Chapter One

Introduction

1.1 Introduction

The attractions of quadbikes over tractors or utility trucks (also known as pick-up trucks or utes elsewhere) to farmers include affordability, compactness, speed into remote areas, low impact on plant beds and other sensitive surfaces and the ability to carry loads of more than one third of the vehicle's own weight (Low, 2000). For the purposes of this study, quadbikes were defined as four-wheeled motorbike-derived vehicles with handlebar steering systems which may or may not require weight-shift in riding.

The New Zealand farming community has a reputation for improvisation and finding novel money-saving applications for products conceived for other purposes. This is probably true of farmers everywhere, but the remoteness of New Zealand from the big manufacturing centres of the Northern Hemisphere, and the commensurately high cost of imported equipment has contributed to this culture.

The presence in the market of three and four-wheeled recreational All-Terrain Vehicles (ATV) since the 1970s and '80s has presented an opportunity for farm owners and contractors to not only improve transportation into remote areas and hence reduce labour costs, but more significantly to cut capital outlay on vehicles by having a single machine that can potentially replace several others. The widespread uptake of the four-wheeled ATV (quadbike) has resulted in a reduction in the use of horses, two-wheeled motorbikes, light tractors, and 4WD utility trucks such as Landrovers and Jeeps. Approximately, 70,000 quadbikes are now in use in New Zealand farming. Unfortunately, this surge has been accompanied by high rates of injury and damage.

Direct insurers costs were in excess of $3.6 million on new and on-going quadbike-related ACC claims in 2003-4. The Department of Labour [Occupational Safety and Health section] spokesman for Agriculture identified quadbike use (Ward, 2002) as their single greatest area of concern in farm safety. There have been on average seven deaths a year involving quadbikes on farms in recent years.

The research reported in this thesis, investigating the problem of Loss of Control Events (LCE) involving quad bikes on New Zealand farms, was designed as a response to this problem.

LCE are defined for the purposes of this research as those situations where the riders on a moving vehicle find themselves unable to prevent either personal injury or damage to the machine from occurring. Near-miss incidents where control was lost, but no damage occurred, were excluded during the analysis stage of the investigation study reported in Chapter Five. The reason for omitting near-misses from this study was that the opportunities for triangulation of data concerning the events were f a . greater where medical records, workshop records and physical damage traces in the landscape were also available. For historical near-miss incidents without witnesses, the potential for objectivity is greatly reduced.

In this chapter, I will discuss the history of quadbikes, the approach and aims of the research, and the structure of this thesis.

1.2 Problem Statement

A literature review by ACC in 2000 concluded that 'current information available in Australia and New Zealand is insufficient to establish the cost, frequency and nature of ATV injuries, or even to confidently adopt research findings based on US statistics' (ACC, 2000).

Despite this clear cautionary statement, intervention strategies such as the ATV helmet campaign were being formulated by ACC, OSH and others based on studies using North American data – regardless of the potentially significant differences in contexts of use between the United States and New Zealand.

The state of knowledge at this point was that: the burden of cost from quadbike LCE and the level of public concern in rural communities were substantial –with fatalities trending up though the 1990s; the majority of machines in New Zealand were bought for occupational use in agriculture; and research in Southland (Brown, 1998) had concluded that the more serious injuries were commonly linked to loss of control events resulting in rollover. Beyond this, the extent and nature of the injury toll in New Zealand remained largely unknown.

1.3 Safe Family Fun: a short history of quadbikes

Honda produced the first three-wheeler (the US90) in the 1970s and it came to public prominence as an agile escape vehicle for 007 in 'Diamonds are Forever'. The resulting perception was that vehicles were fun to ride. They had no mechanical suspension, just balloon tyres which gave it the unique riding characteristics of a motorised Space Hopper, and added to deceptive first impressions that they were just a big safe toy (Karnes, Leonard & Newboldt, 1988).

Figure 1.1 The original 1970s Honda ATV trike

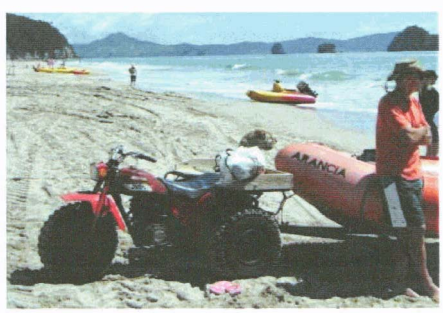

Figure 1.2 1976 model trike still being used for towing on the Coromandel peninsula, North Island

Conceptually they are quite different to motor bikes or small 4WD jeep-like vehicles. The suspension is less of an issue now that most have mechanical systems, but the cornering remains problematic. Rather than leaning into the turn, as you need to on a two-wheeler bike, at low speeds the rider has to lean away from the corner to take the weight off the inner wheels until they lift slightly. This destabilisation is needed as the lack of a differential on the axle means that the inner drive wheels on an ATV do not slow down relative to the outer ones - as they do on a car going round a corner.

This leaning 'towards the danger' is counter-intuitive to people with experience of bicycles and motorbikes.

They are also more likely to roll, and roll more quickly than other vehicle types the riders will have had experience of. Quadbikes have a wheelbase about the same size as that of a go-kart, but whereas the karter's body weight acts just a very few inches from the floor so that the machine skids around corners, the ATV operator is sitting half a metre or so higher. As a result the machine will generally tip before it slides. The higher centre of gravity is due to the perceived need by the designers for the quadbike to have good clearance over rocks etc.

Before the 1970s, there had been attempts to develop utility go-anywhere vehicles in New Zealand but these initiatives ended with the influx of cheaper, smaller recreational ATV from offshore. One of several home-grown examples was the 6x6 Transtruck, designed and built in Canterbury using a Leyland engine (Figure 1.3). South Island farmers who had owned these machines recalled that the local manufacturers went briefly into commercial production before being forced out of the market by the cheaper imported options. The Transtruck was a sturdy unit intended for getting fencing materials, bulk feed and other heavy loads out into the awkward remote corners of the property; a few, such as one below, are still in use thirty years later.

Figure 1.3 Transtruck 6x6, still in use on a Canterbury farm

The term 'all-terrain vehicle' is now used internationally to cover a range of open-topped motorised buggies and three-wheelers designed for off-road use. The

American National Standards Institute (ANSI) defines an ATV as a single rider vehicle that travels on low pressure tyres, has a straddle seat and handlebars for steering rather than a wheel or other means. The four-wheeled versions are known as "quads" or "quadbikes" in New Zealand; "ATVs", "four-wheelers" or "quads" in Australia, the United States and English speaking Canada; and "quadrimotos", or more commonly "vehicules tout-terrain (VTT)" in French speaking countries. They are sometimes also bracketed as Off Highway Vehicles (OHV) or Off Road Vehicles (ORV).

Originally no bigger than 250cc, models now come with engines from 50cc to 800cc and are basically divided into two types, sport models and utility vehicles. Sports models are designed to be faster and lighter than the utility quadbikes.

Figure 1.4 Sports models such as this one are lighter and more manoeuvrable

1.3.1 Usage

Roughly 290,000 trikes were sold in North America in the 1970s (Ford & Mazis, 1996), but sales expanded dramatically in the early 1980s. A further 290,000 were sold in the year of 982 alone, and at the peak in 1984, 464,000 trikes and 161,000 quadbikes were bought in the United States.

The new concept of four-wheeled ATV caught on very fast. Consumer Product Safety Commission (CPSC) figures quoted by Ford & Mazis, (1996) show the four-wheeled ATV having only 2.5% of the US market in 1983. In Canada, studies conducted in the mid 1980s (DeLisle, Laberge-Nadeau & Brown, 1988; DeLisle, Laberge-Nadeau & Brown, 1989) found approximately 85% of the riders had been using trikes, and just 15% quadbikes. However, the Honda Big Red and the Suzuki QuadRunner launched late in 1983 proved very successful and trikes quickly lost their dominant market share to the four-wheelers. The Honda Big Red had mechanical suspension and racks for carrying loads which made it popular with hunters and trail riders in North America.

Figure 1.5 Early two-wheeled drive 250cc model – very easy to steer by comparison to heavier more recent 4WD quadbikes

The QuadRunner was a lightweight beginners' machine, which although designed for recreation was very popular due to its manoeuvrability and ease of steering – not only in North America but also with older riders in New Zealand who still complain about its replacement by the heavier newer models.

All-wheel drive vehicles have clear advantages for the trail riders and farmers who wish to haul loads, and in 1986 the first 4WD quadbike was produced – the Honda

FourTrax. The other manufacturers quickly produced their own versions and the 4x4 became, and remains to this day, the most popular utility type. They outsell the two-wheel drive models by a ratio of 3:1 in the New Zealand farming market.

Figure 1.6 Late model 4WD Honda on a large South Island sheep station

1.3.2 Concerns with quadbikes

Concerns about quadbikes were registered at an early stage. The first of the three or four wheeler ATV that would be recognised today as such, was shipped from Japan to Honda California in 1970 for assessment of suitability on the US market (Cabaniss, Wegis & Thomas, 1992). It was marketed as being fun for all ages from 7 to 70. The engineer is reported to have taken it out for a test ride and promptly rolled it over. He recommended replacing the fixed axle with a differential axle so that turns could be easier and not require one tyre to be lifted off the floor, as described earlier. He also suggested replacing the long banana seat with a saddle seat, as he felt the former encouraged passengers.

Initial public concern resulted in action (Deppa, 1984) by the Consumer Product Safety Commission (CPSC) in 1984. They conducted case study investigations and some engineering analysis. The findings included serious doubts about the stability and handling characteristics, which resulted in the release of a number of "Safety Alerts" as a means of providing information to the public.

By 1985, deaths per year per 1,000 ATV in use were peaking at 0.15 (Ford & Mazis, 1996), which was four times the rate reported just three years previously. This was attributed in part to the very high number of novice riders that were out on their new machines for the first time (Newman, 1985). Riders in their first month were found by Newman to have 13 times the risk than those with more than four weeks experience.

From these early days, there was particular concern about the high numbers of young riders being hurt. In 1986 Honda declined a request from CPSC to cease production of ATV intended for use by children under the age of 12. It had been found that children had twice the incidence of death and injury from ATV as adult riders (Newman, 1985).

Pressure continued to mount on the manufacturers, as concerns about injury rates were raised in a number of reports from academics as well as Government agencies (Deppa, 1986; Kriel, Sheehan, Krach, Kriel & Rolewicz, 1986; Sneed, Stover & Fine, 1986, Trager, Grayman & Harr, 1986). It is not possible to tell how much of a problem was presented by the quadbikes as opposed to the trikes in these incidents though, as many of the North American publications grouped them all as ATV without further distinction. In those studies of incidents at this time where it was known how many wheels the machine in question had however, the three-wheeler machines were suggested to be especially dangerous. They were linked to an injury rate twice that of the four-wheelers by Cabaniss et al (1992) in the years that both types were commonly in use. Early assessments had been limited to epidemiological and mechanical engineering exercises, but by 1987 studies critical of conceptual aspects of ATV were being reported in the ergonomics and human factors literature (Karnes, Leonard & Scheider, 1987; Kvalseth, 1987).

By the late 1980s, the US Department of Justice (DOJ) had prepared its case and filed a complaint alleging that "the mechanical properties of ATV, when coupled with their deceptively safe appearance, result in a risk of injury and death to users", particularly for inexperienced and young operators (United States v. American

Honda Motor Company Inc, 1988). The DOJ complaint also highlighted that the promotional messages reinforced the incorrect public perception that these vehicles were especially safe and stable. In fact four specific design features were identified as causing problems - especially to young and novice riders for whom the concept of the machines did not fit their expectations. These were: high centre of gravity combined with small wheelbase, the need for counter-intuitive weight shift to the outer tyre when cornering, the balloon tyres designed to substitute for suspension which would 'rebound' when braking or turning hard on bumps, and finally the excessive grip achieved on hard paved surfaces by the soft knobbly tyres designed for soft surfaces.

The action against the manufacturer resulted in a settlement that included a number of interventions voluntarily adopted not just by Honda but by all the main players of the industry. The compromise deals included the voluntary withdrawal of the three-wheeler ATVs from the United States market – although Ford & Mazis (1996) note that by the time this happened the manufacturers had already decided the future was with quadbikes which were accounting for 94% of the sales, and had ceased production of the three-wheelers anyway. In New Zealand, no such withdrawal of trikes from the market took place.

Injured riders and the families of those who have died using ATV in the USA had little success in private actions against the manufacturers. Wegis, a lawyer who had previously worked for the Consumer Product Safety Commission (CPSC), developed a 35 point ATV investigation checklist (Cabaniss et al., 1992) for the use of plaintiff teams filing legal actions against the ATV manufacturers. Wegis stressed the importance of meticulous preparation as the manufacturers were spending in the region of six times as much on the legal proceedings as the plaintiff, and also conducting market research on how best sell their defence to the jurors.

There are opposing views on the success of the US Government agency the CPSC in minimising the risks to the public. The CPSC have consistently defended their approach (Rodgers, 1993; Rodger, 1996; Rodgers & Adler, 2001) principally by

pointing out that there was a fatality rate of 1.5 per 1,000 machines in 1985 prior to decrees taking effect, and by 1997 that fatality rate had halved. Others, including Moore and Magat (1997), argue that the Government achieved little that altered the course the manufacturers wanted to take. Profits were, and continue to be, maximised by misleading potential buyers, while carefully telling the public just enough about the real risks to keep their legal position and hence court costs tenable (Ford & Mazis, 1996). The situation in the United States has escalated in recent years to the extent that the formal efforts of CPSC are being supplemented and extended by more passionate Community lobbying groups such as the Concerned Families for ATV Safety (http://www.atvsafetynet.org/).

Apart from a local study in Southland (Brown, 1988) in the early '90s, no formal research was done on quadbike incidents in New Zealand until 1996 when an Agricultural Safety Focus Group coordinated by OSH ran a survey on ATV use in New Zealand (OSH, 1998). The project was promising but the findings, as reported in Chapter Two, were not as useful as they could have been due to inconsistencies by the OSH staff collecting the data in the field, and to political and social biases introduced by their collaborators, Federated Farmers.

A small number of quadbikes were sold in New Zealand for adventure tourism in the 1990s, but from personal communications received during this study, it appears that operators have increasingly switched to lower-risk alternatives as quadbikes proved too hazardous for customers. New Zealand now accounts for approximately 1% of worldwide quadbike sales (Cooper-Smith, 2004)

1.4 Approach of the research

'Because every factor interacts in a social system, because every thing, every property, every relation is therefore in a state of mutual dependence with everything else, ordinary cause-and-effect analysis of events is rarely possible. In fact it is nearly always grossly misleading; ..'
(L.J. Henderson, from his Sociology 23 Lectures 1941. Published in: Barber, 1970. p139)

1.4.1 Systems approach

An ergonomics approach is followed in investigating the problem of quadbike LCE on farms. It considers LCE from the perspective of the interactions between the user, their equipment, the task and their physical and social environment. This is the first study to apply a systems perspective to quadbike LCE.

1.4.2 Participatory methods

A consistent message that emerges in the agricultural injury prevention literature is that pragmatic participative methods need to be used in the development of interventions (Bentley, Moore, Tappin, Legg, Parker, & Ashby, 2005; Glasscock, Hansen, Rasmussen, Carstensen, Lauritsen, 1994; O'Neill, 1997; O'Neill, 2001).

'There is probably no other industry in which interactions with economic constraints, cultural factors and engineering design are so critical to the development of ergonomics solutions, and in which participative approaches are so crucial to their implementation'. (O'Neill, 2001).

The benefits of participative methods generally are reported to include improved design ideas and smoother implementation (Wilson, Haines & Morris, 2005) and these have been found to apply in agriculture as elsewhere. This research therefore adopted key features of a Participatory methodology (Haines, Wilson, Vink & Koningsfeld, 2002) in the collection of data and the development of interventions.

1.4.3 Intervention development

In the conflict between the desirable and the possible, the possible always wins, … The practice of field research is the art of the possible' (Buchanan et al., 1988: 54-55)

During the process of setting up the pilot studies, it very quickly became clear that to gain the support of the largely self-employed farming community, the overall exercise had to make sense to them, with their participation representing a worthwhile use of their time. One way of achieving this was to explore system-wide risk factors, and to also embrace remedial interventions.

1.5 Aims of the research

The aims of the research reported in this thesis were to:

1. Establish the scale of the problem of loss of control events (LCE) involving quadbikes on New Zealand farms
2. Establish an understanding of the context of quadbike use on New Zealand farms, including the functional requirements of the tasks relating to the quadbike
3. Develop a suitable investigative method for the analysis of quadbike LCE on New Zealand farms
4. Identify risk factors for LCE and their interactions
5. Identify potential interventions that would reduce the incidence and/or severity of quadbike-related LCE on New Zealand farms.

An ancillary aim was to also compare the characteristics of the LCE on New Zealand farms with those reported in North America to assess whether or not the practice of importing intervention ideas was supported by the evidence base.

1.6 Structure of the thesis

The structure of the thesis reflects the sequential progression of the studies as the research aims were met. This sequence is shown diagrammatically in Figure 1.7.

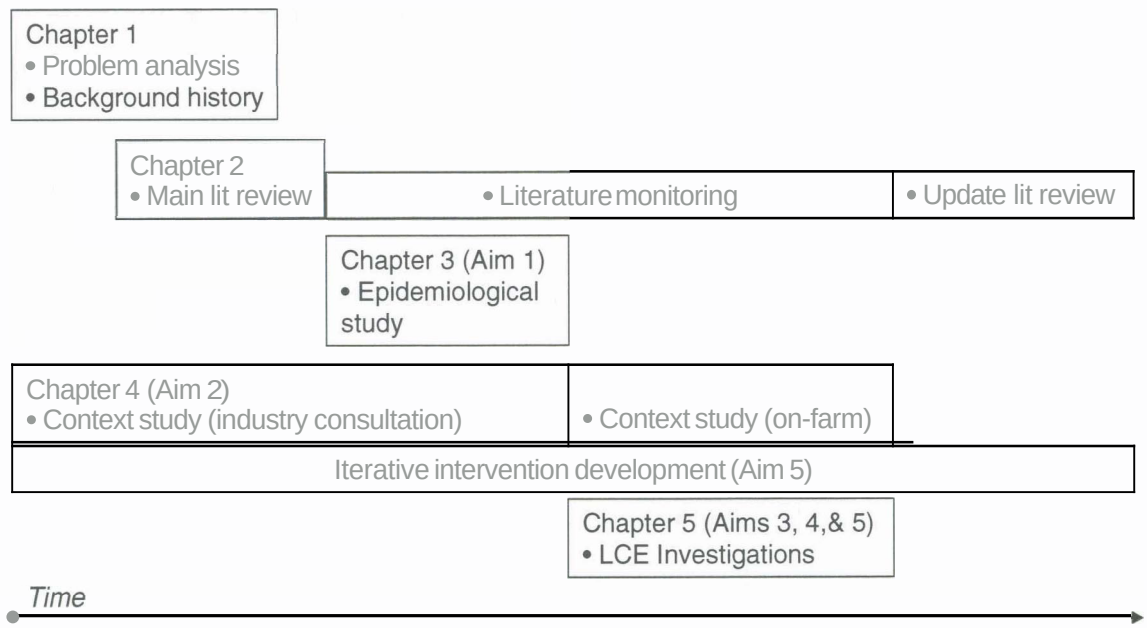

Figure 1.7 Diagram showing sequential progression of studies

The aim of the literature review in Chapter Two was to critically analyse the existing body of literature related to the study aims, and discuss: established knowledge, gaps in understanding and conflicting evidence. This chapter deals with the literature relating specifically to quadbike LCE, quadbike use and interventions. Potentially useful theoretical structures and methods are discussed in the relevant chapters, most notably Chapter Five where the literature on various investigative approaches, incident causation models and issues such as recall reliability is reviewed.

The objective of the research reported in Chapter Three was to develop a more detailed overview of the problem in New Zealand, drawing on archival data, predominantly those collected by the state-run insurer the Accident Compensation Corporation. The study is a descriptive epidemiological analysis of ACC Claims Data, in the period July 2000 – July 2001. The particular aims of this

epidemiological study were to identify patterns and trends in quadbike-related claims, and to determine incident event/injury mechanism information.

The "context for ergonomics change" (Kleiner, 2006), is explored in Chapter Four, via incident-independent analysis of the tasks, the user characteristics and the machines. The aim of the study reported in this chapter was to gain an understanding of the systems within which quadbikes operate on New Zealand farms. This was necessary in order to interpret investigation data to sufficient depth, and to develop interventions that fitted within the system as a whole - interventions that would effectively address problems without creating others.

The aims of the research reported in Chapter Five were to develop a suitable investigative method for the analysis of quadbike LCE on New Zealand farms, identify risk factors for LCE and their interactions, and to identify potential interventions that would reduce the incidence and/or severity of quadbike-related LCE on New Zealand farms. The methodology section includes discussion on investigative approaches, incident causation models and issues pertinent to the design of the site procedures and interview schedule design such as recall reliability and context dependent memory. The findings section employs a new interactive and information processing model for off-road vehicle incidents, developed during this study.

In Chapter Six the key findings are reviewed and the unique contribution of both methodology and content to knowledge are discussed. Directions for future research are outlined.

1.7 Ethical considerations

An Ethical Application was submitted to the Massey University Human Ethics Committee (MUHEC). Following further explanation and discussion with the Chair - Professor Sylvia Rumball, appropriate amendments were made and the proposed protocol was approved as PN Protocol – 011128 (Appendix I).

The contract signed by ACC and the Researcher also included provisions reflecting the concerns and the agreed means of addressing them. The specific ethical considerations identified, and the means by which they were addressed, are as follows.

1.7.1 Working with ACC claims data

The concerns of ACC were that the data should not be used for other than the agreed purposes, and that individuals should not be personally identifiable in any papers, reports, presentations etc. arising from the study. Assurances were given to ACC that the data would be stored in a secure place and destroyed after the completion of the research. Additionally, ACC was assured that no individual would be identified in any report published. These were also Massey University Ethics Committee requirements. The publications based on these records used only aggregated data.

The data set of 850 cases (claims) was provided by ACC in electronic disc form. Upon receipt the data were checked for completeness and obvious corruptions or errors, i.e. internal contradictions in gender, location or rider age. All information relating to claimant identity and non-essential confidential details were then deleted. This version was then saved as an EXCEL Master file, and the ACC original version as received was destroyed.

1.7.2 Interviewing ACC claimants

The primary ethical issue identified was that the individuals may be fearful that sensitive information provided during the study would find its way back to ACC, and as a consequence, the support they were receiving could be reduced. It became apparent that in some cases, legal disputes were in progress with the local ACC office on this, or other, claims.

It was made clear in the Information Sheet provided to each person taking part (Appendix I) that confidentiality could be guaranteed as the interviewer was not an ACC employee and therefore could not and would not release data at a later date. Each case was given a unique identification code number in place of the claimant name. The list linking names to codes (necessary for later iterations of analysis) was not stored with the site notes.

On site, before commencing the interview, each subject was told that the researcher was an independent consultant conducting research leading to a PhD under the auspices of Massey University. Specific questions about data security and reporting were answered and personal assurances regarding destruction of data at the completion of the study were given.

1.7.3 Conducting site visits and interviews

Confidentiality of data was of paramount concern for the site work in general. Any fears held by subjects that their comments might get back to their employer, colleagues or insurers would also impact directly on the quality and completeness of information gathered. Clear and pragmatic ethical compliance was therefore also a key component in the methodology. The researcher aimed to establish a high level of trust with the people being interviewed. This contributed to the decision to undertake costly and time-consuming face to face field interviews – as opposed to the postal, telephone or brief doorstep interviews used in previous quadbike studies in New Zealand.

On site, each individual had the choice of being interviewed alone or with family members, employers or colleagues. Care was taken to ensure that the subject was indeed comfortable with others being present, where this was requested, and was not accepting this under duress. The occurrence of LCE resulting in injuries to workers and stock, and damage to the machines or property, can understandably provoke tension between the rider and others around them. Blame attribution and disagreement over the causal factors were still generating ill-ease on many farms at the time of the site visits. The owner or manager of the farm asked to be present in three cases in order to know what was being said about the reasons for the LCE, and where blame was being placed. They appeared to be concerned that a biased account of events would be handed to OSH or ACC, with adverse outcomes for the farm operation or themselves personally. The importance of confidentiality was explained to the employers and the interviews proceeded without their presence. In one case however, the employer was not prepared to offer sufficient privacy for the subject to speak openly and the limited data collected were not entered onto the LCE database.

Discussions on how best to protect the identity of contributors reporting relatively small numbers of events were held with technical aviation writers at the Civil Aviation Authority and designer/administrators of the New Zealand CHIRP system on good practice in the publishing of Confidential Reporting System findings in commercial aviation. The underlying principle suggested, and adopted, was that all non-essential detail that could triangulate to identify the individual should be stripped out. This differed from case to case, but commonly included specific region, exact age and gender.