Workforce survey of occupational exposures and health effects in New Zealand

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Abstract

This thesis is based on the first workforce survey in New Zealand to assess occupational exposures and health in a random sample of the working population. The aims of this thesis were to: i) describe the prevalence and distribution of occupational exposures and workplace practices in the New Zealand working population; ii) identify gender and ethnic differences in occupational exposure; and iii) examine which occupational risk factors contribute to the risk of respiratory disease.

Over a two year period 10,000 individuals aged 20-64 were randomly selected from the Electoral Roll and invited to take part in a telephone interview. The interview obtained information on lifetime work history, occupational exposures including dust/chemical exposures and certain physical and organisational factors, and selected health effects including respiratory symptoms. A total of 3,003 interviews were completed (37% response rate).

Occupational exposure to dust/chemical and certain physical factors were disproportionately experienced by workers in the agricultural, trades, and manufacturing sectors, where prevalences were as high as 75%. However, exposures also occurred in other occupational groups not traditionally associated with hazardous exposures (for example the legislators and managers group). Substantial differences in exposure prevalence were observed between males and females and Māori and non-Māori workers. The occupations positively associated with current and adult-onset asthma included printers, bakers, and sawmill labourers, as well as several occupations that have not been previously associated with asthma (for example teachers and certain sales professionals). Finally, a positive association between work-related stress and asthma was identified.

This thesis indicates that the traditional chemical and physical exposures are common in the New Zealand working population, and that emerging factors such as organisational and psychosocial exposures are also prevalent and relevant to occupational health. While the distribution of occupational exposures and risk factors for asthma were concentrated in certain occupational groups, they were also more widely spread across the workforce than previously assumed. Besides occupation, the demographic characteristics of a worker also appeared to determine their occupational exposure. The findings of this thesis illustrate that workforce surveys are a valuable tool for assessing a wide range of exposures in a wide range of workers, and therefore should be carried out on a regular basis.

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CHAPTER 1

Introduction, aims, and outline of the thesis

1.1 Work and ill-health

In New Zealand, it has been estimated that work factors contribute to 700-1000 deaths and about 17,000-20,000 new cases of disease each year (Mannetje & Pearce 2005). The leading causes of death attributable to occupational risk factors include cancer (237-425 deaths per year), ischemic heart disease (246 deaths), and respiratory disease (205 deaths). The highest incidence estimates for work-related disease include musculoskeletal disorders (10,413 cases per year), diseases of the ear (3,354 cases), and skin disorders (1,792 cases) (Mannetje & Pearce 2005). These figures represent a considerable burden for a population of just 4 million and significant health, economic (Pezzullo & Crook 2006), and social gains are to be made from the prevention of occupational disease. However, these estimates rely heavily on overseas data, due to the lack of New Zealand specific information on occupational exposure prevalence and risk factors for occupational disease.

A wide range of workplace exposures have been implicated in occupational disease aetiology. However, there are a number of issues that have hampered the study of occupational health: a) *Latency* – the number of workplace accidents is easy to enumerate and thus, until recently, there has been a disproportionate focus on occupational injury. The link between work-related exposures and disease is harder to establish, largely due to the latent onset of disease; b) *Multiple causality* – attributing disease to an occupational exposure is not clear-cut. There are very few diseases where occupational exposures are the sole causal factor (for example asbestos and mesothelioma), multiple hazardous exposures are present in many work environments and lifestyle factors (for example smoking) also contribute to disease risk; c) *Narrow focus* - the majority of studies in the occupational health literature have focused on specific exposures in specific worker groups. These are likely to represent the tip of the iceberg and general exposures not specific to certain industries have often been overlooked. In addition, the prevalences of occupational exposures and disease are not distributed equally across the working population, thus it is essential to examine the prevalence and distribution of risk factors in the whole working population in order to target prevention efforts.

The capability for collecting data on occupational exposure and disease prevalence in New Zealand is currently very limited and national estimates have been based on overseas exposure prevalence data (from Finland in particular) (Mannetje & Pearce 2005). Relying on exposure estimates from overseas may not be appropriate given the differences in legal, economic, and social infrastructures between countries.

This thesis is based on the first workforce survey in New Zealand to assess occupational exposures and health in a random sample of the working population. The term occupational exposure used throughout this thesis includes dust and chemical exposures as well as physical factors (for example lifting), organisational factors (for example irregular hours), and work-related stress. The findings of this thesis will contribute to the limited knowledge base and provide a snapshot of what New Zealanders in a range of different jobs are exposed to in their workplaces, identify the problem areas, and inform the development of occupational health and safety policies and decision-making in New Zealand.

1.2 Aims and outline of the thesis

The objectives of this thesis are to:

i) Describe the prevalence and distribution of occupational exposures and workplace practices in the New Zealand working population;

ii) Identify gender and ethnic differences in occupational exposure;

iii) Examine which occupational risk factors contribute to the risk of respiratory disease.

<u>Section 1. Introduction and methods</u>

Chapter 1 Introduction, aims, and outline of the thesis

This chapter gives a brief introduction of what is currently known about the burden of occupational ill-health in New Zealand and describes some of the problems that hamper the study of occupational disease. This is followed by a description of the aims and structure of the thesis.

Chapter 2 Background

This chapter describes New Zealand's current state of occupational health and safety and outlines the available evidence from epidemiological studies of occupational exposure and health in New Zealand, highlighting the need for a survey of occupational exposures in the working population. This chapter also describes workforce surveys carried out overseas, and finally, provides an overview of the background for the specific topics covered in this thesis.

Chapter 3 The New Zealand Workforce Survey: self-reported occupational exposures

This chapter describes the cross-sectional survey of a random sample of the New Zealand population (n=3,003), upon which the findings of this thesis are based. The chapter also presents the prevalences of self-reported occupational exposures, including dust/chemical exposures, physical and organisational factors, and the use of personal protective equipment by occupational and industry groups. The strengths and limitations of the survey are discussed.

Section 2. Demographic differences in occupational exposure

This section examines gender and ethnic differences in exposure to occupational risk factors. Social disparities in health are pervasive in society; however the contribution of the work environment to these inequalities is unknown. In particular, there have been few occupational health and exposure studies on female and minority workers, thus existing prevention efforts may not adequately address the exposure profiles of these groups.

Chapter 4 Gender differences in occupational exposure patterns

In this chapter, the prevalences of occupational exposures are compared between the 1,431 men and 1,572 women in the survey. The results were examined to determine whether any observed differences were due to men and women working in different occupations and therefore being exposed to different risk factors, or whether gender differences also existed for men and women working in the same job.

Chapter 5 Ethnic differences in occupational exposure patterns in New Zealand

In this chapter, the prevalences of occupational exposures are compared between the 273 Māori (New Zealand's indigenous people) and 2,724 non-Māori workers in the survey. The results were examined to determine whether any observed differences were due to Māori and non-Māori working in different occupations or whether Māori and non-Māori were exposed to different risk factors even within the same job. The results were also examined separately for males and females.

Section 3. Work-related risk factors for asthma

In this section, the survey data are used to investigate occupational risk factors for current and adult-onset asthma. In New Zealand, it has been estimated that about 1 in 6 adults have asthma (Crane et al. 1994); however, the causal factors for this chronic disease are the subject of ongoing debate. The proportion of asthma cases attributable to occupational exposures is unknown, but is estimated to range between 15 and 20% (Balmes et al. 2003, Toren & Blanc 2009). Occupational asthma is the most common work-related respiratory disease in westernised countries (Kogevinas et al. 1999) and over 300 workplace agents have been implicated in its aetiology (Maestrelli et al. 2009). Therefore, although the survey collected information on a range of other health outcomes, this section of the thesis focuses on the occupational risk factors for asthma symptoms.

Chapter 6 The New Zealand Workforce Survey: occupational risk factors for asthma

This chapter utilises the work history data collected in the workforce survey and examines associations between occupation and the risks of current and adult-onset asthma. Occupations were investigated that have been consistently found to have an increased risk of asthma, for example: laboratory workers, woodworkers, hairdressers, as well as occupations that have not been studied in relation to asthma previously.

Chapter 7 Work-related stress and asthma: results from a workforce survey in New Zealand

This chapter investigates the association between self-reported job stress and current and adult-onset asthma. The chapter also examines whether other risk factors for asthma (for example: occupation, smoking status, and obesity) were potential confounders in this association.

Section 4. Discussion and conclusions

Chapter 8 Discussion and conclusions

Chapter 8 summarises the main findings of the thesis. The limitations of the survey are discussed and recommendations are made for future surveillance, research, and policy in the context of the current state of occupational health and safety in New Zealand.

CHAPTER 2

Background

2.1 Occupational health and safety in New Zealand

The principal legislation governing occupational health and safety (OHS) in New Zealand is the Health and Safety in Employment (HSE) Act 1992. This legislative framework is underpinned by self-regulation and voluntary compliance and therefore the onus falls on employers to identify, assess, and control hazards in the workplace. A number of regulations, codes of practice, and industry guidelines are available to assist employers to achieve compliance with the HSE Act with an emphasis on performance-based (rather than prescriptive) standards (Allen & Clarke 2006). The Department of Labour (DoL) is the Government agency responsible for administering the HSE Act, which includes providing education and information on how to comply and enforcement and prosecution in circumstances where the employer has failed to take all practicable steps to prevent harm in the workplace. This function was formerly provided by the Occupational Safety and Health (OSH) service within the DoL, which was established in 1988 and formalised through the HSE Act (Allen & Clarke 2006). The OSH service was disestablished in 2004 and merged into the Workplace Group within the DoL which currently has wider service delivery functions (for example employment relations) (Allen & Clarke 2006). The two other relevant pieces of legislation in New Zealand are the Hazardous Substances and New Organisms (HSNO) Act 1996 and the Accident Compensation (AC) Act 2001 (formerly the Injury Prevention, Rehabilitation and Compensation Act). The HSNO Act and associated regulations set out controls which must be complied with to ensure the safe use of hazardous substances (as well as managing the approval of new organisms). The AC Act regulates the compensation, rehabilitation, and injury prevention system in New Zealand. There is currently no comprehensive occupational exposure and disease monitoring undertaken at a national level and the current state of data collection is summarised in the following sections.

Occupational exposures in New Zealand

There are currently no legislative requirements for any agency to carry out monitoring of occupational exposures. The only exposure information collected by the DoL is the Asbestos Exposure Database (a voluntary system). Prior to 1988 when occupational health resources were transferred to the DoL (formerly the OSH service), the then Department of Health proactively carried out workplace exposure monitoring. This monitoring data is either not publicly available or has been lost through the transfer of responsibilities from one agency to another. With the introduction of the HSE Act, the onus was put on employers to carry out monitoring, and therefore very little monitoring information remains in the public domain.

Under the HSE Act, employers are responsible for identifying, assessing, and controlling all hazards in the workplace. The hierarchy of controls set out in the Act requires employers to eliminate hazards, and where this is not practicable, to isolate or minimise them. Steps for minimising exposure to a significant hazard include monitoring an employees' exposure to a hazard. Therefore the onus is on employers to carry out exposure monitoring and although departmental inspectors have the power under the HSE Act to enter a workplace and order monitoring (or carry out basic sampling), this is generally only done in response to complaints or incidents rather than for proactive compliance assessments.

Various industries undertake exposure monitoring but there is no coordinated effort to centrally record these data and exposure measurement data are rarely publicly available (Driscoll 2006). DoL inspectors have the right to access any exposure monitoring information collected by an employer, however if the information is retained by the Department, it is stored in individual case files and not publicly available. Thus, there is no central repository of exposure data in comparison to, for example, the National Exposure Database (NEDB) in the United Kingdom (UK) or the MEGA database in Germany. In the case of the NEDB in the UK, workplace samples are collected by occupational hygiene inspectors, although the amount of data added to the database has declined over time (Brooke et al. 2006).

In New Zealand, the National Occupational Health and Safety Advisory Committee (NOHSAC) was established (2003-2009) to provide independent advice to the Minister of Labour on issues relating to occupational health and safety. The committee produced a series of technical reports including a review of Australian and New Zealand workplace exposure surveillance systems (Driscoll 2006), which involved a survey of current exposure surveillance systems based on consultation with relevant organisations and agencies. The report identified one industry-based surveillance system in the forestry industry but concluded that there was no national exposure surveillance system in New Zealand (Driscoll 2006). International approaches to exposure surveillance systems have also been reviewed (Brooke et al. 2006) and recommendations have been made for New

Zealand based on the available evidence (Pearce et al. 2006), the majority of which have not been implemented (National Occupational Health and Safety Advisory Committee 2008).

Due to the lack of national exposure monitoring, epidemiological studies are often the only valid source of publicly available exposure data. Table 2.1 lists epidemiological studies in New Zealand that have included occupational exposure data (both objectively measured and self-reported) and have been published in the scientific literature.

Only 13 studies were identified where actual exposure measurements were recorded including measurements of serum dioxin levels, wood dust, blood lead levels, welding fumes, and noise levels. Several studies measured inhalable wood dust exposure in sawmill and wood workers (Douwes et al. 2006, Douwes et al. 2000, Fransman et al. 2003, Norrish et al. 1992). These studies observed respiratory health effects in sawmill workers even though average dust levels were generally below the workplace exposure standard (WES) of 5 milligrams per cubic metre (mg/m^3) at the time of study (Douwes et al. 2006, Fransman et al. 2003). The average dust levels reported in these studies were also below the recently revised WES of 2 mg/m^3 (as at December 2010). Similarly, two studies of welders reported that respiratory symptoms were common despite exposure to constituents of welding fume generally being below WES levels (Dryson & Rogers 1991, Fishwick et al. 2004). The suggestion that adverse health effects may occur at levels below the exposure standards demonstrates the need for the collection of information on hazardous occupational exposures in order to assess the applicability of the current WES levels and to more generally contribute to the evidence base for OHS policy development.

The majority of the studies of exposure measurements were conducted in specific groups of workers and generally involved small numbers (with the exception of the studies of lead exposure). As a result, there is virtually no information on the prevalence or levels of occupational exposures, such as wood dust and welding fume, in the New Zealand working population, even though these exposures also occur in many other occupations besides the ones studied. In addition, due to the type of occupations studied, the majority of exposure measurements were collected from male workers. Finally, most of the studies involved sampling at one point in time rather than repeated measurements over time and thus provide limited information on the frequency of exposure.

The studies of self-reported exposure prevalence were able to examine larger numbers of workers compared to the studies of objective exposure measurements; however, the studies were limited to only a few specific exposures including environmental tobacco smoke (ETS) (Jones et al. 2001, Ministry of Health 1996, Whitlock et al. 1998), night shift work (Fransen et al. 2006, Gander et al. 2007, Paine et al. 2004), and farming exposures (Firth et al. 2007b, Kimbell-Dunn et al. 2001, Rothstein et al. 2004). Only two studies, one of night work (Paine et al. 2004) and one of ETS (Ministry of Health 1996), were based on randomly selected population-based samples. There has also been a lack of studies examining non-traditional factors, such as psychosocial and organisational factors. The few studies that have examined psychosocial factors in New Zealand have been largely based in the healthcare industry where stressors include dealing with difficult patients (Dewe 1989, McKenna et al. 2003a) and horizontal interpersonal violence (McKenna et al. 2003b). In summary, the few occupational exposure studies currently available cannot provide a complete picture of the prevalence and levels of occupational risk factors for disease in New Zealand. The exposures which have the greatest impact on occupational ill-health are therefore not known.

Table 2.1 Epidemiological studies conducted in New Zealand that have included occupational exposure measurements

Authors, year	Exposure(s)	Number of subjects	Worker group	Main findings
Exposure measurements				
(Collins et al. 2009)	Serum dioxin levels	346	Former phenoxy herbicide production workers exposed to dioxin	Exposed workers had mean levels of 2,3,7,8-TCDD of 9.9 ng kg^{-1} compared with mean levels of unexposed workers of 4.9 ng kg^{-1}. Differences in mean levels observed by department
(McLean et al. 2009b)	Serum dioxin levels	71 exposed & 23 non-exposed	Former sawmill workers exposed to pentachlorophenol	Mean levels of dioxin congeners were elevated compared to the mean levels of the non-exposed group
(Douwes et al. 2006)	Inhalable dust levels	183	Sawmill workers	The geometric mean dust concentration for all workers was 0.52 milligrams per cubic metre (mg/m^3). Geometric mean levels were $0.62mg/m^3$ for high dry dust exposure & $0.80mg/m^3$ for high green dust exposure
(Fransman et al. 2003)	Personal inhalable dust, endotoxin, abietic acid, terpene, formaldehyde	139 measurements	Plywood mill workers	Geometric mean dust level was $0.7mg/m^3$. Dust levels & abietic acid levels higher in composer area; higher terpene exposure in green end of process
(Douwes et al. 2000)	Airborne dust, endotoxin, beta-glucan	37	Two sawmills	50% of endotoxin samples elevated (>$50EU/m^3$), planing department had highest mean exposures to dust, endotoxin, & beta-glucan
(Norrish et al. 1992)	Airborne wood dust	50	Wood workers	Range 1.0-$24.5mg/m^3$. 32% of samples exceeded the WES of 5 mg/m^3
(Firth et al. 2006)	Inhalable dust & noise levels	60	Farmers in Southland	Median inhalable dust levels for different farming types ranged from 0.54-$1.7mg/m^3$ & 10% of participants had levels >$5mg/m^3$. Median noise levels ranged from 84.8-86.8 decibels for different farming types & 35% of participants had levels >85 decibels
(Fawcett et al. 1996)	Blood lead levels	779	Dunedin cohort of NZers at age 21	High lead levels significantly associated with the high-risk occupational group (i.e. car mechanical work, metal work, boat building, house painting etc)
(Grant et al. 1992)	Blood lead levels	1425	Workers in occupations exposed to lead	6% had blood lead levels above recommended limits. Radiator repairers & smelter/furnacemen had highest mean red cell lead levels at 3.8μmol/L
(Hinton et al. 1984)	Blood lead levels	1319 males & 186 females	31 occupations from South Island industries	Occupations with mean red cell lead levels >4μmol/L included spray painters, smelter/furnacemen, paint removers, scrap dealers & manufacturers of lead products
(Jones & Stoddart 1998)	Radiation use	10 (378 procedures)	Orthopaedic registrars	Radiation exposure was within recommended levels
(Fishwick et al. 2004)	Total fume & metal fumes (aluminium, cobalt, chromium, copper, iron, manganese, molybdenum, nickel, lead)	34	Welders	Exposure levels were generally low & below regulatory levels
(Dryson & Rogers 1991)	Welding: ozone, nitrogen dioxide, fluoride, carbon monoxide, aluminium, chromium, iron, nickel, zinc, & total dust	16	Welders	Nitrogen dioxide levels above WES for 4 welders; dust levels highest in plasma cutters; no excessive urinary uptake

Table 2.1 Epidemiological studies conducted in New Zealand that have included occupational exposure measurements

Authors, year	Exposure(s)	Number of subjects	Worker group	Main findings
Self-reported prevalences of exposure				
(Ruttenberg et al. 2001)	Boat building exposures	151	Boat builders	98% of workers reported exposure to solvents; 90% to epoxy resins; 76% to glues; 65% to isocyanates; 47% to detergents; & 46% to oils or lubricants
(Firth et al. 2000)	Work-related calls to the National Poisons Centre between 1990-1998	5340 work-related calls	General	Agricultural chemicals; solvents & other organic liquids; detergents, surfactants, disinfectants & cleaners were the most common agents enquired about.
(Jones et al. 2001)	Environmental tobacco smoke	435	Restaurant & bar workers	59% exposed to ETS
(Whitlock et al. 1998)	Environmental tobacco smoke	7725	All workers	Higher ETS prevalences in lower status occupational groups
(Ministry of Health 1996)	Environmental tobacco smoke	2020 NZ residents	Indoor workers	25% of men & 11% of women exposed during work hours
(Paine et al. 2004)	Night work (between midnight & 5am)	2670	General	10% of women & 15% of men, 16% of Maori & 11% of non-Maori reported night work
(Gander et al. 2007)	Night duty	1366	Junior doctors	28% worked more than 3 nights in previous 2 weeks
(Fransen et al. 2006)	Shift work	15687	General	21% reported shift work & 15% reported working at least one night per week
(Kimbell-Dunn et al. 2001)	Farming exposures	1706	Farmers	Prevalences of animal, crop, & chemical exposures reported
(Firth et al. 2007b)	Organophosphates, glyphosate, & phenoxy herbicides	586	Farmers	20% reported use of organophosphates; 54% reported use of glyphosate; & 16% reported phenoxy herbicide use. Exposure intensity scores were assigned & farmers classified as high, medium, or low.
(Rothstein et al. 2004)	Chemicals	586	Farmers	87% reported chemical use; glyphosates & detergents were the most common. 53% of all chemicals were applied by spraying or backpack.
Self-reported prevalences of psychosocial factors				
(Gardner & Hini 2006)	Self-reported stress and stressors	849	Veterinarians	Women experienced more work-related stress than men. The main sources of stress were hours worked, client expectations, & unexpected outcomes.
(Firth et al. 2007c)	Farming-related stressors	1015	Farmers	The most stressful items were increased work load at peak times; dealing with ACC; bad weather; & complying with health and safety legislation. Differences in stressor scores by gender were observed.
(Palliser et al. 2005)	Work-related stress	413	Dentists	Dentists with high scores for patient-related; time-related; income-related; & job-related stressors were more likely to have higher GHQ scores (a measure of psychological distress) compared with dentists with low/medium scores
(Clarke & Singh 2004)	Psychological distress (GHQ)	172	Doctors	29% were classified as cases of psychological distress

Table 2.1 Epidemiological studies conducted in New Zealand that have included occupational exposure measurements

Authors, year	Exposure(s)	Number of subjects	Worker group	Main findings
(McKenna et al. 2003a)	Threats & violent behaviour	551	Nurses	Verbal threats, verbal sexual harassment, & physical intimidation from patients were the most common threats. 22% reported a most distressing incident
(McKenna et al. 2003b)	Interpersonal conflict	551	Nurses	Horizontal violence was common; 38% reported distress about conflict
(Dryson et al. 1996)	Stressors	5467	General	Median scores for total stressors & sub-categories of stressors reported
(Dewe 1989)	Stressor frequency	1801	Nurses	Stressors with the highest mean frequency scores for tension & tiredness included work overload; dealing with difficult patients; & difficulties involved in nursing the critically ill
(Dewe 1988)	Stressor frequency across wards	1801	Nurses	Nurses in the medical, continuing care, & orthopaedic wards experienced more stressors more frequently
(Dryson 1986)	Self-reported stress	1342 men	General workers	8% 'often' stressed; 46% 'sometimes' stressed, & 47% 'rarely' stressed

NB: excludes risk factors for infectious diseases

Abbreviations

ETS	Environmental tobacco smoke
WES	Workplace exposure standard
GHQ	General health questionnaire

Occupational disease and injury in New Zealand

There are two main sources of occupational disease and injury data in New Zealand: the Notifiable Occupational Disease System (NODS) of the DoL and the Accident Compensation Corporation (ACC) claims data.

NODS is a voluntary system where any individual can report a health problem that may be related to work. In 1998, the NODS database was incorporated into the Health and Safety Accident Recording Database (HASARD), known as ‘Workbench’ since 2005. Workbench records all mandatory notifications of serious harm or accidents in the workplace. The majority of notifications to NODS are made by general practitioners (GP) and thus relies on their knowledge of occupational exposures as causal factors and their diligence in reporting. The number of notifications to NODS has declined in recent years (Department of Labour 2006) and the voluntary nature of the system means that cases of occupational disease are grossly underreported.

ACC provides no-fault personal injury (including certain occupational diseases) insurance cover for all New Zealand residents and visitors to New Zealand. While the ACC claims data provides a valuable source of information, particularly for work-related injury, data is still limited to cases that have won compensation. In the case of occupational disease, the link between exposure and health is more difficult to establish, and therefore compensate, thus occupational disease is likely to be underrepresented in data based on compensated ACC claims. There are currently 41 occupational diseases covered under Schedule 2 of the AC Act 2001 as falling within the definition of ‘work-related personal injury’ (Accident Compensation Corporation 2010).

NOHSAC produced technical reports on the estimated burden of occupational disease and injury in New Zealand (Driscoll et al. 2004), the profile of OHS in New Zealand (Allen & Clarke 2006), and the methods and systems used to measure and monitor occupational disease and injury (King et al. 2005). These reports have reviewed the available evidence for occupational disease and injury and current OHS systems in New Zealand and concluded that there is no comprehensive data collection of occupational disease and injury. In addition, there is poor recording of occupation and work-relatedness in existing data sets and little coordination between the existing data systems (King et al. 2005). The review of current surveillance systems identified opportunities for improvement and specific recommendations were made for improving data quality (Pearce et al. 2005), again, the majority of which have not been implemented (National Occupational Health and Safety Advisory Committee 2008).

As a result of the lack of available routine data, epidemiological studies are often the only way to assess the incidence or prevalence of occupational diseases in New Zealand and to identify their causes. Table 2.2 lists the epidemiological studies (n=108) of occupational health and injury conducted in New Zealand that have been published in the scientific literature. The majority of studies have focused on cancer (n=36), injury (n=22), respiratory disease (n=19), and musculoskeletal disorders (MSD; n=12). The studies of respiratory disease, cancer, and MSD are described below. These are the most frequently studied outcomes in New Zealand studies of work-related disease and injury, and also the outcomes for which specific occupational exposure data are lacking.

Respiratory disease

Studies of occupational asthma, both in New Zealand and overseas, have traditionally focused on specific groups of workers. Studies in New Zealand of specific occupational groups have reported positive associations in sawmill workers (Douwes et al. 2001, Douwes et al. 2006, Fransman et al. 2003) and welders (Erkinjuntti-Pekkanen et al. 1999, Fishwick et al. 2004, Fishwick et al. 1997b) for both self-reported asthma symptoms and objective markers of lung function decline. Three studies have also investigated the association between farming and asthma (Douwes et al. 2007, Kimbell-Dunn et al. 1999, Kimbell-Dunn et al. 2001), two of which found that farmers have a lower prevalence of asthma symptoms compared with the general population (Douwes et al. 2007, Kimbell-Dunn et al. 1999). While a few of the studies measured average levels of exposures, such as inhalable wood dust for sawmill workers (Douwes et al. 2006) and metal fume for welders (Fishwick et al. 2004), other studies used surrogates for exposure such as job titles or areas of work (Douwes et al. 2001, Douwes et al. 2006), task (for example welding) on the study day (Bradshaw et al. 1998, Fishwick et al. 1997b), and self-reported exposure (Kimbell-Dunn et al. 2001).

The only other population-based study in New Zealand (Fishwick et al. 1997c) (n=1,609) to examine occupation in relation to respiratory symptoms was part of the European Community Respiratory Health Survey (ECRHS). The ECRHS assessed the association between current occupation and asthma defined as bronchial hyperresponsiveness (BHR; using a methacholine challenge test) and self-reported asthma symptoms or medication in 15,637 randomly selected people aged 20-44 years from 12 industrialised countries (Kogevinas et al. 1999). The New Zealand study (Fishwick et al. 1997c) reported positive associations between asthma (wheezing or BHR) and current employment as a farmer or farm worker, laboratory technician, and other food processing worker (other than baker) compared to the professional, administrative, clerical and service workers group. Chemical workers and plastic and rubber workers were also more likely to have asthma, although the numbers were small. One of the limitations of this study was that current occupation (classified into 21 occupational groups) was used and although previous occupations were recorded if the worker had changed jobs due to respiratory symptoms, previous exposures were generally not taken into account.

Cancer

The evidence for occupational cancer in New Zealand is largely based on case-control studies where cases were obtained from the New Zealand Cancer Registry. In particular, a series of case-control studies for the period 1980-1984 examined 19,904 cancer registrations of male patients aged 20 years or older. For each cancer site examined, the registrations of the other cancer sites formed the control group and the occupation at the time of registration was recorded. These studies identified which occupations were associated with specific cancers, including stomach cancer (Dockerty et al. 1991) and brain cancer (Reif et al. 1989c), as well as the risk of specific cancers for farmers (Reif et al. 1989b), meat workers (Reif et al. 1989a), electrical workers (Pearce et al. 1989), forestry workers (Reif et al. 1989d), wood workers (Kawachi et al. 1989a), painters (Bethwaite et al. 1990) and asbestos-related work (Glass et al. 1991). The majority of occupational cancer studies in New Zealand have examined job title as a surrogate for exposure and, with the exception of the most recent case-control studies (Dryson et al. 2008, Mannetje et al. 2008, McLean et al. 2009c), investigated the occupation at the time of registration or death, therefore previous occupational exposures and the latency period before cancer-onset were not addressed. Only a few studies have identified the responsible agents within these occupations, such as agricultural chemical spraying (self-report) (Pearce et al. 1987c, Smith et al. 1984) and electromagnetic field exposure (assessed using a job exposure matrix (JEM)) (Bethwaite et al. 2001a).

Musculoskeletal disorders

Most of the studies of work-related MSDs have involved patients presenting for treatment or cases that have won compensation (i.e. ACC claims) and therefore there is no information on the prevalence of MSDs or the prevalence of risk factors for MSDs in the working population. Studies of specific occupational groups included veterinarians (Scuffham et al. 2010), nurses (Coggan et al. 1994, Norton et al. 1995), clerical workers (Fogg & Henderson 1996), and a study of a random sample of nurses, postal workers, and office workers (Harcombe et al. 2010). Studies from overseas have shown that a wide range of physical and psychosocial risk factors have been associated with MSD. Physical risk factors include lifting, use of hand tools, vibration, and the combination of repetition, force and posture (Buckle & Devereux 2002, Lings & Leboeuf-Yde 2000, MacFarlane et al. 2000). Psychosocial factors include decision latitude, psychological distress, monotonous work, social support from supervisors and co-workers, and other causes of job strain (Huang et al. 2002, Kerr et al. 2001, MacFarlane et al. 2000). In New Zealand, only two studies have investigated a range of self-reported work-related risk factors, including psychosocial factors (Harcombe et al. 2010, Scuffham et al. 2010). Harcombe et al recently reported on risk factors for MSD in a random sample of nurses, postal workers, and office workers and found that those with high job strain (low job control and high work demands) were more than twice as likely to report low back, neck, shoulder, wrist/hand, and knee pain. The study also reported that physical work tasks showed modest (~40%) associations with low back, shoulder, and wrist/hand pain (Harcombe et al. 2010); however, ‘physical work tasks’ were examined as a group rather than as individual work tasks.

In summary, very few studies have examined risks of occupational disease and injury in the working population. Job title is often the only indicator of exposure available and studies of specific exposures are lacking, particularly exposure to physical, psychosocial, and organisational factors. Finally, a greater proportion of studies have been conducted in men (particularly for cancer) and only two studies have examined female workers only (Firth et al. 2007a, Fogg & Henderson 1996).

Table 2.2 Epidemiological studies conducted in New Zealand of work-related disease and injury

Authors, year	Exposure(s)	Health outcome(s)	Study design	Number of subjects	Gender	Year(s) of study	Main findings (increased risk for:)
CANCER							
(McLean et al. 2009c)	Occupation[#]	Leukaemia	Case-control study	225 cases & 471 controls	Both	2003-2004	Agricultural sectors (greater risk in women); rubber & plastics workers; tailors & dressmakers; cleaners; & builder's labourers
(Dryson et al. 2008)	Occupation[#]	Bladder cancer	Case-control study	213 cases & 471 controls	Both	2003-2004	Hairdressers; sewing machinists; tailors & dressmakers; rubber & plastics workers; building workers; female market farmers & crop growers
(Mannetje et al. 2008)	Occupation[#]	Non-Hodgkin's lymphoma	Case-control study	291 cases & 471 controls	Both	2003-2004	Crop farmers; meat workers; heavy truck drivers; metal product manufacturing workers; & cleaners
(Firth et al. 2007a)	Occupation*	Cancer mortality	Descriptive study	7236 cancer deaths with codeable occupation	Female	1988-1997	Increased PMR for leukaemia in health professionals & bladder cancer in clerical workers for women aged $\geq$20 years
(Firth et al. 1996)	Occupation*	Cancer incidence	Descriptive study	26207 cancer registrations	Male	1972-1984	Increased SIRs for buccal cavity cancer in cooks, waiters & bartenders; laryngeal cancer in protective service workers; bladder cancer in tailors & dressmakers; & brain cancer in spinners, weavers, knitters & dyers
(Delahunt et al. 1995)	Occupation*	Renal cell carcinoma	Case-control study	710 cases & 12756 controls (other cancer)	Male	1978-1986	Fire fighters; glass workers; & painters
(Firth et al. 1993)	Occupation*	Cancer mortality	Descriptive study	All cancer deaths	Male	1973-1986	Elevated SMRs of all cancer for architects & engineers; cooks, waiters & bartenders; hairdressers; & miners, quarrymen & well-drillers
(Preston-Martin et al. 1993)	Occupation*	Brain cancer	Descriptive study	5684 incident brain cancers	Both	1948-1988	Dairy farmers; sheep handlers; livestock workers; farm managers; electrical engineers; & electricians
(Dockerty et al. 1991)	Occupation*	Stomach cancer	Case-control study	1016 cases & 19042 controls (other cancer)	Male	1980-1984	Forestry workers; grain millers; brewers, wine & beverage makers; & field crop workers
(Reif et al. 1989c)	Occupation*	Brain cancer	Case-control study	452 cases & 19452 controls (other cancer)	Male	1980-1984	Livestock farmers; dairy farmers; sheet metal workers; plumber/welders; accountants; mathematicians; & religious workers
(Pearce et al. 1987b)	Occupation*	Testicular cancer	Case-control study	427 cases & 854 controls (other cancer)	Male	1979-1983	Sales & service workers including managers; insurance & real estate workers; & protective service workers
(Pearce et al. 1987a)	Occupation*	Prostate cancer	Case-control study	617 cases & 1234 controls (other cancer)	Male	1979	Certain service & sales workers; & teachers
(Smith et al. 1982b)	Occupation*	Soft tissue sarcoma	Case-control study	102 cases & 306 controls (other cancer)	Male	1976-1980	Similar occupational distribution between cases and controls
(Reif et al. 1989d)	Forestry workers*	Cancer	Case-control study	19904 (other cancers=controls)	Male	1980-1984	Soft tissue sarcoma; NHL; pancreas; stomach; & oesophagus cancer

Table 2.2 Epidemiological studies conducted in New Zealand of work-related disease and injury

Authors, year	Exposure(s)	Health outcome(s)	Study design	Number of subjects	Gender	Year(s) of study	Main findings (increased risk for:)
(Reif et al. 1989b)	Farmers*	Cancer	Case-control study	19904 (other cancers=controls)	Male	1980-1984	Farmers had increased ORs for cancer of the lip & bone cancer & decreased ORs for cancer of the larynx; lung; & testis
(Pearce et al. 1987c)	Farming exposures	Non-Hodgkin's lymphoma	Case-control study	183 cases & 338 controls (other cancer)	Male	1977-1981	Orchard workers & meat works employment
(Pearce et al. 1986c)	Farming exposures & meat works	Non-Hodgkin's lymphoma	Case-control study	83 cases & 396 controls (168 cancer controls)	Male	1977-1981	Fencing work & meat works employment
(Pearce et al. 1986b)	Farming exposures	Multiple myeloma	Case-control study	76 cases & 315 controls (other cancer)	Male	1977-1981	Sheep farming; crop farming; orchard work; beef cattle exposure; & fencing work
(Pearce et al. 1986a)	Agricultural workers	Leukaemia	Case-control study	546 cases & 2184 controls (other cancer)	Male	1979-1983	Livestock farmers & electrical workers
(Pearce et al. 1985b)	Agricultural workers	Malignant lymphoma & multiple myeloma	Case-control study	734 cases & 2936 controls (other cancers)	Male	1977-1981	Increased ORs for agricultural & forestry workers of multiple myeloma & category incl nodular lymphoma, mycosis fungoides & unspecified NHL
(Smith & Pearce 1986)	Phenoxy herbicides	Soft tissue sarcoma	Case-control study	51 cases & 315 controls	Male	1976-1982	No association between phenoxy herbicide exposure & soft tissue sarcoma
(Smith et al. 1984)	Phenoxy herbicides & chlorophenols	Soft tissue sarcoma	Case-control study	82 cases & 92 controls (other cancer)	Male	1976-1980	Moderate association for exposure to chlorophenols
(McLean et al. 2004)	Meat workers	Mortality & cancer incidence	Cohort	6647	Both	1988-2000	Excess risks of lung cancer mortality & incidence; dose-response associations for lung & lymphohaematopoietic cancers with increasing duration of exposure to animal urine, faeces, & blood
(Bethwaite et al. 2001b)	Meat workers[#]	Acute leukaemia	Case-control study	110 cases & 199 controls	Both	1989-1991	Abattoir workers with >2 years employment & workers with contact with animals or animal tissue
(Reif et al. 1989a)	Meat workers*	Cancer	Case-control study	19904 (other cancers=controls)	Male	1980-1984	Laryngeal cancer; soft tissue sarcoma; & acute myeloid leukemia
(Bethwaite et al. 2001a)	Electrical workers[#]	Acute leukaemia	Case-control study	110 cases & 199 controls	Both	1989-1991	Ever employed as an electrical worker; welder/flamecutter; & telephone line worker. Dose-response association with electromagnetic field exposure (assessed by JEM)
(Pearce et al. 1989)	Electrical workers*	Cancer	Case-control study	19904 (other cancers=controls)	Male	1980-1984	Increased ORs for leukaemia: highest odds for radio & TV repairers; electricians; linemen; & power station operators
(McLean et al. 2002)	Pulp & paper mill workers	Mortality & cancer incidence	Cohort	8456	Both	1978-1992	No overall increase in mortality from all causes or all cancers
(Kawachi et al. 1989a)	Wood workers*	Cancer	Case-control study	19904 (other cancers=controls)	Male	1980-1984	Increased ORs for lip; nasopharynx; & liver cancer for woodworkers.

Table 2.2 Epidemiological studies conducted in New Zealand of work-related disease and injury							
Authors, year	**Exposure(s)**	**Health outcome(s)**	**Study design**	**Number of subjects**	**Gender**	**Year(s) of study**	**Main findings (increased risk for:)**
(Bates et al. 2001)	Fire fighters	Testicular cancer	Historical cohort	4221 males	Male	1977-1995	Elevated risk of incident testicular cancer
(Bethwaite et al. 1990)	Painters*	Cancer	Case-control study	19904 (other cancers=controls)	Male	1980-1984	Bladder tumours; kidney tumours; & multiple myeloma
(Fraser & Pearce 1993)	Occupational physical activity	Colon & rectum cancer	Descriptive study	2503 colorectal cancer registrations	Male	1972-1980	Higher incidence rate in sedentary occupations compared to high physical activity occupations
(Kjellstrom & Smartt 2000)	Asbestos	Mesothelioma	Descriptive study	All mesothelioma cases from Cancer Registry	Both	1962-1996	Incidence rates have increased progressively since the 1960s; 25 per million incident cases of mesothelioma for men in 1995
(Glass et al. 1991)	Occupations involving asbestos-related work*	Cancer	Case-control study	19904 (other cancers=controls)	Male	1980-1984	ORs for lung; pleura; & peritoneum cancer highest in group containing machinery fitters, plumbers, welders, boilermakers, metal moulders, metal platers & electricians
(Cooke et al. 1984)	Outdoor work	Malignant melanoma incidence and mortality	Descriptive study	All malignant melanoma registrations & deaths	Male	1972-1976	SES rather than outdoor work had an effect on melanoma risk
(Kawachi et al. 1989b)	Passive smoking	Lung cancer & Ischaemic heart disease	Descriptive study		Both	1985	x2 increased risks of lung cancer & ischaemic heart disease for passive smoking exposure at workplace (from pooled estimates)
*at the time of registration/death							
#ever worked							
ALL CAUSES							
(Pearce & Howard 1985)	Occupation	Mortality	Descriptive study	All deaths	Male	1974-1978	Highest mortality rate for labourers/production/transport workers
(Ayers et al. 2009)	Dentists	Self-reported health	Cross-sectional study	750	Both	2008	47% reported dermatitis-type condition; 59% reported neck problems; & 57% reported lower back problems
(Firth et al. 2001)	Farmers in Southland	Self-reported health	Cross-sectional study	586	Both		55% reported LBP; 19% reported chemical-related illness; & 17% reported injury which prevented normal farm work in last 12 months
(Ruttenberg et al. 2001)	Boat building	Self-reported health	Cross-sectional study	151		1998-1999	32% reported work-related health problem; 22% reported wheeze in previous 12 months; & 26% reported dermatitis
(McBride et al. 2009)	Former phenoxy herbicide production workers exposed to dioxin	Mortality	Historical cohort	1599	Both	1969-1988	No significant excess of all cause or all cancer mortality

Table 2.2 Epidemiological studies conducted in New Zealand of work-related disease and injury

Authors, year	Exposure(s)	Health outcome(s)	Study design	Number of subjects	Gender	Year(s) of study	Main findings (increased risk for:)
(Mannetje et al. 2005)	Phenoxy herbicide producers & sprayers exposed to dioxin	Mortality	Cohort study	1025 producers & 703 sprayers	Both	1969-2000	24% non-significant excess of cancer mortality in producers
(McLean et al. 2009a)	Former sawmill workers exposed to pentachlorophenol (PCP)	Self-reported health & clinical neurological exam	Cross-sectional study	293	Mostly male	2006-2007	Associations between high exposure scores & self-reported tuberculosis, pleurisy or pneumonia & cranial nerve function deficit
(Walls et al. 1998)	Sawmill workers exposed to pentachlorophenol (PCP)	Self-reported health	Cross-sectional study	137 (self-selected)	Male	1996	Associations between high exposure scores & fever/sweating; weight loss; fatigue; nausea; & responses to neuropsychological dysfunction
(Firth et al. 1999)	Heavy engineering plant & foundry	Mortality	Historical cohort	3522	Male	1945-1991	Increased SMRs for musculoskeletal; cancer of the oesophagus; & mesothelioma of the pleura.
(Spicer et al. 1986)	Radiographers	Self-reported health	Cross-sectional study	367	Both		Bad taste in mouth; sinus problems; nasal discharge; catarrh; unexpected fatigue; painful joints; & numb extremities consistently related to exposure
(Brokenshire et al. 1984)	Electricity	Mortality	Descriptive study	95 fatalities (reported to Electricity Division)	Mostly male	1975-1982	52% of fatalities occurred at work
RESPIRATORY DISEASE							
(Fishwick et al. 1997c)**	Current occupation	BHR & self-reported asthma symptoms	Cross-sectional study	1609	Both	2004	Farmers; laboratory technicians; food processors; chemical workers; & plastics & rubber workers
(Fishwick et al. 1997a)**	Current occupation	Self-reported chronic bronchitis, shortness of breath, & lung function	Cross-sectional study	1609	Both	2004	Food processors; chemical processors; bakers; & spray painters. Ever worked with vapours, gases, dust or fumes was significantly associated with chronic bronchitis & reduced lung function
(Walls et al. 2000)	Occupation	Asthma-NODS notifications	Descriptive study	All notifications	Both	1996-1999	54 cases of asthma notified, 21 were accepted as occupationally caused
(Walls et al. 1997)	Occupation	Respiratory diseases-NODS notifications	Descriptive study	All notifications	Both	1993-1996	Of 277 cases notified, 26% confirmed as occupational asthma. Isocyanates & fumes from aluminium smelting were the most common causal agents
(Gallagher et al. 2007)	Horse trainers	Self-reported respiratory symptoms	Cross-sectional study	659 horse trainers & 506 vegetable growers	Both	1999	Increased ORs for bronchitis & organic dust toxic syndrome compared to vegetable growers
(Barnard et al. 2004)	Primary aluminium smelting dust &	Occupational asthma of aluminium smelting (OAAS)	Case-control study nested in a historical cohort	225		1982-2000	Increased ORs for individuals with hayfever, non-significant increased ORs for family history of asthma; history of bronchitis; childhood asthma; &

Table 2.2 Epidemiological studies conducted in New Zealand of work-related disease and injury

Authors, year	Exposure(s)	Health outcome(s)	Study design	Number of subjects	Gender	Year(s) of study	Main findings (increased risk for:)
	fume						wheeze at pre-employment exam
(Glass et al. 1998)	Mussel openers	Self-reported respiratory symptoms & lung function	Cross-sectional study	224	Both	1996	Duration of employment positively associated with work-related respiratory symptoms
(Slater et al. 2000)	Hairdressers	Self-reported asthma symptoms & lung function	Cross-sectional study	100 hairdressers & 106 office & shop workers	Both		No strong associations with symptoms after adjusting for gender, smoking status, & age
(Fishwick et al. 2004)	Welders	Self-reported respiratory symptoms & lung function	Cross-sectional study	49 welders & 26 non-welders	Male		Nickel exposure associated with work-related respiratory symptoms; aluminium exposure associated with lung function decline
(Erkinjuntti-Pekkanen et al. 1999)	Welders	Pulmonary function	2-year follow-up	54 welders & 38 non-welders	Male	1998	Welders who smoked & welders without local exhaust ventilation or respiratory protection had a greater annual decline in pulmonary function (FEV_1)
(Bradshaw et al. 1998)	Welders	Self-reported chronic bronchitis, respiratory symptoms, & pulmonary function	Cross-sectional study	62 welders & 75 non-welders	Mostly male		Chronic bronchitis & work-related respiratory symptoms positively associated with cumulative welding exposure (in years)
(Fishwick et al. 1997b)	Welders	Self-reported respiratory symptoms & lung function	Cross-sectional study	62 welders & 75 non-welders	Mostly male		An acute decrease in lung function was more prevalent among welders, especially for those with no local exhaust ventilation
(Douwes et al. 2007)	Farmers	Self-reported respiratory symptoms, hayfever, & eczema	Cross-sectional study	4288 farmers & 1328 non-farmers	Both		Farmers were less likely to have asthma symptoms, hayfever, & eczema.
(Kimbell-Dunn et al. 2001)	Farmers	Self-reported respiratory symptoms	Cross-sectional study	1706	Both		Working with pigs; poultry; horses; grains; & hay were associated with breathing problems at work
(Kimbell-Dunn et al. 1999)	Farmers	Self-reported asthma symptoms	Cross-sectional study	1706	Both		The 12 month period prevalence of asthma was 12%. Working with horses & oats as crops were associated with asthma
(Douwes et al. 2006)	Sawmill workers	Atopy & lung function	Cross-sectional study	59 cases & 167 controls	Both		Green dust exposure associated with atopy; green & dry dust exposure associated with reduced lung function
(Fransman et al. 2003)	Plywood mill workers (personal inhalable dust, endotoxin, abietic acid, terpene, formaldehyde)	Self-reported respiratory symptoms	Cross-sectional study	112 mill workers & 415 general population	Both		Plywood mill workers had higher ORs for woken by shortness of breath & asthma compared to general population; workers with high exposure to formaldehyde & total terpenes had higher ORs for certain asthma symptoms compared to workers with low exposure
(Douwes et al. 2001)	Sawmill workers	Self-reported asthma symptoms	Cross-sectional study	772 sawmill workers & 592 general population	Both		Higher prevalence of asthma for dust exposed workers compared with general population; workers with high exposure to green and dry dust

Table 2.2 Epidemiological studies conducted in New Zealand of work-related disease and injury							
Authors, year	**Exposure(s)**	**Health outcome(s)**	**Study design**	**Number of subjects**	**Gender**	**Year(s) of study**	**Main findings (increased risk for:)**
							had higher prevalences of asthma & cough symptoms compared with non-exposed workers
(Norrish et al. 1992)	Wood workers	Self-reported respiratory symptoms	Cross-sectional study	44 wood workers & 38 office workers	Male		Higher prevalences of upper and lower respiratory tract symptoms compared to office workers
DERMATITIS							
(Stehr-Green et al. 1993)	Poultry processing workers	Warts	Cross-sectional study	88	Both		44% had wart-like lesions; workers handling dead, raw, unfrozen chickens & workers employed for >1 year were more likely to have developed warts
(Jennings et al. 1984)	Slaughterhouse	Warts	Cross-sectional study	99 exposed & 55 unexposed	Male	1981	Period prevalence rates were 72% for workers who slaughtered cattle & 60% for pigs compared to 22% for textile workers (unexposed)
INJURY							
(Sultana et al. 2007)	Work	Non-fatal work-related traffic crash injuries	Descriptive study	3867 ACC claims	Both	2004-2006	Work-related non-fatal injury rate was 109/100,000 workers per year. Highest rate in plant & machine operators & assemblers
(McNoe et al. 2005)	Work (determined by coronial file review)	Fatal work-related traffic crashes	Descriptive study	10809 potential cases from three databases	Both	1985-1998	Work-related fatal injury rate was 2.01/100,000 workers per year. Highest rate in the transport & storage industry
(Feyer et al. 2001)	Work (determined by coronial file review)	Fatal work injury	Descriptive study	All fatal injuries with external cause of death	Both	1985-1994	Work-related fatal injury rate was 5.03/100,000 workers per year. Agricultural & helicopter pilots & forestry & fishery workers had highest rates
(McCracken et al. 2001)	Work – Maori (determined by coronial file review)	Fatal work injury	Descriptive study	All fatal injuries with external cause of death	Male	1985-1994	Crude rate higher for Maori. Standardisation of Maori rate to non-Maori occupational and industry distributions attenuated ethnic difference
(Horsburgh et al. 2001)	Agricultural work (determined by coronial file review)	Fatal work injury	Descriptive study	All fatal injuries in agricultural production & services sector	Male	1985-1994	Work-related fatal injury rate for agricultural workers was 21.2/100,000 worker-years over study period; machinery & motor vehicles were commonly associated with fatal injury
(Alsop et al. 2000)	Occupation	Injury	Descriptive study (of Dunedin cohort)	948	Both	1993-1994	Highest self-reported injury rates for plant & machine operators & assemblers & workers in the electricity, gas & water & manufacturing industries
(Caradoc-Davies & Hawker 1997)	Occupation & Industry	Work injury	Descriptive study	ACC claims	Both	1986 & 1991	Injury rate was 44.1/1000 workers in 1991. Highest injury rates in manufacturing industry & for plant & machine operators & assemblers
(Dufort et al. 1997)	Occupation – Adolescents	Work injury – Emergency department at a Dunedin hospital	Descriptive study	13882 injuries treated in the emergency department	Both	1990-1993	Highest work-related injury rates in handlers, equipment cleaners, helpers & labourers; & construction & transportation/communication industries.

Table 2.2 Epidemiological studies conducted in New Zealand of work-related disease and injury

Authors, year	Exposure(s)	Health outcome(s)	Study design	Number of subjects	Gender	Year(s) of study	Main findings (increased risk for:)
(Firth & Herbison 1990)	Work	Work injury – Emergency department	Cross-sectional study	655 cases in Dunedin Hospital	Both	10 week period in 1989	Work-related injury attendance rate was 15.8/1000 workers. Production & agricultural workers had the highest rates
(Cryer & Fleming 1987)	Work	Fatal work injury	Descriptive study	All work-related fatal injuries from multiple sources	Both	1975-1984	Work-related fatal injury rate was 7.2/100,000 workers per year. Helicopter & agricultural pilots; demolition labourers; deer cullers & commercial deer shooters had highest rates
(Lilley et al. 2002)	Fatigue in forest workers	Accidents & injury	Cross-sectional study	367	Mostly male		Number of breaks & specific tasks were significant determinants of high levels of fatigue at work. Near-miss injury events were associated with high levels of fatigue
(Bentley & Parker 2001)	Skid work among loggers	Injury	Descriptive study	All lost-time injuries reported to the industry accident reporting scheme		1995-1999	939 lost-time injuries were recorded; 26% of total lost-time injuries occurred on skid sites
(Marshall et al. 1994a)	Forestry workers	Work injury – fatalities & hospitalisations	Descriptive study	All deaths & hospitalisations for work-related injury among forestry workers		1975-1988	Fatality rate was 2.03 for loggers & 0.15/1000 per year for silviculture; hospitalisation rate was 38.93 for loggers & 9.58/1000 per year for silviculture
(Kawachi et al. 1994)	Forestry workers	Work injury – fatalities, hospitalisations, & lost-time injuries	Descriptive study	All fatalities, hospitalisations, & lost-time injuries for loggers & silviculture workers from multiple data sources		1975-1988	39% of injuries were caused by chainsaw contact; highest injury rate observed for loggers with 1-3 years experience (115.8/1000 workers/year)
(Marshall et al. 1994b)	Forestry workers	Work injury	Descriptive study	All compensation claims for work-related injuries among forestry workers		1949-1973	Mean fatality rate for 1949-73 was 2.1 for loggers & 0.1/1000 per year for silviculture; mean permanent disability rate was 7.7 for loggers & 0.4/1000 per year for silviculture workers
(Kawachi et al. 1995)	Chainsaw use among forestry workers	Injury	Descriptive study	All hospitalisations for work-related injuries to forestry workers		1979-1988	Mean rate for 1979-88 of hospital-treated chainsaw injuries was 12.8/1000 per year for loggers & 2.2/1000 per year for silviculture workers
(Macfarlane 1980)	Forestry workers	Hospitalisations (Bay of Plenty hospitals) & fatalities	Descriptive study	155 patients	Mostly male	1970-1998	Falling tree or log was the most common cause of injury & death
(Langley et al. 1995)	Motorcycle/All-terrain vehicle crashes on farms	Fatalities & hospitalisations	Descriptive study	All fatalities & hospitalisations for motorcycle crashes	Both	1978-1989	48% (n=2004) of off-road incidents resulting in hospitalisation occurred on farms
(Cryer & Fleming 1989)	Farmers	Fatal injuries	Descriptive study	237 fatal injuries from multiple sources		1975-1984	65% were vehicle-related; tractor overturns were the most common event

Table 2.2 Epidemiological studies conducted in New Zealand of work-related disease and injury							
Authors, year	**Exposure(s)**	**Health outcome(s)**	**Study design**	**Number of subjects**	**Gender**	**Year(s) of study**	**Main findings (increased risk for:)**
(Fransen et al. 2006)	Shift work	Self-reported work injury requiring medical treatment	Cross-sectional study	15687	Both	1998-1999	Rotating shift work was associated with work injury
(Norrish & Cryer 1990)	Commercial fishermen	Fatal & non-fatal work injury	Descriptive study	All fatal injuries, hospitalisations, & ACC claims for fishermen		1975-1984	Fatal injury rate was 2.6/1000 workers per year, hospitalisation rate was 6.0/1000 workers per year, & claim rate was 104/1000 workers per year.
(Laing et al. 1997)	Meat workers	Hand and lower arm injuries	Descriptive study	All hospitalisations for hand and lower arm injuries among meat workers		1979-1988	Injury rate was 5.3/1000 workers in 1988; hospitalisation rate increased by 60% over period; cutting & piercing was the most common injury event
MUSCULOSKELETAL DISORDERS							
(Dryson & Walls 2001)	Occupation	Upper limb pain (carpal tunnel syndrome, epicondylitis, pain syndromes, non-specific overuse syndrome)	Cross-sectional study	960 patients	Both	1992-1998	Manual workers; clerical workers; word processors; data entry operators; & mail sorters
(Burridge et al. 1997)	Occupation	Hand and lower-arm injuries (hospital admissions)	Descriptive study	26228 hospital admissions	Both	1979-1988	37% work-related. Piercing & cutting instruments & machinery were two most common agents, high numbers of cases in meat workers; carpenters; machine operators; & sawmill workers
(Lam & Thurston 1998)	Occupation	Carpal tunnel syndrome	Cross-sectional study	512 patients	Both	1988-1992	Moderate manual work was a risk factor for females & heavy office/clerical work was a risk factor for males compared to the general population
(Burry & Gravis 1988)	Occupation	Back injury (ACC claims)	Cross-sectional study	420	Male	1984	Labourers; freezing workers; coal miners; & railway workers had highest rates
(Scuffham et al. 2010)	Veterinarians	Self-reported MSD discomfort	Cross-sectional study	867	Both	2008	Period prevalence was 96%. Lower back was most commonly reported site. Risk factors for MSDs requiring time off work included awkward grip or hand movements & dissatisfaction with level & difficulty of work
(Harcombe et al. 2009, Harcombe et al. 2010)	Nurses, postal workers, & office workers	Self-reported MSD	Cross-sectional study	443	Both	2007	72% reported a MSD in the last week. Elbow, wrist/hand, & knee pain prevalence differed by occupation. Physical work tasks showed modest increased ORs for low back, shoulder, & wrist/hand pain. Associations also observed for night shift & neck pain; & high job strain & most MSD types
(Palliser et al. 2005)	Dentists	Self-reported MSD discomfort	Cross-sectional study	413	Both	1999	Annual prevalences of MSD discomfort were 63% for lower back; 63% for neck; & 49% for

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Authors, year	**Exposure(s)**	**Health outcome(s)**	**Study design**	**Number of subjects**	**Gender**	**Year(s) of study**	**Main findings (increased risk for:)**
							shoulders. Dentists with >2 MSD sites in the last year were more likely to have high psychological distress (GHQ) scores
(Fransen et al. 2002)	Physical workplace factors	Chronic low back pain (ACC claims)	Prospective cohort	854	Both	1994-1995	Lifting & driving in job for ¾ of day or more were risk factors for chronic back pain
(Tappin et al. 2008)	Meat workers	MSD (ACC claims & industry injury database)	Descriptive study	9180 claims & 3257 cases	Both	2002-2004	Lifting & knifework were common risk factors for MSD injury
(Norton et al. 1995)	Nursing	Self-reported back pain	Cross-sectional study	4636	Both	1992	Higher prevalence of back pain for nurses working >32 hours per week & for Pacific Island nurses
(Coggan et al. 1994)	Nursing	Self-reported back pain	Cross-sectional study	4636	Both	1992	Lifetime prevalence of nursing-related back pain was 62%; Pacific Island nurses had a higher prevalence of nursing-related back pain
(Fogg & Henderson 1996)	Clerical workers (keyboard users vs. non-keyboard)	Self-reported upper extremity MSD	Cross-sectional study	1073	Female		High levels of self-reported upper extremity MSD strain: 42% for non-keyboard & 48% for keyboard group
REPRODUCTIVE DISORDERS							
(Smith et al. 1982a)	2,4,5-T sprayers	Congenital defects & miscarriages	Cross-sectional study	548 exposed & 441 unexposed (agricultural contractors)	Male (paternal exposure)	1969-1980	No increased risks of defects or miscarriages
SLEEP DISORDERS							
(Gander et al. 2007)	Work patterns incl night duty, shifts, hours worked of junior doctors	Excessive sleepiness, feeling sleepy at the wheel, fatigue-related clinical error	Cross-sectional study	1366 junior doctors	Both	2003	Increased ORs for night duty & schedule changes & excessive sleepiness
(Paine et al. 2004)**	Night work (between midnight & 5am)	Self-reported sleep problems	Cross-sectional study	2670	Both	2001	Increased ORs for current & chronic sleep problems
OTHER							
(Dryson & Ogden 1998)	Occupation	Chronic solvent neurotoxicity (notified to the Dept of Labour)	Case review	193 notified cases	Both	1993-1997	39% classified as verified cases. The most frequent occupations were spray painting; printing; & boatbuilding
(McBride et al. 2003)	Noise exposure in farmers	Hearing loss	Cross-sectional study	586	Both		Driving tractors without cabs & working with metal were risk factors for hearing loss
(Lum et al. 1997)	Health care workers	Needlestick injuries	Cross-sectional study	367	Both	1993	Incidence rate was 22/100 workers per 6 month period

…continued

**population-based	
NB: excludes infectious diseases	
Abbreviations	
ACC	Accident compensation corporation
JEM	Job exposure matrix
BHR	Bronchial hyperresponsiveness
FEV_1	Forced expiratory volume in 1 second
LBP	Low back pain
MSD	Musculoskeletal disorder
NHL	Non-Hodgkin's lymphoma
NODS	Notifiable Occupational Disease System
OR	Odds ratios
PMR	Proportional mortality ratio
SES	Socioeconomic status
SIR	Standardised incidence ratio
SMR	Standardised mortality ratio

The previous sections illustrate that there is a serious lack of comprehensive and reliable information for both occupational health and occupational exposure in New Zealand. The current fragmented approach to data collection does not enable identification of current or emerging hazards and gives no indication of the overall burden of occupational exposure and disease in New Zealand. The paucity of reliable data means that there is a limited evidence base for OHS policy development and decision-making in New Zealand and the lack of recognition of important hazards means that the limited prevention resources will not be targeted effectively. The lack of data on occupational health in New Zealand was recognised by the Occupational Health and Safety Joint Research Portfolio of the Health Research Council, the ACC, and the DoL which issued a request for proposals (RFP) for a study of the current and likely future burden of occupational ill-health in New Zealand and funded the first nationwide New Zealand workforce survey on which the results presented in this thesis are based.

2.2 Workforce surveys

Workforce surveys provide an efficient method of ascertaining exposure in a range of different jobs and industries in order to identify the problem areas and emerging risk factors. This is becoming increasingly important in the changing world of work. The increased demand for flexibility has changed the nature of a ‘typical’ working arrangement from full-time and permanent to non-standard and more precarious forms of employment (Feyer & Broom 2001), thus the need for monitoring and surveillance is even more crucial. In addition, the difficulties of attributing disease to occupational exposure due to latent onset may require a focus on the distribution of hazardous exposures in surveys of this type as an important first step towards disease prevention.

Workforce surveys in other countries

Table 2.3 gives an overview of the workforce surveys carried out in other countries and the occupational exposure information captured. Surveys have only been included if they assess dust/chemical factors and/or physical factors (as opposed to labour force surveys of employment status, income etc). These surveys collect information on a wide range of work environment factors in representative samples of the working population in order to identify the priority areas for research and policy. A number of the surveys are carried out on a regular basis which enables trends to be monitored over time (for example in Finland, Denmark, and Germany). An inventory of the technical characteristics of workforce surveys both in and outside the European Union (EU) has been described in a report from the European Foundation for the Improvement of Living and Working Conditions (Weiler 2007). This comparative report found that working conditions surveys across countries varied widely in their survey methods and the work environment indicators covered. The report also recommended that ongoing surveys should be adapted to accommodate changes in work processes and emerging risk factors, and in particular, hazards in female-dominated occupations.

The largest international study is the European Working Conditions Survey (EWCS) which has been conducted every 5 years since 1991 (Parent-Thirion et al. 2007). The survey has expanded to reflect the growing membership of the EU from 12 countries in 1991 to 31 countries (including 4 non-EU countries) and almost 30,000 workers in 2005. The size and the ongoing nature of the survey enables comparisons to be made between countries and trends to be monitored over time. The latest (fourth) edition of the survey involved approximately 1000 participants from each country and the interviews were conducted face-to-face. The recruitment of participants was based on a multi-stage, stratified and clustered design with a ‘random walk’ procedure for the selection of households (Parent-Thirion et al. 2007).

The EWCS covers a wide range of working environment factors, including working time, physical risk factors, violence, harassment and discrimination in the workplace, the nature of work, work organisation, the impact of work on health, management and communication structures, work and non-working life, satisfaction with working conditions, and income and payment systems. The fourth EWCS (the overall response rate was 48%) reported that despite a shift away from traditional physically demanding industries, such as agriculture and manufacturing, certain risk factors were still prevalent. For example, 20% of participants reported breathing in smoke, fumes, powder or dust etc and 62% reported repetitive hand or arm movements a quarter of the time or more. The most exposed groups were craft and related trades workers, plant and machine operators, and skilled agricultural and fishery workers. The survey also found that the trends for most risk factors have stayed within a narrow range across the four surveys since 1991, and the proportion of workers exposed to vibrations, noise, and repetitive hand or arm movements has even increased over time (Parent-Thirion et al. 2007). Gender differences in physical work environments have also been reported (Burchell et al. 2007), for example, men were more likely to report breathing in smoke, fumes, powder or dust and exposure to vibration, and women were more likely to report repetitive hand or arm movements and lifting or moving people. However, the different occupational distribution of males and females played an important role in the observed gender differences. The gender gap does not appear to have narrowed across the four surveys (Burchell et al. 2007).

As a result of collecting information on a wide range of factors, the EWCS and the surveys modelled on it, only collected information on broad categories of exposure, for example 'breathing in smoke, fumes, powder or dust' and 'handling chemical substances' and the level of detail is therefore limited. In addition, the only health-related questions concerned perceived impact of work on health. National surveys of more detailed exposures include the National Hazard Exposure Worker Surveillance Survey (Australia) and the Workplace Health and Safety survey (UK).

The National Hazard Exposure Worker Surveillance Survey (Australian Safety and Compensation Council 2009) in Australia was a cross-sectional telephone survey conducted in 2008 and involved 1900 workers from five priority industries (transport and storage, health and community services, construction, manufacturing , and agriculture, forestry and fishing) and 2600 workers from both priority and non-priority industries. Participants were selected using random digit telephone dialling. The survey collected information on occupational characteristics, working arrangements, physical and chemical hazards, biological hazards, psychosocial hazards, and control measures. The questions on exposure were open-ended and referred to exposure on a typical day at work during the week prior to the interview. The survey found that between 30-43% of the sample were exposed to dust and/or gases, vapours, smoke or fume, chemicals, loud noise, and vibrating tools, equipment or vehicles in the week prior to the interview. The industries where workers were commonly exposed to workplace substances included mining, agriculture, forestry and fishing, construction, and manufacturing. As the survey targeted priority industries, it is not known to what extent the results accurately reflect population-level estimates. Furthermore, specific occupations and industries were not examined and only limited information was collected on health outcomes.

The Workplace Health and Safety survey (Hodgson et al. 2005) in the UK involved a cross-sectional telephone survey of 10,016 participants (the response rate was 26%) selected using random digit dialling of households. The survey collected information on dusts or fumes that could cause respiratory conditions, chemicals that could cause skin problems, as well as a wide range of physical hazards. Information on self-reported work-related injury and ill-health was also ascertained. Participants were asked whether they were exposed to specific dusts or fumes (for example flour or solder fume) and chemical or biological agents (for example cutting oils or coolants, plants or flowers) in the previous 12 months. The most commonly reported risk factors included chemicals that could cause skin problems (49%), slips/trips (30%), and dusts or fumes that could cause respiratory conditions (29%). The survey had a strong focus on workers' perception and attitudes towards exposures, such as whether workers were quite or very concerned that the risk factors they were exposed to could cause them harm and the perceived change in the levels of risk in the past 12 months.

In summary, the workforce surveys conducted overseas are valuable for assessing the prevalence and distribution of occupational exposures in the working population, and for identifying where the problems areas are. Most of the surveys collect a wide range of information on different aspects of the work environment and often a trade-off is required between the number of exposure variables assessed and the level of detail of these variables. A number of countries, particularly in Europe, have a long-standing tradition of conducting these workforce surveys and have therefore been able to monitor trends over time, while other countries have just recently conducted the first survey of working conditions in their country (for example Australia).

Table 2.3 Workforce surveys of occupational exposure conducted in overseas countries

Survey	Institution	Country	Survey period(s)	Dust/chemical factors	Physical factors	Population sampled	Survey design
National Hazard Exposure Worker Surveillance Survey	Australian Safety & Compensation Council	Australia	2008	Chemical products or substances (for example: cement, cleaning products, disinfectants, solvents, resins, paints, pesticides etc); dust, fumes, gases, vapours, smoke[#]	Loud noise; carry or lift heavy loads; work in twisted or awkward posture; repetitive hand or arm movements; vibration (tools, equipment or vehicles)	RDD sampling; 4,500 participants	Cross-sectional; telephone
Mikrozensus Survey - working conditions supplementary module	Statistics Austria	Austria	1980, 1985, 1991, 1994, & 1999	Dust; dirt, grease, oil; solid or liquid harmful or toxic substances; vapours, gases, smoke; ETS; EMF	Hot/cold conditions; industrial noise; office noise; traffic noise; vibrations; heavy, unwieldy tools; other heavy, physical workload; unergonomic working conditions; repetitive manual tasks; work requiring good manual dexterity & motor skills	SRS of approx 30,000 households	Cross-sectional, face-to-face
Quality of Life and Working Conditions Survey	Ministry of Labour & Social Policy	Bulgaria	2005	Vapours, smoke, dust, fumes or dangerous substances like chemicals, infectious materials; touching or handling dangerous products or substances; radiation	Vibrations; noise; high/low temperatures; painful working postures; moving heavy loads; repetitive movements	Two-stage cluster sampling; 1,002 participants	Cross-sectional, face-to-face
Working Conditions in the Czech Republic in 2000	Research Institute for Labour & Social Affairs	Czech Republic	2000	Chemical agents*	Physical agents*	Multi-stage random sampling; 1,000 participants	Cross-sectional, face-to-face
Danish Work Environment Cohort	National Research Centre for the Working Environment (formerly National Institute of Occupational Health)	Denmark	Every 5 years 1990-2005	Solvents; cleaning agents; wet hands; passive smoking	Heavy lifting (>10kg); loud noise; vibration; high temperatures; repetitive movements	Simple random sampling; 15,228 participants (2005)	Cohort & cross-sectional, face-to-face
European Working Conditions Survey	European Foundation for the Improvement of Living and Working Conditions	European Union	Every 5 years 1991-2010	Breathing in smoke, fumes, powder or dust; handling chemical substances; breathing in vapours such as solvents & thinners; radiation; ETS	Repetitive hand or arm movements; loud noise; vibration; high/low temperatures; tiring or painful positions; lifting or moving people; carrying or moving heavy loads	Multi-stage stratified & clustered design with random walk procedure; 29,766 participants (2005)	Cross-sectional, face-to-face
Work and Health Survey	Finnish Institute of Occupational Health	Finland	1994-5, 1997, 2000, 2003, & 2006	Chemical exposures ns (for example: dusts, detergents, solvents); radiation**	Noise; vibration; exceptional temperatures; repetitive work movements; uncomfortable working positions	Simple random sampling; 5,000 participants	Telephone
Quality of Work Life Survey	Statistics Finland	Finland	1977, 1984, 1990, 1997, 2003, & 2008	Dust; smoke, gases, fumes; irritant substances; dirt in work environment	Noise; heat/cold; difficult working positions; repetitive movements; heavy lifting; vibration	Sample from Labour Force Survey; 4,392 participants (2008)	Cross-sectional, face-to-face

Table 2.3 Workforce surveys of occupational exposure conducted in overseas countries							
Survey	**Institution**	**Country**	**Survey period(s)**	**Dust/chemical factors**	**Physical factors**	**Population sampled**	**Survey design**
SUMER Survey	Labour Relations Directorate & the Directorate for Research, Analysis & Statistics	France	1994, 2003	Chemical products; carcinogenic products ns**	Noise; lift heavy loads; repetitive movements	Sample of 1,792 company doctors administered questionnaire to randomly selected employees; 49,984 participants	Cross-sectional, face-to-face
Working Conditions Survey	Research, Analysis & Statistics Department	France	Every 7 years 1978-2005	Breathing in dust; handling toxic or dangerous products; breathing in fumes; breathing in toxic or dangerous products**	Moving heavy loads; repetitive work; staying for long periods in difficult or tiring positions; making painful or tiring movements; loud or piercing noise levels	Sample from Labour Force Survey; 19,000 participants (2005)	Cross-sectional, face-to-face
Germany BIBB/IAB Survey	Federal Institute for Vocational Traning Affairs (BIBB)/Institute for Employment Research (IAB)/Federal Institute of Occupational Safety and Health (BAuA)	Germany	1979, 1985/86, 1991/92, 1998/99, 2005/06	Handling dangerous materials, radiation; handling microbiological substances; smoke, fumes, vapour; oil, grease, dirt	Carrying or moving heavy loads; strong vibration; noise; low, hot, humid temperature; high frequency of repetitive work; awkward & static posture	Random route procedure; 20,000 participants	Cross-sectional; face-to-face & telephone
The State of Occupational Health and Safety in Hungary (Tarki Omnibusz survey)	Public Foundation for Research on Occupational Safety	Hungary	2001	Contact with harmful substances or products	Noise; vibration; high/low temperatures; lifting or moving heavy objects; repetitive movements; painful & tiring positions	Simple random sampling; 3,751 participants	Cross-sectional, face-to-face
Features and Quality of Work in Italy	Institute for the Development of Vocational Traning (ISFOL)	Italy	2002 & 2006	Dangerous substances; dust; radiation	Repetitive tasks; noise & vibrations; temperature variations; carrying heavy loads; unergonomic posture	Multi-stage random sampling; ~2000 participants	Cross-sectional, telephone
Industrial Safety Health - Survey on technological innovation and labour & Survey on the labour environment	Statistics & Information Department, Ministry of Health, Labour & Welfare	Japan	1993, 1996, 1998, 2001	Chemical agents ns**	Physical agents ns	SRS; 12,000 workers	Cross-sectional, face-to-face
Working Conditions Survey	Korea Occupational Safety & Health Agency	South Korea	2006	Chemical agents*	Physical agents*	SRS; 10,000 households	Cross-sectional, face-to-face

Table 2.3 Workforce surveys of occupational exposure conducted in overseas countries							
Survey	**Institution**	**Country**	**Survey period(s)**	**Dust/chemical factors**	**Physical factors**	**Population sampled**	**Survey design**
Northern Baltic Countries (NORBALT) Living Conditions Survey	Fafo's Centre for International Studies (Norway)	Latvia, Estonia & Lithuania	1994 & 1999	Dust from stones or metal; welding smoke; fumes from organic solvents; asbestos or other carcinogens; hazardous chemicals	Heat/cold; noise; vibration; heavy lifting; repetitive work; work in uncomfortable/unnatural position	Stratified cluster samples; 25,000 participants	Cross-sectional, face-to-face
Netherlands Working Conditions Survey	TNO Work & Employment	Netherland s	2003, 2005 & 2006	Dangerous substances (dermal & inhalation)	Loud noise; heavy physical work; repetitive movements; vibration; uncomfortable postures	SRS, 24,000 participants (2005)	Cross-sectional; postal
TNO Work Situation Survey	TNO Work & Employment	Netherland s	2000, 2002 & 2004	Chemical working conditions**	Heavy work/physical strain; noise; dangerous work	SRS, 4,000 participants (2004)	Cross-sectional; postal
Survey on Workers' Working Conditions	Statistics Department of the Ministry for Labour	Portugal	1999-2000	Breathing in toxic or dangerous products; handling dangerous or toxic products; handling explosive products; radiation	Repetitive & monotonous tasks; lifting/carrying heavy loads; vibrations; loud or piercing noises; working in tiring postures	SRS of establishments; 4,252 employees	Cross-sectional, face-to-face
National Working Conditions Survey	Spanish National Institute for Health & Safety	Spain	1987, 1993, 1997, 1999, 2003 & 2007	Handle dangerous substances; inhale hazardous or toxic dusts & smoke**	Noise; high temperatures; repetitive movements with the hands or arms	Sample of companies; random sample of employees; 4,054 managers & 5,236 workers (2003)	Cross-sectional, face-to-face
Work Environment Survey	Statistics Sweden	Sweden	Two-yearly basis since 1989	Oil or cutting fluids; cleaning agents and/or disinfectants; inorganic dust; organic dust; chemicals; ETS	Heavy lifting; noise; vibrations; heat/cold; repetitive work	SRS; 12,000 participants	Cross-sectional; telephone & postal
Work-related disorders	Swedish Work Environment Authority	Sweden	Annually since 1991	Chemical substances	Noise; vibrations; heat/cold; strenuous working postures; short repetitive tasks; manual heavy labour	SRS; 32,900 participants	Cross-sectional, telephone
Self-reported working conditions	Health & Safety Executive	UK	1995	Breathing fumes, dust & other harmful substances; handling or touching harmful substances or materials	Raised noise levels; use of vibrating machine or vehicle; use of power tools; repeating the same sequence of movements many times; awkward or tiring positions; lifting or moving heavy loads; uncomfortable heat or cold	SRS; 2,230 participants	Cross-sectional, face-to-face
Workplace Health and Safety	Health & Safety Executive	UK	2005	Dusts/fumes that could cause respiratory conditions (flour; spray paints; solder or welding fume); chemicals that could cause skin problems (cutting oils or coolants; soaps or cleaners; solvents; hairdressing chemicals; paints or glues; foods or flour; plants or flowers; wet cement or plaster; rubber chemicals & materials); asbestos; chemicals labelled as carcinogens	Lifting/carrying heavy loads; WBV; HAV; noise; repetitive movements; awkward or tiring positions	RDD sampling of households; 10,016 participants	Cross-sectional; telephone

Table 2.3 Workforce surveys of occupational exposure conducted in overseas countries

Survey	Institution	Country	Survey period(s)	Dust/chemical factors	Physical factors	Population sampled	Survey design
FIT3 Survey	Health & Safety Executive	UK	2006	Dust, fumes or gas; handling harmful materials (soaps, detergents or bleach; rubber or latex materials; alcohol wipes or disinfectants; other foodstuffs; oils incl metal working fluids; printing solvents or printing ink; cement, mortar or plaster; flour or grain; flowers, plants or plant saps; epoxy resins or hardeners; beauty, cosmetic or hair products; tile adhesive)	Noise & vibration; physically moving, lifting or carrying anything heavy	9,127 participants	Cross-sectional, face-to-face
Work Orientation Study of International Social Survey Program	National Opinion Research Centre/University of Chicago	USA	1989, 1997 & 2006		Frequency of dangerous and unhealthy job situations	Multi-stage area probability sample of households; 1,400 participants	Cross-sectional, face-to-face

*questions based on the European Working Conditions Survey

**not all exposure information available

#open-ended questions

Data sourced from the reports of the European Foundation for the Improvement of Living and Working Conditions (http://www.eurofound.europa.eu/ewco/surveys/national/index.htm)

Abbreviations

ns	not specified
ETS	Environmental tobacco smoke
EMF	Electromagnetic fields
HAV	Hand arm vibration
RDD	Random digit dialling
SRS	Stratified random sampling
WBV	Whole body vibration

In New Zealand, the first workforce survey was conducted over 2004-2006 and involved a nationwide telephone survey of a random sample of the New Zealand population aged 20-64 years (n=3,003) selected from the Electoral Roll. The questionnaire used for this survey included questions on lifetime work history, current exposures and workplace practices, and selected health outcomes (see Appendix 1). This thesis presents the first findings of this survey, starting with an overview of the occupational exposures present in the New Zealand workforce, and then focusing on gender differences in occupational exposure, ethnic differences in occupational exposure, and occupational risk factors for asthma symptoms. Background information on these topics is summarised in the following sections.

2.3 Gender differences in occupational exposure and health

The majority of occupational health and exposure assessment studies have been carried out in male populations and, in general, gender differences have been overlooked. A recent report on the state of women's occupational health and safety in New Zealand concluded that men have higher rates of work-related injuries, cancer, hearing disorders, and vibration-related diseases, whereas females are more likely to be affected by upper musculoskeletal disorders, workplace bullying, and sexual harassment (Mannetje et al. 2009). Gender differences in occupational distribution i.e. men and women working in different jobs and therefore being exposed to different risk factors, are likely to play a major role in the observed gender differences in these outcomes (Mannetje et al. 2009). This gender segregation of the workforce is observed throughout the industrialised world; women are more likely to work as professionals (particularly in health and education), service and sales workers, and clerks. These occupations are often characterised by fast-paced, monotonous, and repetitive work tasks. Males are more likely to work in the agricultural, trades, and manufacturing sectors and are therefore more likely to be exposed to dusts and chemicals and to physically demanding tasks such as heavy lifting. Very few studies have been able to examine the influence of the gender segregation of the labour force on differences in occupational exposure prevalence between men and women, with the exception of some workforce surveys. For example, in the fourth EWCS, men reported higher prevalences of exposure to vibration from hand tools or machinery, loud noise, and breathing in smoke, fumes, powder or dust at least half of the time compared to women. On the other hand, women were more likely to report repetitive hand or arm movements and lifting or moving people (Burchell et al. 2007). Men and women working in different occupations played an important role in these observed differences.

Differences in occupational morbidity have also been observed even for men and women with the same job title, suggesting a gender segregation of tasks within the same occupation. A small number of studies have compared the job tasks of men and women with the same job title. Messing et al examined job content for men and women with the same job title for blue-collar employees of a Quebec municipality. The study found that men and women with the same job title did not carry out the same tasks (Messing et al. 1994). 45% of men and 52% of women reported a gendered assignment of tasks. However, the job content analysis was based on only 68 workers in up to 14 job titles and the possibility of differences in perception for the gendered task allocation could not be excluded (Messing et al. 1994). Messing also observed that male and female cleaners in a Quebec hospital had different tasks and therefore different exposures even though they had the same job title (Messing 1998). In addition, a Swedish study of fish processing workers reported that, despite similar job requirements, women had poorer working conditions than men with respect to repetitiveness, constrained neck postures, and psychosocial work environment (Nordander et al. 1999). Several studies have also reported that women are more likely to perform repetitive tasks compared to men in the same job (Hooftman et al. 2005, Strazdins & Bammer 2004). Gender differences in task assignments could be due to the different physical capabilities of men and women, for example men are more likely to carry out heavy lifting. However, Messing argues that social constructions of what is suitable work for men and women also play a role and that many physical tasks assigned to men can be adapted to women (Messing 1998). For example, further analysis of the hospital cleaners study concluded that there was no clear reason why women could not perform the 'heavy' work typically assigned to men (Messing et al. 1998). To date, most of the evidence on differences in occupational exposure for men and women within the same occupation has been based on studies of small numbers of workers or focused on one specific occupational group.

Women have also been found to report poorer psychosocial working conditions and more workplace stressors than men; however, the current evidence for gender differences in work-related stress is inconsistent (Mannetje et al. 2009). Women are more likely to work in high-strain jobs with less decision autonomy, less control over the work process, fewer opportunities for job advancement, and are also more likely to work part-time and have a more temporary or casual work arrangement (Mannetje et al. 2009), all of which could contribute to psychological stress. In particular, part-time and casual work has been associated with lower job control, poorer work conditions, and less health and safety training (Bohle et al. 2008). On the other hand, men are more likely to work in managerial and professional roles, which have been identified as high risk occupations for job stress (Dryson et al. 1996).

Thus, few studies have examined differences in occupational exposure between men and women, particularly within the same occupation, and knowledge of occupational hazards for women remains scarce. An understanding of gender differences in occupational exposure is a necessary first step towards understanding gender differences in occupational morbidity. Chapter 4 of this thesis uses the data of the first New Zealand workforce survey to study the differences in occupational exposure prevalence between men and women and investigates to what extent these differences exist between and within occupations.

2.4 Ethnic differences in occupational exposure and health

While ethnic disparities in health have been well documented, it is unknown to what extent the work environment contributes to these disparities. In New Zealand, there is a paucity of information available on occupational health in Māori workers. Ethnic differences in occupational injury rates have been demonstrated in the U.S (Frumkin et al. 1999, Murray 2003, Robinson 1984), where several studies have shown that Black workers have a higher rate of fatal (Loomis & Richardson 1998, Stout et al. 1996) and non-fatal work-related injury than White workers, even after adjusting for education and potential work experience (Robinson 1987, Robinson 1989).

Minority and indigenous workers are typically overrepresented in low-skilled, manual and therefore relatively more hazardous occupations. Ethnic differences in employment patterns have been shown to explain the higher occupational injury rate in Black workers in the U.S (Chen & Layne 1999, Loomis & Richardson 1998, Strong & Zimmerman 2005). In New Zealand, the different employment patterns between Māori and non-Māori have been shown to contribute to the higher fatal and non-fatal injury rates for Māori.

McCracken et al. examined coronial files for work-related fatal injury occurring for the period 1985-1994 and found that Māori workers had a higher crude fatality rate (6.60/100,000 workers/year) than non-Māori workers (4.96/100,000 workers/year) (Relative Risk (RR)=1.32; 95% CI (confidence interval) 1.06-1.65). Standardisation of the Māori rate to the non-Māori occupational distribution attenuated the difference to RR=1.10 (95% CI 0.86-1.41), suggesting that occupational distribution explains ~70% of the difference between Māori and non-Māori fatality rates (McCracken et al. 2001). A similar pattern was found for non-fatal work-related injury based on ACC claims (McCracken 2002).

The few studies of ethnic differences in occupational hazards were mainly conducted in the U.S in the 1970-80s (Murray 2003, Robinson 1984). A recent cross-sectional study in the U.S of workers in four industries (n=1,282) examined social disparities in reporting of high exposure for Black, Latino, and White workers. Overall, the results illustrated a complex pattern; Black workers were less likely to report exposure to dust, chemicals, noise, back strain, repetitive hand motions, and heavy lifting compared to White workers, and these associations were attenuated after adjusting for industry/job (Quinn et al. 2007). The authors postulated that social differences in the perception or reporting of exposures may be one potential explanation; however, this study only examined four industries with workers in a limited socioeconomic range. In addition to ethnic differences in physical work environments, several studies have reported that minority workers often experience worse psychosocial work environments, for example, they often have less control over the work process, fewer opportunities for job modification and advancement, less decision autonomy, and are more likely to encounter racial discrimination (Hemingway et al. 2001, Krieger et al. 2006, Shannon et al. 2009).

Thus, in New Zealand there is some evidence of ethnic differences in occupational injury rates which appear to be largely attributed to ethnic differences in employment patterns. However, there is a serious lack of information on ethnic disparities in occupational disease rates and risk factors for occupational disease and therefore the contribution of the work environment to ethnic disparities in health remains unknown. Chapter 5 of this thesis uses the data of the first New Zealand workforce survey to study the differences in occupational exposure prevalence between Māori and non-Māori and investigates to what extent these differences exist between and within occupations.

2.5 Occupational asthma

The association between occupational exposures and asthma is often hard to establish due to the lack of recognition of occupational risk factors and the absence of a 'gold standard' for the definition and diagnosis of asthma. In addition, many studies of occupational asthma are unable to distinguish between new-onset asthma caused by workplace exposures and pre-existing asthma exacerbated by workplace exposures. As a result, the proportion of asthma cases attributable to occupational exposures is unknown, but has been estimated to range between 15 and 20% (Balmes et al. 2003, Blanc & Toren 1999, Toren & Blanc 2009). However, substantially higher estimates were reported in a study of the entire employed population of Finland from 1986-1998, which estimated that the attributable fraction of adult-onset asthma due to occupation was 29% for men and 17% for women (Karjalainen et al. 2001).

Certain occupational groups are known to be at particularly high risk of occupational asthma, including laboratory workers, healthcare workers, construction workers, bakers, woodworkers handling western red cedar, and chemical workers exposed to isocyanates. However, the majority of studies of occupations and associated causal agents have traditionally been conducted in specific groups of workers and only some findings have been investigated in epidemiological studies of the working population. Furthermore, studies of specific worker groups have often had small sample sizes and the possibility of the healthy worker effect in such studies i.e. workers leaving a job as a result of the onset of asthma symptoms, cannot always be ruled out.

Several large population-based studies have investigated associations between occupation and asthma symptoms, the most notable of which was the ECRHS. This survey involved 15,637 randomly selected participants aged 20-44 years from 12 industrialised countries. Asthma was based on two definitions: the first definition was based on questionnaire information alone and the second definition was based on questionnaire information combined with BHR assessed using a methacholine challenge. Asthma assessed by questionnaire was defined as: a) woken by an attack of shortness of breath in the past 12 months; or b) asthma attack in the past 12 months; or c) current use of asthma medication (Burney et al. 1994). Positive associations were reported for asthma (BHR and asthma symptoms) and current employment as a farmer, painter, plastics worker, cleaner, spray painter, and agricultural worker. A JEM was created to assess exposure (none, low or high) to biological dusts, mineral dusts, and fumes and gases. Significantly elevated odds of asthma of between 35-60% were demonstrated for high exposure to these agents (Kogevinas et al. 1999). A follow-up of the ECRHS examined the risk of new-onset asthma in participants who were free of asthma symptoms at the time of the first survey (n=6,837). An occupational history for the period between the two surveys (a median of 9 years) was obtained. Elevated risks of new-onset asthma were observed for employment in a pre-defined group of high-risk occupations and for exposure to a pre-defined group of high-risk agents based on an asthma-specific JEM (Kogevinas et al. 2007).

In Finland, the association between occupation and adult-onset asthma was investigated in a follow-up study of the entire employed population during 1986-1998 (Karjalainen et al. 2002, Karjalainen et al. 2001). Finland has one of the most complete national notification systems for occupational asthma in the world as all individuals with clinically well-established asthma are registered for reimbursement of medication from the national health insurance scheme. Study cases were ascertained from the medication reimbursement register and the Finnish Registry of Occupational Diseases and occupation was recorded at the beginning of three census-based cohorts. The highest excess risks of incident asthma for men were observed among bakers, laundry workers, shoemakers and repairers, tanners, fell mongers and pelt dressers, and metal plating and coating workers. For women, risks of incident asthma were highest among shoemakers and repairers, railway and station personnel, jewellery engravers, engine room crew, molders, round-timber workers, and bakers (Karjalainen et al. 2002).

A number of cross-sectional population-based studies of occupational asthma have been carried out, including studies in the U.S (Arif et al. 2003, Arif et al. 2002), Australia (Johnson et al. 2006), Canada (Johnson et al. 2000), the Netherlands (Vermeulen et al. 2002), and France (LeMoual et al. 2004). The studies that have specifically assessed occupational exposures have generally examined self-report of exposure to dust, vapours or fumes or applied a JEM to occupational titles. In France, an asthma-specific JEM was developed for use in the Epidemiological Study of Genetics and Environment in Asthma (EGEA) (Kennedy et al. 2000) and application of the JEM in various studies has found significant associations between asthma and agents such as highly reactive chemicals (Kennedy et al. 2000) and industrial cleaning agents (LeMoual et al. 2004). To date, only one study has examined psychosocial work conditions in relation to asthma. This population-based cohort study found that participants reporting high work stress had a more than two-fold increased risk of developing asthma after approximately 8 years of follow-up compared to those reporting low work stress (Loerbroks et al. 2010).

Most of the population-based studies that have investigated work-related asthma have been hampered by their assessment of occupational exposure. The relevant exposure period for occupational asthma varies according to the specific causal agent(s) involved, however the occupation just before asthma onset is thought to be particularly significant (Kennedy et al. 2000). The ECRHS studies assessed current occupation (classified into 21 occupational groups) and although previous occupation was recorded if the worker had changed jobs due to respiratory symptoms, previous exposures (particularly around the age of asthma onset) were not taken into account. Similarly, the longitudinal studies conducted in Finland (Karjalainen et al. 2002, Karjalainen et al. 2001) were only able to examine occupation at one specific point in time (i.e. at the start of the three census-based cohorts). Several studies have examined employment in a pre-defined group of high-risk occupations or exposure to a pre-defined group of high-risk substances (Johnson et al. 2000, Kogevinas et al. 2007) making it difficult to identify previously unrecognised risk factors for occupational asthma. Finally, ‘new’ risk factors may not be identified if certain groups (for example administrative and clerical) are assumed *a priori* to be the unexposed reference group, as is the case with most previous studies (Karjalainen et al. 2002, Kogevinas et al. 1999).

As a result of varying definitions of both exposure and asthma in previous population-based studies and continually evolving work environments, further information is required on both recognised and previously unrecognised risk factors for occupational asthma in the working population. Chapters 6 and 7 of this thesis examine occupational risk factors for current and adult-onset asthma, including associations with occupation as well as self-reported job stress.

CHAPTER 3

The New Zealand Workforce Survey: self-reported occupational exposures

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Introduction: This study examines the prevalence of a range of occupational risk factors reported by a random sample of the New Zealand working population.

Methods: Men and women aged 20-64 were selected from the New Zealand Electoral Roll and invited to take part in a telephone interview, which collected information on lifetime work history, current workplace exposures and organisational factors, and various health conditions. The prevalences of occupational risk factors in each occupational and industry group are reported.

Results: Three thousand and three interviews were completed (37% of the eligible sample and 55% of those that could be contacted). Trades workers reported the highest prevalences of exposure to dust (75%) and oils and solvents (59%). Agriculture and fishery workers reported the highest prevalences of exposure to pesticides (63%) and acids or alkalis (25%). Plant and machine operators and assemblers reported the highest prevalences of exposure to smoke/fume/gas (43%), working night shift in the previous 4 weeks (18%), and working irregular hours (33%). In the high exposure occupational and industry groups, males reported a higher prevalence of exposure than females. Lifting, exposure to loud noise, and the use of personal protective equipment were reported by > 50% of the manual occupational groups.

Conclusions: This study indicates that occupational exposure to risk factors for work-related disease and injury remains common in the New Zealand working population. While these occupational exposures are disproportionately experienced by workers in certain industries, they also occur in occupational groups not traditionally associated with hazardous exposures or occupational disease.

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Introduction

The nature of work in many westernised countries is rapidly changing. This is likely to impact on the range and type of risk factors workers are exposed to, and their subsequent risk of occupational ill-health. However, the majority of studies on occupational exposures have focused on specific industries and exposures traditionally associated with occupational ill-health, thus potentially overlooking occupational groups and occupational risk factors of particular concern today. The aim of this study was to obtain a comprehensive picture of the current exposures and workplace practices in the New Zealand workforce, in order to identify current and emerging hazards that account for, or will account for, a significant burden of occupational ill-health.

This first paper describes the study methods and presents the prevalence of self-reported exposure to a range of occupational risk factors by occupational and industry groups. This will allow us to benchmark against comparable westernised countries. In contrast to previous workforce surveys, we were able to investigate exposure prevalence by specific occupations and industries, examine organisational factors as well as physical exposures, and investigate the use of subtypes of personal protective equipment (PPE). The study will also be used to assess the relationships between workplace exposures and selected health outcomes (i.e. respiratory symptoms, musculoskeletal problems, and sleep disorders) and to examine gender and ethnic differences in occupational exposure patterns and health. In addition, the findings of this study will be used to validate the New Zealand-specific Job-Exposure-Matrix.

Methods

Ten thousand potential participants aged 20-64 were randomly selected from the Electoral Roll (7000 from the 2003 Electoral Roll and 3000 from the 2005 Electoral Roll when it became available) over a 2-year period (2004-2006). The Electoral Roll is the best sampling frame available in New Zealand as it is ~95% complete and any bias is likely to be small, particularly for employed people. The sample of 10,000 was chosen from ~1,900,000 people aged 20-64 on the Electoral Roll. The invitation to participate in a telephone interview was mailed up to three times and we contacted non-respondents by phone where a phone number was available from the electronic phone book.

The questionnaire included questions about: i) lifetime work history; ii) current workplace exposures; iii) occupational morbidity (respiratory symptoms, sleep patterns, and musculoskeletal problems); and iv) demographics, including age, gender, ethnicity, and lifestyle factors such as smoking.

A complete work history was obtained for all jobs held for a minimum of 6 months. More detailed information was also obtained for the current or most recent job, including a description of the tasks and processes. In addition, we asked whether the following exposures were present in the current work environment: dust; smoke or fume; gas; oils and solvents; acids or alkalis; fungicides, insecticides, herbicides or timber preservatives; and other chemical products (including dyes, inks, and adhesives). Participants were also asked how often their current job involved exposure to a list of physical and organisational factors, including lifting and loud noise (all the time, three quarters of the time, half of the time, one quarter of the time, or never). Questions relating to PPE asked whether any was used at work and which types (goggles, footwear, apron, simple dust mask, filter cartridge respirator, air-supplied respirator or self-contained breathing apparatus (SCBA), rubber or plastic gloves, or hearing protection).

All jobs were coded using the New Zealand Standard Classification of Occupations (NZSCO) 1999 (Statistics New Zealand 2001b) and industries were coded using the Australian and New Zealand Standard Industrial Classification (ANZSIC) 1996 (Statistics New Zealand 1997). The occupational code for current job was based on a detailed task description and the industry code was based on the main activity of the employer.

Ethics approval for the study was obtained from the Massey University Human Ethics Committee (WGTN 03/133).

Statistical analyses

All questionnaire information was entered into an ACCESS database. The prevalence of exposure was defined as the proportion of individuals who reported being exposed as part of their current job, at any frequency, duration or level of exposure. Results were also examined after stratification by gender and age (<45 years and $\geq$45 years) and χ^2 analyses were carried out. We examined differences between respondents and non-respondents by gender, age, Māori ethnicity, occupational code, and the 2001 deprivation index (a census-based index with a relative deprivation score assigned to each geographical meshblock in New Zealand: 1-least deprived to 10-most deprived); this information was available for all potential study participants from the Electoral Roll. All analyses were conducted using STATA (STATA Statistical Software Release, 8.0).

Results

Of the 10,000 invitations, 1,209 were returned to sender and 637 potential participants were classified as ineligible (for example: no longer living in New Zealand, deceased, never worked in New Zealand). Of the remaining 8,154 eligible individuals, 2,719 did not respond to up to three invitation letters. Of those we could contact, 3,003 took part in the interview (an additional 7 questionnaires were missing and therefore excluded) and 2,425 refused to take part. The main reason for refusal was lack of time. Thus, the contact rate (number of successful contacts made/total eligible sample) was 67%; the interview rate (number interviewed/ interviewed plus refused) was 55%; and the overall response rate (number interviewed/total eligible sample) was 37%.

In the group that did not participate, there was a higher proportion of 20- to 34-year- olds, Māori, and unemployed, and a lower proportion of professionals compared to the participants. Differences in deprivation index were also found (Table 3.1). Standardising the study sample to the age, gender, ethnicity, and deprivation distribution of the original sample had only a minimal effect on the results; thus for simplicity, we present the unstandardised results.

There was a similar proportion of men and women in the study sample and the age range was 20-67 years, with the average age of participants being 44 years (Table 3.2). Males worked more paid hours per week on average and reported higher prevalences of workplace exposures, working night shift and irregular hours, and the use of PPE.

Table 3.1 Description of total sample

	Total sample N=9926[a]	Participants N=2989[b]	Non-participants N=6937[c]	Chi^2
	%	%	%	
Gender				
Male	48.6	47.7	49.0	
Female	51.4	52.3	51.0	p=0.25
Age				
20-34	33.3	23.6	37.4	
35-44	26.8	28.2	26.1	
45-54	22.7	28.3	20.3	
>55	17.3	19.8	16.2	p<0.001
Mean age	41.2	43.5	40.2	
SD	12.1	11.3	12.3	
Ethnicity				
Non-Māori	77.5	79.9	76.5	
Māori	14.8	10.9	16.5	
Missing	7.7	9.2	7.1	p<0.001
Occupational (NZSCO) code				
1-Legislators, administrators & managers	9.2	10.3	8.7	
2-Professionals	13.6	20.0	10.8	
3-Technicians & associate professionals	8.2	9.7	7.6	
4-Clerks	8.0	9.8	7.2	
5-Service & sales workers	7.8	7.6	7.9	
6-Agricultural & fishery workers	4.5	5.1	4.3	
7-Trades workers	7.6	7.4	7.6	
8-Plant & machine operators & assemblers	5.3	4.7	5.5	
9-Elementary occupations	3.7	3.1	4.0	
Unemployed	26.0	18.3	29.3	
Missing	6.2	4.1	7.1	p<0.001
New Zealand Deprivation Index 2001				
1 (least deprived)	10.7	14.1	9.3	
2	10.2	11.7	9.5	
3	10.1	11.2	9.6	
4	10.1	11.4	9.5	
5	10.0	11.1	9.5	
6	9.5	9.8	9.4	
7	9.3	8.2	9.8	
8	9.1	7.6	9.7	
9	9.4	7.4	10.2	
10 (most deprived)	8.3	4.7	9.9	
Missing	3.4	2.8	3.7	p<0.001

[a]Seventy-four gender missing
[b]Fourteen gender missing
[c]Sixty gender missing

Table 3.2 Description of study sample

	Total		Men		Women	
	N=3003		N=1420 (47.3%)		N=1583 (52.7%)	
	n	%	n	%	n	%
Age at interview						
20-34	659	21.9	301	21.2	358	22.6
35-44	820	27.3	348	24.5	472	29.8
45-54	868	28.9	402	28.3	466	29.4
>55	656	21.8	369	26.0	287	18.1
Ethnicity						
New Zealand European	2454	81.7	1151	81.1	1303	82.3
Māori	270	9.0	106	7.5	164	10.4
Pacific Island	41	1.4	18	1.3	23	1.5
Other	375	12.5	193	13.6	182	11.5
Hours per week						
Mean (SD)	39 (14.8)		44.7 (13.2)		33.9 (14.2)	
Range	0.8-100		1.5-100		0.8-98	
>40 h	1200	40.1	833	58.8	367	23.3
Missing	8		3		5	
Days per week						
Mean (SD)	4.9 (1.1)		5.2 (1.0)		4.7 (1.2)	
>5 days	679	22.7	432	30.5	247	15.7
Missing	11		3		8	
Exposure						
Dust	881	29.3	569	40.1	312	19.7
Smoke/fume/gas	642	21.4	412	29.0	230	14.5
Oils and solvents	628	20.9	420	29.6	208	13.1
Acids or alkalis	282	9.4	188	13.2	94	5.9
Pesticides	287	9.6	205	14.4	82	5.2
Lifting (25% of time or more)	1177	39.3	608	42.9	569	36.0
Missing	6		3		3	
Loud noise (25% of time or more)	895	29.9	569	40.1	326	20.7
Missing	7		2		5	
Personal protective equipment	1426	47.5	873	61.5	553	35.0
Missing	1				1	
Night shift in previous 4 weeks	204	6.9	138	9.9	66	4.3
Not applicable	73	2.5	33	2.4	40	2.6
Missing	61		30		31	
Irregular hours	483	16.1	284	20.0	199	12.6
Missing	6		2		4	

Exposure prevalence by occupation

Self-reported exposure prevalence by occupational group is presented in Table 3.3 (self-reported exposure prevalence by industry group figures are available at the end of this chapter). Trades workers (NZSCO 7, n=240) reported a relatively high prevalence of exposure to dust, oils and solvents, smoke/fume/gas, and acids or alkalis. When specific occupations were considered, 97% (n=60) of carpenters and joiners (job code: 7112) reported exposure to dust and 58% (n=36) reported exposure to oils and solvents. Ninety-one percent (n=21) of metal moulders, sheet-metal and related workers (job code: 721) reported exposure to dust; 83% (n=19) reported exposure to smoke/fume/gas; and 43% (n=10) reported exposure to acids or alkalis. Exposure to oils and solvents was reported by 84% (n=21) of painters and paperhangers (job code: 7124) and 79% (n=23) of machinery mechanics and fitters (job code: 723).

Agricultural and fishery workers (NZSCO 6, n=181) reported the highest prevalences of exposure to pesticides (68% male; 53% female, p=0.05) and acids or alkalis (31% male; 15% female, p=0.02). There was no marked difference in prevalence of exposure to pesticides between market farmers and crop growers (67%, n=38) and market-oriented animal producers (63%, n=70). Livestock producers (job code: 6121) reported a relatively high prevalence of exposure to acids or alkalis (36%, n=31).

Plant and machine operators and assemblers (NZSCO 8, n=179) reported the highest prevalence of exposure to smoke/fume/gas (47% male; 21% female, p=0.01) and over half of the participants reported exposure to dust. More specifically, industrial plant operators (job code: 81) reported high prevalences of exposure to smoke/fume/gas (75%, n=18) and oils and solvents (54%, n=13).

More than 50% of service and sales workers, agricultural and fishery workers, trades workers, plant and machine operators and assemblers, and elementary occupations reported lifting in their current job a quarter of the time or more (Table 3.3). More than half of the latter three occupational groups also reported exposure to loud noise a quarter of the time or more. In particular, carpenters and joiners reported a high prevalence of both lifting (85%, n=53) and exposure to loud noise (87%, n=54) a quarter of the time or more, and metal moulders, sheet-metal and related workers reported a high prevalence of exposure to loud noise (87%, n=20) a quarter of the time or more.

Plant and machine operators and assemblers reported the highest prevalences of working for at least 3 hours between midnight and 5am (night shift) in the previous 4 weeks. This group also reported working regularly outside the hours of 8am to 5pm (irregular hours). Health and protective service workers also reported relatively high prevalences of night shift work and working irregular hours.

Overall, males reported higher prevalences of exposure than females; however, this was largely attributed to a higher proportion of males in the ‘manual’ occupational groups (NZSCO 6-9). Nevertheless, there were several instances where males reported higher prevalences of exposure than females even within the same occupational group, particularly for elementary occupations and farming. The only exception was a higher prevalence of lifting for females in the professionals group (19% male; 29% female, p=0.01).

While the prevalences of work-related exposures were similar in younger (<45 years) and older (≥45 years) age groups, there were a few exceptions. The younger group (<45 years) reported higher prevalences of exposure to smoke/fume/gas (50% versus 33%, $p=0.01$) and acids or alkalis (27% versus 16%, $p=0.04$) among trades workers; to dust (64% versus 49%, $p=0.05$), oils and solvents (41% versus 27%, $p=0.04$), and lifting (71% versus 46%, $p<0.01$) among plant and machine operators and assemblers; and to loud noise in elementary occupations (67% versus 38%, $p<0.01$). On the other hand, the older group of agricultural and fishery workers reported a higher prevalence of exposure to pesticides than the younger group (56% <45 years; 68% ≥ 45 years, $p=0.09$).

Table 3.3 Self-reported exposure prevalence by current job (1-digit code)

	Total	NZSCO 1 Legislators, Administrators & Managers	NZSCO 2 Professionals	NZSCO 3 Technicians & Associate Professionals	NZSCO 4 Clerks	NZSCO 5 Service & salesworkers	NZSCO 6 Agricultural & fishery workers	NZSCO 7 Trades workers	NZSCO 8 Plant & machine operators & assemblers	NZSCO 9 Elementary workers
	%	%	%	%	%	%	%	%	%	%
Dust	29.4	25.2	17.3	19.3	18.3	20.1	55.8	75.4	55.3	37.2
Smoke/fume/gas	21.4	19.2	15.1	13.6	13.5	23.6	28.2	42.5	43.0	25.7
Oils & solvents	20.9	15.6	12.0	15.6	7.3	21.8	35.9	58.8	33.0	31.9
Acids or alkalis	9.4	6.7	6.9	7.0	2.5	8.3	25.4	21.7	11.7	14.2
Pesticides etc	9.6	5.0	3.7	5.9	2.8	2.9	63.0	16.7	10.6	16.8
Protective equipment	47.5	36.0	35.0	33.6	18.3	54.3	90.6	90.4	82.7	77.9
Night shift	6.9	7.0	7.6	5.2	2.3	8.7	5.7	4.8	17.5	9.1
Irregular hours	16.1	12.1	13.8	12.4	7.9	24.1	27.9	13.8	33.0	23.0
Lifting	39.3	27.4	25.5	31.1	24.2	53.6	70.0	68.8	56.4	64.6
Loud noise	29.9	21.8	19.7	18.1	15.8	24.4	48.9	71.6	67.6	52.2

Personal Protective Equipment

Almost one-half of the sample reported wearing PPE in their current job. There was a high prevalence of PPE use in the occupational groups reporting high prevalences of exposure (Figure 3.1). In most cases, males reported a higher prevalence of PPE use than females. Trades workers reported a relatively high prevalence of the use of goggles (63%, n=150) and hearing protection (64%, n=153). Just less than half reported simple dust mask use (n=117) and 18% (n=43) reported using filter cartridge respirators. Fifty-five percent (n=99) of agricultural and fishery workers reported wearing gloves at work and 47% (n=85) reported hearing protection use. Overall glove use at work was low, except for the health and community services industry where just over one-half reported wearing gloves.

Of those participants reporting exposure to dust, 42% (n=366) reported wearing goggles and only 28% (n=243) reported wearing simple dust masks at work (Figure 3.2). Similarly, a low proportion of those reporting exposure to smoke/fume/gas reported wearing simple dust masks (24%, n=154) or filter cartridge respirators (11%, n=72). Glove use was more common in participants reporting exposure to oils and solvents (51%, n=319), acids or alkalis (62%, n=176), and pesticides (55%, n=158). Of those participants exposed to loud noise a quarter of the time or more, only 40% (n=358) reported wearing hearing protection. Furthermore, only 39% (n=79) of those exposed to loud noise half to three quarters of the time and 47% (n=184) of those exposed three quarters to all of the time reported hearing protection use. Trades workers exposed to loud noise reported a relatively high prevalence of hearing protection use regardless of frequency of exposure (Figure 3.3), whereas the proportion of plant and machine operators and assemblers and elementary workers frequently exposed to loud noise and reporting hearing protection use was barely half.

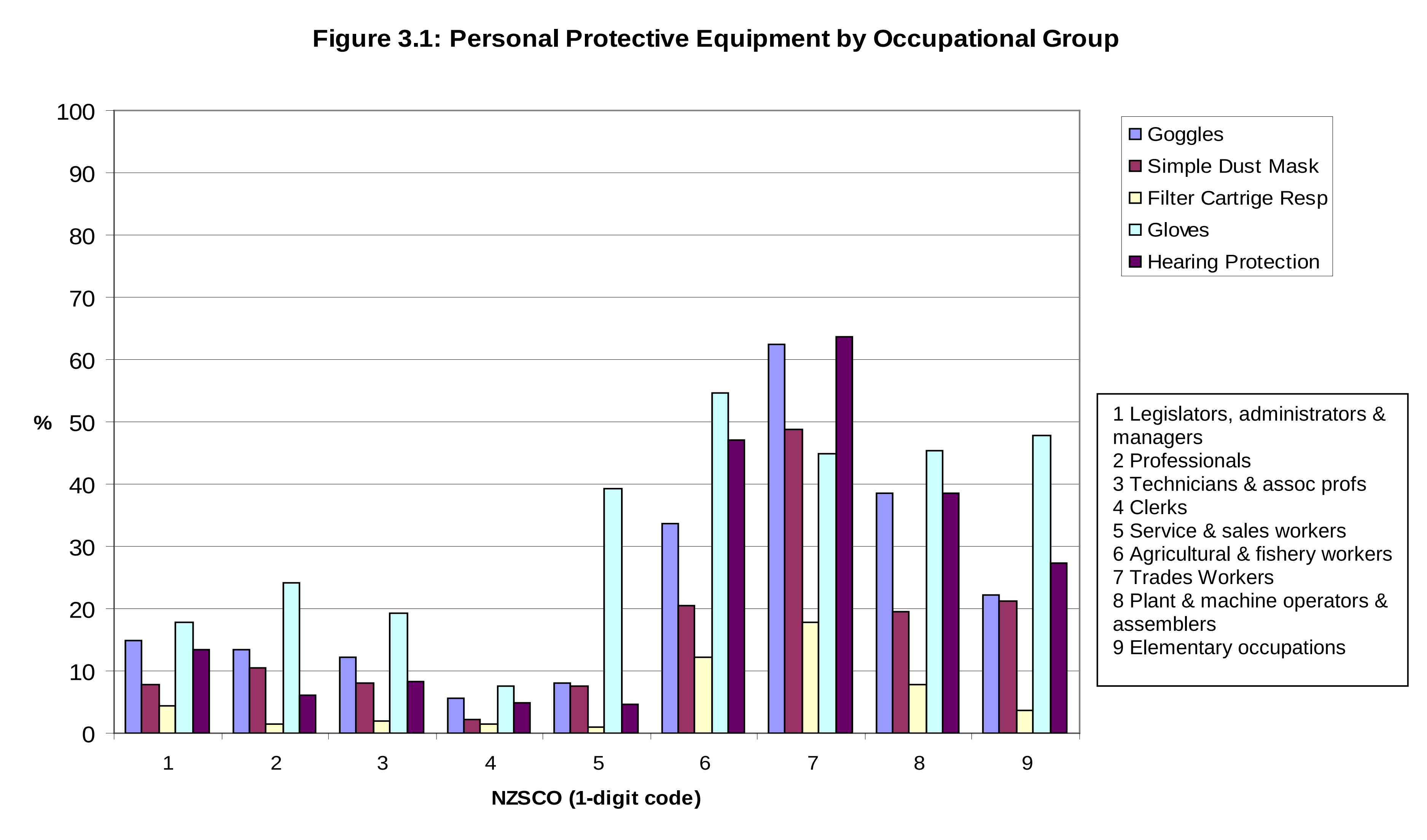


Figure 3.1: Personal Protective Equipment by Occupational Group
100
90
80
70
60
%
50
40
30
20
10
0
1
2
3
4
5
6
7
8
9
NZSCO (1-digit code)
Goggles
Simple Dust Mask
Filter Cartrige Resp
Gloves
Hearing Protection
1 Legislators, administrators & managers
2 Professionals
3 Technicians & assoc profs
4 Clerks
5 Service & sales workers
6 Agricultural & fishery workers
7 Trades Workers
8 Plant & machine operators & assemblers
9 Elementary occupations

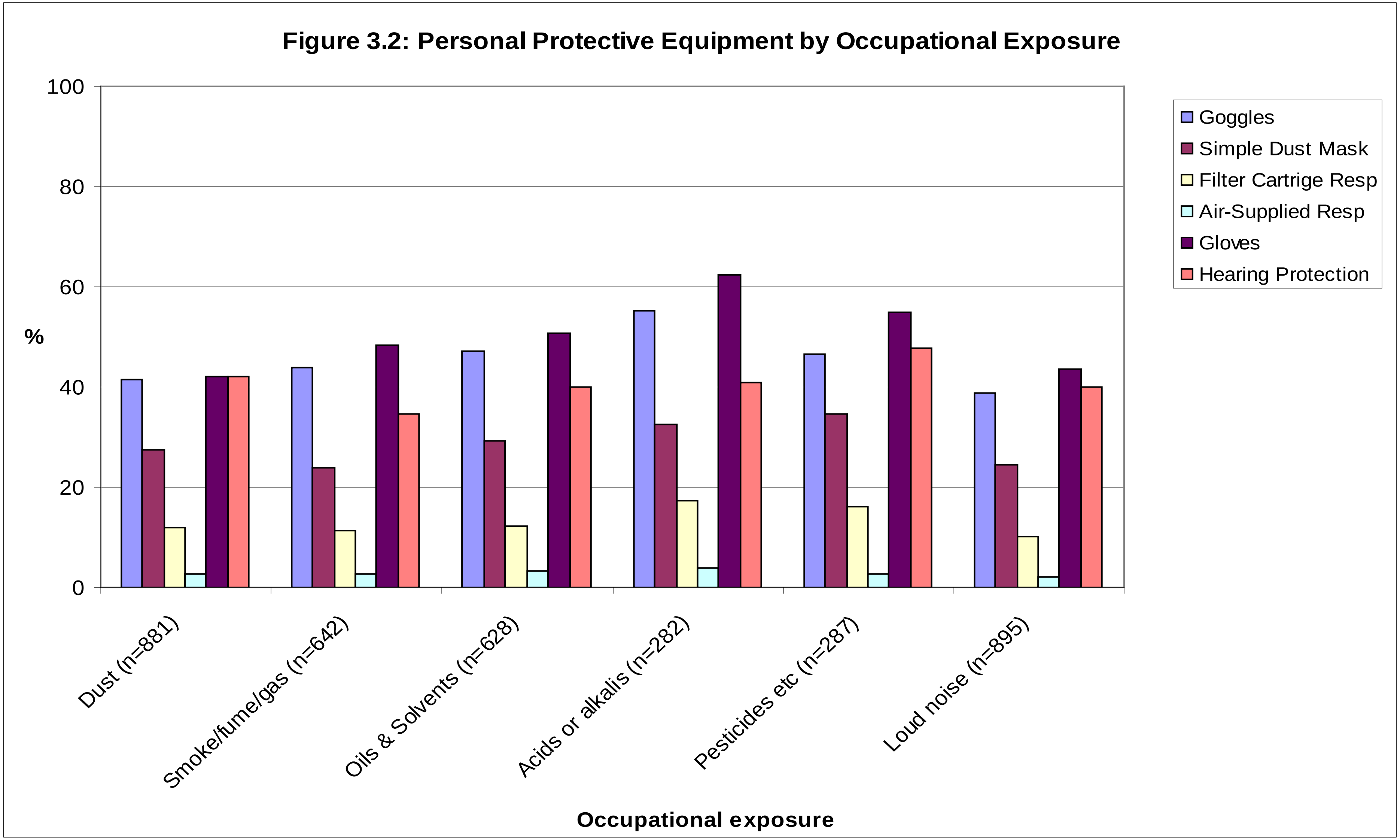
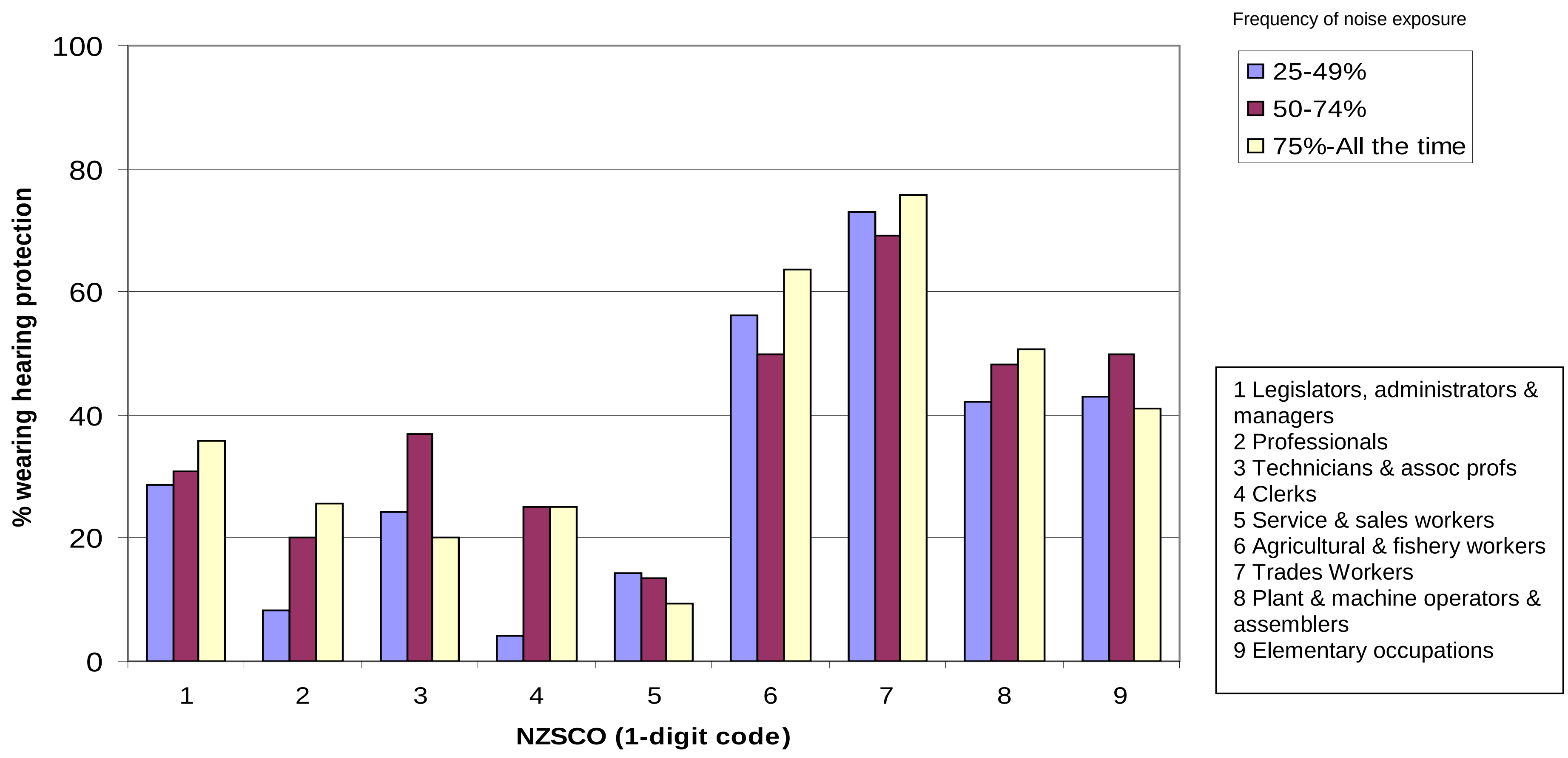


Figure 3.2: Personal Protective Equipment by Occupational Exposure
100
80
60
40
20
0
%
Goggles
Simple Dust Mask
Filter Cartrige Resp
Air-Supplied Resp
Gloves
Hearing Protection
Dust (n=881)
Smoke/fume/gas (n=642)
Oils & Solvents (n=628)
Acids or alkalis (n=282)
Pesticides etc (n=287)
Loud noise (n=895)
Occupational exposure

Figure 3.3: Hearing protection use among respondents exposed to loud noise



Discussion

This study examined the prevalence of a range of occupational risk factors reported by the current working population in New Zealand. The strengths of the study are that it: (i) includes both men and women; (ii) includes 'high-risk' occupations and industries as well as those that have never been studied; and (iii) covers not only chemical and physical exposures but also organisational factors, all of which may contribute to occupational disease and injury. In this first report, we have presented the methods of the study and the prevalences of occupational exposures and use of protective equipment by occupational and industry groups.

Response rate

The response rate of this telephone survey was 37% and the interview rate was 55%, which is typical for this type of survey, where most response rates are reported at <60% (Tourangeau 2004). For example, the response rate of the Workplace Health and Safety Survey Programme in the UK was 26% (n=10,016) (Hodgson et al. 2005). The overall response rate for the fourth European Working Conditions Survey (EWCS) was 48% (Parent-Thirion et al. 2007) (face-to-face interviews). The main determinants of our low response rate were an inability to establish contact with the potential participants and refusal to participate once contact was established. Some groups were underrepresented in our study sample, particularly the younger age groups, Māori, housewives, the unemployed, and the retired (Mannetje et al. 2006). However, the prevalence estimates of self-reported occupational exposures, lifestyle factors, and health did not change appreciably after standardising toward the demographic distribution of the source population, indicating that non-response adjustment of the survey results is not warranted.

Self-reported exposure prevalence

Our findings on the prevalences of self-reported exposure to dust, smoke/fume/gas, and oils and solvents by occupation and industry are generally comparable to those of similar surveys conducted in other countries. In 2005, the fourth EWCS was carried out in almost 30,000 European workers in 31 countries (Parent-Thirion et al. 2007). The survey found that one in five workers reported breathing in smoke, fumes, powder, or dust a quarter of the time or more. In the Finnish Quality of Work Life Survey (2003), 33% of workers reported exposure to dust and 19% reported exposure to smoke, fumes, and gas (Statistics Finland 2003).

In general, the prevalences of workplace exposure for the legislators, administrators and managers group (NZSCO 1) were higher than for the comparable group in the EWCS. The 'exposed' participants of this group were predominantly general managers, production and operation managers, and supply and distribution managers. For dust and pesticide exposure, more than half of the participants in NZSCO 1 were from the agricultural, forestry and fishing, construction, and manufacturing industries. One possible explanation for the relatively high prevalence of exposure in this group could be the smaller size of operations in New Zealand industry and a higher proportion of working 'hands-on' managers. In 2008, 97% of New Zealand enterprises were small-to-medium-enterprises (19 or fewer employees) (Ministry of Economic Development 2008). While this proportion is broadly within the Organisation for Economic and Cooperation Development (OECD) range, New Zealand appears to have a higher proportion of small firms in the manufacturing sector by OECD standards (Mills & Timmins 2004). Small firms have also been found to have worse ergonomic, physical, and chemical work environments, while occupational health and safety management systems are of a higher standard in larger firms

(Bohle et al. 2008). Alternatively, the skills-based classification of the job title ‘manager’ could vary across countries according to the technical requirements of a job and the social construction of what is skilled and unskilled work. For example, ~20% of men in Ireland and the UK are classed as working in managerial occupations compared with just 6% in Germany (Burchell et al. 2007).

Lifting

Thirty-nine percent of the sample reported that their current job involved lifting a quarter of the time or more. Similarly, 35% of the workers in the European Union countries in the EWCS reported carrying or moving heavy loads at least a quarter of the time in their job. The corresponding figures were 39% in Finland and 34% in the UK (Parent-Thirion et al. 2007). In addition, the EWCS findings for lifting by occupational group (Parent-Thirion et al. 2007), including agricultural and fishery workers, trades workers, and plant and machine operators and assemblers, were very similar to the results of the current study.

Loud noise

Exposure to loud noise a quarter of the time or more was reported by 30% of the sample. The EWCS (Parent-Thirion et al. 2007) also reported exposure to loud noise (noise so loud that you would have to raise your voice to talk to people) at least one quarter of the time in 30% of the workers. The current study found slightly higher prevalences of exposure to loud noise among comparable occupational groups. In the Medical Monitoring of Risks survey in France, 18% of employees were exposed to noise exceeding 85 decibels (Directorate for Research Analysis and Statistics of the Ministry of Social Affairs Labour and Solidarity 2003). In the Workplace Health and Safety Survey Programme in the UK, an estimated 19% of employees worked in an environment where the noise level on an average working day was so loud that they had to raise their voice to talk to people or they had work tasks that left them with ringing in their ears or a temporary feeling of deafness (Hodgson et al. 2005).

Personal protective equipment

The prevalence of self-reported PPE use (48%) is slightly higher than figures from overseas studies. In the EWCS, 34% of workers reported PPE use a quarter of the time or more. The corresponding figures for Finland and the UK were 43% and 35%, respectively (Parent-Thirion et al. 2007). In contrast, the prevalence of respirator protection in this study appears to be low (18% in trades workers). In an earlier study of the prevalence of respirator use in industry in a provincial New Zealand city, 37% indicated they always wore a respirator, 54% took the respirator off for a variety of reasons, and 9% indicated they never wore a respirator when required to do so (Laird et al. 1993).

In the current study, 47% of agricultural and fishery workers reported wearing hearing protection at work. Of the agricultural workers exposed to loud noise three quarters to all of the time, 64% reported hearing protection use. In contrast, a cross-sectional study of New Zealand farmers and farm workers (McBride et al. 2003) found that 8% were observed wearing hearing protection ‘most of the time’, 17% ‘some of the time’, and 77% were not observed wearing hearing protection at any time during their tasks. The authors also found that self-reported use of hearing protection was higher than that actually observed, which suggests that individuals overestimate their use of hearing protection. However, although a relatively high proportion of trades workers reported hearing protection use regardless of frequency of noise exposure, barely half of plant and machine operators and assemblers and elementary workers with frequent noise exposure reported hearing protection use. Our study also indicated that, in general, less than half of the participants who reported exposure used PPE that was relevant for that exposure.

Night shift and irregular hours

The prevalence of night shift work in this study is consistent with the 7% of workers that reported working night shift (work undertaken between midnight and 5am) in the New Zealand Time Use Survey 1998/9 (Callister & Dixon 2001). However, in the New Zealand Blood Donors' Health Study (n=15,365), 15% of participants reported working at least one night per week (Fransen et al. 2006). In the current study, we found gender differences in the occurrence of night shift work with 10% of males compared to 4% of females ($p<0.01$) reporting night shift work in the previous 4 weeks. A similar pattern has been documented in other New Zealand studies. The Time Use Survey reported that night work was more common for men than women (8% versus 5%) (Callister & Dixon 2001) and a national survey of insomnia symptoms estimated that women had a lower prevalence of night work than men (10% versus 15%) (Paine et al. 2004). New Zealand appears to have a lower prevalence of night shift work than other countries, although the definition of night shift is varied. It is also possible that our study underrepresents night shift workers due to restrictions on their time availability for the interview. In the EWCS, ~20% of workers reported night shift work (working for at least 2 hours between 10pm and 5am) (Parent-Thirion et al. 2007), while another survey conducted in France reported that ~13% of employees engaged in night work (working between midnight and 5am) (Directorate for Research Analysis and Statistics of the Ministry of Social Affairs Labour and Solidarity 2003).

Gender

This study showed that men are overrepresented among highly exposed occupational groups (for example industrial and manual workers), while occupational groups with low levels of the exposures considered are predominantly held by women (for example office jobs). However, the study also found that in some cases males reported a higher prevalence of exposure than females within the same occupational group. This could be attributed to further occupational segregation by gender within these groups or differential distribution of work tasks. The higher prevalence of lifting for females in the professionals group is likely to be due to the high proportion of nurses in this group.

In summary, the prevalences of certain occupational exposures, lifting, and loud noise in New Zealand are similar to figures reported from overseas surveys. The prevalence of wearing PPE appears relatively high but, in general, less than half of the participants who reported exposure used PPE relevant for that exposure. This study indicates that occupational exposures are disproportionately experienced by workers in certain occupations/industries where exposure prevalence can be as high as 75%; however, they also occur in occupations that are not traditionally associated with hazardous exposures or occupational disease.

Supplementary data to Chapter 3: Figure S3.1

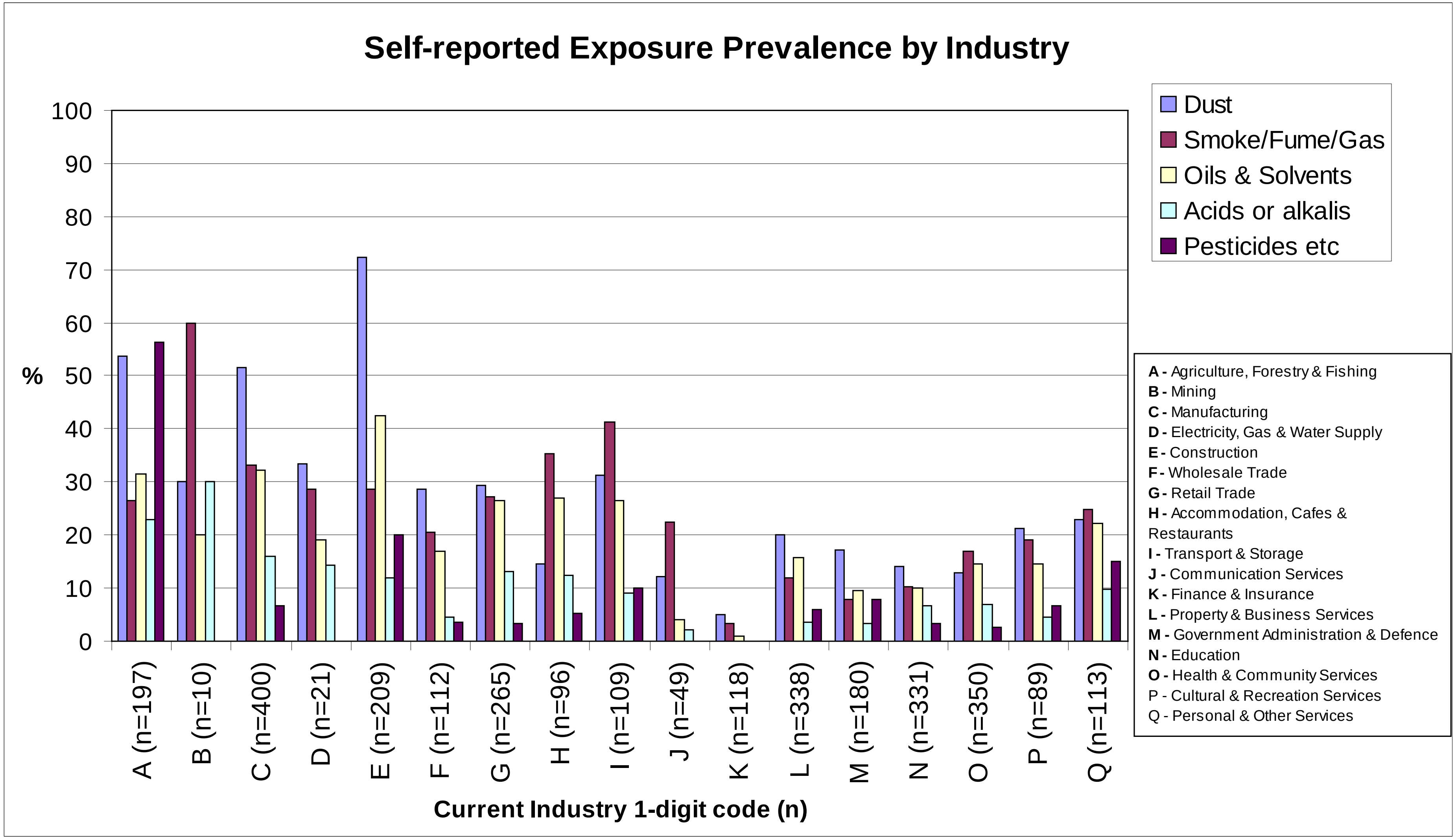
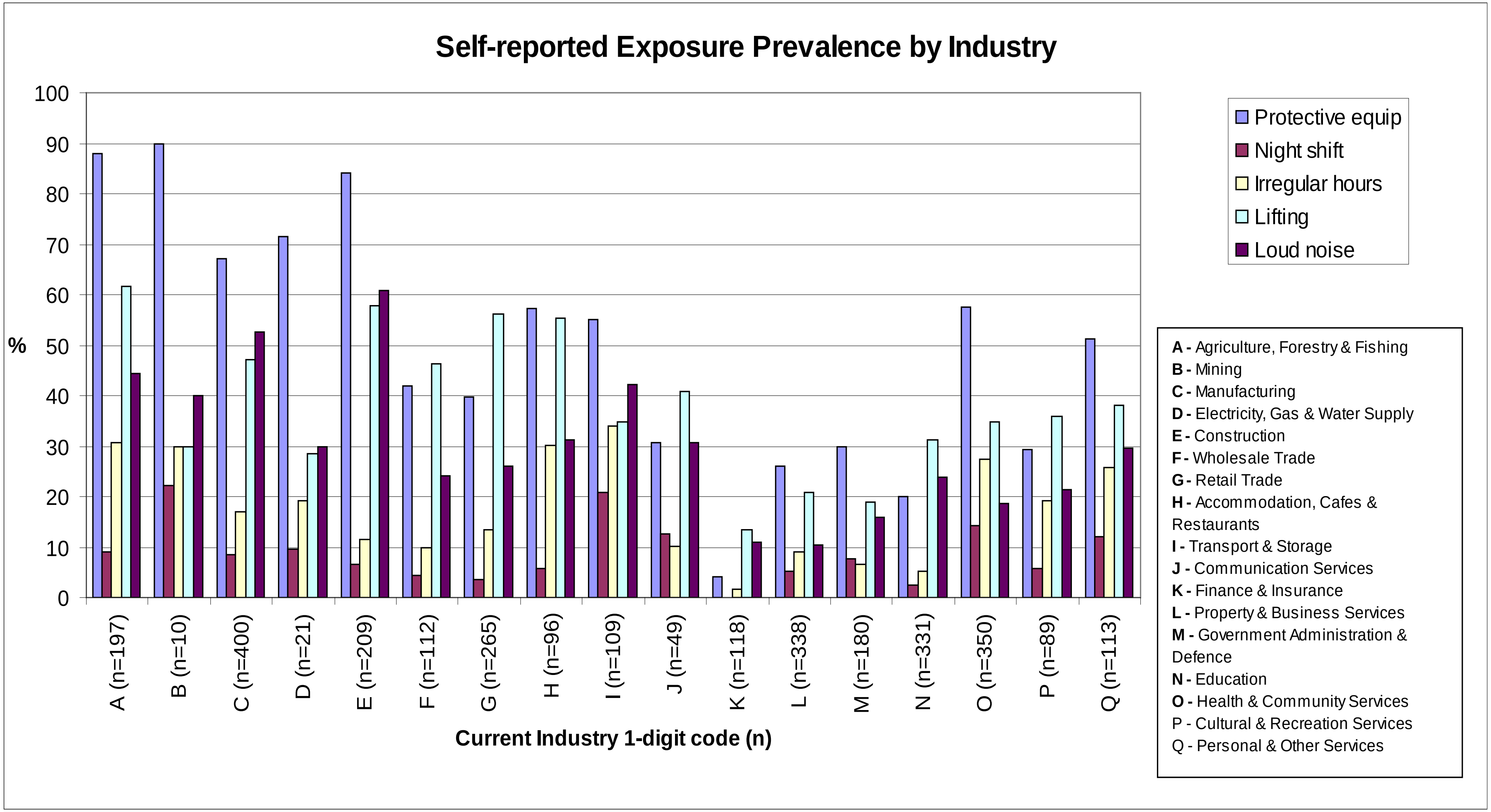


Figure S3.2


Self-reported Exposure Prevalence by Industry
100
90
80
70
60
50
40
30
20
10
0
%
Protective equip
Night shift
Irregular hours
Lifting
Loud noise
A (n=197)
B (n=10)
C (n=400)
D (n=21)
E (n=209)
F (n=112)
G (n=265)
H (n=96)
I (n=109)
J (n=49)
K (n=118)
L (n=338)
M (n=180)
N (n=331)
O (n=350)
P (n=89)
Q (n=113)
Current Industry 1-digit code (n)
A - Agriculture, Forestry & Fishing
B - Mining
C - Manufacturing
D - Electricity, Gas & Water Supply
E - Construction
F - Wholesale Trade
G - Retail Trade
H - Accommodation, Cafes & Restaurants
I - Transport & Storage
J - Communication Services
K - Finance & Insurance
L - Property & Business Services
M - Government Administration & Defence
N - Education
O - Health & Community Services
P - Cultural & Recreation Services
Q - Personal & Other Services

Section 2. Demographic differences in occupational exposure

CHAPTER 4

Gender differences in occupational exposure patterns

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Objectives: We conducted a population-based survey to examine gender differences in occupational exposure patterns and to investigate whether any observed differences are due to: a) gender differences in occupational distribution; and/or b) gender differences in tasks within occupations.

Methods: Men and women aged 20-64 years were randomly selected from the Electoral Roll and invited to take part in a telephone interview, which collected information on self-reported occupational exposure to specific dusts and chemicals, physical exposures, and organisational factors. We used logistic regression to calculate prevalence odds ratios (OR) and 95% confidence intervals (CI) comparing the exposure prevalence of males (n=1,431) and females (n=1,572), adjusting for age. To investigate whether men and women in the same occupation were equally exposed, we also matched males to females on current occupation (5-digit code) (n=1,208) and conducted conditional logistic regression adjusting for age.

Results: Overall, male workers were two to four times more likely to report exposure to dust and chemical substances, loud noise, irregular hours, night shifts, and vibrating tools. Women were 30% more likely to report repetitive tasks and working at high speed and more likely to report exposure to disinfectants, hair dyes, and textile dust. When men were compared with women with the same job title, gender differences were attenuated. However, males remained significantly more likely to report exposure to welding fumes, herbicides, wood dust, solvents, tools that vibrate, irregular hours, and night shift work. Women remained more likely to report repetitive tasks and working at high speed, and in addition were more likely to report awkward or tiring positions compared to men with the same job title.

Conclusion: This population-based study showed substantial differences in occupational exposure patterns between men and women, due to both gender differences in occupational distribution as well as the gender segregation of tasks within the same job.

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The manuscript which appears here differs slightly from the final version published online in Occupational and Environmental Medicine.

Introduction

Women's work has traditionally been considered safe and less hazardous to health in comparison to men's work (Messing 1998). This has resulted in a lack of information on occupational hazards for women workers (Messing et al. 2003), and our knowledge of occupational health and priorities for improving it have mainly been based on studies of men. However, clear gender differences in occupational morbidity have been observed, with males generally having higher rates of work-related injuries, cancer, hearing disorders, and vibration-related diseases, whereas females are more likely to be affected by upper musculoskeletal disorders, workplace bullying, and sexual harassment (Mannetje et al. 2009). Gender differences in occupational distribution i.e. men and women working in different jobs and therefore being exposed to different risk factors, play an important role in many of these differential outcomes (Mannetje et al. 2009). However, differences in occupational morbidity have also been observed for men and women with the same job title, suggesting that even in the same occupation, men and women are not equally exposed to particular risk factors for disease.

However, understanding gender differences in occupational exposure, both between and within occupations, is a necessary first step towards understanding gender differences in occupational morbidity. Very few studies have investigated the prevalence of occupational risk factors in women workers, or compared the distribution of risk factors between women and men. We conducted a population-based survey to examine gender differences in occupational exposure patterns and to investigate whether any observed differences can be explained by: a) gender differences in occupational distribution; and/or b) gender differences in tasks within occupations.

Methods

We conducted a nationwide telephone survey of a random sample of the New Zealand population aged 20-64 years over a 2-year period (2004-2006). The detailed study methodology is described elsewhere (Eng et al. 2010a). Briefly, 10,000 potential participants were randomly selected from the Electoral Roll and sent a letter of invitation to take part in a telephone interview. The interview obtained information on lifetime work history (for jobs with minimum six months duration), current exposures and workplace practices, and questions on selected health outcomes.

Participants were asked whether the following exposures were present (yes/no) in their current work environment: dust; smoke or fume; gas; oils and solvents; acids or alkalis; fungicides, insecticides, herbicides or timber preservatives; and other chemical products (including dyes, inks, and adhesives). If a participant indicated exposure(s), they were also asked to state the name and source of the substance. Participants were also asked how often their current job involved exposure to physical and organisational factors, including awkward or tiring positions, awkward grip or hand movements, lifting, carrying out repetitive tasks, working at very high speed, working to tight deadlines, standing, using tools that vibrate, and loud noise (all the time, three quarters of the time, half of the time, one quarter of the time, or never). The questionnaire obtained information on whether participants worked for at least three hours between midnight and 5am in the previous four weeks (night shift) and whether they regularly worked outside the hours of 8am-5pm (irregular hours). Participants were also asked to rate how stressful they found their current job on a 5-point scale (not at all stressful, mildly stressful, moderately stressful, very stressful, or extremely stressful). In addition, we asked individuals the ages of the members in their household and whether these people required looking after by the participant. The variable ‘household responsibility’ was created based on a positive report of looking after children (0-18 years) or elderly dependents (60+ years) in the household.

Occupations were coded using the New Zealand Standard Classification of Occupations (NZSCO) 1999 (Statistics New Zealand 2001b). This classification scheme is based on the 1988 International Standard Classification of Occupations (ISCO-88). Differences in current workplace exposure between men and women were assessed using prevalence odds ratios (OR) (Pearce 2004) and 95% confidence intervals (CI) using the unexposed as the reference group for each occupational exposure. In the case of job stress, individuals reporting no or mild work-related stress formed the reference group. We conducted unconditional logistic regression in STATA v10.0, adjusting for age (continuous variable).

To investigate whether gender differences in exposure were only due to gender differences in occupational distribution or could also be due to differences within occupations, we also conducted matched analyses where each male participant was matched (1:1) with a female participant on current occupation (5-digit NZSCO code). ORs and 95% CIs were calculated using conditional logistic regression adjusting for age.

Categories of specific occupational exposures (yes/no), for example acetone, caustic soda, timber treatment, were created using a word search programme developed in SAS (version 9.1). The programme was designed to search keywords (including alternative spelling and trade names) in the “name of substance” and “source of substance” text fields. For each newly created exposure category, the original text was checked to ensure that the new category captured all of the exposed participants.

Results

A total of 3,003 interviews were completed (the response rate was 37%). The characteristics of the total sample and the sample of males and females matched on occupation are described in Table 4.1. Women comprised just over one half of the total sample. In both samples, there was a higher proportion of females in the 35-44 year age group, a lower proportion in the oldest age group (55+ years), and a slightly higher proportion of Māori (the indigenous population of New Zealand) females than males. In the total sample, there were higher proportions of females in the professionals, technicians and associate professionals, clerks, and service and sales workers groups, whereas there were higher proportions of males in the legislators, administrators and managers, agricultural and fishery, trades, and plant and machine operators and assemblers groups. There were similar numbers of men and women in the elementary occupational group (for example: cleaners, labourers, packers, and rubbish collectors)

Table 4.1 Description of total and matched samples

	Total sample							Matched sample (males and females with the same occupation)						
	Total		Male		Female		Chi^2	Total		Male		Female		Chi^2
	N=3003		N=1431		N=1572			N=1208		N=604		N=604		
	N	%	N	%	N	%		N	%	N	%	N	%	
Age at interview														
20-34 years	659	21.9	302	21.1	357	22.7		292	24.2	137	22.7	155	25.7	
35-44 years	820	27.3	349	24.4	471	30.0		308	25.5	140	23.2	168	27.8	
45-54 years	868	28.9	404	28.2	464	29.5		332	27.5	168	27.8	164	27.2	
55+ years	656	21.8	376	26.3	280	17.8	p<0.01	276	22.9	159	26.3	117	19.4	p=0.02
Ethnicity														
Māori	273	9.1	109	7.7	164	10.4		106	8.8	42	7.0	64	10.6	
Non-Māori	2724	90.9	1316	92.4	1408	89.6	p=0.01	1101	91.2	561	93.0	540	89.4	p=0.03
Missing	6		6		0			1		1		0		
Smoking														
Never	1517	50.8	707	49.6	810	52.0		635	53.0	319	53.1	316	52.9	
Current	543	18.2	258	18.1	285	18.3		193	16.1	90	15.0	103	17.3	
Ex	925	31.0	461	32.3	464	29.8	p=0.30	370	30.9	192	32.0	178	29.8	p=0.50
Missing	18		5		13			10		3		7		
Deprivation index (New Zealand Deprivation Index 2001)														
1 (least deprived)	422	14.5	223	16.0	199	13.1		192	16.3	112	19.0	80	13.5	
2	351	12.0	182	13.0	169	11.1		147	12.5	81	13.8	66	11.2	
3	336	11.5	173	12.4	163	10.7		143	12.1	75	12.7	68	11.5	
4	343	11.8	164	11.8	179	11.8		137	11.6	66	11.2	71	12.0	
5	336	11.5	151	10.8	185	12.1		126	10.7	61	10.4	65	11.0	
6	294	10.1	129	9.2	165	10.8		119	10.1	53	9.0	66	11.2	
7	248	8.5	98	7.0	150	9.8		109	9.2	49	8.3	60	10.2	
8	226	7.7	106	7.6	120	7.9		90	7.6	38	6.5	52	8.8	
9	222	7.6	114	8.2	108	7.1		66	5.6	33	5.6	33	5.6	
10 (most deprived)	142	4.9	56	4.0	86	5.6	p=0.01	51	4.3	21	3.6	30	5.1	p=0.13
Missing	83		35		48			28		15		13		

…continued

Table 4.1 Description of total and matched samples

	Total sample							Matched sample (males and females with the same occupation)						
	Total		Male		Female		Chi^2	Total		Male		Female		Chi^2
	N=3003		N=1431		N=1572			N=1208		N=604		N=604		
	N	%	N	%	N	%		N	%	N	%	N	%	
Current occupation (New Zealand Standard Classification of Occupations)														
1-Legislators, Administrators & Managers	505	16.8	308	21.5	197	12.5		340	28.2	170	28.2	170	28.2	
2-Professionals	624	20.8	235	16.4	389	24.8		266	22.0	133	22.0	133	22.0	
3-Technicians & Associate Professionals	455	15.2	177	12.4	278	17.7		214	17.7	107	17.7	107	17.7	
4-Clerks	356	11.9	70	4.9	286	18.2		96	8.0	48	8.0	48	8.0	
5-Service & sales workers	348	11.6	88	6.2	260	16.6		112	9.3	56	9.3	56	9.3	
6-Agricultural & Fishery workers	181	6.0	120	8.4	61	3.9		94	7.8	47	7.8	47	7.8	
7-Trades Workers	240	8.0	225	15.7	15	1.0		18	1.5	9	1.5	9	1.5	
8-Plant & Machine Operators & Assemblers	179	6.0	150	10.5	29	1.9		28	2.3	14	2.3	14	2.3	
9-Elementary Workers	113	3.8	57	4.0	56	3.6	$p<0.01$	40	3.3	20	3.3	20	3.3	
Missing	2		1		1									

Table 4.2 compares the prevalence of various occupational exposures between males and females in the total sample (n=3,003), and between males and females in the same occupation (referred to as the matched sample; n=1,208). In the total sample, male workers were more than twice as likely to report exposure to dust and chemical factors. Males were also more likely to be exposed to loud noise (OR=2.70; 95% CI 2.29-3.18); use tools that vibrate (OR=3.80; 95% CI 2.94-4.90); work night shift in the previous month (OR=2.57; 95% CI 1.89-3.50) and work irregular hours (OR=1.76; 95% CI 1.44-2.15). On the other hand, women were 32% more likely to report carrying out repetitive tasks (OR=0.76; 95% CI 0.65-0.89) and 33% more likely to report working at very high speed (OR=0.75; 95% CI 0.65-0.87) a quarter of the time or more. Females were also 52% more likely to report looking after children (0-18 years) or elderly dependents (60+ years) in their household (OR=0.66; 95% CI 0.57-0.78).

Matched sample

There were 827 male participants with no female match for job code and they were subsequently excluded from the matched analyses. For most exposures, matching on occupation attenuated gender differences in exposure (i.e. for the dust and chemical factors, 67-87% of the excess risks observed for males were due to gender differences in occupational distribution). However, compared to women with the same job title, men were still more likely to report exposure to smoke/fume/gas (OR=1.54; 95% CI 1.11-2.14) and oils and solvents (OR=1.62; 95% CI 1.16-2.27). Men were also twice as likely to use tools that vibrate (OR=2.06; 95% CI 1.29-3.29) and work irregular hours (OR=1.97; 95% CI 1.37-2.83), and three times more likely to work night shifts (OR=3.32; 95% CI 1.73-6.36) compared to women with the same job title. Men were also about 50% more likely to report job stress compared to women in the same occupation.

Compared to men with the same job title, female workers were 28% more likely to report carrying out repetitive tasks (OR=0.78; 95% CI 0.59-1.01), 43% more likely to report working at very high speed (OR=0.70; 95% CI 0.55-0.89), and 37% more likely to report awkward or tiring positions (OR=0.73; 95% CI 0.57-0.92). The decreased odds for men of household responsibility increased towards the null value after matching on occupation but remained decreased by 24% (OR=0.76; 95% CI 0.59-0.98).

Table 4.2 Differences in occupational exposure prevalence between males and females

	Exposure in males and females (whole sample)				Exposure in males and females with the same occupation (matched sample)[#]			
	Total	**Male**	**Female**	**OR (95% CI)[§]**	**Total**	**Male**	**Female**	**OR (95% CI)[§]**
Exposure	n=3003	n=1431	n=1572		n=1208	n=604	n=604	
	%	**%**	**%**		**%**	**%**	**%**	
Dust/chemical factors								
Dust	29.3	40.3	19.3	2.83* (2.40-3.33)	23.2	25.0	21.4	1.24 (0.94-1.63)
Smoke/Fume/Gas	21.4	29.5	14.0	2.61* (2.17-3.13)	17.6	20.2	14.9	1.54* (1.11-2.14)
Oils and Solvents	20.9	29.8	12.8	3.00* (2.48-3.62)	15.2	17.9	12.4	1.62* (1.16-2.27)
Acids or alkalis	9.4	13.4	5.8	2.57* (1.98-3.34)	8.0	8.8	7.1	1.35 (0.85-2.15)
Pesticides	9.6	14.5	5.0	3.14* (2.39-4.11)	8.0	8.8	7.3	1.27 (0.75-2.15)
Any of the above	45.4	57.0	34.7	2.52* (2.17-2.92)	38.3	41.1	35.6	1.34* (1.03-1.73)
Physical factors								
Lifting**	39.2	43.1	35.8	1.40* (1.21-1.62)	32.3	31.6	33.1	0.98 (0.74-1.30)
Loud noise**	29.9	40.1	20.5	2.70* (2.29-3.18)	23.2	24.8	21.7	1.21 (0.90-1.63)
Awkward or tiring positions**	56.1	54.5	57.6	0.91 (0.78-1.05)	49.9	45.8	54.1	0.73* (0.57-0.92)
Awkward grip or hand movements**	38.2	40.5	36.1	1.25* (1.08-1.45)	32.1	31.5	32.8	0.94 (0.72-1.22)
Standing**	28.0	27.3	28.6	0.95 (0.81-1.11)	24.6	24.1	25.1	0.91 (0.67-1.22)
Tools that vibrate**	11.4	17.6	5.7	3.80* (2.94-4.90)	8.2	10.3	6.2	2.06* (1.29-3.29)
Organisational factors								
Repetitive tasks**	68.2	64.7	71.5	0.76* (0.65-0.89)	63.8	61.0	66.6	0.78 (0.59-1.01)
Working at very high speed**	51.2	47.0	55.0	0.75* (0.65-0.87)	48.0	43.2	52.7	0.70* (0.55-0.89)
Working to tight deadlines**	73.1	74.9	71.4	1.26* (1.07-1.49)	73.7	73.2	74.1	1.04 (0.79-1.36)
Night shift	7.1	10.2	4.3	2.57* (1.89-3.50)	5.7	8.0	3.4	3.32* (1.73-6.36)
Irregular hours	16.1	20.1	12.5	1.76* (1.44-2.15)	14.4	17.9	11.0	1.97* (1.37-2.83)
Stress								
Not at all-Mildly	39.7	36.6	42.6	1.00 (ref)	37.1	33.0	41.1	1.00 (ref)
Moderately	45.2	48.5	42.2	1.36* (1.16-1.59)	46.3	49.5	43.1	1.52* (1.17-1.99)
Very-Extremely	15.1	15.0	15.3	1.14 (0.92-1.42)	16.6	17.5	15.8	1.43* (1.00-2.05)
Household responsibility	34.7	29.3	39.6	0.66* (0.57-0.78)	32.8	30.0	35.6	0.76* (0.59-0.98)

Prevalence odds ratios and 95% confidence intervals using the unexposed as the reference group for each occupational factor.

[#]Males and females matched on current occupation (New Zealand Standard Classification of Occupations 5-digit code)

[§]adjusted for age

[*]statistically significant at $p<0.05$

**1/4 of the time or more

Specific occupational exposures

Table 4.3 compares the prevalence of specific occupational exposures between men and women for the total and matched samples.

Of the 61 specific exposures under study, 43 were more common among men ($p<0.05$) in the total sample. Specific exposures more than 10 times more common in the male working population compared to the female working population included: hydraulic oil; welding fumes; paint thinner; paint dust; kerosene; diesel fuel; printing; insulation material; sulphuric acid; timber treatment; fibreglass; and cutting fluid. Of the 61 specific exposures under study, 6 were more common among women ($p<0.05$): hair dye; textile dust; household dust; environmental tobacco smoke (ETS); bleach; and disinfectant. When comparing men and women with the same job title, 4 exposures remained significantly more common in men: welding fumes, herbicides, wood dust, and solvents

Table 4.3 Differences in specific occupational exposure prevalence between males and females

	Exposure in males and females (whole sample)					Exposure in males and females with the same occupation (matched sample)[#]				
	Total		Male	Female	OR (95% CI)[§]	Total		Male	Female	OR (95% CI)[§]
	N=3003		N=1431	N=1572		N=1208		N=604	N=604	
Exposure	**N**	%	%	%		**N**	%	%	%	
Acids and alkalis										
Alkalis	105	3.5	4.3	2.8	1.54* (1.03-2.28)	46	3.8	4.3	3.3	1.41 (0.75-2.66)
Acids	195	6.5	10.6	2.8	4.22* (2.99-5.96)	65	5.4	6.5	4.3	1.74 (0.98-3.09)
Hydrochloric acid	31	1.0	1.8	0.3	5.98* (2.29-15.63)	13	1.1	1.5	0.7	3.05 (0.80-11.63)
Sulphuric acid	45	1.5	2.9	0.3	11.75* (4.19-32.93)	12	1.0	1.5	0.5	3.19 (0.86-11.90)
Cleaning products										
Cleaning products	411	13.7	14.2	13.2	1.11 (0.90-1.37)	148	12.3	12.3	12.3	0.97 (0.66-1.44)
Bleach	51	1.7	1.1	2.3	0.45* (0.25-0.83)	12	1.0	0.8	1.2	0.57 (0.18-1.83)
Disinfectant	127	4.2	3.0	5.3	0.56* (0.38-0.81)	30	2.5	2.2	2.8	0.76 (0.36-1.57)
Caustic soda	54	1.8	2.0	1.7	1.19 (0.69-2.04)	28	2.3	2.5	2.2	1.24 (0.57-2.71)
Chlorine products	112	3.7	3.5	3.9	0.88 (0.60-1.29)	36	3.0	2.5	3.5	0.66 (0.33-1.32)
Pesticides										
Fungicides	61	2.0	2.7	1.4	1.96* (1.16-3.33)	24	2.0	2.3	1.7	1.31 (0.52-3.27)
Insecticides	70	2.3	3.1	1.6	1.97* (1.20-3.23)	23	1.9	2.5	1.3	2.51 (0.87-7.22)
Herbicides	167	5.6	8.9	2.5	3.64* (2.53-5.24)	77	6.4	8.1	4.6	4.37* (1.85-10.31)
Fertiliser	28	0.9	1.5	0.5	3.31* (1.40-7.81)	12	1.0	1.0	1.0	1.07 (0.33-3.43)
Drench (animal)	30	1.0	1.6	0.5	3.64* (1.56-8.53)	18	1.5	1.8	1.2	2.55 (0.74-8.83)
Timber treatment	69	2.3	4.4	0.4	11.59* (5.00-26.88)	10	0.8	1.0	0.7	1.32 (0.37-4.73)
Dusts										
Agricultural dust	21	0.7	1.1	0.3	3.37* (1.23-9.23)	10	0.8	0.8	0.8	0.89 (0.21-3.78)
Animal dust	21	0.7	1.0	0.5	2.04 (0.82-5.08)	11	0.9	0.8	1.0	0.68 (0.20-2.28)
Grain dust	15	0.5	0.8	0.2	4.46* (1.25-15.88)	10	0.8	1.2	0.5	2.46 (0.60-10.05)
Paper dust	29	1.0	0.9	1.0	0.90 (0.43-1.87)	11	0.9	0.7	1.2	0.45 (0.12-1.62)
Construction dust	87	2.9	5.4	0.6	9.18* (4.73-17.84)	17	1.4	1.3	1.5	0.77 (0.28-2.15)

…continued

Table 4.3 Differences in specific occupational exposure prevalence between males and females

	Exposure in males and females (whole sample)					Exposure in males and females with the same occupation (matched sample)#				
	Total		Male	Female	OR (95% CI)§	Total		Male	Female	OR (95% CI)§
	N=3003		N=1431	N=1572		N=1208		N=604	N=604	
Exposure	N	%	%	%		N	%	%	%	
Metal dust	94	3.1	5.6	0.9	6.91* (3.89-12.28)	10	0.8	1.0	0.7	1.58 (0.44-5.67)
Wood dust	210	7.0	12.4	2.1	6.71* (4.59-9.81)	57	4.7	6.1	3.3	2.11* (1.13-3.93)
Household dust	121	4.0	2.1	5.8	0.35* (0.23-0.53)	46	3.8	3.2	4.5	0.70 (0.38-1.27)
Road dust	142	4.7	6.8	2.9	2.46* (1.71-3.53)	48	4.0	4.1	3.8	1.16 (0.64-2.09)
Flour dust	17	0.6	0.8	0.3	2.61 (0.91-7.44)	9	0.8	1.0	0.5	2.00 (0.49-8.07)
Solvents										
Solvents	331	11.0	15.2	7.2	2.34* (1.84-2.98)	108	8.9	10.8	7.1	1.74* (1.14-2.64)
Acetone	27	0.9	1.1	0.7	1.62 (0.75-3.51)	9	0.8	0.7	0.8	0.97 (0.26-3.68)
Adhesive	125	4.2	6.2	2.4	2.82* (1.91-4.18)	34	2.8	3.0	2.7	1.22 (0.56-2.66)
Alcohol	109	3.6	3.6	3.7	0.99 (0.67-1.46)	38	3.2	3.0	3.3	0.99 (0.50-1.95)
Degreasers	39	1.3	2.0	0.6	3.51* (1.70-7.26)	18	1.5	1.8	1.2	1.53 (0.55-4.27)
Methylated spirits	54	1.8	1.7	1.9	0.91 (0.53-1.57)	17	1.4	1.5	1.3	1.26 (0.48-3.31)
Turpentine	50	1.7	2.3	1.1	2.20* (1.22-3.98)	17	1.4	1.5	1.3	1.38 (0.52-3.67)
Formaldehyde	16	0.5	0.6	0.5	1.08 (0.40-2.90)	8	0.7	1.0	0.3	3.16 (0.63-15.78)
Engine fuels and emissions										
Diesel engine emission	72	2.4	4.2	0.8	5.78* (3.09-10.80)	18	1.5	1.8	1.2	1.51 (0.57-3.95)
Diesel fuel	46	1.5	3.0	0.2	16.40* (5.07-53.04)	7	0.6	1.0	0.2	7.42 (0.87-63.11)
Engine emission	183	6.1	8.7	3.7	2.59* (1.88-3.57)	82	6.8	7.6	6.0	1.38 (0.83-2.29)
Engine oil	98	3.3	6.1	0.7	9.52* (5.06-17.92)	28	2.3	2.8	1.8	1.73 (0.78-3.85)
Kerosene	17	0.6	1.1	0.1	18.34* (2.43-138.73)	3	0.3	0.3	0.2	1.93 (0.17-21.32)
Petrol fuel	25	0.8	1.5	0.2	8.35* (2.49-27.99)	6	0.5	0.7	0.3	2.59 (0.46-14.63)
Petrol fumes	26	0.9	1.3	0.5	3.13* (1.31-7.48)	7	0.6	0.5	0.7	0.59 (0.13-2.76)
Liquefied petroleum gas (LPG)	39	1.3	2.3	0.4	6.78* (2.82-16.28)	16	1.3	1.8	0.8	2.55 (0.86-7.52)

…continued

Table 4.3 Differences in specific occupational exposure prevalence between males and females

	Exposure in males and females (whole sample)					Exposure in males and females with the same occupation (matched sample)[#]				
	Total		Male	Female	OR (95% CI)[§]	Total		Male	Female	OR (95% CI)[§]
	N=3003		N=1431	N=1572		N=1208		N=604	N=604	
Exposure	N	%	%	%		N	%	%	%	
Environmental tobacco smoke (ETS)	36	1.2	0.6	1.7	0.36* (0.17-0.77)	12	1.0	0.8	1.2	0.66 (0.21-2.12)
Machinery oils and fumes										
Machinery oils	42	1.4	2.5	0.5	5.58* (2.47-12.61)	8	0.7	0.8	0.5	1.49 (0.34-6.54)
Machinery fumes	28	0.9	1.5	0.4	4.13* (1.67-10.22)	9	0.8	0.8	0.7	1.40 (0.36-5.43)
Hydraulic oil	30	1.0	2.0	0.1	34.57* (4.70-254.23)	5	0.4	0.7	0.2	4.82 (0.53-43.69)
Lubricants	76	2.5	4.3	1.0	4.81* (2.71-8.52)	20	1.7	1.5	1.8	0.82 (0.33-2.01)
Cutting fluids	20	0.7	1.3	0.1	10.48* (2.42-45.34)	5	0.4	0.7	0.2	4.23 (0.47-37.92)
Welding	88	2.9	5.9	0.2	33.66* (10.61-106.76)	11	0.9	1.5	0.3	5.25* (1.10-25.10)
Ink and dyes										
Dyes	23	0.8	1.1	0.5	2.60* (1.06-6.36)	12	1.0	1.3	0.7	1.92 (0.58-6.40)
Printing	16	0.5	1.1	0.1	17.37* (2.29-131.92)	7	0.6	1.0	0.2	7.08 (0.85-59.18)
Inks	32	1.1	1.4	0.8	1.94 (0.94-4.01)	15	1.2	1.3	1.2	1.40 (0.46-4.23)
Hair dyes	11	0.4	0.1	0.6	0.12* (0.02-0.93)	1	0.1	0.0	0.2	
Fibres										
Fibreglass	20	0.7	1.3	0.1	10.70* (2.47-46.32)	4	0.3	0.3	0.3	0.87 (0.12-6.24)
Insulation material	27	0.9	1.8	0.1	14.29* (3.37-60.56)	4	0.3	0.5	0.2	2.91 (0.30-28.21)
Textile dust	69	2.3	1.2	3.3	0.34* (0.20-0.60)	25	2.1	1.5	2.7	0.59 (0.26-1.34)
Asbestos	21	0.7	1.3	0.2	6.42* (1.89-21.89)	4	0.3	0.5	0.2	2.20 (0.22-22.41)
Paint and lacquers										
Paint and lacquers	151	5.0	8.2	2.2	4.17* (2.82-6.16)	45	3.7	4.1	3.3	1.35 (0.72-2.53)
Paint fumes	47	1.6	2.7	0.6	4.74* (2.28-9.86)	16	1.3	1.5	1.2	1.26 (0.46-3.45)
Acrylic paint	20	0.7	0.5	0.8	0.62 (0.25-1.56)	8	0.7	0.2	1.2	0.15 (0.02-1.26)

…continued

Table 4.3 Differences in specific occupational exposure prevalence between males and females

	Exposure in males and females (whole sample)					Exposure in males and females with the same occupation (matched sample)#				
	Total		**Male**	**Female**	**OR (95% CI)§**	**Total**		**Male**	**Female**	**OR (95% CI)§**
	N=3003		N=1431	N=1572		N=1208		N=604	N=604	
Exposure	**N**	%	%	%		**N**	%	%	%	
Paint thinner	26	0.9	1.8	0.1	28.55* (3.86-211.16)	4	0.3	0.5	0.2	2.70 (0.28-26.34)
Paint dust	17	0.6	1.1	0.1	19.25* (2.54-145.57)	3	0.3	0.3	0.2	1.88 (0.17-20.72)

Prevalence odds ratios and 95% confidence intervals using the unexposed as the reference group for each occupational factor.

#Males and females matched on current occupation (New Zealand Standard Classification of Occupations 5-digit code)

§adjusted for age

*statistically significant at $p<0.05$

Discussion

This study aimed to estimate the gender differences in occupational exposure in a representative sample of the working population of New Zealand.

The study has several limitations. Firstly, the response rate was relatively low (37%) and the implications of this are discussed in more detail elsewhere (Eng et al. 2010a). Briefly, differences between participants and non-participants were observed for age, ethnicity, deprivation, and certain occupational groups. However, these differences were similar for males and females and gender did not appear to be a significant determinant of refusal to participate or non-contact (Mannetje et al. 2011). The analyses presented here are also adjusted for possible determinants of non-response (for example age), and it is therefore unlikely that the observed gender differences in exposure are due to gender differences in survey participation.

Secondly, the characterisation of exposure in this study was based on self-report, thus we cannot rule out the possibility that gender differences in reporting or perception of exposure contributed to the results. However, a Swedish study reported no differences in the validity of reporting physical risk factors for musculoskeletal disorders between men and women (Leijon et al. 2002). Thirdly, the analyses only assessed exposure prevalence in the current job and did not take into account duration or intensity of exposure, which may also impact on gender differences in exposure and ultimately gender differences in occupational health. For example, female workers are more often employed part-time and therefore more likely to experience cumulative exposure. Another limitation of the study is that the numbers did not permit matching males and females on occupation *and* specific industry. For example, for the job title ‘sales worker’, females are more likely to work in retail sales whereas men are more likely to work as manufacturers’ representatives (cited in (Messing et al. 2003)).

On the other hand, this study has several important strengths. Firstly, the men and women covered by this survey were representative of the total working population, as opposed to similar studies that were limited to selected occupation or industry groups (Hooftman et al. 2005, Nordander et al. 1999). Secondly, gender differences were investigated for a wide range of occupational exposures, including specific chemical and physical exposures, as well as organisational factors and stress, thus not only focusing on exposures traditionally associated with men’s work. Thirdly, this is the first study that not only quantified the gender differences in occupational exposure at the population level, but also investigated whether any gender differences in occupational exposure exist for men and women working in the same occupation. Therefore it was possible to investigate whether the observed gender differences in occupational exposure were entirely due to: a) the segregation of men and women into different occupations; or could also be due to b) men and women with the same job title carrying out different tasks.

This study found that men were more likely to be exposed to many of the workplace substances under study. They were also more likely to be exposed to loud noise, vibrating tools, night shift work, and irregular hours. On the other hand, women were more likely to report repetitive tasks, working at high speed, and exposure to certain workplace substances. These findings were not surprising considering that throughout the industrialised world, men and women are concentrated in different jobs and industries; women are more likely to work as professionals (particularly in health and education), service and sales workers, and clerks (typically characterised by fast-paced and repetitive work tasks), while men are more likely to work in the agricultural, trades, and manufacturing sectors (typically characterised by exposure to dusts and chemicals and to physically demanding tasks such as heavy lifting). In this study, the actual gender differences in occupational exposure prevalence are quantified, showing that for general exposure categories the gender difference in prevalence can be up to a factor of 4 while for more specific occupational exposures the gender difference can be more than a factor of 10. The reported quantitative estimates for exposure prevalence in men and women can be useful in occupational health studies focusing on both genders and where information on exposure is not available.

We also found that the different occupational distributions of men and women explained most of the observed differences in exposure prevalence; 67-87% of the excess in exposure to workplace substances, 88% of the increased odds of exposure to loud noise, and 100% of the moderate excess in exposure to lifting were explained by differences in occupation between men and women. The European Working Conditions Survey (EWCS) also reported that occupational distribution played a major role in observed gender differences in chemical and physical exposures (Burchell et al. 2007). In contrast, a cross-sectional study in the U.S. (36% women) reported that there were no major differences between men and women for exposure to dust, chemicals, noise, and hand repetitions before and after adjusting for industry/job. However, this study only examined four industries in a limited socioeconomic range (Quinn et al. 2007).

This study also found that, even after accounting for gender differences in occupation, gender differences in prevalence remained for several exposures; males were still more likely to report exposure to smoke/fume/gas, oils and solvents, vibrating tools, night shift work, and working irregular hours compared to females in the same occupation. Female workers were more likely to report repetitive tasks, working at very high speed, and awkward or tiring positions compared to their male counterparts. For the specific categories of workplace substances, in general, men were more likely to report exposure than women, even within the same occupation.

These findings suggest that men and women with the same job title do not always carry out the same tasks. A few studies have examined men and women with the same job title and reported a gendered assignment of tasks (Messing 1998, Messing et al. 1998, Messing et al. 1994, Nordander et al. 1999). Several studies have reported that women are more likely to perform repetitive tasks compared to men in the same job (Hooftman et al. 2005, Silverstein et al. 1986, Strazdins & Bammer 2004). However, these studies have been based on small numbers or one specific occupational group. Differences in task assignments by gender could be due to the different physical capabilities of men and women or socialised gender roles. The greater relative stature and muscular strength of men compared to women makes them perceivably more suited to physically demanding tasks such as heavy lifting. The same argument can be applied to the suitability of tasks involving dexterity and precision (and therefore repetitiveness) for women. However, Messing argues that social constructions of what is suitable work for men and women also play a role and many physical tasks assigned to men can be adapted to women (Messing 1998). For example, in an observational study of hospital cleaners, Messing et al. concluded that there was no clear reason why women could not perform the ‘heavy’ work typically assigned to men (Messing et al. 1998).

In the current study women were not more likely to report high levels of job stress. Men were 52% more likely to report moderate stress and 43% more likely to report a very or extremely stressful job compared to females in the same occupation. A New Zealand study of 41 companies reported a higher risk of work-related stressors for men, even after adjusting for occupation (Dryson et al. 1996). While women generally report more workplace stressors and poorer psychosocial working conditions than men, the current evidence for a gender difference in work-related stress as an outcome is inconsistent (Mannetje et al. 2009).

The dual exposure of work demands and responsibility for the household may also impact on the relationship between exposure and health, particularly for women. The responsibilities for housework and childcare still largely fall on women. The current study found that women were 52% more likely to report looking after children (0-18 years) or elderly dependents in their household compared to men. This excess was attenuated after matching on occupation but remained elevated at 32%. The New Zealand Time Use Survey reported that women carry out more unpaid work than men regardless of employment status (Statistics New Zealand 2001a). The burden of household responsibilities may result in increased exposure to physically demanding activities as well as less time for recovery after work. Several studies have shown that women spend less time exercising or relaxing outside of work hours compared to men (Strazdins & Bammer 2004). In addition, the responsibility for childcare may also restrict the type of work women can do, for example part-time work which is often associated with routine and repetitive work and lower job control. Unpaid work is an important aspect of women's occupational health and safety and is rarely investigated in epidemiological studies.

In conclusion, this study has found that even in a country such as New Zealand, with relatively good gender equality in employment opportunities, men and women are far from equally exposed to occupational risk factors for disease. Male workers continue to experience a heavier burden of occupational exposure to most dusts and chemicals and certain physically demanding tasks. However, it should be noted that for many of these occupational exposures, the prevalence in women workers was not negligible. For example, 7% of female workers reported exposure to solvents and 4% reported exposure to engine emissions in the overall sample. Compared to men, women workers had a higher prevalence of repetitive tasks, working at very high speed, and certain exposures such as disinfectants, hair dyes, and textile dust. Gender differences in exposure were in part explained by gender differences in occupational distribution, while for some exposures differences in prevalence were even observed for men and women with the same job title. Therefore, there is a need for caution when using job titles as a surrogate for exposure. This study illustrates that gender has a substantial impact on occupational exposure prevalence, even within the same job, and that the influence of gender should not be overlooked in occupational health research.

CHAPTER 5

Ethnic differences in patterns of occupational exposure in New Zealand

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Objectives: To investigate the differences in occupational exposure between Māori (New Zealand’s indigenous people) and non-Māori.

Methods: Participants were randomly selected from the Electoral Roll. Exposure to occupational risk factors was assessed through telephone interviews and exposure prevalences of Māori (n=273) and non-Māori (n=2,724) were compared. Subsequently, Māori were matched with non-Māori on current occupation (n=482) to assess whether ethnic differences also exist within occupations.

Results: Māori were more likely to report exposure to physical strain (for example lifting, standing). Part of these differences remained when Māori were compared with non-Māori in the same job. In addition, Māori women were twice as likely to categorise their job as very or extremely stressful than non-Māori women in the same job, while Māori men were twice as likely to report exposure to dust.

Conclusion: Marked ethnic differences exist in risk factors for occupational ill-health, due to both occupational distribution and the distribution of tasks within occupations.

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The manuscript which appears here reflects what was published, and also incorporates comments received by the examiners as part of the PhD conferment process

Introduction

Ethnic disparities in health have been extensively documented, with minority and indigenous ethnic groups from a range of countries continuing to be disadvantaged in terms of adverse health outcomes (Blakely et al. 2004, Bramley et al. 2005, Hemingway et al. 2001, Robson & Harris 2007). A number of New Zealand studies have consistently found the indigenous Māori population to have higher mortality rates (Blakely et al. 2004, Blakely et al. 2002, Bramley et al. 2005), greater severity of disease (Ellison-Loschmann et al. 2002), and poorer outcomes on a wide range of health indicators (Robson & Harris 2007) than the non-Māori population. These disparities exist even when comparisons are made within the same socioeconomic group (Pearce et al. 1985a) and have been attributed to a range of factors including individual behaviours (for example smoking), structural factors (for example unemployment), access to health services, and institutional racism (Blakely et al. 2005, Harris et al. 2006).

The work environment has been linked to social disparities in health (Krieger 2010, Souza et al. 2010), but it is unknown to what extent workplace exposures contribute to ethnic disparities in health. This is surprising given that work-related injury and disease remain important causes of morbidity and mortality in New Zealand (Driscoll et al. 2004). Ethnic differences in occupational injury rates have been demonstrated in the U.S. (Frumkin et al. 1999, Murray 2003, Robinson 1984), where several studies have shown that black workers have a higher risk of fatal (Loomis & Richardson 1998, Stout et al. 1996) and non-fatal work-related injury than white workers, even after adjusting for education and potential work experience (Robinson 1987, Robinson 1989). Ethnic differences in employment patterns have been shown to explain the higher occupational injury risk in black workers in the U.S. (Chen & Layne 1999, Loomis & Richardson 1998, Strong & Zimmerman 2005). A New Zealand study found that Māori workers had a significantly higher crude fatal occupational injury rate than non-Māori workers, and that occupational distribution explained approximately 70% of this difference (McCracken et al. 2001). A similar pattern was found for non-fatal work-related injury (McCracken 2002).

Thus, there is some evidence of ethnic differences in occupational injury rates. However, there is a lack of information on occupational disease rates or risk factors for occupational disease. Furthermore, ethnic disparities in occupational ill-health may operate at two levels: a) between occupations (different ethnic groups working in different jobs and therefore being exposed to different risk factors); and/or b) within occupations (different ethnic groups being exposed to different risk factors, even within the same job). The latter explanation in particular has been largely unexplored. The aims of this paper were to investigate the differences in occupational exposure between Māori (the indigenous population of New Zealand) and non-Māori, and to study whether any observed differences were due to: a) ethnic differences in exposure between occupations; and/or b) ethnic differences in exposure within occupations.

Methods

We conducted a nationwide telephone survey of a random sample of the New Zealand population aged 20-64 years over a 2-year period (2004-2006). The detailed study methodology is described elsewhere (Eng et al. 2010a). Briefly, 10,000 potential participants were randomly selected from the Electoral Roll and sent a letter of invitation to take part in a telephone interview. The interview obtained information on lifetime work history (for jobs with minimum 6 months duration), current exposures and workplace practices, and included questions on selected health outcomes.

Participants were asked whether the following exposures were present (yes/no) in their current work environment: dust; smoke or fume; gas; oils and solvents; acids or alkalis; fungicides, insecticides, herbicides or timber preservatives; and other chemical products (including dyes, inks, and adhesives). Participants were also asked how often their current job involved exposure to physical and organisational factors, including awkward or tiring positions, awkward grip or hand movements, lifting, carrying out repetitive tasks, working at very high speed, working to tight deadlines, standing, using tools that vibrate, and loud noise (all the time, three quarters of the time, half of the time, one quarter of the time, or never). The questionnaire obtained information on whether participants worked for at least 3 hours between midnight and 5am in the previous 4 weeks (night shift) and whether they regularly worked outside the hours of 8am-5pm (irregular hours). Participants were also asked to rate how stressful they found their current job on a 5-point scale (not at all stressful, mildly stressful, moderately stressful, very stressful, or extremely stressful).

Ethnicity was self-identified, which is the standard practice in New Zealand, and the recording of multiple responses was possible. If participants identified with more than one ethnic group (which included Māori), this was classified into a single ethnicity, which prioritised Māori. This is the standard approach in New Zealand health research (Ministry of Health 2002).

Occupations were coded using the New Zealand Standard Classification of Occupations (NZSCO) 1999 (Statistics New Zealand 2001b). Differences between Māori and non-

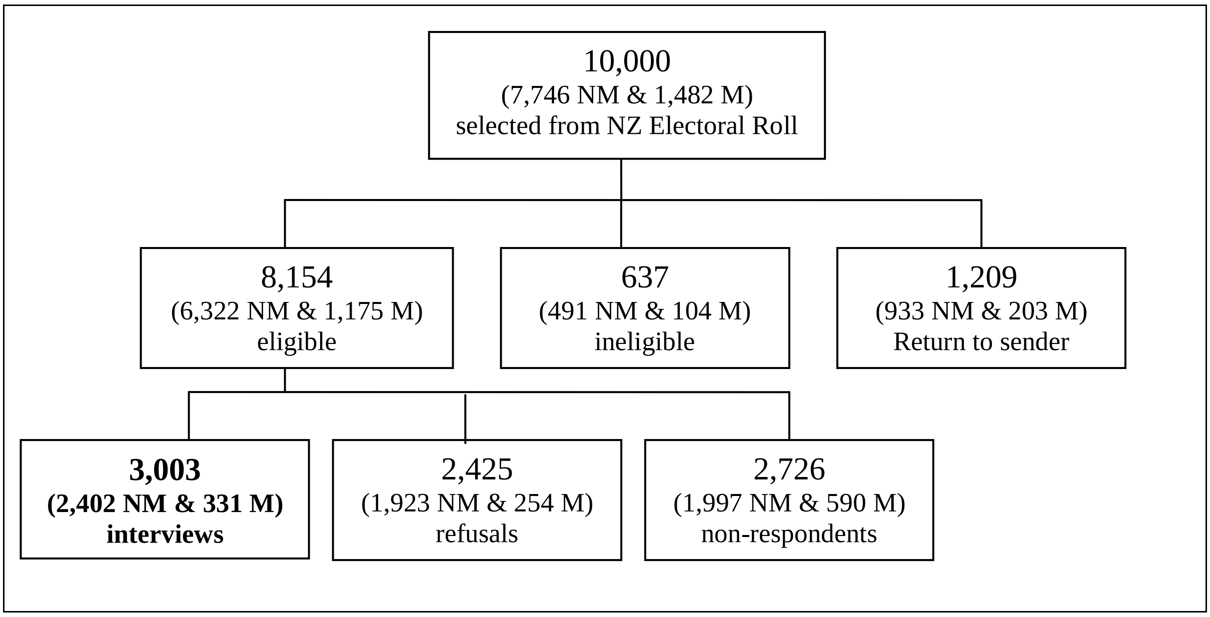
Māori were assessed using prevalence odds ratios (OR) (Pearce 2004) and 95% confidence intervals (CI) and the exposed were compared with the unexposed as the reference group for each occupational exposure. In the case of job stress, individuals who reported no or mild work-related stress formed the reference group. We conducted unconditional logistic regression in STATA v10.0 and adjusted for age (continuous variable) and gender. All analyses were also stratified by gender.

To investigate whether ethnic differences in exposure also exist within occupations, we conducted matched analyses where each Māori participant was matched (1:1) with a New Zealand European participant on current occupation (5-digit NZSCO code) and gender. There were small numbers of Asians, Pacific Islanders and ‘other’ ethnicities, thus these groups were not included in the matched analyses. ORs and 95% CIs were calculated using conditional logistic regression adjusted for age and socioeconomic status (SES), which was estimated using the New Zealand Deprivation Index 2001 (Crampton et al. 2004). This is a census-based index, which assigns a relative deprivation score (10 represents the most deprived 10% of New Zealand areas, while 1 represents the 10% least deprived areas) to each meshblock (representing geographic areas comprising approximately 100 people) (Crampton et al. 2004). Ethical approval for the study was obtained from the Massey University Human Ethics Committee (WGTN 03/133).

Results

The characteristics of the study sample are described in Table 5.1. Māori comprised 9% of the total sample. The Māori sample had a significantly higher proportion of females and current smokers, and a lower proportion of those who had never smoked. Māori also had a significantly higher proportion in the most deprived groups, higher proportions in the plant and machine operators and assemblers and elementary occupations, and a lower proportion in the legislators, administrators and managers group. Figure 5.1 illustrates the study recruitment process using the baseline data from the Electoral Roll. A total of 3,003 interviews were completed and the response rate for the Māori sample was 28% compared to 38% for the non-Māori sample. Of the 331 individuals recorded as Māori on the Electoral Roll, 273 self-identified as Māori in our sample. There were 6 individuals with missing self-identified ethnicity information who were subsequently excluded from these analyses.

Figure 5.1: Study recruitment using Electoral Roll data



NM Non-Māori
M Māori

Table 5.1 Description of study sample

	Total		Non-Māori		Māori		Chi²
	N=2997		N=2724 (90.9%)		N=273 (9.1%)		
	N	%	N	%	N	%	
Age at interview (years)							
20-34	657	21.9	584	21.4	73	26.7	
35-44	819	27.3	739	27.1	80	29.3	
45-54	867	28.9	799	29.3	68	24.9	
>55	654	21.8	602	22.1	52	19.1	p=0.10
Gender							
Male	1425	47.6	1316	48.3	109	39.9	
Female	1572	52.5	1408	51.7	164	60.1	**p=0.01**
Smoking							
Never	1515	50.9	1431	52.8	84	31.2	
Current	541	18.2	447	16.5	94	34.9	
Ex	923	31.0	832	30.7	91	33.8	**p<0.01**
Missing	18		14		4		
Deprivation index							
1 (least deprived)	422	14.5	401	15.1	21	8.1	
2	350	12.0	331	12.5	19	7.3	
3	336	11.5	321	12.1	15	5.8	
4	343	11.8	321	12.1	22	8.4	
5	335	11.5	307	11.6	28	10.7	
6	294	10.1	274	10.3	20	7.7	
7	247	8.5	213	8.0	34	13.0	
8	225	7.7	200	7.5	25	9.6	
9	221	7.6	182	6.9	39	14.9	
10 (most deprived)	141	4.8	103	3.9	38	14.6	**p<0.01**
Missing	83		71		12		
Current occupation (NZSCO)*							
1-Legislators, Administrators & Managers	504	16.8	474	17.4	30	11.0	
2-Professionals	624	20.8	577	21.2	47	17.2	
3-Technicians & Associate Professionals	455	15.2	410	15.1	45	16.5	
4-Clerks	356	11.9	332	12.2	24	8.8	
5-Service & sales workers	348	11.6	309	11.4	39	14.3	
6-Agricultural & Fishery workers	180	6.0	164	6.0	16	5.9	
7-Trades Workers	237	7.9	218	8.0	19	7.0	
8-Plant & Machine Operators & Assemblers	178	5.9	148	5.4	30	11.0	
9-Elementary Workers	113	3.8	90	3.3	23	8.4	**p<0.01**
Missing	2		2		0		

* New Zealand Standard Classification of Occupations 1999

Table 5.2 compares the prevalence of various occupational exposures between Māori and non-Māori in the total sample (n=2,997), and between Māori and non-Māori in the same occupation (referred to as the matched sample; n=482). In the total sample, Māori were less likely to report exposure to acids or alkalis (OR=0.48; 95% CI 0.27-0.85) and less likely to report exposure to oils and solvents, although the finding was not statistically significant (OR=0.84; 95% CI 0.60-1.17). Māori were however, more likely to report exposure to all physical factors under study, including lifting (OR=1.69; 95% CI 1.31-2.18); exposure to loud noise (OR=1.52; 95% CI 1.16-1.99); awkward or tiring positions (OR=1.47; 95% CI 1.13-1.92); awkward grip or hand movements (OR=1.64; 95% CI 1.27-2.11); and standing (OR=1.32; 95% CI 1.01-1.72) a quarter of the time or more in their current job.

There were 32 Māori participants with no match and they were subsequently excluded from the matched analyses. Adjusting for deprivation did not have a major effect on the results (with the exception of using tools that vibrate). Thus, results adjusted for age only are presented. In most cases, matching on occupation and gender attenuated the ethnic differences in exposure. For those exposures with statistically significant increased odds in Māori, 25-100% of the observed excess odds appeared to be due to differences in occupation (i.e. the excess odds were reduced by about 25-100% when we matched for occupation). In particular, the elevated odds observed in the total sample of exposure to loud noise, awkward or tiring positions, night shift work, and working irregular hours, appeared to be largely explained by occupational distribution. However, several associations remained after matching on occupation. The observed reduced odds of exposure to acids or alkalis in Māori workers remained (OR=0.58; 95% CI 0.27-1.22) and the reduced odds were stronger in Māori females than in males (Tables 5.3 & 5.4). The increased odds in Māori workers of lifting (OR=1.47; 95% CI 0.96-2.25) and awkward grip or hand movements (OR=1.31; 95% CI 0.91-1.88) also remained in the matched sample. The odds of reporting use of tools that vibrate in Māori were increased in the matched sample. However, the odds were attenuated after adjusting for deprivation to OR=1.04 (95% CI 0.49-2.22). The odds of reporting a very or extremely stressful job were increased in Māori participants in the matched sample (OR=1.55; 95% CI 0.90-2.65).

Table 5.2 Differences in occupational exposure prevalence between Maori and non-Maori

	Exposure in Maori and non-Maori (whole sample)			Exposure in Maori and non-Maori with the same occupation (matched sample)†		
	Non-Māori	Māori	OR (95% CI)§	NZ Euro	Maori	OR (95% CI)#
Exposure	N=2724	N=273		N=241	N=241	
	%	%		%	%	
Dust/chemical factors						
Dust	29.1	31.1	1.21 (0.92-1.60)	26.1	29.5	1.17 (0.75-1.82)
Smoke/Fume/Gas	21.2	23.1	1.20 (0.89-1.63)	21.2	19.9	0.90 (0.55-1.49)
Oils and Solvents	21.2	17.6	0.84 (0.60-1.17)	19.5	17.0	0.82 (0.49-1.38)
Acids or alkalis	9.9	4.8	0.48* (0.27-0.85)	8.7	5.4	0.58 (0.27-1.22)
Pesticides	9.5	9.5	1.13 (0.74-1.74)	8.7	8.7	1.03 (0.47-2.24)
Any of the above	45.4	44.3	1.03 (0.79-1.33)	45.6	41.9	0.78 (0.51-1.21)
Physical factors						
Lifting**	38.0	50.7	1.69* (1.31-2.18)	41.7	49.2	1.47 (0.96-2.25)
Loud noise**	29.0	36.6	1.52* (1.16-1.99)	30.3	34.0	1.16 (0.73-1.82)
Awkward or tiring positions**	55.2	65.3	1.47* (1.13-1.92)	64.2	65.7	1.00 (0.67-1.49)
Awkward grip or hand movements**	37.1	49.3	1.64* (1.27-2.11)	40.8	50.0	1.31 (0.91-1.88)
Standing**	27.4	33.5	1.32* (1.01-1.72)	29.9	33.8	1.24 (0.81-1.91)
Tools that vibrate**	10.9	14.4	1.45 (1.00-2.11)	9.2	13.8	1.70 (0.85-3.37)
Organisational factors						
Repetitive tasks**	67.6	75.1	1.36* (1.02-1.81)	71.1	74.7	1.09 (0.71-1.67)
Working at very high speed**	50.7	56.3	1.17 (0.91-1.51)	60.0	55.6	0.78 (0.53-1.14)
Working to tight deadlines**	73.0	74.5	1.05 (0.78-1.40)	72.9	73.6	0.92 (0.60-1.41)
Night shift	7.0	8.9	1.43 (0.91-2.27)	7.6	7.9	0.84 (0.37-1.94)
Irregular hours	15.8	19.5	1.36 (0.99-1.88)	17.4	18.3	1.09 (0.63-1.88)
Stress						
Not at all-Mildly	39.4	42.8	1.00 (ref)	42.3	40.6	1.00 (ref)
Moderately	45.9	38.4	0.78 (0.59-1.03)	44.4	39.3	0.93 (0.62-1.38)
Very-Extremely	14.8	18.8	1.18 (0.83-1.68)	13.3	20.1	1.55 (0.90-2.65)

§ adjusted for age and gender
†Maori and NZ European (NZ Euro) matched on current occupation (New Zealand Standard Classification of Occupations 5-digit code) and gender
#adjusted for age
*statistically significant at p<0.05 level
**1/4 of the time or more

Gender differences

For self-reported exposure to dust, an elevated odds ratio was observed in the matched sample, but in Māori men only (OR=2.04; 95% CI 1.03-4.06) (Table 5.3). The reduced odds of self-reported exposure to oils and solvents in Māori men did not change after controlling for occupation. After matching, increased odds in Māori males remained for lifting, awkward grip or hand movements, and standing a quarter of the time or more (Table 5.3). The elevated odds of using tools that vibrate were attenuated after adjusting for deprivation to OR=1.41 (95% CI 0.53-3.74). Amongst Māori females, the excess odds of lifting also remained after controlling for occupation (Table 5.4). In addition, Māori women demonstrated a more than two-fold increased odds of reporting a very or extremely stressful job than non-Māori women in the same occupation (OR=2.25; 95% CI 1.11-4.54)

Table 5.3 Differences in occupational exposure prevalence between Maori and non-Maori males

	Exposure in Maori and non-Maori (whole sample)			**Exposure in Maori and non-Maori with the same occupation (matched sample)†**		
	Non-Maori	**Maori**	**OR (95% CI)§**	**NZ Euro**	**Maori**	**OR (95% CI)§**
	N=1316	**N=109**		**N=94**	**N=94**	
Dust/chemical factors	**%**	**%**		**%**	**%**	
Dust	39.8	45.9	1.24 (0.84-1.85)	35.1	47.9	2.04* (1.03-4.06)
Smoke/Fume/Gas	29.1	33.0	1.16 (0.76-1.77)	33.0	29.8	0.87 (0.43-1.74)
Oils and Solvents	30.2	24.8	0.72 (0.46-1.14)	31.9	25.5	0.73 (0.35-1.49)
Acids or alkalis	13.8	9.2	0.61 (0.31-1.18)	12.8	10.6	0.82 (0.32-2.09)
Pesticides	14.4	15.6	1.16 (0.68-2.00)	16.0	14.9	0.98 (0.37-2.59)
Any of the above	56.8	57.8	1.01 (0.68-1.51)	58.5	57.5	1.00 (0.50-2.00)
Physical factors						
Lifting**	41.9	56.0	1.65* (1.11-2.46)	51.1	59.6	1.45 (0.73-2.88)
Loud noise**	39.4	45.0	1.19 (0.80-1.76)	42.6	45.7	1.03 (0.50-2.11)
Awkward or tiring positions**	53.6	64.2	1.48 (0.98-2.22)	67.7	67.0	0.91 (0.47-1.78)
Awkward grip or hand movements**	39.4	53.2	1.64* (1.10-2.44)	48.9	57.5	1.38 (0.74-2.60)
Standing**	26.3	37.6	1.65* (1.09-2.48)	27.7	39.4	1.93 (0.95-3.92)
Tools that vibrate**	16.8	23.9	1.41 (0.88-2.26)	16.0	25.5	2.14 (0.87-5.27)
Organisational factors						
Repetitive tasks**	63.7	77.1	1.77* (1.11-2.83)	75.5	78.7	1.12 (0.57-2.21)
Working at very high speed**	46.4	54.1	1.23 (0.82-1.83)	64.9	55.3	0.60 (0.32-1.15)
Working to tight deadlines**	74.6	78.5	1.12 (0.69-1.81)	75.5	78.3	0.91 (0.43-1.92)
Night shift	10.0	14.0	1.44 (0.79-2.61)	14.3	12.9	0.72 (0.25-2.11)
Irregular hours	19.5	27.8	1.59* (1.02-2.48)	23.4	25.8	1.18 (0.52-2.67)
Stress						
Not at all-Mildly	36.2	39.3	1.00 (ref)	35.1	38.0	1.00 (ref)
Moderately	48.5	49.5	0.93 (0.61-1.42)	51.1	50.0	0.95 (0.52-1.72)
Very-Extremely	15.3	11.2	0.70 (0.36-1.36)	13.8	12.0	0.77 (0.31-1.90)

§adjusted for age

†Maori and NZ European (NZ Euro) matched on current occupation (New Zealand Standard Classification of Occupations 5-digit code) and gender

*statistically significant at p<0.05 level

**1/4 of the time or more

Table 5.4 Differences in occupational exposure prevalence between Maori and non-Maori females

	Exposure in Maori and non-Maori (whole sample)			Exposure in Maori and non-Maori with the same occupation (matched sample)†		
	Non-Maori	**Maori**	**OR (95% CI)§**	**NZ Euro**	**Maori**	**OR (95% CI)§**
	N=1408	**N=164**		**N=147**	**N=147**	
Dust/chemical factors	**%**	**%**		**%**	**%**	
Dust	19.1	21.3	1.16 (0.78-1.72)	20.4	17.7	0.72 (0.39-1.35)
Smoke/Fume/Gas	13.7	16.5	1.24 (0.80-1.92)	13.6	13.6	0.93 (0.45-1.94)
Oils and Solvents	12.8	12.8	0.99 (0.61-1.61)	11.6	11.6	0.92 (0.43-1.97)
Acids or alkalis	6.3	1.8	0.28* (0.09-0.89)	6.1	2.0	0.32 (0.08-1.18)
Pesticides	5.0	5.5	1.12 (0.55-2.28)	4.1	4.8	1.09 (0.29-4.15)
Any of the above	34.7	35.4	1.03 (0.73-1.45)	37.4	32.0	0.66 (0.37-1.16)
Physical factors						
Lifting**	34.4	47.2	1.70* (1.22-2.35)	35.6	42.5	1.49 (0.86-2.57)
Loud noise**	19.3	31.1	1.87* (1.31-2.68)	22.5	26.5	1.26 (0.70-2.27)
Awkward or tiring positions**	56.7	66.1	1.47* (1.04-2.08)	61.9	64.8	1.05 (0.64-1.72)
Awkward grip or hand movements**	34.9	46.6	1.62* (1.17-2.25)	35.6	45.2	1.27 (0.82-1.97)
Standing**	28.3	30.7	1.12 (0.79-1.59)	31.3	30.1	0.93 (0.53-1.62)
Tools that vibrate**	5.5	8.0	1.48 (0.80-2.73)	4.8	6.2	1.18 (0.40-3.47)
Organisational factors						
Repetitive tasks**	71.2	73.8	1.12 (0.77-1.62)	68.3	72.1	1.07 (0.61-1.86)
Working at very high speed**	54.7	57.7	1.12 (0.80-1.55)	56.9	55.8	0.90 (0.56-1.45)
Working to tight deadlines**	71.4	72.0	1.01 (0.70-1.45)	71.2	70.8	0.93 (0.55-1.55)
Night shift	4.1	5.6	1.40 (0.68-2.89)	3.6	4.9	1.08 (0.28-4.19)
Irregular hours	12.3	14.0	1.16 (0.73-1.85)	13.6	13.6	1.02 (0.48-2.14)
Stress						
Not at all-Mildly	42.3	45.1	1.00 (ref)	46.9	42.2	1.00 (ref)
Moderately	43.4	31.1	0.67* (0.46-0.97)	40.1	32.7	0.91 (0.54-1.56)
Very-Extremely	14.3	23.8	1.55* (1.02-2.36)	12.9	25.2	2.25* (1.11-4.54)

§ adjusted for age

† Maori and New Zealand European (NZ Euro) matched on current occupation (New Zealand Standard Classification of Occupations 5-digit code) and gender

* statistically significant at p<0.05 level

**1/4 of the time or more

Discussion

This study is the first to investigate differences in exposure to occupational hazards between Māori and non-Māori in New Zealand. It collected detailed information on occupational exposures and work tasks for a random sample of both Māori and non-Māori workers, thus being representative of the whole working population, rather than focusing on any specific industry. However, because it is a population-based survey it suffered from a relatively low response rate, particularly for Māori. The underrepresentation of Māori in this study appeared to be due to our inability to establish contact either by mail or by phone rather than refusal to participate (Mannetje et al. 2011). This resulted in a lower proportion of Māori participants in the youngest age-group (20-34 years) than in the Māori non-participants, more Māori participants in the legislators, administrators and managers and professionals groups than in the Māori non-participants, and more Māori non-participants in the most deprived groups than in the Māori participants. We addressed this by adjusting for possible determinants of non-response (age, gender, and deprivation), but the possibility of some residual confounding cannot be excluded. However, any residual confounding would most likely result in an underestimation of exposure prevalence in Māori workers; therefore an overestimation of ethnic differences in occupational hazards between Māori and non-Māori (i.e. false-positive results) is unlikely. The implications of the low overall response rate in this survey are further discussed in Eng et al (Eng et al. 2010a). A further limitation of the current study was the low precision of the effect estimates as a result of the small numbers of Māori workers in the study.

In the current study, Māori workers were not more likely to report exposure to dust and chemical factors and in some instances, were less likely to report exposure to certain substances (for example acids or alkalis). A similar pattern was observed in a study from the U.S. (Quinn et al. 2007). It has been suggested that minority workers often work in more precarious forms of employment and thus may be less likely to self-report occupational exposures, and that perception of exposures may differ by social group (Quinn et al. 2007). Māori were less likely to report exposure to acids or alkalis while this was not the case for exposures that are more easily identified, such as dust and smoke, which could be due to less awareness of the presence of particular substances in the workplace among Māori than among non-Māori, rather than reflecting a real difference in exposure.

In contrast, this study found that Māori were more likely to be exposed to physical factors including lifting, loud noise, awkward or tiring positions, awkward grip or hand movements, standing, and vibrating tools. The odds of these risk factors were in the range of 30%-70% higher in Māori workers in the total sample. Ethnic differences in exposure to occupational hazards have also been documented in the U.S. (Frumkin et al. 1999, Murray 2003, Robinson 1984). These ethnic differences in occupational exposures could be due to: a) the different occupational distribution of Māori and non-Māori; and/or b) Māori and non-Māori with the same job title carrying out different tasks.

a) Ethnic segregation of occupations

A large part of these ethnic differences in occupational exposures was due to differences in occupational distribution, i.e. Māori working in different jobs than non-Māori. New Zealand labour force statistics have consistently indicated that Māori are overrepresented in low-skilled manual occupations and in certain industries such as forestry and manufacturing (Statistics New Zealand 2010) and the present survey also indicates that

Māori are more than twice as likely to be employed in elementary occupations (including cleaners and labourers) than non-Māori. This pattern of minority workers being overrepresented in low-skilled, manual and therefore relatively more hazardous occupations has been observed in a number of countries (Lipscomb et al. 2006, Loomis & Richardson 1998) and was a key explanation for ethnic differences in occupational injury rates in the U.S. Our results indicate that occupational distribution is also an important factor in occupational exposure differences.

b) Ethnic segregation of tasks

This is the first study to compare exposures between Māori and non-Māori within the same job for a range of occupations. Several associations remained or were increased when Māori were compared with non-Māori with the same occupational title. This illustrates that job title is often a poor surrogate for occupational exposure and different ethnic groups with the same job title may not always carry out the same tasks. Both Māori men and women were more likely to report certain physically strenuous tasks (i.e. lifting and awkward grip or hand movements) than non-Māori with the same job title (although the results were not statistically significant). Māori men were also more likely to be exposed to dusty tasks and had non-significant excess odds of performing tasks that required standing one quarter of the time or more. This implies that a worker's ethnicity is a factor in the assignment of job tasks. There have been a few documented historical examples of minority workers being assigned the 'dirtier' and unsafe tasks within the same job (for example African-American steelworkers, cited in (Loomis & Richardson 1998)). Discrimination, for example in assigning more physically demanding tasks to Māori workers, whether consciously or not, is one likely explanation. This would suggest that policies addressing ethnic disparities in occupational health need to not only focus on improving education and employment opportunities for Māori, but must also challenge wider societal practices which may underlie the observed segregation of tasks within jobs, such as discrimination and prejudice.

Job stress

There is a growing body of literature highlighting associations between psychosocial factors and the effects on worker health and safety resulting in an increased risk of cardiovascular disease and musculoskeletal disorders (Bosma et al. 1998, Huang et al. 2002, Radi et al. 2007). We found that Māori women were more likely to report that their job was very or extremely stressful than non-Māori women in the same occupation. There are several potential reasons for this finding. Firstly, there may be differences in what is perceived or reported as stressful in the work environment between Māori and non-Māori. Secondly, minority workers are more likely to experience certain psychosocial risk factors, for example, they often have less control over the work process, fewer opportunities for job modification and advancement, less decision autonomy, and are more likely to encounter racial discrimination (Hemingway et al. 2001, Krieger et al. 2006, Shannon et al. 2009, Siegrist & Marmot 2004). Thirdly, Māori women may face added pressures outside of work, for example, a government report on work-life balance in New Zealand, which was based on consultation with a diverse range of both employees and employers, identified cultural demands particular to Māori, specifically the obligations of the individual towards the wider family (whanau) or tribal collective (Department of Labour 2004). Māori women have been shown to participate more commonly in unpaid work than non-Māori women, such as looking after household members with illness or disability, looking after a child who does not live in the household, and doing voluntary work (Statistics New Zealand 2005). A recent UK study similarly found that, not only was there an association between ethnicity and work stress, but in particular Black Caribbean females who encountered racial discrimination were most likely to report work stress. Qualitative follow-up interviews with Black Caribbean female participants indicated that conflict between work demands and demands from the home was a key source of stress (Smith et al. 2005). Thus, the combination of gender and ethnic disparities in the work environment and additional stressors outside the workplace may have a disproportionate impact on Māori women.

In summary, this study found ethnic differences in occupational exposure prevalence, particularly for physical risk factors such as lifting, loud noise, awkward or tiring positions, awkward grip or hand movements, standing, and vibrating tools. The odds of these risk factors were considerably higher (in the range of 30-70%) in Māori than in non-Māori and this pattern was observed for both men and women. When Māori were compared with non-Māori in the same job, most of these differences in occupational exposure were attenuated, while some of the results were more pronounced after stratifying by gender, illustrating a complex interaction between occupation, ethnicity and gender. Whilst there is limited information available on occupational injury and disease in the Māori workforce, these findings suggest that differences in occupational exposure patterns between Māori and non-Māori exist both between and within occupations and that work should be considered among the determinants of ethnic disparities in health.

Section 3. Work-related risk factors for asthma

Chapter 6 The New Zealand workforce survey: occupational risk factors for asthma

Chapter 7 Work-related stress and asthma: results from a workforce survey

CHAPTER 6

The New Zealand Workforce Survey: occupational risk factors for asthma

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Introduction: We conducted a cross-sectional population-based survey in New Zealand that collected information on work history, current workplace exposures, and selected health outcomes. We report here the findings on occupational risk factors for asthma symptoms.

Methods: A random sample of men and women aged 20-64 years were selected from the New Zealand Electoral Roll and invited to take part in a telephone survey. Current asthma was defined as: (i) woken up by shortness of breath in the past 12 months; or (ii) an attack of asthma in the past 12 months; or (iii) currently taking asthma medication. Adult-onset asthma was defined as first attack of asthma at age 18 or over. Prevalence odds ratios (ORs) for all occupations were calculated using logistic regression adjusting for sex, age, smoking, and deprivation.

Results: Totally, 2,903 participants were included in the analyses. The prevalence of current asthma was 17% and the prevalence of adult-onset asthma was 9%. Prevalence ORs for current asthma were elevated for ever working as a printer (OR=2.26; 95% Confidence Interval (CI) 1.09-4.66), baker (OR=1.98; 95% CI 1.02-3.85), sawmill labourer (OR=3.26; 95% CI 1.05-10.16), metal processing plant operator (OR=2.48; 95% CI 1.22-5.05), and cleaner (OR=1.60; 95% CI 1.09-2.35). Excess risks of adult-onset asthma were also found for ever working as a printer, baker, and sawmill labourer as well as ever-working as a market-oriented animal producer (OR=1.66; 95% CI 1.14-2.41), and other agricultural worker (OR=2.08; 95% CI 1.03-4.20). A number of occupations not previously considered at high risk for asthma were also identified, including teachers and certain sales professionals.

Conclusion: This population-based study has confirmed findings of previous international studies showing elevated risks in a number of high-risk occupations. The strongest risks were consistently observed for printers, bakers, and sawmill labourers. Several occupations were also identified that have not been previously associated with asthma, suggesting that the risk of occupational asthma may be more widely spread across the workforce than previously assumed.

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Introduction

The proportion of asthma cases attributable to occupational exposures has generally been estimated to range between 15 and 20% (Balmes et al. 2003, Blanc & Toren 1999). However, substantially higher estimates were recently reported by a study of the entire employed population of Finland from 1986 to 1998, which estimated that the attributable fraction of adult-onset asthma due to occupation was 29% for men and 17% for women (Karjalainen et al. 2001). Certain occupational groups are known to be at particularly high risk of occupational asthma, including laboratory workers, healthcare workers, construction workers, bakers, woodworkers handling western red cedar, and chemical workers exposed to isocyanates. However, many of these findings are from studies in specific industries, and only some have been investigated in epidemiological studies of the working population. A previous population-based study in New Zealand (n=1,609) found increased risks of asthma symptoms for current employment as a farmer or farm worker, laboratory technician, and food processing worker (other than baker). Excess risks were also observed for chemical workers and plastic and rubber workers, but the numbers were relatively small (Fishwick et al. 1997c).

The nature of work is continually changing and new exposures are emerging. Thus, the aims of this study were to: i) identify occupations currently associated with an increased risk of asthma and ii) identify any previously unrecognised risk factors for occupational asthma. We have, therefore, conducted a nationwide survey of a random sample of the New Zealand population (Eng et al. 2010a). We report here the findings on occupational risk factors for asthma symptoms.

Methods

We conducted a nationwide telephone survey of a random sample of the New Zealand population aged 20-64 years over a 2-year period (2004-2006). The detailed study methodology is described elsewhere (Eng et al. 2010a). Briefly, 10,000 potential participants were randomly selected from the Electoral Roll and sent a letter of invitation to take part in a telephone interview. The interview obtained information on lifetime work history (for jobs with minimum 6 months duration), current exposures and workplace practices, and questions on selected health outcomes, including respiratory symptoms. Respiratory symptoms were assessed using a standardised questionnaire based on the European Community Respiratory Health Survey (ECRHS) (Burney et al. 1994).

Occupations were coded using the New Zealand Standard Classification of Occupations (NZSCO) 1999 (Statistics New Zealand 2001b). Overall asthma prevalence was estimated using the definition from the ECRHS (Burney et al. 1994), which is based on the proportion of participants answering ‘yes’ to ‘woken by an attack of shortness of breath in the past 12 months’, ‘asthma attack in the past 12 months’, or ‘current asthma medication’. This is hereafter referred to as ‘current asthma’. This definition has been widely used in previous population-based studies (Fishwick et al. 1997c, Kogevinas et al. 1999). In addition to ‘current asthma’, which includes childhood asthma caused by factors unrelated to occupational exposures later in life, we also investigated adult-onset asthma, which was defined as a first attack of asthma at age 18 years or older. Participants who had *ever* worked in a particular occupation in their lifetime were compared to those who had *never* worked in that occupation. We also repeated the analyses using (i) the workers’ occupation at the time of asthma-onset for participants with adult-onset asthma versus a comparison group of workers who did not work in that particular occupation at the time of asthma-onset and (ii) the workers' longest-held occupation for the remaining participants versus a comparison group of workers whose longest-held occupation was different from the one studied. These approaches have been commonly used in occupational studies of work history data and they also attenuate the influence of the 'healthy worker effect' (see Discussion).

Prevalence odds ratios (OR) (Pearce 2004) and 95% confidence intervals (CI) were calculated using unconditional logistic regression in STATA v10.0 for all occupations, adjusting for age (continuous variable), sex, smoking (never, ex, current), and the 2001 deprivation index (a census-based index with a relative deprivation score assigned to each geographical meshblock in New Zealand: 1-least deprived to 10-most deprived). The selection of the *a priori* high-risk groups was based on those groups that had consistently shown increased risks in previous studies. Selection was generally based on findings from population-based studies rather than studies of specific subgroups. For example, while an excess risk in food processors has been identified in a few studies, the majority of studies on this topic are of specific processes, for example seafood processing.

Results

Of the 10,000 letters of invitation, 1,209 were returned to sender and 637 potential participants were classified as ineligible. Of the remaining 8,154 eligible individuals, 2,719 did not respond to up to three invitation letters. Of those we could contact, 3,003 took part in the interview (an additional 7 questionnaires were missing and therefore excluded) and 2,425 refused to take part. The contact rate (number of successful contacts made/total eligible sample) was 67%; the response rate (number interviewed/ total eligible sample) was 37%; and the interview rate (number interviewed/ interviewed plus refused) was 55%. The characteristics of the study sample are presented in Table 6.1. The current analyses were based on 2,903 participants excluding those with missing information on smoking or deprivation. The overall prevalence of current asthma was 17% (16% in men and 18% in women) and the prevalence of adult-onset asthma was 9% (6% in men and 12% in women). Information on longest-held occupation was missing for five participants. Of the 269 participants with adult-onset asthma, occupation at the time of onset was available for 218 participants.

Of the nine major NZSCO groups, the only statistically significant elevated risk was observed for ever working in an elementary occupation (NZSCO Group 9), which includes cleaners, labourers, packers, and rubbish collectors (OR=1.36; 95% CI 1.08-1.71; data not shown). When we used longest-held occupation (rather than occupation ever-held), the risk increased to OR=1.56 (95% CI 1.03-2.36). An excess risk in this group was not observed for adult-onset asthma.

Table 6.1 Characteristics of the study participants

	Total N=2903		Men N=1381 (47.6%)		Women N=1522 (52.4%)	
	N	%	N	%	N	%
Smoking						
Never	1475	50.8	686	49.7	789	51.8
Current	532	18.3	251	18.2	281	18.5
Ex	896	30.9	444	32.2	452	29.7
Age						
Mean			44.2			
SD			11.3			
New Zealand deprivation index 2001						
1 (least deprived)	421	14.5	221	16.0	200	13.1
2	349	12.0	182	13.2	167	11.0
3	335	11.5	170	12.3	165	10.8
4	342	11.8	160	11.6	182	12.0
5	333	11.5	148	10.7	185	12.2
6	290	10.0	128	9.3	162	10.6
7	245	8.4	98	7.1	147	9.7
8	226	7.8	105	7.6	121	8.0
9	222	7.7	113	8.2	109	7.2
10 (most deprived)	140	4.8	56	4.1	84	5.5
Asthma Prevalence						
Woken by SOB in past 12 months	281	9.7	139	10.1	142	9.3
Asthma attack in past 12 months	253	8.7	103	7.5	150	9.9
Currently taking asthma medication	275	9.5	105	7.6	170	11.2
Current asthma	496	17.1	220	15.9	276	18.1
Wheeze in past 12 months	688	23.7	308	22.3	380	25.0
Ever had asthma	620	21.4	243	17.6	377	24.8
Doctor-diagnosed asthma	571	19.7	219	15.9	352	23.1
Adult-onset asthma	269	9.3	84	6.1	185	12.2
Doctor-diagnosed adult-onset asthma	246	8.5	75	5.4	171	11.2

SOB - shortness of breath

18 missing for smoking

83 missing for deprivation

The findings for the *a priori* high-risk occupational groups for current and adult-onset asthma are presented in Table 6.2. Adjustment for other *a priori* high-risk occupations had a negligible effect on the results. Most *a priori* high-risk occupations were positively associated with current asthma, although only some of the findings were statistically significant because of the small numbers in some occupational categories. Printers demonstrated statistically significant elevated risks for both current and adult-onset asthma; the greatest risks were for longest-held occupation. Ever being employed as a sawmill labourer showed statistically significant excess risks of current asthma (OR=3.26; 95% CI 1.05-10.16) and adult-onset asthma (OR=6.25; 95% CI 1.86-21.01). Ever working in the bakers and grain millers group also showed an increased risk of current asthma (OR=1.98; 95% CI 1.02-3.85) and a non-significant increased risk of adult-onset asthma (OR=1.69; 95% CI 0.69-4.10). The risk was particularly elevated for baker's assistants. Cleaners showed an increased risk of current asthma for ever working in the occupation (OR=1.60; 95% 1.09-2.35) and a non-significant excess risk for working in the occupation for the longest duration (OR=1.78; 95% CI 0.84-3.74). This group did not show a significantly elevated risk for adult-onset asthma. Metal workers in general did not show an increased risk of current asthma; however within this group, metal processing plant operators had an increased risk associated with ever working in the occupation (OR=2.48; 95% CI 1.22-5.05) and a non-significant excess for working in the occupation for the longest duration (OR=2.49; 95% CI 0.61-10.09). A reduced risk of current asthma was observed for ever working as a dairy farmer (OR=0.42; 95% CI 0.20-0.86). However, market-oriented animal producers showed an excess risk of adult-onset asthma for ever working in this occupation (OR=1.66; 95% CI 1.14-2.41) and a non-significant excess for working in this occupation for the longest duration (OR=1.51; 95% CI 0.87-2.62). A statistically significant increased risk of adult-onset asthma was also observed for ever working in the other agricultural workers group (OR=2.08; 95% CI 1.03-4.20), which includes shepherds, wool classers, and shearing shed hands.

Welders and flamecutters showed non-significant increased risks of current asthma for ever working in this occupation (OR=2.41; 95% CI 0.90-6.51) and for working in this occupation for the longest duration (OR=1.63; 95% CI 0.17-15.79). Although the numbers were small, non-significant excess risks were also observed for adult-onset asthma for ever working in this occupation (OR=1.67; 95% CI 0.37-7.45) and for working in this occupation for the longest duration (OR=4.77; 95% CI 0.48-47.76). Field crop and vegetable growers also showed non-significant elevated risks of both current and adult-onset asthma. In addition, non-significant increased risks of adult-onset asthma were shown for both ever working as a cattle farmer (OR=3.02; 95% CI 0.80-11.35) and longest-held occupation as a cattle farmer (OR=2.93; 95% CI 0.57-15.15), although the numbers were very small.

Table 6.2 Odds ratios (OR) and 95% Confidence Intervals (CI) for *a priori* high-risk occupations

	Ever occupation					Longest-held occupation				
		Current asthma		Adult-onset asthma			Current asthma		Adult-onset asthma	
***A priori* high-risk occupation**	**Total**	**Cases**	**OR (95% CI)[a]**	**Cases**	**OR (95% CI)[a]**	**Total**	**Cases**	**OR (95% CI)[b]**	**Cases**	**OR (95% CI)[b]**
NZSCO code	**N**	**%**		**%**		**N**	**%**		**%**	
Healthcare workers	179	14.5	0.8 (0.5-1.3)	12.3	1.0 (0.7-1.7)	114	14.9	0.8 (0.5-1.4)	13.2	1.2 (0.7-2.1)
2221-Medical doctors	28	28.6	2.1 (0.9-4.9)	10.7	1.3 (0.4-4.4)	18	16.7	1.1 (0.3-3.7)	11.1	1.2 (0.3-5.5)
223-Nursing and midwifery professionals	135	11.9	0.6 (0.4-1.1)	12.6	1.0 (0.6-1.6)	84	14.3	0.8 (0.4-1.5)	13.1	1.1 (0.6-2.1)
Laboratory workers	34	20.6	1.2 (0.5-2.8)	8.8	0.8 (0.2-2.7)	12	16.7	0.9 (0.2-4.2)	16.7	1.8 (0.4-8.5)
32111-Life science technicians	20	25.0	1.6 (0.6-4.3)	10.0	1.0 (0.2-4.4)	5	20.0	1.1 (0.1-10.0)	20.0	3.2 (0.3-30.2)
32112-Medical laboratory technicians	16	18.8	1.1 (0.3-3.8)	6.3	0.5 (0.1-3.8)	7	14.3	0.8 (0.1-6.4)	14.3	1.2 (0.1-10.4)
51411-Hairdressers	38	13.2	0.7 (0.3-1.8)	5.3	0.4 (0.1-1.6)	17	5.9	0.3 (0.0-2.2)	0	-
Metal workers	129	17.1	1.0 (0.6-1.7)	3.9	0.5 (0.2-1.4)	51	9.8	0.5 (0.2-1.4)	5.9	1.0 (0.3-3.1)
721-Metal moulders, sheet-metal and related workers	64	12.5	0.7 (0.3-1.5)	4.7	0.7 (0.2-2.3)	24	8.3	0.4 (0.1-1.9)	8.3	1.6 (0.4-6.8)
722-Blacksmiths, toolmakers and related workers	37	10.8	0.6 (0.2-1.8)	2.7	0.4 (0.1-2.7)	18	0		0	-
812-Metal processing plant operators	36	33.3	2.5 (1.2-5.1)	5.6	0.8 (0.2-3.4)	9	33.3	2.5 (0.6-10.1)	11.1	1.7 (0.2-13.8)
733-Printers	35	31.4	2.3 (1.1-4.7)	17.1	2.2 (0.9-5.5)	13	53.9	5.9 (1.9-17.6)	30.8	5.2 (1.5-17.4)
Rubber & Plastics workers	19	15.8	0.9 (0.3-3.1)	0	-	4	0	-	0	-
82322-Plastics machine operators	9	33.3	2.4 (0.6-9.8)	0	-	0	0	-	0	-
Bakers & Grain millers	43	30.2	2.0 (1.0-3.9)	14.0	1.7 (0.7-4.1)	6	0	-	0	-
74121-Bakers	24	20.8	1.3 (0.5-3.4)	4.2	0.4 (0.1-3.2)	0	0	-	0	-
82742-Baker's assistants	16	37.5	2.5 (0.9-7.0)	25.0	3.6 (1.1-11.4)	0	0	-	0	-
Farmers	462	16.9	1.0 (0.8-1.3)	10.0	1.2 (0.8-1.7)	174	13.2	0.8 (0.5-1.2)	10.3	1.3 (0.8-2.1)
611-Market farmers and crop growers	197	16.2	0.9 (0.6-1.4)	6.6	0.7 (0.4-1.2)	43	14.0	0.8 (0.3-1.9)	4.7	0.5 (0.1-2.3)
6111-Field crop and vegetable growers	23	26.1	1.6 (0.6-4.2)	17.4	2.2 (0.7-6.6)	4	50.0	5.5 (0.8-39.7)	25.0	5.2 (0.5-51.4)
612-Market-oriented animal producers	307	16.3	1.0 (0.7-1.4)	12.7	1.7 (1.1-2.4)	131	13.0	0.7 (0.4-1.3)	12.2	1.5 (0.9-2.6)
6121-Livestock producers	168	11.9	0.7 (0.4-1.1)	12.5	1.6 (1.0-2.6)	90	13.3	0.8 (0.4-1.5)	14.4	1.8 (1.0-3.3)
61211-Dairy farmers	102	7.8	0.4 (0.2-0.9)	10.8	1.4 (0.7-2.6)	52	7.7	0.4 (0.1-1.1)	7.7	0.9 (0.3-2.6)
61212-Sheep farmers	49	14.3	0.9 (0.4-2.0)	10.2	1.2 (0.5-3.0)	25	16.0	1.0 (0.3-2.9)	12.0	1.3 (0.4-4.3)
61213-Cattle farmers	13	7.7	0.5 (0.1-3.6)	23.1	3.0 (0.8-11.4)	8	12.5	0.8 (0.1-7.0)	25.0	2.9 (0.6-15.1)
6122-Mixed livestock producers	14	14.3	0.9 (0.2-3.9)	14.3	2.1 (0.5-9.9)	3	0	-	0	-
6125-Crop and livestock farmer	132	19.7	1.3 (0.8-2.1)	9.9	1.2 (0.7-2.2)	29	13.8	0.8 (0.3-2.3)	10.3	1.3 (0.4-4.5)

…continued

Table 6.2 Odds ratios (OR) and 95% Confidence Intervals (CI) for *a priori* high-risk occupations

		Ever occupation					Longest-held occupation			
		Current asthma		Adult-onset asthma			Current asthma		Adult-onset asthma	
***A priori* high-risk occupation**	**Total**	**Cases**	**OR (95% CI)[a]**	**Cases**	**OR (95% CI)[a]**	**Total**	**Cases**	**OR (95% CI)[b]**	**Cases**	**OR (95% CI)[b]**
NZSCO code	**N**	**%**		**%**		**N**	**%**		**%**	
6126-Other agriculture workers	65	13.9	0.8 (0.4-1.6)	15.4	2.1 (1.0-4.2)	7	14.3	0.8 (0.1-6.6)	0	-
91111-Cleaners	152	25.7	1.6 (1.1-2.4)	13.8	1.3 (0.8-2.1)	35	28.6	1.8 (0.8-3.7)	14.3	1.3 (0.5-3.5)
Woodworkers	171	18.7	1.2 (0.8-1.8)	7.6	1.2 (0.6-2.1)	72	18.1	1.2 (0.6-2.1)	4.2	0.6 (0.2-2.0)
71121-Carpenter/Joiners	52	23.1	1.6 (0.8-3.1)	3.9	0.6 (0.1-2.3)	22	18.2	1.1 (0.4-3.4)	0	-
71122-Builders	85	17.7	1.1 (0.6-2.0)	9.4	1.6 (0.7-3.4)	33	21.2	1.4 (0.6-3.4)	9.1	1.5 (0.5-5.2)
74211-Cabinetmakers	18	22.2	1.5 (0.5-4.7)	5.6	0.7 (0.1-5.4)	9	22.2	1.5 (0.3-7.4)	0	-
91513-Sawmill labourers	13	38.5	3.3 (1.1-10.2)	30.8	6.3 (1.9-21.0)	2	0	-	0	-
Welding and soldering	70	18.6	1.1 (0.6-2.1)	4.3	0.6 (0.2-1.8)	22	4.6	0.2 (0.0-1.7)	4.6	0.6 (0.1-4.6)
72124-Fitters and welders	28	10.7	0.6 (0.2-2.0)	0	-	12	0	-	0	-
81231-Welders and flamecutters	18	33.3	2.4 (0.9-6.5)	11.1	1.7 (0.4-7.5)	4	25.0	1.6 (0.2-15.8)	25.0	4.8 (0.5-47.8)
82922-Electric and electronic equipment assemblers	15	26.7	1.7 (0.5-5.4)	6.7	0.7 (0.1-5.4)	3	0	-	0	-

[a]Adjusted for age, sex, smoking and deprivation (N=2903)

[b]Adjusted for age, sex, smoking and deprivation (N=2898)

Several occupations not previously considered high risk for asthma were identified (Table 6.3). Among teaching professionals, secondary school teachers showed increased risks of current asthma for ever working in the occupation (OR=1.92; 95% CI 1.23-2.98) and for working in the occupation for the longest duration (OR=1.78; 95% CI 1.00-3.18); other teaching professionals also showed elevated risks of both current and adult-onset asthma with ORs ranging from 2.30 to 8.12. Stock clerks showed statistically significant elevated risks for adult-onset asthma and for ever working as a stock clerk for current asthma. Ever being employed as a food processor increased the risk of current (OR=1.59; 95% CI 1.06-2.40) and adult-onset asthma (OR=1.62; 95% CI 0.95-2.77), particularly for baked goods and cereals producing machine operators. Labourers had an excess risk of current asthma for ever working as a labourer (OR=1.54; 95% CI 1.12-2.10) and longest-held occupation as a labourer (OR=1.78; 95% CI 0.87-3.63). Ever working as a chef or police officer also showed statistically significant increased risks of current asthma. Within the finance and sales group, technical representatives, buyers, and purchasing agents all demonstrated excess risks of current and adult-onset asthma, although not all were statistically significant. Tailors and dressmakers and bricklayers and stonemasons also demonstrated non-significant excess risks of current and adult-onset asthma.

Table 6.3 Odds ratios (OR) and 95% Confidence Intervals (CI) for *a posteriori* high-risk occupations

	Ever occupation					Longest-held occupation				
		Current asthma		Adult-onset asthma			Current asthma		Adult-onset asthma	
A posteriori high-risk occupation	**Total**	**Cases**	**OR (95% CI)[a]**	**Cases**	**OR (95% CI)[a]**	**Total**	**Cases**	**OR (95% CI)[b]**	**Cases**	**OR (95% CI)[b]**
NZSCO code	**N**	**%**		**%**		**N**	**%**		**%**	
1228-Research and development managers	26	30.8	2.5 (1.1-5.8)	7.7	0.8 (0.2-3.5)	10	30.0	2.4 (0.6-9.4)	10.0	1.0 (0.1-7.9)
12267-Other catering services managers	58	19.0	1.2 (0.6-2.2)	12.1	1.3 (0.6-2.9)	15	33.3	2.6 (0.9-7.6)	20.0	2.7 (0.7-10.0)
23-Teachers	380	20.8	1.3 (1.0-1.8)	12.6	1.2 (0.9-1.7)	204	20.6	1.3 (0.9-1.9)	13.7	1.3 (0.8-2.0)
231-Tertiary teaching professionals	107	15.0	0.9 (0.5-1.5)	9.4	0.8 (0.4-1.6)	31	12.9	0.8 (0.3-2.3)	9.7	0.9 (0.3-2.9)
232-Secondary school teachers	108	26.9	1.9 (1.2-3.0)	13.9	1.4 (0.8-2.4)	63	25.4	1.8 (1.0-3.2)	12.7	1.2 (0.6-2.6)
233-Primary and early childhood school teachers	201	19.9	1.2 (0.8-1.7)	12.4	1.1 (0.7-1.7)	95	19.0	1.1 (0.6-1.8)	13.7	1.2 (0.7-2.3)
234-Special education teachers	46	26.1	1.7 (0.9-3.3)	17.4	1.7 (0.8-3.6)	10	10.0	0.5 (0.1-4.3)	20.0	1.5 (0.3-7.5)
235-Other teaching professionals	19	36.8	2.9 (1.1-7.5)	21.1	2.3 (0.7-7.1)	5	60.0	8.1 (1.3-49.2)	40.0	5.2 (0.8-32.1)
3131-Photographers & image & sound recording equipment controllers	12	25.0	1.8 (0.5-6.5)	16.7	1.7 (0.4-7.9)	4	0	-	0	-
3222-Dental assistants	13	30.8	2.2 (0.7-7.3)	15.4	1.2 (0.3-5.4)	5	20.0	1.4 (0.2-12.5)	0	-
331-Finance and sales associate professionals	396	20.5	1.3 (1.0-1.8)	7.8	0.8 (0.5-1.2)	118	22.9	1.5 (0.9-2.3)	10.2	1.1 (0.6-2.0)
3315-Sales representatives	257	21.4	1.4 (1.0-1.9)	7.0	0.7 (0.5-1.2)	69	27.5	1.9 (1.1-3.2)	11.6	1.3 (0.6-2.7)
33152-Technical representatives	83	27.7	1.8 (1.1-3.0)	9.6	1.0 (0.5-2.1)	25	40.0	3.0 (1.3-6.7)	24.0	2.9 (1.1-7.5)
3316-Buyers	25	36.0	2.8 (1.2-6.5)	16.0	1.7 (0.6-5.0)	8	25.0	1.6 (0.3-7.8)	25.0	2.8 (0.5-14.3)
33163-Purchasing agents	15	40.0	3.4 (1.2-9.7)	13.3	1.6 (0.4-7.2)	4	25.0	1.7 (0.2-16.4)	25.0	3.6 (0.4-37.5)
41311-Stock clerks	80	26.3	1.8 (1.1-3.1)	16.3	2.8 (1.5-5.3)	14	28.6	1.8 (0.6-6.0)	28.6	7.2 (2.2-24.0)
51221-Chefs	44	29.6	2.1 (1.1-4.0)	13.6	1.7 (0.7-4.1)	13	15.4	0.8 (0.2-3.8)	7.7	0.8 (0.1-6.6)
51522-Police Officers	21	33.3	2.7 (1.1-6.8)	9.5	1.3 (0.3-5.8)	11	27.3	2.0 (0.5-7.4)	9.1	1.3 (0.2-10.3)
7111-Bricklayers and stonemasons	12	33.3	2.6 (0.8-8.9)	16.7	3.3 (0.7-15.3)	4	25.0	1.8 (0.2-17.9)	0	
7431-Tailors and dressmakers	12	41.7	3.1 (1.0-9.9)	16.7	1.6 (0.4-7.6)	5	40.0	2.9 (0.5-17.5)	40.0	4.5 (0.7-27.7)
82-Stationary machine operators and assemblers	380	21.1	1.4 (1.0-1.8)	9.2	1.0 (0.7-1.4)	113	17.7	1.0 (0.6-1.7)	6.2	0.7 (0.3-1.4)
82111-Machine tool operators	28	32.1	2.4 (1.1-5.4)	7.1	0.8 (0.2-3.6)	7	14.3	0.9 (0.1-7.5)	0	
827-Food and related products processing machine operators	138	23.9	1.6 (1.1-2.4)	12.3	1.6 (1.0-2.8)	40	17.5	1.1 (0.5-2.4)	10.0	1.4 (0.5-4.0)
8271-Meat and fish processing machine operators	80	20.0	1.3 (0.7-2.2)	11.3	1.5 (0.7-3.0)	22	18.2	1.2 (0.4-3.5)	13.6	2.0 (0.6-6.8)
8272-Dairy products machine operators	24	25.0	1.8 (0.7-4.6)	8.3	1.1 (0.3-5.0)	9	11.1	0.7 (0.1-5.3)	11.1	1.8 (0.2-15.0)
8274-Baked goods and cereals producing machine operators	18	38.9	2.7 (1.0-7.0)	27.8	4.2 (1.4-12.1)	3	0	-	0	-
915-Labourers	264	23.1	1.5 (1.1-2.1)	9.1	1.3 (0.8-2.0)	39	28.2	1.8 (0.9-3.6)	10.3	1.5 (0.5-4.2)

[a]Adjusted for age, sex, smoking and deprivation (N=2903)

[b]Adjusted for age, sex, smoking and deprivation (N=2898)

Discussion

This population-based survey has shown elevated risks of asthma in a number of occupations previously identified as 'high-risk', and has also identified a number of 'new' occupations with elevated risks. In particular, printers, bakers, and sawmill labourers were identified as high-risk occupations for current or adult-onset asthma. Elevated risks of current asthma were observed for metal processing plant operators and cleaners, and associations were identified between adult-onset asthma and market-oriented animal producers and other agricultural workers. Excess risks were also consistently demonstrated for welders and flamecutters and field crop and vegetable growers, although the findings were not statistically significant. In most cases, the results were stronger for longest-held occupation. *A posteriori* occupations that demonstrated elevated risks of both current and adult-onset asthma included stock clerks, food processors (particularly, baked goods and cereals producing machine operators), technical representatives, and other teaching professionals.

The implications of the low response rate on the representativeness of the sample are discussed in Eng et al (Eng et al. 2010a). Briefly, although the response rate was relatively low, we have adjusted for possible determinants of non-response, including age, sex, smoking, and deprivation, and it therefore appears unlikely that our findings are strongly affected by response bias. As with many previous studies (Johnson et al. 2006, Vermeulen et al. 2002), asthma was self-reported, but the questions used have good validity relative to clinical asthma (Pekkanen & Pearce 1999). In addition, the estimated prevalence of 'current asthma' (17%) is similar to that from previous New Zealand surveys where response rates were higher (Douwes et al. 2006) and is also similar to that reported by the

New Zealand Asthma and Respiratory Foundation (Holt & Beasley 2001). Furthermore, as the asthma symptom questionnaire was part of a wider workforce survey, selection on the basis of asthma symptoms is unlikely. The primary analyses involved comparisons of ever having worked in an occupation with never having worked in that particular occupation; thus, the reference group contains other high-risk occupations that could have biased the results. However, this ‘ever versus never’ comparison is commonly applied in occupational studies using work history data, and if it does result in any bias, then it is likely to lead to an underestimation of risk. We also adjusted for other high-risk occupations in the analyses and this only had a small effect on the results. Furthermore, there are several potential problems with selecting a single reference group including: i) weak statistical power to detect associations due to small numbers, particularly for the ‘ever worked’ analyses where the comparison group would be restricted to participants who worked exclusively in ‘unexposed’ occupations in their lifetime; ii) issues of bias arising from comparing to an ‘unexposed’ group who are likely to differ on a number of factors other than the one under study; and iii) previous studies have acknowledged that the assumption of lack of exposure in the reference group is not entirely plausible (Karjalainen et al. 2002). Moreover, this study has identified several *a posteriori* occupations with an increased risk of asthma (for example teachers and certain sales professionals) that would have been included in the ‘unexposed’ reference group if we had used one.

We studied a large number of occupational groups and it is therefore possible that some of our results (particularly for the *a posteriori* findings) may have been due to chance. Nevertheless, several of the *a priori* occupational groups identified in our analyses have been consistently reported by other studies to be at high-risk of asthma, and the consistency of excess risks in certain occupations in this study independent of the disease definition (current asthma versus adult-onset asthma) and exposure definition (ever-held occupation versus longest-held occupation or occupation at time of asthma onset) used suggests that the findings are relatively robust.

Finally, we acknowledge that the definition of asthma used in this study does not permit us to make a distinction between new-onset asthma and pre-existing asthma exacerbated by work. The aim of the study was to conduct exploratory analyses to identify occupations at high risk of asthma and determining whether the observed excess risks are due to new cases of asthma or pre-existing asthma exacerbated by work will require more detailed, longitudinal studies.

This study has several important strengths. In contrast to the population-based ECRHS studies, which assessed current occupation, one advantage of this study is that we were able to collect lifetime occupational data and thus longest-held occupation. While it is still possible that some of the excess risks observed could reflect the self-selection of subjects into ‘low-exposed’ occupations, using the lifetime work history reduces this potential bias, as well as more generally reducing the influence of the ‘healthy worker effect’. In addition, although several longitudinal studies on occupational risk factors for incident asthma have been conducted in Finland (Karjalainen et al. 2002, Karjalainen et al. 2001), these have involved a limited follow-up (for example 13 years in these studies) and only examined occupation at specific points in time (i.e. at the start of the three census-based cohorts) in comparison to our lifetime work history approach. Another advantage of the current study is that we collected information on lifestyle factors and were thus able to adjust for smoking.

Our population-based study has confirmed previous studies showing elevated risks in a number of well-known high-risk occupations. In particular, increased risks of asthma in bakers (Brisman 2002, Houba et al. 1998), sawmill workers (Demers et al. 1997, Douwes et al. 2001, Douwes et al. 2006, Schlunssen et al. 2002), welders and flamecutters (Bradshaw et al. 1998, Fishwick et al. 2004, Hammond et al. 2005, Toren et al. 1999), metal workers (Jaakkola et al. 2003, Karjalainen et al. 2002, Kogevinas et al. 1999, Vermeulen et al. 2002), elementary occupations (Arif et al. 2003, Kraut et al. 1997), and cleaners (Arif et al. 2003, Kogevinas et al. 1999, Medina-Ramon et al. 2003, Zock et al. 2001) have been documented extensively by others. Causal exposures have been identified for some occupations, for example flour dust for bakers (Brisman 2002, Houba et al. 1998) and hard and softwood dust for sawmill workers (Demers et al. 1997). In general, the *a priori* findings are similar to those of population-based studies in other industrialised countries, particularly the ECRHS (Kogevinas et al. 1999) and studies from Spain (Kogevinas et al. 1996), Finland (Karjalainen et al. 2002, Karjalainen et al. 2000), and the Netherlands (Vermeulen et al. 2002). The ECRHS found elevated risks of current asthma for metal-making workers and an increased risk of asthma was reported among cleaners in 11 out of the 12 countries studied (Kogevinas et al. 1999). The Spanish component of the ECHRS found an excess risk of current asthma for bakers and welders, solderers and electronic assemblers (Kogevinas et al. 1996). The Dutch study also reported elevated risks of current asthma symptoms for workers in the metal and printing industries (Vermeulen et al. 2002). Several Finnish studies have investigated adult-onset asthma, one of which reported that welders and bakers had relatively high incidences of occupational asthma (Karjalainen et al. 2000). Another Finnish study of the entire employed population reported an excess of adult-onset asthma in bakers for both men and women and in metal workers for men (Karjalainen et al. 2002).

Relatively few studies have identified printing as a high-risk industry for respiratory symptoms (Bang et al. 2005, Ng et al. 1994, Vermeulen et al. 2002). Exposure to solvents, acrylic resins, dyes, glues, sealants, vegetable gum, and paper dust may occur, but it is unclear what the main risk factors are. The evidence for farmers is less consistent with some studies suggesting that farming is a risk factor and others suggesting that it may be protective against asthma (Douwes et al. 2007, Fishwick et al. 1997c, Kimbell-Dunn et al. 1999, Kogevinas et al. 1999). The ECRHS consistently found elevated risks of current asthma symptoms for farmers across the 12 participating countries with an overall risk of OR=1.73 (95% CI 1.00-3.01) (Kogevinas et al. 1999). The New Zealand component of the ECRHS reported an excess risk of asthma symptoms of OR=1.95 (95% CI 0.74-5.11) compared to the professional, administrative, clerical, and service group (Fishwick et al. 1997c). On the other hand, a cross-sectional survey of a random sample of New Zealand farmers found a lower overall prevalence of asthma in farmers compared to the general population (Kimbell-Dunn et al. 1999). However, in this study, asthma prevalence was higher for horse breeders/groomers, pig farmers, poultry farmers, those working with oat crops, and those involved in grain processing. This is to some degree consistent with our finding of an excess risk of adult-onset asthma in market-oriented animal producers and (non-significant) elevated risks of both current and adult-onset asthma in field crop and vegetable growers. This latter occupational group also includes greenhouse workers who have previously been shown to have an increased risk of asthma (Kronqvist et al. 2005, Monso 2004, Radon et al. 2002). A more recent cross-sectional study conducted in New Zealand reported that farmers were less likely to have asthma symptoms, with no significant differences between dairy, sheep and beef, and horticultural farmers (Douwes et al. 2007). Other recent studies have also shown protective effects of farming on asthma (reviewed in (Douwes et al. 2009)). These mixed results may be explained by the hypothesised differential effect of farming on different asthma phenotypes, with farming exposures potentially being a risk factor for non-allergic asthma and a protective factor for allergic asthma (Douwes et al. 2009). Some evidence for this was found in a recent study in Norway where farming was positively associated with non-atopic asthma but inversely associated with atopic asthma (Eduard et al. 2004). This differential effect may explain why we found some farming groups (field crop and vegetable growers) to have a higher risk of asthma and others (dairy farmers) to have a reduced risk.

The surprising finding of elevated risks in teachers and sales professionals warrants further investigation to determine whether these associations are real or chance findings. The increased risks could also reflect the self-selection of subjects with asthma into these occupations because they believe these workplaces will not exacerbate their symptoms. Alternatively, teachers are more likely to be exposed to certain asthma risk factors such as viral infections, indoor allergens, and volatile organic compounds (Daisey et al. 2003). Using data from the Third National Health and Nutrition Examination Survey in the USA, Arif et al. found an increased risk of work-related asthma among workers in the educational services (OR=2.54 95% CI 0.94-6.86) (Arif et al. 2002). Further analyses of the same data examining specific occupational groups found a non-significant excess risk for teachers (OR=2.05; 95% CI 0.71-5.92) (Arif et al. 2003). The state-based Sentinel Event Notification System for Occupational Risks (SENSOR) in the USA indicated that for 1993-1999, overall, the educational services industry was the third most frequently reported industry associated with work-related asthma (cited in (Mazurek et al. 2008)). Further analyses of the SENSOR data reported that 9% of work-related asthma cases were in the educational services industry. The most frequently reported agents for cases in this industry were indoor air pollutants (28%), unspecified mould (16%), dusts (14%), and cleaning products (7%). Overall, work-related asthma cases from elementary and secondary schools accounted for nearly three quarters of all work-related asthma cases in the educational services (Mazurek et al. 2008).

The excess risk observed in food processors is consistent with the findings of the New Zealand part of the ECRHS, which found that food processors other than bakers had a more than 2-fold increased risk of current asthma (OR=2.14; 95% CI 0.94-4.86) (Fishwick et al. 1997c). A population-based Finnish study also reported a high incidence rate of occupational asthma for other food manufacturing workers (Karjalainen et al. 2000).

There is limited evidence on the risk of asthma symptoms in sales workers. Examining the industry in addition to the occupation may provide some insight into the excess risks observed in this group. Although the evidence is sparse, other population-based surveys have also identified excess asthma risks in the protective services industry (Arif et al. 2003) and in stock clerks (LeMoual et al. 2004).

In summary, this population-based study has identified several high-risk occupations for asthma symptoms. Elevated asthma risks were consistently found for printers, bakers, and sawmill labourers, which is consistent with findings of studies in other westernised countries. A number of occupations were identified that have not been previously associated with asthma risk, suggesting that the risk of occupational asthma may be more widely spread across the workforce than previously assumed.

CHAPTER 7

Work-related stress and asthma: results from a workforce survey in New Zealand

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Background:
We assessed the association between work-related stress and asthma in a cross-sectional workforce survey in New Zealand.
Methods:
Men and women randomly selected from the Electoral Roll were invited to take part in a telephone interview, which collected information on current workplace exposures and respiratory symptoms. Participants rated how stressful they found their current job on a 5-point scale. We conducted unconditional logistic regression to calculate prevalence odds ratios (OR) and 95% confidence intervals (CI) for job stress and both current and adult-onset asthma, adjusting for age, sex, smoking, and deprivation. Analyses were also stratified by sex, smoking status, and body mass index (BMI).
Results:
Results were based on 2,903 interviews. Participants with very or extremely stressful jobs were twice as likely to have current asthma (OR=1.98; 95% CI 1.52-2.58) and 50% more likely to have adult-onset asthma (OR=1.50; 95% CI 1.05-2.15) compared to those with not at all or mildly stressful jobs. This association was evident for both sexes and was not explained by either occupation, BMI or smoking, although the results did differ by smoking status.
Conclusion: Our study adds to the sparse evidence on the relationship between work-related stress and asthma in adult working populations.

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Introduction

There is growing evidence highlighting the potential role of emotional stress in asthma development (Douwes et al. 2010). A number of studies have reported positive associations between asthma and measures of stress, which have varied widely and included stressful life events (Lietzen et al. 2010), psychological distress (Chittleborough et al. 2010), war-related stressors (Wright et al. 2010), maternal anxiety (Cookson et al. 2009), community violence (Sternthal et al. 2010), and post traumatic stress disorder (Goodwin et al. 2007). Most of the evidence is based on cross-sectional studies and therefore it is unclear whether stress causes asthma or whether it merely exacerbates pre-existing asthma. Recent evidence from prospective studies has found evidence of an association between maternal stress (Cookson et al. 2009) and early childhood stressors (Suglia et al. 2010) and subsequent childhood asthma, as well as associations between stress and new-onset asthma in adults (Lietzen et al. 2010, Loerbroks et al. 2010, Wright et al. 2010), suggesting that the relationship may be causal. Only one study has investigated work-related stress. This population-based cohort study found that participants reporting high work stress had a more than two-fold increased risk of developing asthma after approximately 8 years of follow-up compared to those reporting low work stress (RR=2.30; 95% CI 1.16-4.54) (Loerbroks et al. 2010). Thus, the evidence for work-related stress, a common source of stress, as a risk factor for asthma is limited. We have examined the associations between work-related stress and asthma symptoms in a large cross-sectional workforce survey in New Zealand.

Methods

We conducted a national telephone survey of a random sample of the New Zealand population aged 20-64 (Eng et al. 2010a). 10,000 potential participants were randomly selected from the Electoral Roll. The interview obtained information on job history, current exposures, and questions on health, including respiratory symptoms. Respiratory symptoms were assessed using the European Community Respiratory Health Survey (ECRHS) (Burney et al. 1994) questionnaire. Participants rated how stressful they found their current job on a 5-point scale (not at all stressful, mildly stressful, moderately stressful, very stressful, or extremely stressful). We categorised job stress into 3 levels: not at all-mildly, moderately, and very-extremely stressful.

'Current asthma' was defined as answering 'yes' to 'woken by an attack of shortness of breath in the past 12 months', 'asthma attack in the past 12 months' or 'current asthma medication' (Burney et al. 1994). 'Adult-onset asthma' was defined as a first attack of asthma at age 18 years or older. Prevalence odds ratios (OR) (Pearce 2004) and 95% confidence intervals (CI) were calculated using unconditional logistic regression in STATA v10.0, adjusting for age, sex, smoking status (never, ex, current), smoking pack-years, body mass index (BMI) based on self-reported height and weight, current occupation (1-digit code), and the 2001 deprivation index (a census-based index with a relative deprivation score assigned to each geographical meshblock). We also stratified by sex, smoking status, and BMI (18.5-24, 25-29, 30+). Ethical approval for the study was obtained from the Massey University Human Ethics Committee (WGTN 03/133).

Results

3,003 interviews were completed (37% response rate) (Eng et al. 2010a). The current analyses were based on 2,903 participants (48% male; 52% female; average age: 44 years) excluding those with missing information on smoking or deprivation. The overall prevalence of current asthma and adult-onset asthma was 17% and 9% respectively. No or mild work-related stress was reported by 40% of participants; 45% reported moderately stressful jobs; and 15% reported very or extremely stressful jobs.

Participants with very or extremely stressful jobs were twice as likely to have current asthma (OR=1.98; 95% CI 1.52-2.58) compared to those reporting not at all or mildly stressful jobs (Table 7.1). This association was present in both males (OR=1.87; 95% CI 1.27-2.76) and females (OR=2.02; 95% CI 1.40-2.91), but the shape of the dose-response curve differed between the sexes. In males, a U-shaped association was found for both current and adult-onset asthma, with a reduced asthma risk for the group reporting moderate job stress compared to no or mild job stress (significant only for current asthma), whereas a linear dose-response association was observed for females. Adjusting for occupation (1-digit code) and *a priori* high-risk occupational groups (Eng et al. 2010b) did not markedly change the results (data not shown). Similar patterns were observed for adult-onset asthma (Table 7.1), although the associations tended to be weaker i.e. participants with very or extremely stressful jobs were 50% more likely to have adult-onset asthma (OR=1.50; 95% CI 1.05-2.15) compared to those reporting not at all or mildly stressful jobs.

Table 7.1 Odds Ratios (OR) and 95% Confidence Intervals (CI) for job stress and asthma symptoms stratified by smoking status

Job Stress	Not at all - Mildly			Moderately			Very - Extremely		
	N	%	OR (95% CI)	N	%	OR (95% CI)	N	%	OR (95% CI)
Current asthma									
Total[#]	179	15.7	1.00 (ref)	197	15.1	0.98 (0.79-1.22)	117	26.7	1.98* (1.52-2.58)
Never smoker	91	15.5	1.00 (ref)	100	14.7	0.94 (0.69-1.27)	62	31.2	2.47* (1.70-3.60)
Current smoker	47	21.8	1.00 (ref)	40	18.4	0.84 (0.52-1.35)	23	23.5	1.04 (0.58-1.85)
Ex-smoker	41	12.1	1.00 (ref)	57	13.9	1.28 (0.82-1.97)	32	22.5	2.21* (1.32-3.71)
Male[†]	84	16.7	1.00 (ref)	79	11.7	0.67* (0.48-0.93)	56	26.9	1.87* (1.27-2.76)
Never smoker[§]	50	19.8	1.00 (ref)	44	13.1	0.62* (0.39-0.96)	30	30.9	1.83* (1.07-3.13)
Current smoker[§]	20	21.1	1.00 (ref)	13	11.4	0.48 (0.22-1.03)	10	22.2	1.03 (0.43-2.45)
Ex-smoker[§]	14	9.1	1.00 (ref)	22	9.7	1.10 (0.54-2.23)	16	24.2	3.23* (1.47-7.10)
Female[†]	95	14.8	1.00 (ref)	118	18.6	1.34 (1.00-1.80)	61	26.4	2.02* (1.40-2.91)
Never smoker[§]	41	12.2	1.00 (ref)	56	16.3	1.39 (0.90-2.14)	32	31.4	3.28* (1.93-5.57)
Current smoker[§]	27	22.3	1.00 (ref)	27	26.0	1.25 (0.66-2.34)	13	24.5	1.02 (0.47-2.22)
Ex-smoker[§]	27	14.7	1.00 (ref)	35	18.9	1.43 (0.82-2.49)	16	21.1	1.65 (0.83-3.30)
Adult-onset asthma									
Total[#]	98	8.6	1.00 (ref)	116	8.9	1.12 (0.84-1.49)	52	11.9	1.50* (1.05-2.15)
Never smoker	50	8.5	1.00 (ref)	57	8.4	1.00 (0.67-1.50)	26	13.1	1.60 (0.96-2.67)
Current smoker	14	6.5	1.00 (ref)	19	8.7	1.56 (0.75-3.24)	10	10.2	1.68 (0.70-3.99)
Ex-smoker	34	10.1	1.00 (ref)	40	9.7	1.17 (0.71-1.91)	16	11.3	1.25 (0.66-2.38)
Male[†]	31	6.2	1.00 (ref)	33	4.9	0.77 (0.46-1.28)	18	8.7	1.41 (0.76-2.59)
Never smoker[§]	21	8.3	1.00 (ref)	20	6	0.68 (0.36-1.29)	11	11.3	1.21 (0.55-2.65)
Current smoker[§]	1	1.1	1.00 (ref)	3	2.6	2.46 (0.25-24.18)	3	6.7	7.29 (0.73-72.92)
Ex-smoker[§]	9	5.8	1.00 (ref)	10	4.4	0.79 (0.31-2.00)	4	6.1	1.08 (0.32-3.64)
Female[†]	67	10.5	1.00 (ref)	83	13.1	1.33 (0.94-1.88)	34	14.7	1.48 (0.95-2.31)
Never smoker[§]	29	8.6	1.00 (ref)	37	10.8	1.28 (0.76-2.14)	15	14.7	1.87 (0.95-3.65)
Current smoker[§]	13	10.7	1.00 (ref)	16	15.4	1.50 (0.68-3.29)	7	13.2	1.20 (0.44-3.22)
Ex-smoker[§]	25	13.6	1.00 (ref)	30	16.2	1.35 (0.75-2.43)	12	15.8	1.34 (0.63-2.87)

[#]adjusted for age, sex, smoking status and deprivation

[†]adjusted for age, smoking status and deprivation

[§]adjusted for age and deprivation

*statistically significant at p<0.05

We also investigated the roles of smoking and BMI in the association between stress and asthma as these have been suggested to be linked to both asthma and stress. Adjusting for smoking status (or smoking pack-years) and BMI did not have a major effect on the results. However, smoking appeared to modify the association between stress and current asthma, with the association being absent in current smokers (Table 7.1). This was not the case for BMI with all three categories (normal, overweight, obese) showing excess risks of current asthma (results not shown). We did, however, find some interesting associations between stress and obesity, and obesity and asthma. In particular, males reporting a very or extremely stressful job were almost 70% more likely to be obese i.e. have a BMI above 30 (OR=1.66; 95% CI 1.13-2.44), while this association was absent in women (OR=0.97; 95% CI 0.66-1.44). On the other hand, obese females were more likely to have current asthma (OR=1.89; 95% CI 1.33-2.70) and adult-onset asthma (OR=1.64; 95% CI 1.09-2.46) compared to females of normal weight (BMI 18.5-24), while for men obesity was not a risk factor for current asthma (OR=1.29; 95%CI 0.86-1.93) or adult-onset asthma (OR=0.98; 95%CI 0.53-1.83).

Conclusion

We have shown excess risks of current and adult-onset asthma for workers with very or extremely stressful jobs. However, because it was a population-based survey, the response rate was low, the implications of which are discussed in Eng et al (Eng et al. 2010a). Briefly, although the response rate was relatively low, we adjusted for possible determinants of non-response, including age, sex, smoking, and deprivation, and it therefore appears unlikely that our findings are strongly affected by response bias. Furthermore, the response rate is typical for this type of survey, where most response rates are reported at below 60% (Tourangeau 2004). Asthma was self-reported, however symptom questionnaires have shown good validity relative to clinical asthma (Pekkanen & Pearce 1999). In addition, the estimated prevalence of ‘current asthma’ (17%) was similar to that reported in the New Zealand part of the ECRHS (15.5%) (Crane et al. 1994). A further limitation of the study is that our assessment of job stress was based on a single question rather than a multi-item scale.

These findings were based on a cross-sectional study and we therefore cannot exclude the possibility that these associations were due to reverse causation (i.e. asthma causing job stress), nor can we exclude the possibility that symptom perception was influenced by the experience of high job stress. In general, individuals who experience high levels of stress are likely to differ on factors such as lifestyle and personality traits compared to those who do not experience high stress levels, and therefore may be more likely to perceive both higher stress levels and symptoms of asthma. In addition, our study cannot elucidate whether work-related stress causes new-onset asthma or merely exacerbates pre-existing asthma. The fact that we found the strongest associations with ‘current asthma’ - which includes childhood asthma - suggests that at least part of the association was due to asthma exacerbations. However, a previous prospective cohort study was able to relate work stress assessed at baseline with incident asthma (Loerbroks et al. 2010), with relative risk estimates very similar to those observed in our study, suggesting that job stress could play a part in the causal pathway of asthma development. The underlying mechanisms for this association are largely unknown, but, several studies suggest that stress acts through altered regulation of the hypothalamic-pituitary-adrenal (HPA) axis and sympathetic-adreno-medullary (SAM) nervous system resulting in immunomodulatory effects involving a Th_2 (atopic) response (Haczku & Panettieri 2010, Vig et al. 2006).

For men we observed a U-shaped association between increasing levels of work stress and asthma, whereas a more linear association was observed for female workers. If real, these findings may be due to sex differences in perceiving or reporting work-related stress, differences in how work-related stress is experienced by male and female workers, or there may be biological differences in inflammatory and/or neurological responses to stress resulting in differences in asthma susceptibility.

The association between job stress and current asthma differed according to smoking status, with the association being absent in current smokers. The prevalence of current asthma was high in current smokers, irrespective of the level of job stress, suggesting that job stress does not significantly add to the increase in current asthma risk already present in current smokers. This difference by smoking status was mainly seen for current asthma and not for adult-onset asthma. This may be because, in contrast to current asthma, the prevalence of adult-onset asthma was not higher in current smokers, which may be the result of individuals faced with adult-onset asthma deciding to quit smoking, especially those for whom smoking is perceived to be the cause of their respiratory symptoms (Troisi et al. 1995).

Obesity was neither a confounder nor an effect modifier in the association between job stress and asthma. However, we did observe that for men, job stress was associated with obesity whilst this was not the case for women. This may be due to the specific job characteristics associated with job stress in men also being associated with obesity (i.e. managerial jobs). On the other hand, obesity was associated with asthma for women but not for men. This pattern has been observed previously (Ford 2005) and biological differences (such as sex hormones) have been suggested as causal factors in the association between obesity and asthma in females (Kim & Camargo 2003).

In summary, our study suggests that work-related stress is associated with asthma, which is consistent with the findings of the only other study reporting on the association between work-related stress and asthma (Loerbroks et al. 2010). None of the potential confounders studied explained this association, but our findings did highlight the importance of considering the association by sex and smoking status. Workplace interventions aimed at reducing stress levels may alleviate to some extent the burden of respiratory disease, as well as reducing the burden of other stress-related conditions such as cardiovascular disease, obesity, and musculoskeletal disorders. Further longitudinal studies are required to elucidate the association between job stress and asthma.

Section 4. Discussion and conclusions

CHAPTER 8

Discussion and conclusions

This thesis was based on the information collected from the first workforce survey in New Zealand to assess occupational exposures, workplace practices, and selected health outcomes in a random sample of the working population. The main findings are summarised below, followed by a discussion of methodological issues, limitations, and recommendations for further research and surveillance.

8.1 Main findings

1) Occupational exposures remain common in the New Zealand workforce. These exposures were disproportionately experienced by certain occupational groups (Chapter 3)

The thesis indicated that exposure to risk factors for work-related disease and injury remains common in the New Zealand working population. These occupational exposures were disproportionately experienced by workers in the agricultural, trades, and plant and machine operators and assemblers groups where exposure prevalences were high. For example, 75% of trades workers and 55% of plant and machine operators and assemblers reported exposure to dust in their current job. In addition, more than 50% of the workers in these groups reported exposure to lifting and loud noise a quarter of the time or more. The prevalences of lifting, loud noise, and certain workplace substances appeared to be comparable to results from overseas workforce surveys (Parent-Thirion et al. 2007). The prevalence of self-reported PPE use (48%) was higher than figures from overseas surveys (Parent-Thirion et al. 2007), but less than half of participants who reported exposure used PPE relevant for that exposure. For instance, only 47% of those exposed to loud noise three quarters to all of the time reported the use of hearing protection. This information on the prevalence and distribution of occupational exposures and PPE in the New Zealand population has not been collected previously and the findings suggest that, despite the continually changing nature of work, the ‘traditional’ chemical and physical risk factors and the industries in which they are concentrated remain significant problem areas. As a result, the limited OHS resources should be targeted to workers in these high-risk industries. Furthermore, the under-utilisation of appropriate PPE warrants further attention.

2) <u>Occupational exposures were not limited to ‘high-risk’ occupations (Chapter 3)</u>

Whilst the burden of occupational risk factors was concentrated in certain high-risk groups as outlined above, exposures also occurred in other occupational groups not traditionally associated with hazardous exposures. For example, about one in five workers in the non-manual occupational groups reported exposure to dust, with the prevalence as high as 25% in the legislators and managers group. These prevalences of exposure for the non-manual occupations in New Zealand appeared to be higher than for comparable groups in overseas surveys (although the questions were not directly comparable) (Parent-Thirion et al. 2007). One possible explanation could be the smaller size of operations in New Zealand industry and therefore a greater likelihood of workers being exposed. Alternatively, the application of the skills-based job classification, for example for the job title ‘manager’, could vary across countries. The majority of workers were employed in the non-manual groups, and therefore a larger number of these workers were exposed to occupational risk factors compared to the number of workers from the high-risk industries. For example, agricultural workers reported the highest prevalence of exposure to pesticides (63%); however, a larger number of workers were exposed to pesticides in occupational groups other than agricultural. Therefore considering the absolute numbers of workers exposed, the industries not typically associated with hazardous exposures (i.e. the non-manual industries) should be included in future studies examining the overall burden of occupational exposures and ill-health.

3) <u>There were substantial differences in occupational exposure prevalence between men and women (Chapter 4)</u>

Gender differences were demonstrated for a wide range of dust and chemical exposures as well as physical factors. Male workers were two to four times more likely to report exposure to dust and chemical factors, loud noise, irregular hours, night shifts, and vibrating tools. On the other hand, women were 30% more likely to report repetitive tasks and working at high speed. Although the majority of specific exposures were more common in men, certain exposures were more common in women including exposure to disinfectants, bleach, hair dyes, and textile dust. When men were compared to women in the same occupation, men were two to three times more likely to report exposure to vibrating tools, night shift work, and irregular hours and two to five times more likely to report exposure to welding fumes, herbicides, wood dust, and solvents compared to women with the same job title. In contrast, females were 30-40% more likely to report repetitive tasks, working at high speed, and awkward or tiring positions compared to males with the same job. Thus, the different occupational exposure profiles between men and women existed both between and within occupations. The existence of gender differences within occupations suggests that men and women with the same occupational title do not always carry out the same tasks, which could be attributed to the different physical capabilities of men and women or social constructions of what is suitable work for men and women. Therefore, gender not only influences the type of job a worker has but also the type of tasks carried out within that job and consequently the impact of gender must be considered when targeting prevention activities and in studies of occupational health in general.

4) <u>There were ethnic differences in occupational exposure prevalence, particularly for physical risk factors (Chapter 5)</u>

Māori workers were more likely to report exposure to all of the physical factors under study, for example Māori workers were 70% more likely to report lifting and 65% more likely to report awkward grip or hand movements. When comparing Māori with non-Māori in the same job, ethnic differences were attenuated (for example 25-100% of the observed excess odds in Māori appeared to be due to differences in occupation). Nonetheless, Māori were 50% more likely to report lifting and 30% more likely to report awkward grip or hand movements compared to non-Māori with the same job title (although these findings were not statistically significant). Ethnic differences were also observed when men and women were examined separately. Māori males were twice as likely to report exposure to dust and also had a non-significant excess of reporting tasks involving standing compared to non-Māori males with the same job title and Māori women were more than twice as likely to report a very or extremely stressful job compared to non-Māori women with the same occupation. In general, the differences observed between Māori and non-Māori were not as large as for the gender differences described in point 3 above and concerned different risk factors. However, ethnic differences in occupational exposure were similarly due to both differences in occupational distribution and differences in task assignments within occupations. While certain factors such as lower socioeconomic status and education levels might explain the selection of Māori into certain occupational groups, discrimination may play a role in the differential assignment of tasks within the same occupation between Māori and non-Māori workers. These findings suggest that policies addressing ethnic disparities in occupational health need to not only focus on improving education and employment opportunities for Māori, but must also challenge wider societal practices which may underlie the observed segregation of tasks within jobs, such as discrimination and prejudice.

5) The occupations identified to have the strongest association with asthma were printers, bakers, and sawmill workers (Chapter 6)

This thesis reported significant associations between current and adult-onset asthma and a number of occupations; however the strongest associations were observed for printers, bakers, and sawmill workers. Elevated odds of current asthma were also observed for metal processing plant operators and cleaners, and associations were identified between adult-onset asthma and market-oriented animal producers and other agricultural workers. Overseas studies have similarly found excess risks for bakers (Kogevinas et al. 1996), sawmill workers (Demers et al. 1997), metal workers (Kogevinas et al. 1999), and cleaners (Kogevinas et al. 1999). Causal exposures have been identified for some occupations, for example flour dust for bakers (Houba et al. 1998) and wood dust for sawmill workers (Demers et al. 1997), but the main causal exposures for other occupations (for example printers) remain unclear. The finding for sawmill workers was consistent with several other New Zealand studies which found associations between wood dust exposure in sawmills and asthma symptoms (Douwes et al. 2001, Douwes et al. 2006, Fransman et al. 2003). In addition, several other occupations within the wood workers group, such as carpenters/joiners and cabinet makers, were also moderately associated with asthma (although these were not statistically significant). Together these findings suggest that wood dust in particular may be an important risk factor for occupational asthma in New Zealand. A concerted effort should be made to monitor and ultimately reduce the levels of wood dust in New Zealand workplaces, as well as monitoring the other recognised causal exposures (for example flour dust) of the occupations associated with an increased asthma risk.

6) Other occupations associated with an increased asthma risk included teachers and certain sales professionals (Chapter 6)

A number of occupations not previously considered to be associated with an increased risk of asthma were also identified, including certain teaching and sales professionals (for example technical representatives and purchasing agents), stock clerks, and food processors. There is some limited evidence for elevated asthma risks in teachers (Arif et al. 2003) and food processors (Fishwick et al. 1997c); however, causal exposures for the former group have not yet been identified and studies of the latter group have mainly concerned specific groups of food processors. Further studies are required to examine the causal exposures of these newly identified occupations, particularly if the exposures are not necessarily specific to one industry, for example indoor air pollutants have been suggested as a potential explanation for the increased asthma risk in teachers (Daisey et al. 2003).

7) Work-related stress was associated with an increased asthma risk (Chapter 7)

Participants with very or extremely stressful jobs were twice as likely to have current asthma and 50% more likely to have adult-onset asthma compared to those reporting no or mild work-related stress. These associations were observed for both men and women and could not be explained by potential confounders such as occupation, smoking status, and obesity. Very few studies have examined the association between work-related stress and asthma; however, the findings of a recent prospective cohort study suggest that work stress could play a part in the causal pathway of asthma development (Loerbroks et al. 2010). The prevalence of a very or extremely stressful job was high (15%), i.e. considerably higher in comparison with the prevalence of the high-risk occupations identified in Chapter 6, and therefore high job stress has a greater potential to contribute to the burden of work-related asthma in the population. Further longitudinal studies are required to elucidate the association between job stress and asthma.

8) <u>Workforce surveys are a valuable tool for assessing a wide range of occupational exposures in the working population</u>

Chapter 2 highlighted the absence of comprehensive occupational exposure and occupational health information in New Zealand and the need for workforce surveys such as the one presented here. The findings of this thesis illustrated the main strengths of workforce surveys: a) it was population-based (did not exclude any occupation, industry or demographic group); and b) it focused on a wide range of potentially hazardous occupational exposures (not only physical and chemical but also organisational and psychosocial factors).

a) Population-based approach – *the diversity of the workforce*

The population-based approach enabled the prevalences of occupational exposure to be reported across the working population as well as for specific occupations and industries. This is particularly important in the absence of a comprehensive national data collection system and to obtain an overview of the burden of occupational exposure in the New Zealand population. This approach enabled the identification of occupations and industries with higher prevalences of exposure and also the reporting of exposure prevalences for occupations and industries generally not studied within occupational health research (Chapter 3).

The population-based approach also enabled the detection of occupational groups with a higher risk of respiratory symptoms (Chapter 6), also including occupations that would not have been identified in a strategy focusing on specific worker groups (for example our finding of an increased asthma risk in teachers and certain sales professionals).

Finally, the population-based approach allowed us to examine the exposure profiles of different demographic groups, including groups that are generally understudied such as women and ethnic minorities. The working population is becoming increasingly diverse, with increasing numbers of females and Māori workers making up the New Zealand workforce (Department of Labour 2010). As mentioned above, this thesis identified substantial differences in occupational exposure patterns between men and women (Chapter 4) and Māori and non-Māori workers (Chapter 5). The findings thus contribute to knowledge of occupational hazards for female (for example repetitive tasks) and Māori workers (for example lifting).

b) Risk factor approach – *the diversity of exposures*

This thesis found that the 'traditional' exposures were still common in the New Zealand workforce, particularly in the high-risk areas of agriculture, trades, and manufacturing. The thesis was also able to investigate a wide range of specific dust and chemical exposures in the population (for example wood dust, methylated spirits). These exposures include known or suspected carcinogens and risk factors for respiratory disease. Whilst this was the first workforce survey carried out in New Zealand, the fourth EWCS (conducted every 5 years) found that despite a shift away from the traditional, physically demanding sectors, prevalences of physical and chemical exposures have remained relatively steady since 1990 (Parent-Thirion et al. 2007).

The findings of this thesis also illustrated that the term ‘occupational exposure’ should not be limited to chemical and ergonomic exposures but also needs to encompass organisational and psychosocial exposures. The current survey examined prevalences of a wide range of occupational exposures, including chemical, physical, organisational, and psychosocial exposures. The two most commonly reported risk factors of all the exposures under study were organisational factors: working to tight deadlines (73%) and carrying out repetitive tasks (68%) a quarter of the time or more. The importance of organisational and psychosocial exposures in occupational health has been illustrated by studies reporting associations between various organisational factors and adverse outcomes such as musculoskeletal disorders (Kerr et al. 2001) and stress-related diseases (Holmes 2001), shift work and cancer risk (Straif et al. 2007), and work-related stress as a risk factor for cardiovascular disease (Bosma et al. 1998) and musculoskeletal symptoms (Huang et al. 2002). Chapter 7 illustrated an association between work-related stress and current and adult-onset asthma, for which the evidence is currently very limited. Thus, this thesis was able to identify relatively ‘new’ risk factors for occupational ill-health (using asthma as our case study), such as job stress in the association with asthma, job stress and obesity in males (Chapter 7), and the yet unexplored exposures of the occupations discovered *a posteriori* to have an association with asthma.

Finally, information on exposures collected from workforce surveys - both traditional and emerging exposures - can also be used to provide prevalence data for expert-based information systems. For example, the exposure prevalence data from the current workforce survey will provide baseline estimates for projects currently in progress, such as the New Zealand Job Exposure Matrix (NZJEM) and the New Zealand-specific Information System on Occupational Exposure to Carcinogens (NZ-CAREX).

8.2 Methodological issues and limitations

The two major limitations of the workforce survey concern: 1) the recruitment of study participants; and 2) the nature of the exposure and health information collected.

1) <u>The recruitment of study participants</u>

The response rate of the survey was 37%. Thus, it was important to evaluate whether the participants were representative of the source population. Although certain groups were underrepresented in our study sample, particularly the youngest age group (20-34 year olds), Māori, the unemployed, and individuals in the most deprived group, the prevalence estimates of self-reported occupational exposures, lifestyle factors, and health outcomes under study did not change appreciably after standardising towards the demographic distribution of the source population. In addition, in all analyses, we adjusted for possible determinants of non-response (for example: age, gender, smoking, and deprivation) and it was therefore unlikely that our results were strongly affected by response bias. The differences between participants and non-participants were more pertinent for Māori workers, however while the possibility of residual confounding cannot be excluded, it was more likely to result in an underestimation of exposure prevalence for Māori workers, and therefore an underestimation of the differences in exposure between Māori and non-Māori workers.

The recruitment of study participants was labour intensive. The invitation letter was mailed up to three times and we contacted non-respondents by phone where a phone number was listed in the electronic phone book. Only 41% of individuals consented to participate via the mailed invitation and thus the majority of participants were recruited over the phone. We were unable to establish contact with 33% of the total eligible sample and we could not find a listed phone number for the majority of these non-respondents. The telephone interviews, which took an average of 45 minutes to complete, were conducted over a two year period by a team of up to 10 part-time interviewers, thus the overall data collection process was time-consuming and resource intensive. However, with these limitations in mind, workforce surveys are still the most efficient method for assessing a wide range of exposures in a range of different jobs and industries in comparison to other surveillance methods.

2) <u>The nature of the information collected</u>

One of the biggest limitations of the workforce survey was the relatively crude exposure assessment. It is practically impossible to objectively assess the level and intensity of exposure using a questionnaire. Because the exposures were self-reported, the responses to most questions were inevitably subjective, for example ‘lifting’ could refer to a wide range of different weights and movements. In addition, many hazardous agents (for example occupational carcinogens) may not be recognisable to participants (Pearce et al. 2006), for example they may be able to report the colour or smell of a certain substance but may not be aware of its specific name or chemical properties. Thus, the possibility that differences in reporting or perception of exposures may have affected the results cannot be ruled out. For example, we discussed in Chapters 4 and 5 the possible influences of gender and ethnicity on exposure reporting. Ideally, actual exposure measurements or ‘walk-through’ observational surveys by occupational hygiene experts would be carried out to corroborate the self-reported results. More detailed information on the ‘dose’ and duration of exposure is essential for examining causal associations with occupational disease. Nonetheless, the prevalences of certain occupational risk factors reported in this thesis were similar to estimates of self-reported exposure from overseas workforce surveys. Furthermore, the collection of these relatively crude exposure data from workforce surveys is important for providing population-level estimates of the prevalence of occupational exposures.

Certain exposures included in the questionnaire were assessed using a single question rather than a multi-item scale. For example, our assessment of job stress was based on a single question compared to previous studies of work-related stress, many of which have used Karasek’s job content questionnaire (Karasek et al. 1998). However, because the workforce survey collected information on a wide range of exposures, a balance was required between the detail of the information collected and the practical length of the questionnaire.

The extent of an individual’s exposure is also affected by the provision and use of exposure controls. The current survey collected limited information on the use of PPE but not on the frequency or duration of use. Employers are required to take all practicable steps to minimise harm which includes providing PPE when they are unable to eliminate or isolate a hazard. Chapter 3 showed that less than half of participants exposed to specific substances used PPE relevant for that exposure. Therefore, more information is required on the prevalence and effectiveness of control measures.

A further limitation of the workforce survey was its cross-sectional study design. While this was useful for providing a snapshot of current exposures, it was not possible to determine whether the identified risk factors for asthma (Chapters 6 and 7) cause new onset asthma or merely exacerbate pre-existing asthma, or whether the association between stress and asthma was not due to reverse causation. However, the contribution of the workforce survey was to identify occupational risk factors for asthma and more detailed, longitudinal studies are required to determine the nature and direction of the causal relationships involved. Finally, the associations between ever-held and longest-held occupation and asthma in Chapter 6 did not take into account duration of employment or cumulative exposure (for example, using a JEM based on all job titles held) and thus the current data should be further utilised.

8.3 Recommendations and future research

8.3.1 Surveillance

1) <u>Occupational exposure surveillance should be carried out in New Zealand</u>

In Chapter 2, the lack of exposure surveillance in New Zealand was outlined. This thesis demonstrated that risk factors for work-related disease and injury were common in the New Zealand workforce and that they were associated with adverse health effects. The results also demonstrated where the problem areas were (i.e. agricultural, trades, and manufacturing) and consequently where limited resources should be targeted. Therefore occupational exposure surveillance should be carried out in New Zealand. Exposure data specific to New Zealand is important due to the 'self–responsibility' nature of the OHS legislative framework, the different demographic profile of the workforce (for example the increasing participation of Māori workers), and the relatively higher prevalence of certain occupational exposures in the non-manual groups in comparison to overseas surveys. There are several options for occupational exposure surveillance: 1) workforce surveys; 2) workplace observational surveys; 3) workplace measurements; and 4) registers of exposed persons. Some countries have integrated systems, such as the Danish National System (Brooke et al. 2006). Options 1 and 3 are discussed in the following recommendations.

2) <u>Workforce surveys should be conducted at regular intervals</u>

New Zealand's health and safety legislative framework is underpinned by self-responsibility and voluntary compliance. While this 'hands off' approach has inherent advantages for employers, there is no collective knowledge of what hazards are present in New Zealand workplaces or the effectiveness of self-regulated hazard management systems. Thus, we recommend that workforce surveys should be conducted at regular intervals for example every 5 years. This will be essential to keep abreast of emerging risk factors, the changing nature of work (including precarious and temporary work arrangements), and to monitor trends. Furthermore, until now, there has been a lack of information on non-traditional hazards such as psychosocial and organisational risk factors in New Zealand. The advantages of workforce surveys were described in Chapter 2, however they are the most sensitive method to detect change over time and the most likely to adequately capture the diversity of exposures and the diversity of workers reported in this thesis. Unfortunately the recommendation for regular workforce surveys is not new (Pearce et al. 2006) but this thesis provided the baseline dataset and illustrated the capability of the data, for example, identifying where the problem areas are, who is at risk, and the potentially adverse effects of emerging risk factors.

Brooke et al reviewed 24 international exposure surveillance systems and concluded that workforce surveys were likely to be the most feasible data collection method for the surveillance of exposures in New Zealand in relation to eight priority health outcomes (respiratory disease, occupational cancer, contact dermatitis, infectious and parasitic disease, cardiovascular disease, musculoskeletal disorders, mental or neuropsychiatric disorders, and noise-induced hearing loss) (Brooke et al. 2006). In addition, the European Foundation for the Improvement of Living and Working Conditions promotes the use of regular workforce surveys in Europe (see Table 2.3) and the EWCS is conducted at 5-yearly intervals and covers a wide range of exposures, including physical, psychosocial, and organisational factors as well as aspects of work-life balance (Parent-Thirion et al. 2007). The success of ongoing, regular workforce surveys in other countries supports the case for a similar approach in New Zealand.

3) <u>The capacity for collecting exposure measurement data in New Zealand needs to be rebuilt</u>

In an ideal world, actual workplace measurements would be collected to corroborate and complement the self-reported exposure results from regular workforce surveys, the shortcomings of which have already been outlined. As discussed in Chapter 2, some countries have central repositories of exposure measurements such as the UK (NEDB) and Germany (MEGA) where exposure measurements are collected by governmental inspectors. However, it should be noted that the data collected by the NEDB has declined since the 1990s and the data collected by MEGA is collected in a non-random manner

(Brooke et al. 2006). In New Zealand, the former Department of Health used to carry out some workplace exposure monitoring. However, as a consequence of the existing voluntary and performance-based OHS framework, the employer is responsible for monitoring exposure to hazards. Investigations are most often carried out in response to incidents or complaints i.e. after the harm has occurred, and there is very little resource available for proactive compliance surveys or monitoring. Funding allocated for OHS activities has declined over time and the expertise of the Government's technical OHS workforce has greatly diminished (Allen & Clarke 2006). For example, in 2005 there were only 40 occupational hygienists nationwide (Allen & Clarke 2006). The number of inspectors has also been decreasing over time (Pearce et al. 2007). The decline in both the technical capacity for conducting exposure measurements and funding for OHS activities in general needs to be reversed. While workforce surveys can tell us where exposures are present, objective workplace measurements are required to determine the level and intensity of exposures in relation to levels at which adverse health effects may occur as well as provide evidence for compliance assessment and the development of appropriate policies and interventions.

8.3.2 Research

1) <u>Further studies are required on workplace size and work-life balance in New Zealand</u>

In Chapter 3, we discussed the role of workplace size as a potential explanation for the relatively higher prevalences of exposure in the non-manual occupations; however we did not collect any data to support this. Information on occupational hazards and level of compliance by workplace size would be valuable in determining whether smaller workplaces in New Zealand have more hazardous environments.

The potential interaction between workplace exposures and factors external to work has also been highlighted in this thesis, for example, the higher prevalence of household responsibility for women in Chapter 4 or the higher levels of job stress for Māori women compared to non-Māori women with the same job in Chapter 5. Future workforce surveys should collect more detailed information on risk factors external to work (for example unpaid work, work-life balance), particularly for female and Māori workers. The interaction between occupational risk factors (for example physical work tasks) and factors outside of work (for example less time to recover after work) requires more attention in order to fully assess the risk of occupational disease and injury.

2) <u>The dataset of the current workforce survey should be further utilised.</u>

The occupational exposures and asthma symptoms reported in this thesis were only part of the data that were collected for the workforce survey. Therefore, further analyses should be carried out which fully utilise the rich dataset. In particular, exploring the prevalence and distribution of more specific categories of exposure (for example ‘wood dust’ as opposed to the more general category of ‘dust’ which may also include general house dust) as well as the investigation of frequency and duration of exposure (for example average number of hours exposed) would provide a more sensitive representation of potentially hazardous exposures that may adversely impact upon health. This would also provide greater insight into why some non-manual occupations have relatively high prevalences of self-reported exposure.

The nature of occupational exposure (particularly airborne exposure) is also determined by work activity (such as whether the work tasks associated with exposure are active or passive), control measures (such as ventilation and use of PPE), and work environment factors (such as the proportion of time spent working outside). The prevalence of PPE use among participants reporting categories of exposure has been presented in Chapter 3 (Figure 3.2) of this thesis and therefore it would be useful to also examine the prevalence and type of ventilation systems and active versus passive work activity among participants reporting occupational exposure. In the case of active versus passive work, an occupational hygiene expert could classify work tasks in relation to exposure as active (i.e. exposure is generated from participant's work) or passive (i.e. exposure is generated by other people's work within the workplace) based on the detailed job description. This information, in addition to other details from the task description, could provide a crude indication of the intensity of exposure. The prevalence of PPE and ventilation systems among participants reporting occupational exposure could also be examined by occupational and industry groups, in order to provide an indication of the general safety culture of different sectors. Thus, further analyses are possible using the self-reported information on the work setting, activity, and control measures in order to obtain a more complete picture of exposure.

Further to considering contextual factors, multiple hazardous exposures often occur in many work environments. Therefore, whilst it was important to examine the prevalence and distribution of individual exposures, it would be useful to investigate clusters of exposures (i.e. which exposures most often occur together) and the number of reported exposures by occupation, industry, as well as by gender and ethnicity. The workforce survey collected a wide range of exposure information and therefore future analyses could examine clusters of not only dust and chemical factors, but also ergonomic factors. In addition, investigation of the number and types of PPE that frequently occur together would also be very interesting to explore in further analyses, particularly as the questions on self-reported PPE data in the survey were not specific to any given exposure.

Investigating clusters of exposures and clusters of PPE would help delineate some of the patterns observed in Chapter 3, for example the most frequently reported PPE measure among participants exposed to loud noise (a quarter of the time or more) was glove use - with hearing protection being the second most frequently reported measure.

Further analyses of the current survey data should also examine the relationship between socioeconomic status (SES) and occupational exposure. Socioeconomic status is closely associated with occupation, and it is also associated with ethnicity (i.e. Māori are overrepresented in the most deprived groups). Exploring differences by deprivation in patterns of occupational exposure both between and within occupations would provide useful insight into whether deprivation has an effect on exposure to occupational hazards beyond social sorting of occupation, as well as further elucidating the complex interaction between occupation, deprivation and ethnicity.

In addition, as mentioned earlier, the exposure prevalence data from the current workforce survey will be used for information systems such as the NZJEM and therefore has the potential to be utilised for other similar information systems. Finally, further analyses of occupation and asthma should include years of employment (i.e. duration of exposure), utilise the self-reported exposure data, or apply a JEM to assess cumulative exposures based on all job titles held. The results identifying occupations at high risk of asthma presented in this thesis (Chapter 6) was the first step and examining specific exposures (using self-reported exposures as well as a JEM) and duration and timing of exposure is the next step in elucidating the nature of work-related asthma.

8.4 Conclusions

In today's world of work, the concept of occupational exposure is increasingly heterogeneous in so far as exposure entails a wide range of different aspects of the work environment. The traditional chemical and physical exposures remain common in New Zealand, however there is also a new breed of risk factors i.e. organisational and psychosocial factors, which are highly prevalent, affect certain social groups more than others, and are associated with adverse health effects.

The distribution of occupational exposures is also more widely spread across the workforce than previously assumed. While occupational exposures are disproportionately experienced by workers in certain high-risk groups, they also occur in occupational groups not traditionally associated with hazardous exposures. The distribution of occupational exposures also varies according to the demographic characteristics of a worker. Thus, occupational exposure is not only determined by the type of occupation a worker has, but also by their demographic characteristics and how these are perceived by society. In particular, substantial differences in exposure were observed by gender, which also appears to play an important role in ethnic differences in exposure prevalence and in the association between stress and asthma.

Thus, the diversity of the workforce and the diversity of occupational exposures, as well as the potentially damaging effect of these exposures on health and well-being necessitate the national collection of occupational exposure and health information. Regular workforce surveys of the current and emerging occupational hazards in New Zealand workplaces should form the minimum requirement of an occupational exposure surveillance system

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Appendices

Appendix 1: Workforce survey questionnaire

Appendix 2: Statements of contribution to Doctoral thesis containing publications

Workplace Exposures Questionnaire

Subject ID #: **BA** ☐☐☐☐☐

Name: ☐

Today's date: ☐ Day ☐ Month ☐ Year

Phone number: ☐

E-mail: ☐

Date of Birth: ☐ Day ☐ Month ☐ Year

Gender:
- 1 ☐ Male
- 2 ☐ Female

To which ethnic group or groups do you belong?

Specify:

European/ Pakeha	Maori	Pacific Island	Other
☐	☐	☐	☐

☐

Part 1: Lifetime Work History

1. Please tell me all the jobs you have held in order from the first job you ever held to the most recent job ever held.

Interviewer:
Please include all jobs that lasted at least 6 months in total. Please start with the first job after leaving school and end with the most recent.
The list should be without gaps, meaning that also e.g. unemployed periods or periods taking care of children should be reported here.
The last year in the work history should be the year of interview.

Job Number	Who was your **employer**? (Name and Location)	Over what **period** did you work for this employer?	What was the **main activity** of the **company** or **organisation** you worked for? *(For example: sheep farming, selling shoes, making clothes)*	What **department** did you work in, and what was your **job title**?
1.	Name ………………… Location ………………….	From: …….. *(year)* To: …….. *(year)* Total time employed: …………... *years*		Department: ………………. Job title: ……………….
2.	Name ………………… Location ………………….	From: …….. *(year)* To: …….. *(year)* Total time employed: …………... *years*		Department: ………………. Job title: ……………….
3.	Name ………………… Location ………………….	From: …….. *(year)* To: …….. *(year)* Total time employed: …………... *years*		Department: ………………. Job title: ……………….
4.	Name ………………… Location ………………….	From: …….. *(year)* To: …….. *(year)* Total time employed: …………... *years*		Department: ………………. Job title: ……………….

		Who was your **employer**? (Name and Location)	Over what **period** did you work for this employer?	What was the **main activity** of the company or organisation you worked for?	What **department** did you work in, and what was your **job title**?
	5.	Name ………………… Location ………………….	From: ……. *(year)* To: ……. *(year)* Total time employed: …………... *years*		Department: ………………. Job title: ……………….
	6.	Name ………………… Location ………………….	From: ……. *(year)* To: ……. *(year)* Total time employed: …………... *years*		Department: ………………. Job title: ……………….
	7.	Name ………………… Location ………………….	From: ……. *(year)* To: ……. *(year)* Total time employed: …………... *years*		Department: ………………. Job title: ……………….
	8.	Name ………………… Location ………………….	From: ……. *(year)* To: ……. *(year)* Total time employed: …………... *years*		Department: ………………. Job title: ……………….
	9.	Name ………………… Location ………………….	From: ……. *(year)* To: ……. *(year)* Total time employed: …………... *years*		Department: ………………. Job title: ……………….
	10.	Name ………………… Location ………………….	From: ……. *(year)* To: ……. *(year)* Total time employed: …………... *years*		Department: ………………. Job title: ………………. *Interviewer: use add-in if more than 10 jobs*

Part 2: Your current or most recent job

I will now ask you some more questions about **your current job.**

Interviewer: Here we include only jobs for pay, profit or income. This part needs to be completed for all the jobs the respondent is currently holding. For example, if someone worked days in a factory and evenings as a cleaner, part 2 needs to be completed twice (use add-in). If the subject has no current job (e.g. is unemployed, taking care of children, sick leave, retired): this part should be completed for the last job held

1. **Period of Employment:**

From ……………… *(year)* To ………………. *(year)*

Interviewer: if the subject still works in this job, please write down CURRENT for end-year

2. How many **hours per week** do you work in this job? (on average) ………………. *(hours per week)*

3. How many **days per week** do you work in this job? (on average):………………….. *(days per week)*

4. Do you regularly work **outside 8-5 o'clock** for this job?

Yes □1→ ***if yes,*** please specify:……………………..
No □2 …..… …………………………
……...…………………………
…………………………………
…………………………………

5. What is the **main activity** of the company or organisation you work for?

(for example: what was produced, what service was provided)

…………………………………………………………
…………………………………………………………
…………………………………………………………
…………………………………………………………
…………………………………………………………
…………………………………………………………

6. What **department** do you work in?

…………………………………………………………

7. What is **your job title?**

…………………………………………………………

8. Please **describe your specific job** in detail:

Interviewer: Try to go through each point e.g: what do you do, how do you do it etc. If no response: ask respondent to describe a typical working day.

What do you do?
How do you do it?
What **materials** do you use?
What **tools** or **machinery** do you use?
What type of **process** is it?

…………………………………………………………
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9. In the environment where you work/worked were any of the following present?

** Interviewer: Please list **all**. If you tick any of these boxes please complete question 10 otherwise go to question 11.*

- **Dust:** e.g. coal, metal, wood, grain, textile fibres, or insulation material ☐
- **Smoke** or **fume:** e.g. combustion products, engine emission, metal fume ☐
- **Gas:** e.g. combustion gases, refrigerant ☐
- **Oils** and **solvents:** e.g. lubricants, cutting oils, degreasers, thinners ☐
- **Acids** or **alkalis** ☐
- **Fungicides, Insecticides, Herbicides** or **Timber Preservatives** ☐
- **Other chemical products** e.g. dyes, inks, adhesives etc. ☐

10. Please state the names of the substances you are/were exposed to, how many weeks per year and hours per day you are/were exposed, and the source of the substance.

Name/s of Substance	Weeks per year exposed	Hours per day exposed	Source of Substance

Name/s of Substance	Weeks per year exposed	Hours per day exposed	Source of Substance

11. What type of **ventilation** does/did your work area have? *(interviewer: please list all)*

- No Ventilation ☐
- Open doors and windows ☐
- Ventilation fan ducted to outside ☐
- Air conditioning ☐
- Fume hood with fan and air filters ☐
- ………………………………… Other ☐

12. How **effective** is/was the ventilation of your work area? *(interviewer: please list all)*

- Not at all effective ☐ 1
- Moderately effective ☐ 2
- Very effective ☐ 3
- Don't know ☐ 4

13. Do/did you wear any **protective equipment** while at work?

- Yes ☐ 1
- No ☐ 2 → *to 15*
- Don't know ☐ 3

14. If yes, which of the following do you use? For which tasks? *(interviewer: please list all)*

Goggles ☐
For which tasks:..
....
....

Footwear ☐
For which tasks:..
....
....

Apron ☐
For which tasks:..
....
....

Simple Dust Mask ☐
For which tasks:..
....
....

Filter Cartridge Respirator ☐
For which tasks:..
....
....

Air-Supplied Respirator or SCBA ☐
For which tasks:..
....
....

Rubber or Plastic Gloves ☐
For which tasks:..
....
....

Hearing protection (specify) .... ☐
For which tasks:..
....
....

Other ☐
For which tasks:..
....
....

15. How often does this job involve any of these situations? *(interviewer: please list each situation. Please ask for an estimation of the part of working time this occurs)*

	(estimation of part of working time)	All the time (1)	(2)	¾ (3)	(4)	½ (5)	(6)	¼ (7)	(8)	never % (9)
a)	awkward or tiring positions	☐		☐		☐		☐		☐
b)	awkward grip or hand movements	☐		☐		☐		☐		☐
c)	lifting	☐		☐		☐		☐		☐
d)	carrying out repetitive tasks	☐		☐		☐		☐		☐
e)	working at very high speed	☐		☐		☐		☐		☐
f)	working to tight deadlines	☐		☐		☐		☐		☐
g)	boring work	☐		☐		☐		☐		☐
h)	working in cold / damp environment	☐		☐		☐		☐		☐
i)	working in an (unpleasant) hot / warm environment	☐		☐		☐		☐		☐
j)	standing (still)	☐		☐		☐		☐		☐
k)	sitting	☐		☐		☐		☐		☐
l)	tools that vibrate	☐		☐		☐		☐		☐
m)	working outside	☐		☐		☐		☐		☐
n)	loud noise	☐		☐		☐		☐		☐

16. The following questions are about how satisfied you are with different aspects of your current job.

(interviewer: please list all)

The answers are on a five point scale from very satisfied to very dissatisfied.

you can answer 1-very satisfied
2-satisfied
3-neutral
4-dissatisfied
5-very dissatisfied or
n.a.-does not apply

	(satisfaction)	1	2	3	4	5	na
a)	The total number of working hours per week?	☐	☐	☐	☐	☐	☐
b)	Contact & co-operation between yourself & senior management?	☐	☐	☐	☐	☐	☐
c)	The level of enjoyment of your work?	☐	☐	☐	☐	☐	☐
d)	The level of difficulty of your work?	☐	☐	☐	☐	☐	☐
e)	The help & support given to you by colleagues?	☐	☐	☐	☐	☐	☐
f)	The way your work is organised?	☐	☐	☐	☐	☐	☐
g)	The level of mental demands of your work?	☐	☐	☐	☐	☐	☐
h)	The times of the day you are asked to work?	☐	☐	☐	☐	☐	☐
i)	The help & support given to you by your supervisor?	☐	☐	☐	☐	☐	☐
j)	The way your organisation is run?	☐	☐	☐	☐	☐	☐
k)	The total number of hours overtime offered / expected per week?	☐	☐	☐	☐	☐	☐
l)	Co-operation among you and your fellow workers?	☐	☐	☐	☐	☐	☐
m)	Work, as a whole?	☐	☐	☐	☐	☐	☐
n)	The level of physical demands of your work?	☐	☐	☐	☐	☐	☐

17. In general, how do you find your current job?

(interviewer: please list all)

Not at all stressful ☐1
Mildly stressful ☐2
Moderately stressful ☐3
Very stressful ☐4
Extremely stressful ☐5

18. In the last 4 weeks, did you work for pay, profit or income for at least 3 hours between midnight and 5 am?

Yes ☐1
No ☐2 → ***to next part***

19. In the last 4 weeks, what is the total number of nights that you worked for at least 3 hours between midnight and 5am?

________ Nights in 4 weeks

Part 3: You and your household

1. Have you ever smoked tobacco?

Yes ☐1
No ☐2 → ***to 7***

2. What do/did you smoke? *(interviewer: please list all)*

Cigars ☐ Cigarettes ☐ Pipe ☐ Other ☐

3. In what year did you start smoking?: ________

4. Do you still smoke? Yes ☐1 → ***to 6***

No ☐2

5. What year did you stop smoking? ____

6. How many do/did you smoke per day?: _______

7. How tall are you (in cm)? ______________ cm

8. How much to you weigh (in kg)? _________ kg

9. How many people in your household are in each of the following age-groups *(excluding yourself)*?

0-5 years ____
6-12 years ____
13-18 years ____
19-24 years ____
25-60 years ____
60+ years ____

10. How many of these people need looking after by you *(excluding yourself)*? _______ *people*

Part 4: Respiratory symptoms

1. Have you had wheezing or whistling in your chest at any time in the past 12 months?

Yes □1
No □2 → ***to 5***

2. Have you been at all breathless when the wheeze noise was present?

Yes □1
No □2

3. Have you had this wheezing or whistling in the chest when you did not have a cold?

Yes □1
No □2

4. How many attacks of wheezing or whistling have you had in the past 12 months?

none □1
1-3 times □2
4-12 times □3
more than 12 times □4

5. Have you been woken by an attack of shortness of breath at any time in the past 12 months?

Yes □1
No □2

6. Have you been woken by an attack of coughing at any time in the past 12 months?

Yes □1
No □2

7. Have you ever had asthma?

Yes □1
No □2 → ***to 13***

8. Was the diagnosis confirmed by a doctor?

Yes □1
No □2

9. How old were you when you had your first attack of asthma?

_____ years

10. How old were you when you had your last attack of asthma?

_____ years

11. Have you had an attack of asthma in the past 12 months?

Yes □1
No □2

12. Are you currently taking any medicine (including inhalers, aerosols or tablets) for asthma?

Yes □1
No □2

13. Do you have any nasal allergies including hay fever?

Yes □1
No □2 → ***to 16***

14. How old were you when you first had hay fever or nasal allergy?

_____ years

15. How old were you when you had hay fever or nasal allergy for the last time?

_____ years

16. Do you cough almost daily for at least part of the year?

Yes □1
No □2 → ***to 20***

17. Do you usually have this cough in winter?

Yes □1
No □2

18. Do you cough up phlegm almost daily for at least part of the year?

Yes □1
No □2 → ***to 20***

19. Do you usually have this cough (with phlegm) in winter?

Yes □1
No □2

20. In the past 12 months, how often have you been unable to work because of respiratory symptoms, i.e. cough, phlegm, wheezing/whistling or shortness of breath?

Never □1
1-7 days □2
8-30 days □3
At least 31 days □4
Don't know □5

21. Have you ever had eczema (or atopic dermatitis)?

Yes □1
No □2 → ***to next part***

22. Was the diagnosis confirmed by a doctor?

Yes □1
No □2

Part 5: Sleep Patterns

1. How many hours sleep do you usually get **on a day off** (counting naps as well)? …………… hours

2. How often do you get enough sleep?

0 ☐ Never 1 ☐ Rarely 2 ☐ Often 3 ☐ Always

3. How often do you wake up feeling refreshed?

0 ☐ Never 1 ☐ Rarely 2 ☐ Often 3 ☐ Always

4. How often do you snore?

0 ☐ Never 1 ☐ Rarely 2 ☐ Often 3 ☐ Always

5. Has anyone ever told you that you stop breathing sometimes during sleep?

1 ☐ Yes 0 ☐ No

6. How likely are you to doze off or fall asleep in the following situations?
Please choose one answer for each of the following:

	would never doze	*slight chance*	*moderate chance*	*high chance*
a) Sitting and reading	0 ☐	1 ☐	2 ☐	3 ☐
b) watching TV	0 ☐	1 ☐	2 ☐	3 ☐
c) Sitting inactive in a public place (eg. theatre, meeting)	0 ☐	1 ☐	2 ☐	3 ☐
d) Lying down in the afternoon when circumstances permit	0 ☐	1 ☐	2 ☐	3 ☐
e) Sitting and talking to someone	0 ☐	1 ☐	2 ☐	3 ☐
f) Sitting quietly after a lunch <u>without</u> alcohol	0 ☐	1 ☐	2 ☐	3 ☐
g) In a car, while stopped for a few minutes in traffic	0 ☐	1 ☐	2 ☐	3 ☐

7. Do you consider that you have a sleep problem?

1 ☐ Yes 0 ☐ No → ***to next part***

8. How long have you had a sleep problem?

1 ☐ less than 4 weeks 2 ☐ 1-6 months 3 ☐ More than 6 months

Comments welcome →……………………………………………………………………

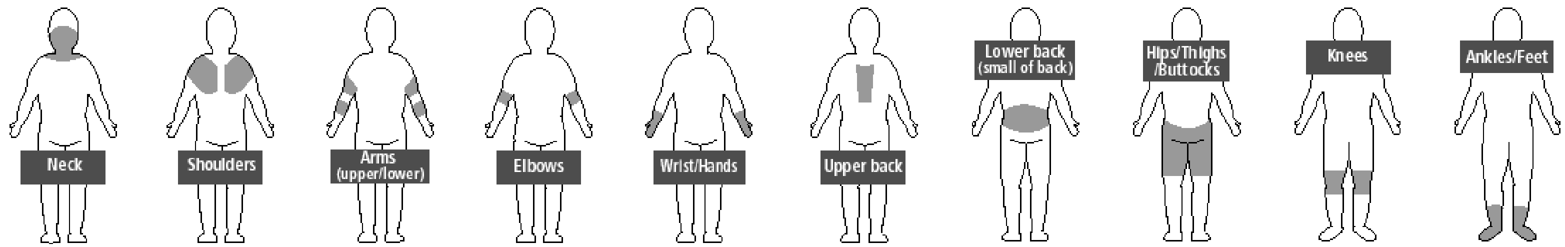
Part 6: Muscle and joint aches

1. *Interviewer: please complete this question by starting with the list of body parts (Q1). If any is 'yes', complete all other questions (Q2-Q4) for this body part, then continue with the list of body parts (Q1).*

MUSCLE AND JOINT ACHES AND PAINS

PLEASE ANSWER ALL THE QUESTIONS, EVEN IF YOU HAVE NEVER HAD ANY TROUBLE IN ANY PARTS OF THE BODY.

	Q1 Have you at any time during the last 12 months **had any trouble** (such as aches, pains, discomfort, numbness) in your:	**Q2** During the last 12 months, have you been **prevented from carrying out normal activities** (e.g. housework, hobbies, gardening) because of this trouble?	**Q3** During the last 12 months have you been **absent from work** because of this trouble in your:	**Q4** How often **do you get,** or **have you had** this trouble during the last 12 months?
Neck	No ☐ 1 Yes ☐ 2	No ☐ 1 Yes ☐ 2	No ☐ 1 Yes ☐ 2	Daily ☐ 1, one or more times: a week ☐ 2 a month ☐ 3 a year ☐ 4 one episode of trouble only ☐ 5 Never ☐ 6
Shoulders	No ☐ 1 Yes ☐ 2	No ☐ 1 Yes ☐ 2	No ☐ 1 Yes ☐ 2	Daily ☐ 1, one or more times: a week ☐ 2 a month ☐ 3 a year ☐ 4 one episode of trouble only ☐ 5 Never ☐ 6
Arms (upper and lower)	No ☐ 1 Yes ☐ 2	No ☐ 1 Yes ☐ 2	No ☐ 1 Yes ☐ 2	Daily ☐ 1, one or more times: a week ☐ 2 a month ☐ 3 a year ☐ 4 one episode of trouble only ☐ 5 Never ☐ 6
Elbows	No ☐ 1 Yes ☐ 2	No ☐ 1 Yes ☐ 2	No ☐ 1 Yes ☐ 2	Daily ☐ 1, one or more times: a week ☐ 2 a month ☐ 3 a year ☐ 4 one episode of trouble only ☐ 5 Never ☐ 6
Wrists/Hands	No ☐ 1 Yes ☐ 2	No ☐ 1 Yes ☐ 2	No ☐ 1 Yes ☐ 2	Daily ☐ 1, one or more times: a week ☐ 2 a month ☐ 3 a year ☐ 4 one episode of trouble only ☐ 5 Never ☐ 6
Upper back	No ☐ 1 Yes ☐ 2	No ☐ 1 Yes ☐ 2	No ☐ 1 Yes ☐ 2	Daily ☐ 1, one or more times: a week ☐ 2 a month ☐ 3 a year ☐ 4 one episode of trouble only ☐ 5 Never ☐ 6
Lower back (small of back)	No ☐ 1 Yes ☐ 2	No ☐ 1 Yes ☐ 2	No ☐ 1 Yes ☐ 2	Daily ☐ 1, one or more times: a week ☐ 2 a month ☐ 3 a year ☐ 4 one episode of trouble only ☐ 5 Never ☐ 6
Hips/Thighs/Buttocks	No ☐ 1 Yes ☐ 2	No ☐ 1 Yes ☐ 2	No ☐ 1 Yes ☐ 2	Daily ☐ 1, one or more times: a week ☐ 2 a month ☐ 3 a year ☐ 4 one episode of trouble only ☐ 5 Never ☐ 6
Knees	No ☐ 1 Yes ☐ 2	No ☐ 1 Yes ☐ 2	No ☐ 1 Yes ☐ 2	Daily ☐ 1, one or more times: a week ☐ 2 a month ☐ 3 a year ☐ 4 one episode of trouble only ☐ 5 Never ☐ 6
Ankles/Feet	No ☐ 1 Yes ☐ 2	No ☐ 1 Yes ☐ 2	No ☐ 1 Yes ☐ 2	Daily ☐ 1, one or more times: a week ☐ 2 a month ☐ 3 a year ☐ 4 one episode of trouble only ☐ 5 Never ☐ 6



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STATEMENT OF CONTRIBUTION TO DOCTORAL THESIS CONTAINING PUBLICATIONS

(To appear at the end of each thesis chapter/section/appendix submitted as an article/paper or collected as an appendix at the end of the thesis)

We, the candidate and the candidate's Principal Supervisor, certify that all co-authors have consented to their work being included in the thesis and they have accepted the candidate's contribution as indicated below in the *Statement of Originality*.

Name of Candidate: Amanda Eng

Name/Title of Principal Supervisor: Andrea 't Mannetje - Senior Research Fellow

Name of Published Paper: The New Zealand workforce survey I: self-reported occupational exposures

In which Chapter is the Published Work: 3

What percentage of the Published Work was contributed by the candidate: 90%

Amanda Eng
Candidate's Signature

22/2/2011
Date

Principal Supervisor's signature

22/2/2011
Date

DRC 16

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Name of Candidate: Amanda Eng

Name/Title of Principal Supervisor: Andrea 't Mannetje, Senior Research Fellow

Name of Published Paper: Ethnic differences in patterns of occupational exposure in New Zealand

In which Chapter is the Published Work: 5

What percentage of the Published Work was contributed by the candidate: 90%

Candidate's Signature

22/2/2011
Date

Principal Supervisor's signature

22/2/2011
Date

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Name of Candidate: Amanda Eng

Name/Title of Principal Supervisor: Andrea 't Mannetje, Senior Research Fellow

Name of Published Paper: The New Zealand Workforce Survey II: occupational risk factors for asthma

In which Chapter is the Published Work: 6

What percentage of the Published Work was contributed by the candidate: 90%

Amanda Eng

Candidate's Signature

22/02/2011

Date

Principal Supervisor's signature

22/2/2011

Date