and Information Technology, 11*(5), 293-307.

Howard, R. (1985). Utopia: where workers craft new technology. *Technology Review, 88*, 42-49.

Ijzelenberg, W., Molenaar, D., & Burdorf, A. (2004). Different risk factors for musculoskeletal complaints and musculoskeletal sickness absence. *Scandinavian Journal of Work Environment & Health, 30*(1), 56-63.

Imada, A. S. (1986, September 29 - October 3). *Is participatory ergonomics appropriate across cultures? Trends and future criteria.* Paper presented at the Proceedings of the Human Factors Society 30th Annual Meeting, Dayton, Ohio.

Imada, A. S., & Bowman, M. E. (1992). *Change by design, human factors by necessity: lessons in participatory ergonomics.* Paper presented at the Proceedings of the Human Factors Society 36th Annual Meeting, Atlanta, Georgia.

Imada, A. S., Noro, K., & Nagamachi, M. (1986). *Participatory ergonomics: methods for improving individual and organizational effectiveness.* Paper presented at the Human Factors in Organizational Design and Management - II, Amsterdam.

Imada, A. S., & Stawoway, G. (1996). *The effects of a participatory ergonomics redesign of food service stands on speed of service in a professional baseball stadium.* Paper presented at the Human Factors in Organizational Design and Management V.

Jensen, P. L. (1997). Can participatory ergonomics become 'the way we do things in this firm' - The Scandinavian approach to participatory ergonomics. *Ergonomics, 40*(10), 1078-1087.

Jensen, P. L. (2002). Human factors and ergonomics in the planning of production. *International Journal of Industrial Ergonomics, 29*(3), 121-131.

Jorgensen, M. (1990). Automation in the Danish meat industry - a case study on social shaping of technology. In W. Karwowski & M. Rahimi (Eds.), *Ergonomics of Hybrid Automated Systems II* (p. 101-108). Amsterdam: Elsevier.

Kawakami, T., Kogi, K., Toyama, N., & Yoshikawa, T. (2004). Participatory Approaches to Improving Safety and Health under Trade Union Initiative - Experiences of the POSITIVE Training Program in Asia. *Industrial Health, 42*(2), 196 - 206.

Kawakami, T., & Kogi, K. (2005). Ergonomics support for local initiative in improving safety and health at work: International Labour Organization experiences in industrially developing countries. *Ergonomics, 48*(5), 581-590.

Koningsveld, E. A. P., Dul, J., Van Rhijn, G. W., & Vink, P. (2005). Enhancing the Impact of Ergonomics Interventions. *Ergonomics, 48*(5), 559 - 580.

Kuorinka, I. (2001). Participatory ergonomics at the shop floor level. In W. Karwowski (Ed.), *International Encyclopedia of Ergonomics and Human Factors* (Vol. 1, pp. 1290-1292).

Kuorinka, I., & Patry, L. (1995). Participation as a Means of Promoting Occupational-Health. *International Journal of Industrial Ergonomics, 15*(5), 365-370.

Lamonde, F., & Montreuil, S. (1995). Work, ergonomics and industrial relations. *Relations Industrielles-Industrial Relations, 50*(4), 719-740.

Langford, J., Wilson, J. R., & Haines, H. (2003). Beyond Focus Groups? The Use of Group Discussion Methods in Participatory Design. In J. Langford & D. McDonagh (Eds.), *Focus Groups: Supporting Effective Product Development* (pp. 157 - 170). London: Taylor & Francis.

Lanoie, P., & Tavenas, S. (1996). Costs and benefits of preventing workplace accidents: The case of participatory ergonomics. *Safety Science, 24*(3), 181-196.

Leana, C. R., Locke, E. A., & Schweiger, D. M. (1990). Fact and fiction in analyzing research on participative decision making: a critique of Cotton, Vollrath, Lengnick-Hall and Jennings. *The Academy of Management Review, 15*(1), 137-146.

Leivo, A. (2005). Field study of the effects of a self-implemented feedback program on housekeeping performance. *International Journal of Industrial Ergonomics, 35*(5), 471-485.

Leong, L., & Greenslade, E. (1997). *Meat Industry Injury Prevention Project - Case Study Four: OOS prevention in the workplace*. Wellington: New Zealand Council of Trade Unions.

Lewin, K. (1947). Frontiers in group dynamics. *Human Relations, 1*(1), 5-41.

Luria, G., Zohar, D., & Erev, I. (2008). The effect of workers' visibility on effectiveness of intervention programs: Supervisory-based safety interventions. *Journal of Safety Research, 39*(3), 273-280.

Malchaire, J. B., & Piette, A. (2002). Co-ordinated strategy of prevention and control of the biomechanical factors associated with the risk of musculoskeletal disorders. *International Archives of Occupational and Environmental Health, 75*, 459-467.

Mattila, P., Elo, A., Kuosma, E., & Kyla-Setala, E. (2006). Effect of a participative work conference on psychosocial work environment and well-being. *European Journal of Work and Organizational Psychology, 15*(4), 459-476.

McNeese, M. D., Zaff, B. S., Citera, M., Brown, C. E., & Whitaker, R. (1995). Akadam - Eliciting User Knowledge to Support Participatory Ergonomics. *International Journal of Industrial Ergonomics, 15*(5), 345-363.

Montreuil, S., & Laville, A. (1986, 15-17 April 1985). *Cooperation between ergonomists and workers in the study of posture in order to modify work conditions.* Paper presented at The ergonomics of working postures - the proceedings of the first international occupational ergonomics symposium, Zadar, Yugoslavia.

Moore, D., & Tappin, D. (1997). *Meat Industry Injury Prevention Project - Case Study Five: ergonomics awareness training*. Wellington: New Zealand Council of Trade Unions.

Motamedzade, M., Shahnavaz, H., Kazemnejad, A., Azar, A., & Karimi, H. (2003). The impact of participatory erognomics on working conditions, quality, and productivity. *International Journal of Occupational Safety and Ergonomics, 9*(2), 135-147.

Mumford, E. (1991). Participation in systems design - what can it offer? In B. Shackel & S. J. Richardson (Eds.), *Human Factors for Informatics Usability* (pp. 267-290): Cambridge University Press.

National Research Council. (1999). *Work-related musculoskeletal disorders*. Washington, DC: National Academy Press.

Nagamachi, M. (1993). *Participatory ergonomics: a unique technology of ergonomics science.* Paper presented at the Proceedings of the International Ergonomics Association World Conference on Ergonomics of Materials Handling and Information Processing at Work, Warsaw, Poland.

Nagamachi, M., & Tanaka, T. (1995). *Participatory ergonomics for reengineering in a chemical fiber company.* Paper presented at the Proceedings of the Human Factors and Ergonomics Society 39th Annual Meeting.

O'Brien, D. D. (1981). Designing systems for new users. *Design Studies, 2*(3), 139-150.

O'Neill, D. (2005). The promotion of ergonomics in industrially developing countries. *International Journal of Industrial Ergonomics, 35*(2), 163-168.

Oram, R. (2008, March 2). The value chain. *Sunday Star Times*. Retrieved from http://www.stuff.co.nz/print/4422193a6445.html.

Painter, B., & Smith, T. J. (1986). *Benefits of a participatory safety and hazard management program in a British Columbia forestry and logging organization.* Paper presented at the Human Factors in Organizational Design and Management - II, Amsterdam.

Rafferty, J., & Tapsell, J. (2001). Self-managed work teams and manufacturing strategies: cultural influences in the search for team effectiveness and competitive advantage. *Human Factors and Ergonomics in Manufacturing, 11*(1), 19-34.

Reason, J. (2000). Human error: models and management. *British Medical Journal, 320*, 768-770.

Rubinstein, S. P. (Ed.). (1987). *Participative systems at work*. New York: Human Sciences Press.

Sanoff, H. (1985). The application of participatory methods in design and evaluation. *Design Studies, 6*(4), 178-180.

Sen, T. K. (1987). Participative Group Techniques. In G. Salvendy (Ed.), *Handbook of Human Factors* (1st ed., pp. 453-469). New York: John Wiley & Sons.

Shadbolt, N. (2005). Eliciting response. In J. Wilson & E. N. Corlett (Eds.), *Evaluation of human work: a practical ergonomics methodology* (3rd ed., p. 185-218). Boca Raton, Florida: CRC Press.

Shannon, H. S., Robson, L. S., & Sale, J. E. M. (2001). Creating safer and healthier workplaces: Role of organizational factors and job characteristics. *American Journal of Industrial Medicine, 40*(3), 319-334.

Shaw, K., Haslam, C., & Haslam, R. A. (2007). *A staged approach to reducing musculoskeletal disorders (MSDs) in the workplace: A long term follow-up* (No. RR545). Norwich: HSE Books.

Shipley, P. (1995). The analysis of organizations as an aid for ergonomics practice. In J. Wilson & E. N. Corlett (Eds.), *Evaluation of human work: a practical ergonomics methodology* (2nd ed., pp. 993-1016). London: Taylor & Francis.

Silverstein, B. A., Stetson, D. S., Keyserling, W. M., & Fine, L. J. (1997). Work-related musculoskeletal disorders: Comparison of data sources for surveillance. *American Journal of Industrial Medicine, 31*(5), 600-608.

Sinclair, U. (1906). *The Jungle*. New York: Doubleday.

Simard, M., & Marchand, A. (1997). Workgroups' propensity to comply with safety rules: The influence of micro-macro organisational factors. *Ergonomics, 40*(2), 172-188.

Smith, M. J. (1994). *Employee participation and preventing occupational diseases caused by new technologies.* Paper presented at the Human Factors in Organizational Design and Management - IV, Amsterdam.

Smith, M. J., & Zehel, D. (1992). Case Study No. 9 - a stress reduction intervention programme for meat processors. *Conditions of Work Digest, 11*(2), 204-213.

St-Vincent, M., Lortie, M., & Chicoine, D. (2001). Participatory ergonomics training in the manufacturing sector and ergonomic analysis tools. *Relations Industrielles-Industrial Relations, 56*(3), 491-515.

Stannard, N. (1990). *Engineering for safety in industry: panel discussion.* Paper presented at the Twenty-sixth meat industry research conference, Hamilton.

Stuckey, R., Fox, J., & Yaxley, R. (1995, September 20-22, 1995). *Problem solving in applied ergonomics: a training program for abattoir boners and slaughtermen.* Paper presented at the The Technical Papers of the Asian Pacific Conference on Occupational Health and Safety, Brisbane, Australia.

Toulouse, G., & Richard, J. G. (2001). Slaughterhouses. In W. Karwowski (Ed.), *International Encyclopedia of Ergonomics and Human Factors* (p. 1588-1590).

Urlings, I. J. M., Bronkhorst, R. E., & van der Grinten, M. P. (1998, August 19-22, 1998). *A participatory ergonomics approach to redesign working methods and tools of glaziers.* Paper presented at the Human Factors in Organizational Design and Management - VI, The Hague, The Netherlands.

van der Molen, H. F., Sluiter, J. K., Hulshof, C. T. J., Vink, P., van Duivenbooden, C., & Frings-Dresen, M. H. W. (2005). Conceptual framework for the implementation of interventions in the construction industry. *Scandinavian Journal of Work Environment & Health, 31*, 96-103.

van der Molen, H. F., Sluiter, J. K., Hulshof, C. T. J., Vink, P., Van Duivenbooden, J. C., Holman, R., et al. (2006). *Is a participatory approach effective to stimulate using ergonomic measures?* Paper presented at the Meeting diversity in ergonomics, Maastricht.

Viikari-Juntura, E. (1997). The scientific basis for making guidelines and standards to prevent work-related musculoskeletal disorders. *Ergonomics, 40*(10), 1097-1117.

Vink, P., & Kompier, M. A. J. (1997). Improving office work: A participatory ergonomic experiment in a naturalistic setting. *Ergonomics, 40*(4), 435-449.

Vink, P. (Ed.). (2005). *Comfort and design: principles and good practice*. Boca Raton: CRC Press.

Vink, P., Koningsveld, E. A. P., Molenbroek, J. F., & van Eijk, D. J. (2006, 10-14 July 2006). *Increase in productivity and comfort by applying participatory ergonomics: 8 success factors.* Paper presented at the Meeting diversity in ergonomics, Proceedings of the IEA2006, Maastricht.

Wall, T. D., & Lischeron, J. A. (1977). *Worker participation: a critique of the literature and some fresh evidence*. Maidenhead: McGraw-Hill.

Wallersteiner, A., & Arnold, A. K. (1989). *Ergonomic solutions to address the occupational health problems of the meat processing industry*. Paper presented at the 22nd Annual Conference of the Human Factors Association of Canada. Toronto, Ontario.

Walters, D. (2002). *Working safely in small enterprises in Europe*. Brussels: JAC Offset.

Waterson, P. E. (2005). Sociotechnical design of work systems. In J. Wilson & E. N. Corlett (Eds.), *Evaluation of human work: a practical ergonomics methodology* (3rd ed., pp. 769-791): CRC Press.

Webb, E. J., Campbell, D. T., Schwartz, R. D., & Sechrest, L. (1966). *Unobtrusive Measures*. Chicago: Rand McNally.

Wells, R., Mathiassen, S. E., Medbo, L., & Winkel, J. (2007). Time--A key issue for musculoskeletal health and manufacturing. *Applied Ergonomics, 38*(6), 733-744.

Westgaard, R. H. (2000). Work-related musculoskeletal complaints: some ergonomics challenges upon the start of a new century. *Applied Ergonomics, 31*(6), 569 - 580.

Whysall, Z., Haslam, C., & Haslam, R. A. (2006). Implementing health and safety interventions in the workplace: an exploratory study. *International Journal of Industrial Ergonomics, 36*, 809-818.

Whyte, W. F. (Ed.). (1991). *Participatory Action Research*. California: Sage Publications.

Wilson, J. R. (1995). Ergonomics and participation. In J. R. Wilson & E. N. Corlett (Eds.), *Evaluation of human work: a practical ergonomics methodology* (2nd ed., pp. 1071-1096). London: Taylor and Francis.

Wilson, J. R. (2000). Fundamentals of ergonomics in theory and practice. *Applied Ergonomics, 31*, 557-567.

Wilson, J., & Grey, S. M. (1990). But what are the issues in work redesign? In C. M. Haslegrave, J. Wilson, E. N. Corlett & I. Manenica (Eds.), *Work design in practice* (pp. 7-15). London: Taylor & Francis.

Wilson, J., & Grey-Taylor, S. M. (1995). Simultaneous engineering for self-directed work teams implementation: A case study in the electronics industry. *International Journal of Industrial Ergonomics, 16*, 353-365.

Wilson, J., & Haines, H. (1998, 9-11 September 1998). *Participatory design in the organisational context.* Paper presented at the Global Ergonomics: proceedings of the ergonomics conference, Capetown, South Africa.

Wood, G. (1997). Minimizing fatigue during repetitive jobs: optimal work-rest scehdules. *Human Factors, 39*(1), 83-101.

Woods, V., & Buckle, P. (2006). Musculoskeletal ill health amongst cleaners and recommendations for work organisational change. *International Journal of Industrial Ergonomics, 36*, 61-72.

Worksafe Australia. (1994). *Positive performance indicators for OHS, beyond lost time injuries. Part 1 - issues*. Canberra: Worksafe Australia.

Worksafe Victoria. (2006). *Manual Handling in the Red Meat Industry*. Melbourne: Victorian Workcover Authority.

Zink, K. J., Steimle, U., & Schroder, D. (2008). Comprehensive change management concepts - development of a participatory approach. *Applied Ergonomics, 39*(4), 527-538.

Appendices

(Reformatting of some of the original documents was required to meet Massey University page layout requirements when writing this thesis; however the content of all the appendices remains unchanged.)

Appendix 1: Information sheet and consent form for the Accident Register Survey and the Health & Safety Staff Questionnaire

Addressing Work-Related Musculoskeletal Disorders In Meat and Seafood Processing

SURVEY PARTICIPANT INFORMATION SHEET

The Project

Researchers from COHFE, a unit of the Crown Research Institute, Forest Research, in collaboration with researchers from Massey University and the University of Auckland have been granted funding for a two-year study looking at work-related musculoskeletal disorders (MSD – or often referred to as strains and sprains). This funding comes from the Health Research Council, ACC, and the Department of Labour. The research will focus on addressing work-related MSD in the meat processing and seafood processing industries. The research aims are to: identify high MSD-risk tasks, identify key factors that help create or prevent MSD, develop interventions, and identify any barriers to their implementation. The researchers will be working alongside the industries in all phases of the project. The study commenced in August 2004, and will be completed in June 2006.

Your Participation

The purpose of this survey is provide a clearer picture of the high MSD-risk tasks in meat and seafood processing and to collect information on potential MSD causes and solutions from the group of people involved in their management on a daily basis. Your company is invited to take part in this project. We anticipate that the questionnaire will take approximately 20 minutes, depending on how much you have to say and also depending on the number of accident register entries.

Project Procedures

The data you provide will only be used in summary form. This and other sources of information will then be summarised to produce a list of tasks for further assessment and possible ideas for reducing MSD injury risk. These will be discussed and developed further by the Health and Safety Forum within your industry. This summary information will be used in publications and presentations about the research project, and will appear on your Safer Industry group website as well as the COHFE website (www.cohfe.co.nz). All the information you provide will be stored securely and destroyed five years after the project ends.

Participant's rights

You are under no obligation to accept this invitation: if you decide to participate, you have the right to:

- decline to answer any particular question in the Accident Register Survey;
- withdraw from the study at any time during your participation, and at any time during the four-week period following your participation (ie. withdraw permission to use data collected);
- ask any questions about the study at any time during participation;
- provide information on the understanding that your name will not be used unless you give permission to the researcher;
- be given access to a summary of the project findings when it is concluded

Contact Details

David Tappin, COHFE, PO Box 300 540, Albany, Auckland. Tel: 09 415 9850 Mobile: 027 2906958
Email: d.c.tappin@massey.ac.nz

Thank you for your assistance in this research.
David Tappin (COHFE) & Dr Tim Bentley (Massey University).

This project has been reviewed and approved by the Massey University Human Ethics Committee, (MUAHEC 04/080). If you have any concerns about the conduct of this research, please contact Dr Barry McDonald, Acting Chair, Massey University Regional Human Ethics Committee: Albany, telephone 09 414 0800 x41039, email B.McDonald@massey.ac.nz.

Addressing Work-related Musculoskeletal Disorders in Meat and Seafood Processing

We are obliged to obtain formal consent from survey participants – please fill in your details below and return it to us with your survey response (via email, fax or post).

PARTICIPANT CONSENT FORM – survey and questionnaire

This consent from will be held for a period of five (5) years

I have read the Information Sheet and have had the details of the study explained to me. My questions have been answered to my satisfaction, and I understand that I may ask further questions at any time.

I agree to participate in this study under the conditions set out in the Information Sheet.

Signature: **Date:**

Full Name (printed):

Appendix 2: Information sheet and consent form for the Task Assessments and Plant Staff Interviews

Addressing Work-related Musculoskeletal Disorders in Meat and Seafood Processing

PARTICIPANT INFORMATION SHEET: Task assessments and interviews

Contact Details

David Tappin, COHFE, PO Box 300540, Albany. Tel: 09 415 9850 or 027 290 6954. Email: d.c.tappin@massey.ac.nz
Dr Tim Bentley, Massey University, P. Bag 102904, Albany. Tel: 09 414 0800 (x 9578). Email: t.a.bentley@massey.ac.nz

The Project

Researchers from COHFE, a unit of Forest Research, along with researchers from Massey University and the University of Auckland have been granted funding for a two-year study looking at musculoskeletal disorders (MSD – or strains and sprains). This funding comes from the Health Research Council, ACC, and the Department of Labour. The research aims to address work-related MSD in meat and seafood processing. The study runs from August 2004 to June 2006.

Your Participation

As you are involved in work areas where MSD risk factors are present you are invited to take part in this project. Task assessments and interviews will be carried out in more than 40 meat and seafood processing plants. David Tappin will conduct these, along with one other researcher from COHFE on some occasions. The purpose of these assessments is to build our understanding of the factors that contribute to MSD (strains & sprains) in meat and seafood processing.

1. The first step will involve answering questions about your work tasks, and your thoughts about MSD causes and solutions.
2. If you are working at certain processing tasks, we will ask if we can observe you while you work. We may also ask you to describe what you are doing as you work, although you will be asked beforehand whether you are happy to do this. The observations will take around 15 minutes.
3. The researcher(s) may ask you if they can videotape and/or photograph parts of the task. The purpose of this is to assist with analysis of the data at a later stage. No one outside the research team will be permitted to view the recording / photos, which will be securely held in the researcher's office. You can refuse permission for video / photographs to be taken, and can ask for the recording to be stopped at any stage.
4. Providing you are agreeable, the researcher(s) will briefly look at your work equipment and workspace. This may involve collecting some physical measurements of your work area, and measurement of some body dimensions (e.g. elbow height, forward reach). These measurements would be taken in your workspace, with your usual footwear and work clothing on. The purpose of this step is to see how well workspaces and equipment match the people using them.

Project Procedures

The data you provide will only appear in summary form for all plants visited. It will be used, along with other data from the project, to produce a list of possible ideas for reducing MSD risk. Summary information from the task assessments will be used in publications about the study, and will be placed on your Safer Industry forum website and the COHFE website (www.cohfe.co.nz). All information you provide will be stored securely and destroyed five years after the project ends.

Participant's rights

You are under no obligation to accept this invitation. If you decide to participate, you have the right to:

- decline to answer any particular question during the informal interview;
- withdraw from the study at any time during your participation, and at any time during the four-week period following your participation (ie. withdraw permission to use data collected);
- ask any questions about the study at any time during participation;
- provide information on the understanding that your name will not be used unless you give permission to the researcher
- be given access to a summary of the project findings when it is concluded;
- ask for the video tape or camera to be turned off at any time during the task assessment.

Thank you for your assistance in this research.

David Tappin *COHFE* Dr Tim Bentley *Massey University*

This project has been reviewed and approved by the Massey University Human Ethics Committee, (MUAHEC 04/080). If you have any concerns about the conduct of this research, please contact Dr Barry McDonald, Acting Chair, Massey University Regional Human Ethics Committee: Albany, telephone 09 414 0800 x41039, email B.McDonald@massey.ac.nz.

Addressing Work-related Musculoskeletal Disorders in Meat and Seafood Processing

PARTICIPANT CONSENT FORM – Task assessments and interviews

This consent from will be held for a period of five (5) years

I have read the Information Sheet and have had the details of the study explained to me. My questions have been answered to my satisfaction, and I understand that I may ask further questions at any time.

I agree/do not agree to my conducting work tasks being video taped / photographed.

I agree to participate in this study under the conditions set out in the Information Sheet.

Signature: **Date:**

Full Name (printed):

Appendix 3: Health & Safety Staff Questionnaire and Accident Register Survey

COHFE Centre for Human Factors and Ergonomics   Massey University

Musculoskeletal Disorders in Meat Processing

1. Your name:
2. Your job title/ position:
3. Plant name and location:
4. Species processed at your plant:
5. Number of full-time equivalent *processing* staff during
   - Maximum/peak season:
   - Minimum/low season:
6. When is your peak season and how long does it last?
7. When is your low season and how long does it last?
8. What proportion of your processing staff are female: male:
9. Is your plant an ACC accredited employer?
10. How long have you been working in the meat processing industry?
    - Years: - Months:
11. How long have you been involved in health and safety?
    - In Meat Processing:
    - In other industries:
12. How are musculoskeletal disorders prevented at your plant?
13. What changes would you make that would further reduce the risk of musculoskeletal disorders at your plant?

14. What things may make it difficult to prevent musculoskeletal disorders, either at your plant or in the meat processing industry as a whole? For example, it may be difficult to rotate people between tasks due to training issues.

15. The following table is to give people an opportunity to say where they think the problems lie in the industry as a whole. From your own experience in the meat processing industry, what would you consider to be the **five tasks most likely to lead to musculoskeletal disorders**? Also, what is it about each task that you feel makes it high risk?

Put the one you think most likely at the top (No. 1).

	Department / Job Title	**Task**	**Why?**
1			
2			
3			
4			
5			

16. Are there any other comments you would like to make about musculoskeletal disorders and their prevention in your industry?

COHFE Centre for Human Factors and Ergonomics — Massey University

Accident Register Records Survey

Please go through the Accident Register(s) at your plant and record the following details for each musculoskeletal disorder (strain/sprain) entry for the 12 month period: 1 **Jan 2004 – 31 Dec 2004**. Alternatively, if you wish to save time, you could send us your accident register records for this period (with identifying features such as names removed). All information will be treated as confidential. Only the researchers will know which records come from which plant. Thanks for your help.

Dept	**Job Title**	**Task** that the employee was doing at the time	**Species** that the employee was involved with at the time	**Body Part Affected**	**Severity**	**Month** Of injury
Boning room	Boner	Table boning	Venison	Right shoulder	5 days off work	Dec
Loading area	Packer	Degambrelling	Sheep	Lower back	Rest of day off, then back to work	June
Slaughter area	Slaughterer	Halving saw	Beef	Right wrist	No time off work, doctor visit and medication	March

Photocopy this sheet or add rows as needed.

If you have any questions about how to fill in the form, or what we will do with the information, please contact: David Tappin at COHFE on 09 415 9850. We would very much appreciate that you return the completed forms by **Friday March 18th, 2005** to: David Tappin at d.c.tappin@massey.ac.nz , or PO Box 300 540, Albany, or Fax: 09 415 9028.

Appendix 4: Checklist for organising plant visits

1. Phone the contact person for the plant (based on contact list from stage one, or name provided by MIHSF company representative).
2. Explain the study and seek their agreement to be involved. Provide copies of the press release and stage one report if required.
3. Organise visit date(s) – ideally when target tasks are operating.
4. Organise visit times – based on shift times, travel times, staff availability.
5. Inform them of the desire to speak with as many as possible of the following roles:
    - Management:
        - Plant
        - Health and safety
        - Personnel
        - Production
        - Quality Assurance
        - Engineering and maintenance
    - Union:
        - Shed President (where applicable)
        - Union delegate(s)
    - Line supervision
        - Task area supervisor(s) – day and night shifts where relevant
        - Trainers
    - As many staff as possible working in the target task areas – day and night shifts where relevant.
6. Inform them of the desire to also:
    - Observe target tasks *(Sheep - gutting, Y cutting, aitch boning, packing, and Beef - gutting, quarter boning, packing)*
    - Collect measurements from target tasks and workers
    - Ideally, to also collect video and photographs of target tasks if possible.
7. Collect additional baseline information necessary – break times, site and company restrictions, etc.
8. Send copies in advance of the information sheets and consent forms for disseminating as necessary, and make known our desire to have consent forms signed from each person involved.

Appendix 5: Semi-structured interview schedule

Preamble

- Explain the study, provide the information sheet, answer questions, complete the consent form (where relevant).
- Interviewee information – task they are working on, job title, age, industry experience.

1. In your opinion, in which tasks are sprains and strains most likely to occur? (If none, go to 5.)
2. What do you think are the main causal factors for these sprains and strains (for tasks from 1. and high MSD-risk tasks from stage one)?
3. What has been done to prevent sprains and strains (for tasks from 1. and high MSD-risk tasks from stage one)?
4. How successful have these measures been? (Go to 6.)
5. If there are no sprains and strains, what are the factors that have prevented them?
6. Were there any barriers experienced, and how were they overcome?
7. Are there any other interventions planned, or any interventions you would like to try?
8. Can you foresee any barriers to these interventions, and how might you overcome them?
9. Points not otherwise covered, e.g. workload and workflow variations and management, task training, retention and advancement, remuneration, knife sharpening, change management, H&S management, injury management.

Appendix 6: A summary of MSD risk factors

Work pace
Compression is allowed on a regular basis - to increase earnings &/or go home early. Involves slaughter and boning, all species. Often supported by unions - seen as a perk for staff. Examples quoted are: increased tally from 33/hour to 36/hour to finish 30 minutes early, increased tally from 280/hr to 420/hr on one occasion.
We have to work at pace of fastest person, which means everyone else suffers as they try to keep up.
Workload peaks are created by doing a few carcasses at once to have time for a longer rest.
Can miss out on sufficient break/meal time if these are compressed in order to finish earlier.
The control of workpace can be in the hands of one person (breakdown) who can control pace and if necessary 'jump' carcasses into the room to further increase throughput.
Increase in lamb tally from that which plant was built for (6.8-7.2 then, 8.4-8.6 now).
Production pressures lead to an increase in grip force.
Notice an increase in reports when tally goes from 3500 to 4000 lambs/shift.
Pressure to ensure packing machines are constantly kept full. Fast work pace, often with postural constraint and accuracy compromised.
The natural working rhythm may be different between individuals, and increasing workpace will mean more people are compromising their work methods to keep up (affecting MSD risk & yield/quality).
Management are reluctant to make changes that may reduce the current standard of performance.
Management seem prepared to sacrifice workers health for increased productivity.
High work speed, particularly in jobs on the chain.
Task rotation
There is no rotation, meaning overexposure to high risk tasks. Some of the common reasons stated include seniority barriers, reluctance to rotate, and insufficient skill levels.
Rotation around equally physically stressful tasks (or the same stressors - e.g. working above shoulder height), where risk isn't recognised or it is assumed that rotation addresses the risk.
Informal rotation, which can contribute to patch protection and limited task variation as a result.
Limited rotation - due to staff resistance, hourly rate discrepancies, physical difficulties in changing task positions, insufficient task training to enable rotation, absenteeism and insufficient replacement staff, seniority.
Not enough physical space to enable rotation in time to keep up with the chain.
Limited range of light duty tasks or easier tasks on the rotation cycle as these tasks have been mechanised (e.g. french racking).
Rotation periods not matched to the task demands (too short or too long).
Rotation in packing is every 2.5 hours - not every 15 min as in slaughter floor.
Loyalty between management and senior workers - don't want to rock the boat and see them leave, therefore management may not support a change like rotation if senior workers don't want it.
Job allocation
Opportunities have to be offered to the next person on the seniority list. Might not be a good match with task requirements (training levels, experience, etc).
Seniority varies among plants and can be by: department, plant, shift, job type, or more than one of these. If a person moves they lose seniority and start from the bottom again in the new area. This inflexibility becomes a risk factor as staff are less able to move to fill gaps in other areas (opportunities for change, to counter absenteeism) or even rotating around a range of tasks.
Task training
Limited task training given - creating MSD risk through being unfamiliar with the task and not learning sustainable techniques.
Buddy training - no guarantee that trainer has the required skills and is able to impart them.
Limited room on line for buddy training - difficult to train in this environment. (Buddy training requires trainer to go faster and get enough time to teach, therefore quality and yield suffer for both.)
Lack of a dead rail for training. Learners have to therefore work at normal pace of the chain - struggle to keep up, learn bad habits.
Pay is not training related. No incentive to become more skilled, just outlast others to rise in seniority.
Buddy system without formal task descriptions allows bad habits and shortcuts to be passed on without identifying its a short cut. This then becomes normal practice.
Difficult to resource - finding spare staff to replace those being trained and finding the time to train.

Made harder by absenteeism and high staff turnover.
Unfamiliarity with techniques required for veal. Takes some time to regain (or become) familiar with the techniques required due to the short season and high work intensity during the season.
Tensed rather than relaxed technique - especially with knife hand (gripping too hard all the time) and especially with staff new to the task.
More complex cuts now, and a greater range of them, means that the amount of task training required has increased.
Staff who are unfamiliar with the task(s) have to physically work harder until they become familiar.
Some resistance to newly trained staff as they are slower.
Reluctance among some experienced staff to share skills with younger staff.
Very high family presence in the plant. So intergenerational advice gets passed on (good and bad) making change very hard to implement.
Early reporting and injury management
Older workers are believed to underreport injuries.
The existence of illness beliefs held by staff
Poor medical management
Increased risk through returning to work too soon from injury or where the work pace is too fast for the current level of rehabilitation.
Ignoring early warning signs, unable to detect problems as they occur
Physical task requirements
Aging workforce. Perceived to be less physically capable of doing the job. People tend to stay working as long as possible (loss of earnings, loss of mana, hoping for redundancy) and are therefore more likely to get injured. Will keep working until they can't return.
The ageing workforce have a greater likelihood of pre-existing conditions (more years to accumulate wear and tear) which may increase the risk of MSD.
New entrants into the industry appear less physically prepared than in previous generations. This may result in higher turnover of new staff (who opt out of the industry because of the physical demands), greater length of time required to gain necessary conditioning for the job, and increased risk of MSD until this conditioning is gained. (People may not do other work during the off-season.)
People who underestimate MSD risk &/or work as fast as they can.
A general mismatch between the physical abilities of the workforce and the demands of the task.
Carcass weights have increased over the years. Average lamb weights have increased from 13-16kg, ewes from 20-35kg.
Resistance to female workers as this changes dynamics. It is also perceived that there is a limited choice of tasks for them.
New staff - not used to tasks or using a knife. Worst on night shift. New staff also unwilling to spend their own time sharpening knife whereas older staff do.
Many tasks are very repetitive, which coupled with a fast fixed pace, and high forces increase the chances of MSD occurring
MSD risk is created by the desire to optimise earnings to cover them during the off season, and plant management wanting to encourage throughput of stock as it arrives. Also made difficult because of varying levels of physical capability (size, strength, fitness, presence/absence of injury).
A greater amount of the kill is boned (92%) and not exported whole, and more is chilled not frozen.
Static posture - task invariability
Increasing hygiene requirements also increases MSD risk through requiring additional task steps, physical constraint.
Force - gripping and cutting, but especially the non-knife hand
Workspace and equipment design
Overreaching through chasing the chain (especially side boning if rail decreases in height) to create more rest time (reaching up), or to keep up (bending forward as rail gets lower).
Limited workspace to move without constraint or compromise
Workspace designs that only accommodate people of a specific size, strength. End up recruiting workers for the task.
Inconsistent stair geometry and instability through damage / lack of bracing.
Big variation in table height due to sloping floor/drains but can't use this to their advantage to accommodate different heights as each table is task specific.
Keep conveyor level and use fall of the floor (for drainage) to get some variation in table height.
Manual chain - not automated so have to pull carcasses into area to work on them.

Work areas that are set up for right handed operation only.
Boot design hasn't changed in 40 years - leads to sore knees, backs, hips from prolonged standing on hard floors.
Work heights too high (1190mm), have to reach up and also lean forward over conveyor.
No height adjustability on any work table.
Narrow circulation routes - not room for two to pass (worse when carton lids are open).
Whizzard knife use in bone trimming - creates acceleration/deceleration forces, vibration, prolonged gripping, plus holding/restraining with the non-knife hand. All increase the risk of wrist MSD.
Slippery standing surfaces
Patched concrete floor - surfaces varied for traction.
Poor posture from poor design of workspace & facilities
Staff participation
Changes made which don't involve staff (or only in a limited way) - MSD risks may not be addressed, changes may introduce new risks, and are less likely to have support of staff.
Problems pointed out in trialling but these were ignored and no explanation given.
Mistakes in resulting from changes without consultation are only fixed when they cause enough injuries, therefore a wall goes up between workers and mgmt.
Adversarial relationship between management and workers.
Some resistance to change - concerned about the unknown, happy enough with the present, don't want to break tradition. There would have to be a good reason to change.
Generally a low level of involvement of workers in decision making.
Knife sharpness / training
Blunt knives - much harder than with sharp knife (greater force, stronger grip, time required, extra movements). Once the edge goes then skills are irrelevant as can't get the job done in the minimum number of moves.
Knife skills low - too much to learn in one go (angle, feathering, steeling, grinding).
C Graders at extra risk also as reluctant / under confident to speak up.
Noise
High noise levels making hearing protection necessary. Communication is affected and noise can lead to stress, influence balance, bring on fatigue and diminish performance.
Potential cause of peripheral vasoconstriction and increased muscle tension.
Work flow
Changes to workload in the middle of a run (e.g. prime - cow or chilled to hot, or different product spec). No time to acclimatise, change technique, set up, etc.
Chilled prime - very hard fat to cut through. Worse on Mondays and after long weekends.
Sawmen set the pace for the boning room - create peaks and troughs. Supervisor and QC also determine pace by setting volume.
Imbalance of boning room staff to packers at times. Packers are last line of responsibility for quality - need time to do it right and this may conflict with the volume coming through, especially if cuts are small - therefore lots of checking and handling cf a smaller number of larger cuts.
Can't always control flow for aitch boning - sometimes start Monday with chilled mutton.
Slow fattening season (such as this year with low rainfall) can produce a big surge of stock all at once later on as farmers try to get rid of them before winter.
Weather fluctuations can lead to peaks and troughs in workflow
Less experienced staff can struggle when the pace is set by more senior workers.
Packers/trimmers who have little influence over tally and compression face higher risk of MSD.
Line imbalances between boners and packers - insufficient packers for the amount of product coming through (e.g. with two breakdown saws operating). Sometimes the result of boners & butchers becoming supervisors - don't have empathy with packers/trimmers.
Shift staff do the cleaning also (leading to long work hours, overexposure to risk factors, insufficient rest between shifts)
Long season peak.
All year work is good for income but doesn't give body a chance to rest.
Competitive culture, no room for MSD or people complaining of it.
Plant keen to shorten season as it reduces overheads of keeping plant open. Downside is the effect on turnover, training, etc and overexposure to MSD risks. Also affects the type of people who come here - those with less choice.
Short season for bobbies, so staff often new and with little experience in meat industry. Those coming

from other plants may not be released on time if downtime doesn't coincide. Only a two week build up to full tally.
Offseason length varies for each chain and has increased in length overall. Now 2 months for chain 1, 3-4 months for chain 2 & 6 months for chain 3. Correspondingly, turnover is low for chain 1, 20% for chain 2 & more than 50% for chain 3.
Hard to retain staff as the season is only 3 months - so very big turnover from year to year.
Higher workload at the start of the season. Increased risk through greater exposure to MSD risks possibly coupled with lower physical conditioning after time away from the job.
Lack of autonomy in processing line tasks
Low job content on processing lines
Seasonality creates peaks and troughs in workload (e.g. fat lambs and bobby calves).
Knife and glove design
Poor glove fit (mesh, cut-resistant) - lead to discomfort, extra grip force, reduced dexterity and tactility
Too many glove layers (cotton or cut-resistant / liner / mesh) - lead to discomfort, extra grip force, reduced dexterity and tactility
Making gloves compulsory for both hands and all tasks without determining whether fit is acceptable for all staff and task performance is unaffected.
Some potential issues with reduced 'feel', awkward movement, grip fatigue (have to grip harder) with cut-resistant gloves (although have reduced cuts, bone scratches)
Tape on glove over cut resistant glove too tight - can reduce circulation.
Glove tensioners (plastic) - too tight at wrist for some people.
Nitrile gloves worn to reduce leptospirosis risk and reduce microbial count. Staff like them as it means they don't have to wash their hands therefore saves time in rest breaks. Negatives are the cost (2-5 cents each = $1 per day per person) and that they further increase the grip force required for the task. Cut-resistant gloves are $7-17 per glove.
Longer knife blades result in higher wrist torsion forces when cutting with blade tip.
High muscle tension in extensor digitorum communis.
Concerns about developing poor work habits as people feel protected by wearing cut-resistant gloves.
Thermal environment
Coldness, high humidity, high air velocity and temperature fluctuations - impair manual dexterity.
Cold, wet conditions coupled with vibration (whizzard knives).
2 degree Celsius environments more likely to lead to neck & low back pain compared with 8-12 deg C.
Rest / recovery breaks
Inherent rest pauses (spontaneous / as required) aren't possible in most positions on the chain.
Repetition - repeated actions, short work cycles, limited range of movements
In high repetition tasks micropausing is difficult to achieve - even if highly skilled - if the cycle time is extended by poorly placed equipment.
Insufficient recovery time
Plant design
Physical modifications over time that result in the workspace having unpredictable changes left over.
Slaughter floor is not suited to the species - inflexibility in height is one problem.
Shift design
Long run times (though they reduce in length over the shift).
Long shifts (11 hours at peak).
Increased hours during season peak (e.g. going to 9 hour days & Saturday mornings). Especially hard if prolonged for a few weeks. Examples - 3 seasons ago they worked 14 Saturdays in a row and had a very high rate of MSD, work Saturdays in peak season to make up for xmas break, hours increase from 8.25 - 9.25 during season peak.
Night shift have more MSD problems - blames there being no management around to supervise.
Staff trying to do too much to get extra money (more per day, and working Saturday).
Longer hours per week now compared with a few years ago.
Long work hours, combined with travel time, may mean only a few hours at home before needing to come into work again for Sat am/pm. Worse if also involved in cleaning after the shift ends.
Believe the manning is too tight (2 on the rail doing 3 peoples work) - resulting in inexperienced staff and older staff finding it too hard and leaving. Specs and yield increase but experience decreases so remaining senior staff are overstretched.
Saturday morning work - can be 15 weeks duration. Total injuries/hour spike up during this period.
Seven day operation all season - in response to competition.

Added stressors of long hours and night shifts are: early starts (4am), poorer nutrition, travelling in the dark, family pressures.
Difficult to make changes in night shift and ensure they're followed through with as intended.
Maintenance
Fitters/engineers don't work in with the rest of the plant very well. They just stick stuff in without consultation - very ad hoc.
Mechanical problems increasing handling tasks (e.g. ramps are too steep, cartons jam and slide back, so that staff need to push to clear queues of cartons frequently from awkward angles).
Poor maintenance on some equipment (e.g. stiff rollers & castors, old roller drive belts, trimming tool blades, hock cutters blades). The result is more force needing to be applied manually.
Machinery breakdowns (e.g. printers) create peaks in workload.
Recruitment / retention
High staff turnover (often on shifts with a shorter season &/or plants a long way from settlements) means less experienced staff available for complex tasks (less rotation) and less resources available to train new staff.
Staff turnover high with C graders, but lower with A & B graders.
For many staff this is one of two jobs they have (especially in plants with short seasons). Problems may arise from people continuing to work at their offseason job during the processing season.
Losing experienced staff to other employers (e.g. new meat plant nearby and all senior boners left, taking average age from 40's to mid-20's), resulting in underskilled workforce and learners teaching new staff how to bone. More employment options open to people now.
High staff turnover on night shift as everyone wants to get onto days. Therefore the most experienced night shift people get the first chance at vacancies on days, leading to loss of staff and experience from night shift. Night shift gets its staff from outside (younger, less experienced, more transient, lower seniority), Day shift gets its staff from nights (older, more experienced). Does make it easier to introduce change on nights\ however.
Have trouble getting staff since pre-employment drug screening introduced (people don't bother coming back).
Short season and long off season so staff are difficult to retain, have to recruit new staff with attendant problems of training people unfamiliar with the tasks and industry.
Core base of skilled workers has shrunk, therefore more inexperienced staff by proportion. They're not listening to older workers and good advice is therefore not getting passed down to next generation.
Management don't like to put money into peole who wont be around long. Unions not that fussed either about low seniority staff.
Limited opportunities to advance in the industry, partly due to seniority but also because of the narrow range of task types.
Retention of staff also difficult in veal as only offering 8 weeks of work.
Workers are perceived to have a lower work ethic (late, undisciplined), not as bright, unfit, and poorer attitude than in the past. Often the ones who can't hold down a job elsewhere.
Harder to recruit and retain staff for geographically isolated plants.
Labour shortage in some areas of the country (low unemployment rates currently) results in lower numbers recruited, holes in workforce, and overloading of existing staff / exposure to greater MSD risk
Competitive, perfectionist attributes.
Attendance
High absenteeism levels - affects ability to rotate (not enough experienced people to maintain rotations) thereby increasing risk for remaining staff, reduces ability to train staff (no spare people or spare time), people may end up working in jobs they're not trained for. Increases as season progresses and staff get fatigued (& also have money in the bank).
Changes to the Holidays Act - medical certificate not required for absences of three days or less. Staff now taking more sick leave resulting in short notice of staff absences - difficult to get replacements, increased work for remaining staff, reduced rotation options. Especially a problem on Friday nightshift - people want to go out, not to work.
Absenteeism makes it more difficult to implement rotation in night shift as they are the pool resource for day shift.
Absenteeism may mean not being to work to the top specification - lost profits as they have to work to a less profitable specification with the staff that are there. Lost earnings increases the chance of staff leaving to earn more elsewhere.
Seasonal work seems not to have been considered in the Holidays Act. After six months work staff get

up to 2 days sick leave without needing a note, therefore there is only 1 month in a 7/12 season to use their 5 days sick leave. Very high absenteeism in the last month of the season as a result. Staff who choose not to be so cynical get overloaded when absenteeism occurs and are loathe to take sick leave for fear of being associated with the others, but increase their risk of injury through overload - exacerbated by not reporting/addressing early.
Remuneration / Job grades
Piece rate payment system - rewards working faster than people are capable of safely maintaining.
Complex payment systems and lots of grades - reduces ability/motivation to rotate
Peaks in workflow created by piece rate payment for boners. Ends up affecting packers downstream.
Big financial incentive to skip through training as quickly as possible to earn at the highest rate. Any potential MSD risk is very much secondary.
Bonus payment structures such as increasing rates by 150% once over the target 2000 bobbies/shift.
Low exchange rates affecting the profitability of the industry, reducing likelihood of spending money on pay increases or changes to the industry.
Health and safety management
Poor systems for identifying, assessing, addressing, and monitoring risks.
Managers look at h&s as a lost cause - they can't see any way through the mire. If something is suggested it will not be considered if it doesn't bring more money in directly. Many in mgmt have only worked in the meat industry and don't understand how good h&s ideas can make business sense. Productivity is number one, everything else is seen as a cost.
Extraordinary events may not be recorded by the hazard management process as they are outside normal operating conditions. However, extraordinary events (e.g. carcass falling from rail, less staff present than normal) may present significant risk.
Beef gutting
Lean forward to reach into carcass - carcass also swings away when force applied which further increases reach.
Pushing against sides of gut cavity - to create room to work (sore forearms).
Some reaching up to open and bending forward to free pluck. Prime carcasses just fit in - nearly too long. No rail height adjustment.
Permanently on the job due to skill and size requirements. One other person can relieve if required.
Very wide trays, labourers have to reach in a long way, edge is very sharp to lean against and can't get feet under tray.
Beef boning
Cutting clods and point end of brisket - most force applied, lots of pulling down required.
Cutting out aitch bone and knuckle. Lots of force and pulling down with hook.
Staff perceive side boning to be harder than quarter boning as are working upwards to free some cuts and also working against the grain. On quarter boning the cuts all fall down, therefore less lifting.
Static postures when working on trimming tables. Also bent forward and repetitive.
MSD in non-knife hand through gripping, restraining, lifting, holding, carrying, etc. (Muscle tension is found to be higher).
Inappropriate rail height - reaching up or bending forward to do task. Chasing the chain and therefore reaching up (doing this to either get a rest pause or because not sufficiently skilled).
Wrist overextending, wrenching and sudden jerking to free meat cuts.
Throwing or carrying meat from boning rail to trimming table. Mostly affects non-knife hand.
Having to do table-based tasks on the rail as table staff are not sufficiently trained.
Heavy weight of cuts handled.
High number of specs - increases speed of work, but no extra time given for this (or time for training).
Reaching across the table for cuts to trim.
Lifting meat up onto conveyor (400-580mm height difference between table and conveyor).
Boning room long and thin - no overall viewpoint for supervisors.
Cutting force increased when the arm is required to work in an end-range or elevated position.
Lifting in combination with flexion and rotation.
Wrist in ulnar deviation, away from midline position.
Working above mid-chest height likely to lead to static muscle work, discomfort and fatigue (hands above heart level).
Sheep / beef packing
Handling heavy cuts (10kg+) in IW (individual wrapping) area
Packing belt is too high. Staff are almost all short females.

Carton design requires reaching over and in to place meat. Have to take care to prevent touching liner with apron (hygiene).
Staff have to help close cartons (meant to be automatic as it goes under rail on conveyor). Extra task to do and hygiene risk.
Lifting, wrist twist as meat wrapped (done to hold shape of cut in hot boning), repetitive.
Lifting, turning as it's run over the skinning machine. Repetitive, weight, cut risk.
Bulk line has most problems - preparing bags, lifting meat, placing meat in bags, large weight, repetitive, fast pace.
Lifting and twisting around to transfer bagged meat from table/conveyor into cartons (180 degrees) - bulk line. Weights average 2-3 kg but can be up to 7-8kg.
Other general tasks with risk include reaching up to get cartons, lining cartons prior to filling.
Cryovac line - transferring meat from lazy susan into boxes on bench. Requires 180 degree transfer and lifting up from approx 700 into boxes at approximately 850mm.
Working with back to the flow of meat - can't see big piles coming so can't anticipate / pace as well.
Picking pieces off belt as it goes up a slope away from packer. If they get behind then they need to reach up higher as they chase the meat.
Cryovac cuts lifted over edge of conveyor and bagged, then lifted onto cryovac. Lots of reaching, lifting, twisting, heavy loads, repetitive.
Packer workload is increased by all cuts coming off tables being dumped on the same conveyor travelling to them. Packers have to handle and sort, looking for their particular cuts to trim and pack.
Introducing modifications to the room eg extra table positions tends to result in extra handling to and from the table as rail and heights didn’t allow for it.
Packing area too compact for ease of movement and handling. Can't get to all areas to clear blockages easily and quickly.
Bagging action - twisting under load hard for new staff, repetitive task.
Use of tweezers in gloved hands for removing bone chips.
Carton weight (27.2kg) - very heavy to handle.
Manually transferring meat from conveyor to box behind (drypack area). Constant movement, turning, handling. Light weights however.
Leaning forward over conveyor to reach product.
No reservoir/buffer for meat at end of conveyor, meaning the packer has to keep working if product is there, with no chance of pause or extra time if something goes wrong. Packers can create their own buffer by putting them to one side until there is a lull (or pushing them back down the conveyor). This means double handling of the product, often with awkward reaches/lifting, and working during what would be their rest time. This is because meat is only allowed to in room for 20-30 minutes before being chilled. MAF concerned about meat being at the bottom of a pile for too long.
Lifting and placing meat from cryovac/conveyor into cartons behind them.
Weight and force required with big lamb legs.
A lot of double handling as tables, conveyors are repositioned to accommodate different cuts (e.g. observed placing excess cuts in bin as overflow until packer caught up).
Lifting boxes of meat (not cartons) - large weights & forces.
Packing/bagging legs - heavy, repetitive, one-handed actions (chump-on legs are heavier).
Reprocessing rib/racks which are brought in by blue sacks and plastic boxes. Very heavy. Should be 20kg but are more like 40kg.
2.5 kg loins are lifted into 'air' bags. Daily weights handled are therefore very high
Lifting - onto/off cryovac & other packing machines, onto/off conveyors and scales, into cartons (90 degree turn), onto/off strapping machine.
Pairing and weighing french racks - fast, repetitive, reaching, requires accuracy.
Reaching down the conveyor to retrieve cuts if they go past.
Carry meat from meat belt to cartons in bulk packing (180 degree rotation), stooping to reach meat off conveyor underneath top.
Scales at 790mm (above head conveyor is 1700 - gets in the way), rollers very stiff, gap between rollers and conveyor, forces are 3-.5-5.5kg to pull box onto & off scales.
Bad edging detail - sharp stainless steel edges. Can't rest arm and mean that product can't be slid off but must be lifted.
Insufficient working space for packing staff.
Very heavy work for packers as the boners do little to the product so it comes through very fast.
Lifting and twisting (90 degree rotation) to transfer product from cryovac to carton/conveyor.

50% increase in meat volume has occurred in the room without a reciprocal increase in packing space. Therefore bottlenecks and problems such as dropped meat, snags, etc leading to repacking occur as well as increased injury risk.
Carton chutes design. Problems: reaching up or creating headstrike risk if too low.
Have to turn cuts over before bagging as the meat rolls over as it travels from boner to packer. Extra handling of weight and increased task cycle time (less rest pauses).
Having to pick meat off conveyor one handed (are right angles to conveyor so if they use two hands it requires twisting and reaching). Can be very difficult if cuts heavy.
Harder at beginning (mutton) and end of the season (large lambs)
Saddle bagging - long and heavy cuts. Can lead to wrist problems.
Sometimes packers have to make cartons up as well. No time for this therefore they rush more, space is cluttered, concern about contamination (box bits, dropped cartons, etc).
Number of carton sizes is increasing, however they are getting smaller and lighter (90% of what they pack out weighs less than 10 kg). Repetition and reaching are the issues, not weight.
Y Cutting
Highly repetitive.
Very limited task variation.
Fixed work pace.
Punching through long/matted wool on brisket.
Floor very tight, only enough room for one pace backwards (600-800mm), and very little room for accommodating an extra person on the chain (buddy training).
Wrong knife being used (can't use skinning knife).
Poor technique - wrong knife angle when cutting up legs (takes a long time to become competent).
Stooping forward to reach carcass (especially mutton, old ewes).
Arms flexed forward - postural constraint.
Have to rinse three times now (hygiene requirements) instead of just once. Takes more time and makes task harder at the same tally.
Hardest sheep are rams, those with long wool, Merinos (blunt the knife), large sheep (larger movements required), spring lambs (hard to skin).
Having to manually clear brisket (sh & wrist strain) when brisket roller breaks down.
No brisket roller.
Right sided sterilisers only.
Not enough distance between halal and hangup to allow blood to drain and kicking to stop - makes Y cut harder to perform.
Forces required to push flayer if blades aren't sharp.
Using a blunt knife for the task.
Compliance requires spear cut rather than underrunning - requires adopting different upper limb postures leading to sore shoulders and wrists.
No rotation and no space for extra pairs of hands to work on the Y cut tasks.
Aitch boning
Highly repetitive.
High level of skill required to be able to bone within the time available & without applying lots of force. Key element of task is cutting through the ligament / joint capsule in acetabulum otherwise grip force/pull is very high. Extra/redundant movements of staff indicate that they are still learning and/or are using a blunt knife. They look fast but are not efficient and yield/quality suffers (if it's a 3 move cut and they take more or have lots of flourishes then they need attention).
Discomfort in non-knife hand through constant gripping, wide grip, slippery meat, transferring to table.
Lifting hind quarters onto rail to bone.
Constant gripping of non-knife hand. Wrist twist/constraint with knife hand.
Fast work pace
Reaching up to rail, not height adjustable, some staff working above shoulder height.
Thick rump fat - harder to cut through.
Cold meat/fat makes hands cold.
Tallies unmatched to leg size.
Larger carcasses in winter are harder (heavier, larger, fatty ewes).
Low table height in some places - requires forward bending when trimming legs.
Sudden jerk on non-knife arm as first leg drops away. Then have to lift up onto table.
Very narrow area to aitch bone (approx 800mm) and small, crowded room.

Hook height low (1700mm) requiring boner to bend down to pull of aitch and leg.
Have to throw aitch onto waste conveyor (but can drop legs onto table).
Observed double handling as line starts up after a break. Aitch boners come and take legs off rail and move down to the tables with them.
Long periods of one specification. No break, even if they rotate as all tasks are the same. Used to rotate onto french racking, but now have a machine to do this.
Lift trimmed legs up onto conveyor
Sheep gutting
High repetition and workpace
Gripping force, with pronation and wrist twisting, required to detach gut from carcass.
Awkward movement/reach (rotate 180 degrees from carcass to gut trays behind them while carrying gut - some step, some twist). Poor workstation geometry - limited space laterally (800mm), reach into guts of up to 300mm, reach over trays resulting in guts being up to 400mm horizontally from body, 200-300mm lift up to prevent runners touching the rail/tray edge, possible constraint of other work areas and waste chute.
Weight of guts and having to lift them into trays (and not touch edge for hygiene reasons).
Precision task so head leans in, feet kept back to avoid cross contamination between carcasses. Results in bend forward required (up to 300mm plus swing of carcass away as they work) to remove guts as load is below standing knuckle height for most (would be even lower with older sheep), therefore taking weight with bent back.
Brisket cutter is between guttee and pluck removal - reduces options for available space as brisket cutter is fixed position. Saw box gets in the way of guttee transferring guts to tray (especially if they are starting to get behind and move down the line a bit).
Very hot & humid - affects concentration.
Low rail height increases bend forward required.
Hardest with sheep and mutton as guts are bigger (heavier and longer therefore more lifting up), and carcass is longer (bend forward required).
Pluck removal is difficult too as lot of knife work in the carcass, working blind, fast and changes of angle, bent forward.
Guttee also takes kidneys out - runs out of room and time.
Sheep are heavier now cf 20 years ago (therefore guts heavier too). Average is now 17kg, average then 11kg.
Can be harder for taller staff - stooping to reach up into carcass.
Animal welfare requirements mean that sheep don't stand in yard for long before slaughter, therefore fuller gut (heavier).
Line too low for pluck removal - common floor level.
Lambs get bigger as season progresses (approx 18kg today) and this makes task harder. Farmers get more $ for more weight but workers don't get more for processing larger animals.
MSD awareness
Staff attitudes: fatalistic acceptance of pain and the need to work through it.
Lack of management training on MSD prevention can also create problems through building in or not recognising hazards in physical design, work organisation, industrial relations, h&s management.
Commonly held belief that MSD are caused by one or a small number of factors.
A blame the victim attitude exists in many staff, both workers and managers.
Other tasks
Lifting heavy weights and twisting
Awkward postures and reaches when done on the cradle. Are changing to the table.
Rodding - Limited room, technique is critical, few can do it, therefore overexposure.
High force, awkward postures, repetitive.
High force, repetitive (shoulders)
Reaching up (esp. smaller animals), hard technique to learn, blunt knife makes it much harder.
Manually handling leg onto rail after hoof removed - equipment not allowing for full variation in carcass size.
Long legged animals present the work very low for tall leggers.
Cold, lots of manual handling required (highest turnover of staff here).
High forces required, repetitive, upper limb constraint, no rotation as is a A grade job.
Pelting machine doesn't always get it all off. Have to finish it by hand. High forces, repetitive.
Spreaders not ideal - sheep hooves come out and pelter goes flying back against wall.

Limited room behind for leaning back to pull.
Repetitive, gripping and pulling, slippery.
Repetitive, high force, fast pace (hard on thumbs).
Lifting lambs onto saw table - heavy, repetitive
All 3 rails require unhooking sides from rail to place on sawbed on the same side.
Breakdown staff have to lift heavy cuts onto the tables (approx 15kg).
Short task cycle (5 sec) in which time operator has to open lid, extract rack, insert new rack, shut lid. Also lots of twisting and turning as well as lifting racks.
High grip force for both hands, repetitive (leads to lateral epicondylitis).
Changeover from wide spreader to narrow spreader - lifting legs onto spreader, high force.
Harder at beginning (mutton) and end of the season (large lambs)
Physically ripping out cuts with their hands.
Bobbies all have to be handled into the restrainer chute for stunning.
Bobbies dig in with front hooves at chute throat - as you would.
Unloading ramp angle too steep results in animals falling or stumbling, injuries and more handling.
Unpredictable nature of live animals
Calves kick more than sheep, hanging can be harder and heaviest calves are up to 50kg.
Weights are very high, esp. on large animals.
Hard with larger animals. Also no rise and fall with stags - have to bend forward to work on carcass.
Task harder if pace increases and if blade gets clogged (is changed twice a day) as they have to handle the meat more to deskin it and task takes longer.
Informal rotation - prolonged exposure to legging task
Pulling pigs through bath (tubman).
Inability to keep up due to lack of experience, skilled ones get breaks to rest and maintain knives, unskilled do not - aggravating the difference with each cycle.
Forceful task (cutting through ribs) as well as repetitive.

Appendix 7: Post-study survey of MIHSF members

The aim of this survey is to gather feedback from MIHSF members on their involvement in the MSD study. Responses will be confidential, with only a summary of results used in publications. Thanks for taking the time to answer these questions.

Name:

Job title (between 6/04-6/08, ie. during the study period):

Length of time involved in the meat processing industry (to present day):

To what extent do you agree with the following statements:

		Strongly disagree (1)	Disagree (2)	Neither agree or disagree (3)	Agree (4)	Strongly agree (5)
1.	I felt involved in the study.					
2.	I felt I had the right amount of control in the study.					
3.	I am satisfied with the outcomes from the study.					
4.	I find the intervention report from the study useful.					
5	The MIHSF has a strong influence on the interventions being implemented in industry.					

6. Is there anything about the study you would like to have seen done differently?

7. What changes in industry have occurred as a result of the study?

8. What changes in industry do you anticipate will occur as a result of the study?

9. Do you have anything else you would like to add?

Appendix 8: Draft MSD interventions

Intervention Headings	**Implemented by plants (n)**	**Planning to implement (n)**	**Supported by the literature**	**H&S staff questionnaire**	**Identified by the researcher**
Work pace					
Limit compression to a fixed amount per run (e.g. 5min/run (20mins/shift)).	1				
Compression not allowed. Missed hooks are made up at the end of the shift to a pre-determined maximum.	2		Y		
Jumping carcasses ahead of the chain to compress runs has been controlled so there is a minimum number of minutes to be worked and a fixed workpace.	1				
The reduction of work compression was recommended in a previous NZ study (1993-1996) in the meat processing industry. The factors that increase MSD risk through work compression may also reduce product quality and yield.			Y		
Task Rotation					
Formalised so that all staff in all tasks involved do rotate. Informal rotation may mean that some staff choose not to rotate, or do so at different times than the rotation system was designed for, potentially compromising the safety of all staff involved in the rotation cycle.	1	2	Y	Y	
The timing of, and number of tasks involved in, formal rotation take into account: task cycle length, physical requirements of tasks, available trained staff, rest tasks, travel distances, equipment/workspace adjustments.	1	3			
Task training provided to ensure that all staff are competent on all the rotation tasks before being involved.	1		Y	Y	
Want to improve attendance (e.g. trained casual staff, attendance bonus) so that there are no holes in skills for meeting production / achieving rotation.		1		Y	
Have a pool of staff trained and ready to step into rotation cycle if required (absenteeism, staff leave, increased workload requires it).	1			Y	
Overcame reluctance of some staff to rotate by providing discrete task training/refreshing after hours (saved face/esteem and filled gaps in skill knowledge). A gradual process - got buy-in person by person.	1				
All staff are on the same pay rate - makes rotation possible. Can draw on staff from either boning or packing to fill gaps (if task trained) as pay or grade are not barriers.	4			Y	
Want to develop a rotation chart to allow others to easily see what tasks are undertaken in each work area. Would enable OHN, Drs, etc to better advise alternative duties if they also know exactly what tasks are involved in the rotation.		1			
Want fine-tuning of rotation cycles so variation in physical demands is accounted for, not just what's easiest to organise for quick changeover.		1			
Rotation is informal and is used as a way of spreading new people around so that bottlenecks are minimised. Daily rotation expected as minimum. Rotation is encouraged by health and safety staff and supervisors.	5	1		Y	
Rotation (slaughter and boning) every 15 min in most cases - within a small number of tasks that are close enough together for a quick changeover. Not formalised.	6				
There is less division of labour or job specialisation in some smaller plants (lower tally therefore more time per carcass and each staff is doing more tasks). This increase in the breadth of tasks undertaken by each person (referred to as job enlargement) provides more physical and mental task variety and less repetition.	2				
Rest / recovery breaks					
5 minute breaks in the middle of each run (except last if short). Enough time to maintain knife, recover, go to the toilet, smoke break in some cases. Leave a gap in the	5		Y		

chain so that the break is staggered as it works its way down. Both slaughter and boning. Paid under some circumstances, not in others.					
7 min breaks in the middle of the first three runs (2.75-3 hour run length). Use floater in slaughter so there's no empty hooks.	1				
Micropauses every hour for 1 minute (slaughter and boning). Chain stops. Also signals task rotation. Time used for micropauses, knife maintenance.	1				
Want to trial 1-2 min/hour micropauses. Measure overall productivity, rework/quality, staff turnover, injuries to determine their effect. Resolve debate about who pays.		3		Y	
Compulsory micropauses for 20 seconds every 15 minutes when they rotate. Implement this as part of the task (e.g. washing, steeling).	1				
Have casual breaks during runs, staff replace each other for a short break (within grade jobs).	1				
Have floater(s) available to give every staff a break. Only works if no-one is away. Not always available when needed most.	2				
Have rovers who move along the slaughter chain providing a break for everyone person, on every run (5-10 minute breaks). Keep them as rovers even when short-staffed. Rovers need to be skilled in each of the tasks.	1				
20 minute smokos (2 hour runs)	2				
Short runs - 1.5 hour maximum. Limits exposure to the tasks with highest injury risk.	1				
Have two 5 min breaks during the shift, primarily for knife sharpening.	1				
Physical task requirements					
Set maximum weights at 27kg. Loads greater than this become a two person task.	1				
Would like a department for older workers with tasks that are less physically demanding (e.g. cutting chops).		1			
Want to start working out a strategy (career path) for workers nearing retirement workers rather than let them work on and possibly injure themselves. Could include: training roles, light duty jobs (may impact on task rotation however), capped hours of work during season peak (no longer days, limited weekend work).		3			
Want to make jobs physically easier so that a larger range of people could be employed to do them (older workers, both genders). MSD risks reduce and therefore staff that would otherwise be injured stay at work along with those that leave because it's too hard.		1			
Improve physical preparedness of staff through pre-employment physical training, encouraging staff to maintain fitness through the season.		1			
Industry has to overcome lack of skills and ageing workforce by designing out heavy work. Trends should be towards casual and jobsharing arrangements.		2			
Have two labourers positions in a training room as step down positions for older boners wanting to ease out of full tally work in boning.	1				
Recruitment and retention					
National recruiting drive for the industry to counter high staff turnover (e.g. as in dairy farming and teaching). Define what makes meat processing jobs attractive compared with other industries.		1			
New staff are trained for 2 weeks by WINZ (ex-meat worker), paid for by NZITO.	1				
Recruit separately for day & night to get a mix of experience on shifts - not all new staff are put on nights.	1				
Try to get a balance of young and old, male and female when recruiting.	1				
Try and maintain workforce stability (low staff turnover) through recruiting wisely and keeping staff happy. Is a priority as it reduces recruitment & training load, helps maintain productivity, keeps skill levels high in the plant and makes the plant easier to manage.	3				
Annual recruiting drive – look to employ staff from outside the region to meet plant needs if necessary (staff numbers, required skills).	5				
Have reciprocal arrangements with other processors (NZ, overseas, seafood), or help arrange other work in the off-season (forestry, farming, manufacturing, construction)	5	1			
Requirement to disclose other employment at recruitment.	2				
Pre-employment medical for new staff.	1			Y	
Night shift is the training shift - is used as a source of new staff for day shift.	2				
Want to improve the profile of the meat industry to make it easier for workers to		1			

borrow money and get insurance (workers reported not being able to get loans because of perceived low job security offered by the industry - disincentive to stay in industry).					
Labourers are kept in employment even in quiet times. While this incurs a cost, this is offset by the advantages of having them available to fill in for staff absences as well as not having to recruit when the plant gets busy. During quieter times they are trained by the contract staff they work alongside.	1				
Would like to make the season as long as possible (e.g. process other species) to provide steady employment so as to reduce staff turnover and to reduce risk of overexposure through intensive work periods.		2			
Run a holiday scheme during the off season. This enables day shift staff to have a break and provides a bit more work to night shift staff (helps reduce staff turnover).		1			
Ensure that in a long season there is still provision made for annual leave.					Y
Work flow					
Want to store chilled product at the upper margin of the acceptable temperature range over the weekend. Ensure that chiller temperatures are within intended ranges and are not too cold.		3			
Want to raise temperature of prime carcasses/fatty ewes before they arrive in boning (especially over 2+ day breaks).		1			
Where carcasses are overchilled, would like to make provisions for staff to work at a slower tally.		1		Y	
Spray chillers - keeps meat moist, fat is not as hard.	1				
Tally is set at a pace that enables sufficient time for those staff present to complete their task accurately, sterilise/steel, and recover.	1				
Have pro rata system to allow for different staffing levels and training levels. Tallies are based on the number of staff and their skills. Daily pay remains the same. Operates in both slaughter and boning.	2				
Reduced tallies for first few weeks until staff can cope with increased speed and still have sufficient recovery time.	2	1		Y	
Maintain a constant chain speed and increase shift length / staff to accommodate greater kill numbers.	1				
Have a slower chain at the beginning of the season to help learners get used to it. Once at full speed the experienced and new staff get mixed up across all chains.	2				
Tally reduces for heavier grades.	2				
Maximum daily tally limits (paid by piece rate) and no compression allowed.	1				
Bone on the curve - necessary as chilled fat on certain grades is thicker and is a significant factor for MSD.	1				
Boning - try to change products by shift rather than within shifts, particularly when going from hot to chilled boning. Changing between prime, bull, cow requires change in pace and technique and takes time to achieve	1				
Boning - Start prime at a lower tally (provides warmup time), increase as shift progresses and workers get used to it.	3				
Try to process prime first, then bull, then cow (by shift and by season).	2				
Start the season with easier product (boner cow).	1	1			
Two people packing heavy cuts - if sufficient staff are available.	1				
If shortstaffed then butchers and labourers can step up/down to fill gaps (on butchers rates).	1				
Have a spare pool of multitasked who can step in to cover and help any struggling staff.	1				
Staff numbers are based on covering the average absenteeism so that there are enough people for the job.	1				
Break up runs of mutton with lambs to get a rest for staff. Mutton requires more force, lambs are quicker repetitions.	1				
Send surplus stock to other plants within company to avoid overstretching staff.	1				
Better awareness of achieving balance in the room (avoiding bottlenecks, recognising increases in workload through product changes, increase in carcass weights. Meeting quality and specifications may require slower pace, more staff in packing, short rest breaks to achieve it.	1			Y	
Remuneration / Job grades					
Set maximum tallies / work pace by run, shift, week.					Y

Set sustainable limits on the maximum number of hours permitted to work/day, and number of shifts/week.	1				
Pay staff well (although piece rate) - low staff turnover as a result (less than 5%).	1				
There is not the same incentive to do more than threshold for reaching bonus payment - this acts as a de facto maximum limit per shift.	1				
Minimise the number of grades and payment systems to enable easier management of staff within rotation systems and to cover for staff absences.	1	2		Y	
Job Allocation					
Promote staff based on task competency and reliability. Provides motivation for staff to get skilled. Seniority effectively stops at the gate, where it gives a right for people to be on site and determines start and finish dates. Task competence and reliability determine what jobs they do. Focus more on the abilities of the staff to find the best people for the position.	3	4		Y	
Positions in the room are determined by competency and seniority. Try to stick roughly to seniority but do promote out of order if required.	9				
Would like to try and maintain staff dignity by having the assessment method for task placement clearly set out in the contract. (For circumstances such as staff promotion or when there are more A graders than there are positions available.)		1			
Remove disincentive to change departments or shifts by ensuring seniority lists allow for this (by department across all shifts, and plant).	2	1			
Try and achieve consistent policy in the meat industry regarding seniority across all regions and unions.		2		Y	
Want to talk to unions about allowing competent people to step into rotations irrespective of their seniority.		1			
Dummy numbers in the seniority list to enable staff movements between grades, departments and shifts.	1				
Attendance					
Want to limit the amount of sick leave allowed annually.		1			
Have a casual pool of staff to call on if people are away. Start a new one each season to cover staff leaving.	3				
Only work during the week, not weekends. Helped to reduce absenteeism (conflicted with sport and younger staff started work on the weekend shift).	1				
Staff shortages are manageable when not working 7 days as the weekenders are available as casual staff.	1				
The effects of absenteeism are managed to a limited extent by maintaining tally but discarding product that would normally be kept or reducing the level of processing required.	1				
Bonus for high levels of attendance.					Y
Don't put job sheets up until the beginning of the shift to reduce the chances of absenteeism from people avoiding unpopular tasks.	1				
Staff participation					
Involvement of all relevant staff in the proposed changes and meaningful inclusion of their input through such steps as: establishment of a working party (management, staff, unions), visits by task experts and designers to other sites, staff comments on concept drawings, staff trialing of prototypes, full-time involvement of specific staff to collect ideas and input from other staff, regular input/feedback meetings with all staff affected by proposed changes, bringing people back during the off-season to have input into and trial changes, involving other system users (e.g. cleaners) in the design process.	8	1	Y		
Health and safety reps are in each dept (voted on by staff). Meet every three months minimum or ideally every month. Members include union reps, supervisors, health and safety staff, maintenance staff.	1				
Long lead in time for plant modifications, which allows time for consultation and refining designs with the processing staff concerned.	1	2		Y	
Hazard identification competition - staff outline hazard and suggest solution, feedback given to them on how it was managed. Staff go into prize draw. Encourages early reporting and hazard management.	1				
Effective liaison between staff affected, health and safety staff, supervisors, engineers and management regarding potential workplace changes. (Not just involving staff who are present when changes are to be made - during off-season for example.)	2	1			

Trialing of proposed changes at relevant stages of the design. Can include: concept design walkthroughs, off-line trialing of mock-up, operational trialing of prototype (with consideration given to extreme operational conditions, eg; different workpaces, staffing levels), and evaluative trialing of design once bedded in. Important to establish the objectives of each trialing stage - what information needs to be collected, what needs to be tested, who needs to be involved.	1				
Shift design					
Determine ideal shift structure for workload (especially peak workload) and available workforce. Set a maximum number of hours permitted to work per day and a maximum number of shifts per week, then monitor this.	1	1		Y	
Reducing run lengths over the course of the shift.	5				
Maximum run length of 2.5 hours, with 30 minute breaks between.	1				
4x10 hour days preferred by staff - more time off, found it easier to recruit/retain staff, more time to recover.	3				
Reduced length of shift from 10 hours to 8 hours with 2 hour runs.	3	1			
Used to run third shift (Fri-Sun). Now extend day or night shift by a few hours in peak season. Third shift had high absenteeism, difficult to train staff, hard to recruit and retain.	1				
Getting rid of night shift. Only work one permanent night shift, all the rest are day shift (M-F) only.	1				
Changed from day and evening shifts operating for 6 days to current system (4 on, 4 off - days only, 5x2hour runs). This helped stop double shifting.	1	1			
Health and safety management					
Want H&S to be a higher priority in plants. Educate management, engineers, vets on H&S importance and production gains that can accrue. Recognition by management of the effects of extended work hours and workload peaks on MSD, absenteeism and staff turnover.		5			
Look at what other industries do to manage their MSD issues.		1			
Provide OHNs with the autonomy to design, trial and implement interventions rapidly in response to an incident or identified hazard. Although this is reactive, the necessary changes at least get made quickly.	1				
Would like to see more managers coming in with management backgrounds but who may know little about meat processing. Processors who become managers often need to contract in people with management systems skills, and commonly spend time back on the process line during busy periods rather than managing the issues creating problems.		1			
Early reporting and injury management					
Early reporting of discomfort is actively encouraged with staff. Cases are resolved through intensive treatment, advice/training, task modifications. Good communication required between supervisors, health and safety staff, trainers, engineers.	8	1	Y	Y	
Occupational Health Nurses (covering all shifts) have preventive and investigative roles as well as clinical.	3			Y	
Occupational physicians / Doctors on site in clinics for short periods each week (covering all shifts / departments). Also have trained first aiders in each department.	6			Y	
Physiotherapist on site for periods of time each week (covering all shifts / departments). Involved in early intervention treatment, rehabilitation, exercise programmes and injury prevention advice. Work in with other medical staff and trainers on task technique. Time on site ranges from 1 visit / week to 30 hours / week	7	1		Y	
Plant coordinates their own case management, with more emphasis on injury prevention (proactive) rather than injury management (reactive). Significant cost savings accrued.	1				
A graduated return to work programme - involving the staff involved, health professionals, and relevant supervisors. Programme is several weeks long. Encourages staff who get sore/injured to get fit and is also good for physically unprepared new staff. Involves occupational assessment and placement post-injury.	1			y	
Return to work / Alternative duties programmes are designed with a list of tasks that encompass different skill levels / grades as well. Alternative jobs do not jeopardise existing task rotation systems (e.g. second person on physically hard jobs, sorting meat on the conveyor). People are paid at full rate if they have had normal production in the	4	1	Y	Y	

past week and report the injury/discomfort to the plant immediately (removes reporting disincentive and enables early injury management).					
Comprehensive incident investigation to identify and work out how to address contributory factors	1		Y	Y	
External contractors assist with hazard management as well as rehabilitation and return to work programmes.	1				
Pre-employment medical screening for MSD. Results are used to help direct staff to work in particular areas. Includes baseline measurement of fitness levels, or grip strength for rehabilitation if injuries occur.	3			Y	
Use positive performance indicators (e.g. risk factors identified and addressed) for measuring health and safety in preference to negative measures such as LTI frequency.			Y		
Invite Doctors on site to increase their understanding of the industry, the tasks and management strategies.	2				
Information on exercises provided pre-employment to increase strength and flexibility prior to starting work.	1			Y	
Health and safety committee has the support of management, supervisors, maintenance staff and workforce. Has moved from reactive to proactive as pre-existing issues have been addressed.	1		Y		
Need a robust hazard identification system for meat plants - not just a generic one or just physical hazards. Two examples raised were IMABS, or KEA auditing where people fill out a hazard report form which is then assessed, commented on, and reported back to person who raised it within 24 hours, monitored and checked after one month.	2		Y	Y	
Have a conference for meat OHN staff (all companies) to share successful interventions, and discuss common problems.					Y
Maintenance					
Good preventive maintenance system (rollers, castors, rails, etc).	3	2			
Spare conveyor belts available on a trolley in case of breakdown.	1				
Want to train maintenance staff on: principles of MSD prevention relevant to their role, requirements of tasks on which they have an impact (e.g. sharpening flay knives), and to be more efficient/knowledgeable on machines (reduce repair time).		3			
Have separate contract cleaners - reduces total hours for processing staff, important during season peak.	4				
Involvement of engineers in plant problems and redesign issues.	1				
Plant design					
Presence of daylight in all work areas - windowsill above head height for light and a view into the plant.	5	1			
Want simple travel routes, straight with sufficient circulation space to prevent bottlenecks.		1			
Keep clearways free of trip hazards, & keep circulation space at elbow height the same as at toe height.	1				
For new sheds, provide extra length in chain for future demands that will inevitably take up space and cramp staff. Base the extra space on additions that have occurred in the last generation (e.g. additional equipment, additional staff, more sterilisers/washers, new hygiene checkpoints).					Y
In designing new rooms, place services in such a way that a consistent floor level can be achieved. This would require changes in rail height rather than floor level.	2	2			
Plant layouts to offer a spare position at each rotation group - for training and doubling up when less experienced people have to be brought in to key positions.					Y
Position management offices close to the processing areas ideally visible for both. Enables informal contact and supervision. Staff feel more involved and less isolated.	1		Y		
Want a plant design that is easier to clean - less time involved, less risk of injury.		1			
Consistent step / floor surfacing (granulated - non-slip)	3				
Want more washup facilities and closer lunchroom to use break time more effectively.		1			
Workspace and equipment design					
Boning - trimming area geometry should be such that product can be dropped onto slides by boners without lifting, moving with the cut or throwing cuts (ie use gravity). Same applies for waste. Trimmers should be able to easily reach cuts, work on them	2	2	Y		

and transfer to waste and meat conveyor without excessive lifting, reaching or bending. Work area configured to suit 95% of male and female staff.					
Work areas to be comfortable for both left and right handed operation.					Y
Want to provide height adjustability in workstations where large height differences (product and staff) warrant it to prevent working with arms elevated or needing to bend forward. Through adjustable stands, rails &/or worksurfaces. The aim is for the task to be undertaken between shoulder and hip height depending on task requirements (product size, force requirements). Individual height adjustable workstations are prevalent in the NZ seafood processing industry.		2	Y	Y	
Want to use autofeed conveyors where possible to reduce the need to handle products/waste to other areas.		2			
Want to provide clear space in all work areas for leg/foot placement.		1			
Position sterilising gear for knives to minimise twisting, reaching, and travel distances.	1				
Use of acrylic attached to the rail has helped provide a more constant level of friction than steel (easier to push), reduced noise, and reduced rail maintenance.	1				
Legging stand has been increased in width & depth to provide more space for moving in the legging task.	1				
Enable staff to get as close as possible to what they are working on so that handling or applying force can be done as close to their centre of gravity as possible. Remove restrictions to foot and leg placement, and ensure work platforms extend as far as possible under the load – including horizontal adjustment if required.	1	1			
Design trolleys so that they can be pushed and manoeuvred while standing upright (rather than stooping to push trolleys that are made low enough to fit under structures.					Y
Modify and trial D handle meat hooks to reduce rotation in the operators hand (e.g. through handle shape, thumb or finger holes)					Y
Want to trial footwear insoles (inserts to existing boots) / alternative boot designs for reducing discomfort from standing on hard surfaces for long periods (along with other trial considerations including: slip resistance, cleanability, durability/cost ratio).		2			
Knife & Glove design					
Trial knives with different tang designs as a way of reducing run-through risk (e.g. Victory).	1				
Want to trial knives with different steel characteristics to determine the effects of blade flexibility and steel hardness on task performance.		1			
Trial knives with different grip and handle characteristics for providing good friction and minimising grip force requirements.		1	Y		
Different design knives (handle design, blade length) are available to provide some choice for staff to meet individual preferences. (Have to hand old one in to get new one.)	4	1			
Gloves - trial different gloves and glove combinations to find the best fitting range for the staff, the least number of layers, and the least effect on usability (some plants find knives 'stick' on liner gloves, others find CR gloves alone are too slippery). Advice on glove design and use: fit and the effects of poor fit, performance specifications, over-taping.	1	4	Y		
Thermal environment					
Provide baffles/barriers to reduce drafts in work areas.	1				
Investigate the feasibility of providing cooling only where the meat is, rather than the whole room.					Y
Mats used to compensate for cold, hard floor. Some benefits reported but trip hazards, and no benefit when moving around the place, potential hygiene problems.	1				
Better quality boots (freezer style) supplied to workers standing for long periods.	1				
Noise					
Want to use radio headsets instead of muffs and very loud radio - easier to communicate.		5			
Company subsidise radio headsets and pay to put in aerials to get good reception in slaughter and boning	1				
Not having to use hearing protection means that staff are able to communicate verbally more effectively - possibly helps with team development and enables issues to be raised early.	1	1	Y		

Task Training					
Comprehensive induction training over 1-2 days covering: company values, hygiene, safety, MSD and how to prevent them, task skills, knife skills.	4			Y	
Have seasonal re-inductions to cover main risks and processes to manage them.	1				
Write an induction document each year for staff, with updated information. Information includes stretches and exercises. Could also include MSD risks and methods of prevention.	1				
Implementation of a 12 week training programme in a training room (off line). Have experienced staff teaching in the room. New staff are employed on a provisional basis for these 12 weeks. Learn all the task skills at their own pace before adding speed. Helps overcome accessory and redundant movements that occur when learning and adapting to new task processes. Also used for injured staff returning to work.	1				
Have a training table / dead rail where trainers work offline with trainees. As they get more competent they go on-line and gradually build up to full workpace.	4		Y		
Provision made for some off-line training within the department (for training without workpace pressure).	2				
Trainers are trained on how to train/teach others. (People involved in training should therefore be certified trainers, not just people who are skilled at the tasks but may not be able to impart that knowledge to others.)	1	3	Y	Y	
Train through using ITO unit standards. Staff have to be signed off (induction and training) before they can work on a task.	4	2		Y	
Trainers and others (e.g. H&S Manager, Production Manager, Supervisor) identify where people may be having difficulties - task training is then targeted toward these people through individual training and development plans. Assessed annually.	4			Y	
Full time trainers (task training, knife sharpening) in each department so that standards are maintained even when the plant is busy.	6			Y	
Casual staff are called back in prior to the season starting for induction and to get them trained and ready for stepping in when required.	1				
Want to develop task technique training - plant initiated and managed. Use for showing good/bad task techniques. Trainers film skilled staff to illustrate good and bad techniques (a training resource for all staff). Trainers can also film staff and use the footage as an individual training tool to help identify and correct mistakes, and improve their own technique.		3			
Alter task technique to reduce required effort (e.g. reduce handgrip to minimum required for the task).	3				
Want to develop standard operating procedures that describe each task in detail so it is easier to learn. SOPs not to assume prior task knowledge and to include relevant health and safety information as part of the task description.		2			
Would like to ensure that managers and supervisors are aware of their responsiblities to prevent and manage MSD in their work areas (and how to achieve this), so that interventions are implemented and MSD trends are closely monitered and managed. Requires good communication between staff and supervisors/managers.		2		Y	
Knife sharpness training					
Knife sharpening training (PPCS, ACC), especially valuable for new staff (more than 1 session often needed)	9	4	Y	Y	
Parallel grinders, knife setters and training to increase standards of knife sharpness.	1	2			
Have more than one sharp knife in pouch in case needed throughout the run.	1				
Full time knife trainer/mentor for all staff (training trainers for each department, induction, refresher training).	5				
Staff encouraged to help each other with getting a sharp knife, or covering while they sharpen their knife.	1				
Knife sharpening trainer for each department (not full time)	3			Y	
Knives returned to one area for sharpening (within the plant, or leased knives returned to supplier). Maintains overall high levels of knife sharpness, reduces time and resources spent sharpening and training. Used by some seafood processors.		1	Y		
Send people with knife related injuries back to the trainers for extra tuition. No limit on how many times they can use this resource.	1				
MSD awareness training					
Design guidelines for physical design changes on plant. Including information on:		4	Y		

MSD risk factors and those that physical design can address, layout principles with examples (rail and table heights, workspace geometry), guidelines for getting the most useful information from consultation and trialing, anthropometric data and how to apply it. Aimed at H&S/compliance staff, engineering staff, and line management.					
More information on MSD causation and prevention for all staff, including: achieving work fitness and flexibility, redundant and accessory movements that occur when a task is being learnt and which decrease as they become more skilled, working at a constant pace rather than peaks & troughs, physical sustainability and the concept of gradual onset conditions occurring through overexposure (e.g. long work hours, overtime, double shifts, second jobs), and the cumulative effect of exposure to relatively minor risk factors.	2	2	Y	Y	
Fitness programmes provided at a gym on site / in the community.	2			Y	
Wellness programme for all staff covering: fitness, nutrition, and injury prevention principles.		1			
Training on active micropausing, and stretching exercises.	6	1		Y	
Provide MSD information and guidelines for plants to make their own video on MSD prevention using their own people. (This has worked well in the past with other issues, e.g. Leptospirosis).		1			
Warmup at the start of each shift (staff encouraged to follow same processes as they would for sport).	2			Y	
Sheep/beef packing					
Pack straight from tables - reduces manual handling required	1				
Belts drive product into open bags - no lifting and holding by packer.	2				
No manual handling beyond where cuts are placed in cartons - no lifting or carrying. Indexed scales conveyor, foot operated.	2				
Considering splitting meat belt into 2 - individually wrapped on one side and trimmed product on the other. Would reduce reach, search time on the belt, and dropped product.		1			
Reconfigured scales area to reduce twisting. Scales now in conveyor line so that no lifting/twisting required.	3				
Use compactor to flatten down bulk meat and get it square (not bulging) - makes scale work easier and also stacking onto containers faster and safer for chiller staff. Less unstable stacks, better use of volume (more cartons).	1				
Conveyor design principles: full width conveyor belt with no raised edges (cuts can be slid off rather than lifted off), packing/trimming tables same or lower height than conveyor (no lifting required), guide on conveyor to move meat away from middle and towards the edges (reduce reaching, belts motor driven where possible (less manual handling), conveyors to maintain desired meat presentation for packers (prevent extra handling step), unidirectional rollers used for where a manual change of direction is required (reduce force required), prevent tight turns for conveyors as manual intervention is then required to keep cartons moving.	4	2			
Carton design: consider designing cartons with side handles to make moving them easier (particularly for heavier cartons), and consider the effects of carton dimensions on reducing reach across the carton when packing and not being obstructed by the lid.					Y
Want mechanised control of pace into packing room to ensure that the work pace is sustainable for all staff. Need buffer areas to even out surges and provide a constant workflow into the room.		1			
Loop conveyor system for meat cuts, which reduces the need to reach or rush to prevent backlogs.	4				
Have sections of roller conveyors that can be positioned where required to reduce handling/lifting.	5				
Task rotation (15-20 minutes) between heavy and light packing tasks.	3				
All staff are the same grade so this is no barrier to rotation.	1				
Formal daily rotation in packing (staff fully trained on all tasks). Labellers and strappers excluded in one case - important to have consistent quality in this task.	3				
Rotation every 2 hours between main packing tasks.	1				
Rotation every 30-40 minutes between main packing tasks.	1				

Workspace design principles: find heights that are comfortable for staff and the tasks conducted there, no lifting product onto higher surfaces (not fighting against gravity), sufficient space between top and lower belts to enable visibility and unconstrained access, provide foot/legspace in all work areas, index carton chutes, reduce carton backing-up pressure on scales/strapper, sufficient floorspace to prevent circulation bottlenecks, once cartons are full there should be no manual handling from that point on.	3	2			
Packers work in pairs: provides company, motivation for each other, good for new staff, and they can help each other with brief breaks when required.	1				
Alternate sides for staff where possible, so are working left to right, then right to left.	1				
Introduction of dixies and accompanying trolleys to help reduce carrying.	3				
Aitch boning					
Rotation every hour with table boners (30 min rotation with boners and bandsaw).	6				
Workspace designed so that boners can adopt their own pace of work, can drop legs directly down onto table/conveyor and aitch bone directly down waste chute, and push meat across onto conveyor (no throwing or lifting required). Hook needs to be height adjustable by the boner (minimum 200mm) and also swivel so that the task is between shoulder and elbow height for workers of different heights, handedness, and legs of different sizes.	5	1			
Do aitch boning plus trim and bone on table if required. Gives some variety - not working off the hook all the time.	3				
Multiskilled staff so that there are many more people (male & female) who can aitch bone.	2	1			
Reduced tally at the beginning of the season for at least a week, and for new staff.	2				
Break up aitch boning with other specs where possible so that it's not done all shift.	2				
Chain is slowed for absenteeism and for cuts that take more time to complete.	1				
Monitor workload - keep it sustainable for the slowest person.	1				
Use cutting boards on tables to reduce knife bluntening.	1				
Want an indexed line into the boning room to control the workpace of the room.		1			
Detailed task technique training including basic anatomy to improve understanding of where and what to cut, and the use of body weight rather than pulling to assist when applying force.					Y
Sheep gutting					
Rotation every 15 min around 4-7 tasks (including labourer tasks in some cases). Rotation periods also 10 min (1) and 20 min (1).	9				
Carousel system (in place since plant opened). Minimal manual handling as tray moves in under the offal as it is removed.	2				
Increase number of staff in rotation, or increase number of guttees for bigger sheep.	2				
Reduce chain speed for sheep.	1				
For small plants, one person does all the tasks (butcher and labourer) rather than dividing the job up. Is an alternative to rotation as it achieves the same reduction in MSD risk.	1				
Gut tray and standing platform heights modified so that guts do not have to be lifted up (to avoid any surface contact of runners).	1	1			
Configure workspace so that there is no bending forward to reach carcass, enough travel room for feet under the carcass so that the guttee can get under the load as it is handled, no lifting up is required, and no walking or trunk twisting is required to transfer gut contents into trays.					Y
Want adjustable / higher chain for sheep gutting (or rise and fall stands)		4			
Want to allow generous unobstructed platform length to give: room for additional staff when training, room for inexperienced staff to do it solo.		2			
Want to develop a kidney popping tool that makes peeling easier to perform, with less grip force and wrist twisting. Also needs to be reliable and durable.		3			
Pelting - use rail or blocks on the floor to push foot against when pulling shoulders.	1	1			
Pelting - consider exoskeleton development for adding grip power in fleecing tasks.					Y
Beef boning					
Separate height adjustable standing platforms (fixed rail height).	1				
Mechanical assistance for boning tasks. Can reduce manual handling significantly.		1			

Hinged trimming tables so they can be lifted and cleaned under more easily.	2				
Workspace design principles: rail height placing task between shoulder and elbow height, sufficient space laterally to complete the task without chasing the chain, consistent floor level (or height adjustable stands), straight drop for cuts down onto slides/trimming tables, tables run flush onto meat conveyor (minimise manual handling).	3		Y		
Alter rail height to suit boner heights and the tasks being carried out along its length.	1				
Trimmers on boning tables rotate daily - sides of tables (for variation in lateral movements) as well as between tables (for variation in cut types).	3				
Rail boners rotate around rail tasks and also do fat trim task (rest job). All table boners also rotate among themselves. Rotation is every 20 minutes on grass fed and every 30 minutes on grain fed.	1				
Boners do a whole quarter/side each so get variety as they work as they follow it along. Some staff also vary this with rotating among themselves every 10 minutes as well.	3				
Formal task rotation every 30 minutes for boners involving all tasks. Pay rates the same for all boning staff. Same system for trimmers also.	3				
Hot boning is seen as having less MSD risk as it is easier to cut, yield is higher and power consumption lower (no need to store in chillers overnight).	1				
Y Cutting					
Rotation every 15 min (hang up, y cut, brisket roller)	5				
Comprehensive training and slow introduction to Y cut task, butchers start on other tasks first.	2				
Workspace design principles: rail height placing task between shoulder and elbow height, sufficient space laterally to complete the task without chasing the chain, consistent floor level, good task visibility, steriliser per person.					Y
Cutters each walk with chain and do all Y cut tasks on a carcass. Brisket roller and hang up are rest tasks. 15 min rotations. Ideal rotation would be to move from Y cut to first rest task back to Y cut then second rest task. This system enables whole body movement, provides task variety within each cycle and can reduce the risk of bottlenecks through better utilisation of existing space.	4				
Counterbalanced brisket roller.	6				
Sheep cleaning system in yards cleans off dirt and grit, makes wool easier to cut through & knife edge lasts longer.	3				
To reduce bottlenecks the brisket cut is done after inspection so that a few can be done at once, rather than having to cut and sterilise between each one.	1				
Put an extra person in the chain when the brisket roller breaks down.	1	1			
Large distance from halal to Y cut to allow bleeding and stimulation time - makes task easier.	1	1			
Use Victory - Y cut knives. Have a running tip blade so that it slides along meat and blade cuts skin, compared with non-Ycut knives which can catch and make the task harder and slower.	2				
Use of shorter/longer hooks to make up for suboptimal rail height.	1				
Rail height approx 1750mm, making brisket height mid-way between shoulder & elbow for most staff.	2				
Consistency in compliance requirements across the country. Is spear cut required or is underrunning acceptable (variation was noted between plants).					Y
Four in rotation for three positions, creating 25% rest time every rotation cycle.	1				
Sterilisers are on a swivel to allow repositioning to suit personal preferences. Also increase available workspace (so can move down line to keep up or have trainer on line) and reduce leg/foot obstruction.	1				
No floor obstructions, sufficient space for each task area & room for trainer. 1 steriliser/person at hip height.	3				
Use of a combined wash and steriliser unit - save time and space.					Y
Beef Gutting					
Good technique and a sharp knife are most important - don't pull where cut will do.	1				
Boning knife used rather than butchers as more accurate cutting is possible.	1				
For labourers - reduce gut tray width so that the reach is reduced as contents end up closer to the labourer (e.g. angled or two level tray bottom), provide surfaces to lean					Y

against to take weight (without obstructing movement), and provide legroom underneath the tray to get the load closer to their centre of gravity.					
Adjustable rail. Can alter rail height (foot button or pendant hand control) to bring carcass to a good height for gut, pluck (approx. 600mm range used on observation).	5				
Rise and fall stands for guttee (foot operated).	1				
Optimise lighting to improve task visibility (e.g. moveable spotlight behind guttee, headtorch).					Y
Guttee stations with standing platform: move it as close as possible to the carcass so guttees to reduce forward leaning and working away from their body.					Y
Task variation – guttees involved in brisket cut, gut, halving saw.	3				
Rotation every hour with first and second leggers.	1				
Reduced tailgating cattle so gut is not as full - easier to handle, and easier to separate runners and paunch.	1				
Standing in the tray enables getting close to load, therefore less reaching/bending forward (slippery however)	1				
Gut buggy design: large front castors (6-8") positioned to minimise tipping force but without accidental tipping, swivel braking castors at the rear for manoeuvreability, stops on the floor to position buggy and facilitate tipping.	2				

Appendix 9: First eight pages of the draft intervention report for the MIHSF

Addressing MSD in Meat Processing

Evaluation of Draft Interventions:

Comment Sheets for Meat Industry Forum Members

November 2006

Contact: David Tappin (027 290 6958, david.tappin@cohfe.co.nz)

COHFE
Centre for Human Factors and Ergonomics

Massey University

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Background

This document reports on the final stage of the recent study funded by the Health Research Council, ACC, and Department of Labour to identify interventions that may assist in addressing musculoskeletal disorders (MSD). The study was conducted within the meat and seafood processing industries, with separate lists of interventions prepared for each industry.

In the first stage of the study, high risk tasks were identified by the researchers and the Meat Industry Forum based on analysis of ACC and plant injury data (2002-04). The second stage of the study involved assessment of these tasks and the work systems in which they operate in 28 processing plants around the country (2005/06). Information was collected from each plant regarding existing or proposed interventions that help to address MSD. Data on key risk factors and barriers to implementation were also gathered. This is the third and final stage of the study and concerns the development of interventions for industry, based on the data collected in the two earlier stages.

What are we trying to do?

The intention of this report is to gain feedback from Meat Industry Forum members on the priority and detail of the interventions listed.

Once feedback is received from you, and any changes made, the final report will be disseminated to meat processors and government agencies. The final report to industry will include further background information on MSD, including a review of the literature on MSD in meat processing.

About the tables

The interventions in this report are summarised from three sources: the data collected during the site visits, questionnaire responses from the first stage of the study, and intervention ideas that have been reported in MSD and meat processing literature.

Interventions are grouped together under 28 headings. For every intervention heading there is information on relevant key risk factors, implementation barriers, and considerations for implementation. The number of plants who have implemented each intervention or are planning to do so, is indicated in two columns alongside each intervention. It is important to note that this is not a count for all the plants assessed, the interventions were simply those mentioned by the plants as steps to address MSD. Where support exists in the literature for an intervention, this is indicated in a further column.

The order of the intervention headings, and of the intervention under each heading, reflects a priority assigned by COHFE. Each intervention was evaluated on its predicted effect on: addressing MSD key risk factors and its breadth of industry applicability.

Rest breaks

<u>MSD key risk factors and implementation barriers</u>
For every period of work there is an accompanying period of recovery time required. Without sufficient recovery time…

<u>Recommended intervention approach</u>
Establishing the right balance of recovery opportunities will be different for each situation, and will be influenced by……

Current interventions in the 28 plants - in order of potential to reduce MSD risk nationally, as judged by the research team	Plants already doing it	Plants planning to do it	Support for it in the literature	COHFE priority rating 1=highest 10=lowest	**Your priority rating 1-10**
1. 5 minute breaks in the middle of each run (except last if short).	5		Y	3	
	1			5	
Other intervention ideas you have, and potential barriers to these …					

What we would like you to do

We have prioritised each intervention on its potential to reduce MSD nationally, and would now like you to add your priority for each intervention based on how strong an idea you think it is from an industry perspective. (The final order of interventions that are given to industry will be based on both ratings.)

Steps:

1. Familiarise yourself with the intervention headings.
2. We want to know how strong you think each intervention idea is. We would like you to prioritise each intervention on a scale of 1-10 (where 1 is the highest priority, down to 10 being the lowest priority). When prioritising each intervention, we would like you to consider:
   - Its likely acceptance by the industry (e.g. how practical it is, cost, resistance).
   - The likelihood of its implementation (e.g. whether barriers can be overcome).
   - How easy it would be to implement (e.g. time required, cost).
3. Make any changes or additions to the wording of the introductory information and the interventions themselves. This could include information that you feel is missing or where further clarification is required to improve understanding.
4. Add any further interventions you think are missing from those listed.

Rest breaks

MSD key risk factors and implementation barriers
For every period of work there is an accompanying period of recovery time required. Without sufficient recovery time…

Recommended intervention approach
Establishing the right balance of recovery opportunities will be different for each situation, and will be influenced by……

Current interventions in the 28 plants - in order of potential to reduce MSD risk nationally, as judged by the research team	Plants already doing it	Plants planning to do it	Support for it in the literature	COHFE priority rating 1=highest 10=lowest	**Your priority rating** **1-10**
2. 5 minute breaks in the middle of each run (except last if short).	5		Y	3	
	1			5	
Other intervention ideas you have, and potential barriers to these …					

5. Please complete and return these forms (post or email) by Friday 15th December.
6. For further assistance or clarification on this process, contact David Tappin
(027 290 6958, david.tappin@cohfe.co.nz)

Intervention Headings

We have grouped the intervention headings into five categories to help your navigation through the document. The interventions in each category are prioritised based on its potential to reduce MSD nationally.

Job Design	**Organisational Design**	**Physical Design**	**Training Design**	**Task Specific Design**
Work Pace Task Rotation Rest Breaks Physical Task Requirements	Recruitment / retention Work flow Remuneration / job grades Job Allocation Attendance Staff Participation Shift Design Health & Safety Management Early Reporting and Injury Management Maintenance	Plant Design Workspace and Equipment Design Knife and Glove Design Thermal Environment Noise	Task Training Knife Sharpening Training MSD Awareness Training	Sheep/Beef Packing Aitch Boning Sheep Gutting Beef Boning Y Cutting Beef Gutting

Work Pace

MSD key risk factors and implementation barriers

Compressing the same amount of work into a shorter period increases MSD risk through: removing rest breaks or the opportunity for brief pauses, and increasing the work pace leading to compromises in work methods in order to keep up. Compression can therefore result in previously acceptable physical task demands becoming unsustainable for some people. Commonly those most at risk are packers, labourers and others who lack sufficient influence on the degree of compression.

Barriers to change include reluctance to trade early finish times for reduced MSD risks, and the control of change being in the hands of a small group of influential staff whose views, personal characteristics and MSD risk profiles may not be representative of all those affected.

Recommended intervention approach

Compression should be phased out over time, or if this proves too difficult, then capped.

Current interventions in the 28 plants **- in order of potential to reduce MSD risk nationally, as judged by the research team**	Plants already doing it	Plants planning to do it	Support for it in the literature	COHFE priority rating 1=highest 10=lowest	***Your priority rating*** ***1-10***
1. Compression not allowed. Any missed hooks can be made up at the end of the shift to a pre-determined maximum.	2		Y	2	
2. Limit compression to a fixed amount per run (e.g. 5min/run (20mins/shift)).	1			3	
3. Jumping carcasses ahead of the chain to compress runs has been controlled so there is a minimum number of minutes to be worked and a fixed work pace.	1			3	

Other interventions identified during the study	Support for it in the literature	COHFE priority rating 1=highest 10=lowest	***Your priority rating*** ***1-10***
1. The reduction of work compression was recommended in a previous NZ study (1993-1996) in the meat processing industry. The factors that increase MSD risk through work compression may also reduce product quality and yield.	Y	1	

Other intervention ideas you have, and potential barriers to these …

Appendix 10: A selection of published papers on work reported in this thesis

Tappin, D. C., Vitalis, A., Bentley, T. A., Ashby, L., Moore, D., Parker, R., et al. (2005b, 18-21 July). *An ergonomics study of musculoskeletal disorders in meat processing in New Zealand.* Paper presented at the 3rd International Conference on Ergonomics and Safety for Global Business Quality and Productivity - Ergon-Axia 2005, San Diego [CD-ROM].

Tappin, D. C., Vitalis, A., & Bentley, T. A. (2006, 10-14 July). *Adopting an industry-wide participative approach in facilitating MSD intervention implementation.* Paper presented at the Meeting diversity in ergonomics, Proceedings of the IEA2006, Maastricht [CD-ROM].

Tappin, D., Bentley, T. A., & Vitalis, A. (2007, 7-9 November). *Some insights from applying an industry-wide participative approach to addressing MSD risk factors.* Paper presented at the 14th New Zealand Ergonomics Society Conference, Waiheke Island.

Tappin, D., Bentley, T. A., & Vitalis, A. (2008). The role of contextual factors for musculoskeletal disorders in the New Zealand meat processing industry. *Ergonomics, 51*(10), 1576-1593.

Tappin, D. C., Bentley, T. A., Vitalis, A., & Macky, K. (2008). An analysis of sprain and strain injury data for the New Zealand meat processing industry from national and industry injury surveillance databases. *Ergonomics, 51*(11), 1721-1734.

Paper presented at the 3rd International Conference on Ergonomics and Safety for Global Business Quality and Productivity - Ergon-Axia 2005, San Diego [CD-ROM].

An Ergonomics Study of Musculoskeletal Disorders in Meat Processing in New Zealand

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ABSTRACT

Musculoskeletal Disorders (MSD) incidence is very high in the New Zealand meat processing industry. The aims of this study were to determine the extent of MSD in the industry and identify high MSD-risk tasks and processes. Data on MSD from three sources were collected and analysed, along with questionnaire responses on risk perception from a sample of meat plant health and safety staff. Tasks most frequently incurring MSD in sheep and beef processing staff included knife-based and packaging tasks in boning, and knife-based and gutting tasks in slaughter. Specific tasks by species in both these areas were also identified.

Keywords

MSD, strains and sprains, meat processing, boning, slaughter

INTRODUCTION

Musculoskeletal Disorders (MSD) are the most common category of non-fatal occupational injury and lost-time in New Zealand workplaces [1]. The meat processing industry specifically, has a higher MSD compensation claims incidence rate than any other sector, based on a list of industries identified as high priorities by the Occupational Safety and Health service of the Department of Labour (OSH) and Accident Compensation Corporation (ACC). 2002/03 ACC compensation claims data shows that the incidence rate for meat processing was 59 claims per 1000 FTE; more than twice the rate for the next highest industry (construction). MSD have had both the highest number of claims and the highest total cost of claims for the state insurer (ACC) over the past ten years [1]. The high incidence of MSD among injury types is also apparent in other countries where injury data is reliably collected [4], [6].

Within the meat processing industry, MSD appear as a significant problem. The Bureau of Labor Statistics (1982-1990) show meatpacking plants had the highest occupational injury and illness rates in the United States for seven consecutive years. In Canada, meat and poultry processing were the highest risk industries for work related MSD among workers' compensation board claims [9]. The Australian meat processing industry is classified as one of the high risk injuries for sprain and strain injuries with the direct cost of injuries from employees in the industry estimated to be $300 million per year [3].

The study on which this paper is based, is the first part of a two year government-funded injury prevention research project currently in progress and aimed at reducing MSD incidence in meat processing and seafood processing in New Zealand. The project has three stages. The first stage is exploratory, aiming to map the extent and distribution of MSD in both industries. Stage two identifies key risk and key protective factors for MSD in high-risk tasks and processes. Stage three involves partnership with industry to develop intervention strategies by which MSD risk can be reduced.

This paper focuses on the first stage of research, describing the initial findings of injury epidemiological data in the meat processing industry with implications for the second stage of the research. In particular, the aims of this study are to:

i. determine the extent of the MSD problem in the meat processing industry

ii. identify high MSD-risk tasks and processes in the meat processing industry

As the second largest export income earner behind dairy produce the meat processing industry represents a significant sector of New Zealand's economy. Country-wide there are around 81 processing plants servicing approximately 32,000 farms producing sheep, beef, veal, venison and pork for slaughter and further processing. The vast majority of meat processed is exported, however a number of smaller plants are involved in processing meat for the local market. The industry employs approximately 23,000 people (1.8% of the full-time equivalent workforce in New Zealand).

Meat processing operates on a chain-based system, with tallies based on production requirements determining the work pace throughout the plant. As the meat processing industry is closely aligned with the agriculture sector, it is prone to the same fluctuations in workloads brought about by seasonality (e.g. calving and lambing) and weather variations (e.g. drought or floods).

By the early 1990s, the New Zealand meat processing industry had already recognised the need to address MSD. Between 1993 and 1996, an ACC-funded Injury Prevention Programme was conducted in the meat processing industry. This programme was in response to the high incidence of ACC compensation claims and costs, particularly strains and sprains [2]. Relevant research findings included the need for better understanding of MSD risk factors, particularly those related to work organisation, with inclusion of these into the scheduling of work, task training and plant design [8]. The findings from the project provided an evidence base for intervention aims that have been pursued by the industry subsequently [7].

ACC and OSH, the two government agencies most concerned with injury prevention, established, and continue to coordinate, 'Safer Industry Forums' within high-risk industries. These forums enable information sharing and targeted injury prevention initiatives within the industry. Positive implementation of these safer practices can, in turn, lead to financial benefits such as a reduction in insurance levies and prosecutions. The meat processing industry forum, which is supported by both employer group and employee group representatives, provided the primary contact between this study and the meat processing industry. Regular dialogue occurred between the study researchers, and forum members (individually and collectively). To enhance information flow and ensure the involvement of the entire industry, contact was also made with health and safety personnel at each individual meat plant. This contact, both at industry and plant levels will continue throughout the ensuing stages of the project.

METHODS

The project adopted an *action research* approach where each stage of the research helped to inform the next. This approach is responsive to industry changes, enabling the methodology to be refined as understanding grows. With the degree of industry participation that is required to collect data and develop intervention strategies, such an approach is essential if issues only become apparent as the research progresses, or proposed methods do not produce data helpful to the aims.

Four main streams of data concerning MSD were collected, two of these from injury databases at a national level and two through collaboration with key personnel in individual processing plants. The adoption of a participative approach in the collection of data from industry served several purposes. First, industry participation is a key component of the research project. Establishing rapport and understanding between the researchers and the industry benefits both parties in the aim of reducing MSD incidence. Input from subject matter experts as well as industry level experts helps to provide context to the study. Second, gaining a better understanding of the industry through individual plant contact will help to improve the validity and credibility of outputs from the research. At the most fundamental level, the credibility of the research is enhanced by ensuring that the whole industry has been contacted and invited to participate. Third, in the absence of a detailed profile of the entire industry, contacting each plant provided information that was not available elsewhere (e.g. staff numbers, species processed, and personnel expertise). The approach also facilitated the collection of opinions relating to MSD and organisational issues. Finally, the participative approach adopted in this study was an attempt to address the problematic issues relating to the gradual onset of MSD and the associated design of existing injury databases. The latter are often reliant on high level data that may not be collected for injury prevention purposes and this could be offset somewhat by the inclusion of data from other more detailed but less specific sources such as questions on specific injury prevention topics. Figure 1 presents an overview of the methods used in this study.

ACC Injury Data

The Accident Compensation Corporation provides 24 hour 'no fault' cover for occupational and leisure accidents in New Zealand. The researchers analysed all MSD injury claims in the meat processing industry accepted by ACC between July 2002-June 2004. Within the meat processing industry, the terminology given to both sudden and gradual onset MSD is 'strains and sprains'. ACC diagnosis categories that encompass both sudden and gradual onset MSD conditions were therefore included in the analysis to maintain some consistency between industry and ACC data. The two main accepted claim types are treatment claims (visit to Doctor) and compensation claims (usually lost earnings). Actual claim cost to ACC was unknown. Because of funders' ethical requirements, the claimants' identities were also unknown.

A useable data set of 9180 accepted ACC claims cases was available for analysis. This study reports on findings from a descriptive analysis of the more useful data variables available (year, month, age, gender, ethnicity, region, and claim type), and content analysis of narrative text provided in 12.6% of claims (n=1153). These 1153 claims were from individuals working in non-ACC accredited organisations, the majority of which are smaller companies (ACC accredited companies manage their own claims). New variables were produced from the narrative fields including; 'activity at time of MSD injury'; 'injury agency'; MSD initiating event'; and 'location/department'. The purpose of this analysis was to identify any specific work areas and events where MSD were more likely to occur to help in the overall targeting of tasks for Stage 2.

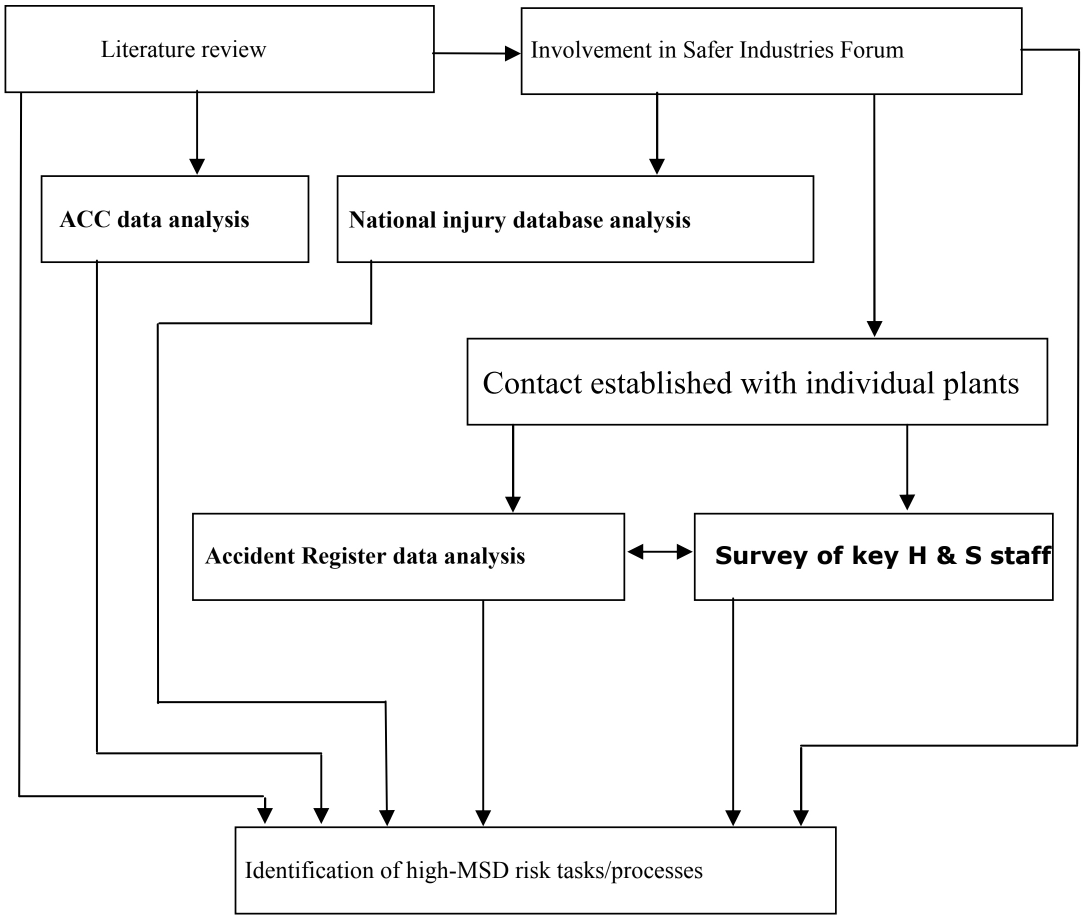

Figure 1. Methods used in Stage 1 of the Research Project

National Injury Database for Meat Processing (NID)

The NID is a meat processing industry initiative intended to provide injury information at a more detailed level than ACC data. Data fields include those specific to the industry (such as animal species), or those which help in identifying injury trends (e.g. task, department). Unlike ACC data, which only captures incidents where medical intervention occurs, the NID records all incidents, thus providing a larger pool of data. However, fewer than one third (approximately 29%) of the industry workforce is represented by the companies that contribute data to the NID. FTE representation in the NID for the two main sectors is approximately 40% for sheep processing and 10-15% for beef processing. MSD are recorded in the NID as strains and sprains, including both gradual and sudden onset conditions. A useable total of 3257 MSD records from 2004 data were included in a descriptive analysis of date, species, department, and task variables.

Severity and frequency indicators were also included in the analysis. In line with ethical requirements, plant and personal details were absent from the NID data.

Accident Register Analysis

Under New Zealand health and safety legislation, companies are required to possess and maintain accident registers, and employees are responsible for reporting their own accidents when they occur. Accident register records are therefore a source of data at a level below ACC data, although, as all accidents are recorded, this will include all ACC cases as well. Via the accident registers, the researchers were able to gather data from that part of the meat processing industry not contributing to the NID. From this data, it was possible to identify tasks / events where MSD injuries were most prevalent. Information requested from the companies' registers included: department, job title, task, species, body part involved, severity, and incident date.

A form was developed and piloted by a sample of plants and others involved in the meat processing industry. Processing plants (excluding those involved in the NID, whose data were already provided through that database) were contacted by phone (or via the company health and safety manager in two companies). The person responsible for health and safety management (or their designate) for the plant was invited to participate in the accident register data collection activity. Sixty-nine plants (from a total of 73) agreed to participate and were sent forms (8 plants had already contributed their data through the NID and 4 plants declined to participate).

Health and Safety Staff Questionnaire

At the same time as the accident register activity was being conducted, a questionnaire was sent out to the health and safety managers at 77 plants. The health and safety questionnaire covered four main topics: processing plant details (e.g. species, FTE processing staff), respondent details (e.g. industry experience), MSD management practices at the plant, and respondent opinions on the tasks most likely to lead to MSD and reasons why. The purpose of this survey was twofold; to collect further information about the industry not available elsewhere; and to provide people with an opportunity to give their opinions on MSD problem areas in the industry.

While an absence of some data means that our understanding of the industry may still be incomplete, the use of the four data sources provided a better overview of the industry than previously available. Each data source complemented the other, providing qualitative and quantitative information at national and plant levels.

RESULTS

Accident Compensation Corporation Injury Data

Of the 9,180 accepted claims in the sample, 80.4% were for male claimants. Treatment claims comprised 59.5% (n=5462) of the sample, compensation claims 25% (n=2319) and other claims (hospital treatments – details unknown) 15.2% (n=1399). The gender ratio for each claim type was the same as for the total sample. Incidence rates were unable to be calculated due to a lack of reliable industry demographic data.

Age ranges for claimants were between 15-70 with a mean claimant age of 37.9 years (sd 11.7). There were no differences for gender by age or by year (mean age males: 38.1 years; females: 36.8 years). The ethnicity of claimants was consistent with NZ census data percentages for stated occupation. New Zealand European were 57.3% of the sample (n=5264), New Zealand Maori were 27.9% (n=2565), and Pacific Island were 3.7% (n=336). Claimant ethnicity was not recorded or unknown in 7.9% of cases.

Most claimants were from the main farming regions of the country where processing plants are located: Waikato (11.3%), Hawkes Bay (13%), Canterbury (19.1%), Otago (12.7%) and Southland (16.6%). Females accounted for 22.8% of claims in Waikato, 25.3% of claims in Hawkes Bay, 24.3% of claims in Southland, but only 11.4% of claims in Canterbury and 15.2% of claims in Otago. Almost half (48%) of the claims occurred in the first four months of each of the two years, with a corresponding dip in claims between July and November each year. This is consistent with the pattern of work within the industry, where stock are fattened for slaughter over the months where there is the most abundant feed available (all species, other than pig, are pasture-fed throughout the year in New Zealand). Many plants have an off-season and are either closed or on reduced hours during the winter months.

Most MSD were diagnosed as sudden onset (76%), while gradual onset MSD accounted for 18.5% of claims; 5.5% were of unknown nature. The most common body parts involved were back/spine (27.8%), wrist/hand (23%), shoulder (16.9%), arm/elbow (14.3%) and lower limb (9.9%).

Analysis of the narrative description of injury circumstances (one line) was conducted for activity/task at the time of the MSD, and the injury agency involved. Only 12.6% of claims had narrative descriptions. These were from claimants employed by plants who were not accredited by ACC, most of whom would be smaller non-export plants. Tasks most commonly associated with MSD injury were: lifting tasks (35% of non-accredited cases), knife work-boning (6%), knife work-trimming (3%). Other common tasks mentioned included skinning/pelting (5%) and handling live animals (4%). For lifting-related MSD cases, the most commonly mentioned injury agencies were: lifting boxes (28% of lifting-related MSD) or animal carcasses/meat (37%). Lifting-related MSD injuries most frequently involved back/spine (51% of lifting-related MSD), shoulder (19%), hand/wrist (11%) and neck (8%).

National Industry Database for Meat Processing Data

A total of 3257 MSD-related NID cases for 2004 were included in the analysis. Claimants age, gender, ethnicity and region were not included in the database. The most common body parts injured were: back/spine (24%), wrist/hand (31.3%), shoulder (16%), arm/elbow (14.4%) and lower limb (11.1%). These percentages are closely aligned with those of the ACC data. Sheep were the predominant species involved (n=2861; 88%) which is consistent with the sectors contributing to the database. Other species were beef (n=322; 10%), venison and pork.

Month of injury data showed a pattern of higher numbers of incidents occurring in the first four months of the year (67.8%), consistent with expected industry workloads. The fact that this figure was higher than that found in ACC data may be due to sheep being the main species involved. Sheep have a greater peak for processing between January and April.

NID data for department and task type were analysed for the two main species represented – sheep and beef. Table 1 shows the main tasks mentioned in MSD incidents for both species. Cost estimates for these injuries were among the highest for strains and sprains. Injuries in some tasks incurred higher costs (e.g. for surgery). However, these were far less common than injuries in the tasks listed in Table 1.

Table 1: NID Incidents by Department and Task For Sheep and Beef

Department	Main Tasks Mentioned	Sheep (% of total for species)	Beef (% of total for species)
Boning room		1380 (48.2%)	185 (57.4%)
	Knifework	*783 (27.4%)*	*90 (28%)*
	Packaging	*202 (7%)*	*42 (13%)*
	Saw operation	*101 (3.5%)*	
Slaughter floor		667 (23.3%)	86 (26.7%)
	Knifework	*398 (13.9%)*	*52 (16.1%)*
	Gutting (knife task)	*69 (2.4%)*	

Accident Register Survey Data
Of the 69 plants which agreed to participate in the survey, 29 submitted accident register data for 2004 (42% response rate) for a total of 4045 MSD incidents. This sample of plants represents approximately 43% of the industry workforce. The 29 plants appear to be representative of the industry as a whole, by region, size, and species processed. The most common body parts injured were wrist/hand (26%), back/spine (21%), shoulder (18%), arm/elbow (15%) and lower limb (8%). In a further 9% of cases, the affected body part was not specified. These figures are very similar to the ACC and NID results. The two main species in which the incidents occurred were, again, sheep (41.5%) and beef (35.7%). In 19.4% of cases, the species was not specified. The number of incidents occurring in the first four months of the year was 49%. This is consistent with the ACC figures and is due to the higher levels of work exposure than occurs throughout the rest of the year (more work hours / shifts, less plant downtime). Information on severity was provided in only 19% of cases.

Variations between plants in both terminology and the type of data collected made data comparison difficult. Some fields were also missing (e.g. species, task) from otherwise complete data sets. Both of these factors limited the analysis that could be conducted with the Accident Register data. However, there is sufficient information to enable a breakdown of department and task by major species. Table 2 provides a summary of the main findings.

Table 2: Accident Register Data by Department and Task for Sheep and Beef

Department	Main Tasks Mentioned	Sheep (% of total for species)	Beef (% of total for species)
Boning room		954 (56.9%)	831 (57.5%)
	Boning - knife	*283 (16.9%)*	*331 (22.9%)*
	Packaging	*51 (3%)*	*114 (7.9%)*
	Saw operation	*45 (2.7%)*	
Slaughter floor		491 (29.3%)	378 (26.2%)
	Pelting	*45 (2.7%)*	
	Gutting (knife task)	*36 (2.1%)*	*25 (1.7%)*
	Legging		*25 (1.7%)*

Work within the boning and slaughter departments is broken down into a large number of tasks. Most of these do not appear significant because of the small numbers of injuries involved. Without further information on task prevalence it is not possible to determine how significant they might be. However, some tasks that may be relevant include: cleaning tasks (across a number of departments for both beef and sheep), H boning (sheep boning), kidney removal (sheep slaughter), chiller/freezer tasks (all species), offal (sheep and beef slaughter) and maintenance tasks (all species).

Health and Safety Staff Questionnaire Data

The questionnaire had a higher response rate than the Accident Register collection activity. This may have been because the questionnaire took less time to complete. Of the 77 plants sent the questionnaire, 44 responded (57% response rate). The number of processing staff that these plants represent is 76% of the total industry workforce. Staff had been involved in the meat industry for an average of 6.7 years (range 0.6-40 years), with experience in health and safety in meat processing averaging 2.6 years (range 0.1 – 10 years). The results most relevant to this study came from the survey recipients' perceptions on the tasks most likely to lead to MSD within the industry. Table 3 provides a summary of the data for the two main species – sheep and beef.

Table 3: Staff Opinions on Tasks Most Likely to Lead to MSD in Meat Processing

Task	Weighted Total	Main reasons stated
Sheep		
Boning	67	Repetitive, fast work-pace, limited rotation, extreme wrist movements
Boning – 'H'	18	Constant muscle tension, strain on wrists and shoulders
Packing – boning	36	High workload, repetitive, limited training, heavy lifting and reaching, poor layout
Slaughter	46	Fast work-pace, repetitive, limited rotation, awkward body postures to reach task
Slaughter – pelting	12	High forces required – punching, pulling
Slaughter – Y cut	6	Repetitive, limited rotation
Beef		
Boning	68	Fast work-pace, minimal rotation, long hours, high forces, repetitive, aging workforce
Boning – quarters	16	A/a plus constant gripping, lifting heavy weights
Packing – boning	28	Repetitive, fast pace, constant gripping, lifting, heavy weights
Slaughter	15	Fast work-pace, repetitive, awkward postures, pulling / pushing
Chillers/Freezers	12	Lifting, reaching, repetitive

Table 3 provides some insight into the perceptions of staff working within the industry on health and safety issues. The highest rating tasks reflect the findings from the accident data sources. Also of interest are the reasons why the task received the rating. Most of these are less concerned with physical design issues than with work organisation issues. This could be a function of the questionnaire sample, in that only people who perceived MSD as a problem worth investigating returned the questionnaire, or the findings may provide an insight into the level of awareness of MSD prevention within the industry as a whole. Future surveys are planned as part of Stage 2 that may shed more light on the state of preparedness for change within certain strata of the industry.

DISCUSSION

The two main aims of this study were to determine the extent of MSD in the meat processing industry, and to identify high MSD-risk tasks and processes on which to focus further attention in Stage 2 of the larger project. The findings from the four data sources investigated have gone a long way towards achieving these aims, with some caveats. Perhaps predictably, there were weaknesses and inconsistencies in all four data sources, which makes drawing conclusions from them more difficult. There were also limitations in the methodology, which affected the validity of the results. However, despite these factors, we also know that these are currently the best data sources available concerning the New Zealand meat processing industry. Triangulation of findings from each of the data sources will help to strengthen their merit overall.

As ACC data was collected from the entire industry, the two year dataset provides a good overview of industry demographics and is unlike the other data in this regard. Regrettably, the lack of task or species detail limits the ability to draw further conclusions from it. The opportunity for useful data from the accident descriptions is wasted, with only 12.6% (and all from smaller plants) providing this information. Its existence is useful however, as smaller plants were not well represented in the NID and accident register surveys.

Analysis resulted in valuable new information including the number of cases by month and the regions in which they occurred. This information will help with planning the site visits for Stage 2, particularly investigating workload and exposure in some tasks throughout the season. The reason for the lower ratio of females involved in MSD cases in two meat processing regions was not a subject of early speculation as it will be part of the investigations in Stage 2. While the tasks identified from the accident descriptions were only low numbers, they closely match those from the other three data sources. A major limitation of using the ACC data, which also applies to the other data sources, is that incidence rates cannot be determined without workforce and exposure information. Thus, tasks with high incidence of injury may not be identified. Collaboration with the industry will help to increase the likelihood of addressing this shortcoming. Another limitation relates to the absence of actual injury cost, creating a risk of focusing on the wrong tasks.

High MSD-risk tasks from the NID records include knifework and packaging in boning of both sheep and beef, along with slaughter-floors for both species. However, there is insufficient data on specific tasks within slaughter. These findings closely match those for the Accident Register Survey, where some tasks are also more prevalent than others in both beef and sheep slaughter departments. As these two data sources cover the same information, collected through two different channels, it is significant to note that they account for approximately 72% of the industry workforce. The most significant limitations of the NID, other than the inability to determine incidence, are the lack of data fields for age, gender, and ethnicity, and the number of unspecified entries for task, department and species.

There were a number of positive outcomes from the NID analysis. First, findings built on lessons learnt through two earlier surveys conducted in meat and sawmilling industries by the researchers [5]. Second, the process of contacting each plant individually extended contact networks leading to enhanced industry information and providing a sound basis for ongoing research relationships. These relationships supplement the Safer Industries Forum group, particularly as smaller plants, geographically isolated plants, or some plants of multi-site companies are not involved directly with the forum.

The results from the Health and Safety staff questionnaire provided further evidence to support the findings from the national and plant accident data. Here, inconsistent data fields made it difficult to aggregate findings. However, the same departments and broad task types were indicated for both sheep and beef. Major limitations relate to the unknown nature of any biases affecting which high MSD-risk tasks are listed and in which order. This bias was further amplified because a small amount of aggregation was necessary to make use of the data.

The findings from this study provide the focus for the next stage of research, involving task assessments on site. Boning and slaughter departments will be targeted initially, with primary attention given to the tasks listed in tables 1 to 3. Further analysis for less common species will also occur to ensure their representation in the research project.

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REFERENCES

1 Accident Compensation Corporation, 2004, ACC Injury Statistics 2004 (Third Edition), ACC Wellington, New Zealand.

2 Blewden, M.; Wyllie, A., 1998, Outcome evaluation findings from a pilot injury prevention project in the meat industry, Journal of Occupational Health and Safety – Australia and New Zealand, 14, 4, 401-408.

3 Caple, D.; Hodgson, R., 1992, Meat processing industry – 100 micro ergonomic solutions. In: Proceedings of the 28th Annual Conference of the Ergonomics Society of Australia Inc, Melbourne, Australia: 2- 4 December 1992, 315 – 321.

4 Kuorinka, I.; Forcier, L., 1995, Work related musculoskeletal disorders (WMSDs): A reference book for prevention. ISBN: 0-7484-0131-8

5 Moore, D.; Tappin, D.; Vitalis, A., 2004, Accident Register Surveys: developing league tables of tasks linked to high incidences of musculoskeletal disorders. In: Proceedings of the 12th Conference of the NZ Ergonomics Society, Taupo, New Zealand: 5-6 August 2004, 82-87.

6 National Research Council; Institute of Medicine, 2001, Musculoskeletal Disorders and the Workplace – Low Back and Upper Extremities. ISBN: 0-309-07284-0

7 NZCTU, 1997, Meat Industry Injury Prevention Project, Case Studies 1-6, NZCTU, Wellington, New Zealand

8 Slappendel, C.; Moore, D.; Tappin, D., 1996, Ergonomics in the meat processing industry. In: Proceedings of the 7th Conference of the New Zealand Ergonomics Society, Wellington, New Zealand: 2-3 August 1996, 217-223.

9 Yassi, A.; Sprout, J.; Tate, A., 1996, Upper limb repetitive strain injuries in Manitoba, American Journal of Industrial Medicine, 30, 461 – 472.

Paper presented at the Meeting diversity in ergonomics, Proceedings of the IEA2006, Maastricht [CD-ROM].

Adopting an industry-wide participative approach in facilitating MSD intervention implementation

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Abstract

Musculoskeletal disorders (MSD) are a significant problem in the New Zealand meat and seafood processing industries with very high incidence rates and associated injury costs. A participative approach was used to investigate MSD in these two industries in a three stage government-funded research study. Safer Industry forums representing processing companies, employer and employee groups and government agencies are involved in each of the three stages. These forums are the primary means of industry participation, augmented by ongoing interaction with processing plants. This paper reports on the overall approach based on the findings of the first two stages. Reflections on the approach are discussed using the participatory ergonomics framework as a template. Strengths and weaknesses of the study in the context of the industries themselves and overall project aims are also discussed.

Keywords: WMSD, participatory ergonomics, meat processing, seafood processing

1. Background

Through analysis of occupational injury statistics, New Zealand government agencies responsible for injury prevention (Health Research Council, Accident Compensation Corporation [ACC], and the Department of Labour) recognised that work-related MSD represented a serious problem for the New Zealand workforce and commissioned research to investigate the issue. In fact, MSD are the most common category of non-fatal occupational injury and lost-time in New Zealand workplaces and consistently have the highest total claims costs for the state insurer (ACC) [1]. This two year study (2004-2006) is a consequence of their efforts to direct research at MSD in two industries: red meat processing and seafood processing.

In addition to setting the research scope and objectives, an essential requirement of the funders was that the research engages with industry stakeholders throughout the study to increase buy-in by informing key stakeholders about MSD issues, and enabling the stakeholders to better prioritise MSD issues within their industry for future control and prevention.

There are three stages in the study. The first stage involved mapping MSD in each industry through multiple sources and identifying high risk tasks. National and industry injury data formed the basis of the Stage one analysis [2]. The aim of the second stage was to identify key risk factors for MSD, intervention ideas and implementation barriers. On-site data was collected from a representative sample of 43 meat and seafood processing plants throughout New Zealand. Stage three, which is still in progress, aims to develop intervention strategies that anticipate implementation barriers in partnership with industry.

The meat and seafood processing industries are important to New Zealand's economy, being the second and fourth largest export earners respectively. The two industries employ a combined total of approximately 2.5% of the New Zealand workforce in over 150 processing plants, with meat processing directly employing approximately 23,000 people and seafood processing around 6,000.

These two industries were initially targeted by the research team due to their high MSD incidence. Meat processing has the highest MSD compensation claims incidence rate identified by Accident Compensation Corporation (ACC) and the Department of Labour at 59 claims per 1000 FTE (2002/03 data). This is more than double that for the next highest industry. The MSD compensation claims incidence rate for seafood processing was 24 claims per 1000 FTE for the same period, placing it fourth on the list of high priority industries. MSD are also the main injury type in both industries, accounting for approximately half the total number of injuries and more than half the direct costs from all injuries.

A similar picture is evident from injury statistics in meat processing internationally. Moore & Garg [3] report from Bureau of Labor Statistics that annual crude incidence rates between 1976-1994 were approximately three times higher for the meat products industry compared with private industry. In 2000, meatpacking still had the highest incidence rate of repeated trauma of all US private industries [4]. In Canada, meat and poultry processing were the highest risk industries for work related MSD among workers' compensation board claims [5]. Caple [6] reports that the rate of MSD injury claims in Australia is four times higher than the manufacturing industry, with manual handling claims in meat processing costing almost 50% more than other injuries.

There has been little research on MSD in seafood processing. Nordander *et al* [7] evaluated the impact of MSD risk factors among male and female fish industry workers in Sweden and found that female workers had worse working conditions than men for a range of risk factors. Women also had higher prevalence of neck and upper limb conditions and more often than men left the industry because of these complaints. Olafsdottir & Rafnsson [8] found that the prevalence of upper limb musculoskeletal symptoms among women increased after the introduction of a processing line in 11 fish fillet plants. A reduction in numbers of workers, reduced rotation opportunities and higher workforce turnover were stated as possible reasons for this increase. No data that compared MSD incidence in seafood processing with other industries could be found, other than the New Zealand ACC data.

In New Zealand, previous efforts to address MSD in both these industries have focused on generic national injury awareness and education programmes by government agencies. Injury mitigation through early reporting, rehabilitation and early return to work programmes have also been developed and adopted, helping to reduce reported incidence and ongoing injury costs. There have been no initiatives within seafood processing specifically targeting MSD.

However in meat processing, an ACC-funded Injury Prevention Programme was conducted in 1993-1996 which focused on MSD and cuts. Case studies were developed introducing organisational factors such as work scheduling, task training, and plant and equipment design as means of addressing more systemic MSD risks [9].

No direct changes to organisational factors or plant design have resulted from this programme. However, improving knife sharpness and introducing cut resistant gloves are two issues advocated in the programme that have been further developed commercially and are slowly being adopted by most plants in the two industries. Possible reasons for the low uptake of interventions are: the programme did not engage sufficiently with the industry (only three processing plants from one company were involved), no group was established as 'champions' to facilitate the development of changes once the programme funding ended, the stage of change of the industry was unknown and programme outputs were probably pitched at the wrong level [10]. All of these factors meant that the industry did not acquire adequate ownership or involvement with the programme.

The current study has learnt from these lessons and is structured so that each industry is engaged throughout the study, there is an industry group with a mandate to facilitate change beyond the study, and the process of developing workable interventions occurs participatively across each industry.

2. The participative approach used in this study

The term 'participatory ergonomics' (PE) is relatively new and variously used. It has been used to describe a range of different approaches and methods of engaging with stakeholders. To many ergonomists, its use may seem redundant, as participation is assumed a people-centred approach. Its presence however, and the growth in its use by ergonomists, indicate that there is an obvious need for such knowledge.

Wilson *et al* [11] define PE as "the involvement of people in planning and controlling a significant amount of their own work activities, with sufficient knowledge and power to influence both processes and outcomes in order to achieve desirable goals" (p 933).

Some of the reasons for the increase in PE include: more human-centred work systems with emphasis on an involved, responsible workforce, recognition of the complexity of motivation and performance, increased union acceptance of participation, flatter organisational structures, the introduction of new systems and methods of organising them, and the development of a more participative culture within many western countries [11].

Wilson *et al.* [11] outline a range of tools and methods used in PE, including those developed for PE as well as those developed elsewhere but applied within PE. Haines *et al.* [15] developed a PE framework with the aims of providing clarity and organisation to the field of PE, as well as providing practical guidance for the implementation of PE assist with clarifying and designing PE initiatives.

Expectations of participation are also increasingly evident in legislation and standards both in New Zealand and overseas, an example being the HSE Amendment Act (2002) requiring employee participation in the improvement of health and safety, both at the plant and industry governance levels. Participative methods have also been used as a way of spreading meagre ergonomics resources more widely, for developing more system-specific interventions, and enhancing their ownership, acceptance and likely success.

Many studies which have used participative methods have been concerned with identifying specific injury risk issues or implementing interventions within a work system [12] or as part of a longer term continuous improvement program [13]. Moore & Garg [3] report on the evaluation of a long term PE program to address MSD in a meat processing plant which resulted in reductions in lost-time incidence rates and total workers compensation costs. There are few studies which have implications across an industry sector however [3, 14].

Elements of an action research approach were also considered for the current study, with emphasis on each stage informing the next, participation, cooperation, co-learning and balancing both research and industry desired outcomes [16]. Consistent with this approach, additional participative methods have been incorporated into the study as it progresses. This has arisen out of the need to engage people at all levels in both industries - the micro-macroparticipation spectrum [17], for collecting data, disseminating information and results on the study, developing sufficient trust and credibility to gain access to all areas of the industries and to glean information on intervention barriers.

The high incidence and long history of MSD in both industries has created scepticism within some parts of the industries about attempts to address the problem. This is more prevalent in meat, consistent with their higher MSD incidence, and is strongly held by some who have 'survived' the industry so far. However, the existence of the HSE Act, falling profits from exports due to high exchange rates, low unemployment reducing the number of potential recruits, and concerns about an aging skilled workforce have all contributed to increased attention by the industries. These pressure factors reinforced the need for a participative approach so that interventions were developed, and seen to be so, within industry. Tapping into process-level and industry-level knowledge also improves the chances of identifying potential implementation barriers and subsequently developing interventions that take account of these.

The primary means of engaging with each industry was through Safer Industry forums, established in 2002 by ACC, OSH and the industries themselves. These groups represent the main stakeholders for each industry (companies, employee and employer groups, government bodies) and their purpose is information sharing and targeting injury prevention initiatives within the industry.

To ensure that both industries were kept informed on the study, contact was also made with relevant personnel at each processing plant. This network of people became the primary contacts at plant level for disseminating information on the study, collecting data, and organising site visits. In addition, this step helped allay concerns they may have had regarding MSD and the study itself. It also provided information about the industries that was not available from any other source. Further involvement with the industries has grown from these two channels to include: regional forum involvement, presentations to national workshops and meetings, informal site visits with processing plants, and meetings with company management, unions, and training organisations.

In Stage one, injury data was collected from: the ACC database (2002-2004 data), a meat processing industry database (2004 data), accident register records from a sample of plants (29 meat plants, 13 seafood plants), and questionnaire responses from health and safety staff at 44 meat plants and 16 seafood plants.

Stage 2 enabled the direct involvement of meat processors through task assessments and interviews conducted at one third of the processing plants for both meat and seafood processing (approximately 250 on-site hours). The interaction varied slightly for each plant, depending on staff availability and production pressures. Data collection methods included: semi-structured interviews, observation, limited postural analysis and dimensional analysis of key workplace elements where feasible.

Methods being employed in Stage three include: prioritising and developing draft intervention ideas through the Safer Industry forums, involving both the Safer Industry forums and individual plant contacts as the next stage for developing intervention ideas, and using these existing networks for continued presentation and dissemination of study findings. Table 1 expresses this multi-layered participative study using the participatory ergonomics framework (PEF) [15].

Table 1. A description of the study using the PEF

Dimension	Category
Permanence	Temporary (two year study), Safer Industry forums are ongoing however.
Involvement	Full direct participation – site assessments Direct representative - most members of industry forums, plant contacts (all stages) Delegated participation – some members of safer industry forums
Level of influence	Industry (group of organisations)
Decision making	Group delegation (ACC, OSH influence) Individual and group consultation as forum sits across companies within industries
Mix of participants	Senior management, internal specialists, union, external advisors, cross-industry organisations. Operators during Stage two
Requirement to participate	Voluntary
Topics addressed	Formulation of policies/strategies Design of work organisation Physical design/specification
Brief	Problems identification Solution development
Role of ergonomics specialist	Initiates, informs, and guides process

3. Reflections on the use of the participative approach in the industry context

Table 1 provides a useful framework for discussion of the various experiences we gained from the research.

Overall there is a need for more follow-on work to this study if MSD are to be seriously addressed, as two years is insufficient to achieve any lasting changes. Additionally, we found that the task of having to deal with two industries was too large as there was not enough time to be in regular contact with forums and plants across both industries.

With respect to staff involvement, we found that senior management support, as well as support from government agencies, was essential in gaining access to the industries and to industry data sources. This support also helped to create positive involvement of plant managers and health and safety professionals on site, and subsequently enabled access to a range of plant staff and tasks. Although personal involvement of work floor staff was limited to those interviewed during Stage 2 site visits, this information was vital in raising issues that no other source identified. Such information is needed for developing interventions that are seen as credible at all levels of the industries.

The Safer Industry forums are the key to the success of the whole approach. Without them, or an equivalent body established for the purpose, there would be little progress due to the absence of industry networks regarding health and safety, and inertia within industry in getting such a study off the ground. In addition to this logistic support, the forums can make decisions allocate funds and propose changes for wider industry discussion. The current member composition of forums is representative of each industry, with support provided from the industry bodies and from ACC. The meat processing forum is better established however, and is chaired by a representative of one of the processing companies, with union representation also. This MSD study is only a small part of their role. A possible development to devolve administration but for the forums to remain informed would be the establishment of PE group(s) outside the forum structures to look specifically at MSD problems.

In the context of this study, the topics addressed span across organisational design, physical design and education design.

The brief for the study was largely determined by government agencies. This lack of opportunity to continue through to implementation and evaluation of interventions means there is a risk of losing momentum which may give industry participants a sense of futility in what they have achieved. This situation may be improved if more ground work is carried out within the industry to build relationships and get a sense of commitment at all levels to find the solution to MSD problems. This is important for an industry where traditionally any changes are difficult to bring about.

The large size of the study means that there are a number of roles to adopt outside the Safer Industry forums, at plant management or work floor levels. Individuals may not understand their role in the project and will understandably want to see something in return for their input. Recognising these roles and need for feedback, maintaining a consistent approach at all plants and with all individuals, is both important and difficult to achieve.

Finally, the researchers realise that we are far from the stage of developing an ‘ideal’ PE programme, but recognise that better results have been achieved so far than the previous study in meat processing (1993-96). Key to this has been gaining the support of the Safer Industry forums, and the subsequent participative development of draft interventions (both short and long term in nature) that identify potential implementation barriers and seek to overcome these.

4. Discussion

The nature of participation with the two industries has evolved over the course of the study as relationships and understanding of the industries has grown. The Safer Industry forums have remained the primary vehicle, while contact with individual processing plants, site visits, and presentations have been developed progressively throughout the study. Flow of intervention ideas between the industries via the researchers has also occurred. Researcher relationships have differed between forums through differences in the organisational structures, industry cultures and the relative priority assigned to MSD.

There are some lessons learnt from the approach taken which could influence how future studies of this nature are planned. While involving two similar industries enriches the findings and enables transfer of ideas, focusing on one industry is more feasible within tight timeframe and cost constraints. The short research timeframe also makes it difficult to establish rapport with the industries and allied groups as well as participatively detecting and designing potential interventions. Such research requests, where there is no allowance given for implementation and evaluation of interventions, also run the risk of leaving industries with no champion or resource to implement change and industries disinclined to support further studies. A more collaborative and pre-emptive approach between funders and industry [3] would also assist in determining realistic research objectives and timeframes and creating the right climate for participation prior to commencing the study [17]. Interacting with workers on process lines, particularly in smaller processing plants, was not always feasible if their involvement resulted in production and/or pay losses. This was also a consequence of needing to visit plants during their processing season, but was outweighed by the benefits of visiting widely and improved our understanding of the industries.

An industry-wide participative study such as this has to balance critical research rigour with industry pragmatism. An approach that is too academic will reduce the chances of fitting in with the industries and along with this, reduce also the likelihood that research outputs will be taken seriously. Being too closely influenced by industry constraints, practices and norms of behaviour will reduce the rigour of the research as commercial pressures can steer researchers unduly.

Engaging with the industries, establishing good relationships, developing credibility, and providing education on MSD principles and prevention are all important steps that ideally need to be in place before a PE programme can be established. The current study can be viewed as laying these foundations for establishing a more formal PE programme to follow, whose main aim would be to implement and evaluate interventions from the current study.

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References

[1] Accident Compensation Corporation, ACC Injury Statistics 2004 (Third Edition), ACC Wellington, New Zealand.
[2] Tappin D, Vitalis A, Bentley T, Ashby L, Moore D, Parker R, Trevelyan F. An ergonomics study of musculoskeletal disorders in meat processing in New Zealand. Third International Conference on Ergonomics and Safety for Global Business Quality and Productivity – Ergon-Axia 2005, 18-21 July 2005, San Diego.
[3] Moore J, Garg A. The effectiveness of participatory ergonomics in the red meat packing industry: evaluation of a corporation. International Journal of Industrial Ergonomics (1998), 47-58.
[4] Piedrahita H, Punnett L, Shahnavaz H. Musculoskeletal symptoms in cold exposed and non-cold exposed workers. International Journal of Industrial Ergonomics 34 (2004) 271-278.
[5] Yassi A, Sprout J, Tate D. Upper limb repetitive strain injuries in Manitoba. American Journal of Industrial Medicine 30, 461-472.
[6] Caple D. The 45 syndrome: age and MSD incidence amongst meat workers. In Proceedings of the XVth Triennial Congress of the International Ergonomics Association, August 24-29, 2003, Seoul, Korea, Vol 2.
[7] Nordander C, Ohlsson K, Balogh I, Rylander L, Palsson B, Skerfving S. Fish processing work: the impact of two sex dependent exposure profiles on musculoskeletal health. Occupational and Environmental Medicine (1999), 256-264.
[8] Olafsdottir H, Rafnsson V. Increase in musculoskeletal symptoms of upper limbs among women after introduction of the flow-line in fish-fillet plants. International Journal of Industrial Ergonomics (1998), 69-77.
[9] Slappendel C, Moore D, Tappin D. Ergonomics in the meat processing industry. In Proceedings of the 7th

Conference of the NZ Ergonomics Society 1996, 213-233.
[10] Haslam R. Targeting ergonomics interventions – learning from health promotion. Applied Ergonomics (2002) 241-249.
[11] Wilson J, Haines H, Morris W. Participatory Ergonomics. In; Wilson J, Corlett E (Eds) Evaluation of Human Work (3rd ed.) 933-962
[12] Theberge N, Granzow K, Cole D, Laing A. Negotiating participation: understanding the "how" in an ergonomic change team. Applied Ergonomics, 239-248.
[13] Haims M, Carayon P. Theory and practice for the implementation of 'in-house' continuous improvement participatory ergonomic programs. Applied Ergonomics, 461-472.
[14] de Jong A, Vink P. Participatory ergonomics applied in installation work. Applied Ergonomics, 439-448.
[15] Haines H, Wilson J, Vink P, Koningsfeld E. Validating a framework for participatory ergonomics (the PEF). Ergonomics (2002), 309-327.
[16] Rosencrance J, Cook T. The use of participatory action research and ergonomics in the prevention of work-related musculoskeletal disorders in the newspaper industry. Applied Occupational and Environmental (2000), 255-262.
[17] Wilson J, Haines H. Participatory ergonomics. In; Salvendy G (ed.) Handbook of Human Factors and Ergonomics (2nd ed.), 490-513.

Paper presented at the 14th New Zealand Ergonomics Society Conference, Waiheke Island (2007).

SOME INSIGHTS FROM APPLYING AN INDUSTRY-WIDE PARTICIPATIVE APPROACH TO ADDRESSING MSD RISK FACTORS

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ABSTRACT

Participatory ergonomics is traditionally applied within a single organisation, perhaps involving a number of departments or plants but usually all falling within one employer. In this study, a participative approach was applied across an industry of multiple employers, sites and regions. The purpose of the study was to identify interventions to reduce MSD risk. The main reasons for a participative approach included the need for the findings to have industry credibility, to identify and account for implementation barriers with the interventions, and requiring support for industry-level MSD interventions. The existence of a key stakeholder group for the industry made such an approach feasible. While there are caveats, this approach appears to be a suitable method of meaningfully engaging with all levels of an industry.

INTRODUCTION

The meat processing industry is an important part of New Zealand's export-based economy and a large employer in many regions. It also has the highest incidence of MSD work compensation claims of all major industries nationally and a long history of such incidence rates. In 2004, government funding was made available for identifying MSD risks and interventions in meat processing. The participative approach taken by the researchers from COHFE and Massey University was due partly to the fit between this approach and the character of the industry, and due also to the fit with the researchers' shared philosophy on ergonomics and MSD causation.

Participatory ergonomics is defined by Wilson, Haines & Morris (2005) as "the involvement of people in planning and controlling a significant amount of their own work activities, with sufficient knowledge and power to influence both processes and outcomes in order to achieve desirable goals" (p 933), where the amount of control, knowledge and power necessary to achieve the goals need to be clear from the start. While the ergonomists had most control over the research process in this study, all the power lay with the stakeholder group (Meat Industry Forum – MIF) regarding industry access, their involvement in knowledge dissemination and generating intervention ideas, and in implementing industry-level change. An additional network of contacts was also gradually established, representing parts of the industry not covered by the MIF. This improved industry representativeness, provided a wider level of participation and dissemination of knowledge, and ensured that politically difficult or sensitive issues were identified and discussed.

Few studies reported in the literature have applied a participative approach across an industry. Moore & Garg (1998) report on the evaluation of a long term PE program to address MSD in two meat processing plants within the same company, while Kardborn (1998) report on a handtool development programme across six manufacturing companies. However, there is no discussion of the considerations for an approach that spans multiple organisations. Haines et al. (2002) tested and refined a conceptual participatory ergonomics framework (PEF) using seven independently conducted case studies. Future work in the current study includes the evaluation of this framework for industry-wide participative studies.

Previous interventions aimed at addressing MSD in meat processing have been tried with only limited success, and those that require changes at an industry level met with inertia and difficulties in getting information to those who need it. Overcoming these barriers required the participation and cooperation of significant numbers within the industry for initiatives to be successful (e.g. changes in labour rules).

It was anticipated that a participative approach would help develop trust and acceptance of the study by the industry and the MIF. Historically sceptical of outsiders giving advice on injury prevention, the industry remains slow to move the longstanding issue of MSD. Part of this may be due to low levels of understanding about MSD causation and the primary focus for MSD prevention placed on automation and injury management. Many in the industry are also distrustful of advice arising from outside their immediate work area, plant, company, or region. A participative approach was hoped to provide a new angle for addressing MSD. The commonly stated PE benefits of better designed interventions and greater acceptance and ownership of them were also strong reasons for such an approach to the study.

An additional aim of applying a participative methodology was to be able to tap into task and industry knowledge through engaging with subject-matter experts at plant and industry levels. It was anticipated that this information would provide contextual relevance for the design of data collection processes and data interpretation through to prioritising and refining 'barrier-free' interventions.

The approach was also seen as being better matched to the investigation of MSD at an industry level than a more traditional 'expert' risk analysis approach. The large amount of task variation throughout the industry would mean that a more micro approach would either miss useful data or be very expensive to resource. The flow of ideas and information between researchers and participants helped to improve each others perspective and provided insight that may not have occurred with more traditional approaches. Many of the intervention ideas derived from the study require an industry-level response to implement, and the same communication networks established during the study can be used to achieve this. The methods for each stage of the study are briefly outlined below in relation to key study aims.

METHOD

1. Map the distribution of MSD in the industry and identify high MSD-risk tasks
Researchers engaged with the MIF at the outset, providing information on the process, MSD, and seeking information about the industry. The MIF facilitated access to the processing plants and other stakeholders. Information about the study was disseminated through the MIF and presentations were made by the researchers at industry meetings. Contact was also independently established with all processing plants nationally. Data on MSD was requested from each plant along with one years accident register records. Findings were triangulated with records from two other meat processing injury databases. The initial conclusions from analysis of this data were discussed with the MIF and agreed results were sent to each processing plant.

2. Identify key MSD risk factors and industry-derived interventions
The second stage of the study involved assessment high risk tasks and the work systems in which they operate in a representative sample of 28 processing plants. Following agreement on the method and sampling frame, the MIF again facilitated plant visits. Interviews took place with: processing staff, union representatives, supervisors, managers, engineers, and h&s staff. Both normal processing operations and specific task events were assessed. Data collected included: MSD risk factors and protective factors, implementation barriers, information about existing or proposed interventions and their levels of success.

3. Develop, in partnership with industry, interventions to reduce MSD risk
The MIF provided input on content, intervention priority, and the format that would be most suitable for the industry-based audience. Intervention ideas were initially prioritised by researchers on the basis of their; potential to reduce MSD, and their breadth of industry applicability. The MIF also rated the interventions on their likely impact on reducing MSD, and the likelihood of their implementation by industry. Once finalised the intervention document (Tappin et al, 2007) was distributed through the channels established during the study. This was followed by presentations to companies, unions and government agencies.

CONCLUSIONS

Applying a participative approach to addressing MSD in the meat processing industry has highlighted strengths and limitations of the approach. de Jong & Vink (2002) state that there is no single approach that can be effective in every case, and that "the most appropriate strategy should be chosen for each project" (Haines et al, 1998). In this study that strategy was to engage widely with the industry to facilitate a change in attitude toward addressing MSD and a shared responsibility to do so.

The need to develop industry rapport, identify potential barriers and interventions that overcame these, led to the adoption of an industry-wide participative approach for this study. While there are caveats, this appears to be a feasible method of meaningfully engaging with all levels of an industry. A wide range of MSD risk factors and interventions that addressed them were identified, including those that require an industry-wide response. The ownership of ideas that this approach creates across many stakeholders in the industry may also provide impetus to their development beyond the short study timeframe. The Participatory Ergonomics Framework of Haines et al (2002) is stated by the authors as being useful in setting up and supporting participatory ergonomics initiatives, and in contributing to a better understanding of what is involved in participative changes. It is also potentially useful as a tool for outlining and refining a participative approach to members of a work system as well as selling an approach to potential funders. For an industry-wide study there are possible refinements that could be made to the framework that reflect unique elements of this approach.

Participative methods are implicit in our work as ergonomists. Wilson (1991) states that there is "a vast array of approaches, philosophies and techniques which may come under the heading of (or masquerade as) participation" (p. 69). When deciding on the approach most suited to meeting a brief we would do well to reflect on how best we can serve those affected by our work (Code of Professional Conduct, section 1: 4). Such models as the Participatory Ergonomics Framework and the principles of successful injury prevention initiatives from the NZ Injury Prevention Strategy should be essential reading for helping meet this fundamental aim.

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References

de Jong, A. M., & Vink, P. (2002). Participatory ergonomics applied in installation work. *Applied Ergonomics, 33*, 439-448.

Kardborn, A. (1998). Inter-organisational participation and user focus in a large-scale product development programme: The Swedish hand tool project. *International Journal of Industrial Ergonomics, 21*, 369-381.

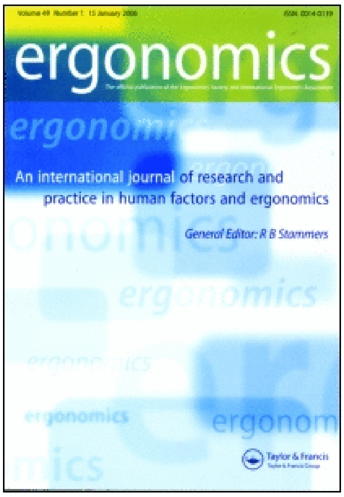
Haines, H., Wilson, J. R., Vink, P., & Koningsveld, E. (2002). Validating a framework for participatory ergonomics (the PEF). *Ergonomics, 45*(4), 309-327.

Moore, J. S., & Garg, A. (1998). The effectiveness of participatory ergonomics in the red meat packing industry: evaluation of a corporation. *International Journal of Industrial Ergonomics, 21*(1), 47-58.

Tappin, D. C., Moore, D., Bentley, T. A., Parker, R., Ashby, L., Vitalis, A., et al. (2007). *Industry interventions for addressing musculoskeletal disorders (strains/sprains) in New Zealand meat processing* (Vol 8, No 5). Rotorua: COHFE.

Wilson, J. R. (1991). Participation - a Framework and a Foundation for Ergonomics. *Journal of Occupational Psychology, 64*(1), 67-80.

Wilson, J., Haines, H., & Morris, W. (2005). Participatory Ergonomics. In J. R. Wilson & E. N. Corlett (Eds.), *The Evaluation of Human Work* (Third ed., pp. 933-962). Boca Raton, Florida: CRC Press.



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The role of contextual factors for musculoskeletal disorders in the New Zealand meat processing industry

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The role of contextual factors for musculoskeletal disorders in the New Zealand meat processing industry

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Musculoskeletal disorders (MSD) are the leading cause of occupational injury internationally. In New Zealand, the highest incidence of MSD is in meat processing, accounting for over half the injury compensation costs for the sector. MSD in meat processing have proven highly resistant to physical, micro-level interventions, suggesting a new approach is required. This paper reports on part of a 2-year study looking at MSD in the New Zealand meat processing industry. The qualitative study involved interviews with 237 workers, management, union and safety personnel in 28 processing sites. These data were summarised into a list of contextual factors, which, it is postulated, may create conditions under which greater exposure to physical and psychosocial factors can occur in meat processing. Some of the contextual factors are recognised as problematic by the industry, but have not previously been associated with MSD risk. The paper concludes by reflecting on conducting MSD research with a focus on contextual factors and how this may influence MSD prevention. The manuscript provides industry-based data on MSD risk and outlines the approach used in its collection. Identifying contextual factors and understanding their role in creating MSD risk may help improve the acceptance and effectiveness of MSD interventions in industry.

Keywords: musculoskeletal disorders; contextual risk factors; organisational factors; meat processing; occupational injury

1. Introduction

Musculoskeletal disorders (MSD) is a term used to describe a wide range of conditions that affect muscles, tendons, nerves, bones and joints. These can occur when physical and psychosocial demands are too great, resulting in discomfort, pain or functional impairment (National Research Council/Institute of Medicine 2001, Buckle and Devereux 2002). MSD can occur either suddenly or gradually over time and can involve any part of the body but are often related to the body parts involved in work tasks (i.e. upper limbs, neck and trunk).

MSD are the most common occupational injury claim type in New Zealand (Accident Compensation Corporation 2005), with high prevalence also reported internationally (National Research Council/Institute of Medicine 2001, Health and Safety Executive 2007). In New Zealand, the highest industry incidence of accepted MSD claims is found in

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the meat processing industry, with MSD accounting for over half the injury compensation costs to the Accident Compensation Corporation for the sector (Accident Compensation Corporation 2007) and a claims incidence of approximately twice that of comparative processing industries. A similar situation exists in Australia, where the meat processing MSD claims rate is four times higher than the manufacturing industry (Caple 2003). In the US, meat packing plants had the highest incidence rates of repeated trauma disorders in private industries in 2002, with 812 cases per 10,000 full-time workers (Bureau of Labour Statistics cited Piedrahita *et al.* 2004). In Canada, meat and poultry processing are reported as the highest risk industries for work-related MSD among workers compensation board claims (Yassi *et al.* 1996).

The range of risk factors for work-related MSD is well recognised (Bongers *et al.* 1993, Bernard 1997, National Research Council/Institute of Medicine 2001), although much of the emphasis of epidemiological, medical and ergonomics research has highlighted the role of physical, psychosocial and individual factors, while the organisational and contextual factors that underlie them have not received the same level of attention (National Research Council/Institute of Medicine 2001, Warren 2001, Buckle 2005). Many models also exist that illustrate the complexities of MSD causation. Some place more emphasis on the pathophysiology of MSD (Hagberg *et al.* 1995, Kumar 2001), while others outline risk factors according to the current state of research knowledge. National Research Council/ Institute of Medicine (2001) describe the association between physical exposure and the development of MSD as occurring '. . . in a broad context of economic and cultural factors and reflects the interaction of elements intrinsic to, as well as extrinsic to, the individual' (p. 28). The authors include these factors in a conceptual model for the development of MSD and use the term 'contextual factors' to refer to the social, economic, cultural, political and organisational factors that are seen as creating the conditions under which physical and psychosocial risk factors can occur. These contextual factors include forces that are external to the industry but which act on it (e.g. the effects of drought or low national unemployment) and, which, in turn, may influence the structure or management of the industry and organisations within it (e.g. systems of payment or length of the working week). These may then result in the occurrence of commonly accepted risk factors for individual workers on the production line (e.g. static postures, repetition, monotony, low autonomy, etc.).

Karsh (2006) developed an integrated model from nine existing models, in which the social and cultural context of the organisation will directly influence both the organisation of work as well as psychological work demands. Work organisation factors directly affect both psychological and physical work demands, which in turn can influence each other. Faucett (2005) also used existing theoretical models to develop an integrated model of MSD incorporating psychological and social factors. Emphasis is placed on the role that management systems can play in introducing MSD risks and latent failures through organisational policies aimed at improving worker productivity. However, these models pay little attention to industry-level and wider economic and societal influences on MSD risk, factors explored in the present study. This need to consider factors outside the immediate work environment in relation to systems design as well as injury prevention, including those of concern from an industrial sociology perspective, has support in the literature (Dwyer 1995, Moray 2000, Aptel *et al.* 2002, Woods 2005).

The comparatively small amount of literature on MSD risk factors for meat processing work follows a similar pattern to that of the wider literature, with a focus on physical risk factors. For example, in Australia, Waniganayake and Steele (1990), in a study of 29 abattoirs, identified high frequency handling, awkward grips, forward reaching, stooping and twisting, workstation design and handling of heavy loads as the most commonly occurring manual handling risk factors. In a study of Swedish butchers, Magnusson *et al.* (1987) observed the main causes of MSD to be exertion of high forces during meat cutting, frequent and heavy manual handling and inappropriate working postures.

A number of studies and reviews have taken a broader, systems approach to MSD analysis and some have pointed to the importance of contextual factors for MSD in meat processing. In a study of the Canadian meat packing industry, Novek *et al.* (1990) argued that changes in technology, labour relations and work organisation were largely responsible for increased frequency and severity of physical injury. Work by Nossent *et al.* (1995), looking at the meat industry in 10 European Union countries, provided good illustration of the role of contextual factors on MSD risk, noting that the predominantly Tayloristic production line work and hierarchical organisational structure result in hazards such as lack of autonomy and control over one's work, strenuous work rhythms and time constraints, short-cycled repetitive work, and highly divided work with low job content.

In Gjessing *et al.* (1994), Habes describes some of the factors that resulted in increased injuries, illnesses and staff turnover in the American meat processing industry during the 1980s. These included an industry recession followed by restructuring, technological changes, increased production rates and reduced wages, machine pacing and division of labour. A further example of a study that has identified contextual factors comes from Caple (1992), where interventions were developed to address MSD in Australian meat processing plants. Among the risk factors identified was the paced work demand of production lines, the existence of seniority systems reducing task rotation options and the effects of piece rate payment systems on work pace and individual sustainability.

While these studies have acknowledged the role of work organisation and other contextual factors in MSD risk, this has had little impact on the New Zealand meat processing sector. An earlier study to consider MSD in the industry was a government-funded pilot programme undertaken in three meat processing plants between 1993–96. MSD were the most common and costly injuries in all three plants and MSD contributory factors identified included work compression, variations in workload and workflow, the implications of limited task training and job seniority and poor workspace design. In one boning room, modifications were made over the course of the programme and the modified injury severity rate (lost days and time on alternative duties) was measured. Results showed a 90% decrease over the three processing seasons, with stakeholders stating that a 'large' effect was through greater worker/union and management commitment to reducing injuries, reduced work compression rates and better training for learners (Blewden and Wyllie 1998). Recommendations to the industry from this pilot programme (Slappendel *et al.* 1996) included strengthening the industry's health and safety infrastructure for the benefit of all stakeholders, improving information sharing on injury prevention and planning for anticipated demographic changes in the workforce. Also recognised was the need to change the culture regarding an acceptable level of injury (Slappendel *et al.* 1996), effectively avoiding the 'ergonomic pitfall' of Winkel and Westgaard (1996). In a discussion paper of the New Zealand meat processing industry, Slappendel (1996) also noted the need to increase understanding of MSD risk factors, particularly those related to work organisation. The intention was to get this information included into task training, management decisions on work scheduling and line balancing, and plant design. Unfortunately, few of the desired changes from this work have occurred.

It is unsurprising, therefore, that reported MSD cases in meat processing have remained at high levels and have proven highly resistant over time to micro-level interventions arising from a number of government-led injury prevention campaigns. Indeed, the wider literature would suggest that multifactorial solution approaches that address the range of contributory factors are likely to have the greatest effect in reducing MSD (Hagberg *et al.* 1995, National Research Council/Institute of Medicine 2001, Silverstein and Clark 2004). Additionally, micro-level interventions have commonly targeted specific system elements or risk factors rather than all elements of the broader work system as advocated by Hagberg *et al.* (1995), Moray (2000) and Buckle (2005).

The paper reports on findings from the second stage of a two-year, government-funded study targeting MSD in the New Zealand meat processing industry. The aims of the study reported here were to identify and understand contextual factors creating conditions for MSD risk. Overall aims for each of the three stages of the study are outlined in Tappin *et al.* (2006). This paper argues that a broader range of MSD risk factors can be identified within meat processing than currently occurs, that these contextual factors are latent failures for MSD in the industry and that this approach is consistent with existing theoretical frameworks for MSD causation (National Research Council/Institute of Medicine 2001, Karsh 2006). The causal mechanisms that linked contextual, physical and psychosocial factors to the onset of MSD injury were not a concern for the study, although the inter-relationships between contributory factors were important.

2. Method

The qualitative study, conducted over an 8 month period, involved data collection from 28 New Zealand meat processing sites, representing 15 of the 31 companies working in the industry and just over one-third of the total number of processing plants nationally. A total of 250 h of on-site analysis was undertaken across the study sample. The 28 processing plants were selected for inclusion in the study to be representative of the New Zealand meat processing industry based on geographical region by number of plants and employees, species processed, company, plant size and MSD claims data. This was essentially a convenience sample that reflected logistic and cost considerations associated with extensive travel to distant parts of the country and, in some cases, willingness of companies and individual plants to be involved in the study. The sample comprised plants processing: sheep (12), beef (10), veal (three), venison (two), pork (one). Plants were selected randomly within each region, with reselection required in some instances due to plant closure/unavailability and to ensure sufficient representation by company and single/multi-species processing sites. A total of 14 plants processed single species, the remaining 14 plants processed two or more species. Plant sizes ranged from 30 to 2200 employees (at peak season).

Site visits were arranged through the company health and safety manager and the person on site responsible for managing health and safety (the job title of this person varied depending on plant/company size). Among the aims for each site visit was the collection of information on the presence of MSD risk factors. High-risk tasks for the species being processed, identified in earlier epidemiological research using national MSD data and other sources of information (Tappin *et al.* 2005), provided a consistent initial focus for each visit.

The qualitative study followed an exploratory approach, as no previous research had fully examined the role of contextual MSD risk factors in this industry, and only anecdotal information on these risk factors was available to researchers prior to the study. Semi-structured interviews were conducted with staff including: those engaged on high risk tasks; other workers on related tasks (e.g. up and down stream, or part of the same task rotation group); supervisors; health and safety staff; union officials; managers. Other methods used on site included: observation of high-risk tasks (including, where possible, participant observation and raw event/time recording); assessment of physical risk factors (postural analysis, measurement of relevant workplace dimensions/weights); and archival data collection (including staffing data, shift structure, incident data, production data, procedures).

Interviews lasted between 10 and 90 min and were conducted in a range of settings, including the production floor, 'smoko' (lunch) room and offices alongside the processing areas. There was some inconsistency between sites in the number and nature of staff interviews and physical risk factor assessment due to plant and production variations, limited workspace and staff unavailability. Some 237 staff across the plants were interviewed, including 69 managers and supervisors, 134 process staff and union representatives (employed in slaughter, boning, packing) and 34 people employed in health and safety. The semi-structured interview schedule consisted of nine questions related to their current place of employment, covering: high MSD-risk tasks; MSD risk factors; MSD interventions; their success and implementation barriers. Follow-up questions about risk factors helped establish links between contextual and physical risk factors. For example, high levels of task repetition were due to job specialisation, which was contributed to by barriers to job rotation or enlargement.

Qualitative thematic content analysis was conducted on MSD risk factor data. The interview notes, together with other data collected on site, were organised into various themes that gradually emerged from the data collected across the 28 processing plants. Internal validity was reinforced with direct quotes from a range of participants to support key points. This list of themes was revised and expanded based on new information derived as the study progressed and more site assessments were undertaken.

Once all 28 site assessments were completed, the process of organising the responses on MSD risk factors was revisited. The criteria for establishing the list of contextual factors included the number of plants at which it was raised (greater than 25% of the plants in the sample). One exception to this was economic contextual factors. These were less often mentioned in the interviews but are widely recognised by the industry as potential business threats (e.g. high exchange rates, low unemployment) and are logically linked to increased MSD risk.

The findings were triangulated with the literature on MSD risk factors and expert opinion of the researchers themselves based on their knowledge of the industry, to ensure that each factor merited its inclusion. This information was combined with other findings from this stage of the study to produce a draft document on key risk factors, intervention strategies and implementation barriers. This was developed with the Meat Industry Health and Safety Forum, a group representing key stakeholders in the New Zealand meat processing industry, who provided input to help interpret and contextualise the information gathered, thereby further adding to the validity of the findings.

3. Results and discussion

3.1. An overview of contextual factors identified

Figure 1 provides an overview of the relationship between the various contextual factors identified in the study. The conceptual model is based on a systems approach with arrows indicating the direction of influence for contextual factors and their role in increasing exposure to physical and psychosocial risk factors.

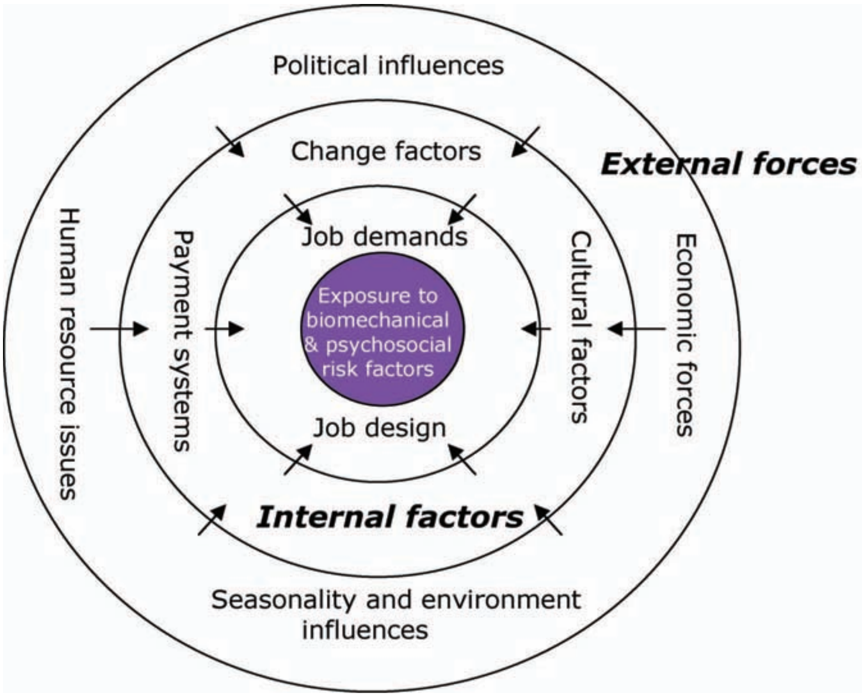

Figure 1. A conceptual model for the role of contextual factors in meat processing musculoskeletal disorders.

Table 1 outlines each of the theme groups shown in Figure 1, together with key contextual factors within each group, and the basis for its inclusion. It should be noted that factors within these nine areas interact with each other, as well as contributing to the presence of physical and psychosocial risk factors and that the list generated in Table 1 reflects contextual factors that were found to be present in the industry, but were not necessarily present in all plants examined. Table 1 also indicates whether the contextual factors were internal or external to the meat processing industry.

Factors that were most commonly mentioned in relation to MSD risk were job demands and human resource issues, matters that most directly affect the staff involved. The least mentioned factors were those relating to external forces about which the staff interviewed generally have the least involvement with and influence over. Payment and scheduling systems were also less mentioned, possibly due to these factors being considered favourable by staff as they allowed some control over hours of work and earnings.

The responses in Table 1 may also reflect the level of awareness about MSD among the staff interviewed. Many of the MSD risks raised by staff concerned physical factors within their own work environment; however, the proportion of contextual factors mentioned increased in the interviews with managers and increased again with health and safety staff interviews. Table 2 shows interview responses by staff grouping across all 28 plants. Unfortunately, data on age, experience and seniority of the staff interviewed were not consistently available, preventing consideration of these demographic factors in the analysis.

Table 1. Contextual factors for musculoskeletal disorders (MSD) in meat processing.

Contextual factor group	Contextual factor origin	Contextual factor	Plants identifying this factor (%)	Staff interviewed identifying this factor (%)	Industry data support
Cultural influences	Internal	1. competitive and entrenched culture	68	14	
		2. 'blame the victim' culture	43	7	
		3. mono-causality belief	50	7	
		4. machoistic culture	68	12	
		5. culture of high work pace	89	24	
Political and human relations influences	External & internal	1. hygiene compliance requirements	46	11	
		2. adversarial relationship between management and workers	64	13	
		3. low level of workforce participation	64	13	
		4. seniority factors	75	16	
Economic factors	External	1. export focus	7	1	MIA Annual Report
		2. high exchange rates	4	–	MIA Annual Report
		3. low national unemployment	11	2	Statistics NZ
		4. company mergers, plant closures	18	3	Rural News NZ
Human resource issues	External & internal	1. labour resourcing	93	30	MIA Annual Report
		2. ageing workforce	64	14	
		3. preparedness of new recruits	71	28	
		4. staff and skill retention issues	89	38	
		5. limited career path	39	5	
		6. training factors	89	38	
Seasonality and environment influences	External & internal	1. off-season issues – recruitment, retention	71	19	MIA Annual Report
		2. workload variability	68	19	
		3. weather impacts on workflow	46	14	Meat & Wool New Zealand 2008

(*continued*)

Table 1. (*Continued*).

Contextual factor group	Contextual factor origin	Contextual factor	Plants identifying this factor (%)	Staff interviewed identifying this factor (%)	Industry data support
Job demand factors	Internal	1. production pressures	100	39	
		2. increases in carcass weights	39	9	NZ Meat Statistics
		3. work compression and scheduling	82	27	
		4. variability in workflow	71	19	
		5. low control of work planning and method	82	26	
		6. task complexity	46	14	
Job design factors	Internal	1. high job specialisation	54	14	
		2. barriers to job rotation and enlargement	96	29	
Payment and scheduling systems	Internal	1. work compression	50	7	
		2. piece-rate work	36	5	
		3. bonus systems	43	5	
Change factors	Internal	1. entrenched industry resistant to change	86	19	
		2. competitive nature of industry	71	14	
		3. low participation of workforce	64	12	
		4.pre-contemplative management	39	8	
		5. industry scepticism about MSD	71	11	

MIA = Meat Industry Association; NZ = New Zealand.

Table 2. Contextual factors for musculoskeletal disorders (MSD) in meat processing by staff grouping.

Contextual factor group	Contextual factor	Managers & Supervisors (%)	OHS staff (%)	Processing staff & union reps (%)
Cultural influences	1. competitive and entrenched culture	12	47	6
	2. 'blame the victim' culture	3	26	4
	3. mono-causality belief	7	35	0
	4. machoistic culture	12	44	4
	5. culture of high work pace	26	50	17
Political and human relations influences	1. hygiene compliance requirements	16	18	7
	2. adversarial relationship between management and workers	9	29	11
	3. low level of workforce participation	14	21	10
	4. seniority factors	29	38	4
Economic factors	1. export focus	1	3	0
	2. high exchange rates	1	0	0
	3. low national unemployment	1	9	0
	4. company mergers, plant closures	3	9	1
Human resource issues	1. labour resourcing	54	76	6
	2. ageing workforce	23	41	2
	3. preparedness of new recruits	36	44	6
	4. staff and skill retention issues	70	74	13
	5. limited career path	6	18	1
	6. training factors	68	56	18
Seasonality and environment influences	1. off-season issues – recruitment, retention	29	53	4
	2. workload variability	26	24	15
	3. weather impacts on workflow	20	24	8
Job demand factors	1. production pressures	54	50	28
	2. increases in carcass weights	10	12	7
	3. work compression and scheduling	42	35	17
	4. variability in workflow	20	24	16
	5. low control of work planning and method	32	41	19
	6. task complexity	22	26	6
Job design factors	1. high job specialisation	20	26	7
	2. barriers to job rotation and enlargement	51	59	10

(*continued*)

Table 2. (*Continued*).

Contextual factor group	Contextual factor	Managers & Supervisors (%)	OHS staff (%)	Processing staff & union reps (%)
Payment and scheduling systems	1. work compression	16	15	0
	2. piece-rate work	10	9	0
	3. bonus systems	12	15	0
Change factors	1. entrenched industry resistant to change	22	47	10
	2. competitive nature of industry	20	44	3
	3. low participation of workforce	13	29	7
	4. pre-contemplative management	6	26	4
	5. industry scepticism about MSD	13	38	3

OHS = occupational health and safety.

The figures show that a higher percentage of health and safety staff raised contextual factors when asked about MSD risks compared with managers and processing staff. This could be due to their greater awareness of MSD as well as their more frequent involvement in addressing risks and managing cases. They also mentioned cultural influences and change factors far more than the other two groups of staff, again possibly indicating a greater knowledge of MSD multicausality specific to meat processing. Managers and supervisors mentioned many of the same factors relating to human resourcing, job demands and job design factors, with smaller numbers also raising a wider range of contextual factors. By comparison, processing staff were more likely to raise risk factors that related to the aspects of work with which they were most familiar (job demands, human resource issues).

Sections 3.2 to 3.10 discuss the interview findings in more detail for each of the contextual factor themes presented in Table 1.

3.2. Cultural influences on musculoskeletal disorder risk

The industry has a highly competitive culture, where companies and plants compete for the same resource in a tight seasonal market (Ministry of Agriculture and Forestry 2003). While there is sharing of health and safety information at an industry level through national forums, individual companies are less likely to share information that might result in other organisations improving productivity or reducing lost-time injuries. Historically, information sharing between plants within the same company has also been restricted (Slappendel *et al.* 1996). This high level of competition combines with truncated processing seasons, increasingly complex processing requirements and payment systems based on throughput, to create a strongly entrenched industry focus on production volumes. This in turn can result in high work pace, long work hours and limited rest breaks. These entrenched industry work practices relating to production can become obstacles to addressing MSD risk.

Second, a 'blame the victim' attitude pervades parts of the industry, where MSD injuries are attributed to factors such as individual technique, resilience and false reporting. Such thinking is a major impediment to prevention efforts. Similarly, the assumption that MSD injuries have a single major cause is a view held by many people interviewed in the study. Not recognising that MSD are complex events with multiple risk factors has resulted in a flawed approach to previous MSD prevention efforts.

Finally, the meat processing industry has a reputation as a highly machoistic culture, where speed and resilience to injury are widely respected and rewarded, and where pain is regarded as inevitable and something that needs to be worked through. Despite a growing culture of early reporting of symptoms and more comprehensive injury prevention, there is still the belief among many that MSD, like pain, are an unavoidable consequence of some processing tasks. These factors all act as barriers to implementing change and reduce the likelihood of the industry adopting improved work organisation and job design measures to reduce MSD risk.

3.3. Political and human relations influences on musculoskeletal disorder risk

Regulatory bodies and overseas buyers impose strict hygiene compliance requirements on each stage of meat processing. These requirements are referred to as the top business priority, along with production, and ahead of health and safety issues. MSD risks may therefore not be addressed where they might affect hygiene compliance (e.g. physical design constraints to avoid contact with certain surfaces).

Another important political factor is the often adversarial relationship between management and the workforce in the meat processing industry. This first emerged following the introduction of scientific management-based working arrangements in New Zealand around the 1930s, where butchers lost considerable control and earnings potential as the task of processing a carcass ceased to be the responsibility of individual butchers and their teams, being divided instead into many highly specialised, short task cycle jobs (Inkson and Cammock 1984). Consequently, the industry has since become increasingly unionised, with relations between management and labour very divided at times. Clearly, such a situation has serious implications for employee involvement in health and safety and other aspects of work planning and design and stands as a barrier to reducing MSD risk across the industry.

This history of adversarial bargaining has led to scepticism about issues such as work-related injury, meaning management may be less responsive to reports of MSD. This attitude may become more entrenched with time, given the very high MSD incidence rates in the industry. Occasionally, health and safety issues are reportedly used to bargain for improved conditions of employment, but not always conditions related to the issues initially raised. Such practices only serve to increase scepticism and under-emphasise the occurrence of MSD. Against this background, the opportunities for staff to participate in matters affecting their workplace is restricted in most plants by the nature of production line jobs with low autonomy, narrow task scope and social isolation.

Staff seniority is a potential MSD risk factor as it can act as a barrier to changes that reduce MSD risk. Seniority exists in most plants to provide both workers and employers with greater security through defining when staff will return after seasonal shutdowns, to which tasks and pay levels. Workers who have been in the plant the longest will have the highest 'seniority numbers' and have the greatest job security across the working year. While there are many different seniority systems in place, they can increase MSD risk through restricting training, rotation, staff transfers and potentially contributing to staff turnover as advancement may depend on others retiring or leaving the plant. Advancement and remuneration across the industry is often based on seniority along with skill and attendance, presenting a potential barrier to skill acquisition for meat processing workers. Moreover, workers with low seniority may be restricted from training for high seniority tasks, while senior workers may not rotate to low seniority tasks. Some seniority systems can also act as disincentives to transfer between departments or shifts as staff lose their seniority through such a move.

3.4. Economic factors for musculoskeletal disorder risk

In recent years, fluctuations in exchange rates have been a significant factor in reducing profitability, which in turn has placed greater emphasis on increasing production, reducing production costs and increasing value-added production (Meat Industry Association of New Zealand 2007). Some of the changes made have consequently increased MSD risks, for example, through reducing staffing levels, recovery time and training time, along with increasing work pace and processing requirements for certain tasks.

Further business pressures are occurring as a result of record lows in national unemployment. The resultant scarcity of potential employees requires that some plants operate with less staff, potentially overloading existing staff and reducing opportunities for training as the emphasis is placed on throughput rather than skill development. Buyouts, mergers and plant closedowns have also been relatively common in the industry for the past two decades, as the industry has evolved to accommodate reduced profitability, new meat inspection standards, new technologies, industry deregulation and farmers converting to other land uses. This has resulted in a lot of change and, undoubtedly, staff concern over the security of work conditions and ongoing employment, all of which add to the potential MSD risk.

3.5. Human resource issues for musculoskeletal disorder risk

Labour resourcing problems for geographically isolated plants, along with a shortage of competent workers due to low unemployment, comparatively low wages, a limited career structure and the presence of more attractive job opportunities, have all led to worker and skill shortages in the industry and the over-exposure of existing workers to MSD risk. Long off-seasons in some areas of meat processing and the requirement to work night shifts and/or weekends during the busy season further reduces the attraction of employment in this industry.

The occurrence of MSD among existing staff and retirement of highly skilled older staff further exacerbates these concerns as higher staff turnover has incrementally reduced the industry's skill base. An ageing workforce may also succumb more quickly to physical workload demands, despite their skills and experience. Older workers may also have greater likelihood of pre-existing conditions, through wear and tear on their musculoskeletal systems over the years, making MSD injury more likely.

New entrants and younger workers are reported by many in the industry as being less physically prepared for heavy work than has been the case in the past. Should this be the case, then this may result in higher turnover of new staff who may not be able to cope with the physical demands of the job and require a greater length of time to build necessary conditioning for the job, with increased risk of MSD injury until such conditioning is achieved. The industry has generally been slow to reduce physical task requirements to increase the pool of staff – including young and old, male and female – that are able to carry out the work sustainably.

A number of training factors also affect MSD risk across the industry. As mentioned earlier, tenure as well as skills determines advancement and remuneration, thus limiting training opportunities for workers. Seniority can be a barrier to training as senior workers may resist training of lower seniority employees for high seniority tasks. On the job training arrangements prevail across the industry, meaning issues such as production noise, divided attention and the passing of bad habits (e.g. poor technique) or incomplete information (e.g. through poor communication) reduce training effectiveness and increase MSD risk.

3.6. Seasonality and environmental influences on musculoskeletal disorder risk

Work across the industry is highly seasonal and many meat processing plants have an off-season ranging from several weeks to several months. Workloads during the season are often very high to keep up with the stock becoming available for slaughter and processing. The timing for starting up processing lines while recruiting and training staff (the required staff based on predicted stock volumes) can introduce further MSD risks through overloading and under-training. Work pace and work duration concerns during the processing season arising from seasonality and line balancing factors can lead to extended hours, increased work pace and reduced training time. These factors lead to an increased risk of MSD through greater exposure to physical and psychosocial risk factors, which may be coupled with lower physical conditioning after time away from the job. Weather fluctuations can further exacerbate the problems of seasonality and stock procurement, creating workload peaks and troughs as farmers sell or withhold their stock (which is all pasture grazed), or choose to send them to companies with more attractive payment rates.

3.7. Job demand factors for musculoskeletal disorder risk

Increases in productivity and production have had a significant impact on the pace of work and other physical risk factors in meat processing. This reported increase in productivity is evidenced through Meatworkers' Union estimates of volumes of meat exported, which rose significantly between 1980 (23 tonnes per person employed in meat processing) and 2004 (37 tonnes). Increases in average carcass weight over a similar period are around 30% for sheep and 15% for beef (New Zealand Meat Statistics 2007). While an increase in carcass weights over the years has played a part, there are other important influences on production pressure. Notable among these are competition within the industry, an overwhelming emphasis on productivity rather than yield, mechanisation that has involved further job specialisation and speeding up of the production chain and seasonality and weather fluctuations that produce variations in work flow.

Workers who return to work too early following MSD injury face an increased risk of injury where the work pace is too great for the current level of rehabilitation, and plants may not have sufficient measures for enabling the graduated reintroduction to work. Similarly, new entrants may experience serious difficulties trying to keep up with their more seasoned colleagues while skills and physical preparedness are developed. Compounding these factors is the lack of control over work planning, work methods and, in many cases, work pace. This lack of control can also adversely affect social support at work, both of which are associated with increased MSD risk (Bongers *et al.* 1993, National Research Council/Institute of Medicine 2001, Woods 2005).

Task complexity has also increased markedly in recent years due to hygiene compliance and a wider range of further processing requirements. This has added greatly to the range of skills that meat processing workers need, while training has not always been well-enough resourced to ensure these new skills are present where needed. Modifications to plant, workspace, packaging and line balancing are also often required. Any lag between a change in product requirements and accompanying changes in the work system can lead to the occurrence of MSD risk as workers adopt to meet the shortfall. As many of these special requirements are either seasonal or sporadic, workers do not always get the opportunity to learn the required techniques well enough to avoid redundant energy wastage, leading to further MSD risk.

3.8. Job design factors for musculoskeletal disorder risk

High levels of task specialisation dominate the meat processing industry, with many workers experiencing little or no variety in their work. The problems for such job design arrangements are well understood and involve low levels of challenge and job satisfaction, which may also have a bearing on the experience and reporting of musculoskeletal pain or discomfort. Although it is generally accepted that job specialisation increases exposure to both physical and psycho-social risk factors for MSD, the physical design of plant and production lines means that, in the majority of cases, job design alternatives are limited to possible task rotation. While task rotation, where used appropriately, can help spread the physical loading around the body and also counter boredom, the reality is that much of the rotation that does occur in meat processing plants tends to be to similar tasks and may do little to relieve exposure to MSD risk factors.

Moreover, there are a number of barriers to task rotation. Notably, workers with high seniority numbers are unlikely to rotate to lower seniority tasks in many plants, while higher seniority tasks are fiercely protected by task incumbents. These arrangements are seen as overriding any concerns about occupational health and safety, as seniority, with its associated higher pay and mana (respect), represents the main form of career path provided by the industry. Where seniority is not a barrier, then pay grades can be, where tasks in the rotation cycle involve more than one pay rate. Rotation may also be problematic when working at a high pace, as it can be seen by workers and management as potentially compromising output.

3.9. Payment and scheduling systems

The meat processing industry uses payment incentives to maximise output and work pace during the short production season and periods of high demand. Payment and scheduling systems commonly in use across the industry include piece rate working, compression of work hours and bonus-driven working. Each of these systems can create high-paced work and an accompanying increased exposure to MSD risk factors (Trevelyan and Haslam 2001). Lacey *et al*. (2007) also report that perceptions of low job control, little supervisor support and high physical demand were associated with increased areas of pain and poorer general physical health. Exacerbating the problem of increased work pace is the fact that the nature of the production line usually means that all workers must try and keep up with the fastest worker, meaning many workers are working at a faster pace than they should, due to pressure from colleagues who are dependent upon them for their level of earnings. Again, payment systems that encourage fast-paced work are a barrier to rotation and other measures designed to reduce exposure to MSD risk factors, including off-line training, or changes in rest break regimes to allow more recovery time.

3.10. Change factors for musculoskeletal disorder risk

Change in attitudes towards worker health and the implementation of measures to reduce MSD is very difficult to achieve in New Zealand. The meat processing industry is highly entrenched and resistant to change. The competitive forces make productivity a constant priority and focus, even to the extent where quality may be negatively impacted and yield reduced due to production pressure. The low participation of the workforce in health and safety further acts as a barrier to change.

With regard to change to reduce MSD risk, management have long been pre-contemplative about the industry having a major MSD problem, despite the evidence of national and company data to the contrary. Where the industry and individual managers are pre-contemplative about MSD, it is unsurprising that calls for improvements in working conditions to reduce exposure to MSD risk factors are ignored (Barrett *et al.* 2005). Industry scepticism about MSD is another barrier to change and represents a further obstacle to tackling high levels of MSD across the industry. As MSD often fails to present as a specifically diagnosed injury, sufferers of non-specific disorders that comprise a large proportion of reported MSD can be seen as malingerers by management and colleagues. The insidious nature of MSD discomfort and the lack of obvious visible signs and symptoms (compared with knife cuts, for example) may contribute further to these perceptions. Colleagues may also apply pressure for MSD sufferers to keep up in order to achieve bonuses or finish early, further exacerbating the problem.

3.11. Reflections on the approach and implications for theory and prevention of musculoskeletal disorders

In adopting contextual factors as the level of analysis for understanding MSD risk in the meat processing industry, this paper has sought to understand and characterise the role or influence of these factors in maintaining the high incidence of MSD in this sector. In doing so, the authors have not sought to minimise or ignore the importance of physical risk factors in MSD aetiology. On the contrary, the study has sought to examine the role that contextual factors have in creating conditions under which physical and psychosocial factors can occur. While MSD research has increasingly focused on the role of organisational risk factors (Bongers *et al.* 1993, Carayon *et al.* 1999, Shannon *et al.* 2001, Devereux *et al.* 2004), this study examined a wider group of external and internal contextual factors, including cultural and social influences on MSD risk (National Research Council/Institute of Medicine 2001, Karsh 2006). The attention to these factors reflects their important role in producing conditions of work that result in high MSD incidence. Cultural factors, for example, were found to impact on workplace issues such as flexibility in job design and training provision, while issues such as 'blame the victim' and 'work through the pain' values are significant barriers to effective prevention. Economic and political forces have produced change across the industry that has contributed to increased MSD risk, while payment systems used across much of the industry further encouraged an overwhelming productivity focus and culture of speed on the production line.

The study has theoretical implications for MSD analysis and prevention. Karsh's (2006) integrated model highlights where contextual risk factors for meat processing fit in a causation model. This study provides support for Karsh's model, where wider cultural, social and economic influences can be critical precursors to exposure to physical and psychosocial MSD risk factors in the industrial workplace. The contextual factors that became evident during the data analysis are an important finding for the overall study, of which this paper is one part. In many cases, they indicate the presence of industry level MSD risks hitherto unrecognised by the industry and therefore unaddressed, necessitating their inclusion in the participative development of interventions that subsequently occurred. The method for determining contextual factors and themes was also robust.

The findings of the study also give rise to the issue of prevention. While changes to physical aspects of the work of meat processing workers, such as improvements in knife sharpness and maintenance, may be relatively easy to implement, wider economic, political, social and cultural influences are often beyond the direct control and influence of the industry. However, the first step to addressing the problem associated with such contextual factors is to recognise their influence on what occurs in the workplace. In doing so, the industry can begin to adopt a change in mindset towards the problem and consider options for reducing the influence of external contextual factors such as seasonality, customer and regulatory requirements and human resource issues, while addressing more directly the internal contextual factors, such as cultural influences and payment systems.

Lessons from this study for the prevention of MSD include the requirement for a long-term, multi-faceted approach. Industry ownership of the issue is required, from recognising the risks to developing solutions to them. There is a need to change industry attitudes from contemplative to preparing for change where possible (Haslam 2002), with the rationale that the pre-contemplative will be dragged along by momentum of changes by others. It is also essential that the whole or majority of the industry is involved. While the scale of such an undertaking may make it harder to develop momentum, it means that external contextual risk factors will at least be recognised, if not addressed.

The adoption of a participative approach to this research has played a vital part in industry acceptance and ownership of the findings of the study and a commitment to addressing the issues at the heart of the MSD problem in meat processing. The industry is beginning to understand the implications of not addressing contextual risk factors for the future of an industry where human capital is increasingly scarce and the importance of employee retention, health and longevity of employment are crucial elements to their survival.

As with all such fieldwork, the study had limitations. The sample of meat processing sites represented only one-third of the New Zealand industry, meaning a possible bias towards companies willing to participate and their perspectives on MSD. There was also some variation in the data able to be collected for each site, although this was not thought to markedly impact on the quality of information gathered. Variations in levels of awareness about MSD among the staff interviewed affected their responses, as they received no prompts regarding MSD risk factors. Similarly, staff interviewed in work areas with genuinely lower MSD incidence had less to say about MSD and associated risk factors. Therefore, it is possible that with a different sample of plants there would also be differences in the summary of contextual factors.

4. Conclusions

This study has made an important contribution to the understanding of MSD causation and prevention in the New Zealand meat processing industry. Moreover, the implications for research in similar industry settings both in New Zealand and internationally are significant, where the aim is to understand the broader context for the presence of physical and psychosocial risk factors in the workplace and to develop effective and sustainable solutions that address the underlying causes of exposure to physical risk factors for MSD. Such research may require an industry-level participative ergonomics approach and a willingness to confront and break down prevailing attitudes across the industry, which stand as solid barriers to the prevention of MSD. The first step to achieving such a change is to identify and analyse the role of external and internal contextual risk factors and help the industry to understand the implications of not addressing the MSD problem at this level..

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References

Accident Compensation Corporation, 2005. *Section 3.1. All work related claims – Number and cost of new and ongoing paid entitlement claims by diagnosis. ACC Injury Statistics 2005*. Wellington: ACC.

Accident Compensation Corporation, 2007. *New entitlement MSD and total claims by industry (2000–2006), ACC Data*. Wellington: ACC.

Aptel, M., Aublet-Cuvelier, A., and Cnockaert, J.C., 2002. Work-related musculoskeletal disorders of the upper limb. *Joint Bone Spine*, 69, 546–555.

Barrett, J.H., *et al.*, 2005. Assessing attitudes and beliefs using the stage of change paradigm – case study of health and safety appraisal within a manufacturing company. *International Journal of Industrial Ergonomics*, 35, 871–887.

Bernard, B., 1997. *Musculoskeletal disorders and workplace factors*. NIOSH Publication No 97–141. Cincinnati, OH: DHHA.

Blewden, M. and Wyllie, A., 1998. Outcome evaluation findings from a pilot injury prevention project in the meat industry. *Journal of Occupational Health and Safety – Australia & NZ*, 14 (4), 401–408.

Bongers, P.M., *et al.*, 1993. Psychosocial factors at work and musculoskeletal disease. *Scandinavian Journal of Work Environment and Health*, 19, 297–312.

Buckle, P.W., 2005. Ergonomics and musculoskeletal disorders: overview. *Occupational Medicine*, 55, 164–167.

Buckle, P.W. and Devereux, J.J., 2002. The nature of work-related neck and upper limb musculoskeletal disorders. *Applied Ergonomics*, 33, 207–217.

Caple, D., 2003. The 45 syndrome: Age and MSD incidence amongst meat workers. *In*: *Proceedings of the XVth triennial congress of the International Ergonomics Association and the 7th joint conference of the Ergonomics Society of Korea and the Japan Ergonomics Society*, vol. 2. Seoul, Korea, 24–29 August 2003. Seoul, Korea.

Caple, D.C., 1992. Musculoskeletal injury prevention – meat industry intervention study. *In*: *Unlocking potential for the future productivity and quality of life: Proceedings of the Ergonomics Society of Australia conference*. Melbourne: ESA.

Carayon, P., Smith, M.J., and Haims, M.C., 1999. Work organization, job stress, and work-related musculoskeletal disorders. *Human Factors*, 41 (4), 644–663.

Devereux, J., *et al.*, 2004. *The role of work stress and psychological factors in the development of musculoskeletal disorders*. Research Report 273. London: Health and Safety Executive.

Dwyer, T., 1995. Industrial accidents: A sociological analysis. *In*: C. Slappendel, ed. *Health and safety in New Zealand workplaces*. Palmerston North: Dunmore Press, 249–265.

Faucett, J., 2005. Integrating 'psychosocial' factors into a theoretical model for work-related musculoskeletal disorders. *Theoretical Issues in Ergonomics Science*, 6 (6), 531–550.

Gjessing, C.C., Schoenborn, T.F., and Cohen, A., eds., 1994. *Participatory ergonomic interventions in meatpacking plants*. Cincinnati, OH: CDC & NIOSH.

Hagberg, M., *et al.*, 1995. *Work-related musculoskeletal disorders (WMSDs): a reference book for prevention*. London: Taylor & Francis.

Haslam, R.A., 2002. Targeting ergonomics interventions – learning from health promotion. *Applied Ergonomics*, 33, 241–249.

Health and Safety Executive, 2007. *Musculoskeletal disorders* [online]. Available from: http://www.hse.gov.uk/statistics/causdis/musc.htm [Accessed 30 May 2007].

Inkson, K. and Cammock, P., 1984. Labour process theory and the chain system in the New Zealand meatworks. *New Zealand Journal of Industrial Relations*, 9, 149–160.

Karsh, B.T., 2006. Theories of work-related musculoskeletal disorders: Implications for ergonomic interventions. *Theoretical Issues in Ergonomics Science*, 7 (1), 71–88.

Kumar, S., 2001. Theories of musculoskeletal injury causation. *Ergonomics*, 44, 17–47.

Lacey, R.J., Lewis, M., and Sim, J., 2007. Piecework, musculoskeletal pain and the impact of workplace psychosocial factors. *Occupational Medicine*, 57, 430–437.

Magnusson, M., *et al.*, 1987. An ergonomic study of work methods and physical disorders among professional butchers. *Applied Ergonomics*, 18 (1), 43–50.

Meat Industry Association of New Zealand, 2007. *Annual report 2007*. Wellington: MIA.

Meat and Wool New Zealand, 2008. *Sheep and beef mid-season update*. Paper No. P08001.

Ministry of Agriculture and Forestry, 2003. *Report on the contribution of the land-based primary industries to New Zealand's economic growth*. Wellington: MAF.

Moray, N., 2000. Culture, politics and ergonomics. *Ergonomics*, 43 (7), 858–868.

National Research Council/Institute of Medicine., 2001. *Musculoskeletal disorders and the workplace: Low back and upper extremities*. Washington, DC: National Academy Press.

New Zealand Meat Statistics, 2007. *Meat and wool economic service statistics* [online]. Available from: www.nzmeatstats.co.nz [Accessed 4 February 2008].

Nossent, S., de Groot, B., and Verschuren, R., 1995. *Working conditions in the European meat processing industry*. Dublin, Republic of Ireland: European Foundation for the Improvement of Living and Working Life.

Novek, J., Yassi, A., and Spiegel, J., 1990. Mechanisation, the labour process, and injury risks in the Canadian meat packing industry. *International Journal of Health Services*, 20 (2), 281–296.

Piedrahita, H., Punnett, L., and Shahnavaz, H., 2004. Musculoskeletal symptoms in cold exposed and non-cold exposed workers. *International Journal of Industrial Ergonomics*, 34, 271–278.

Shannon, H.S., Robson, L.S., and Sale, J.E.M., 2001. Creating safer and healthier workplaces: role of organizational factors and job characteristics. *American Journal of Industrial Medicine*, 40, 319–334.

Silverstein, B. and Clark, R., 2004. Interventions to reduce work-related musculoskeletal disorders. *Journal of Electromyography and Kinesiology*, 14, 135–152.

Slappendel, C., 1996. *Strains/sprains injuries in the meat industry: work organisation as a factor in their prevention*. Unpublished discussion paper.

Slappendel, C., Moore, D., and Tappin, D., 1996. Ergonomics in the meat processing industry. *In*: *Proceedings of the 7th conference of the New Zealand Ergonomics Society*, Wellington, Palmerston North: New Zealand Ergonomics Society, 217–223.

Statistics New Zealand, 2006. *Labour market statistics 2006*. Wellington: Statistics New Zealand.

Tappin, D., *et al.*, 2005. An ergonomics study of musculoskeletal disorders in meat processing in New Zealand. *In*: *Proceedings of the 3rd International Conference on Ergonomics and Safety for Global Business Quality and Productivity – Ergon-Axia 2005*, 18–21 July, San Diego.

Tappin, D., *et al.*, 2006. Investigating MSD in the New Zealand Meat Processing and Seafood Processing Industries. *In*: *Proceedings of the 16th International Ergonomics Association world congress on ergonomics*. Maastricht, Netherlands: IEA.

Trevelyan, F.C. and Haslam, R.A., 2001. Musculoskeletal disorders in a handmade brick manufacturing plant. *International Journal of Industrial Ergonomics*, 27, 43–55.

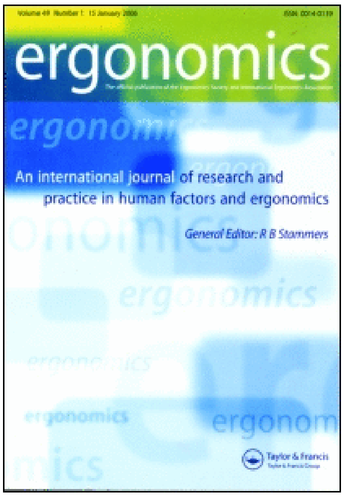
Waniganayake, A. and Steele, P., 1990. Meat industry survey of abattoirs. *In*: *Proceedings of the 26th annual conference of the Ergonomics Society of Australia*. Paper presented at the Ergonomic Design of Products for the Consumer conference, Adelaide.

Warren, N., 2001. Work stress and musculoskeletal disorder etiology: The relative roles of psychosocial and physical risk factors. *Work*, 17, 2212–2234.

Winkel, J. and Westgaard, R.H., 1996. A model for solving work related musculoskeletal problems in a profitable way. *Applied Ergonomics*, 27 (2), 71–77.

Woods, V., 2005. Work-related musculoskeletal health and social support. *Occupational Medicine*, 55, 177–189.

Yassi, A., Sprout, J., and Tate, D., 1996. Upper limb repetitive strain injuries in Manitoba. *American Journal of Industrial Medicine*, 30, 461–472.



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An analysis of sprain and strain injury data for the New Zealand meat processing industry from national and industry injury surveillance databases

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An analysis of sprain and strain injury data for the New Zealand meat processing industry from national and industry injury surveillance databases

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Data on musculoskeletal disorders (MSD) in meat processing and the tasks in which they occur is limited in the literature. This paper provides a summary of such data from the New Zealand industry. Despite the high incidence of MSD in meat processing in New Zealand, little research has been undertaken to identify and assess high-risk tasks and develop interventions to address them. This paper reports on the initial stages of a 2-year government funded project to address these issues. Findings are presented from the analysis of data from two injury surveillance databases. Accident Compensation Corporation national data claims assisted in defining the industry and indicated factors for further assessment, including consideration of claimants' gender, ethnicity and geographical region. National Injury Database industry data claims helped to identify specific tasks in which MSD are more likely to occur by departments and for the two main animal species processed. These factors have helped shape the assessment of high-risk tasks currently undertaken in the meat processing industry.

Keywords: MSD; meat processing; strains and sprains; boning; slaughter

1. Introduction

According to Accident Compensation Corporation (ACC) data, musculoskeletal disorders (MSD) are the leading cause of non-fatal occupational injury and lost time in New Zealand (NZ) workplaces (Accident Compensation Corporation 2005). Indeed, MSD are responsible for the highest number of claims and the highest total cost of claims for the state insurer (ACC) over recent years. NZ's experience reflects a significant problem internationally regarding MSD incidence and costs (e.g. Kuorinka and Forcier 1995, National Research Council 2001, Buckle and Devereux 2002, Health and Safety Executive 2007). Relevant to this study is that, worldwide, MSD feature strongly in the meat processing industry. For example, Piedrahita *et al.* (2004) reports that, in 2000, meatpacking had the highest incidence rates of repeated trauma of all private industries. Previously, Bureau of Labour Statistics (1982–1990) showed that meatpacking plants had the highest occupational injury and illness rates in the US for seven consecutive years (Genaidy *et al.* 1995). In Canada, meat and poultry processing were the highest risk industries for work-related MSD among workers' compensation board claims (Yassi *et al.*

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1996). In Australia, Caple (2003) reports that the rate of meat processing MSD injury claims is four times higher than the manufacturing industry and that manual handling claims in meat processing cost almost 50% more than other injuries.

The NZ meat processing industry also has a higher MSD compensation claim incidence rate than any other sector, based on a list of industries identified as high priorities by the Occupational Safety and Health service of the Department of Labour (OSH) and ACC. From 2002/03 ACC compensation claims data, MSD incidence rate for meat processing was 59 claims per 1000 full-time equivalent workers (FTE) compared to 20 per 1000 FTE for forestry and logging and 16 per 1000 FTE for construction, two other high priority industries (Accident Compensation Corporation 2003). Meat processing also had the largest annual increase in the number of MSD compensation claims between 2000/01 and 2002/03.

The meat processing industry is NZ's second largest export income earner behind dairy produce. There are approximately 80 meat processing plants situated around NZ, servicing 32,000 farms producing sheep, beef, veal, venison and pork for slaughter and further processing (MAF 2005). Most of the meat processed is exported; however, a number of smaller plants are involved in processing meat for the local market. The large number of very small slaughter operations (homekill) and retail butchers scattered throughout the country have been excluded from this study. Overall, the meat processing industry employs approximately 23,000 people (1.8% of NZ workforce). As the industry is closely aligned with the agriculture sector, it is prone to the same fluctuations in production brought about by seasonality (animals in NZ are pasture-fed all year) and weather variations as farmers respond to changes in available feed. These factors, along with the high claims incidence of compensable MSD, make the meat processing industry a high priority for injury prevention research.

There are many different classification systems for MSD diagnoses. Van Eerd *et al.* (2003) recently reviewed 27 such systems, concluding that the lack of a universally accepted classification system for MSD has limited both research and resulting efforts to reduce their burden (p. 935). Many MSD definitions specify certain regions of the body, are based on specific diagnoses or focus on gradual onset conditions rather than acute (sudden onset) conditions. Within the NZ meat processing industry, gradual and sudden onset MSD are collectively referred to as 'strains and sprains' and are classified as such in industry-based injury databases. Therefore, in order to maintain some consistency between industry and ACC data and to meet the wishes of the research sponsors, MSD in this study have been considered synonymous with the industry term 'strains and sprains' and are defined as 'a collective name for a range of conditions that affect the muscles, tendons, bones and joints' (Accident Compensation Corporation 2001). Accordingly, MSD can occur in any part of the body's musculoskeletal system and can be either gradual or sudden in onset.

The need to address MSD issues has been previously recognised by the NZ meat processing industry. Between 1993–1996, an ACC funded Injury Prevention Programme was conducted within the industry in response to the high incidence of ACC compensation claims and costs, particularly strains and sprains (Blewden and Wyllie 1998). Findings from the programme highlighted the need for better understanding of MSD risk factors, particularly those related to work organisation, and suggested that risk factors be considered in the scheduling of work, task training and plant design (Slappendel *et al* 1996). The Injury Prevention Programme provided the evidence base for subsequent industry intervention strategies (Greenslade *et al.* 1996, Moore *et al.* 2004).

The present study emerges from recognition by NZ funding agencies that MSD are a significant cause of injury and compensation cost in many industry sectors in NZ. Three national bodies, the Health Research Council of New Zealand, ACC and the Department of Labour recently established a Joint Research Portfolio (JRP) in Occupational Health and Safety for generating a targeted programme of research in NZ occupational health and safety. Funding was provided by the JRP for a 2 year research programme into MSD incidence in both the meat and seafood processing industries.

This paper reports on part of a wider study that seeks to address some of the knowledge gaps identified in Slappendel *et al*. (1996). The broader study had three major stages: an exploratory stage – to map the extent and distribution of MSD in both the meat and seafood processing industries; an analysis stage – analysing key risk factors for MSD in high risk tasks/processes; and an intervention stage – developing intervention strategies in partnership with industry, aimed at reducing MSD risk. This paper focuses solely on the meat processing industry and reports on the findings of two injury data sources from stage 1 of the study. All three stages of the study have been completed, with the MSD interventions developed by industry reported in Tappin *et al*. (2007).

The aims of the research reported in this paper are to:

(i) determine the extent of the MSD problem in the NZ meat processing industry;
(ii) identify high MSD-risk tasks and processes in the meat processing industry;
(iii) provide an evidence base for directing focused research in the later phases of the study at areas of greatest MSD risk.

2. Method

2.1. Accident Compensation Corporation claims

A descriptive epidemiological analysis was undertaken for all claims accepted by ACC during the period July 2002–June 2004 that were associated with MSD-related injuries in the meat processing industry. Data for accepted claims were extracted from ACC's main claims database for specific diagnosis categories (soft tissue injury, occupational overuse syndrome, gradual process (localised inflammation), gradual process (compression syndrome) and pain syndrome), as well as specific codes from the READ clinical coding system (Accident Compensation Corporation 2008); gradual process, sprain/strain, tendon injury and unspecified conditions. Including READ codes increased the total number of accepted claims for consideration by 14% and the total of 'cleaned' claims by 5.6%.

There were three types of accepted claims, including treatment claims (usually a visit to a health professional), compensation claims (usually to claim for lost earnings) and other claims (usually claims made through bulk-funded organisations such as hospitals). In line with ACC's and Massey University's ethical guidelines, no information that might identify a claimant was made available to the researchers. The data were cleaned by removing cases that were either not MSD-related ($n = 1801$), had insufficient information within the various data fields to be able to determine the nature of the injury ($n = 1229$) or were erroneously included in the dataset ($n = 174$). This left a useable dataset of 9180 accepted ACC claims cases (from an original 12,384). A descriptive analysis of these data was undertaken to determine the distribution of the variables presented in Table 1 among the meat processing MSD claims cases. This involved simple frequency distribution and cross tabulations.

A multivariate analysis, using logistic regression, was conducted to determine the relative predictive ability of the independent variables listed in Table 1 in relation to the

Table 1. Accident Compensation Corporation musculoskeletal disorders (MSD) dataset: variables available for analysis.

Variable name	Variable description or example
Year of MSD	2002–2004
Month of MSD	January-December
Gender of claimant	
Age of claimant (years)	15–70
Ethnicity of claimant	e.g. New Zealand European
Region of claimant's workplace	e.g. Waikato
Medical fee vs. entitlement	
Sudden vs. gradual onset of MSD	Soft tissue injury/gradual process
Diagnosis	e.g. Carpal Tunnel Syndrome; lumbar sprain
Body part injured	e.g. Back, wrist, ankle
Activity at time of MSD*	e.g. 'Boning mutton. Pain in both wrists when working and doing hand movement.'
Injury agency*	e.g. Box or crate, slippery underfoot surface, live animal

*From content analysis of free-text narrative.

dichotomous dependent variable (treatment vs. compensation claim). Logistic regression was used for the multivariate analysis, as most variables were categorical in nature.

Finally, a content analysis was undertaken of cases for which narrative text descriptions of the injury circumstances were recorded (n = 1153; 12.6%). Narrative text data are not collected by ACC for accredited organisations, which are responsible for their own injury management. Thus, the cases with narrative data represented claims for individuals working in non-ACC accredited organisations, the majority of which are smaller companies. Narrative fields were content-analysed and coded to produce two new variables (Table 1): 'activity at time of MSD injury' and 'injury agency'. Inter-coder reliability (between the data coder and a co-investigator) was conducted on a random sample of 20% of cases with narrative text data (n = 231). The rate of agreement for each of the variables coded was $>80\%$. All data were analysed using the Statistical Package for the Social Sciences – version 12.0 (SPSS Inc., Chicago, IL, USA).

2.2. *National Injury Database for meat processing*

The National Injury Database (NID) was established in 1997 with the support of the meat processing industry to provide more detailed injury incident information than can be obtained from ACC data alone. Thus, data fields are included that are specific to meat processing (e.g. species, knife hand), along with those that help in identifying injury trends (e.g. task, job title, department). As all incidents are recorded, irrespective of severity, this provides a larger pool of data than only those injuries that incur direct costs through ACC. The NID enables companies to enter and access their own information on all injury incidents, while data summaries can be produced for the industry as a whole. Not all companies have contributed data to the scheme. Estimated FTE coverage for 2004 data is 27% of the industry workforce and coverage of the two main sectors is approximately 40% for sheep processing and 10–15% for beef processing (P. Dowd 2005, personal communication).

A descriptive epidemiological analysis was undertaken for all MSD-related NID records during 2004, a dataset of 3257. In line with Massey University's ethical guidelines, no information from which the claimant or the meat processing company could be identified was provided to the researchers. A descriptive analysis of these data, using frequency analysis and cross tabulations, was undertaken to determine the distribution of the variables presented in Table 2. NID data fields for department, task and injury details provided better indication of high-risk tasks and processes than the accident details field, which in most cases did not provide further useful information. A content analysis of the accident details narrative was therefore not conducted.

The NID and ACC databases were complementary in meeting the aims of the study. NID data provided information specific to species, work area, task and knife hand, all of which were absent from ACC data, but provided no data regarding age, gender, ethnicity and geographical region, all fields that were present in ACC data. Thus, while they do not collectively provide comprehensive information on MSD injuries in meat processing, there are certainly benefits to be gained by considering both data sources.

3. Results

3.1. *Accident Compensation Corporation data*

3.1.1. *Claim status and sample demographics*

A total of 9180 MSD-related accepted ACC claims cases were included in the analysis following data cleaning. These cases comprised treatment claims (health professional treatment costs) (n = 5462; 59.5%), compensation claims (lost earnings) (n = 2319; 25%) and other claims (mostly bulk-funded) (1399; 15.2%). For the purpose of this analysis, the variable 'treatment vs. compensation' was considered the best available proxy for severity, in the absence of a more accurate measure of severity, such as a severity rating or actual cost of claim. The rationale for this decision was that compensation claims involved time away from work (more than 7 d before compensation for lost earnings is paid by ACC) and these claims were therefore likely to be of greater severity. Conversely, treatment

Table 2. National Injury Database musculoskeletal disorders (MSD) dataset: relevant variables available for analysis.

Variable name	Variable description or example
Date of MSD	Day/month/year
Species involved	e.g. Beef, sheep, veal
Department	e.g. Slaughter floor, boning room, freezers
Specific task	e.g. Boning-table, packing-offal, kidney removal
Job title	e.g. Butcher, boner, labourer
Injury type	e.g. Strain/sprain, knife cut, other
Body part involved	e.g. Back, wrist, ankle
Accident details	Brief outline of event (one line)
Body side	Left, right, not specified
Knife side	Knife, non-knife, not specified
Lost time	Light duties, time off work
Severity	1–4 scale, negligible – fatality
Frequency	1–4 scale, remotely possible – happens all the time
Injury cost	Direct cost, estimated full cost

claims were relatively minor, requiring visit(s) to health professionals without significant time away from work.

Male claimants (n = 7383; 80.4%) dominated the sample. However, it was not possible to generate claim incidence rate data for gender as no reliable industry demographic data (from which to determine exposure) was available to the researchers. Claimants' ages ranged between 15–70 with a mean claimant age of 37.9 (SD 11.7) years. No significant difference for gender by age or by year of claim was observed (mean age: males 38.1 years; females 36.8 years). Claimants were predominantly NZ European (n = 5264; 57.3%) or NZ Maori (n = 2565; 27.9%), with 6.9% being of Pacific Island or other ethnicity. In 7.9% of cases, the ethnicity of the claimant was not recorded or unknown. The proportion of claims for NZ Maori is higher than would be expected, based on the numbers of Maori employed in meat processing (approximately 20%, from 2001 census data).

3.1.2. Geographic and temporal distribution of claimants

Meat processing MSD occur in highest proportions in the Canterbury (19.1%), Southland (16.6%), Gisborne/Hawkes Bay (13.1%), Otago (12.7%) and Waikato (11.3%) regions. This distribution is consistent with the main sheep and beef farming regions of NZ and the accompanying location of processing plants (based on available FTE data for plants).

Figure 1 shows the monthly distribution of claims over the 2-year period of the analysis. The data represent the month in which the MSD was incurred. The majority of MSD were incurred during the January–May period, with 58.6% of MSD occurring during this 5-month period (59.2% in 2002/03 and 57.8% in 2003/4). This is consistent

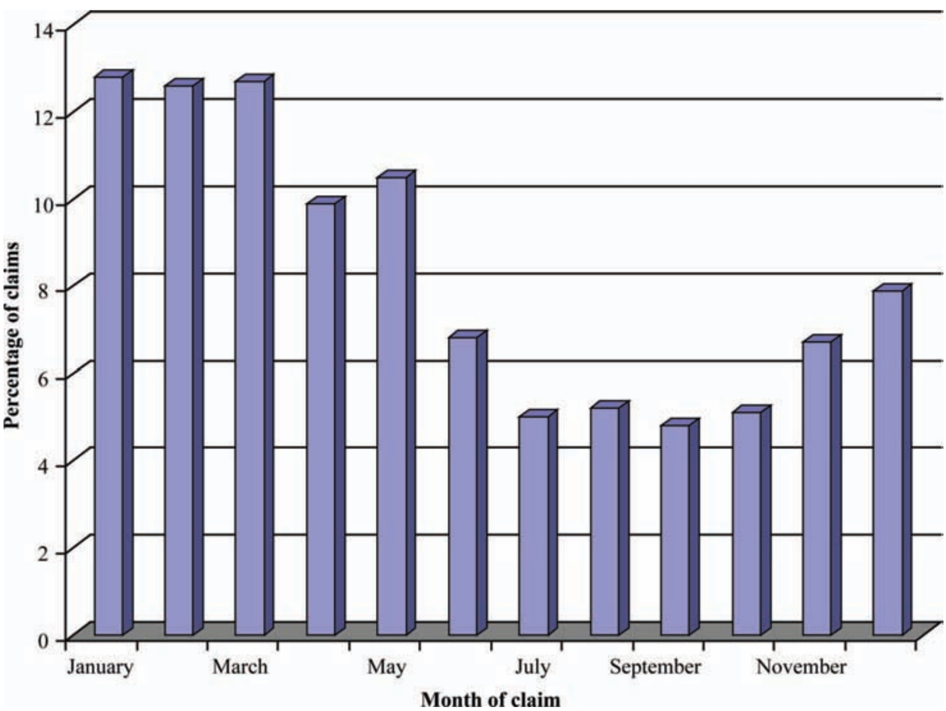

Figure 1. Monthly distribution of musculoskeletal disorder claims.

with the workload peak for most processing plants (for sheep and beef in particular), which falls somewhere between November and June for most processors, to accommodate seasonal fluctuations in stock numbers and reduced availability of stock feed going into winter. Some plants do not have such a peak in workload during this period, while other species (e.g. veal) have peaks at different times of the year.

3.1.3. Diagnosis and body part injured

Most MSD (81%) were categorised in the database as 'soft tissue' or 'sudden onset' MSD injuries, while the remaining 19% were 'gradual onset' injuries. A total of 53.7% of cases were injuries to the upper limb, 27.8% to the upper/lower back and 10% to the lower limb (Figure 2), with a large proportion of MSD located at the hand/wrist (23%) and shoulder (16.5%). For actual diagnosis, lumbar spine-related MSD were easily the major injury type (21.1%), followed by wrist sprains other than carpal tunnel injuries (9.3%), carpal tunnel syndrome (6.8%), sprains and tendonitis of the upper arm (9.2%), shoulder MSD including rotator cuff syndrome (9.1%), various shoulder sprains, tendonitis and tendon ruptures and elbow sprains, tennis elbow and epicondylitis (7.5%).

3.1.4. Logistic regression analysis

Logistic regression was used to explore the predictors of MSD injury severity using the dichotomous dependent variable of whether someone received either medical treatment for their injury or a compensation payment for lost earnings. The independent predictor variables included in the model were: age; month of reporting; gender; ethnicity; whether the injury was caused by an animal as an external agency; whether the employer was ACC accredited; the geographic region in which the injury occurred; the body part injured; whether the injury was classified as sudden (soft tissue) or gradual onset (gradual process); the injury diagnosis by body region. Each of the categorical variables was recoded to create a new variable for each category with the values of 1 and 0. All variables were forced into the regression analysis. The final regression model meets the Hosmer–Lemshow test for goodness of fit (χ^2 (8) = 6.85, $p = 0.552$) and improves the correct classification rate from an initial 70.8% to 73.0%. While this difference is not large, the

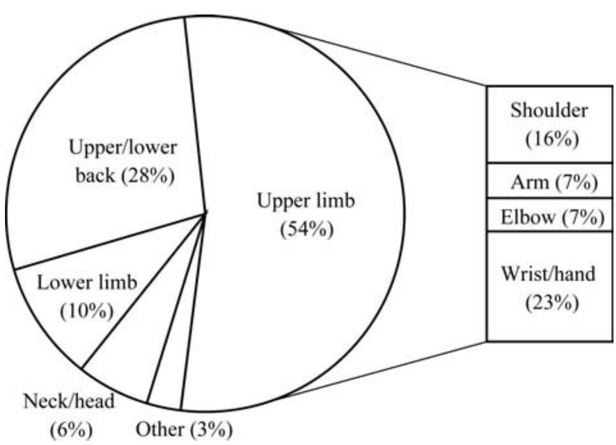

Figure 2. Distribution of musculoskeletal disorder injuries by body part injured.

change from the initial −2 log likelihood of 7624.85 to the final value of 7008.50 is statistically significant (χ^2 (45) = 616.35, $p = 0.000$). The final logistic regression model does, therefore, significantly reduce the amount of unexplained variance, although the obtained Nagelkerke pseudo R^2 of 0.13 also indicates that considerable variation in severity remains unexplained by the model.

As Table 3 shows, the month in which the injury was recorded, the ethnicity of the employee, the geographic region in which the injury occurred, whether or not the injury was sudden or gradual onset and the injury diagnosis were all predictive of injury severity.

Table 3. Logistic regression for treatment (0) vs. compensation claims (1) (n = 6316).

Variable	B	Wald	*p*	Exp(B)
Age	< 0.001	1.62	0.203	1.00
Month	−0.03	15.19	< 0.001	0.97
Gender	−0.02	0.08	0.780	0.98
Ethnicity		29.11	< 0.001	
New Zealand Maori	0.52	8.79	0.003	1.68
New Zealand European	0.17	1.02	0.313	1.19
Pacific Island	0.04	0.03	0.867	1.04
Accredited agency (1) or not (0)	0.10	1.15	0.284	1.11
Extragenic animal agency	0.59	0.72	0.397	1.06
Region		164.46	< 0.001	
Northland	0.54	10.89	0.001	1.71
Auckland	−0.30	2.23	0.136	0.74
Bay of Plenty	0.57	13.63	< 0.001	1.78
Waikato	−0.09	0.59	0.443	0.91
Gisborne/Hawkes Bay	−0.69	31.84	0.000	0.50
Manawatu/Wanganui	< 0.001	< 0.001	0.993	1.00
Taranaki	0.93	27.23	< 0.001	2.53
Wellington	−1.04	9.44	0.002	0.35
Nelson/Marlborough	0.10	0.11	0.741	1.11
Canterbury	0.01	0.01	0.944	1.01
West Coast	1.35	5.70	0.017	3.85
Otago/Southland	0.38	9.83	0.002	1.40
Body part injured		4.82	0.681	
Sudden onset (0) gradual onset (1)	1.05	35.09	< 0.001	2.86
Injury diagnosis by body region		82.22	< 0.001	
Thoracic sprain/disc disorder	−1.83	13.29	< 0.001	0.16
Knee ligament/joint damage	−0.79	1.81	0.179	0.45
Ankle sprain	−1.12	3.44	0.064	0.33
Lumbar sprain/disc disorder	−1.52	9.53	0.002	0.22
Carpal tunnel syndrome	−0.01	< 0.001	0.984	0.99
Cervical sprain/disc disorder	−2.05	16.93	< 0.001	0.13
Sacrum/pelvis/hip sprain	−1.79	9.95	0.002	0.17
Foot sprain	−2.12	7.95	0.005	0.12
Shoulder tendon/joint damage	−0.85	3.00	0.083	0.43
Elbow tendon/joint damage	−0.84	2.35	0.125	0.43
Rib-chest sprain/muscle tear	−2.15	14.59	< 0.001	0.12
Hand tendon/ligament damage	−1.19	4.78	0.029	0.30
Forearm muscle tear	−0.79	2.37	0.124	0.45
Upper arm muscle tear	−1.29	6.93	0.008	0.28
Wrist tendon/ligament damage	−0.80	2.26	0.133	0.45
Thigh muscle tear	−1.33	5.12	0.024	0.26
Lower leg muscle tear	−1.27	3.18	0.074	0.28

The finding for injury month is consistent with the distribution shown in Figure 1. With regard to ethnicity, an examination of the regression coefficients and change in the odds ratio ($exp(B)$) indicates that Maori are more likely to be in the entitlement MSD category than non-Maori. ACC claims data from 2000/01 and 2001/02 show a similar pattern with work-related injury incidence rates for Maori being significantly higher than other ethnic groups (OSH 2001, Statistics New Zealand 2003, Accident Compensation Corporation 2004). Analysis of new claims data for 2003 and 2004 data indicate a continuation of this trend.

Regions where the odds of receiving compensation payments were higher were Northland, Bay of Plenty, Gisborne/Hawkes Bay, Taranaki, Wellington and Otago/Southland. Employee age, gender and whether or not they worked for an accredited employer were found to be independent of the measure of MSD severity used in this study.

In considering MSD severity predictor variables pertinent to the nature of the injury, Table 3 shows that employees with gradual onset MSD injuries were more likely to receive compensation payments than those with sudden onset MSD injuries. However, the actual body part injured was independent of injury severity. This said, injury diagnoses pertinent to thoracic spine, lumbar spine, cervical spine, sacrum/pelvis, foot, ribs/chest, hand and upper arm were associated with a greater likelihood of being treatment rather than compensation claims. The most significant of these is the lumbar spine, which accounts for 21% of cases in the ACC data sample. Thoracic and cervical spine injuries comprise 12%, with upper arm (9%) and hand (5%) also having significant numbers of injury claims. Overall, predictor variables most strongly associated with more severe injuries were regional area, the injury being a gradual onset MSD and being Maori in ethnicity.

3.1.5. Activity at time of musculoskeletal disorder

Activity or task at time of MSD was identified from the narrative description of injury circumstances for non-accredited cases (n = 1153), for which narrative text is recorded by ACC. Figure 3 shows the distribution of activity at the time of the MSD injury.

Lifting tasks (n = 409; 35% of non-accredited cases) were most commonly associated with MSD injury, with knife work the only other significant activity. Knife work (n = 149; 13%) included the sub-categories of boning (n = 72; 6%); trimming (n = 30; 3%) and unspecified knife use (n = 36; 3%). Other common activities/tasks included: walking or running (n = 78; 7%); skinning/pelting (n = 60; 5%); pushing (n = 50; 4%) or pulling (n = 61; 5%); ascending/descending (n = 42; (4%); handling live animals (n = 42; 4%).

3.1.6. Agency for musculoskeletal injuries

Further analysis of the narrative was conducted to determine the injury agency for MSD involving lifting tasks. Figure 4 shows the distribution of injury agency for MSD injuries involving lifting tasks.

A large proportion of MSD cases involved lifting boxes (n = 115; 28% of lifting-related MSD) or animal carcasses/meat (n = 151; 37%). Due to lack of detail in the accident descriptions, the extent to which these injury agencies relate to similar tasks is unknown. However, it is likely that claims involving the more prevalent injury agencies occurred in slaughter (particularly meat and carcass) and boning/packing (particularly meat and box/container).

Lifting-related MSD injuries were most frequently located at the back/spine (n = 207; 51% of lifting cases), shoulder (n = 77; 19%), hand/wrist (n = 43; 11%) and neck

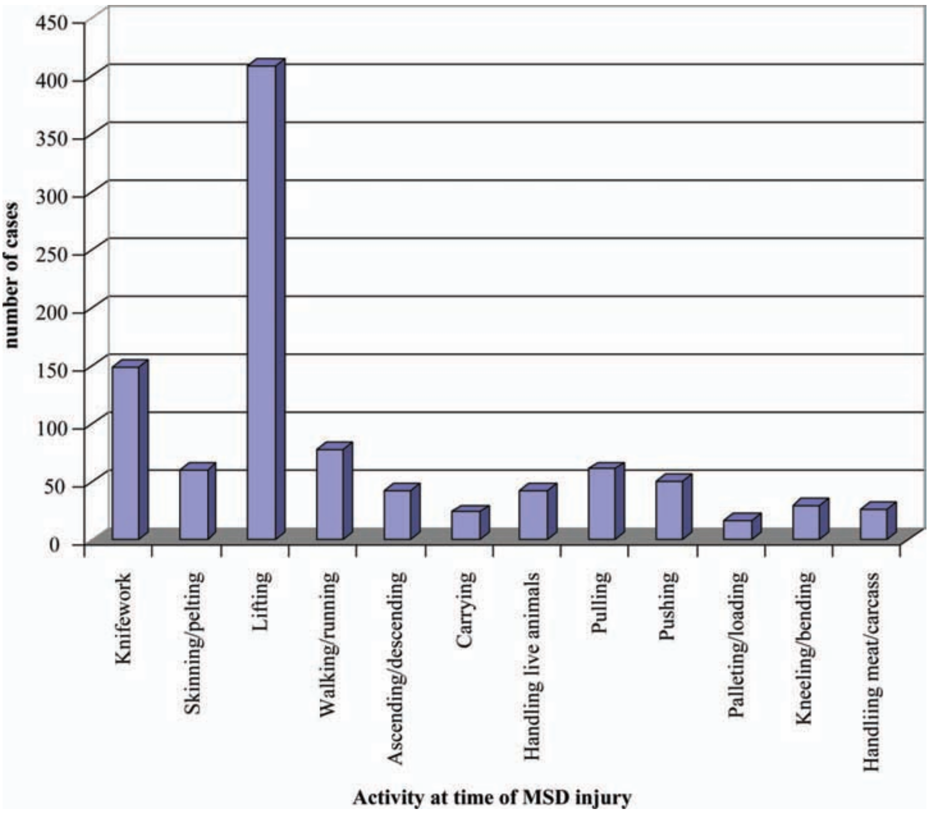

Figure 3. Activity at time of musculoskeletal disorder (MSD) injury.

(n = 33; 8%). Just 19% of lifting-related MSD resulted in entitlement claims (n = 77), compared to a figure of 25% for the larger MSD database, suggesting other MSD not involving lifting are of a greater severity.

3.2. National Injury Database data

3.2.1. Sample demographics

MSD-related cases from 2004 included in the analysis totalled 3257. These cases included 3208 recorded as 'strain/sprain' and a further 49 gradual onset cases recorded under 'other'. Age, gender and ethnicity were absent from this database. Sheep were the predominant species involved (n = 2861; 88%), which is consistent with the companies contributing to the database. Other species were beef (n = 322; 10%), venison and pork.

3.2.2. Temporal distribution

Month of injury showed a pattern of higher numbers of incidents occurring in the first 6 months of the year (81%) than in the second 6 months, with incidents in January to May accounting for 77% (n = 2569) of the total for 2004. This pattern is also apparent in the

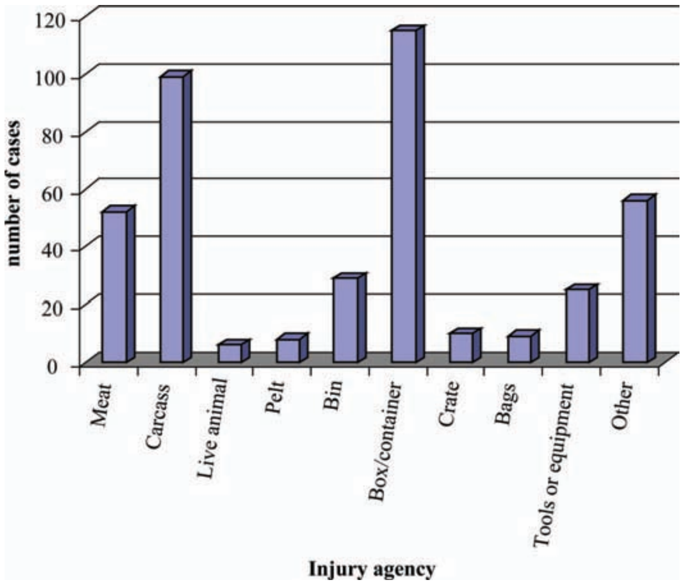

Figure 4. Distribution of injury agency for musculoskeletal injuries involving lifting tasks.

previous 2 years' data, where incidents for the first 5 months were 74% (n = 3515) in 2002 and 70% (n = 2775) in 2003. These findings are in line with those for ACC data and reflect the seasonality of the industry. The higher percentages for NID is likely to be due to sheep being the main species involved as they have a greater peak for processing in these months than do other species.

3.2.3. *Body part injured*

The most common body parts injured were wrist/hand (31.3%), back/spine (24%), shoulder (16%), arm/elbow (14.4%) and lower limb (11.1%). These percentages are closely aligned with those of the ACC data and reflect the high-risk tasks for MSD identified below.

3.2.4. *Department and task by species*

Analysis of MSD cases by department and task was undertaken for sheep and beef. This provided the most useful level of information for achieving the study objectives from the fields available for analysis. The frequency of incidents was the main measure used, since severity data were incomplete as not all contributors provided complete cost-related information. Most injuries occurred in the slaughter and boning departments (74% for sheep and 84% for beef), which is consistent with the number of staff usually employed in these two areas. Table 4 lists tasks with the highest number of MSD incidents in 2004 for the two main species. In those cases where cost data were provided, average cost estimates for these injuries were among the highest for all strains and sprains. Analysis of knife-work tasks indicated that MSD injuries involving the upper limb are evenly distributed between knife and non-knife arms, through both handling the knife and gripping/handling the meat that is being cut.

Table 4. Most common incidents in the National Injury Database by department and task for sheep and beef.

Department	Task	Sheep (% of total for sheep)	Beef (% of total for beef)
Boning		1424 (50.6)	185 (57.4)
	Knifework	814 (28.9)	90 (28)
	Packing	204 (7.3)	42 (13)
	Saw operation	104 (3.7)	
Slaughter		667 (23.7)	86 (26.7)
	Knifework	398 (14.2)	52 (16)
	Gutting	71 (2.5)	7 (2.2)
	Y cutting	58 (2.1)	

Bearing in mind the small size of the sample of ACC claims with narrative text, these findings are similar to those from the analysis of non-accredited ACC claims, where lifting and knife-work were the two main activities involved.

4. Discussion

The majority of MSD compensation cases for the NZ meat processing industry for the period of the analysis were of relatively low severity, with about 60% of cases requiring medical visits to the doctor only. Interestingly, just one in five of MSD cases for this sector were gradual process injuries, with the remaining cases recorded as sudden onset or soft tissue injuries. This was a lower proportion than expected, given the relentless and repetitive nature of many production line tasks in the industry. However, as many sudden and gradual onset cases share the same risk factors, it is possible that gradual onset cases presented acutely for treatment and were diagnosed and categorised accordingly.

With regard to the body part affected, injuries were located at the upper limb in approximately 60% of cases for ACC injury data, with a similar pattern for the NID injury data with 62% of cases involving the upper limb. These figures are predictable given the heavy workload on the upper limbs that occurs in this industry, where many tasks are knife-based, repetitive, slippery, possibly heavy and the pace of work is usually fixed.

ACC MSD injuries were predominantly incurred by European male or Maori male employees, although this finding is of limited importance as no reliable industry demographic information was available from which to determine the relative exposure of these population groups. ACC MSD injuries occurred most frequently in the lower South Island region (Canterbury, Otago and Southland) and during the summer months of January, February and March. This is consistent with the proportion of the industry workforce located in these regions (approximately 40%) and the workload peak for sheep, which is the predominant species processed at this time. Results for NID claims were similar, most occurring in the first few months of the year due to sheep being the main species processed by participating companies.

From ACC data, based on compensation claims as opposed to medical fees only as a proxy for severity, a number of variables were found to be significant predictors of greater MSD injury severity. Unsurprisingly, gradual process injuries were more likely to be compensation claims, as were being of Maori ethnicity and working in certain geographical regions. According to ACC injury statistics, Maori have historically had a higher injury incidence for entitlement claims compared to other ethnic groups, as is the case with meat processing MSD. It is hypothesised by ACC that a partial reason for this higher incidence rate could be that a larger proportion of Maori work in occupations in which the incidence rate is higher than the average. The number of Maori employed in meat processing is approximately 20%, significantly higher than the number of Maori as a percentage of the total workforce (11%). However, it remains unclear why Maori meat processing workers were over-represented in MSD compensation claims. While it was beyond the scope of the study, further insight might arise through considering ethnicity employment figures and MSD incidence, by region and by high MSD-risk tasks. It is also unclear why geographical region might be a significant predictor of MSD injury severity.

Among the relatively small number of ACC claims possessing accident descriptions, the most common activity or task at the time of the MSD was reported to be lifting, although lifting injuries were less likely to lead to entitlement claims than non-lifting injuries. Boxes of meat were the most common agency involved in lifting MSD, with other common agencies being meat and animal carcasses. NID data fields enabled a more specific analysis of where injuries occur. Injury frequency by task provided the most complete and useful information and highlighted a small number of tasks where MSD injuries were more likely to occur. These tasks occurred in the boning and slaughter areas and involved either knife use in the handling of carcasses or meat (Y cut, gutting) or simply handling meat (packing, saw operation).

Although the findings of this study provide a rich insight into the incidence and causes of MSD in NZ, a more comprehensive insight is constrained by the incompleteness of the recorded data available to the researchers. Limitations of the study include: being unable to determine injury incidence rates for either data source; potential errors in diagnoses by health professionals to increase the chances of claims being accepted by ACC; not having narrative text descriptions for a larger sample of ACC claims and the risk of bias as claims with narrative were predominantly from smaller companies, data entry errors in ACC claims between diagnoses and body region involved; lack of age, gender and ethnicity data for NID claims; under-representation of some species by NID data; potential differences in data-field interpretation between plants contributing NID data.

5. Conclusion

Based on the findings of this study, and those of a similar analysis of industry accident register records and questionnaire results (Tappin *et al.* 2005), a number of priority areas for more focused ergonomics research have been identified for beef and sheep processing. These include specific tasks in boning and slaughter departments that involve significant musculoskeletal stress to the back, arm and wrist areas and lifting/handling activities, particularly meat and packed boxes. Further research as part of the present programme will include detailed task analysis of high MSD-risk tasks and involvement of the meat processing industry in the development of interventions to address them.

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References

Accident Compensation Corporation, 2001. *Code of Practice for Manual Handling*. Wellington: ACC.

Accident Compensation Corporation, 2003. *Work related new and ongoing entitlement claims in selected industries by minor diagnosis*. Wellington: ACC.

Accident Compensation Corporation, 2004. *Section 3.1. Number and cost of new and ongoing paid entitlement claims by claimant ethnicity*. ACC Injury Statistics 2004. 3rd ed. Wellington: ACC.
Accident Compensation Corporation, 2005. *Section 3.1. All work related claims – number and cost of new and ongoing paid entitlement claims by diagnosis*. ACC Injury Statistics 2005. Wellington: ACC.
Accident Compensation Corporation, 2008. *ACC53 READ code reference list* [online]. Available from: http://www.acc.co.nz/for-providers/resources/WCMZ002353 [Accessed 19 May 2008].
Blewden, M. and Wyllie, A., 1998. Outcome evaluation findings from a pilot injury prevention project in the meat industry. *Journal of Occupational Health and Safety – Australia and New Zealand*, 14, 401–408.
Buckle, P.W. and Devereux, J.J., 2002. The nature of work-related neck and upper limb musculoskeletal disorders. *Applied Ergonomics*, 33, 207–217.
Caple, D., 2003. The 45 syndrome: Age and MSD incidence amongst meat workers. *In*: *Proceedings of the XVth triennial congress of the International Ergonomics Association and the 7th joint conference of the Ergonomics Society of Korea and the Japan Ergonomics Society*, vol. 2, 24–29 August 2003, Seoul, Korea, 24–29 CD-ROM.
Genaidy, A.M., Delgado, E., and Bustos, T., 1995. Active microbreak effects on musculoskeletal comfort ratings in meatpacking plants. *Journal of Industrial Medicine*, 8, 375–379.
Greenslade, E., *et al*., 1996. *Meat Industry Injury Prevention Project: Case studies 1–6*. Wellington: NZCTU.
Health and Safety Executive, 2007. *Musculoskeletal disorders* [online]. Available from: http://www.hse.gov.uk/statistics/causdis/musculoskeletal/index.htm [Accessed 19 May 2008].
Kuorinka, I. and Forcier, L., eds. 1995. *Work related musculoskeletal disorders (WMSDs): A reference book for prevention*. London: Taylor & Francis.
MAF, 2005. *Agricultural, Horticultural and Forestry industry statistics*. [online]. Available from: www.maf.govt.nz/statistics/index.htm [Accessed 5 July 2005].
Moore, D., Tappin, D., and Vitalis, A., 2004. Accident register surveys: developing league tables of tasks linked to high incidences of musculoskeletal disorders. *In*: *Proceedings of the 12th conference of the NZ Ergonomics Society*, 5–6 August, Taupo, New Zealand, 82–87, Palmerston North: NZES.
National Research Council and Institute of Medicine, 2001. *Musculoskeletal disorders and the workplace: low back and upper extremities*. Washington: National Academy Press.
OSH, 2001. Part B2.3. *Ethnic group, workplace accident insurance statistics report 2000/01*. Wellington: Department of Labour.
Piedrahita, H., Punnett, L., and Shahnavaz, H., 2004. Musculoskeletal symptoms in cold exposed and non-cold exposed workers. *International Journal of Industrial Ergonomics*, 34, 271–278.
Slappendel, C., Moore, D., and Tappin, D., 1996. Ergonomics in the meat processing industry. *In*: *Proceedings of the 7th conference of the New Zealand Ergonomics Society*, 2–3 August 1996, Wellington, New Zealand, 217–223, Palmerston North: NZES.
Statistics New Zealand, 2003. *Appendix 2. Injury statistics 2001/2002: Work related injuries*. Wellington: Statistics New Zealand.
Tappin, D., *et al*., 2005. An ergonomics study of musculoskeletal disorders in meat processing in New Zealand. *In*: *3rd international conference on ergonomics and safety for global business quality and productivity,* Ergon-Axia 2005 , 18–21 July 2005, San Diego, CD-ROM.
Tappin, D.C., *et al*., 2007. *Industry interventions for addressing musculoskeletal disorders (strains/sprains) in New Zealand meat processing*. COHFE report, volume 8, no 5. Rotorua: COHFE.
Van Eerd, D., *et al*., 2003. Classification systems for upper-limb musculoskeletal disorders in workers: a review of the literature. *Journal of Clinical Epidemiology*, 56, 925–936.
Yassi, A., Sprout, J., and Tate, D., 1996. Upper limb repetitive strain injuries in Manitoba. *American Journal of Industrial Medicine*, 30, 461–472.