Investigation of causative factors associated with summertime workplace fatalities

A RESEARCH REPORT

Department of Labour
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ACRONYM LIST

ACC	Accident Compensation Corporation
ANZSIC	Australian New Zealand Standard Industrial Classification
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
AT	Apparent Temperature
ATC	All-Terrain Cycle
ATV	All-Terrain Vehicle
BS	Bystander (in a place of work)
BST	British Summer Time
CET	Central European Time
CEST	Central European Summer Time
CI	Confidence Interval
CPI	Consumer Price Index
DHB	District Health Board
DoL	Department of Labour
EMP	Employee
GMT	Greenwich Mean Time
Human Engineering	Human Engineering (Australia) Pty Limited
HSE	Health and Safety Executive
ISE	Industry Safety Experts
ISO	International Organization for Standardization
NS	Not (statistically) Significant
OSH	Occupational Safety and Health
PPE	Personal Protective Equipment
SE	Self Employed
S&H	Safety and Health
SPAD	Signal Passed At Danger

DEFINITIONS

Human Factors / Ergonomics	Human factors is the discipline concerned with ensuring that systems and technologies are effectively designed to take account of the needs and expectations; and the capabilities and limitations of the people that use them. This incorporates all aspects of human integration with systems and technologies including cognitive, behavioural, physiological and anatomical factors. These sciences are applied towards two main objectives: the most productive use of human capabilities, and the maintenance of human health and well-being.
Human Error	In this study 'Human error' has been used to classify a variety of incidents where memory lapses, slips in behaviour, or mistakes (e.g. misjudgements, misinterpretations, distraction errors, silly decisions, inadequate knowledge) have led to a fatality.
Procedural Violation	Contravention of procedures typically occurs because procedures are inappropriate or unnecessarily onerous; workers have been inadequately trained or inducted; the work force has little understanding of basis for the procedure(s); and/or because workplace cultures prioritise other issues above safety.
Primary cause	The 'agent' recorded as being directly related to the death of the victim(s) at the time when the incident occurred. *See Appendix D for breakdown and explanations*
Contributing factor(s)	The main reason(s) the fatality occurred; looking at the workplace, the environment, the society and the people.

FOREWORD

Over a three-week period in the summer of 2005-2006 the Department of Labour investigated the work-related deaths of 10 New Zealanders.

For anyone not directly affected by such a loss it is hard to comprehend the enormity of such workplace fatalities – for families and loved ones; for colleagues; for employers; and for communities.

This apparent increase over three summer weeks – 15 percent of all recorded fatalities in the 2005-2006 year – begged important questions: Are workers more likely to be killed in work-related incidents during the summertime? And if so, then what factors might contribute to such a trend, and possibly be targeted in the hope of reducing future fatalities?

The Department of Labour responded with a research project to identify if a statistical relationship could be identified between seasonal work trends and workplace fatalities. The Department provided researchers with its database of 362 workplace fatality records for the six years from 2000 to 2005. Although this data set was relatively small for the scale of analysis being conducted, it represented the most reliable data available.

The findings of this research are presented in this report.

In summary, males, working in the agriculture industry, aged between 55 and 64, are most likely to have a fatal incident in their workplace during the summertime. The research also shows that workplace fatalities occur more often at certain times of the day, in certain areas of the country, and are more likely to involve a vehicle than not.

The research is very much a first step as the Department of Labour tries to better understand the causes and how to prevent fatalities at work.

This report helps us to frame new questions, like, why are there more workplace fatalities between 10.30am and noon, and between 2.30pm and 3.30pm? And from them, yet more questions: What is the impact of nutritional factors on concentration? Has technology like ride-on farm bikes extended the working lives of people in the agriculture sector? And what challenges might this present?

This research report provides clues to the answers, but not the answers themselves. These will come from further work the Department of Labour now wants to carry out in partnership with stakeholders including industry, business and unions.

But those three weeks after Christmas 2005 remain a strong reminder that we need to continue to look to the causes of summer fatalities, and continuously look to improve our health and safety systems to address these causes.

Craig Armitage
Group manager, workplace policy
Department of Labour

EXECUTIVE SUMMARY

INTRODUCTION

The apparent increase in the number of workplace fatalities during the summer months in New Zealand has raised concerns among health and safety organisations as well as the general public. An important step towards achieving a goal of 'Healthy people in safe and productive workplaces' is to first establish through statistical analysis whether the seasonal summertime peak in fatalities does, in fact, exist and, if so, what industrial sectors and geographical regions are most responsible for it. Ultimately, the Department of Labour seeks to identify the major causal factors of workplace fatalities and to establish effective preventative strategies.

This study has been carried out to investigate the perceived seasonal trend in workplace fatalities and to identify the factors that are associated with it or have a contributing effect on occurrence.

AIMS

There were two principal aims of the project: The first was to confirm whether or not a seasonal trend exists for summertime workplace fatalities both for nationwide occurrence, and for industries and geographical regions; the second was to identify the major causal factors for the workplace fatalities particularly during the summer season. In order to achieve these aims the following specific objectives were identified:

- Identify and confirm the trend of workplace fatalities over the past several years.
- Identify and confirm the seasonal trend of workplace fatalities in terms of their occurrences nationwide, and with different industries and regions.
- Identify the potential contributing factors for summertime fatalities, including the environmental factors, sociological factors, workplace factors, and individual/personal factors.
- Verify contributing factors by independent evidence.
- Develop the profiles of contributing factors for summertime workplace fatalities and identify potential intervention strategies.

SCOPE OF THE STUDY

This study focuses on workplace fatalities in New Zealand and uses Department of Labour data only. Department of Labour provided the researchers with a database of 365 workplace fatality records from 2000 to 2005 inclusive. It was appreciated that while this data set might appear to be relatively small for the scale of analysis to be conducted, it was the most reliable data set available at the time of the study and was considered sufficient to obtain some good indications regarding the objectives of work. The fatality data set was sorted for any possible recording errors and/or record duplications. As a result, a total of 362 Department of Labour fatal incident records were identified to be usable for further detailed analysis.

Other types of incident data such as Accident Compensation Corporation (ACC) data and serious harm data were used as a reference for comparison purposes only; further detailed analysis of those data was beyond the scope of this study.

METHODS

Nationwide workplace fatality data from Department of Labour databases, covering the past six years (2000 to 2005 inclusive), were statistically analysed to investigate annual and seasonal trends (by industry, region, workers' age, employment status, and other variables). The analysis included 362 fatal incidents. The data were coded using the ANZSIC (Australian New Zealand Standard Industrial Classification Codes) system for the detailed analysis by industrial sectors. It should be noted that the ANZSIC system classifies the 'Agriculture, Forestry & Fishing' as one industry sector and this report uses this as a standard classification (and sometimes 'agriculture' for short), however, Department of Labour data do not cover fishing.

Data normalisation was carried out as necessary and when a reliable denominator was available. This reduces or eliminates the potential bias of incident occurrence due to the variation of some 'risk exposure' factors, such as the change in total population of the workforce over time.
In addition to analysis of the existing data, the fatality investigation reports were reviewed in order to determine the factors that contributed to incident occurrence.

Semi structured interviews were conducted in order to identify issues that may be associated with a summer peak in work related fatalities. Interviews were held with Department of Labour investigators, advisors and engineers, and many industry experts, including representatives from Business New Zealand and the Council of Trade Unions. In addition, a very broad and detailed literature review was conducted to uncover any independent evidence in support of workplace factors, environmental factors, sociological factors, and personal/individual factors that might contribute to seasonal variations in fatality rate. Preliminary analyses of the serious harm data were conducted in order to investigate similarities in trends between the fatalities and the serious harm data sets.

FINDINGS

This study has identified a number of findings, many of which are new and are supported by independent evidence. The key findings from the research are summarised below:

Seasonal trends of workplace fatalities:

- While work related fatality rates fell consistently from 2001/2002 to 2004/2005, there was a significant upturn in the rate of work related fatalities during 2005/2006.
- In the period from 2000 – 2005 the rate of workplace fatalities was higher in summer (December–February) and autumn (March-May) than throughout the rest of the year. While there appeared to be a clear peak in the number of fatalities that occurred in January the limited size of the data set meant that this could not be confirmed through statistical testing.
- The increase in summertime work related fatalities, and to a large extent the increase in autumn work related fatalities, can essentially be explained by the seasonal variation in fatalities in the agriculture industry.
- Within the agriculture sector, January has the highest workplace fatality rate, followed by April and October.
- Male workers aged between 55 and 64 years have the highest incidence of work related summertime fatalities. This trend is applicable to all industries but particularly to the agriculture sector.
- Male workers between 35 and 44 years of age are most likely to have a work-related fatal incident in the autumn. This trend is applicable to all industries, and in particular to the agriculture industry. Independent of season, older workers (aged 65 and above) are suffering the most effects from workplace fatalities.
- The mid north region and the southern region are most affected by seasonal variations in the occurrence of work-related fatal incidents. In the northern part of New Zealand (northern and mid north regions), work-related fatal incidents involving employees tend to occur more in the summer; and in the southern part of the country (central and southern regions), work-related fatal incidents tend to occur more in the autumn.
- There are two peak times when work-related fatal incidents are most likely to occur, one is late morning (between 10:30 and 12:30), and the other is mid afternoon (between 14:30 and 15:30). This trend is applicable for all industries, but is particularly relevant to the agriculture sector.
- When time of day data are examined by season, work related fatal incidents in summer tend to occur in the morning time (from sunrise to noon); and work related fatal incidents in autumn tend to occur more in the afternoon (from noon to sunset).
- Within the agriculture industry, 'Forestry and logging' is the sub-sector with the highest summertime fatality rate, followed by 'Horticulture & fruit growing'.

- 52% of work related fatalities involved a vehicle. Vehicle rollovers accounted for 23% of total workplace fatalities investigated and nearly 40% of workplace fatalities in the agriculture sector. All-Terrain Vehicles (ATVs) were involved in only a relatively small percentage (approximately one quarter) of the vehicle rollovers recorded.

- Human Error and procedural violations contributed to a large proportion of work related fatalities. The vast majority of human errors and violations can be prevented by improved equipment or workplace systems design. In 22% of the fatalities reported, a failure in design could be recognised, either by the investigator at the time or during subsequent review of the incident report.

Primary causes of workplace fatalities:

These 'primary causes' were recorded as being directly related to the death of the victims at the time when the incident occurred. These are the events at the moment when the incident actually happened. For the purposes of injury prevention, it is more important to understand what the main reasons (or contributing factors) were that lead to the fatalities recorded. This study has attempted to identify these contributing factors surrounding the workplace, the environment, the society and the people.

- 52% of work related fatalities involved a vehicle.
- Nearly 50% of the total workplace deaths from 2000 to 2005 were directly due to one of three causes:
  - The first and most frequent cause for work-related death is vehicle rollover (accounting for 23% of total workplace fatalities investigated).
  - The second cause of workplace fatalities is fall from height (accounting for 9.7% of total workplace fatalities investigated).
  - The third cause of workplace fatalities is fatal crush injuries accounting for 17% of total workplace fatalities investigated. Crush injuries involving a vehicle (non rollover) contributing 8.4%, and non vehicular contributing 8.7%.

Direct contributing factors to workplace fatalities:

Seven factors have been identified from the workplace fatality investigation reports as directly contributing to a high proportion of the fatalities that occurred during 2000 to 2005. They are:

- Human error (>43.1%)*
- Procedural violation (>27.7%)*
- Poor/inadequate equipment/workplace design (22.1%)
- Poor safety culture (11.7%)
- Unsafe supervision 10.0%)
- Lack of personal protective equipment (PPE) (8.7%)
- Lack of experience (7.69%).

The research indicates that 'human error' and 'procedural violations' have contributed to nearly 70% of work-related fatalities over the past six years.

It is critical that the term 'human error' is properly understood. Identifying 'human error' allows us to ask why a person's decisions and actions made sense to them at the time. It should be seen as a symptom of other things that are wrong deeper in the work system. 'Human error' is not simply identifying the mistakes people make.

* In an additional 16% of cases, an unsafe behaviour was identified that could have been either a human error or a procedural violation

In the report, ‘human error’ has been used to classify a variety of incidents where memory lapses, slips in behaviour or mistakes (e.g. misjudgements, misinterpretations, distraction errors, silly decisions, inadequate knowledge) have led to a fatality.

These slips, lapses and mistakes are only one part of the cause of injuries. A memory lapse may have occurred because a person was asked to do a task they had not done for some time. A slip in behaviour could have occurred as a result of fatigue. A mistake, such as a misjudgement, may have been made because the person making a decision was given incorrect information to base a decision on. A procedural violation could have occurred because of pressure to complete a task, resulting in a risky shortcut being taken.

The vast majority of human errors and violations can be avoided, or at least minimised. Consequently this finding demonstrates an area where significant improvements can be made. The research points to areas such as workplace systems design, training and workplace culture, where improvements could make a huge difference to incident, injury and fatality rates.

Other workplace factors likely to contribute to increased risk of work related fatalities:

- Hours worked per day. (Applicable for all industries, and in particular for ‘Dairy & cattle farming’ within the agriculture industry).
- Lack of recovery from fatigue. (Applicable for all industries, in particular for ‘Agriculture, Forestry & Fishing’, and for ‘Construction’).
- Tight timescales/deadlines. (Applicable for ‘Horticulture & fruit growing’ sector within the agriculture industry).
- Staffing levels. (Applicable for all industries, particularly for ‘Horticulture & fruit growing’ sector within the agriculture industry).
- Amount of casual labour. (Applicable for all industries, particularly for ‘Horticulture & fruit growing’ sector within the agriculture industry).

The following environmental factors are likely to contribute to increased risk of work related fatalities:

- Rain/wet days. (Applicable for all industries, particularly for the agriculture industry).
- High temperatures. (Applicable for all industries, particularly for agriculture, ‘Cultural, recreational & other services’, and ‘Manufacturing’).
- Longer hours of sunshine. (Applicable for agriculture, ‘Cultural, recreational & other services’, ‘Manufacturing’, and ‘Transport & storage’).

The following sociological factors are likely to contribute to increased risk of work related fatalities:

- Increased consumption of alcohol. (Applicable for all industries, in particular ‘Agriculture, Forestry & Fishing’).
- More tourists (and temporary workers). (Applicable for agriculture, ‘Construction’, ‘Cultural, recreational & other services’, and ‘Transport & storage’).
- School holidays and public holidays. (Applicable for Agriculture, and for Manufacturing).
- Daylight saving.

The following individual factors are also likely to contribute to increase risk of work related fatalities:

- Gender (male workers, employees, and self-employed). (Applicable for all industries).
- From the age, gender, industry, season, and time of day data combined it may be postulated that:
  - Male workers working in the agriculture industry, aged between 55 and 64, are most likely to have a fatal incident in their workplace during the summertime between sunrise and noon.
  - Male workers working in the agriculture industry, aged between 35 and 44, are most likely to have a work-related fatal incident during the autumn between noon and sunset.
- Return to work after a long holiday[1]. (Applicable for all industries).

THE DEPARTMENT OF LABOUR'S NEXT STEPS

This study is the first step to improving the Department of Labour's understanding of the reasons behind workplace fatalities. This research highlights some initial areas of workplace health and safety practice in New Zealand which can be improved. The Department of Labour intends to take a positive approach to the findings, focussing on ways to raise awareness and promote direct action to reduce workplace fatalities.

The Department of Labour will focus on the following approaches to deliver information and guidance.

Emphasise the benefits
Focus on actions that will reduce the work toll. Identify the benefits of safe work practices and demonstrate that they outweigh the perceived costs.

Deliver messages locally
Awareness-raising will be accompanied by realistic and practical advice on how to improve health and safety in New Zealand's workplaces. Messages will be targeted and personalised to specific at-risk groups. Small-scale, low-key safety initiatives locally delivered will be an effective part of personalising safety messages.

Work together
The Department will develop collaborative approaches and partnerships for the delivery of messages. We will actively seek the support of others, industry representatives, business organisations, unions, and businesses to promote awareness and action in workplaces and the wider community.

[1] E.g. for a period of more than one week.

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We are also grateful to all the industry safety experts from the various organisations listed in 2.2.4 for their participation in the interviews and workshops that provided the background and direction for this research.

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1. INTRODUCTION

1.1 Background

1.1.1 The apparent increase in the number of workplace fatalities during the summer months in New Zealand has raised concerns among health and safety organisations as well as the general public. The social and economic costs of workplace fatalities are high and the Department of Labour is committed to achieving “Healthy people in safe and productive workplaces” (Dyson, 2005).

1.1.2 An important step towards achieving this goal is to first establish through statistical analysis whether the seasonal summertime peak in fatalities does, in fact, exist and, if so, what industrial sectors and geographical regions are most responsible for it. Ultimately the Department of Labour seeks to identify the major causal factors and establish effective preventative strategies.

1.2 Aims and Objectives

1.2.1 There were two principal aims of the project: The first was to confirm whether or not a seasonal trend exists for summertime workplace fatalities both for nationwide occurrence, and for industries and geographical regions, the second was to identify the major causal factors for the workplace fatalities particularly during the summer season. In order to achieve these aims the following specific objectives were identified:

- Identify and confirm the trend of workplace fatalities over the past several years.
- Identify and confirm the seasonal trend of workplace fatalities in terms of their occurrences nationwide, and with different industries and regions.
- Identify the potential contributing factors for summertime fatalities, including the environmental factors, sociological factors, workplace factors, and individual/personal factors.
- Verify contributing factors by independent evidence.
- Develop the profiles of contributing factors for summertime workplace fatalities.

1.3 Scope of the Study

1.3.1 This study focuses on workplace fatalities in New Zealand as recorded in the Department of Labour’s database dated from the beginning of 2000 to the end of 2005, since reliable data were only available over this period at the time when this study was commissioned. Other types of incident data such as Accident Compensation Corporation (ACC) data and serious harm data are used as a reference for comparison purposes only in this report, but further detailed analysis of those data was beyond the scope of this study. Occupational disease is not included in the analysis.

1.3.2 The study will cover the following subject areas in relation to workplace fatalities:

- Seasonal trends of workplace fatalities.
- Primary causes of workplace fatalities.
- Direct contributing factors in the workplace to work related fatalities.
- Other workplace factors likely to contribute to increased risk of work related fatalities.

- Environmental factors which are likely to contribute to increased risk of work related fatalities.
- Sociological factors which are likely to contribute to increased risk of work related fatalities.
- Individual/personal factors which are likely to contribute to increased risk of work related fatalities.

2. METHODOLOGY

2.1 Data Collection and Collation, and Review of Workplace Fatality Investigation Reports

2.1.1 The Department of Labour provided the researchers with a database of 365 workplace fatality records from 2000 to 2005 inclusive. It was appreciated that while this data set might appear to be relatively small for the scale of the analysis to be conducted, it was the most reliable data set available at the time of the study and was considered sufficient to obtain some good indications regarding the objectives of work.

2.1.2

2.1.3 The fatality data set was sorted for any possible recording errors and/or record duplications. As a result, a total of 362 fatal incident records were identified to be usable for further detailed analysis.

2.1.4 On the basis of the fatality data, a master datasheet was developed with various information fields against each record. Some of the fields were already available with the basic data set (e.g., date of incident, Workplace Services (OSH[2]) region, age of the victim), and some were added by the project team in order to facilitate the required analyses. The additional incident classification fields added by the project team were used to record the contributing factors associated with each incident. The classification system was based on the Human Factors Analysis Classification System (HFACS) (Wiegmann & Shappell, 1997; Shappell and Wiegmann, 2000) and is summarised in Table 1 below. The classification system was agreed to in advance by the Department of Labour project management team. Each of the fatality reports provided by the Department of Labour (315 in total) were systematically reviewed and the contributing factors were recorded accordingly.

Table 1 – Classification System

UNSAFE ACTS	
Procedural Violation	Where specifically stated or known
Human Error	E.g. lack of attention, equipment left running while carrying out other work, lack of awareness of a dangerous situation
Unknown	Either procedural violation or human error
PRECONDITIONS FOR UNSAFE ACTS	
Poor Equipment Maintenance	
Lack of Experience	
Poor / inadequate equipment / workspace design	E.g. no alarm fitted, tool not suited to job, "bad use of equipment"
Slip, trip, fall	Only to do with walking / running etc. includes stairs
Long / inappropriate work hours / fatigue	
Alcohol / drugs	
Existing health problems	
Lack of PPE	
OTHER FACTORS	
Poor safety culture	
Unsafe supervision	
Poor communications	
Slow medical response	
No factors identified	

[2] Occupational Safety and Health

2.1.5 In addition, complex formulae were developed which allowed for geographical location, time of year and daylight savings to determine whether incidents occurred during daylight hours, dawn, dusk or at night time.

2.1.6 The original incident data were classified into five broad categories, including Agriculture, Construction, Forestry, Mines & Quarries, and Industrial/Commercial. Each incident was recorded against one of these five categories. While it may be relatively simple to record and to analyse the incident data under these broad categories, they were considered too broad to provide a useful classification for targeting preventative strategies. 'Industrial/Commercial', for example, included a great number of very varied industry sub-sectors. Therefore, each incident record was re-coded using the ANZSIC (Australian New Zealand Standard industrial Classification Codes) system. This classification was considered to be the most appropriate in order to accurately determine which industry sectors are most at risk of fatality events. It should be noted that the ANZSIC system classifies the 'Agriculture, Forestry & Fishing' as one industry sector and this report uses this as a standard classification (and sometimes 'agriculture' for short), although the Department of Labour data does not cover fishing. The ANZSIC coding of the fatality data was completed at the Department of Labour by a safety expert and checked by the project technical team. A high level of the ANZSIC system is shown in **Appendix A**.

2.2 Consultation with ISEs (Industry Safety Experts)

2.2.1 Semi-structured interviews were conducted with a number of ISEs with expertise and experience in safety and health, and/or in related subject areas. The ISEs represented different industries, research organisations and regions in New Zealand.

2.2.2 Most consultations were carried out through face-to-face interviews in Wellington and Auckland, and each interview lasted between 1.5 and 2 hours. The interviews were guided by a list of questions and before they attended the interview, the ISEs were sent a 'Briefing Note' that explained the purpose of the interview. The note contained a list of questions/issues to be discussed.

2.2.3 ISEs from a particular type of industry were asked to complete a survey form towards the end of the interview regarding their opinions on the seasonal activities within that industry. They were asked to give a relative rating (in terms of 'high', 'medium' or 'low') on a number of workplace factors for their seasonal changes across the year. Some of these factors include 'hours worked per day'; 'level of staffing'; 'physical or mental work demands'; 'non-work related activities'; 'work involving machineries'; 'variation in work activities'; 'need to work in remote locations'; 'fatigue/tiredness' and so on (16 topics in total). The ISEs were encouraged to add more topic issues if they were not included in the rating list. It was the intention of the exercise to help the research team better understand the industry-specific issues across different seasons of the year. The Briefing Note and the Seasonal Activity Survey Form are provided in **Appendix B**.

2.2.4 The ISEs consulted represented a wide range of industries and type of organisations. For practical reasons, it was not possible to interview representatives from all industry sub-sectors across the country. However, sufficient information was obtained to achieve the objectives of the present study. The list of organisations is shown below:

- **Department of Labour:** Team Leader; Health and Safety Advisor; Principal Advisor; Senior Policy Advisor; Business Advisor; Health & Safety Inspectors; Safety Engineer and Data Entry Contractor.

- **Employers & Manufacturers Association (EMA) (Northern region):** Occupational Health & Safety Managers.
- **Federated Farmers of New Zealand (Inc.):** President; Policy Advisor.
- **Horticulture New Zealand:** Chief Executive; Senior Business Managers.
- **Site Safe New Zealand:** Executive Director; Training Manager.
- **Roading New Zealand:** Chief Executive.
- **EMA (Central region):** Health & Safety Consultant.
- **New Zealand Safety Council:** Executive Director.
- **University of Otago:** Injury Prevention Research Unit, Dunedin School of Medicine.
- **University of Auckland:** Department of Management and Employment Relations.
- **Massey University:** Occupational Health & Safety
- **Fletcher Construction Auckland:** Operations Manager.
- **Works Infrastructure:** General Manager.
- **OnTrack, New Zealand Railways Corporation:** Risk & Safety Manager.
- **Amalgamated Workers Union:** Auckland Representative.

2.3 Literature Review

2.3.1 A comprehensive literature review was conducted. The focus of the literature review was to review research findings of seasonal issues in relation to workplace safety and to identify independent evidence pertaining to the factors which are shown to be significantly associated with the occurrence of workplace fatalities. A wide range of information sources were used for the literature search. Some of the primary sources of the research data are listed below:

- Human Engineering's internal library (both in Australia and UK) and electronic database, which contains a wide range of published literature on workplace safety and general ergonomics/human factors reports.
- Human Factors Research Catalogue CD (UK, 2005-06)
- HSE research reports database online[3].
- SCIRUS[4] (one of the most comprehensive science-specific search engine on the Internet).
- NCBI[5] (National Center for Biotechnology Information).
- Statistics New Zealand[6]

[3] http://www.hse.gov.uk/research/rrhtm/index.htm
[4] http://www.scirus.com/srsapp/
[5] http://www.ncbi.nlm.nih.gov/

- National Farm Injury Data Centre[7]

2.4 Detailed Data Analysis

Trend analysis

2.4.1 The workplace fatality data were analysed for their annual and seasonal trends, firstly based on the overall fatality data, and secondly on the cases related to different industries and regions. Detailed analysis was also performed to investigate the relationship between such factors as employment status and workers age, and the occurrence of workplace fatalities with seasonal changes.

2.4.2 Data normalisation was carried out as necessary and when a reliable denominator was available. This reduces or eliminates the potential bias of incident occurrence due to the variation of some 'risk exposure' factors, such as the change in total population of the workforce over time.

2.4.3 Statistical analyses were conducted, using chi^2 tests, on the annual/seasonal trends of fatality occurrence to test if the variation between seasons (and years) was statistically significant. The basic principle of these tests was to identify whether a certain 'peak season' (i.e., with a relatively higher number of fatal incidents) was due to chance. If the data show that for a certain month the number of incidents is greater than the monthly 'norm', the chi^2 test will be able to verify whether or not the peak is for certain, or due to chance. The minimal acceptable level of significance was set at $p \leq 0.05$, which means that the likelihood of a peak (or a trough) occurrence of the event (in this case, the number of incidents per month) by chance is less than 5%. Where $p \leq 0.05$, it is significantly likely that the variation of event occurrence is due to other factors.

2.4.4 In most cases in this report, a trend graph is presented only when the results are found to be statistically significant. This is because the small numbers involved can lead to very visible peaks and troughs in groups that are not significant and entirely due to chance, thus the figures can be misleading. In certain instances, however, some normalised results (although not statistically significant) are also presented, but these are for illustration purpose only, and this will be clearly stated in the relevant section in relation to the illustration.

2.4.5 95% Confidence Intervals (CI) were calculated (shown in the graph as error bars at each data point) with some normalised data when reliable denominators were available. These would normally indicate that 95% of the observed (or recorded) data are expected to fall within the specified range of variation.

Identification of a wide range of associated factors for fatality occurrence

2.4.6 The fatality database has recorded only a small number of relevant factors in relation to each incident (e.g. date, industry, region, employment status, age, etc.), but there are far more factors that may have played an important role in the occurrence of fatal incident across the seasons. These include environmental factors, sociological factors, individual factors, and workplace factors. Statistical tests with correlation analysis (using both parametric and non-parametric tests depending on the type of data) were conducted to identify the level or strength of association between each type of the factors and the workplace fatalities. The significance levels of association were divided into four levels, including $p \leq 0.05$, $p \leq 0.01$, $p \leq 0.001$, and NS (not significant, $p > 0.05$). These will also be described in the relevant section.

[6] http://www.stats.govt.nz/default.htm
[7] http://www.acahs.med.usyd.edu.au/nfidc/

3. RESULTS OF DETAILED DATA ANALYSIS

3.1 Overview of Workplace Fatalities from 2000 to 2005

3.1.1 This section reports the overall trend of fatality occurrence on an annual basis over the past 6 years (2000-05), including the overall annual trend for all industries and all regions; the annual trend for different industries and for different geographical regions. Further detailed analysis on seasonal trend of workplace fatalities is reported in section 3.2.

Overall workplace fatalities by year

3.1.2 The workplace fatality data collected over the past six years (2000-05, 362 cases in total) were first analysed on an annual basis to identify the pattern of changes in the fatality rate over this period. Figure 1 shows that the annual trend in workplace fatalities once peaked between 2001 and 2002 (73-74 cases per year), and since then there was a gradual decline year on year. However, the occurrence of workplace fatalities has increased from 47 cases in 2004 to 65 cases in 2005, or by some 38%. Statistical analysis (chi^2 test) has shown that such an increase is statistically significant at $p \leq 0.01$ level.

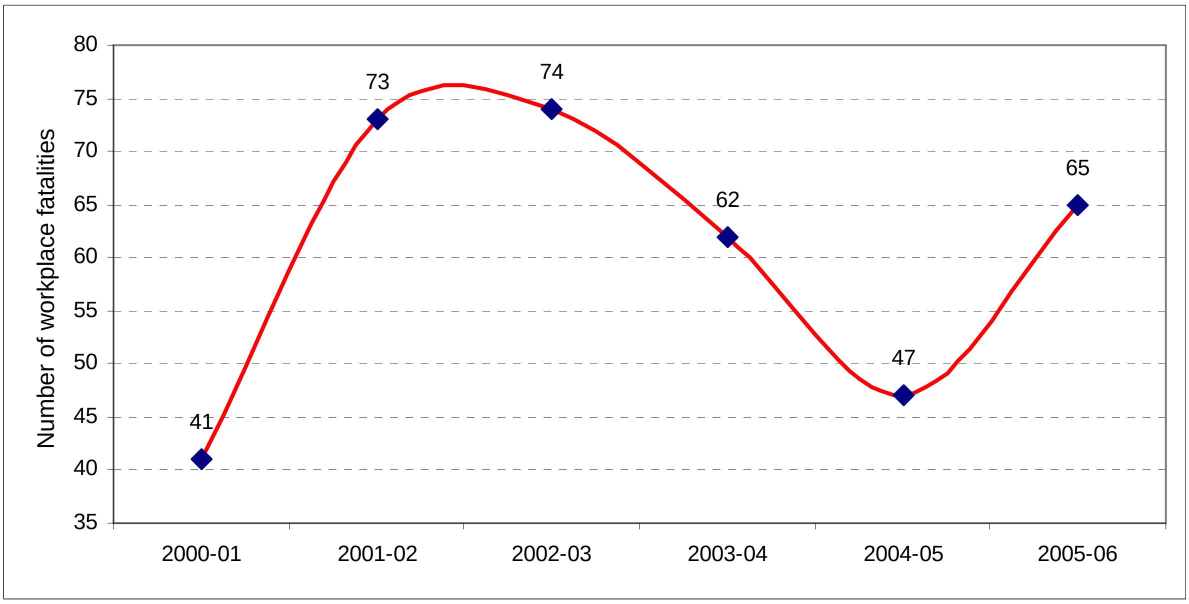


Figure 1 – Trend of workplace fatalities from 2000 to 2005[8]

3.1.3 However, there is a possibility that the increase in the number of fatal incidents in recent years is due to a greater number of people working in industry, thus increasing the chance of having more incidents overall during this time. The data were therefore normalised by the total number of employees over the same period, which gives a fatality rate per 100,000 employees per year, as shown in Figure 2.

3.1.4 A similar trend in the occurrence of workplace fatalities was observed with the normalised data as was observed with the original fatality data. The result indicates a 34% increase in workplace fatality rate in 2005 (at the rate of 0.78) relative to 2004 (0.58). It is therefore evident that there has been a recent increase in the number of workplace fatalities since the end of 2004.

[8] The fatality data were recorded based on the financial year in New Zealand, from 1st July to 30th June, thus such format as 2000-01 is used in the graph.

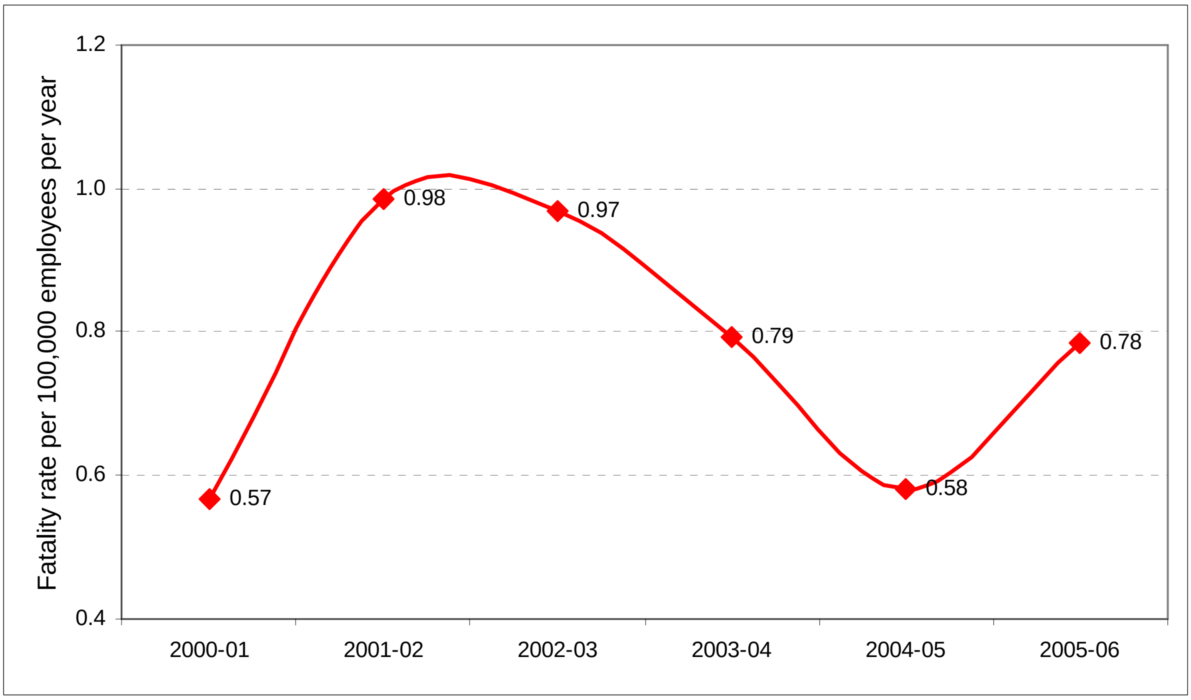


Figure 2 – Normalised rate of workplace fatalities from 2000 to 2005

3.1.5 It is also useful to see whether or not the trend of workplace fatality rate would be compatible with that of the serious harms data. The serious harm data set is far bigger than the fatalities data set and therefore a potentially more reliable source of information. It is generally accepted that trends in fatality occurrence would follow trends in the occurrence of serious harm incidents. Figure 3 shows the normalised results of workplace fatalities and serious harms over the same period from 2000 to 2005. It is interesting to see that over the same period from 2004 to 2005, while the fatality rate has increased by some 34%, the rate of serious harm injuries has dropped by some 41%. Such a change in the rate of serious harms is statistically significant ($p \leq 0.001$).

3.1.6 One of the reasons for such a difference in trends between the two types of data sets is possibly due to the change in incident reporting policies and the method/standard of data recording with respect to the serious harm injuries. Some ISEs commented during interviews that under the government policies and regulations, both employers and employees are encouraged to report serious harm workplace injuries. However, whether or not an injury should be counted as a serious harm injury has always been a very grey area. This has led to the receipt of many reports which should not technically be classified as serious harm, yet all of the reports have been logged in the serious harm data. The issue of over-reporting in the serious harm database was raised by several ISEs. However, there have been some changes in more recent years with respect to the categorisation and recording of serious harms, which may have resulted in reduced number incidents since 2005. Further investigation and analyses of the serious harms database will confirm or discount this type of postulation and provide for a better understanding of the disparity in trends between the two databases. These issues are discussed further in Section 6.

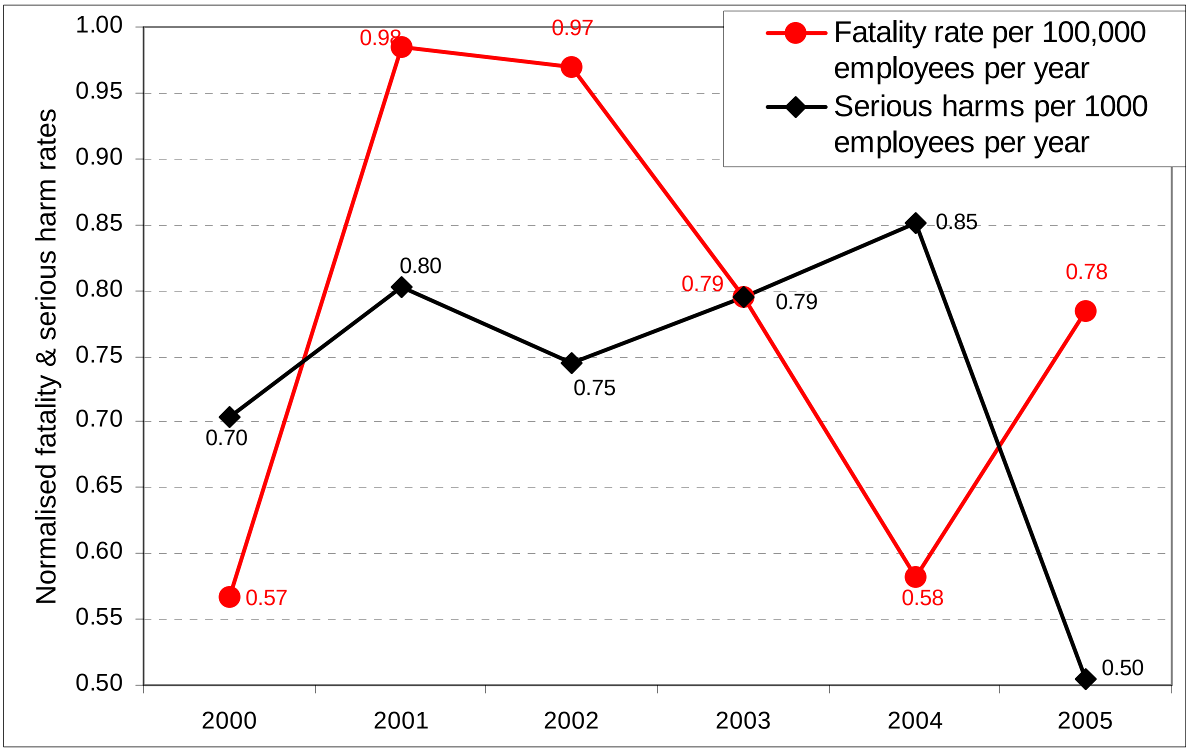


Figure 3 – Comparison between workplace fatality rate and serious harm rate over the same period (2000-05)

Overall workplace fatalities by industries

3.1.7 The workplace fatality data were also analysed for annual trend by different industries. Figure 4 shows the number of workplace fatalities for different industries as classified by ANZSIC system over the period from 2000 to 2006. This indicates a relatively higher fatality rates for the industries including ‘Agriculture, Forestry & Fishing’, ‘Construction’, ‘Cultural & Recreational Services’, ‘Transport & Storage’, and ‘Manufacturing’. Figure 5 shows the normalised results for these industries with relatively higher fatality rates over the past 6 years (2000-05).

3.1.8 The normalised data clearly demonstrate that efforts to reduce or eliminate workplace fatalities should be targeted at the ANZSIC industrial classification ‘Agriculture, Forestry & Fishing’. This is discussed further in sections 3.2.5 to 3.2.7

3.1.9 One of the useful aspects of these results is that 4 out of 5 major industrial sectors (as shown in Figure 5) have shown an increase in their workplace fatality rates over the past two years. The ‘Agriculture’ sector in particular started such an upward trend since 2003, followed by the sector of ‘Transport & Storage’ and ‘Construction’. However, it must be noted that the annual variation in fatality rates for all these industries does not reach a significant level ($p>0.05$). This is mainly due to the fact that the data set is small for each industrial sector. A larger data set may be able to confirm an actual seasonal trend for different industrial sectors, but at this stage, the graphs in Figures 4 & 5 should be used for illustration purpose only.

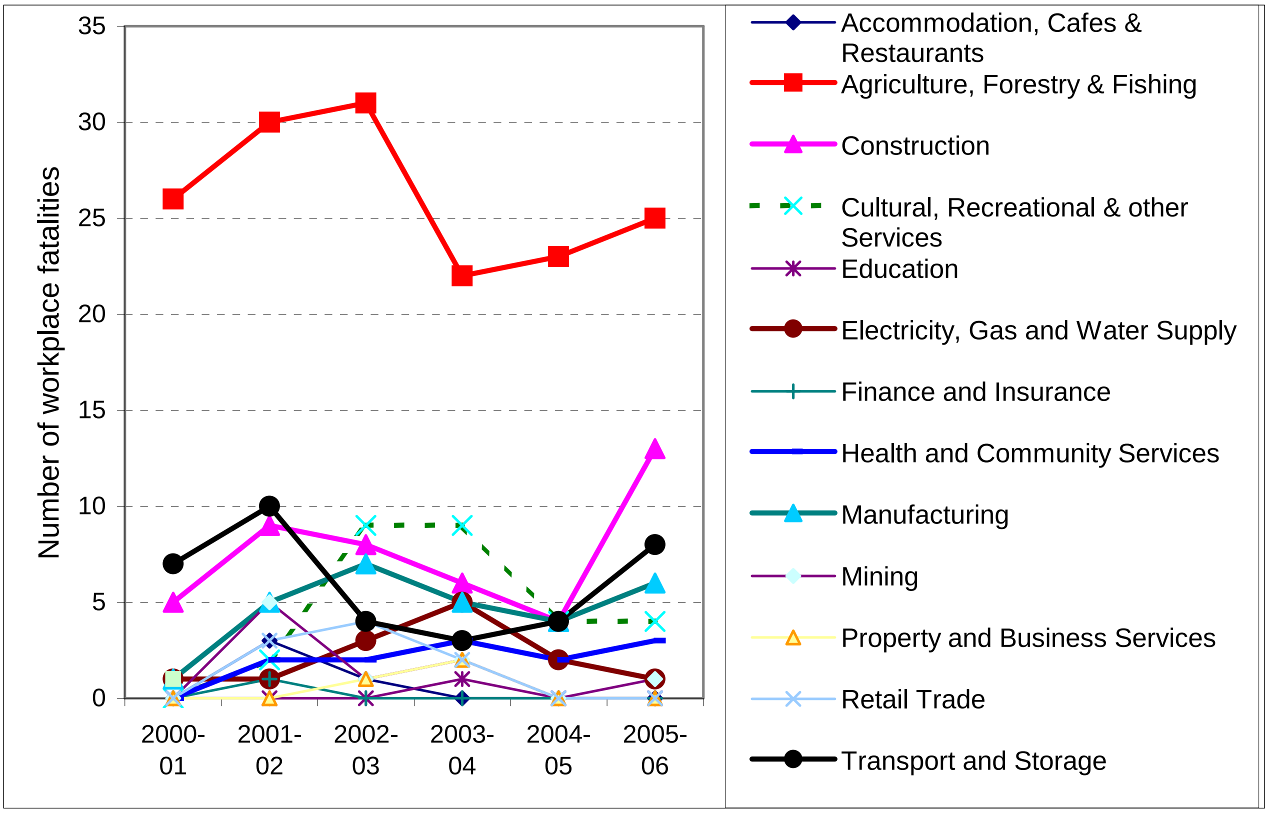


Figure 4 – Trend of workplace fatalities by industries from 2000 to 2005

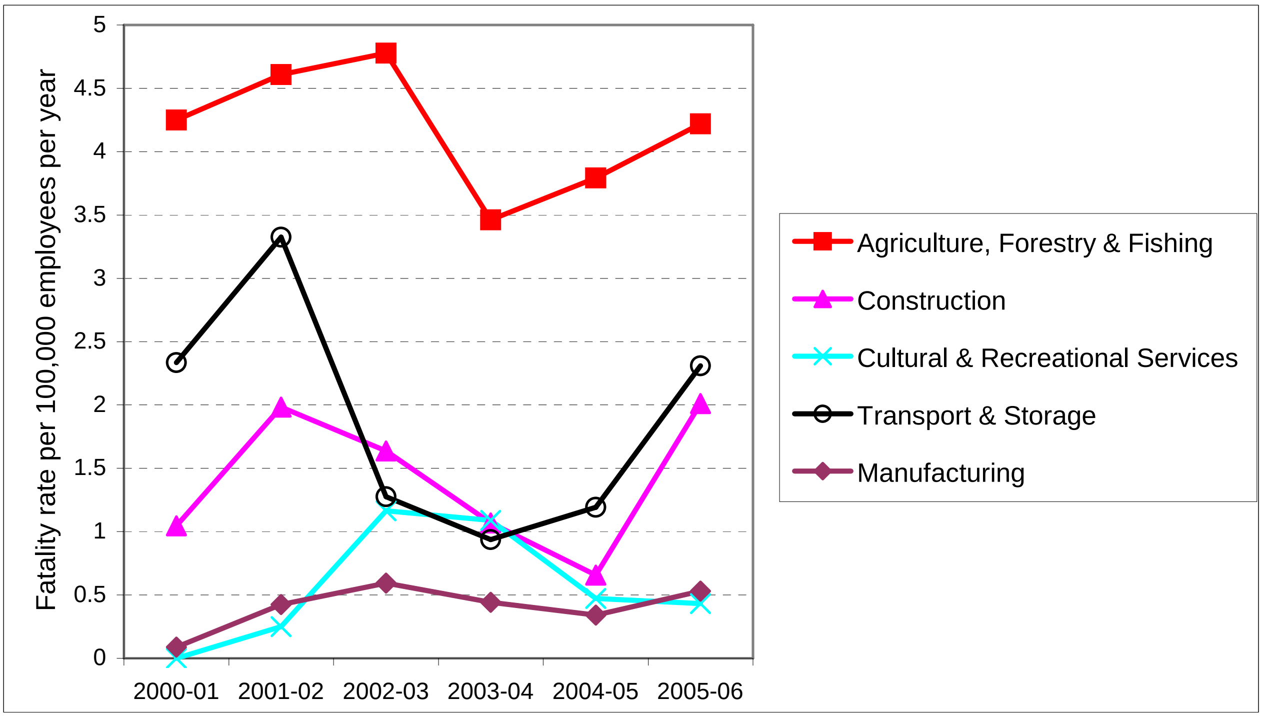


Figure 5 – Normalised results for some major industries with relatively higher fatality rate

Overall workplace fatalities by geographical regions

3.1.10 The workplace fatality data were also analysed for their annual trend by geographical regions. There are 17 Workplace Services regional offices throughout New Zealand and the fatal incidents have been recorded under these regional names. However, if the overall fatality data set is further divided by such a number of regions, the resultant data set would be so small that no meaningful analysis could be achieved. In addition, maintaining the granularity of 17 regions is unnecessary since any preventative strategies would not be targeted at such small areas particularly since there is no real geographical difference between many of the regions, the boundaries of which represent administrative divisions only.

3.1.11 Therefore, after the consultation with the ISEs from the Department of Labour, the areas of New Zealand are classified into four larger regions, including Northern Region, Mid North Region, Central Region, and Southern Region. A map to show these regions is in **Appendix C**.

3.1.12 The 17 Workplace Services regional offices (and the corresponding fatality data) were coded by their geographical locations within the four larger regions. The data were also normalised by the number of employees in the corresponding regions over the same period of time[9]. Figure 6 shows the normalised results.

3.1.13 In general, the normalised regional data show that the 'Mid North Region' had the highest rate of workplace fatalities by the end of 2003, but it was overtaken by the 'Southern Region' from 2004. Overall all regions have indicated an increase in workplace fatalities for 2005. However, due to the small data set, all the annual changes within these regions are not statistically significant ($p>0.05$), suggesting that these results should be taken as indicative rather than conclusive.

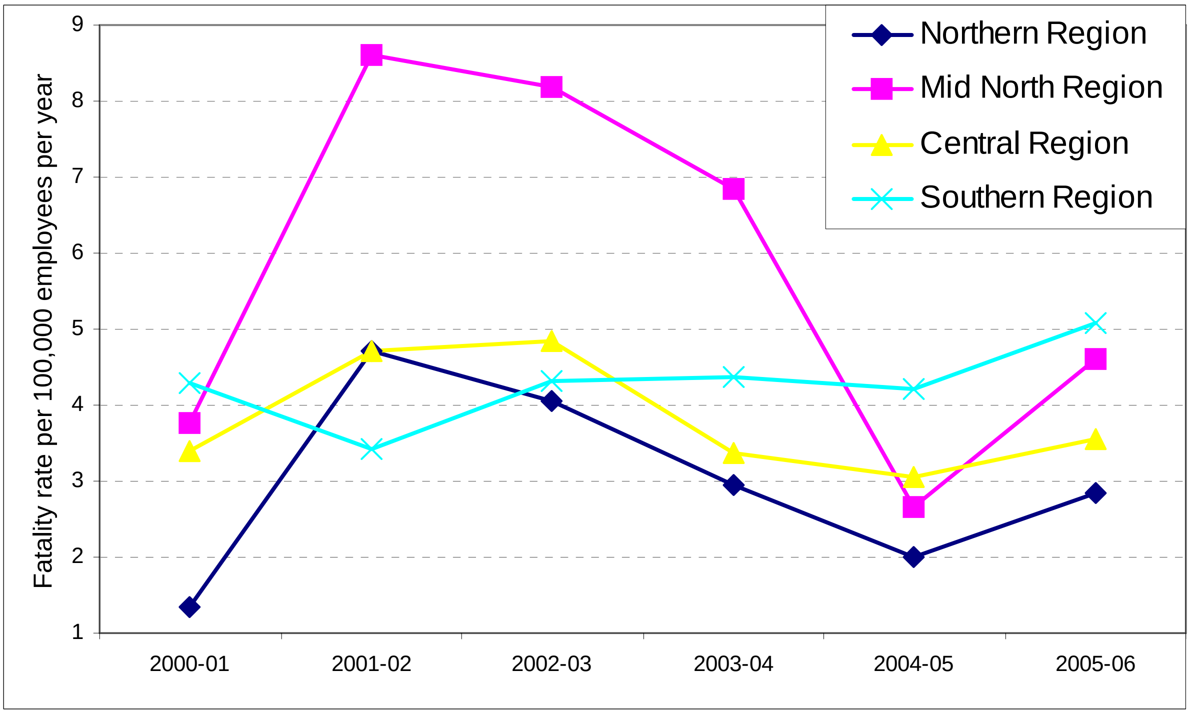


Figure 6 – Rate of workplace fatalities by geographical regions

[9] Source: Statistics New Zealand, Household Labour Force Survey (HLFS), 1986-2006.

3.2 Seasonal Trend of Workplace Fatalities

3.2.1 This section reports on the analyses of seasonal trends in workplace fatalities. The analyses explore seasonal trends in workplace fatalities for the data set as a whole; by industry and region; by employment status; and by age group.

Overall seasonal trend of workplace fatalities

3.2.2 The overall workplace fatality data were analysed on monthly and quarterly (seasonal) basis. Figure 7 shows the monthly trend of workplace fatalities from 2000 to 2005. The result is presented with the month 'July' on the far left and 'June' on the far right. This is to accommodate the financial year along which the data were recorded and to show the summertime period (Dec.-Feb.) close to the central section of the graph, making the results easier to read.

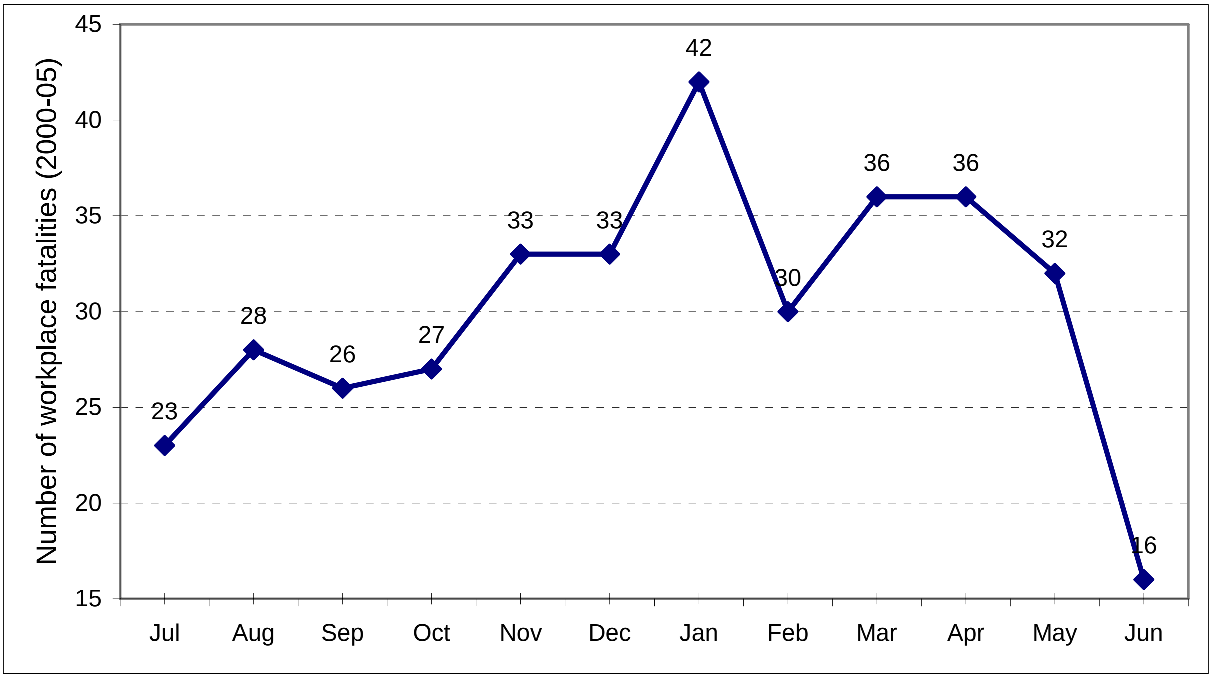


Figure 7 – Monthly trend of workplace fatalities (2000-05)

3.2.3 Despite the fact that there appears to be a January peak in fatality occurrence over the past six years, statistical analysis with the chi^2 test showed that the overall monthly variation of workplace fatalities was insignificant ($p>0.05$). This is again considered to be due to the relatively small original data set which is further divided into 12 separate data groups for each month of the analysis.

3.2.4 Figure 8 shows the seasonal change in workplace fatalities over the past six years (2000-05). In this analysis, the seasons in New Zealand are defined as the Spring (September-November), Summer (December-February), Autumn (March-May), and Winter (June-August). The results indicate that there is a relative 22% increase in fatality occurrence for the summer (105 cases) as compared with the spring (86 cases). There is also a higher level of workplace fatalities in the autumn. Relatively fewer fatal incidents occurred during the winter as compared to other seasons. The same pattern was confirmed by the normalised data (shown in Figure 9). This seasonal trend has been found to be statistically significant ($p\leq0.05$).

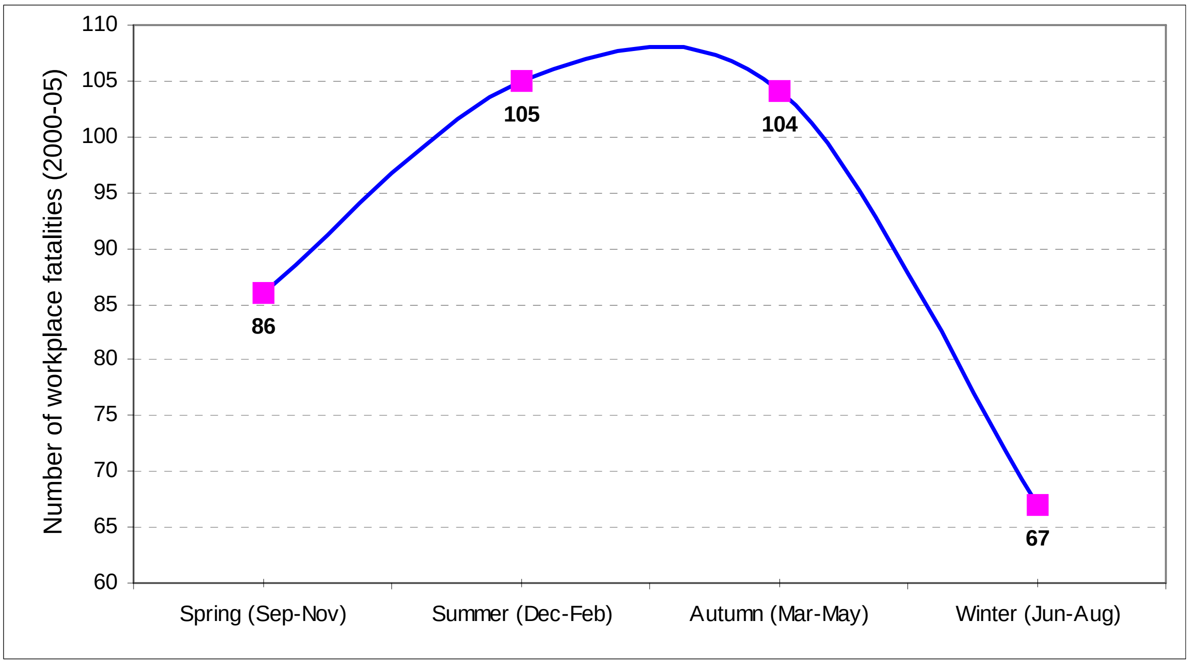


Figure 8 – Seasonal trend of workplace fatalities (2000-05)

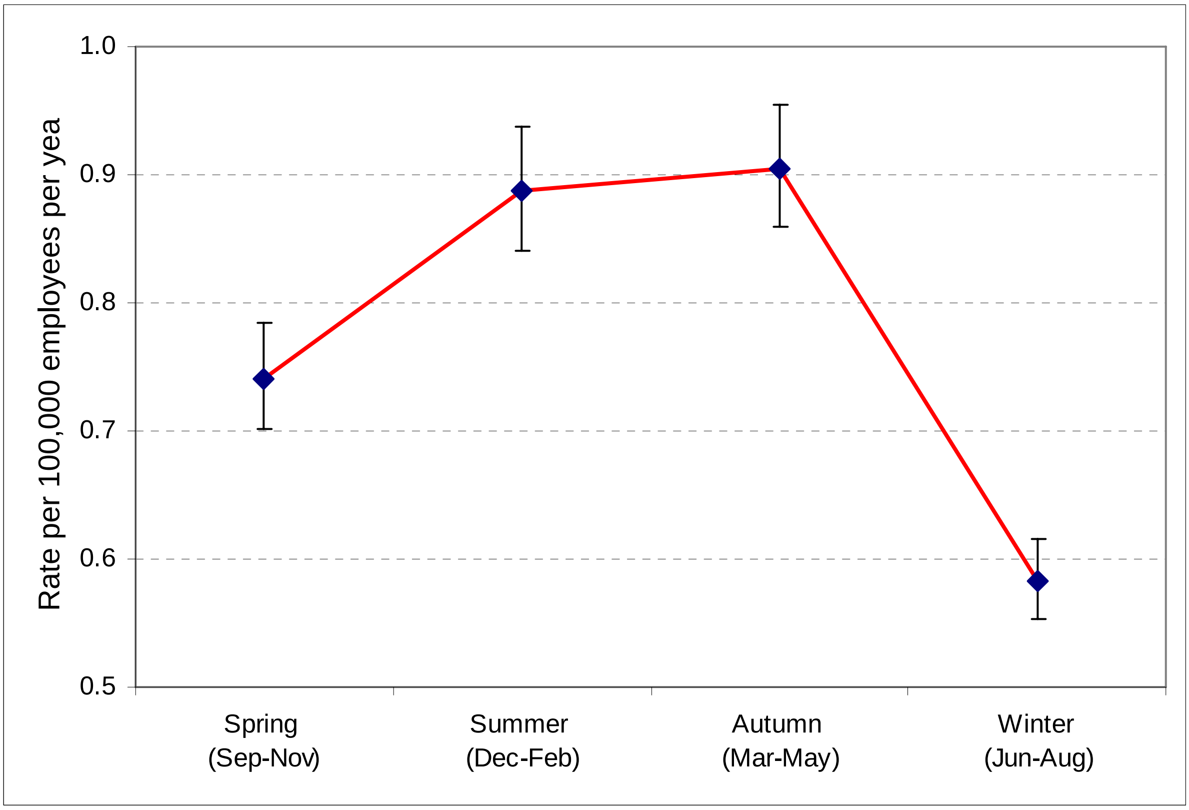


Figure 9 – Seasonal trend of workplace fatality rate (2000-05, with 95%CI)

3.2.5 ***Seasonal trend of workplace fatalities by industries***

The seasonal trend of workplace fatality data over the past six years (2000-05) was analysed for all the industries as classified by the ANZSIC system. The results showed that only one industrial sector (i.e., 'Agriculture, Forestry & Fishing') had a significant seasonal variation in their fatality rate ($p \leq 0.01$). All the other industries had little or insignificant seasonal variation, as illustrated in Figure 10.

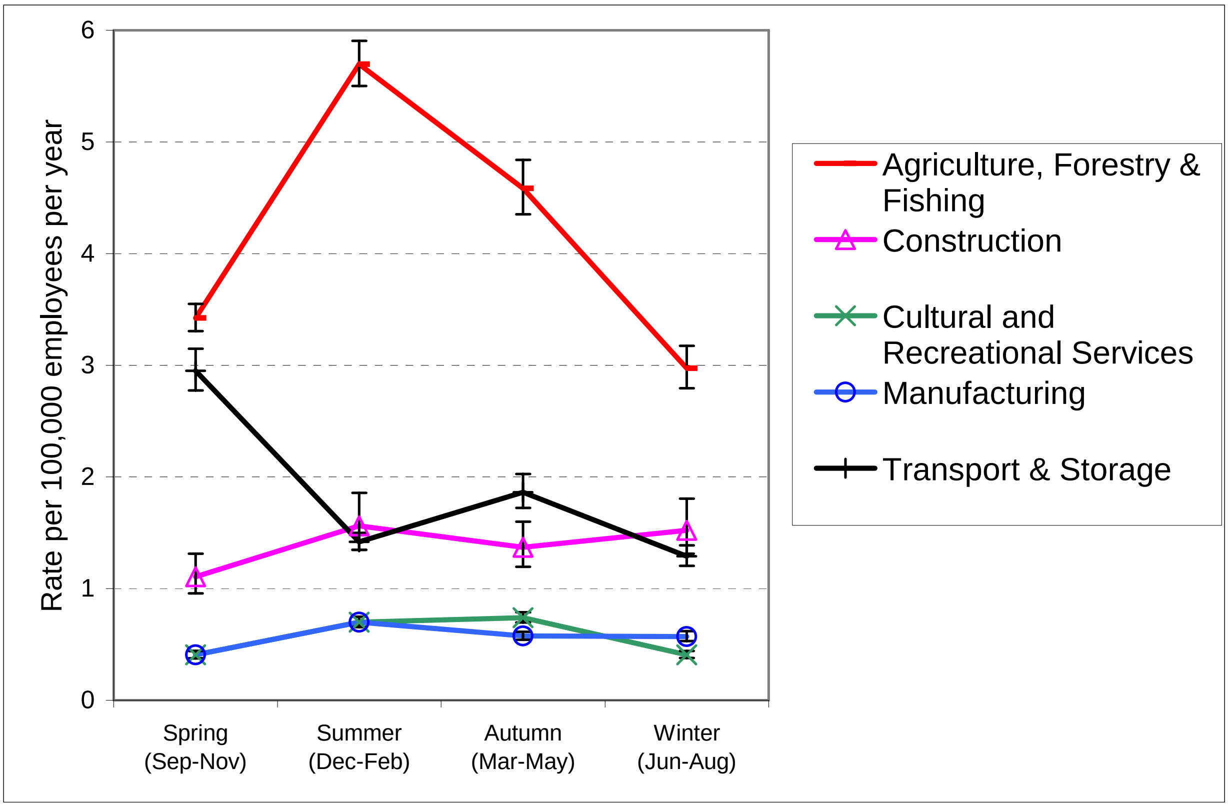


Figure 10 - Seasonal rate of workplace fatalities for some major industries (2000-2005, with 95%CI)

3.2.6 In order to get an insight within the agriculture sector as to which month has the highest number of fatalities and which sub-sectors are at higher risks in relation to fatal incidents, further detailed analyses were carried out. Figure 11 shows that there is a January peak in workplace fatalities within the agriculture sector, followed by two more peaks, one is in April and the other in October. This trend is statistically significant at $p \leq 0.05$ level.

3.2.7 Figure 12 shows that within the agriculture sector, 'Forestry and logging' is the sector with the highest summertime fatality rate, followed by 'Horticulture & fruit growing'. However, these apparent seasonal peaks did not reach an acceptable level of significance ($p > 0.05$). The results in Figure 12 therefore need further analysis. An important next step in targeting preventative measures within the agriculture industry sector is to gather employee numbers [10] for the industrial sub-sectors (e.g. Forestry and logging, Horticulture & fruit growing, Services to agriculture, Dairy cattle farming, etc.) that form part of this industry group. Using these data, spikes in the fatality rates associated with the highest risk sub-sectors and sub-sub-sectors can be identified providing clearer direction for fatality prevention strategies.

[10] Not available within the timeframes for this study

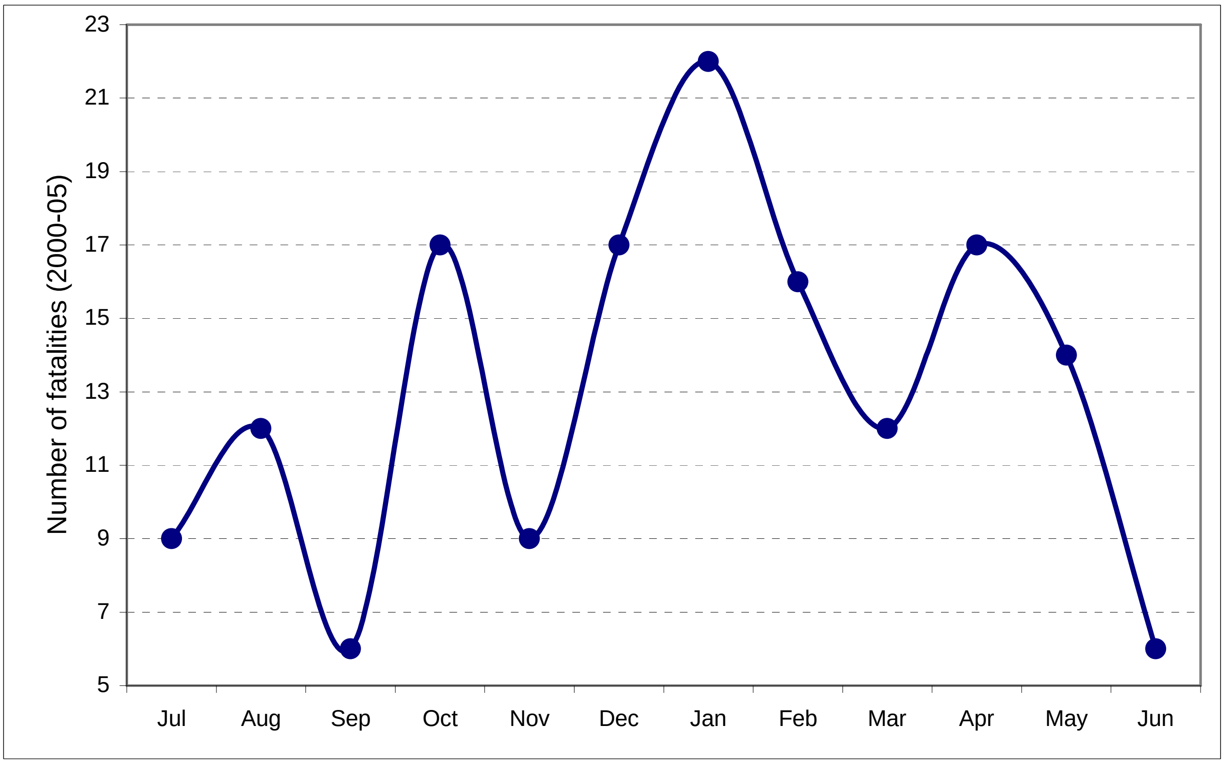


Figure 11 – Monthly trend of workplace fatalities for the 'Agriculture, Forestry & Fishing' industry (2000-05)

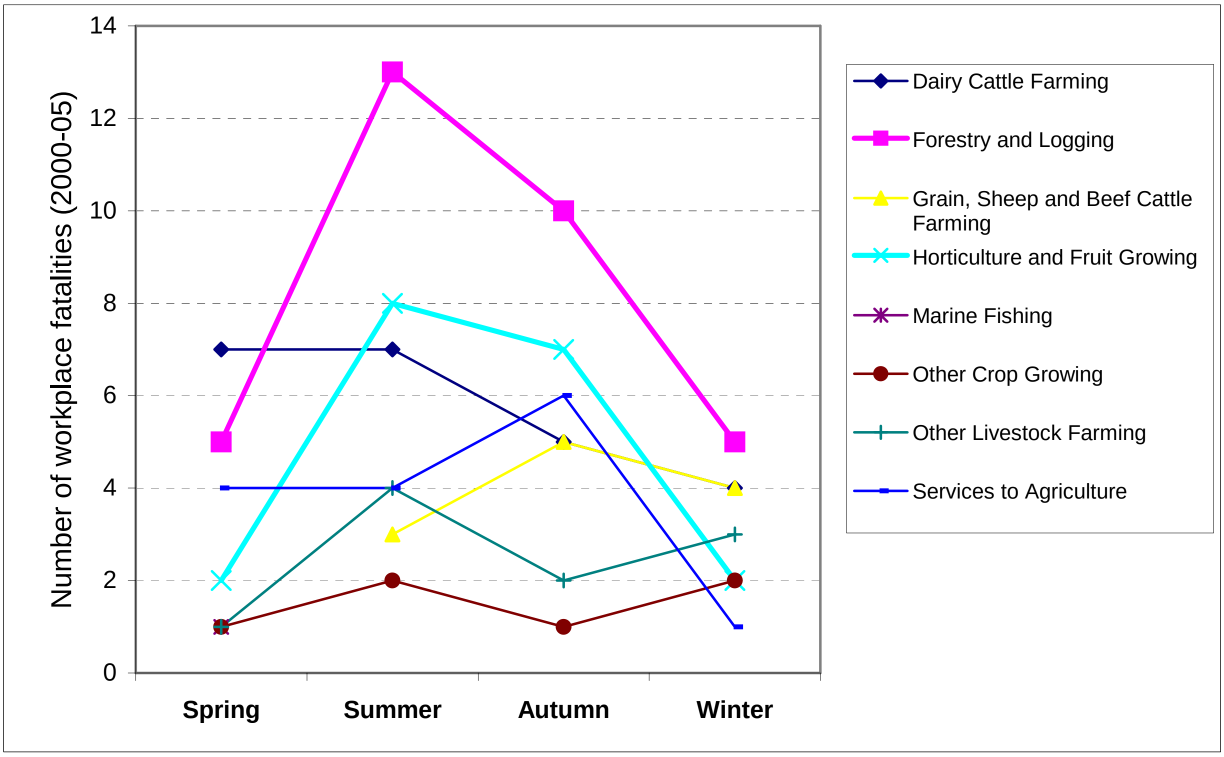


Figure 12 – Seasonal trend of sub-sectors within the 'Agriculture, Forestry & Fishing' with workplace fatalities (2000-05)

Seasonal trend of workplace fatalities by regions

3.2.8 Figure 13 below illustrates the seasonal trends associated with workplace fatality rates by geographical region. Of the four regions, both the 'Mid North region' and the 'Southern region' show a summertime increase in fatality rate. The Southern region also has a higher level of workplace fatalities in the autumn. Due to the limited number of cases recorded over the past six years for these regions, only the data set from the Southern region was strong enough to reach a statistically significant level ($p \leq 0.05$).

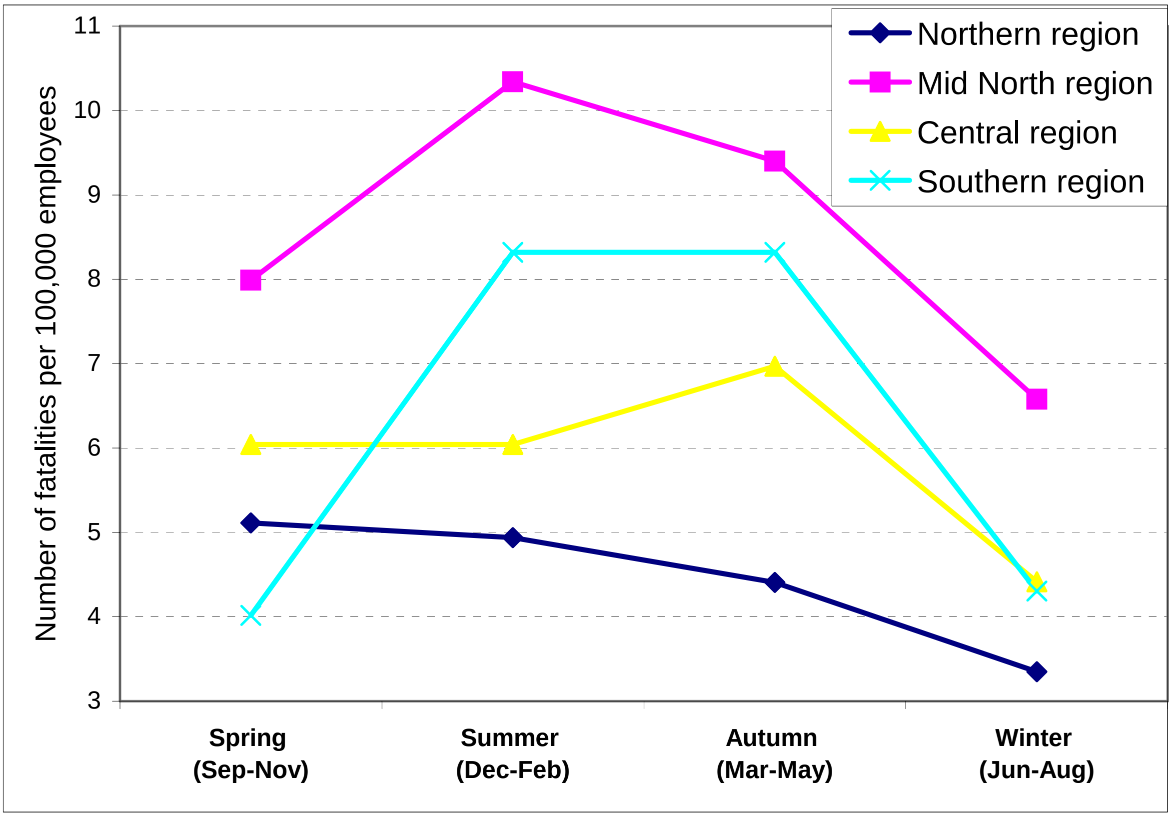


Figure 13 – Rate of seasonal workplace fatalities by regions (2000-05)

Seasonal trend of workplace fatalities by employment status

3.2.9 The workplace fatality data over the past six years (2000-05) were analysed by the victim's employment status, including the victims who were either employees (EMP), self employed (SE), or bystanders (BS). Figure 14 shows some indicative results, although all the seasonal trends of the data as analysed by employment status did not reach a statistically significant level ($p > 0.05$).

3.2.10 Figure 14 suggests that it is the employed who are most at risk of having a workplace fatality. However, this assumption cannot be made until denominator data can be obtained. Given that the numbers of self employed are likely to be relatively low, normalised data may show a very different picture.

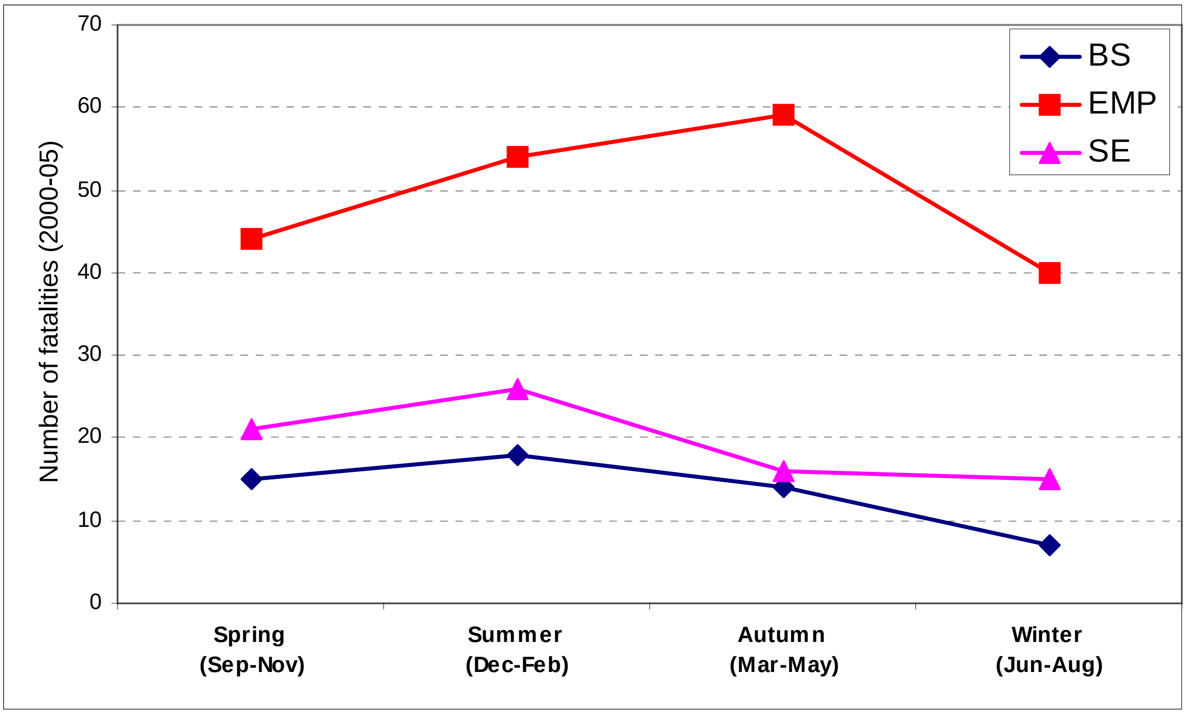


Figure 14 – Seasonal trend of workplace fatalities by the employment status (2000-05)

(Note: EMP-employees; SE-self employed; BS-bystanders)

Seasonal trend of workplace fatalities by employment status for different industries

3.2.11 Further exploration of the employment status by industry, shows that the people working in the agriculture sector, either employed or self-employed, tend to have more fatal incidents in summertime as compared to other seasons. This seasonal trend is very close, but not up to, a significant level (p=0.073, close to 0.05).

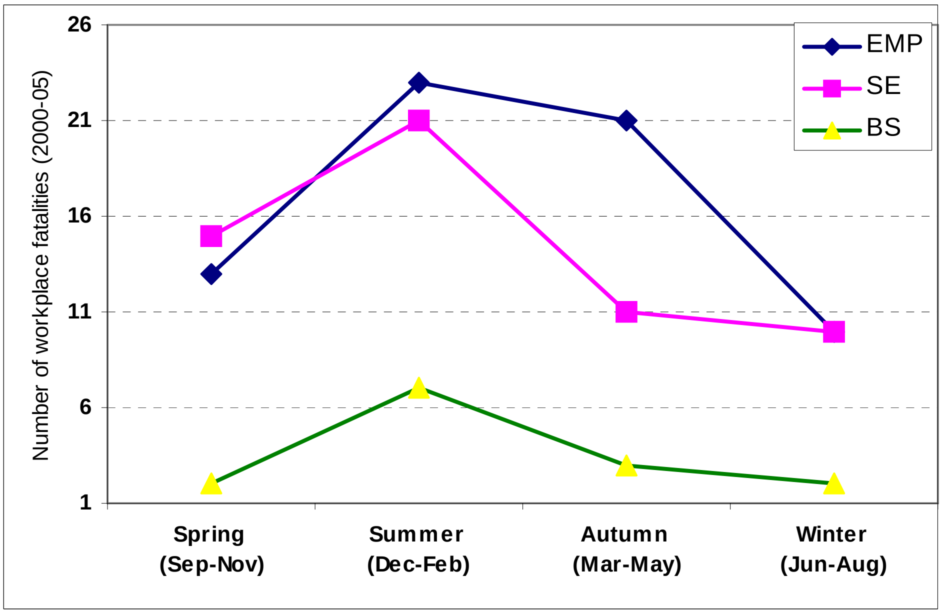


Figure 15 – Seasonal trend of workplace fatalities by employment status within the 'Agriculture, Forestry & Fishing' industry (2000-05)

(Note: EMP-employees; SE-self employed; BS-bystanders)

Seasonal trend of workplace fatalities by employment status for different regions

3.2.12 The workplace fatality data were analysed for a possible seasonal trend by employment status for geographical regions, including the Northern region, Mid North region, Central region and Southern region. Although some apparent seasonal changes in workplace fatalities (with the EMP data, for example) are shown in Figure 16, these changes are not statistically significant (p>0.05).

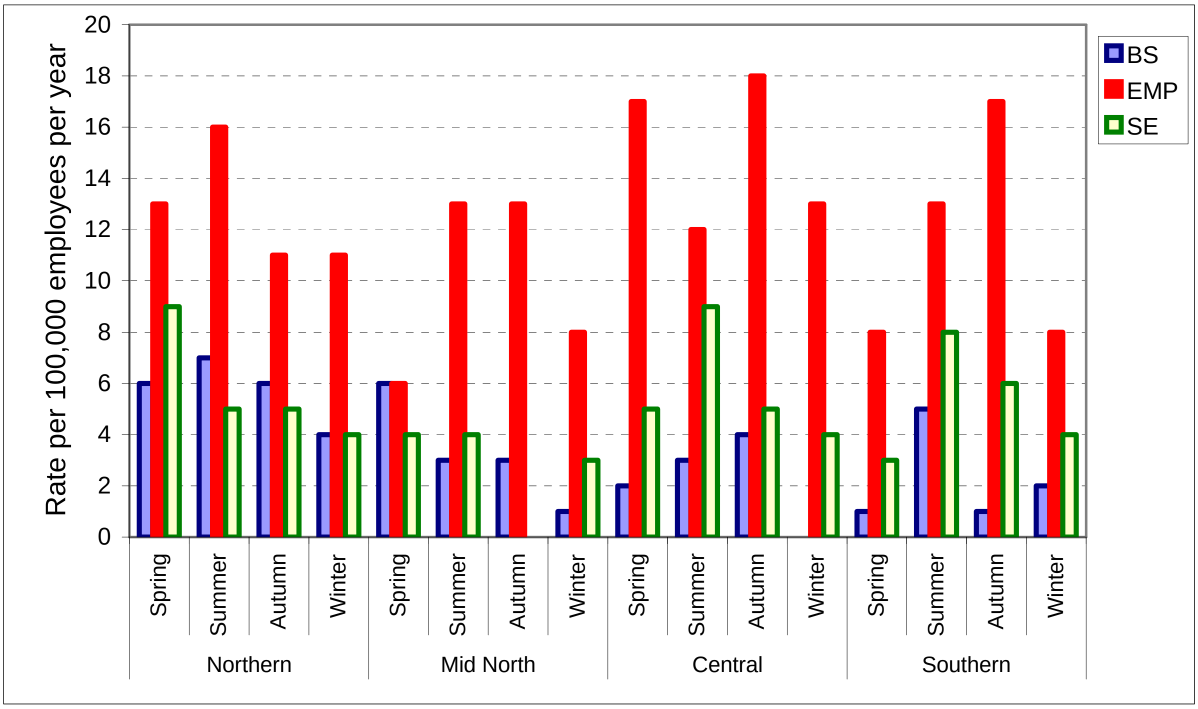


Figure 16 – Seasonal trend of workplace fatalities by employment status for different regions (2000-05)

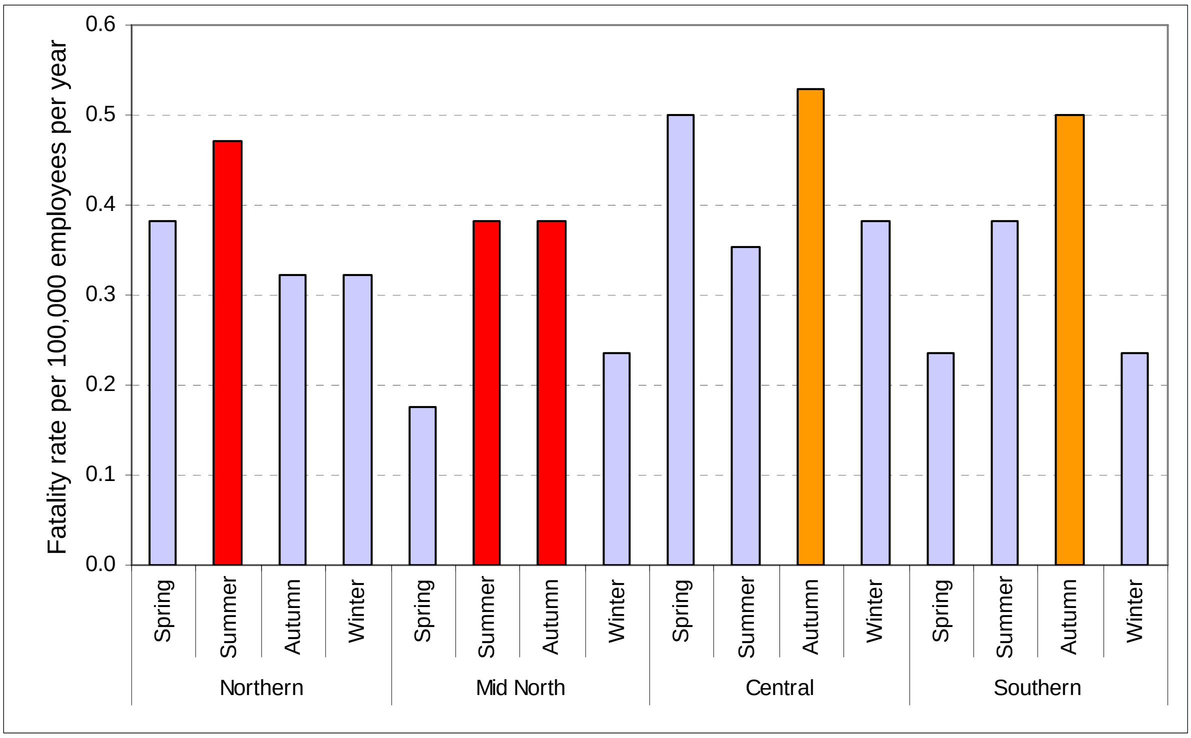


Figure 17 – Normalised fatality rate for employees in different regions (2000-05)

3.2.13 The normalised results in Figure 17 (with the EMP data only due to limited data availability) suggest that while in the northern part of New Zealand (Northern and Mid North regions) there tend to be more workplace fatalities in the summertime (highlighted in red bars), in the southern part of the country (Central and Southern regions), more fatal incidents tend to occur in the autumn (orange bars). The Central region also tends to have a higher fatality rate during windy springtime. It needs to be noted here, however, that the evidence obtained so far from the fatality data analysis is technically not strong enough to reach a conclusion, and these results should be interpreted with the support from other independent evidence.

Seasonal trend of workplace fatalities by age groups

3.2.14 Figure 18 below illustrates the seasonal trends of workplace fatalities in relation to the age groups of those involved in the incidents. The data were based on total fatal incidents from 2000 to 2005.

3.2.15 The data indicate that the people with the highest summertime fatality occurrence are between 55 and 64 years of age. This is a significant finding at the at $p \leq 0.05$ level. The data also shows that those aged 35-44 are more likely to have fatal incident in the autumn. This was significant at the $p \leq 0.05$ level. Other apparent seasonal trends with different age groups were not statistically significant ($p > 0.05$).

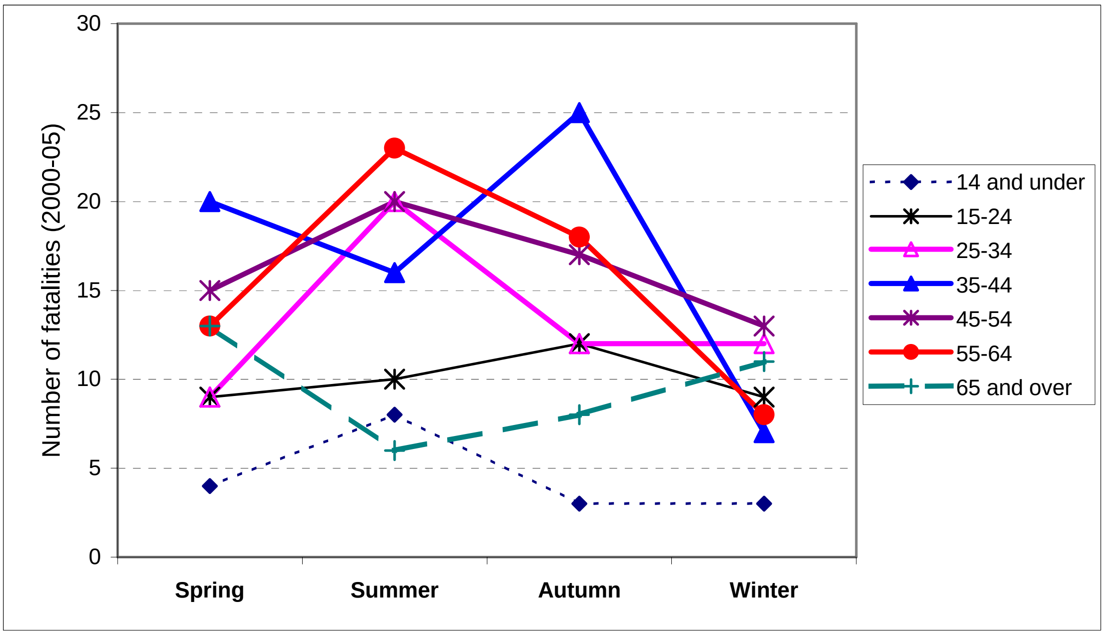


Figure 18 – Seasonal trend of workplace fatalities by age groups

(overall occurrence 2000-05)

3.2.16 Figure 19 shows the normalised results of the seasonal trend by age groups. One of the major findings from the normalised data is that the results confirm the high-risk group of 55-64 for summer season (red columns). The normalised data also confirmed the autumn peak of work-related fatalities with the 35-44 age group.

3.2.17 In addition, the normalised results suggest that there is a gradual increase in fatality rate by those aged 65 and over from the summertime through to the spring, with the summer having the lowest fatality rate and the spring having the highest rate. The overall fatality rate of the 65+ group is much higher than that of any other age groups. The next section investigates which industrial sector these high-risk groups tend to work in, and whether it would follow a similar seasonal pattern.

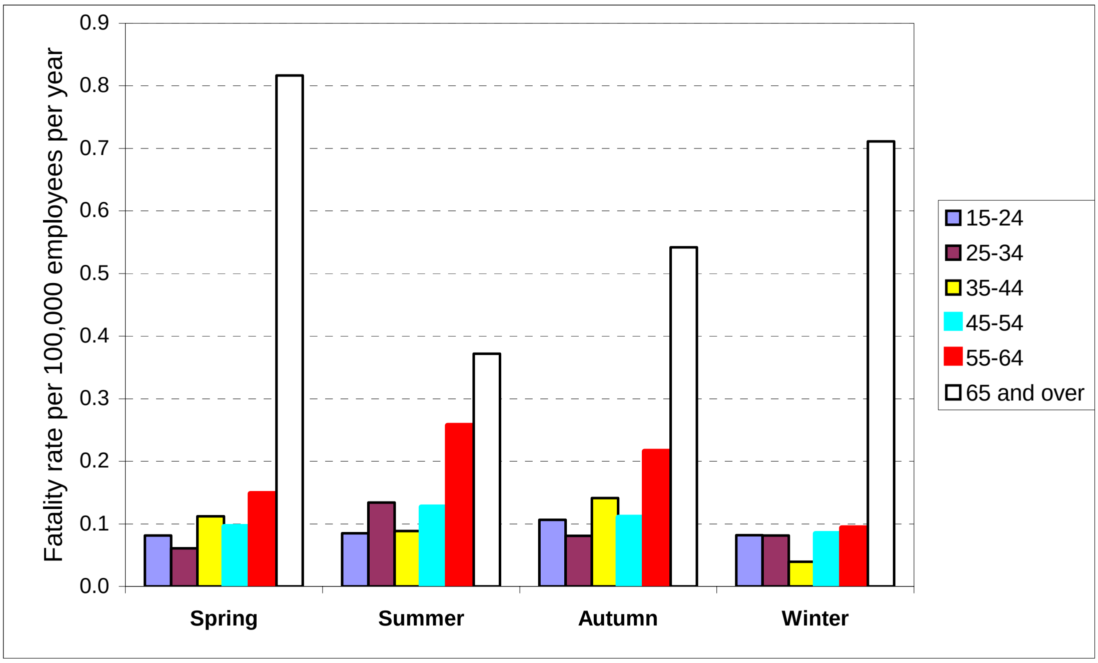


Figure 19 – Normalised seasonal fatality rate by age (2000-05)[11]

Seasonal trend of workplace fatalities by age groups for different industries

3.2.18 The workplace fatality data from 2000 to 2005 were analysed by each age group, for each industrial sector as classified by the ANZSIC system. Statistical analysis was carried out to identify if there is a significant seasonal change for each age group within each industry. The results demonstrate that only the agriculture sector had a significant seasonal trend of age-related workplace fatalities, with the 55-64 age group having the highest fatality occurrence in the summer ($p \leq 0.05$) and 35-44 age group having the highest fatal incidents in the autumn ($p \leq 0.05$) (Figure 20). These results are in line with the previous findings confirming that, as far as workplace fatalities are concerned, the employees aged 55-64 are most vulnerable during the summertime; the employees aged 35-44 are most vulnerable during the autumn, and most of them are working in the agriculture industry sector.

3.2.19 People in other age groups, do not show a significant variation in their seasonal involvement in workplace fatalities for the agriculture industry. No significant seasonal patterns were found with any age groups working in any other industries, except for agriculture.

3.2.20 The normalised results by age groups for the agriculture sector show a summer peak fatality rate with the 55-64 age group (Figure 21). This result is consistent with the previous findings. Figure 21 also demonstrates that those 65+ workers tend to have higher fatality rate during autumn while their involvement in other seasons is relatively stable[12].

[11] Data source: Employment by age (1986-2006), Statistics New Zealand, Household Labour Force Survey (HLFS).

[12] Note: These normalised results were based on the denominators which were available up to 2001. These were all that were available at the time when the analysis was carried out.

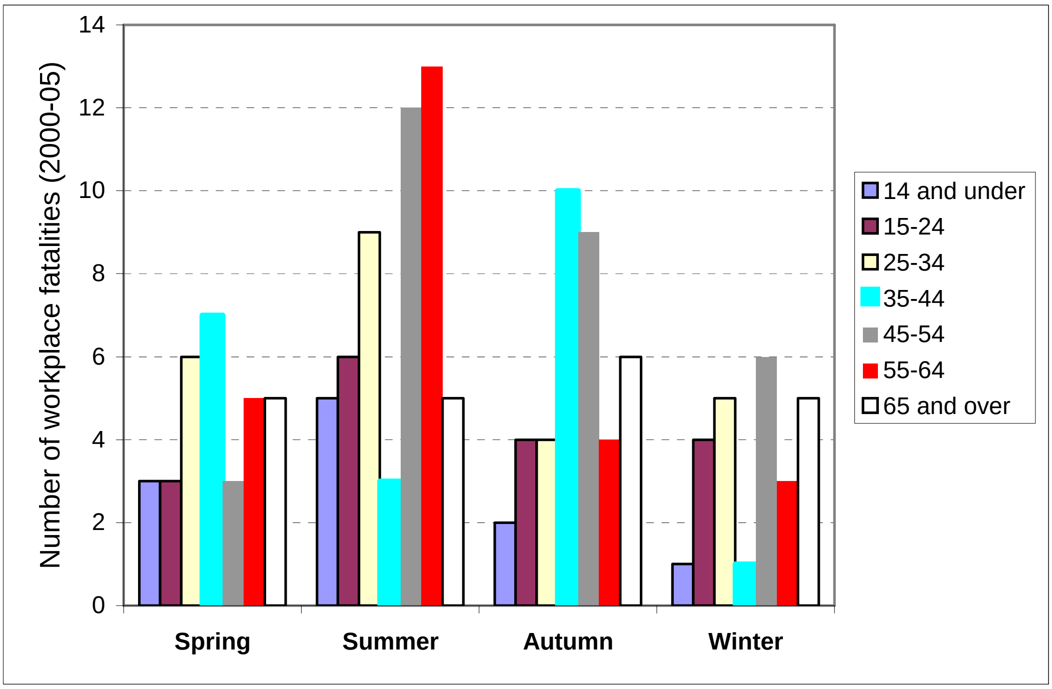


Figure 20 – Workplace fatalities by age groups in 'Agriculture, Forestry & Fishing' (2000-05)

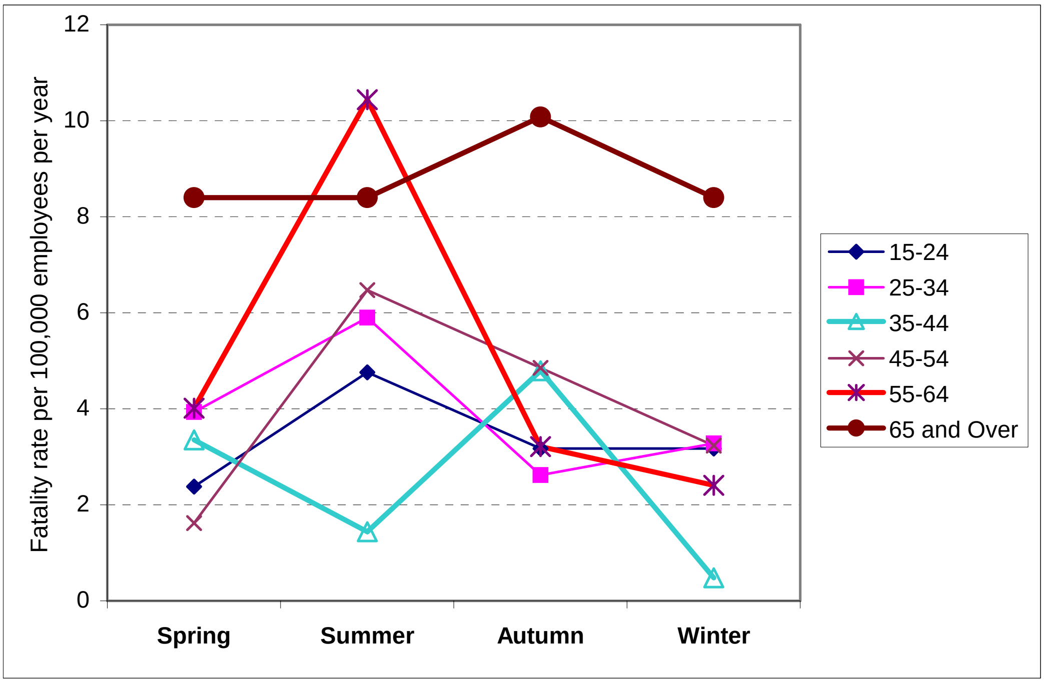
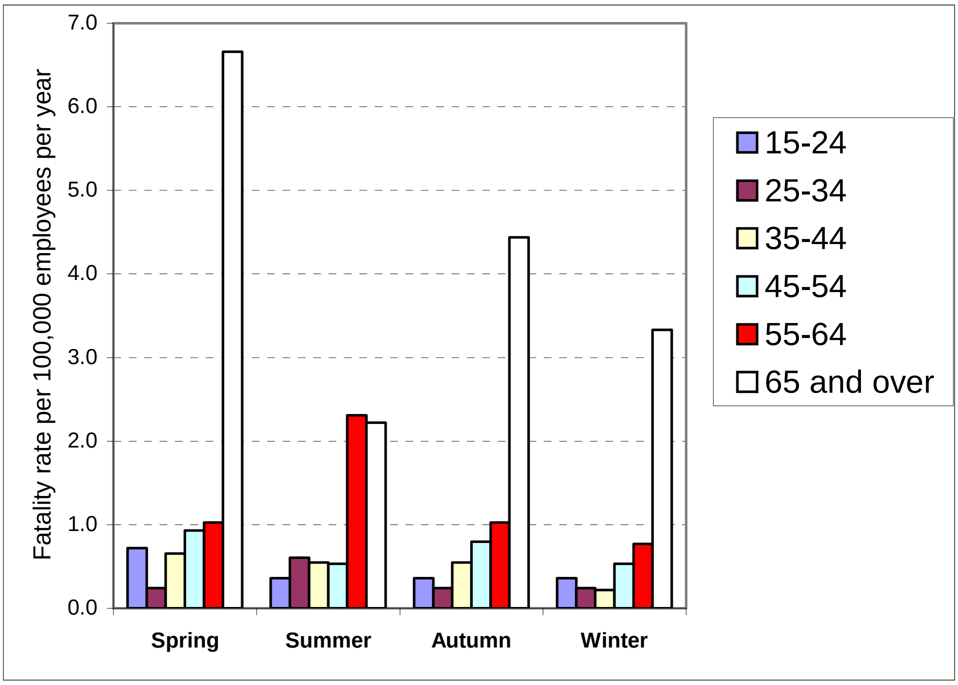


Figure 21 - Normalised fatality rate with people in different age groups in the 'Agriculture, Forestry & Fishing' industry (2000-05)[13]

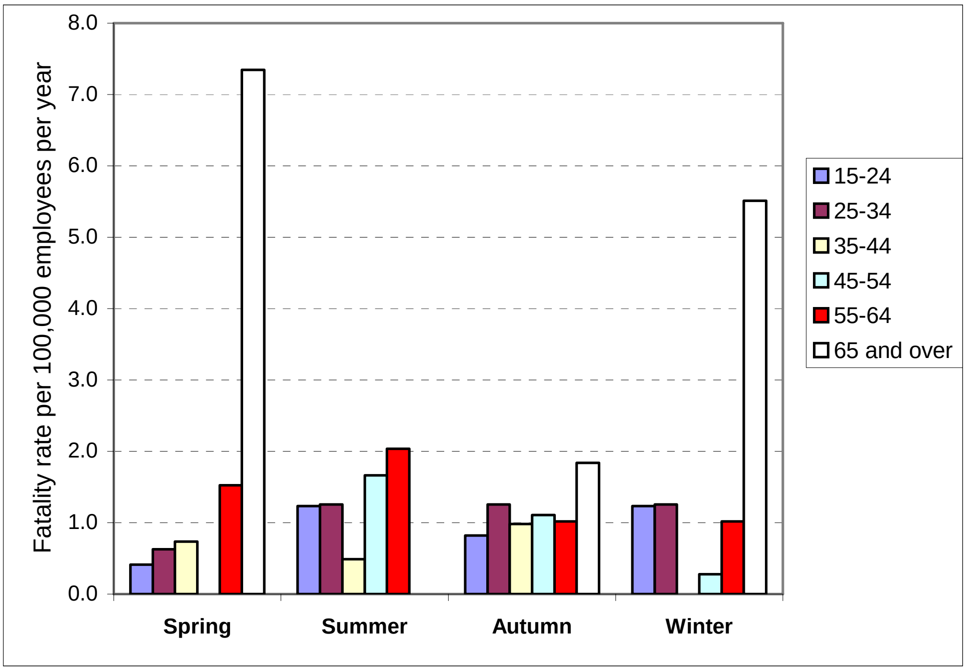
[13] Source: Statistics New Zealand, 2001 Census.

Seasonal trend of workplace fatalities by age groups for different regions

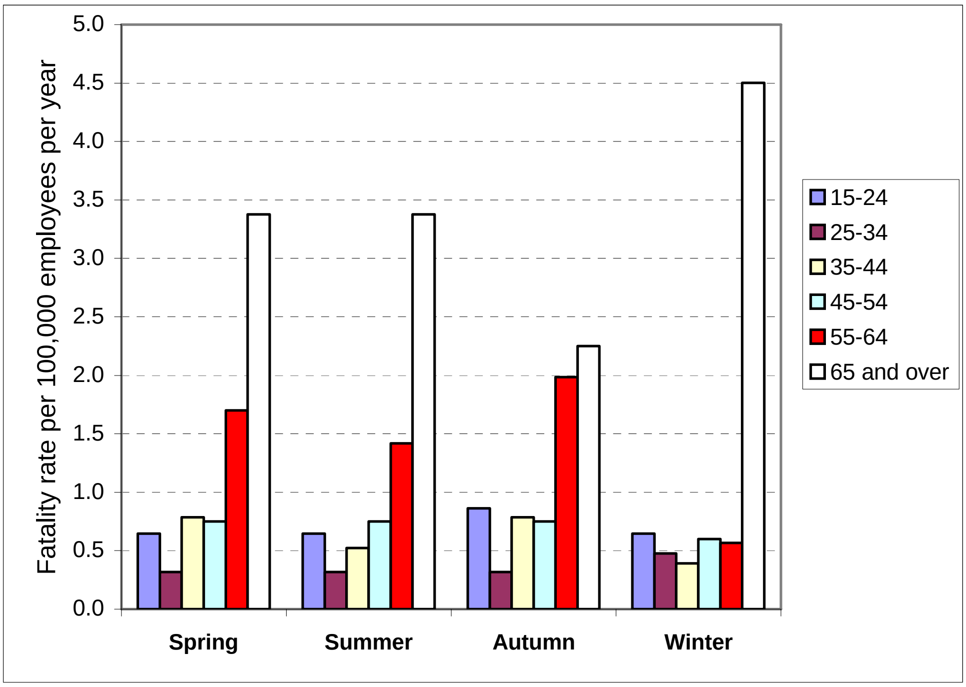
3.2.21 The workplace fatality data over the last 6 years (2000-05) were analysed for each geographical region by age groups. Of the four large regions and a total number of 362 fatalities over the 6-year period, the Northern region had 101 fatalities (or 27.9% of the national total), the Mid North region had 73 (20.2%), the Central region had 101 (27.9%), and the Southern region had 87 (24.0%). However, when dividing the data set by regions and then by different age groups, the actual data size becomes so small that statistical tests indicate only the Southern region had a significant seasonal variation (at $p \leq 0.05$ level) in workplace fatalities (between all age groups). In addition, employee population may vary between these regions, thus the data would need to be normalised to make the results meaningful. The normalised results for these regions are shown in Figure 22 below. These results will be discussed later in section 6.



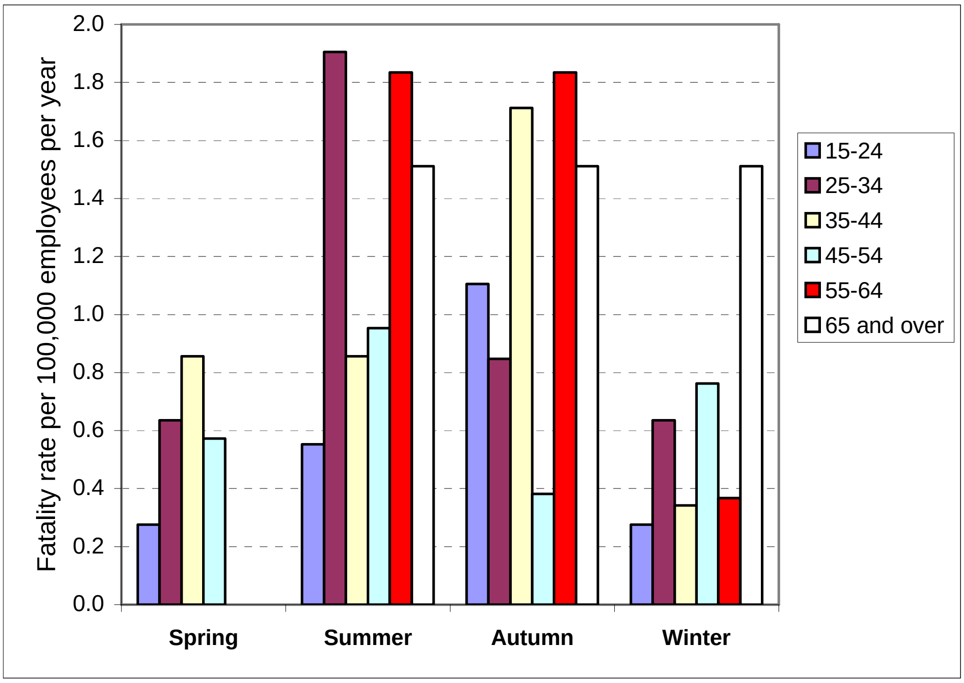
- Northern region



- Mid North region



- Central region



- Southern region

Figure 22 – Seasonal rate of workplace fatalities by age groups for different regions

(See footnote 10 for data source)

Time of day

3.2.22 Figure 23 shows the fatal incidents that occurred in the workplace from 2000 to 2005 at different times of day. There are two peaks for the fatal occurrences, one is between 11:00 and 12:00, and the other is around 15:00. These variations are highly significant at $p<0.001$ level.

3.2.23 Further analysis of the fatality data by industry indicates that such a pattern is in line with the incident occurrence in the agriculture industry ($p<0.001$), while the daily variations of the incident times for all other industries are insignificant, as shown in Figure 24.

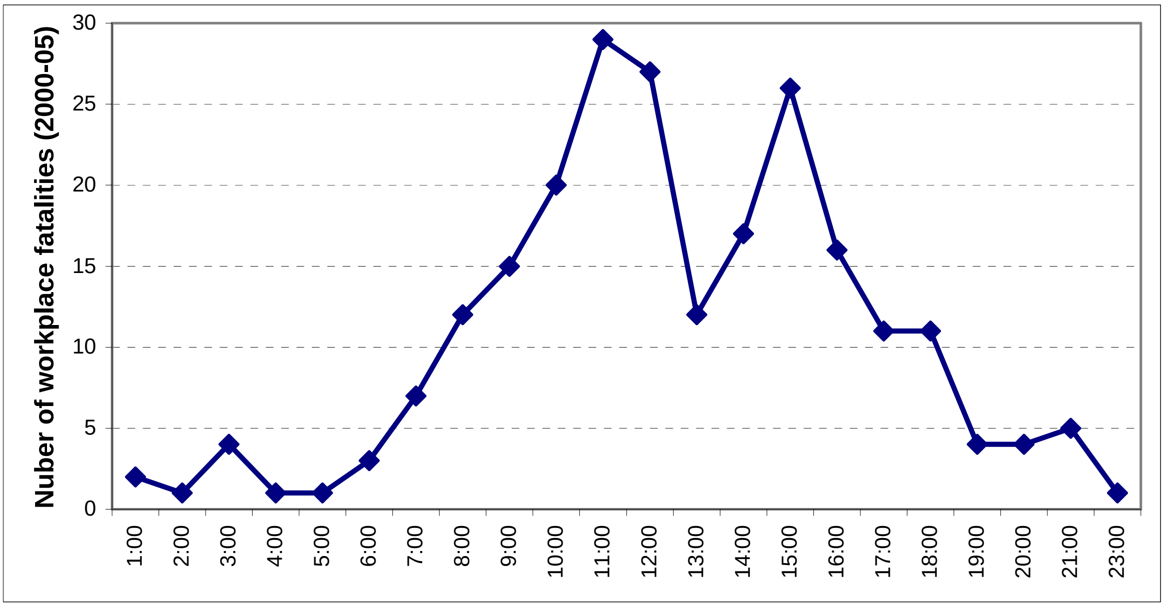


Figure 23 – Distribution of workplace fatalities by time of day (2000-05)

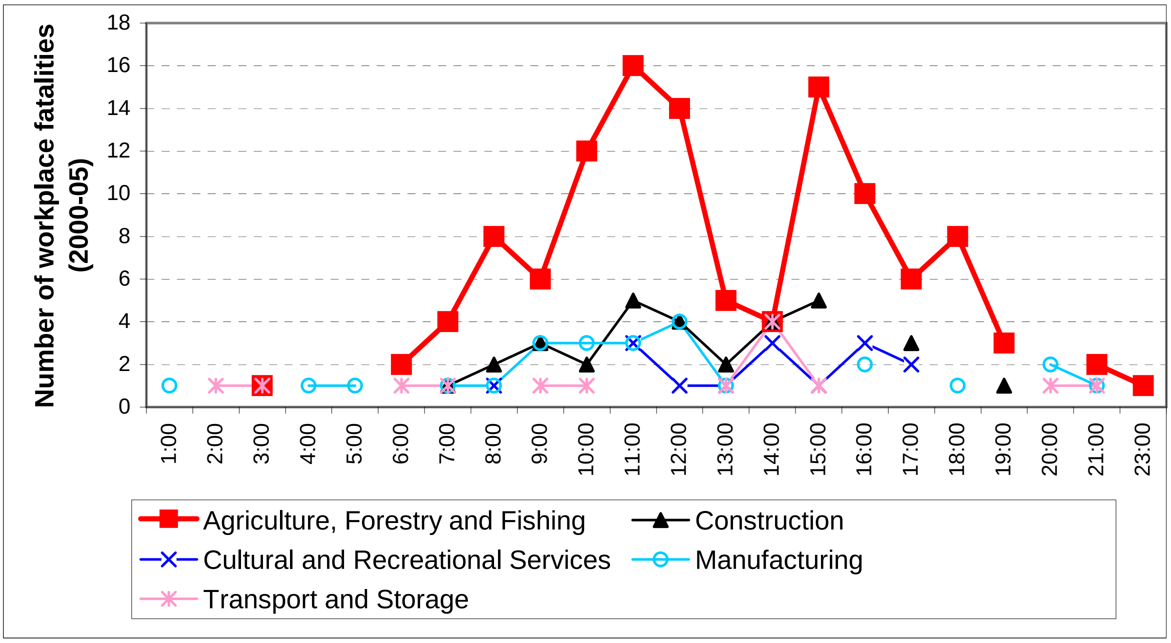


Figure 24 – Distribution of workplace fatalities by time of day by industries (2000-05)

3.2.24 Figure 25 shows the trends of workplace fatalities between time of day and the season. To achieve this analysis, software code was written to work out whether fatalities occurred during daylight, twilight or night time hours. This code looped through each record and calculated the region and then the sunrise/sunset times for that region at that time of year. Five times of day were identified:

- Dawn=Twilight to Sunrise
- Morning=Sunrise to Noon
- Afternoon=Noon to Sunset

- Dusk=Sunset to Twilight end
- Evening=Twilight end to Twilight start

3.2.25 The graphs in Figure 25 suggest that during the summer, fatal workplace incidents are more likely to occur in the morning (from sunrise to noon), and during autumn, more fatal incidents tend to occur in the afternoon (from noon to sunset).

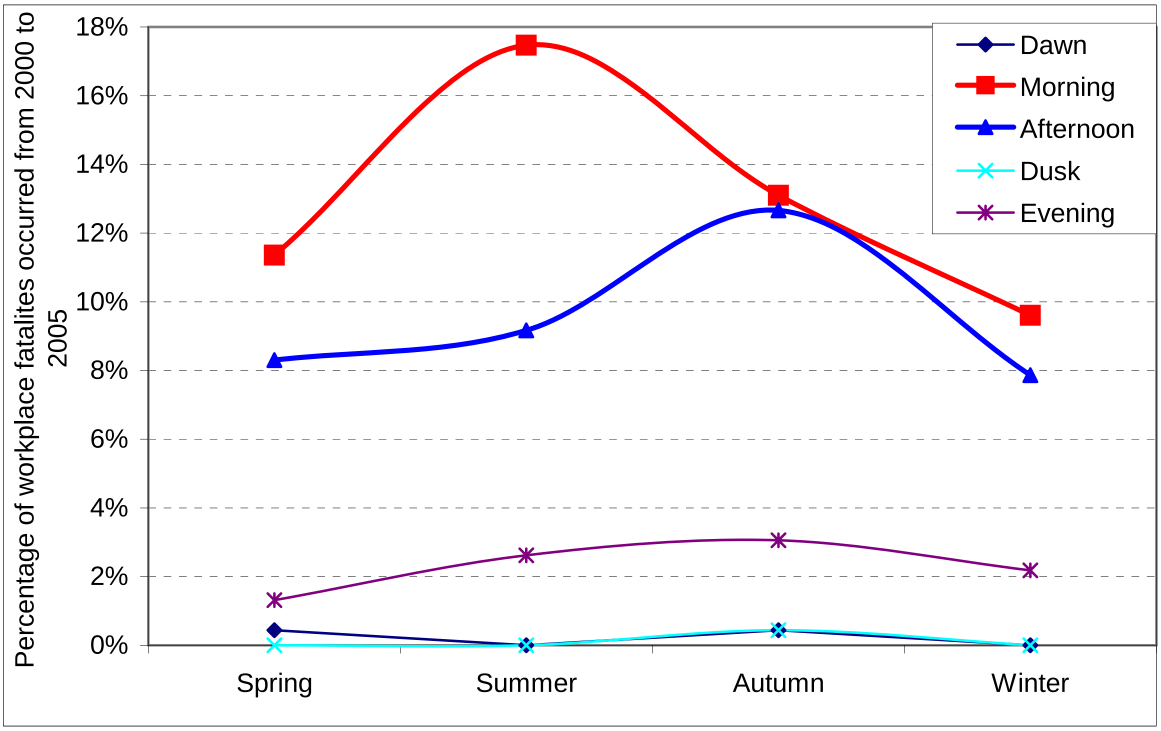


Figure 25 – Trends of workplace fatalities between time of day and the season (2000-05)

Day of the week

3.2.26 The workplace fatality data over the past 6 years (2000-05) were also analysed by day of the week, and the weekly trend is shown in Figure 26 below. As expected, more fatal incidents are likely to happen during the weekdays (Monday to Friday) as compared to weekends (Saturday to Sunday) and such a difference is statistically significant ($p<0.001$). However, there is no significant difference between weekdays (Monday-Friday) with regard to the frequency of fatal occurrences ($p>0.05$). There is also no significant variation in fatality occurrence between Saturday and Sunday ($p>0.05$), although there are slightly more incidents on Saturdays than on Sundays in the 6-year record. These issues will be discussed in further detail in section 6 with other independent evidence.

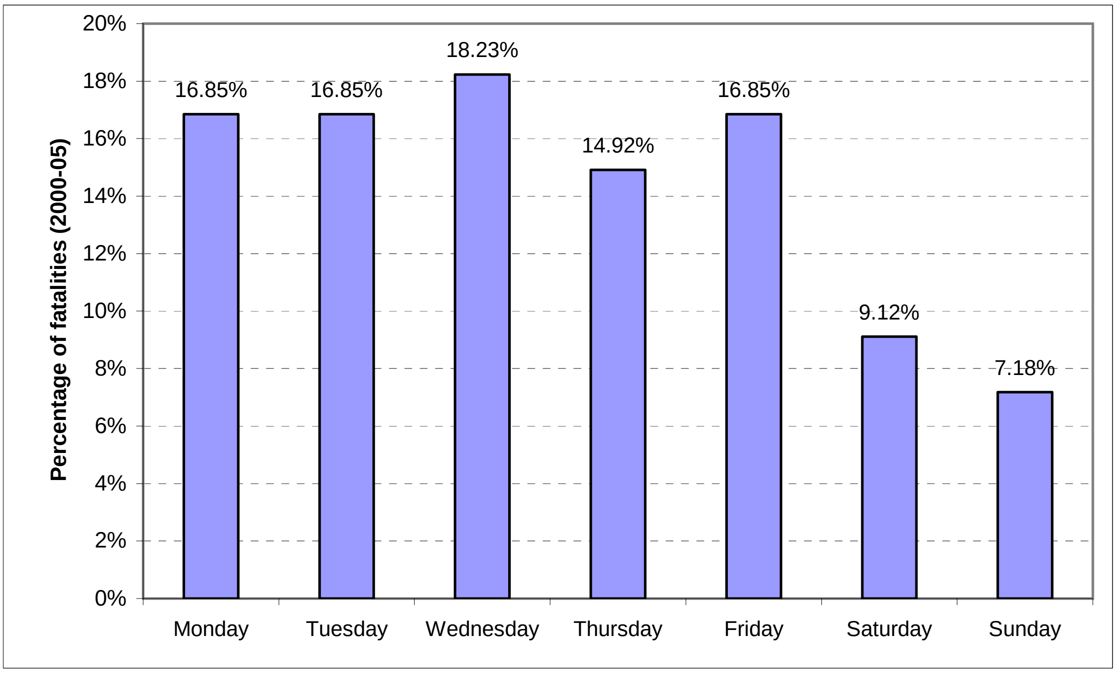


Figure 26 - Trends of workplace fatalities by day of the week (2000-05)

4. IDENTIFICATION OF CONTRIBUTING FACTORS TO SUMMERTIME FATALITIES

4.1 Overview

4.1.1 The work reported in section 3 has identified various seasonal trends of workplace fatalities in relation to industrial sectors, regions, employee ages and employment status. The work reported in this section concerns the identification of factors which are associated with, or have a contributory effect on, the occurrence of the seasonal changes in workplace fatalities. Some of these factors have been identified in the previous analyses using the data directly recorded along with the fatality investigation, such as the type of industry and the employees' age. However, for either technical or practical reasons, a great deal of potentially useful information cannot be recorded in the fatalities database, such as detailed weather conditions at the time when the incident happened, and any sociological background information around the fatalities. Those factors might have played some contributing roles in the occurrence of the fatal incidents. This section aims to identify a wider range of potentially contributory factors including workplace factors, environmental factors, sociological factors, and personal or individual factors, and to assess the extent to which they may have contributed to the incidents recorded in the fatalities database.

4.2 Workplace Factors

4.2.1 Workplace factors and task specific/operational factors are very often the most relevant to workplace fatalities. The development of effective preventive measures to reduce the incidence of seasonal workplace fatalities arising from workplace/operational factors should be a priority for the Department if it is to achieve its goal of workplace safety.

4.2.2 The workplace factors that were identified and analysed were obtained mainly from two primary information sources: workplace fatality investigation reports and interviews with ISEs (Industry Safety Experts).

Analysis of workplace fatality investigation reports

4.2.3 Of the total 362 workplace fatal incidents from 2000 to 2005, 299 full investigation reports were available for detailed review by the project team. Each of these reports were read/analysed by the research team and relevant information was extracted.

4.2.4 In those workplace fatality investigation reports, the 'direct causes' of death were recorded by the investigators. These have since been classified. For example, whether the death was due to 'drowning' or 'fall from height'. This information provides good insight into 'what happened', but gives little information of 'why it happened'. These 'direct causes' were captured by the research team during the course of the report analysis. Figure 27 below summarises the results. Vehicle rollovers caused nearly one quarter of all fatal work related deaths during 2000 to 2005. Vehicular related fatal incidents are discussed further in section 4.2.7.

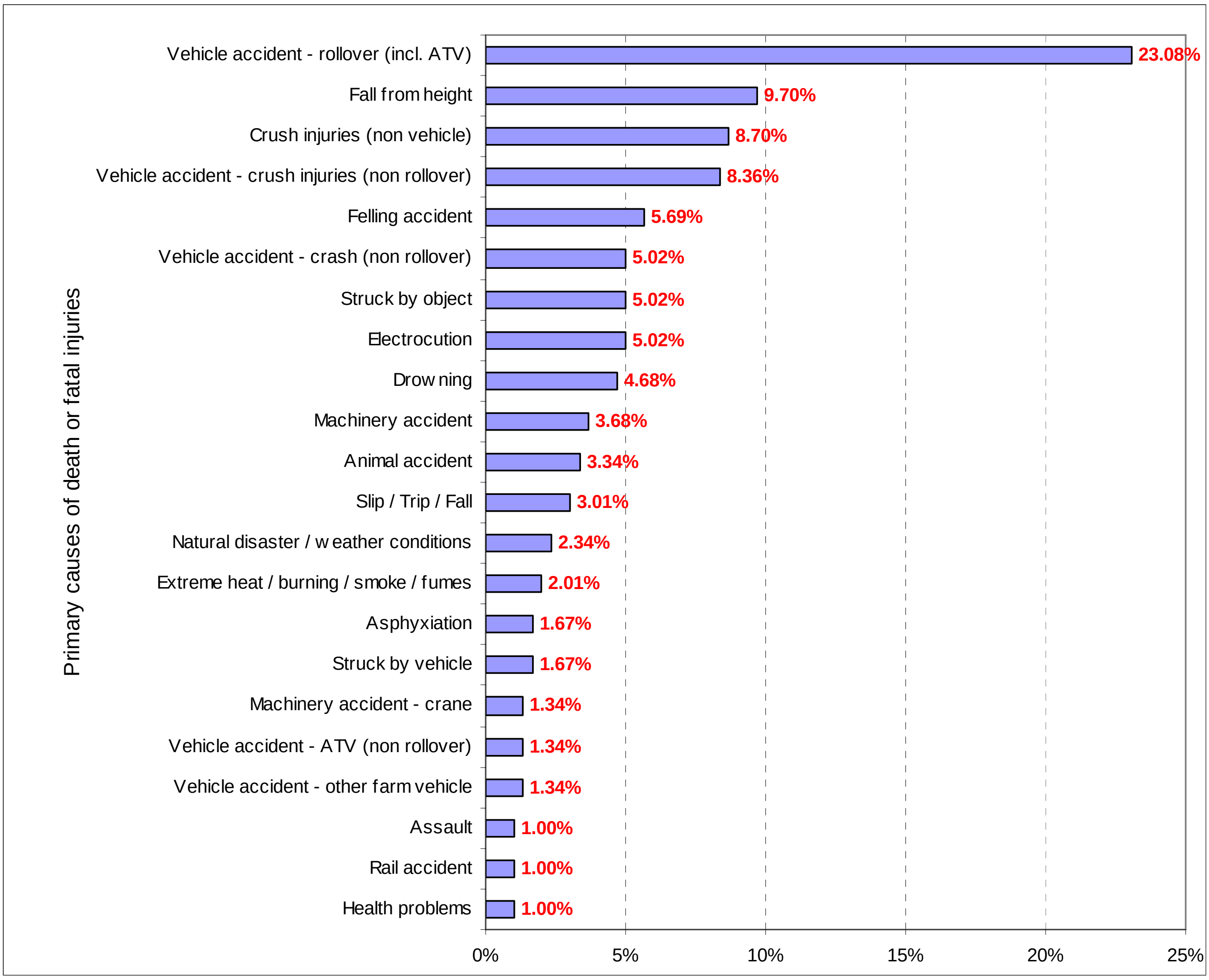


Figure 27 – Primary causes of death or fatal injuries for the incident**s investigated**

(299 between 2000 and 2005)

4.2.5 In order to gain further insight into what caused each of the fatalities, each of the incident reports were reviewed and categorised according to the contributory factors that led directly to the incident occurring. While the categorisation of incidents relied entirely on the interpretation of the information recorded by investigators it provides important direction on the types of preventative strategies that should be considered.

4.2.6 One or more contributory factors were recorded for each incident. The majority of fatalities were associated with multiple (e.g. 2 or 3) contributory factors. Figure 28 lists each contributory factor and the percentage of workplace fatalities associated with it. The data show that “Human Error” contributed to at least 43% of the fatalities recorded and that “Procedural Violation” contributed to at least 27% of the fatalities recorded. In addition, in 16% of cases, a behaviour occurred that may have been either a procedural violation or human error[14]. The vast majority of human errors or violations can be prevented by improved equipment or workplace systems design. In 22% of the fatalities reported, a failure in design could be recognised, either by the investigator at the time or during subsequent review of the incident report.

[14] In these cases the knowledge of the analyst reviewing the report was insufficient to know whether procedures were in place that were violated.

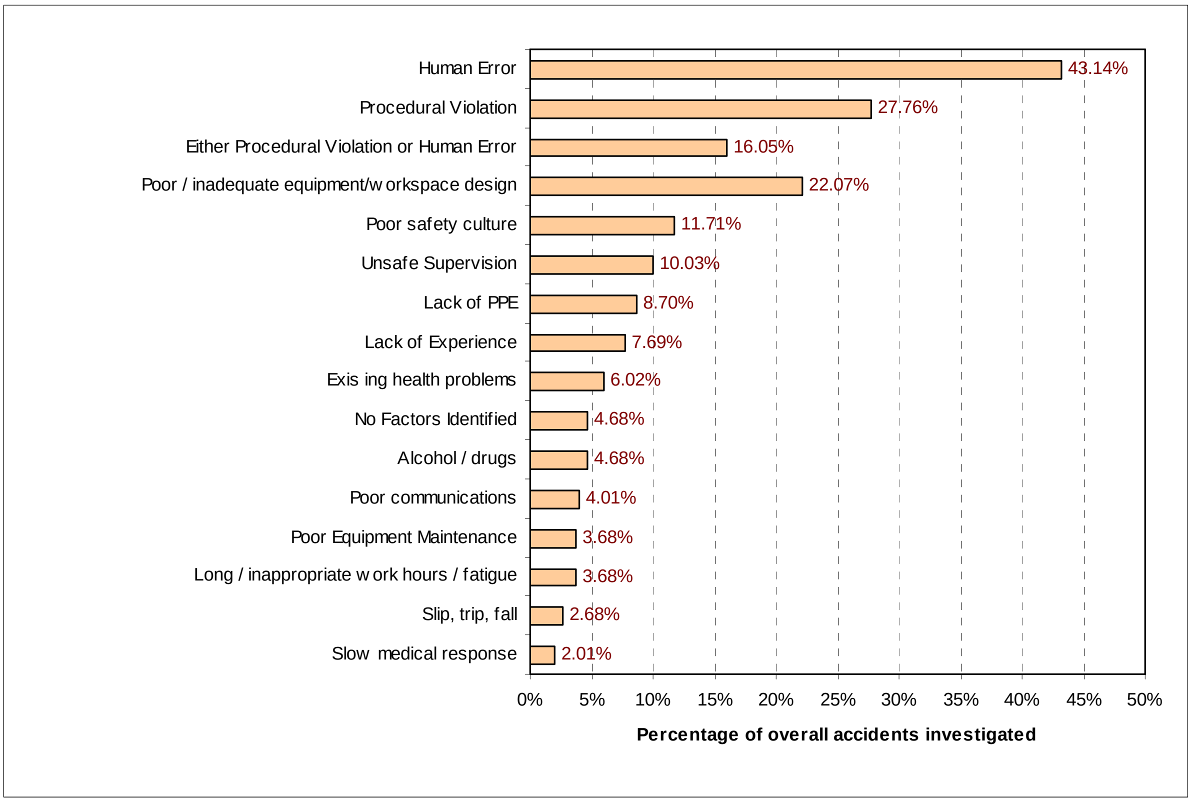


Figure 28 – Contributing factors as identified by the investigators

(299 workplace fatality investigation reports from 2000 to 2005. Please note that there are multiple counts for the contributing factors because each **incident** almost always involved more than one factors)

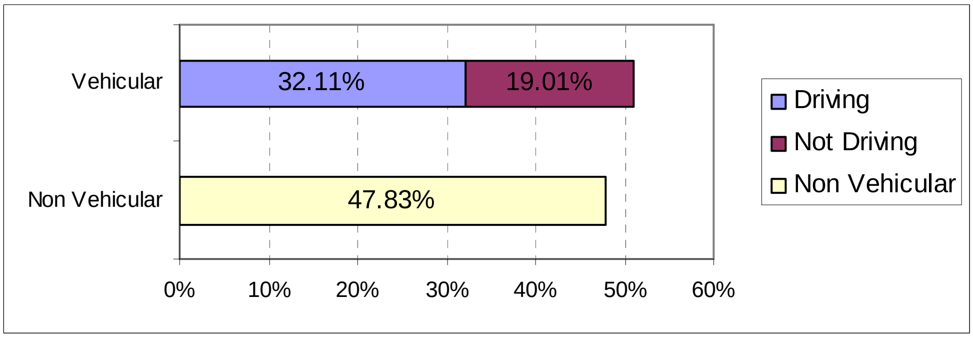


Figure 29 - Vehicular statistics

4.2.7 Figure 29 shows that, of all the fatal incidents during 2000 to 2005 in the Department of Labour's database 52% involved vehicles. Of those, approximately 1/3 of the fatalities occurred to a person who was not driving a moving vehicle at the time. Where the fatality occurred to a person in or driving a moving vehicle, the fatality reports indicate that wearing a seatbelt or helmet could have prevented the fatality in up to 33% of cases (nearly 8% of all fatalities).

Interviews of Industry Safety Experts

4.2.8 For the identification of a wider range of workplace factors for different industries, the experts' assessments that were obtained from the ISE consultation (described in section 2.3) were used for the analysis. The focus of this exercise was to look into those seasonal related factors in or surrounding the workplace, which have not been covered by the investigators. The following workplace factors were investigated in this process:

- Hours worked per day
- Level of staffing
- Level of casual labour
- Need to work in remote locations
- Non-work related activities
- Level of supervision or support whilst working
- Visitors/non-workers attending work sites
- Physical or mental work demands
- Variation in work activities
- Work involving machineries
- Work involving vehicles
- Demand for work at heights
- Work under poor weather conditions
- Lack of recovery from fatigue
- Tight timescales / deadlines
- Use of hazardous substances

4.2.9 The workplace factors were analysed for their possible association with the occurrences of workplace fatalities. Correlation coefficients were calculated between the expert ratings on the seasonal changes of the workplace factors for different industries, and the occurrence of workplace fatalities during the corresponding seasons for the corresponding industries.

4.2.10 ISE rating data were only available for the following top-level ANZSIC industries and the sub-sectors shown:

- **Agriculture, Forestry & Fishing**
  - Sub sector: Forestry & logging
  - Sub-sector: Horticulture & fruit growing
  - Sub-sector: Dairy & cattle farming

- **Construction**
    - o Sub-sector: Residential construction
    - o Civil construction and commercial construction
- **Manufacturing**
    - o Sub-sector: Wood processing

4.2.11 Table 2 shows the results of correlation analysis between those workplace factors that have been quantified for their seasonal changes (by expert ratings) and workplace fatalities for different industrial sectors. The table includes only the factors which have been found to be significantly associated with seasonal workplace fatalities corresponding to at least one or more industries. These results are based on the workplace fatality data and the ISE rating scores, and are independent of the findings that have been obtained by using other analytical methods such as the analysis of workplace fatality investigation reports.

Table 2 – Correlation coefficients between some workplace factors and workplace fatalities for different industries

Factors	Overall fatalities	Agriculture, Forestry & Fishing	Horticulture & fruit growing	Construction	Manufac-turing
Hours worked per day	0.66*	0.70* (ISE ratings on dairy & cattle farming)	NS	NS	NS
Level of staffing	0.63*	0.30*	0.75*	NS	NS
Level of casual labour	0.60* Ratings on construction	0.28*	0.76*	NS	NS
Visitors/non-workers attending work sites	0.59* Ratings on construction	NS	0.74*	NS	0.64*
Variation in work activities	NS	0.28*	NS	-0.41*	NS
Work involving vehicles	NS	NS	0.71*	-0.34*	NS
Work under poor weather conditions	-0.69* Ratings on construction	NS	NS	NS	NS
Lack of recovery from fatigue	0.60* Ratings on agriculture	0.33**	NS	0.33*	NS
Tight timescales / deadlines	NS	NS	0.75*	NS	NS
Use of hazardous substances	0.58* Ratings on construction	NS	NS	NS	NS

Note: * statistically significant at $p \leq 0.05$ level; ** $p \leq 0.01$. NS: not significant ($p > 0.05$).

4.2.12 The correlation coefficients indicate a statistical association between the occurrence of workplace fatalities and some workplace factors that have been rated by the ISEs for seasonal variations. A positive correlation indicates that an increase in the workplace factor is related to an increase in the occurrence of workplace fatalities. For example, 'Hours worked per day' (which generally goes up in summer and down in winter) is positively correlated with the occurrence of workplace fatalities in all industries, which means that more hours worked per day are related to more work-related fatal incidents. A negative correlation would suggest that a change in the workplace factor towards a certain direction (either increase or decrease) is associated with a change in the work-related fatalities in the opposite direction. For example, in the 'Construction' sector 'Work involving vehicles' is negatively correlated with the work-related fatal incidents, suggesting that more vehicle use at work (e.g., prepare the work site and building materials before the building work takes place) is related to fewer fatal incidents (possibly due to reduced chance of falling from height). The meanings of all these correlation results are summarised and described in Table 5, and some relevant issues will be discussed in section 6.4.

4.2.13 Initially, the results indicate that several workplace factors are significantly associated with the occurrence of workplace fatalities in some industrial sectors. 'Level of casual labour', for example, is positively associated with workplace fatalities in the agriculture industry, and with its sub-sector 'Horticulture & fruit growing', suggesting that increased casual labour is related to a higher rate of workplace incidents. This finding is in line with the fact that there is an increased labour demand in the horticulture industry during the summer and through to autumn seasons to cope with crop harvesting (February-May)[15] (with reference to Figure 12).

4.2.14 A highly significant correlation was also found between 'Average Weekly Paid Hours[16] and the workplace fatality data for all industries ($r=0.54$, $p \leq 0.001$), suggesting that longer work hours in summer could also be a contributing factor to the increase in workplace fatalities.

4.2.15 It needs to be understood that the correlation analysis can only tell which factors are strongly (to a level of significance) associated with the occurrence of an event (in this case, workplace fatalities), thus they *may* have played a contributory role in the incidents. However, this does not necessarily mean that these factors have actually caused or contributed to those incidents. For example, while the pattern of ice cream sales may correlate with the pattern of workplace fatalities there is not necessarily a causal relationship between the two. The causal effects of these factors will need to be interpreted in connection with a wide range of multiple factors, including the environmental conditions, the sociological conditions, the individuals involved, as well as the actual work activities.

4.3 Environmental Factors

4.3.1 Various types of environmental factors have been investigated for their possible association with the occurrence of workplace fatalities. A wide range of environmental indicators were included in the analysis, such as temperature, rainfall, sunshine, humidity, fog, frost, snow, wind, gales, and so on.

4.3.2 Environmental data were provided by NIWA Climate Services at the request of the project team. The data were recorded by various weather stations across New Zealand on monthly basis from 2000 to 2005. In New Zealand, weather conditions vary between different regions during the same period of time. Therefore, it was necessary to analyse the environmental data with the fatality data on a regional basis. The environmental data

[15] Medium-Long-term Horticulture and Viticulture Seasonal Labour Strategy. Supporting Industries with Seasonal Labour Demands to Achieve Sustainable Growth. Report prepared by The Horticulture and Viticulture Seasonal Working Group, 2005.
[16] Data source: Labour Market Statistics 2005, Part 7: Hours of Work.

were sorted according to the four regions as used in this study (i.e., Northern, Mid North, Central, and Southern). Correlation coefficients were calculated between the environmental data and the overall workplace fatality data for the same region over the same period.

4.3.3 Correlation analyses were also performed between the regional fatality data for each major industry with the relevant environmental data in a similar manner. Table 3 shows the results.

4.3.4 As mentioned earlier in section 4.2, the environmental factors that were found to significantly correlate with the occurrence of workplace fatalities suggest that these factors are associated with increased workplace fatalities, but they may or may not have played a direct contributory role.

Table 3 – Correlation coefficients between some environmental factors and workplace fatalities (2000-05)

Factors	Overall fatalities	Agriculture, Forestry & Fishing	Construction	Cultural, Recreational & Other Services	Manufac-turing	Transport & Storage
Mean monthly rainfall (mm)	0.29***	NS	NS	-0.23**	-0.22**	-0.19*
Mean monthly wet days (rainfall≥1mm)	NS	0.71***	-0.20**	-0.23**	-0.37***	NS
Mean monthly air temperature (°C)	0.27**	0.60***	NS	0.40***	0.50***	NS
Sunshine (hours)		0.42***	NS	0.37***	0.43***	0.20**
Ground frost (No. of days)	NS	-0.42***	NS	-0.35***	NS	-0.35***
Fog	NS	NS	NS	NS	NS	NS
Snow	NS	NS	NS	NS	NS	NS
Mean speed of wind (km/h)	NS	NS	NS	NS	0.18*	0.21**
Gale (days)	NS	NS	NS	NS	NS	NS

Note: * statistically significant at $p \leq 0.05$ level; ** $p \leq 0.01$; *** $p \leq 0.001$; NS: not significant ($p > 0.05$).

4.3.5 The correlation tests indicate a positive or negative association between some of the environmental factors and the occurrence of workplace fatalities. For example, ‘wet days’ are positively correlated with the workplace fatalities in the agriculture industry, suggesting that the more wet days, the more likely the incident occurrence in this sector (e.g. vehicle rollover on slippery ground). However, in the ‘Construction’ sector, wet days reduce the likelihood of a fatal incident (probably because less high risk external work is carried out). Thus the correlation is negative. The meanings of these results are described and summarised in Table 5, and some relevant issues will be discussed in section 6.5.

4.4 Sociological Factors

4.4.1 Various types of sociological factors have been analysed for their possible association with the occurrence of workplace fatalities. These factors were mainly based on the data published in Statistics New Zealand[17]. Other relevant data sources provided information on possible factors such as school holidays, public holidays[18], and daylight saving[19]. The following factors were analysed for their possible association with the occurrence of workplace fatalities:

- Overseas tourist arrivals
- Short-term arrivals-NZ residents
- School holidays
- Public holidays
- Daylight saving
- Economic survey of manufacturing (operating income-actual)
- Economic survey of manufacturing (operating income-seasonally adjusted)
- Economic survey of manufacturing (operating income-salaries & wages)
- Economic survey of manufacturing (operating income-operating expenditure)
- Household estimate (mean year ended)
- Marriage rate
- Divorce rate
- DHB financial statistics
- Consumer Price Index (CPI)
- Value of building work
- Birth rate
- Death rate
- Alcohol consumption-total wine
- Alcohol consumption-total beer
- Total alcohol consumption

[17] Data source: Statistics New Zealand, Oct. 2006.
[18] http://www.fourcorners.co.nz/new-zealand/public-holidays/
[19] http://webexhibits.org/daylightsaving/newZealand.html

- Tobacco consumption (tonnes)
- Cigarettes consumption (million)
- Export Price Indexes (services)

4.4.2 Table 4 below summaries those sociological factors that were shown to be significantly associated with the occurrence of workplace fatalities for at least one industrial sector.

Table 4 – Correlation coefficients between some sociological factors and workplace fatalities (2000-05)

Factors	Overall fatalities	Agriculture, Forestry & Fishing	Construction	Cultural, Recreational & Other Services	Manufac-turing	Transport & Storage
Overseas tourist arrivals	NS	0.31*	0.36*	0.58*	NS	0.57**
Short-term arrivals-NZ residents	NS	NS	0.49*	NS	NS	NS
School holidays	NS	0.29*	NS	NS	0.43*	NS
Public holidays	NS	0.29*	NS	NS	NS	NS
Daylight saving	NS	0.28*	NS	NS	NS	NS
Household estimate (mean year ended)	NS	NS	NS	-0.53*	NS	NS
Consumer Price Index (CPI)	NS	NS	NS	-0.54*	NS	NS
Alcohol consumption-beer	0.41*	0.65***	NS	NS	NS	NS
Total alcohol consumption	NS	0.59**	NS	NS	NS	NS
Tobacco (tonnes)	NS	0.42*	NS	NS	NS	NS

Note: * statistically significant at $p \leq 0.05$ level; ** $p \leq 0.01$; *** $p \leq 0.001$; NS: not significant ($p > 0.05$).

4.4.3 Some sociological factors are found to be positively correlated with the occurrence of workplace fatalities, for example, people arriving from the overseas as tourists. The more tourist arrivals, the higher the work-related fatal incidents in some industries such as the agriculture sector. This may suggest that there is increased number of casual labourers during the tourist season. Casual labour has been regarded as an incident-contributing factor by other independent studies (summarised in Table 6). Increased tourists may also mean that there are more visitors/non-workers attending the work sites, another factor found to be related to the workplace fatalities (Table 2).

4.4.4 Another example is beer consumption, which is most significantly correlated with the workplace fatality data. However, as explained earlier, this does not necessarily mean that many work related fatal incidents were caused by beer drinking. This contributing factor will need to be considered in combination with other seasonal factors, and with other independent evidence. The meanings of these results are described and summarised in Table 5, with relevant discussions in section 6.6.

4.5 Individual/Personal Factors

4.5.1 The analysis has looked into individual/personal factors of those involved in the workplace fatal incidents, such as their age, gender, employment status. Some of this information was recorded in the database and some was extracted from the workplace fatality investigation reports. This type of directly recorded information (and the detailed analysis as reported in section 3.2) is considered to be more conclusive than the analysis of indirectly recorded data using correlation analysis.

4.5.2 Detailed analyses have previously shown that age is an important contributing factor, with those aged between 55 and 64 years being most likely to have fatal incidents in the summertime ($p<0.05$), and those between 35 and 44 years of age being most vulnerable during the autumn. In addition, the normalised data showed that older people (aged 65 and above) were found to have much higher fatality rate throughout the year as compared to other age groups, and they are particularly vulnerable during the autumn (section 3.2).

4.5.3 As far as gender is concerned, of the 362 workplace fatalities that occurred from 2000 to 2005, 30 were female (8.3%), and 319 were male (88.1%)[20]. It is obvious that male workers are the major source of concern in relation to their involvement in the workplace fatalities. Further analysis using the normalised data showed a consistent result as obtained from the previous analysis (reported in section 3.2), indicating that the male workers aged between 55 and 64 had a higher rate of fatal incidents (3.69 per 100,000 workers per year) as compared to other age groups (45-54: 2.15; 35-44: 1.99; 25-34: 1.94; 15-24: 1.67) over the past six years (2000-05), apart from those aged over 65 who had the highest fatal incident rate (12.85), and most of them work in the agriculture sector.

4.5.4 For work employment status, 56.6% of the fatal incidents (205 out of 362 fatalities during 2000-05) were with those employed, followed by 23.2% (84 out of 362) of those self-employed, and 15.2% (55 out of 362) bystanders[21].

4.5.5 In summary, based on the data analysis using different methods and from different points of view, it has become evident that males working in agriculture industry, aged between 55 and 64, are most likely to have a fatal incident in their workplace during the summertime. This finding has been found to be conclusive and has been confirmed by different analysis and by statistical testing.

4.5.6 For the older workers aged 65 and over, although the results were not shown to be significant by statistical test, possibly due to the small data set available, their rate of involvement in the workplace fatalities was the highest among all age groups following data normalisation by worker populations. This result is indicative and can be used, in conjunction with other types of evidence, when developing safety strategies to tackle workplace fatal incidents.

[20] There were 13 cases that the victims' gender was unknown.
[21] There were 18 cases that the victims' employment status was unknown.

4.6 Summary of Contributing Factors

4.6.1 Table 5 below summaries the contributing factors which have been identified in this chapter, using correlation analysis, it does therefore not include the contributing factors extracted from the fatality reports (see 4.2.4 to 4.2.7). It must be noted that factors identified through correlation are not conclusive and they will need to be analysed/interpreted together with other factors as identified in other sources (e.g., incident investigation reports, ISE feedback), and with the support of independent evidence as reported in the next section.

Table 5 – Summary of contributing factors

Factors	Industries the factor is associated with	Correlation coefficients & level of significance	Note	Description
Workplace factors				
Hours worked per day	All industries	0.66*		More hours worked per day are related to more workplace fatalities.
	Agriculture – sub sector: Dairy & cattle farming	0.70*		Longer work hours are associated with more fatalities particular in this sector.
Level of staffing	All industries	0.63*	Monthly data 00-05	Higher level of staffing is related to more fatalities.
	Agriculture, Forestry & Fishing	0.30*	Monthly data 00-05	
	Agriculture –sub sector: Horticulture & fruit growing	0.75*	Month total 00-05	
Level of casual labour	All industries	0.60*	Monthly data 00-05	More casual labours are associated with more fatalities.
	Agriculture, Forestry & Fishing	0.28*	Monthly data 00-05	
	Agriculture –sub sector: Horticulture & fruit growing	0.76*	Month total 00-05	
Visitors/non-workers attending work sites	All industries	0.59*	Monthly data 00-05	More non-workers attending work sites are associated with more workplace fatalities.
	Agriculture –sub sector: Horticulture & fruit growing	0.74*	Month total 00-05	
	Manufacturing	0.64*	Month total 00-05	

Factors	Industries the factor is associated with	Correlation coefficients & level of significance	Note	Description
Variation in work activities	Agriculture, Forestry & Fishing	0.28*	Monthly data 00-05	More frequent variation in work activities in agriculture is associated with an increase in fatal incidents.
	Construction	-0.41*	Monthly data 00-05	More work varieties in construction are associated with fewer fatalities in this sector.
Work involving vehicles	Agriculture –Sub sector: Horticulture & fruit growing	0.71*	Month total 00-05	Work involving vehicles is related to an increase in fatal incidents.
	Construction	-0.34*	Monthly data 00-05	More vehicle use in work (e.g. prepare the work site and building materials) is related to fewer fatal incidents (possibly as there is less chance of falling from height).
Work under poor weather conditions	All industries	-0.69*		The worse the weather, the more likely a fatal incident.
Lack of recovery from fatigue	All industries	0.60*	Monthly data 00-05	Lack of recovery from fatigue is related to an increase in fatal incidents.
	Agriculture, Forestry & Fishing	0.33**	Monthly data 00-05	
	Construction	0.33*	Monthly data 00-05	
Tight timescales/ deadlines	Agriculture –Sub sector: Horticulture & fruit growing	0.75*	Month total 00-05	Tighter timescales or rush work to meet deadlines in this sector are associated with an increase in fatal incidents.
Use of hazardous substances	All industries	0.58*	Monthly data 00-05	An increase in the use of hazardous substances is associated with an increase in workplace fatalities.
Environmental factors				

Factors	Industries the factor is associated with	Correlation coefficients & level of significance	Note	Description
Mean monthly rainfall (mm)	All industries	0.29***	Monthly data 00-05	Higher rainfall is related to more fatal incidents overall.
	Cultural, recreational & other services	-0.23**		For these sectors, higher rainfall is associated with fewer fatal incidents. (Possibly due to more indoor/less outdoor activities.)
	Manufacturing	-0.22**		
	Transport & storage	-0.19*		
Mean monthly wet days (rainfall≥1mm)	Agriculture, Forestry & Fishing	0.71***	Monthly data 00-05	Wet weather/days are associated with an increase in fatal incidents in the agriculture industry.
	Construction	-0.20**		Wet weather/days are related to fewer fatal incidents in these sectors. (Possibly due to more internal work).
	Cultural, recreational & other services	-0.23**		
	Manufacturing	-0.37***		
Mean monthly air temperature (°C)	All industries	0.27**	Monthly data 00-05	Higher air temperature is associated with an increase in workplace fatalities (summertime effect)
	Agriculture, Forestry & Fishing	0.60***		
	Cultural, recreational & other services	0.40***		
	Manufacturing	0.50***		
Sunshine (hours)	Agriculture, Forestry & Fishing	0.42***	Monthly data 00-05	More sunshine hours are related to an increase in fatal incidents in these sectors (possibly due to longer work hours).
	Cultural, recreational & other services	0.37***		
	Manufacturing	0.43***		
	Transport & storage	0.20**		
Ground frost (No. of days)	Agriculture, Forestry & Fishing	-0.42***	Monthly data 00-05	More days with ground frost are associated with fewer fatal incidents in these sectors (non-summer season, possibly due to shorter work hours)
	Cultural, recreational & other services	-0.35***		
	Transport & storage	-0.35***		
Mean speed of wind (km/h)	Manufacturing	0.18*	Monthly data 00-05	Stronger wind is associated with an increase in fatal incidents.
	Transport & storage	0.21**		
Sociological factors				

Factors	Industries the factor is associated with	Correlation coefficients & level of significance	Note	Description
Overseas tourist arrivals	Agriculture, Forestry & fishing	0.31*	Monthly data 01-05	An increase in tourists is associated with an increase in fatal incidents in these sectors (also see 'casual labours')
	Construction	0.36*		
	Cultural, recreational & other services	0.58*		
	Transport & storage	0.57**		
Short-term arrivals-NZ residents	Construction	0.49*	Monthly data 00-05	An increase in temporary NZ workers is associated with an increase in fatal incidents.
School holidays	Agriculture, Forestry & Fishing	0.29*	Monthly data 00-05	More fatal incidents tend to happen in school holiday times.
	Manufacturing	0.43*		
Public holidays	Agriculture, Forestry & Fishing	0.29*	Monthly data 00-05	More fatal incidents are associated with public holidays.
Daylight saving	Agriculture, Forestry & Fishing	0.28*	Monthly data 00-05	More fatalities tend to occur during daylight saving period (overlap with summertime)
Household estimate	Cultural, recreational & other services	-0.53*		As household value increases, the number of fatal incidents tends to decrease in this sector.
Consumer Price Index (CPI)	Cultural, recreational & other services	-0.54*	Quarterly data 00-05	As the CPI increases, the number of workplace fatalities tends to decrease in this sector.
Alcohol consumption-beer	All industries	0.41*	Quarterly data 00-05	Alcohol consumption is associated with an increase in workplace fatalities.
	Agriculture, Forestry & Fishing	0.65***		
Total alcohol consumption	Agriculture, Forestry & Fishing	0.59**	Quarterly data 00-05	

Factors	Industries the factor is associated with	Correlation coefficients & level of significance	Note	Description
Tobacco consumption	Agriculture, Forestry & Fishing	0.42*	Quarterly data 00-05	Smoking is associated with an increase in the occurrence of fatal incidents. (Possibly due to the close correlation between smoking tobacco & drinking alcohol.)
Individual factors				
Age	All industries, also for ‘Agriculture, forestry & fishing’	Chi^2 test P≤0.05, and confirmed by normalisation	55-64 years old	Higher summertime fatalities
			35-44 years old	Higher autumn-time fatalities
		Normalisation only	65+	More vulnerable during the autumn
Gender	All industries	Descriptive statistics	88.1% male 8.3% female (see note 17)	The majority of workplace fatalities are male workers.
Employment status	All industries	Descriptive statistics	EMP:56.6% SE: 23.2% BS: 15.2%	Most workplace fatalities involved those who were employed, but no significant seasonal trend was found by employment status.

Note: *statistically significant at p≤0.05 level; ** p≤0.01; ***p≤0.001.

5. VERIFICATION OF CONTRIBUTING FACTORS WITH INDEPENDENT EVIDENCE

5.1 Overview

5.1.1 Independent evidence pertaining to the factors which are shown to be significantly associated with the occurrence of workplace fatalities, was collected and reviewed. This was done to find out or confirm, from a human factors point of view, which factors have been found to affect human behaviour or performance in other scientific studies. Independent evidence was also studied for some of the factors which have not been tested in the present study for their association with the occurrence of workplace fatalities (due to lack of data), but may be important for the improvement of workplace safety, especially in summertime. The findings are summarised in Table 6 below.

5.2 Summary of Independent Evidence

5.2.1 The contributing factors that have been identified in this study are shown below with a summary of the corresponding independent evidence. The strength of association of a contributing factor with the occurrence of workplace fatalities (whether it is for all industries or for a particular industrial sector) is marked by a star symbol*. Where * indicates 'significant' (where $p \leq 0.05$), and ** or *** indicates 'highly significant' ($p \leq 0.01$ and $p \leq 0.001$). This provides an indication as to the reliability of the results and the importance of the factors in their contribution to the occurrence of workplace fatalities. The level of support by independent evidence for a particular factor is subjectively assessed as 'strong', 'moderate' or 'weak'. This is based on the findings of the literature research, whether it shows a sufficient amount of evidence (strong) in relation to the factor, some indirect evidence (moderate), or little or no evidence (weak).

Table 6 – Summary of independent evidence pertaining to the factors which have been found to be significantly associated with the occurrence of workplace fatalities

Contributing factors	Significance of association[22] and strength of support by independent evidence	Independent evidence
Workplace (and performance based) factors		
Hours worked per day (work duration); and issues about Shift work	1. All industries* 2. Agriculture – sub sector: Dairy & cattle farming* Independent evidence support: **Strong**	Long hours of work may result in workers obtaining less than the necessary 7-8 hours of sleep and cause fatigue (Hartley et al., 1995). The relative risk of crash involvement for vehicle drivers who reported a driving time in excess of 8 hours was almost twice that for drivers who had driven fewer hours (Jones and Stein, 1987). 'Hours worked per week' was identified to be an important risk factor related to machine-related farm injuries. Dairy farms, farms with non-resident workers, and large farms were associated with an increased risk of injuries (Layde et al., 1995). Haque and Bott (1997) stated that "…a driver working shifts may be 'out of synch' with his friends, family and the neighbourhood in general." This problem could be worse in summer due to social events like picnics and barbecues, etc.

[22] $*p \leq 0.05$; $**p \leq 0.01$; $***p \leq 0.001$.

Contributing factors	Significance of association[22] and strength of support by independent evidence	Independent evidence
		Shift work contributes to fatigue in workers because it limits the amount of sleep that workers are able to obtain to ensure that they are able to maintain sufficient alertness when at work (Folkard and Monk, 1985). For example, human error and poor judgement, related to sleep loss and shift work during the early morning hours, were cited as contributing to the Space Shuttle Challenger incident (Folkard and Sutton, 2000). An Indian study examined the risks of heat induced workplace incidents (4125 cases in the textile industry) and the heat tolerability of the rotating day and permanent night shift workers in hot-dry and hot-humid environment (Nag and Nag, 2001). Incident prevalence was significantly high in the summer months when the ambient temperature was high (hot-dry). The influence of hot climate in incident causation was evident from the shift-wise variations in the occurrence of incidents. The longitudinal study showed that the night workers were more vulnerable and less tolerant to heat, as compared to the rotating day workers. (Also see 'Temperature').
Level of staffing	1. All industries* 2. Agriculture, forestry & fishing* 3. Agriculture –sub sector: Horticulture & fruit* Independent evidence support: **Moderate**	Staffing levels are related to worker stress and workload, which in turn affect the likelihood of human error (e.g., Reason, 1990; Parkes and Sparkes, 1998). Nurse staffing has been related to patient safety. Research reveals a close link between inappropriate nurse staffing levels and higher rates of unwanted outcomes for patients (CHSRF, 2006).
Level of casual labour	1. All industries Agriculture, Forestry & Fishing* 2. Agriculture –sub sector: Horticulture & fruit growing* Independent evidence support: **Moderate**	Zierold et al. (2004) reported a survey result concerning summer work and injury among middle school students. Of the 3189 'working students' who responded to the survey, the majority were employed in informal job settings such as working for someone in a home, newspaper delivery, and working on family farms or family businesses. Overall, 18% of children reported being injured at work. Variables that were associated with injury included having a 'near miss' incident at work, having a co-worker injured, and being asked to do something dangerous. The health and safety issues of casual, temporary and migrant labour, especially in agriculture, have been recognised by HSE[23]

[23] HSE, 2006: Health and Safety in agriculture. http://www.hse.gov.uk/agriculture/hsagriculture.htm

Contributing factors	Significance of association[22] and strength of support by independent evidence	Independent evidence
Visitors/non-workers attending work sites	1. All industries Agriculture, Forestry & Fishing* 2. Agriculture –sub sector: Horticulture & fruit growing* 3. Manufacturing* Independent evidence support: **Weak**	Pickett et al. (1995) identified the four most common reasons for children's involvement in fatal incidents with farm tractors: inadequate supervision, permitting children to be in the area of moving or unguarded machinery, allowing children to accompany workers using farm machinery, and having children performing work related tasks inappropriate for their age. (Also see 'Industrial/occupational related evidence').
Variation in work activities	1. Agriculture, Forestry & Fishing* 2. Construction* Independent evidence support: **Weak**	N/A
Work involving vehicles	1. Agriculture –Sub sector: Horticulture & fruit growing* 2. Construction* Independent evidence support: **Moderate**	In the agriculture industry in the UK, of the 489 people killed over the past 10 years (1995-2005), transport related incidents (being run over or vehicle overturns) accounted for 24% of fatalities.
Work under poor weather conditions	All industries*	See 'Environmental factors'.

Contributing factors	Significance of association[22] and strength of support by independent evidence	Independent evidence
Lack of recovery from fatigue	1. All industries* 2. Agriculture, Forestry & Fishing** 3. Construction* Independent evidence support: **Strong**	Fatigue is directly related to human error and incident occurrence (e.g. Haworth et al., 1989; Reason, 1990). Philip et al. (1996) surveyed 567 vehicle drivers travelling on summer vacations on a European highway for their subjective daytime sleepiness while driving and any sleep deprivation just prior to departure. 50% of the responders had a sleep restriction just prior to departure (mean –203 minutes) compared to usual total sleep time during the year; 10% had no nocturnal sleep prior to departure. Drivers younger than 30 years were significantly more acutely sleep deprived than other drivers. Economic migrants (those with low economic status) also experienced significant acute sleep restriction. Fatigue can also be viewed as having a multifactorial origin, influenced by non-work related circumstances and personal characteristics, with a prolonged character that may affect an individual's performance and ability to function at work (Lewis and Wessely, 1992). Fatigue can reduce the ability of the worker to process important visual and perceptive information relevant to avoiding an incident (Hsiao and Simeonov, 2001). Fatigue and need for recovery were found to be independent risk factors for being injured in an occupational incident (Swaen et al., 2003).
Tight timescales/ deadlines	Agriculture –Sub sector: Horticulture & fruit growing Independent evidence support: **Strong**	There is a large quantity of evidence to show that increased time pressure (e.g., due to late service) and mental workload lead to stress, decreased human performance, inattention and more human error (e.g., Michon, 1985; Hancock, 1989; Reason, 1990; Schlegel, 1993; Hancock et al. 1995). Vehicle drivers are found to be stressed and irritated in traffic congestion and tend to exhibit aggressive or unsafe behaviour when driving in those situations (Turner et al., 1975; Stokols et al., 1978; Hennessy and Wiesenthal, 1997).
Use of hazardous substances	All industries* Independent evidence support: **Weak**	A British study confirmed that chemical incidents were most frequent in the summer, between 12:00 and 17:59, and least frequent between 0:00 and 5:59 (Olowokure et al., 2004). (Also see 'Time of day').
Time of day (and time into shift)	All industries*** Agriculture, Forestry & Fishing*** (Figures 23 & 24) Independent evidence support: **Strong**	Research has shown truck drivers are susceptible to both sudden fatigue, due to temporary irregularities of the sleep cycle, and accumulated fatigue due to long working hours (US Congress, 1988). In fact, most road incidents occur between 4am and 7:30 am, which is well within the time span when drivers are most likely to fall asleep. There is also a crash risk during the mid-afternoon 'siesta hours' (Mitler et al., 1988). Monthly variation of road traffic incidents in Riyadh, Saudi Arabia, between 1989 and 1993 was reported by Nofal and

Contributing factors	Significance of association[22] and strength of support by independent evidence	Independent evidence
		Saeed (1997) with reference to time of day, lighting conditions and weather conditions. Total incidents were found to be positively correlated with increased temperatures and inversely correlated with increased relative humidity and rain. Maximal incident rate was evident during the summer season particularly between 12 noon and 15:00. This period is characterized by heavy traffic and intense sunlight in their local environment. Folkard (1997) analysed several previous studies of hours of driving and crash risk and found that there was a rise in likelihood of a crash at 2 hours into the trip before risk dropped back to starting levels at 4 hours into the trip. The likelihood of a crash then started to rise again the more hours driven until at 11 hours the risk was higher than at any previous time. This result was in agreement with another study of lorry drivers that showed that the risk of an incident was worst in the first 4 hours of a shift unless the driver worked for longer than 12 hours (Hamelin, 1987). In order to understand time-related incident risk with shift work in Poland, Oginski et al. (2000) investigated 668 incidents in the metallurgical industry in terms of time of day, time on task, consecutive day of the shift block, day of the week, and season. The incident rate was similar on all shifts but more severe incidents happened in the night time. Somewhat more incidents occurred in the second half of the shift, in the second part of a shift block, and in summer compared with winter. There were fewer injuries at weekends. A Swedish study demonstrated that the peak traffic incident risk was at 4:00am for the summertime, shortly after the early summer sunrise and with consistently higher night time risk than for winter driving. It was concluded that early morning driving is several times more dangerous than driving during the forenoon. Apart from alcohol the effect seems related to sleepiness, but not to darkness (Akerstedt et al., 2001). The work-related fatal traffic injuries in New Zealand have been found to peak at around 10am, and remained relatively high from 10am till 15:00 (New Zealand Environmental and Occupational Health Research Centre, 2003). A UK study on SPAD incidents with normalised data showed peaks in early morning (7:00-8:00), after lunch (14:30-15:00), and late evening (around 22:30) (Li and Lock, 2003). Olowokure et al. (2004) reported that chemical incidents in the UK were most frequent in the summer, between 12:00 and 17:59, and least frequent between 0:00 and 5:59. (Also see ‘Day of the week’). In a study related to road incidents in the UK, ‘at blame’ company car drivers were found to have two peak times for

Contributing factors	Significance of association[22] and strength of support by independent evidence	Independent evidence
		incident involvement. The first was between 8:00 and 9:00 in the morning; the second was between 8:00 and 9:00 in the evening (Clarke et al., 2005). (Also see 'Circadian rhythms – reduced wakefulness/alertness')
Day of the week	All industries*** (Figure 26) Independent evidence support: **Strong**	Williams' analysis of causes of SPADs (1977) suggested that day of the week was a relatively unimportant factor. var der Flier and Schoonman (1988) determined that the distribution of incidents throughout the days of the week corresponds with the number of driver shifts. Their report supported the suggestion that the important factor is not the day of the week but the time when an incident occurs in relation to the individual's shift pattern. Adcock & Sparkes (1993) determined that SPAD rates are lower at weekends than on weekdays. The day with the least amount of SPADs is Sunday, it was thought that this was because (at that time) Sunday work was voluntary and therefore the drivers working on that day were self-selected and perhaps keener. This was more likely due to reduced service levels at weekends. A Polish study reported that in the metallurgical industry, there were fewer incidents at weekends as compared to weekdays (Oginski et al. 2000) (Also see 'Time of day'). On New Zealand's roads, most working crashes (94%) occurred between Monday and Saturday, and the incident rates on each of those days were similar. Most commuting crashes (85%) happened between Monday and Friday. A minority of working decedents (6%) or commuters (6%) were fatally injured outside the working days (New Zealand Environmental and Occupational Health Research Centre, 2003). In a UK study, Olowokure et al. (2004) investigated whether there were temporal or seasonal patterns in the occurrence of chemical incidents recorded from January 1997 to December 2001. The data analysis showed more incidents occurred in the summer and they were more likely to occur on Thursdays and least likely on Saturdays. Incidents were most frequent between 12:00 and 17:59 and least frequent between 0:00 and 5:59.
Industrial/ occupational related evidence	See the results of detailed analysis in section 3.2 Independent evidence support: **Strong**	In a study to assess rates and patterns of agricultural machinery injuries in farm children over a 5-year period ending 31 March 1990, Pickett et al. (1995) identified a prominent summer peak in the occurrence of fatal injuries. The farm tractor was the machine most commonly associated with these injuries. Common reasons associated with the injury risk included: inadequate supervision, permitting children to be in

Contributing factors	Significance of association[22] and strength of support by independent evidence	Independent evidence
		the area of moving or unguarded machinery, allowing children to accompany workers using farm machinery, and having children performing work related tasks inappropriate for their age. Rodriguez et al. (1996) identified that incidents with tractors are a major preventable morbimortality factor in rural areas for children safety. An early study found that the industries with the highest rates of work-related death were ‘Mining’, ‘Agriculture, Forestry and Fishing’, ‘Construction’, and ‘Transport & storage’ (New Zealand Environmental and Occupational Health Research Centre, 1999). Falls from heights were found to be one of the main concerns with migrant workers in farming industry in Greece (Alexe et al., 2003). Young migrant workers also tend to suffer severe multiple injuries from machinery. The study suggested the enforcement of safety guidance and regulations for poorly trained workers including migrants concerning farming machinery, and discouragement of risky farming activities among elderly individuals. (See also ‘Tourists’). Pegula (2004) reported that in the USA, the industries with overall fatality rate (measured as per 100,000 workers from 1995 to 2001) from high to low were: mining (26.0), agriculture, forestry and fishing (23.2), construction (13.9), transportation and public utilities (12.4), wholesale trade (4.7), manufacturing (3.4), retail trade (2.8), services (2.0), and finance, insurance and real estate (1.2). A Canadian study looked into the magnitude of both fatal and non-fatal farm machinery injuries in Alberta children and adolescents (0-17 years) between 1990 and 1997 (Lim et al., 2004). A total of 302 farm machinery injuries were recorded in this period, and of these, 14 resulted in death. ATVs were the most common cause of injury (n=76, or 25.2%), followed by tractors (n=72, 23.8%), and power take-offs (n=15, 5.0%). The predominant injury mechanism was entanglement (n=69), followed by falls from machines (n=57), and being pinned/struck by a machine (n=49). There were significantly more injuries reported during the summer and autumn than during the winter and spring. Those injured in the autumn were significantly older than those injured in the spring; and injury rates were significantly higher during the school holidays. In a study to determine occupational facial fractures in central Switzerland during 2000-02, Eggensperger et al. (2006) found that 69% of the injuries occurred in farm and forestry workers and in construction labourers during the summertime (33%). Workers in these occupations carried a 127-fold (for farm and forestry) and a 44-fold (construction) higher risk of incurring maxillofacial injuries than did service and office workers. The incidents were most frequently caused by being struck by an

Contributing factors	Significance of association[22] and strength of support by independent evidence	Independent evidence
		object or an animal. The study called for the introduction of personalized safety measures in these high-risk occupations. Railway related incidents in Turkey account for 213 deaths per year per 100 million passengers during 1997 and 2003 (Ozdogan et al., 2006). This quoted study evaluated the epidemiological aspects of these casualties and found that train-pedestrian incidents caused the highest number of mortality and level crossing incidents caused the highest numbers of casualties. The majority of the fatalities and injuries occurred in males and most often in the 25-60 age group. Summer time was the season with the highest number of fatalities and injuries. (Also see 'Age' and 'Gender').
Environmental factors		
Rainfall	1. All industries*** 2. Cultural, recreational & other services** 3. Manufacturing** 4. Transport & storage* Independent evidence support: **Moderate**	Williams (1977) investigated the possibility of the influence of rain on SPADs. Particularly the possibility that it may influence distance perception and cause misjudgement. He found that there was an approximate 60% increase in the perceived distance of a signal in 'rain conditions'. Schandersson (1993) conducted a quantitative analysis of external factors associated with road incidents. The analysis "indicates that although heavy rainfall increases incident risk, small amounts of rain might actually decrease the incident rate compared to dry conditions. These results are not satisfactorily explained by differences in speed. Most likely there are also other aspects of driver behaviour that are important - aspects related to driver vision and behaviour." For railway related incidents, evidence suggests that rain (especially heavy rain) does not reduce adhesion as much because it tends to wash the rails and remove the slurry (Jenks, 1997).
Wet day	1. Agriculture, Forestry & Fishing*** 2. Construction** 3. Cultural, recreational & other services** 4. Manufacturing*** Independent evidence support: **Moderate**	In two of the nine 'accident accounts' of a work-related road traffic incidents (Clarke et al., 2005), the feature of wet day was mentioned: "It was early in the morning on a wet day in autumn….", or "It was the middle of the morning on a wet day in winter…".
Temperature	1. All industries** 2. Agriculture, Forestry & Fishing*** 3. Cultural, recreational & other services*** 4. Manufacturing***	Joki (1982) reported decreases in human performance as the temperature rises. This was based on observations of both physical work and office work. A study by Ramsey et al. (1983) of unsafe behaviours in industrial settings showed a rise in safety-related errors began at about 74°F (23°C) and increased with temperature, particularly at high workload levels.

Contributing factors	Significance of association[22] and strength of support by independent evidence	Independent evidence
	Independent evidence support: **Moderate**	Ramsey (1995) concluded from a review of past studies that, as long as a hot climate is not 'uncomfortable', neither light physical work nor mental task performance was affected by a warm environment. However, as the temperature rises above the comfort level, problems may arise first of a subjective nature and then of physical problems which impair workers' efficiency. High temperature during summer has been identified as a major factor contributing to increased road incidents in Saudi Arabia (Nofal and Saeed, 1997). The authors suggested that the high temperature especially between 12 noon and 3pm might lead to increased stress and decreased performance of intellectual tasks which require considerable physical effort and motor skills. (Also see 'Time of day'). Ergonomics guidelines recommend a comfortable air temperature in summer should be between 20 and 24°C (20-21°C in winter) (Kroemer and Grandjean, 1997). ISO 7730 (1994) recommends a summer temperature range of 72-78°F (22.2-25.6°C) and ASHRAE Standard for Thermal Comfort makes a similar recommendation. Buxton et al (1999) reported that thermal environment was an important factor influencing driver performance. However, their measurements of the thermal environment in train cabs did not show that the environment was stressful, this may be partially due to the fact that their measurements were taken in the winter only. Nag and Nag (2001) studied the risks of heat induced workplace incidents in Indian textile industry, and the heat tolerability of the rotating day and permanent night shift workers in hot-dry and hot-humid environment. They found that incident prevalence was significantly higher in the summer months when the ambient temperature was high (hot-dry). The longitudinal study showed that the night workers were more vulnerable and less tolerant to heat, as compared to the rotating day workers. (Also see 'Hours worked per day; and issues about shift work'). The relationship between hot weather conditions and work-related incidents in central Italy was investigated by Morabito et al. (2006) over a 6-year period (1998-03). The findings indicate that hot weather conditions might represent a risk factor for work-related incidents during summer. The peak of work-related incidents occurred on days characterized by high, but not extreme, thermal conditions. Workers were reported to change their behaviour when heat stress increases, reducing risks by adopting preventive measures. The study suggested that days with an average daytime AT (Apparent Temperature) value ranging between 24.8C° and 27.5C° were at the highest

Contributing factors	Significance of association[22] and strength of support by independent evidence	Independent evidence
		risk of work-related incidents. Such information may be useful for the development of a watch/warning system that might be used by employers for planning work activities.
Sunshine hours	1. All industries* 2. Agriculture, Forestry & Fishing*** 3. Cultural, recreational & other services*** 4. Manufacturing*** 5. Transport & storage** Independent evidence support: **Moderate**	Dray et al. (1999) found that sunlight is the primary contributing factor identified as leading to 'misread' SPADs. Prolonged visual exposure to bright sunlight reduces the sensitivity of the eyes to visual targets with different luminance levels and delays dark adaptation (Hood and Finkelstein, 1986).
Ground frost	1. Agriculture, Forestry & Fishing*** 2. Cultural, recreational & other services*** 3. Transport & storage*** Independent evidence support: **Weak**	N/A
Strong wind	Manufacturing* Independent evidence support: **Weak**	N/A
Sociological factors		
Summer months/ season	See the results of seasonal trend analysis in section 3.2 Independent evidence support: **Strong**	Smith et al. (1986) reported that, in Georgia, motorcycle-associated fatalities occurred most frequently during summer months, on weekends, and during afternoon and evening hours. A similar trend has also been reported by others demonstrating that more traffic incidents occurred in the summer, and more frequently at 12-18 hours driving (Beyaztas and Alagozlu, 2002). Abel and Welte (1987) reported an analysis of monthly, seasonal and day-of-the-week trends for four types of violent deaths (suicide, homicide, traffic incident and miscellaneous accident) which occurred in Erie County, New York, between 1973 and 1983. Of a total of 3787 violent deaths, there was no seasonal trend noted for any type of death except traffic deaths, which increased during the summer. There was a general trend for increased deaths on weekends for each type of death except suicide. The authors speculate that this

Contributing factors	Significance of association[22] and strength of support by independent evidence	Independent evidence
		culturally entrained temporal variable may be related to increased alcohol consumption during weekends. Niino et al. (1995) reported a Japanese study to assess the prevalence and circumstances of falls by season among the elderly living in a rural community. Interview surveys were conducted among 1321 elderly individuals (aged 65+) every three months between 1992 and 1993. The results showed the prevalence of falls (i.e., the rate of those surveyed with falls) were 7.4% in summer, 5.9% in autumn, 6.5% in winter and 6.7 in spring. However, the seasonal variation was not statistically significant. Also in each season, there was no significant difference between genders. The seasonal differences in rate of falls were considered to be due to the climate change of the area. Rodriguez et al. (1996) reported a review of a small sample (11) of serious childhood injuries related to tractor incidents in Chile. The majority of the incidents occurred in males and during the summer months. The authors suggested that incidents with tractors are major preventable morbimortality factor in rural areas. (Also see 'Industrial/occupational related evidence'). In a study to examine the patterns of seasonal variation in mortality in Moscow between 1993 and 1995, McKee et al. (1998) found a marked summer increase in accidental deaths among young people, especially from incidents and other deaths associated with alcohol consumption. Wick et al. (2006) reported that in Australia, most accidental deaths in adults due to electrocution occurred in late spring and summer, accounting for 64% of the total cases investigated over a 30-year period from 1973 to 2002. The lowest number of accidental deaths occurred in winter and early spring. This report also showed a significantly higher rate of electrocution deaths among males, with a summer predominance of fatal incidents, most likely due to increased outdoor activities in better weather conditions. In a PhD Thesis, Moore (2006) reported that all LCE (Loss of Control Events) and the LCE with serious injury outcomes in New Zealand farms have high summer and early spring peaks. The research also showed that over half of all LCE, not just the January ones, take place on hard and dry ground; and about a third take place in the muddy wet slippery conditions. The author stated that quadbikes work best in soft ground conditions where the contract area between tyre and ground is high. They loose traction more easily on hard ground especially if the surface has been made slick by a shower.

Contributing factors	Significance of association[22] and strength of support by independent evidence	Independent evidence
Tourists	1. Agriculture, Forestry & Fishing* 2. Construction* 3. Cultural, recreational & other services* 4. Transport & storage** Independent evidence support: **Moderate**	Young migrant workers were found to be more likely to have incidents (e.g. falls from heights, injured by machinery) in the agriculture industry in Greece (Alexe et al., 2003). (Also see 'Industrial/occupational related evidence').
School holiday	1. Agriculture, Forestry & Fishing* 2. Manufacturing* Independent evidence support: **Moderate**	In a Canadian study looking into the magnitude of both fatal and non-fatal farm machinery injuries in Alberta children and adolescents (0-17 years) from 1990 to 1997, along with other findings, Lim et al. (2004) found that machinery injury rates were significantly higher during the school holidays than during the study period. (Also see 'Industrial/occupational related evidence').
Public holiday	Agriculture, Forestry & Fishing* Independent evidence support: **Moderate**	Farmer and Williams (2005) examined fatal vehicle crash deaths in the USA from 1986 to 2002 by time of day, day of week, month, and season, and to explore why some days of the year tend to experience a relatively high number of fatalities. Their analysis revealed that summer and fall months have more crash deaths than winter and spring, largely due to increased vehicle travel. July 4 (Independence Day) has more crash deaths on average than any other day of the year, with a relatively high number of deaths involving alcohol. January 1 (New Year's Day) has more pedestrian crash deaths on average, also due to alcohol impairment. On other days the high fatality rates are likely due to increases in holiday or recreational travel. (Also see 'Alcohol').

Contributing factors	Significance of association[22] and strength of support by independent evidence	Independent evidence
Daylight saving	Agriculture, Forestry & Fishing* Independent evidence support: **Moderate**	Whittaker (1996) reported the effect of British Summer Time (BST) on road traffic incident casualties over a 10-year period (1983-93), by comparing incident data (4185 casualties in total) from before and after the onset of BST. The results indicated that the onset of BST in spring was associated with reductions in casualty numbers of 6% in the morning and 11% in the evening. The change back to Greenwich Mean Time (GMT) in autumn produced a reduction (6%) in casualties in the lighter mornings. The darker evenings were associated with significant increases in casualties (4%). There was an overall net reduction in casualty numbers when the analysed period of BST were compared to those during GMT. In the summer of 1980 for the first time clocks in the Federal Republic of Germany were advanced 1h ahead of Central European Time (CET), which had been in use until then. A study was conducted to examine a sample of a total of 1070 accident patients who had incidents on data pairs taken from the moths of May 1979 and May 1980, before and after the introduction of the CEST, Central European Summer Time. A statistically significant increase in incident frequency between 7:30pm and 5:30am was found for the year in 1980 as compared to 1979. This observed increase in incidents was considered to be related to the change in routine for the adaptation to daylight saving time (Pfaff and Weber, 1982). That study also noted that the influence of CEST apparently exceeds a short adjustment phase, and suggested further studies to investigate a possible correlation between daylight saving time and an increased risk of incidents. Whittington (1981) reported that most fatal motorcycle incidents occurred in the summer. (Also see 'Alcohol').
Household	Cultural, recreational & other services* Independent evidence support: **Weak**	Those with low economic status (such as economic migrants) have been reported to experience significant acute sleep restriction during summer, which contributes to lack of recovery from fatigue (Philip et al., 1996). (Also see 'Lack of recovery from fatigue').
Consumer price index	Cultural, recreational & other services* Independent evidence support: **Weak**	N/A

Contributing factors	Significance of association[22] and strength of support by independent evidence	Independent evidence
Effect of alcohol	1. All industries* 2. Agriculture, Forestry & Fishing*** Independent evidence support: **Strong**	Alcohol leaves the body at a rate of 7-10g/hour (1 unit). If an individual imbibes 6 pints of premium strength beer (12 units) during an evening (from 20:00), then ethanol will still be detectable in their blood at 11:00 (13 hours later). (Morgan and Ritson, 2003). Whittington (1981) analysed 51 fatal motorcycle incidents and found that fatal injuries were frequently associated with alcohol consumption and excessive speed. In addition, all those victims were male, and most incidents occurred in the summer. McLellan et al. (1990) carried out a 3-year study to determine the demographics, injury severity, and alcohol positivity of motor vehicle crash victims. The study found a marked seasonal variation in BAC (blood alcohol concentration) positivity, with 46.1% of drivers positive during the summer months. Gilchrist (1990) reported that 20% of SPAD offenders were physically or psychologically unfit at the time of the incident. In a study examining fatal vehicle crash deaths in the USA from 1986 to 2002, Farmer and Williams (2005) reported that July 4 (Independence Day) has more crash deaths on average than any other day of the year, with a relatively high number of deaths involving alcohol. January 1 (New Year's Day) has more pedestrian crash deaths on average, also due to alcohol impairment. (Also see 'Public holiday'). Alcohol consumption, its consequences as a seasonal phenomenon in Estonia, and the social and environmental factors affecting this seasonal change were studied by Silm and Ahas (2005) through a survey among 87 university students. As expected, the peak period of beer and wine consumption is in the summer. These were in line with the seasonal variability of traffic incidents and the frequency of medical treatment. The authors also noted that such a seasonal trend is influenced by, or interlinked with, some natural factors such as temperature and humidity, and some social factors such as celebrations and vacations.
Tobacco/ smoking	Agriculture, Forestry & Fishing* Independent evidence support: **Moderate**	Smoking was significantly related to the risk of being injured in an occupational incident (Swaen et al., 2003). Smoking is regarded as a confounding factor (with alcohol consumption) for raised blood pressure and violent death (Scottish Intercollegiate Guidelines Network, 2003).

Contributing factors	Significance of association[22] and strength of support by independent evidence	Independent evidence
Use of mobile phone while working		Burns et al. (2002) conducted a study comparing the danger of driving a car whilst using a mobile phone with that of driving under the influence of alcohol. They found that even the use of a hands-free phone is more dangerous than driving with more than the UK legal limit of alcohol (80mg/100ml) in the bloodstream.
Individual factors		
Age	1. All industries* 2. Agriculture, Forestry & Fishing* Independent evidence support: **Strong**	Zhang et al. (1998) examined the patterns of fatal motor vehicle traffic crashes (MVTC) by age group (16-24, 25-64, 65+) among Canadian drivers between 1984 and 1993. Compared to the middle-aged group as a reference population, young drivers demonstrated excess risk for risk-taking behaviours and conditions, alcohol and illicit drug use, speeding, non-use of seat belts, fatigue, falling asleep, and inexperience. They also had higher risks during the summer. Excess risk among elderly drivers was noted for their medical and physical conditions, inattention, and improper control actions. The study demonstrated a need for preventive efforts that incorporate age-specific strategies. A previous study on work-related fatal injuries in New Zealand found that there was a dramatic increase in the rate of work-related injury death for those over the age of 65 years (New Zealand Environmental and Occupational Health Research Centre, 1999). In the Netherlands, van Rossum et al. (2001) conducted a 25-year follow-up study of 19019 male civil servants aged 40-69 years to determine the seasonal effect on all-cause and cause-specific mortality and to identify high-risk groups. The results showed a seasonal all-cause mortality, with the ratio of highest mortality rate during winter versus lowest rate during summer of 1.22 (95% CI: 1.1-1.3), largely due to the seasonal nature of ischaemic heart disease, and with older age groups. (Also see ‘Gender’, and ‘Industrial/occupational related evidence’). A study in the US confirmed that “Regardless of the type of workers, the fatality rate of workers aged 55 and older is greater than the fatality rate of workers aged 16 to 54” (Pegula, 2004). Numerous issues on age-related changes in human capabilities especially in vision and some cognitive functions have been reviewed in Li (2004). As is commonly understood, ageing has been related to various types of functional changes, normally towards a capability reduction. This has many implications for work safety of the elderly workers.

Contributing factors	Significance of association[22] and strength of support by independent evidence	Independent evidence
Gender	All industries Majority with male (88.1%) and minority with female (8.3%) Independent evidence support: **Strong**	A previous study investigating work-related fatal injuries in New Zealand reported that the majority of deaths were of males, and their rate of death was more than 30 times that of females (New Zealand Environmental and Occupational Health Research Centre, 1999). The involvement in work-related road traffic incidents was found to be heavily biased towards male drivers/workers, with a male to female ratio of 14.5:1 (Clarke et al., 2003). Wick et al. (2006) reported a significantly higher rate of electrocution deaths among males (M:F=63:3), with a summer predominance of fatal incidents. (Also see 'Summer months/ season'). Ozdogan et al. (2006) reported that most railway related fatalities and injuries in Turkey were in males, and most of the victims were aged between 25-60 years. (Also see 'Industrial/occupational related evidence').
Employment status	All industries EMP: 56.6% SE: 23.2% BS: 15.2% Independent evidence support: **Strong**	The majority of work-related deaths in New Zealand during 1985-1994 were of employees, but the rate of death was also consistently higher for self-employed persons. (New Zealand Environmental and Occupational Health Research Centre, 1999). From 1995 to 2001 in the USA, the wage and salary workers suffered more than 3 times as many fatal occupational injuries as did self-employed workers. However, there were 9 times as many workers in the wage and salary group than in the self-employed group. When fatality rates are compared, the self-employed workers were 2.7 times more likely to be victims of fatal work injuries than their wage/salary counterparts (Pegula, 2004). In a study carried out in England and Wales during periods of four years around the 1981, 1991, and 2001 censuses, Edwards et al. (2006) found that the overall rates of death from injury and poisoning in children have fallen in England and Wales over the past 20 years, except for rates in children in families in which no adult is in paid employment.

Contributing factors	Significance of association[22] and strength of support by independent evidence	Independent evidence
Other personal or medical issues		Anderson et al. (2004) examined if there are diurnal, weekly or seasonal variations in the occurrence of stroke by a population-based study in Auckland. They found that strokes were less likely to occur during the summer and autumn than in the winter or spring. They also noted an increase in the stroke occurrence in the late morning. A Japanese study found that stroke occurred most frequently in summer (26.0%), followed by autumn (25.8%), winter (25.3%), and spring (22.9%). No differences in age were observed among the four seasons, but stroke in men were more frequently observed in summer compared to other seasons. (Ogata et al., 2004).
Circadian rhythms – Reduced wakefulness (alertness)		Researchers have found that 'the neural processes controlling alertness and sleep produce an increased sleep tendency and diminished capacity to function during certain early morning hours (2-7am) and to a lesser degree, during a period in the mid-afternoon (2-5pm), whether or not we have slept' (Mitler et al., 1988). It is well established that the body temperature rhythm is intimately coupled to cyclic changes in arousal such that there is a more pronounced tendency towards sleepiness at certain times of day. During these periods (2-7am, 2-5pm), we are most likely to 'nod off' unintentionally. It is during these times that drivers are most likely to be 'asleep at the wheel', having 'microsleeps, which may result in inattention, forgetfulness and other performance lapses (Mitler et al., 1988; Pheasant, 1991). (Also see 'Time of day').

Contributing factors	Significance of association[22] and strength of support by independent evidence	Independent evidence
Worker return to duty after a holiday break	N/A	A variety of incidents, such as road incidents, have been linked with post-holiday fatigue and lack of sleep, along with recovery from increased alcohol intake. It has been suggested that people take 'power naps' (a short 20 minute rest) during the workday to aid recovery from holidays, as this can increase productivity, and reduce errors & incidents. Within the nuclear industry, Lewis and Swaim (1986) found that shift workers have shown greater impairments at shift handover following a block of 7-8 consecutive days off, compared with a block of 4 consecutive rest days. Wharf (1993) reported that safety risks were higher for the first shift back after time off, although it was unclear whether these were related to the length of time absent. Gilchrist (1990) found that when driving certain units for the first time or after a long break, drivers were more likely to have a SPAD. In a study of air traffic controllers, Becker and Milke (1998) suggested that the ability to handle simultaneous visual and auditory information, or to return to a task after a break, is critical to task performance, and this is the sort of cognitive function most affected by age. Based on the rail incident data recorded from 1998 to 2002, Li (2003) and Li and Lock (2003) reported that train drivers tend to have 191% more SPADs after a period of annual leave than predicted by chance alone. A more recent study by Gibson et al. (2006) found an increased risk of SPADs when the drivers having only a single day's break; a decrease in SPAD risk for breaks between 3 and 7 days; and an increase in risk following a break of at least 7 days or more.

Note: *$p \leq 0.05$; **$p \leq 0.01$; ***$p \leq 0.001$; N/A – Data or independent evidence was not identified or available at the time when this study was carried out.

6. DISCUSSION

6.1 Overview

6.1.1 This study has reviewed the workplace fatality data recorded by the Department of Labour from 2000 to 2005 inclusive in order to investigate seasonal trends and possible contributory factors. The findings of this study are discussed in the following sections, along with associated strategies for the reduction of workplace fatality risks.

6.2 Annual Trends

Overall trend

6.2.1 This study has confirmed an annual trend of workplace fatalities with a peak between 2001 and 2002 (73-74 cases per year). Since then there was a gradual decline in the workplace fatal incidents until 2004. However, the occurrence of fatal incidents at work increased by some 38% from 2004/05 to 2005/06 (Figure 1). Such a trend has been confirmed by normalised data (Figure 2) and by statistical test.

Trends of workplace fatalities and serious harm injuries

6.2.2 By comparing the trend of fatality data with the serious harm data over the same 6-year period (Figure 3, page 9), it is interesting to see that the pattern of changes of the two types of incidents are different year on year. The pattern of serious harm incidents is not indicative of the pattern of workplace fatalities. For example, the workplace fatality rate first decreased from 0.97 per 100,000 workers in 2002 down to 0.79 in 2003, and to 0.58 in 2004; then increased to 0.78 in 2005. During the same period, however, the rate of serious harms first increased from 0.75 per 1000 workers in 2002 to 0.85 in 2004, and then dropped to 0.5 by 2005. The reasons for such a controversial trend in these two types of incident data are unknown, but one explanation is that it may be due to the change in the incident reporting/data recording system over the past two to three years. It was pointed out by some experts that there had been an issue of over-reporting of serious harms in the past, but this situation may have been improved through policy changes for the assessment and recording of work-related serious harms in the database.

6.2.3 Preliminary analysis of seasonal trends in the serious hard data showed further disparities with departmental fatality data, see 6.3.4.

6.2.4 While the focus of the present study is on the issue of workplace fatalities, it is suggested that further research should be carried out to study the data of work-related serious harms for their seasonal trends and for their causal factors.

Trends by industry and by regions

6.2.5 The annual trends by industry (Figures 4 & 5, page 10) indicate that industrial sectors such as ‘Agriculture, Forestry & Fishing’, ‘Transport & storage’, and ‘Construction’ have shown a tendency of increased workplace fatalities since 2003. However, the current data set is not large enough to provide a conclusive result on these trends. Similar issue exists with the annual trend by regions (shown in Figure 6, page 11). Therefore, given the current data set, it is considered to be more appropriate to look at the annual trend of workplace fatalities at a national level, rather than by industries or by regions (Figure 6, page 11).

6.3 Seasonal Trends

Overall trend

6.3.1 The seasonal trend of workplace fatalities is the primary focus area of the present study.

6.3.2 The monthly trend of the 6-year data (2000-05) appears to show a January peak (Figure 7, page 12), although such a trend cannot be confirmed with statistical testing because of the small data set.

6.3.3 However, when analysing the data by seasons (Figure 8, page 13), the data did show a significant seasonal variation ($p \leq 0.05$) and a summer peak, followed by autumn, in the occurrence of workplace fatalities. This trend has been supported by the normalised results (Figure 9, page 13) as well as by a sufficient amount of independent evidence (summarised in Table 5) confirming that more work-related incidents (including fatal and non-fatal) tend to occur in the summer and autumn months.

Seasonal Trends in the serious harm data

6.3.4 A preliminary analysis of the serious harms data over the same period (2000-05) indicated that the workplace incidents resulting in serious harm injuries occurred more often during autumn and winter than in spring and summer. In fact, summer season had the lowest level of serious harm injuries (See Figure 30. This trend is highly significant ($p<0.001$). The reason for the difference in the seasonal trends between workplace fatalities and serious harms is not well understood at this stage. There is an assumption that lower serious harm numbers may be an artefact of lower workplace participation over the summer holiday period. Further investigation is required to understand and analyse the serious harms data in greater detail, using normalisation to account for the effects of seasonal labourers etc.

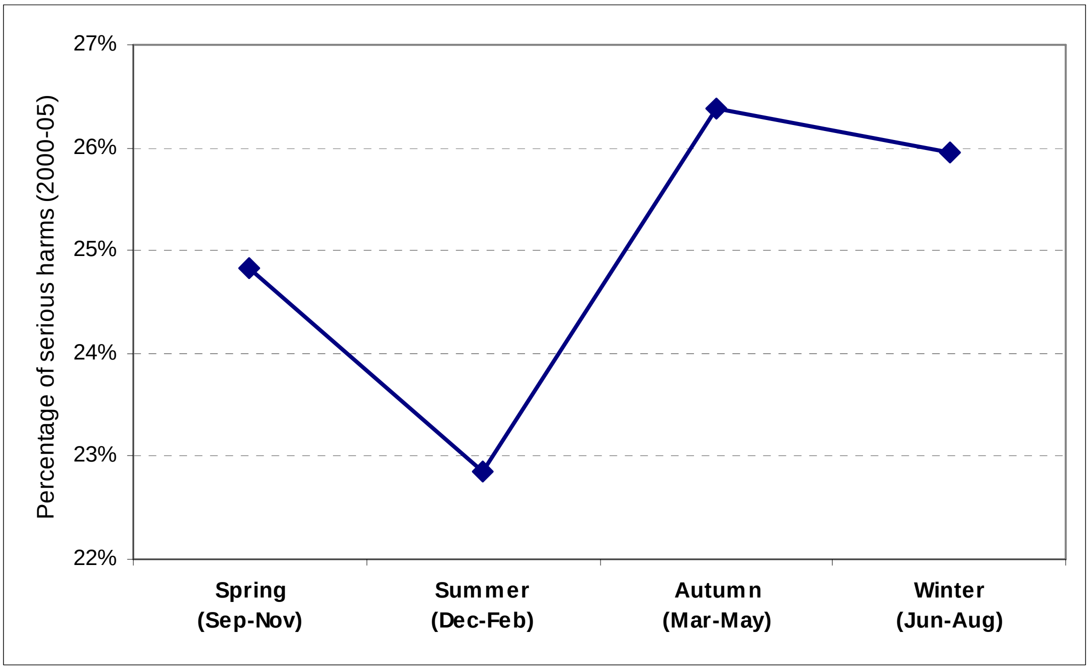


Figure 30: Seasonal Trends in the Serious Harm Data (preliminary analysis only)

Seasonal trend by industries

6.3.5 When analysing the seasonal trend of workplace fatalities by industry, classified according to the ANZSIC system, only the agriculture industry showed a significant seasonal variation in the fatality rate ($p \leq 0.01$, Figure 10). This also suggests that the overall national trend is mainly influenced by the trend of this sector. This result is not surprising because the work activities in the agriculture industry are highly seasonal, and much independent evidence (Table 5) has indicated that, as far as work-related incidents are concerned, the agriculture industry is more vulnerable to the summer season than other industries.

6.3.6 For the agriculture sector, January is seen to have the highest workplace fatality rate, followed by two more peaks, one in April, and the other in October (Figure 11, page 15). These trends are found to be statistically significant ($p \leq 0.05$). This implies that some intervention measures could be developed to target the work activities of workers in this industry during these peak periods.

6.3.7 Further data analysis within the agriculture sector suggested that ‘Forestry and logging’ is the sub-sector with the highest summertime fatality rate, followed by ‘Horticulture & fruit growing’ (Figure 12, page 15). However, while these trends may exist, the current data set cannot technically confirm that these trends are not by chance. This issue will need to be considered with other evidence. Discussions with the experts who are familiar with these sub-sectors suggest that the work activities in these two sectors tend to be more intensive during the summer months than other seasons of the year. There is also an issue of casual labour in these sectors, especially in ‘Horticulture & fruit growing’, along with the increased work demand in summer months. This will be further discussed under ‘Workplace factors’.

Seasonal trend by regions

6.3.8 The mid-north region and the southern region have been found to be most affected by the summer season with regard to the occurrence of work-related fatal incidents (Figure 13, page 16). These results are not surprising because one region (mid north) is relatively more populated with seasonal related industries and work activities, and the other region (southern) is sensitive to seasonal changes with more agricultural activities. Nevertheless, the findings have suggested that some focused campaigns may be beneficial to the improvement of workplace safety in these regions during the summer.

Seasonal trend by employment status

6.3.9 Initial analysis of Department of Labour data suggests that it is the employed who are most at risk of having a workplace fatality. This result is in agreement with a previous study which also showed that in New Zealand the majority of work-related deaths were of employees (New Zealand Environmental and Occupational Health Research Centre, 1999). However, this result cannot be made general until denominator data can be obtained. Given that the numbers of self employed are likely to be relatively low, normalised data may show a very different picture.

6.3.10 An American study has reported that, although wage and salary workers suffered more than 3 times as many fatal work-related injuries as did self-employed workers, when the data were normalised and fatality rates were compared, it became evident that self-employed workers were 2.7 times more likely to be victims of fatal work injuries than their wage and salary counterparts (Pegula, 2004). Combining this independent evidence with the findings of higher seasonal related workplace fatalities in the ‘Agriculture, Forestry & Fishing’ sector (shown in Figure 15, page 17), it appears to be reasonable to suggest that more preventative efforts can be made to the self-employed workers in the agricultural industry to improve their safety at work.

6.3.11 For different regions, there are some apparent seasonal changes in workplace fatalities with the employee status (Figure 16, page 18). For example, in the northern region, there were more work-related fatalities involving employees in the summer than in other seasons; and in the southern region there were more fatal incidents involving employees in the autumn. In general, there appears to be a trend that in the northern part of the country (northern, mid north), more work-related fatal incidents involving the employees tend to occur in the summer; and in the southern part of the country (central, southern) these tend to occur in the autumn (Figure 17, page 19).

Seasonal trend by age groups

6.3.12 An important finding of this study is that, throughout New Zealand, workers of 55-64 years of age have the highest incidence of summertime workplace fatalities (Figure 18, page 20). This result has been confirmed by data normalisation (Figure 19, page 21) and by statistical test. An independent study has also confirmed that “regardless of the type of workers, the fatality rate of workers aged 55 and older is greater than the fatality rate of workers aged 16 to 54 (Pegula, 2004). The same author (Pegula, 2004) also pointed out that the self-employed workers are also generally older than those wage and salary workers.

6.3.13 The present study also found that the workers between 35 and 44 years of age are more likely to have a work-related fatal incident in the autumn. The trend has been confirmed by data normalisation and statistical tests. This is an interesting finding since little published information has been found which directly links the workers of the 35-44 age group with the work-related fatalities in autumn.

6.3.14 Further data analysis by industry confirmed that both seasonal peaks of work-related fatalities (i.e., 55-64 age group for summer, 35-44 for autumn) were significant ($p \leq 0.05$) for the agriculture sector (Figure 20, page 22). Therefore, It is evident to conclude that the workers aged 55-64 are most vulnerable during the summer, and those aged 35-44 are most vulnerable during the autumn, and most of these workers are working in the agriculture industry.

6.3.15 Several ISEs interviewed through the course of this work speculated that the development of ATVs and improved ride-on farm machinery had served to extend the physical working lives of workers in the agriculture industry. Farmers that would, 10 years ago, have had to stop working in the field now continue working as the ATV driver. The very high percentage of vehicle related fatalities (over 50% see Figure 29, page 31) and the very high number of deaths arising because of vehicle (primarily ATV) rollovers supports further speculation that older men, extending their working lives through the use of farm vehicles, are the ones involved in the fatal vehicle related incidents.

6.3.16 The normalised results also indicate that the workers aged 65 and above had a greater work-related fatality rate than any other age groups throughout the year (Figure 19, page 21), but due to the relatively small number of fatality cases involving the people aged 65 and above in the current data set, this result was statistically insignificant. The normalised results by age group and by industry show that the workers aged 65+ tend to have a higher fatality rate in the agriculture industry during the harvest season in autumn (Figures 20 & 21, page 22). A previous New Zealand study also identified a dramatic increase in the rate of work-related fatal injuries for those over the age of 65 years (New Zealand Environmental and Occupational Health Research Centre, 1999).

6.3.17 Further analysis of the workplace fatality data by age group and by geographical region suggests that the peak in summertime fatalities for older workers, is more pronounced in the 55-64 age group, northern and mid north regions, and that further south (central and southern regions) the fatal incidents with this age group, along with the 35-44 age group, become more likely in the autumn (Figure 22, page 25).

6.3.18 In general, it is evident that, as far as worker age is concerned, the current workplace fatality data, and the relevant denominators available, support a reliable analysis of seasonal trends at the national level, and in some cases, at industry level (top ANZSIC level). While attempts have been made to analyse the data at a regional level, the results are limited by the size of the dataset and by the reliability of seasonal worker population data in these regions.

Time of day; day of the week

6.3.19 The overall national data from 2000 to 2005 showed two peak times when work-related fatal incidents occurred, one is between 10:30 and 12:30, and the other is around 15:00. This result is confirmed to be highly significant both for the national trend (Figure 23, page 26) and for the agriculture industry (Figure 24, page 13) ($p<0.001$).

6.3.20 While it may be that the peaks of just before lunch and during the middle of the afternoon can be explained across industry by factors such as loss of concentration before lunch hunger, or the ‘post-lunch dip’, closer examination of the data within the industry sub- sectors (preferably using denominator data) might reveal specific sectors where time of day is a particular concern (e.g. because of shift hand overs or end of day activities).

6.3.21 Similar ‘time of day’ effects have been reported in some previous independent studies often in the area of road transport, indicating that most incidents tend to occur between

10:00 and 15:00 during a working day (New Zealand Environmental and Occupational Health Research Centre, 2003; Nofal and Saeed, 1997; Olowokure et al., 2004).

6.3.22 A closer examination of the time of day data by season suggests that work related fatal incidents in summer tend to occur more in the morning time (from sunrise to noon) and work related fatal incidents in autumn tend to occur more in the afternoon (from noon to sunset). See Figure 25, page 27.

6.3.23 By looking at the workplace fatality data by day of the week, it is within expectation that most fatal incidents occurred during weekdays than during weekends (Figure 26, page 28). This result is also largely in agreement with what is reported by the New Zealand Environmental and Occupational Health Research Centre (2003), apart from that on Saturday, the rate of work-related fatal incidents is not as high as that of fatal traffic injuries.

6.4 Workplace Factors

Primary causes of work-related fatal incidents

6.4.1 According to the workplace fatality investigation reports, the primary cause (or ‘agent’) of workplace fatalities is vehicle rollover, accounting for over 23% of the total work-related deaths that have been investigated over the past 6 years (2000-05). This was followed by fall from height as a second cause, accounting for 9.7%, and non-vehicle crush injuries as a third cause at 8.7%. The fatal crush injuries were up to 17% when considering both vehicle and non-vehicle crushes, (as shown in Figure 27, page 30).

6.4.2 It is noticeable that the three types of primary causes (i.e. vehicle rollover, machinery/vehicle crushes, and fall from height) accounted for almost 50% of the total workplace fatalities from 2000 to 2005. This suggested that if some effective measures can be taken to tackle the factors/reasons behind these major causes, the number of work-related fatal incidents could be significantly reduced.

6.4.3 Further details of the major causes for work-related death or fatal injuries, and the way that these are classified are explained below:

- Vehicle rollover (23.08%): All types of vehicles used for work, such as cars, vans, tractors and ATVs.
- Fall from height (9.70%): Where victim fell from a height more than 1 metre.
- Crush injuries (non vehicle) (8.70%): Incidents where the victim has received fatal crush injuries not directly involving a vehicle, e.g., crushed by machinery such as a recycling / rubbish compactor of truck.
- Vehicle crushes (8.36%): When victim has received fatal crush injuries involving a vehicle, e.g., crushed between vehicle and an obstacle. Excluding rollovers
- Felling incident (5.69%): Fatality incurred when victim involved in the process of felling trees.
- Vehicle incident (5.02%): When victim is involved in a vehicle incident that is other than crushes or being struck by a vehicle.
- Struck by object (5.02%): When victim was struck by object such as rocks and logs (when not actually felling), excluding struck by vehicle.
- Electrocution (5.02%): Where the victim was electrocuted.
- Drowning (4.68%): Drowning incidents, including diving fatalities where victims suffered unknown problems whilst on the dive.

- Machinery incident (3.68%): Where machinery/equipment was involved in the incident, e.g., moving parts of machinery striking/entangling victim.

- Animal incident (3.34%): If an animal contributed to the fatality.

- Slip / trip / fall (3.01%): When victim slipped, tripped or fell whilst walking or running (includes falling down stairs but excludes fall from height incidents).

- Natural disaster / weather conditions (2.34%): Eruptions, avalanches etc.

- Extreme heat / burning / smoke / fumes (2.01%): Where victims were fatally injured by heat, burning, smoke and fumes inhalation.

- Asphyxiation (1.67%): Incidents of asphyxiation and strangulation, excluding drowning.

- Struck by vehicle (1.67%): When victim was struck or run over by a vehicle (e.g., bystander hit by work vehicle)

- Machinery incident – Crane (1.34%): Where machinery / equipment was involved in the incident but specifically involving cranes.

- Vehicle incident – ATV (non rollover) (1.34%): When victim was involved in an ATV incident where the vehicle did not rollover (e.g. struck fence without rolling over and crushing victim).

- Vehicle incident - other farm vehicle (1.34%): Other farm vehicle incident (e.g., Tractors, this excludes ATVs).

- Assault (1.00%): Incidents where the victim was assaulted (e.g., shot, bashed, etc.).

- Rail incident (1.00%): Incident involving train.

- Health problems (1.00%): For example heart attack at work.

6.4.4 It should be noted that these 'primary causes' were recorded as being directly related to the death of the victims at the time when the incident occurred. These are the events at the moment when the incident actually happened. For the purposes of incident prevention, it is more important to understand what the main reasons (or contributing factors) were that lead to the fatalities recorded. The present study has attempted to identify these contributing factors surrounding the workplace, the environment, the society and the people.

Contributing factors

6.4.5 As shown in Figure 28 (page 31), a list of high level 'contributing factors' for the work-related fatal incidents has been identified from the workplace fatality investigation reports. The top six factors (each of which contributed in some way to more than 8% of the fatalities investigated) were:

- Human error (>43.1%)*

- Procedural violation (>27.7%)*

- Poor/inadequate equipment/workplace design (22.1%)

- Poor safety culture (11.7%)

* In an additional 16% of cases, an unsafe behaviour was identified that could have been either a human error or a procedural violation

- Unsafe supervision 10.0%)
- Lack of personal protective equipment (PPE) (8.7%)

6.4.6 The research indicates that 'human error' and 'procedural violations' have contributed to nearly 70% of work-related fatalities over the past six years. It is critical that the term 'human error' is properly understood. Identifying 'human error' allows us to ask why a person's decisions and actions made sense to them at the time. It should be seen as a symptom of other things that are wrong deeper in the work system. 'Human error' is not simply identifying the mistakes people make.

6.4.7 In the report, 'human error' has been used to classify a variety of incidents where memory lapses, slips in behaviour or mistakes (e.g. misjudgements, misinterpretations, distraction errors, silly decisions, inadequate knowledge) have led to a fatality. These slips, lapses and mistakes are only one part of the cause of injuries. A memory lapse may have occurred because a person was asked to do a task they had not done for some time. A slip in behaviour could have occurred as a result of fatigue. A mistake, such as a misjudgement, may have been made because the person making a decision was given incorrect information to base a decision on. A procedural violation could have occurred because of pressure to complete a task, resulting in a risky shortcut being taken.

6.4.8 The vast majority of human errors and violations can be avoided, or at least minimised. Consequently this finding demonstrates an area where significant improvements can be made. The research points to areas such as workplace systems design, training and workplace culture, where improvements could make a huge difference to incident, injury and fatality rates.

6.4.9 A wide range of additional workplace factors have been investigated in the present study for their association with the occurrence of work-related fatalities. Independent evidence was collected in relation to these factors. For some factors, there appears to be strong independent evidence to support the findings, and for other factors, the evidence appears to be relatively weak. The following factors have been identified as having contributory effect on the occurrence of work-related fatal incidents with a strong or moderate independent evidence support:

- **Other workplace factors with strong independent evidence support:**
  - Hours worked per day
  - Lack of recovery from fatigue
  - Tight timescales/deadlines
  - Time of day (10:30-12:30; 14:30-15:30); during summer: AM; autumn: PM)
  - Day of the week (weekdays)
  - Type of industry/workplace (especially 'Agriculture, Forestry & Fishing')
  - Work involving vehicles
- **Other workplace factors with moderate independent evidence support:**
  - Level of staffing
  - Level of casual labour

6.4.10 Strategies for preventing workplace fatalities should concentrate on these factors with strong or at least moderate support from independent evidence.

6.5 Environmental Factors

6.5.1 The present study has identified several environmental factors that are significantly associated with the occurrence of work-related fatal incidents. The literature research has also provided some supporting evidence for these factors, although the published studies are often in the area of transport related incidents, and the reports relating a wide range of industrial incidents to specific environmental factors as used in this study are still rare.

6.5.2 On the basis of the detailed factor analysis and the review of independent evidence, the following environmental factors have been identified as playing contributing roles in the occurrence of work-related fatal incidents:

- Rainfall and wet days
- High temperature
- Sunshine

6.5.3 Rainy or wet days following a shower make the ground surface wet and slippery. This may create problems for ATVs or quadbikes especially when the ground underneath is still hard, due to reduced traction between the tyre and the ground (Moore, 2006). From a human factors point of view, the user expectation that those farm vehicles can work well in soft ground conditions may encourage people to ride the vehicles on wet but relatively hard slopes which do not provide enough traction for the vehicle to stay in balance. This situation becomes worse when the vehicle is loaded.

6.5.4 Other harsh environmental conditions such as strong wind may have contributed to the occurrences of some particular incidents in some industries in the past (e.g., forestry & logging; construction), but due to the limitation of the data available, this condition was not confirmed to be a general contributing factor associated with the workplace fatalities. However, this does not mean that such factors are not important for the industries concerned. On the contrary, when developing preventative strategies for a particular industry, known environmental hazards (e.g. wind, fog) must still be accounted for despite them not being formally recognised as contributory factors to workplace fatalities as a result of this desk top review.

6.5.5 In addition, it should be understood that a certain contributing factor to the occurrence of a workplace incident takes effect in combination with other factors. It is often the case that an incident happens at the ‘wrong time’ (environmental factor), in the ‘wrong place’ (workplace factor), and with the ‘wrong person’ (individual factor). Therefore, when developing preventative measures to tackle work-related fatalities, the environmental factors will need to be considered in conjunction with other workplace or sociological factors. For example, the risks of a vehicle rollover on a steep slope increase on a rainy/wet day if it is just before or just after lunch.

6.5.6 The likelihood of workplace incident increases in the summer when people work longer hours and therefore have limited time to recover from fatigue. This situation becomes worse under poor/harsh environmental conditions.

6.6 Sociological Factors

6.6.1 A number of sociological factors have been identified in the present study, with support from some independent evidence sources.

- **Sociological factors with relatively strong independent evidence support:**
  - Summer months/season
  - Alcohol and drugs
- **Sociological factors with moderate independent evidence support:**
  - Tourists/temporary labour
  - School holiday and public holiday
  - Daylight saving
  - Tobacco smoking

6.6.2 The inclusion of ‘alcohol’ as a contributing factor to the occurrence of workplace fatalities does not necessarily mean that the victims involved in the workplace fatalities investigated had higher blood alcohol levels. Rather this factor has been identified largely from the statistical point of view, on the basis of independent evidence, and under the consideration of the long-term effect of alcohol on human abilities. This factor will also need to be considered in conjunction with other factors (workplace/environmental/individual) when developing preventative strategies. For example, as alcohol can still be detected in the body and have an effect some 13 hours after drinking 6 pints of premium strength beer (12 units) (Morgan and Ritson, 2003), it is advisable not to drink more than a certain amount of alcohol a certain number of hours before carrying out work at height, or handling vehicles/machineries under harsh environmental conditions, even though the alcohol level in the body is within the legal limit for work. Several ISEs consulted through the course of this work expressed the opinion that marijuana usage could be a contributor factor in workplace fatalities. No evidence was available during the course of this study to support these opinions.

6.7 Individual Factors

6.7.1 The following worker individual factors have been identified as major contributing factors to the occurrence of work-related fatal incidents particularly in summer, with strong independent evidence support:

- Age (55-64 years old for summer; 35-44 for autumn, and older workers 65+)
- Gender (male workers)
- Employment (employees, and self-employed)
- Return to work after a long holiday

6.7.2 One of the issues that have not been covered in the incident database is ‘return to work after a long holiday’. This has been identified as a confounding factor with a combination of various factors such as fatigue (e.g., due to sporting activities during the holiday), jetlag and sleep loss, excessive alcohol consumption, and skill erosion. These issues have been documented in some published reports (some are give in Table 6), although systematic studies on the relation between holiday taking (or absence from work) and work-related incidents have been very rare. A relatively recent study found that train drivers are almost twice as likely to pass a red signal after taking a period of long holidays (7 days or more) (Li and Lock, 2003). While more scientific evidence may still be needed in support of this topic, it is advisable to consider this issue when developing preventative strategies to tackle work-related fatalities.

6.8 Fatal Injuries in relation to Serious Harms

6.8.1 Prevention strategies for workplace fatalities should not be guided entirely by this analysis of the Department of Labour fatality data set. As far as work-related incidents are concerned, fatal incidents are only the tip of the iceberg. Workplace fatalities occur only when a number of contributing factors co-exist simultaneously. Depending on the type of industry, research suggests that some 500-2000 smaller injuries take place for each fatality. This is illustrated in the incident pyramid in Figure 31 below. A more detailed analysis of the work-related serious harm injury statistics along with the fatality data is recommended in order to identify some specific relationships between the two data sets for different industries. It is anticipated that such a study will result in a set of more practical solutions for the mitigation of work-related injuries.

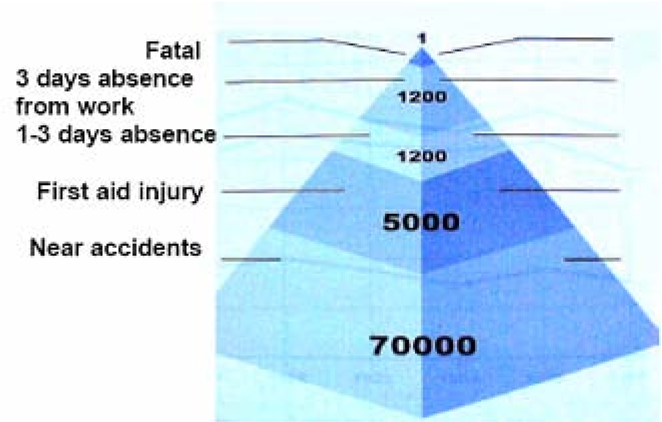


Figure 31 – The incident pyramid (data from R. Skiba, Germany)

7. SUMMARY OF MAJOR FINDINGS

7.1 Summary of Major Findings

7.1.1 Table 7 below summarises the major findings of this study.

Table 7 – Summary of major findings

Major Research Findings	Main reference point	Note
Seasonal trends of workplace fatalities		
More work-related fatal incidents tend to occur in the summer months (December–February), followed by autumn (March-May)	Section 3.2.4; Figures 8 & 9; Table 6.	Strong independent evidence support.
The ‘Agriculture, Forestry & Fishing’ industry is more vulnerable to the summertime workplace fatalities than other industries.	Section 3.2.5; Figure 10; Table 6.	Strong independent evidence support.
Within the agriculture sector, January has the highest workplace fatality rate, followed by April and October.	Section 3.2.6; Figure 11.	
Within the agriculture industry, ‘Forestry and logging’ is the sub-sector with the highest summertime fatality rate, followed by ‘Horticulture & fruit growing’.	Section 3.2.7; Figure 12.	
The mid north region and the southern region have been found to be most affected by the summer season with regard to the occurrence of work-related fatal incidents.	Section 3.2.8; Figure 13.	
In the northern part of New Zealand (northern and mid north regions), work-related fatal incidents involving employees tend to occur more in the summer; and in the southern part of the country (central and southern regions), work-related fatal incidents appear to occur more in the autumn.	Section 3.2.12; Figure 17.	
Workers aged between 55 and 64 years have the highest incident of summertime workplace fatalities. This trend is applicable to all industries, but in particular to the ‘Agriculture, Forestry & Fishing’ industry.	Sections 3.2.14; 3.2.15, 3.2.17, & 3.2.19; Figures 18, 19, 20, & 21; Table 6.	Strong independent evidence support.
Workers between 35 and 44 years of age are more likely to have work-related fatal incidents in the autumn. This trend is applicable to all industries, and in particular to the agriculture industry.	Sections 3.2.14; 3.2.15, 3.2.17, & 3.2.19; Figures 18, 19, 20, & 21.	
Older workers (aged 65 and above) tend to have a higher fatality rate in the agriculture industry than any other age groups during the harvest season in autumn.	Section 3.2.19; Figure 21.	
There are two peak times when work-related fatal incidents are most likely to occur, one is late morning (between 10:30am and 12:30pm), and the other is mid afternoon (2:30 to 3:00pm). This trend is applicable for all industries, and in particular for agriculture.	Sections 3.2.21 & 3.2.22; Figures 23 & 24.	Strong independent evidence support.
When time of day data are examined by season, work related fatal incidents in summer tend to occur in the morning time	Sections 3.2.23 &	

Major Research Findings	Main reference point	Note
(from sunrise to noon); and work related fatal incidents in autumn tend to occur more in the afternoon (from noon to sunset).	3.2.24; Figure 25.	
Most work-related fatal incidents happen during the weekdays (Monday – Friday).	Section 3.2.25; Figure 26. Table 6.	Strong independent evidence support.
Primary causes of workplace fatalities		
52% of work related fatalities involved a vehicle	Section 4.2.7; Figure 29	This is also supported by independent evidence
Nearly 50% of the total workplace deaths from 2000 to 2005 were directly due to one of three causes: • The first and most frequent cause for work-related death is vehicle rollover (accounting for 23% of total workplace fatalities investigated). • The second cause of workplace fatalities is fall from height (accounting for 9.7% of total workplace fatalities investigated). • The third cause of workplace fatalities is fatal crush injuries (by vehicle or by machineries) (accounting for 17% of total workplace fatalities investigated).	Sections 4.2.4, 6.4.1, 6.4.2, & 6.4.3; Figure 27. Table 6.	Strong independent evidence support.
Direct contributing factors to workplace fatalities		
Seven factors have been identified from the workplace fatality investigation reports as directly contributing to a high proportion of the fatalities that occurred during 2000 to 2005. They are: • Human error (associated with at least 43.14% of total work-related fatalities investigated). • Procedural violation (associated with at least 27.76%). Note: Either human error or procedural violation may have contributed to an additional 16.05% • Poor/inadequate equipment/workplace design (22.07%). • Poor safety culture (11.71%). • Unsafe supervision (10.03%). • Lack of PPE (personal protective equipment) (8.70%). • Lack of experience (7.69%).	Sections 6.4.5 & 6.4.6; Figure 28.	Multiple factor involvement counted.

Other workplace factors likely to contribute to increased risk of work related fatalities		
• Hours worked per day. (Applicable for all industries, and in particular for 'Dairy & cattle farming' within the agriculture industry).	Tables 2, 5 & 6.	Strong independent evidence support.
• Lack of recovery from fatigue. (Applicable for all industries, and in particular for 'Agriculture, Forestry & Fishing', and for 'Construction'.	Tables 2, 5 & 6.	Strong independent evidence support.
• Tight timescales/deadlines. (Applicable for 'Horticulture & fruit growing' sector within the 'Agriculture, Forestry & Fishing' industry.	Tables 2, 5 & 6.	Strong independent evidence support.
• Staffing levels. (Applicable for all industries, and particularly for 'Horticulture & fruit growing' sector within the agriculture industry.	Tables 2, 5 & 6.	Moderate independent evidence support.
• Amount of casual labour. (Applicable for all industries, and particularly for 'Horticulture & fruit growing' sector within the agriculture industry.	Tables 2, 5 & 6.	Moderate independent evidence support.
The following environmental factors are likely to contribute to increased risk of work related fatalities		
• Rain / wet days. (Applicable for all industries, and particularly for the agriculture industry).	Tables 3, 5 & 6.	Moderate independent evidence support.
• High temperatures. (Applicable for all industries, and particularly for 'Agriculture, Forestry & Fishing', 'Cultural, recreational & other services', and 'Manufacturing').	Tables 3, 5 & 6.	Moderate independent evidence support.
• Longer hours of sunshine. (Applicable for 'Agriculture, Forestry & Fishing', 'Cultural, recreational & other services', 'Manufacturing', and 'Transport & storage').	Tables 3, 5 & 6.	Moderate independent evidence support.
The following sociological factors are likely to contribute to increased risk of work related fatalities		
• Increased consumption of alcohol. (Applicable for all industries, and in particular for 'Agriculture, Forestry & Fishing').	Tables 4, 5 & 6.	Strong independent evidence support.
• More tourists (and temporary workers). (Applicable for 'Agriculture, Forestry & Fishing', 'Construction', 'Cultural, recreational & other services', and 'Transport & storage'	Tables 4, 5 & 6.	Moderate independent evidence support.
• School holidays and public holidays. (Applicable for 'Agriculture, Forestry & Fishing', and 'Manufacturing'.	Tables 4, 5 & 6.	Moderate independent evidence support.

• Daylight saving.	See ‘Summer months/season’.	
The following individual factors are also likely to contribute to increase risk of work related fatalities		
• Gender (male workers, employees, and self-employed). (Applicable for all industries).	Section 4.5.3; Table 5.	Strong independent evidence support.
• From the age, gender, industry, season, and time of day data combined it may be postulated that: Male workers working in the agriculture industry, aged between 55 and 64, are most likely to have a fatal incident in their workplace during the summertime between sunrise and noon. Male workers working in the agriculture industry, aged between 35 and 44, are most likely to have a work-related fatal incident during the autumn between noon and sunset.	Section 4.5.5; and relevant topics as summarised above.	
• Return to work after a long holiday. (Applicable for all industries).	Table 6.	Moderate independent evidence support.

8. CONCLUSION AND NEXT STEPS

8.1 Conclusion

8.1.1 This study has confirmed that in the period from 2000 – 2005 the rate of workplace fatalities was higher in summer and autumn than throughout the rest of the year. While there appeared to be a clear peak in the number of fatalities that occurred in January the limited size of the data set meant that this could not be confirmed through statistical testing.

8.1.2 The research has identified a number of important findings with regards to workplace, environmental, sociological and individual factors that are associated with, or contribute to, increased risk of workplace fatalities, and provides direction for the development of preventative strategies that should be considered by the Department of Labour. Adopting some or all of the recommendations provided will not only help reduce the incidence of workplace fatalities but is also likely to significantly reduce the incidence of work related serious harm injuries.

8.2 The Department of Labour's Next Steps

8.2.1 This study is the first step to improving the Department of Labour's understanding of the reasons behind workplace fatalities. This research highlights some initial areas of workplace health and safety practice in New Zealand which can be improved. The Department of Labour intends to take a positive approach to the findings, focussing on ways to raise awareness and promote direct action to reduce workplace fatalities.

8.2.2 The Department of Labour will focus on the following approaches to deliver information and guidance:

Emphasise the benefits
Focus on actions that will reduce the work toll. Identify the benefits of safe work practices and demonstrate that they outweigh the perceived costs.

Deliver messages locally
Awareness-raising will be accompanied by realistic and practical advice on how to improve health and safety in New Zealand's workplaces. Messages will be targeted and personalised to specific at-risk groups. Small-scale, low-key safety initiatives locally delivered will be an effective part of personalising safety messages.

Work together
The Department will develop collaborative approaches and partnerships for the delivery of messages. We will actively seek the support of others, industry representatives, business organisations, unions, and businesses to promote awareness and action in workplaces and the wider community.

REFERENCES

1. **Abel, E.L. and Welte, J.W., 1987.** Temporal variation in violent death in Erie County, New York, 1973-1983.

2. **Adcock, S.J., & Sparkes, A.K., 1993.** Analysis of safety related data for drivers. C Business Consultancy, Operational research unit, London.

3. **Akerstedt, T., Kecklund, G. and Horte, L.G., 2001.** Night driving, season, and the risk of highway accidents. Sleep, 24, 4, 401-406.

4. **Alexe, D.M., Petridou, E., Dessypris, N., Skenderis, N. and Trichopoulos, D., 2003.** Characteristics of farm injuries in Greece. J Agric Saf Health, 9, 3, 233-240.

5. **Anderson, N., Feigin, V., Bennett, D., Broad, J., Pledger, M., Anderson, C. and Bonita, R., 2004.** Diurnal, weekly, and seasonal variations in stroke occurrence in a population-based study in Auckland, New Zealand. N Z Med J., 117, 1202, U1078.

6. **Becker, J. T. and Milke, R., 1998.** Cognition and aging in a complex work environment: Relationships with performance among air traffic control specialists. *Aviation, Space and Environmental Medicine*, 69, 944-951.

7. **Beyaztas, F.Y. and Alagozlu, H., 2002.** Evaluation of traffic accident cases admitted to the emergency department of the Cumhuriyet University Hospital in 1998. Ulus Travma Derg. 8, 1, 29-33.

8. **Burns, P.C., Parkes, A., Burton, S., Smith, R.K., & Burch, D., 2002.** How dangerous is driving with a mobile phone? Benchmarking the impairment to alcohol. TRL Report TRL547. Berkshire: TRL Limited.

9. **Buxton, A.C., Bunting, A.J., & King, S., 1999.** Environmental factors in train driver's cabs – Phase 2 Final Report. Defence Evaluation and Research Agency UK, DERA/CHS/PPD/CR000021/1.0.

10. **CHSRF, 2006.** Staffing for safety: A synthesis of the evidence on nurse staffing and patient safety. Canadian Health Services Research Foundation. Ottawa, Ontario.

11. **Clarke, D.D., Ward, P., Bartle, C. and Truman, W., 2005.** An in-depth study of work-related road traffic accidents. Road Safety Research Report No. 58, Department for Transport.

12. **Dray, P., Sutton, L., & Menter, P., 1999.** Signals Passed at Danger (SPADs): A new insight. 6th Annual Railway Safety Congress.

13. **Dyson, H.R., 2005.** Workplace health and safety strategy for New Zealand to 2015. Wellington: Department of Labour.

14. **Edwards, P., Ian Roberts, I., Green, J. and Lutchmun, S., 2006.** Deaths from injury in children and employment status in family: analysis of trends in class specific death rates. British Medical Journal, 333:119.

15. **Eggensperger, N.M., Danz, J., Heinz, Z. and Iizuka, T., 2006.** Occupational maxillofacial fractures: a 3-year survey in central Switzerland. J. Oral Maxillofac. Surg., 64, 2, 270-276.

16. **Farmer, C.M. and Williams, A.F., 2005.** Temporal factors in motor vehicle crash deaths. Inj Prev., 11, 1, 18-23.

17. **Folkard, S., 1997.** Black Times: Temporal determinants of transport safety. *Accident Analysis and Prevention*, 29 (4): 417-430.

18. **Folkard, S. and Monk, T.H. (eds.), 1985.** *Hours of Work, Temporal Factors in Work-Scheduling*. Chichester: John Wiley & Sons.

19. **Folkard, S. and Sutton, L., 2000.** The Impact of Shift work and Fatigue on Safety. Railtrack PLC (S&SD).

20. **Gibson, H., Shelton, J., Mills, A., 2006,** The Impact of Returning from Rest Days on SPAD Incidents, RSSB

21. **Gilchrist, A.O., 1990.** An investigation into the causation of signals passed at danger. Technical memorandum, British Rail Research, Derby. (Report Ref: TM TAG 138).

22. **Hamelin, P., 1987.** Lorry drivers' time habits in work and their involvement in traffic accidents. *Ergonomics*, 30, 1323-1333.

23. **Hancock, P.A., 1989.** A dynamic model of stress and sustained attention. *Human Factors*, 31 (5), 519-537.

24. **Hancock, P.A., Williams, G. and Manning, C.M., 1995.** Influence of task demand characteristics on workload and performance. *The International Journal of Aviation Psychology*, 5 (1), 63-86.

25. **Haque, F.M., & Bott, K.G., 1997.** Driver Fatigue and Shift work. BR Research Limited, RR/SPS/96/031.

26. **Hartley, L.R. Arnold, P.K. Penna, F., Hochstadt, D., Corry, A and Feyer, A.M., 1995.** *Fatigue in the Western Australian Transport Industry, Part 1*. Perth: Murdoch University.

27. **Haworth, N.L., Heffernan, C.J. and Horne, E.J., 1989.** Fatigue in truck accidents. Accident Research Centre, Monash University.

28. **Hennessy, D.A. and Wiesenthal, D.L., 1997.** The relationship between traffic congestion, driver stress and direct versus indirect coping behaviours. *Ergonomics*, 40 (3), 384-361.

29. **Hood, D.C. and Finkelstein, M.A., 1986.** Sensitivity to light (Chapter 5). In: *Handbook of Perception and Human Performance*, (eds. K.R. Boff, L. Kaufman and J.P. Thomas), New York: John Wiley and Sons.

30. **HSE, 2005.** Safe use of all-terrain vehicles (ATVs) in agriculture and forestry. HSE Agriculture Information Sheet No.33.

31. **Hsiao, H. and Simeonov, P., 2001.** Preventing falls from roofs: a critical review. Ergonomics, 44, 537-561.

32. **ISO 7730, 1994.** Moderate thermal environments -- Determination of the PMV and PPD indices and specification of the conditions for thermal comfort. International Standards organisation.

33. **Jenks, C.W., 1997.** Improved methods for increasing wheel/rail adhesion in the presence of natural contaminants. Transit Cooperative Research Program, Transportation Research Board, National Research Council.

34. **Joki, M.V., 1982.** The Effect of the Environment on Human Performance. *Applied Ergonomics*, 13 (4): 269-280.

35. **Jones, I.S. and Stein, H.S., 1987.** Effect of driver hours-of-service on tractor-trailer crash involvement. Arlington, VA.: Insurance Institute for Highway Safety.

36. **Kroemer, K.H.E. and Grandjean, E., 1997.** *Fitting the Task to the Human* (5th Edition). London: Taylor & Francis.

37. **Layde, P.M., Nordstrom, D.L., Stueland, D., Brand, L. and Olson, K.A., 1995.** Machine-related occupational injuries in farm residents. Ann Epidemiol., 5, 6, 419-426.

38. **Lewis, P.M. and Swaim, D.J., 1986.** Evaluation of a 12-hour day shift schedule. In: *Proceedings of the Human Factors Society 30th Annual Meeting*, Dayton, Ohio. Vol. 2:885-889.

39. **Lewis, G. and Wessely, S., 1992.** The epidemiology of fatigue: more questions than answers. J Epidemiol Community Health, 46, 92-97.

40. **Li, G., 2003.** Prioritisation of SPAD risk factors. Technical report to Rail Safety and Standards Board. Human Engineering Ltd. (Ref: HEL/RSSB/03963/RT1).

41. **Li, G., 2004.** Age related human factors issues for train operation and SPAD mitigation. Technical report to Rail Safety and Standards Board. Human Engineering Ltd. (Ref: HEL/RSSB/041019a/RT1).

42. **Li, G. and Lock, D., 2003.** Analysis of the May/summer peak in SPAD occurrences. Technical report to Rail Safety and Standards Board. Human Engineering Ltd., (Ref: HEL/RS/02799a).

43. **Lim, G.W., Belton, K.L., Pickett, W., Schopflocher, D.P. and Voaklander, D.C., 2004.** Fatal and non-fatal machine-related injuries suffered by children in Alberta, Canada, 1990-1997. Am J Ind Med., 45, 2, 177-185.

44. **McKee, M., Sanderson, C., Chenet, L., Vassin, S. and Shkolnikov, V., 1998.** Seasonal variation in mortality in Moscow. J Public Health Med., 20, 3, 268-274.

45. **McLellan, B.A., Vingilis, E., Liban, C.B., Stoduto, G., McMurtry, R.Y. and Nelson, W.R., 1990.** Blood alcohol testing of motor vehicle crash admissions at a regional trauma unit. J Trauma, 30, 4, 418-421.

46. **Michon, J.A., 1985.** A critical view of driver behavior models: What do we know, what should we do? In: *Human Behavior and Traffic Safety*. New York: Plenum Press, 485-520.

47. **Mitler, M.M., Carskadon, M.A., Czeisler, C.A., Dement, W.C., Dinges, D.F. and Graeber, R.C., 1988.** Catastrophes, sleep and public policy: consensus report. *Sleep*, 11, 100-109.

48. **Morabito, M., Cecchi, L., Crisci, A., Modesti, P.A. and Orlandini, S., 2006.** Relationship between work-related accidents and hot weather conditions in Tuscany (central Italy). Ind Health, 44, 3, 458-464.

49. **Morgan, M.Y. and E Bruce Ritson, E.B., 2003.** Alcohol and Health: A Handbook for Students and Medical Practitioners. 4th Edition. London: The Medical Council on Alcohol.

50. **Moore, D.J., 2006.** Loss of control events involving quadbikes on New Zealand farms: risk factor interactions and potential interventions. Doctoral thesis. Department of management Systems, Massey University.

51. **Nag, P.K. and Nag. A., 2001.** Shift work in the hot environment. J Hum Ergol (Tokyo), 30, 1-2, 161-166.

52. **New Zealand Environmental and Occupational Health Research Centre, 1999.** Work-related fatal injuries in New Zealand 1985-1994. Department of Preventive and Social medicine, Dunedin School of Medicine, University of Otago.

53. **New Zealand Environmental and Occupational Health Research Centre, 2003.** Work-related fatal traffic injuries in New Zealand 1985-1998.

54. **Niino, N., Yasumura, S., Haga, H., Ueno, H., Oshima, M. and Higuchi, Y., 1995.** Falls among the elderly living in a rural community – prevalence and circumstances of falls by season. Nippon Koshu Eisei Zasshi, 42, 11, 975-981.

55. **Nofal, F.H. and Saeed, A.A., 1997.** Seasonal variation and weather effects on road traffic accidents in Riyadh city. Public Health, 111, 1, 51-55.

56. **Ogata, T., Kimura, K., Minematsu, K., Kazui, S., Yamaguchi, T., and Japan Multicenter Stroke Investigators' Collaboration, 2004.** Variation in ischemic stroke frequency in Japan by season and by other variables. J Neurol Sci., 225, 1-2, 85-89.

57. **Oginski, A., Oginska, H., Pokorski, J., Kmita, W. and Gozdziela, R., 2000.** Internal and external factors influencing time-related injury risk in continuous shift work. Int. J Occup Saf Ergon. 6, 3, 405-421.

58. **Olowokure, B., Saunders, P.J., Dyer, J.A. and Kibble, A.J., 2004.** Temporal and seasonal variation in the occurrence of chemical incidents. Occup Environ Med., 61, 2, 177-179.

59. **Ozdogan, M., Cakar, S., Agalar, F., Eryilmaz, M., Aytac, B. and Aydinuraz, K., 2006.** The epidemiology of the railway related casualties. Ulus Travma Acil Cerrahi Derg., 12, 3, 235-241.

60. **Parkes, K.R., & Sparkes, T.J., 1998.** Organizational Interventions to reduce work stress: Are they effective? A review of the literature. Health and Safety Executive, Contract Research Report 193, prepared by the University of Oxford.

61. **Parsons, K., 1993.** *Human thermal environments*. London: Taylor & Francis Ltd.

62. **Pegula, S.M., 2004.** Occupational fatalities: self-employed workers and wage and salary workers. Monthly Labor Review, March 2004, 30-40.

63. **Pfaff, G. and Weber, E., 1982.** More accidents due to daylight saving time? A comparative study on the distribution of accidents at different times of day prior to and flowing the introduction of Central European Summer Time (CEST). Int Arch Occup Environ Health, 49, 3-4, 315-323.

64. **Pheasant, S., 1991.** *Ergonomics, Work and Health*. MACMILLAN Press Ltd.

65. **Philip, P., Ghorayeb, I., Stoohs, R., Menny, J.C., Dabadie, P., Bioulac, B. and Guilleminault, C., 1996.** Determinants of sleepiness in automobile drivers. J Psychosom Res., 41, 3, 279-288.

66. **Pickett, W., Brison, R.J. and Hoey, J.R., 1995.** Fatal and hospitalized agricultural machinery injuries to children in Ontario, Canada. Inj Prev. 1, 2, 97-102.

67. **Ramsey, J.D., 1995.** Task performance in heat: A review. *Ergonomics*, 38, 154-165.

68. **Ramsey, J.D., Burford, C.L., Beshir, M.Y. and Jensen, R.C., 1983.** Effects of workplace thermal conditions on safe work behavior. *Journal of Safety Research*, 14 (3), 105-114.

69. **Reason, J., 1990.** Human Error. Cambridge: Cambridge University Press.

70. **Rodriguez, N.A., Cid, F.E., Tojo, S.R. and Martinon, S.J.M., 1996.** Serious childhood accidents involving tractors. An Esp Pediatr., 44, 5, 461-463.

71. **Schandersson, R., 1993.** Traffic accident analyses and perceptual issues. In: *Vision in Vehicles – IV,* (eds: A.G. Gale, I.D. Brown, C.M. Haslegrave, H.W. Kruysse & S.P. Taylor). Amsterdam: North-Holland.

72. **Schlegel, R.E., 1993.** Driver mental workload. In: *Automotive Ergonomics*, (eds. B. Peacock and W. Karwowski), London: Taylor & Francis, 359-382.

73. **Scottish Intercollegiate Guidelines Network, 2003.** The management of harmful drinking and alcohol dependence in primary care. Edinburgh: Scottish Intercollegiate Guidelines Network.

74. **Shappell, S.**A. and Wiegmann, D.A., 2000. The human factors analysis and classification system – HFACS. Office of Aviation Medicine, Washington, DC 20591. DOT/FAA/AM-00/7,

75. **Silm, S. and Ahas, R., 2005.** Seasonality of alcohol-related phenomena in Estonia. Int J Biometeorol., 49, 4, 215-223.

76. **Smith, J.D., Buehler, J.W., Sikes, R.K., Goodman, R.A. and Rogers, D.L., 1986.** Motorcycle-associated fatalities in Georgia, 1980-1981. South Med J., 79, 3, 291-294.

77. **Stokols, D., Novaco, R.W., Stokols, J. and Campbell, J., 1978.** Traffic congestion, Type A behaviour, and stress. *Journal of Applied Psychology*, 63, 467-480.

78. **Swaen, G. M. H., van Amelsvoort, L. G. P. M., Bültmann, U and Kant, I.J., 2003.** Fatigue as a risk factor for being injured in an occupational accident: results from the Maastricht Cohort Study. Occupational and Environmental Medicine, 60, (Suppl I), 188-192.

79. **Turner, C.W., Layton, J.F. and Simons, L.S., 1975.** Naturalistic studies of aggressive behaviour: Aggressive stimuli, victim visibility and horn honking. *Journal of Personality and Social Psychology*, 31, 1098-1107.

80. **US Congress, Office of Technology Assessment, 1988.** Gearing Up for Safety: Motor Carrier Safety in a Competitive Environment. OTA-SET-382. Washington, D.C.: US Government Printing Office.

81. **van der Flier, H. and Schoonman, W., 1988.** Railway Signals Passed at Danger – Situational and Personal Factors Underlying Stop Signal Abuse. *Applied Ergonomics*, 19 (2), 135-141.

82. **Wiegmann, D.A. and Shappell, S.A., 1997.** Human factors analysis of postaccident data: Applying theoretical taxonomies of human error. International Journal of Aviation Psychology, 7,1, 67-81.

83. **Wharf, H.L., 1993.** Research into the Working Time Patterns of Train Drivers and Safety, October 1993.

84. **Whittaker, J.D., 1996.** An investigation into the effects of British Summer Time on road traffic accident casualties in Cheshire. J Accid Emerg Med., 13, 3, 189-192.

85. **Whittington, R.M., 1981.** Motorcycle fatalities: analysis of Birmingham coroner's records. Injury, 12, 4, 267-273.

86. **Wick, R., Gilbert, J.D., Simpson, E. and Byard, R.W., 2006.** Fatal electrocution in adults – a 30-year study. Med Sci Law, 46, 2, 166-172.

87. **Williams, J.C., 1977.** Railway Signals Passed at Danger – Some Further Research. *Ergonomics Abstracts*, 10 (3), 74661.

88. **Zhang, J., Fraser, S., Lindsay, J., Clarke, K. and Mao, Y., 1998.** Age-specific patterns of factors related to fatal motor vehicle traffic crashes: focus on young and elderly drivers. Public Health, 112, 5, 289-295.

89. **Zierold, K.M., Garman, S. and Anderson, H., 2004.** Summer work and injury among middle school students, aged 10-14 years. Occup Environ Med., 61, 6, 518-522.

APPENDIX A

ANZSIC CLASSIFICATION CATEGORIES

ANZSIC Classification	Industry
A	Agriculture, Forestry and Fishing
B	Mining
C	Manufacturing
D	Electricity, Gas and Water Supply
E	Construction
F	Wholesale Trade
G	Retail Trade
H	Accommodation, Cafes and Restaurants
I	Transport and Storage
J	Communication Services
K	Finance and Insurance
L	Property and Business Services
M	Government Administration and Defence
N	Education
O	Health and Community Services
P	Cultural and Recreational Services
Q	Personal and Other Services

APPENDIX B

BRIEFING NOTE AND SEASONAL ACTIVITY FORM

INVESTIGATION INTO SUMMERTIME WORKPLACE FATALITIES

A Briefing Note

Recent workplace fatality statistics indicate an apparent increase in worker fatalities during the summer months in New Zealand. In order to identify effective preventative strategies and mitigation measures the Department of Labour is currently in the process of conducting a detailed study to investigate the reasons and associated causative factors. To support the analysis a number of workshops and meetings with industry representatives are planned to investigate the following factors:

Seasonal trends

- Key differences in work activities between seasons;
- Amount of work in remote locations;
- The numbers and types of serious injuries;
- Use of vehicles;
- Shift work systems used;
- Fatigue levels;
- Hours worked;
- Staff numbers;
- The effect of school holidays on staff numbers;
- Casual labour;
- Use of PPE;
- Non-work related activities;
- Levels of supervision whilst working;
- Extreme weather conditions;
- Numbers of visitors/non-workers attending work sites;
- The effect of tourism on the industry.

Industry working practices

- What communications systems are frequently used? (e.g. Mobile phones, dedicated radios, etc) Are they always reliable?
- Are there known incident types that occur often and may have serious/ fatal consequences in your industry?
- Are their strict policies regarding the admittance of visitors/ non-workers to work sites?
- How would you compare the safety culture in your industry with other industries?
- Is it normal practice to report all safety incidents?
- Are their strict policies regarding safety training/induction? Are they enforced?
- Do seasonal/ casual workers usually receive the same level of induction/ safety training as permanent staff?
- Is the use of personal safety equipment enforced?
- Are risk assessments carried out routinely?
- What fitness for work schemes are in place in your industry? (e.g. are you ok? – not tired, drug and alcohol free) Are they enforced?
- When working in your industry is it normal practice to always have safety supervision or 'a look out' for tasks that may involve risk?
- Is team working prevalent in your industry?
- Do you think the number of self employed people /family businesses in your industry affect incident reporting?
- Do workers frequently use potentially dangerous equipment or hazardous substances?

Workshops and meetings to discuss the issues outlined above should take no more than 2 hours and will be very important for the development of strategies to reduce the number of summer time fatalities.

Our thanks in advance to all those who agree to participate.

Indicative survey of seasonal activities in industry

This is an indicative survey for your opinions about seasonal changes of work demand or activities in your industry. The level of work activities is expressed by Low (L), Medium (M) or High (H). For example, if you think that work duration per day is relatively shorter in May through July as compared with other months of the year, you can put a letter L across these months. Please rate these work-related activities for all the months from January to December, using L, M or H.

Your opinions will help us to understand some of the characteristics of work activities in relation to seasonal changes, and how these may be related to some of work-related fatalities. This list is by no means exhaustive for all industries, so please do add more items if you think that they are important seasonal indicators for your industry. Please also add some descriptions if possible for the reasons of your ratings.

Name: **Type of Industry:**

Type of work indicators	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	*Description*
Hours worked per day													
Level of staffing													
Level of casual labour													
Need to work in remote locations													
Non-work related activities													
Level of supervision or support whilst working													
Visitors/non-workers attending work sites													
Physical or mental work demands													
Variation in work activities													
Work involving machineries													
Work involving vehicles													
Demand for work at heights													
Work under poor weather conditions													
Fatigue/tiredness													
Tight timescales/deadlines													
Use of hazardous substances													

APPENDIX C

GEOGRAPHICAL REGIONS AS DEFINED IN THIS STUDY

APPENDIX D

DEFINITIONS OF PRIMARY CAUSES

Vehicle rollover	Rollover of all types of vehicles used for work, such as cars, vans, tractors and ATVs
Fall from height	Where victim fell from a height more than 1 metre.
Crush injuries (non vehicle)	Incidents where the victim has received fatal crush injuries not directly involving a vehicle, e.g., crushed by machinery such as a recycling / rubbish compactor of truck.
Vehicle crushes	When victim has received fatal crush injuries involving a vehicle, e.g., crushed between vehicle and an obstacle. Excluding rollovers
Felling incident	Fatality incurred when victim involved in the process of felling trees.
Vehicle incident	When victim is involved in a vehicle incident that is other than crushes or being struck by a vehicle.
Struck by object	When victim was struck by object such as rocks and logs (when not actually felling), excluding struck by vehicle.
Electrocution	Where the victim was electrocuted.
Drowning	Drowning incidents, including diving fatalities where victims suffered unknown problems whilst on the dive.
Machinery incident	Where machinery/equipment was involved in the incident, e.g., moving parts of machinery striking/entangling victim.
Animal incident	If an animal that contributed to the fatality.
Slip / trip / fall	Involves when victim slipped, tripped or fell whilst walking or running (includes falling down stairs but excludes fall from height incidents).
Natural disaster / weather conditions	Eruptions, avalanches etc.
Extreme heat / burning / smoke / fumes	Where victims were fatally injured by heat, burning, smoke and fumes inhalation.
Asphyxiation	Incidents of asphyxiation and strangulation, excluding drowning.
Struck by vehicle	When victim was struck or run over by a vehicle (e.g., bystander hit by work vehicle)
Machinery incident – Crane	Where machinery / equipment was involved in the incident but specifically involving cranes.
Vehicle incident – ATV (non rollover)	When victim was involved in an ATV incident where the vehicle did not rollover (e.g. struck fence without rolling over and crushing victim).
Vehicle incident - other farm vehicle	Other farm vehicle incident (e.g., Tractors, this excludes ATVs).
Assault	Incidents where the victim was assaulted (e.g., shot, bashed, etc.).
Rail incident	Incident involving train.
Health problems	For example heart attack at work.

FOR FURTHER INFORMATION ON HEALTH AND SAFETY VISIT WWW.DOL.GOVT.NZ OR PHONE 0800 20 90 20

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