School of Public Health

The Effectiveness of a Manual Handling Workplace Risk Assessment Team in Reducing the Rate and Severity of Occupational Injury

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"I have not been able to discover that repetitive labor injures a man in any way. I have been told by parlor experts that repetitive labor is soul, as well as body-destroying, but that has not been the result of our investigations."

Henry Ford, 1922

ABSTRACT

Globally, there is an increasing tendency for occupational legislation and practice to require that employers actively involve their employees in the process of identifying, assessing and addressing the risk of injury in the workplace. Despite this, there is a paucity of research evaluating the effectiveness of participatory ergonomics in reducing occupational injury outcomes. In particular, a review of the literature fails to identify research that reports a change in the risk of injury at the level of the individual worker. The objectives of this study were to determine whether a participatory ergonomics approach to the control of workplace hazards and manual hazards in particular, could reduce the occurrence and severity of injury among a working population at risk.

The research design was that of a longitudinal pre-post intervention study, with one intervention and three comparison groups. The observational period between 1 July 1988 and the 31 October 1995, comprised a 4.3 year pre-intervention period and a 3-year post-intervention period. The Intervention Group was a population of hospital cleaners at a high risk of injury. Three comparison groups were used, namely orderlies from the same hospital, cleaners from a similar hospital, and all the cleaners in the State of Western Australia. The primary outcome measure of occurrence was that of a lost-time injury (LTI). To obtain parameters of injury severity, each LTI was measured in terms of the associated CPI-adjusted workers' compensation claim cost and the number of hours lost from work (duration). The data were obtained three years after the observational period, to improve the likelihood that the claims had been finalised. Aggregate-level LTI data were obtained for all four groups. Individual-level data were also obtained for the Intervention Group and the Orderly Services Group, whether injured or not. These data included the age, gender, hours worked and work experience of the subjects. Also, where there was an LTI, it was determined whether or not the mechanism of injury was from manual handling. Using these data, two analytical approaches were then undertaken. Study 1 assessed the

aggregate-level LTI data of the four groups. Study 2 evaluated individual-level data for the Intervention Group and the Orderly Services Group.

The results demonstrate statistically significant post-intervention reductions in all measures of LTI occurrence for the Intervention Group. In particular, after allowance for age, gender and work experience, there was a two thirds reduction in the rate of LTI per hour worked No reduction in injury occurrence was observed for any of the comparison groups. The severity of each injury, as measured by claim cost and duration, did not change after the intervention for the Intervention Group.

This study indicates that a small group of unskilled workers, with the facilitation of an ergonomist, can successfully undertake an iterative process of identifying and assessing hazards and make recommendations for their control. In doing so, even where the primary focus is on manual handling hazards, a reduction in the risk of injury from both manual handling and non-manual handling mechanisms can be achieved. Participatory ergonomics, by investing hazard management skills within employees, increases the likelihood that solutions to problems will be accepted, and should release ergonomists to consult to a greater number of workplaces than if they work independently of employee participation. The evaluation of interventions in a variety of workplace settings is recommended, to confirm participatory ergonomics as an effective tool for the reduction of the global burden of occupational injury.

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ABBREVIATIONS

CPI	consumer price index
DALY	disability-adjusted life year
EU	European Union
FCE	functional capacity evaluation
GEE	generalised estimating equations
GLMM	generalised linear mixed models
JSI	job severity index
LTI	lost-time injury
MAWL	maximum acceptable weight limit
MHI	manual handling injury
NIOSH	National Institute of Occupational Safety and Health
OSHA	Occupational Safety and Health Administration
RCT	randomised controlled trial
RWL	recommended weight limit
UK	United Kingdom
USA	United States of America
WRATs	workplace risk assessment team

FOREWORD

At the time of thesis completion, two associated papers have been published in international peer-reviewed journals.[1 2] A third paper has accepted for publication,[3] and a fourth is under editorial consideration.

1. Carrivick PJ, Lee AH, Yau KW. Consultative team to assess manual handling and reduce the risk of occupational injury. *Occup Environ Med* 2001;58(5):339-44.
2. Carrivick PJW, Lee AH, Yau KW. Effectiveness of a workplace risk assessment team in reducing the rate, cost and duration of occupational injury. *JOEM* 2002;44(2):155-159.
3. Carrivick PJW, Lee AH, Yau KW. Effectiveness of a participatory workplace risk assessment team in reducing the risk and severity of musculoskeletal injury. *J Occup Health* 2002; awaiting publication.

CHAPTER ONE

INTRODUCTION

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1.0 BACKGROUND

One hundred million occupational injuries and 11 million occupational diseases are estimated to occur annually throughout the world,[1] with an associated number of days lost estimated at 723 million from injury and 106-250 million from disease.[2] The resultant economic cost to society, depending on the country and the study, is estimated to be between 2-14% of gross national product.[3] Occupational injury also impacts, directly and indirectly, upon organisational profitability and efficiency, and upon the workers who sustain the harm.[4]

Of the many hazards that can exist in workplaces, manual handling alone is the greatest contributor to non-fatal injury and disease; commonly accounting for one third of national injury counts.[5-7] If the global burden of occupational injury and disease is to be reduced, the risk[a] attributable to manual handling must be reduced. To date, however, attempts at manual handling injury risk assessment and risk control have been problematic. Despite the effort by countries to develop workplace manual handling risk management strategies that are informed by valid and practical interventions,[9] there is no evidence that a reduction in the number of injuries has

[a] 'Risk' being defined as the probability and consequence of an event.[8]

occurred,[10] and a suggestion that reported disorders from overexertion or repetitive movements may be increasing.[11]

Although the link between manual handling and injury is demonstrated,[12] many factors impede upon traditional approaches to reducing the risk of injury from this mechanism. Firstly, manual handling is a poorly understood hazard. Little is known of the dose-response relationship, except that it is non-linear;[11] and there is no clear understanding about the pathogenesis of injuries (which are usually musculoskeletal in nature) associated with manual handling.[13] Secondly, attempts to assess the risk of injury have had a narrow focus on the forces involved in manual handling, and the ergonomic basis for the assessment of the risk of manual handling injury has its origin in the 1950's and 1960's. The science informing ergonomics was established to contribute to the design of efficient and productive workplaces, in which the stresses on workers are below the threshold for fatigue and discomfort;[14] not for the purpose of manual handling injury risk assessment *per se*. The empirical approaches used are incomplete, contradictory, and lacking in validity.[15] The risk assessment tools and guidelines generated for use in the workplace, are often impractical or expensive; none account for all major risk factors, and their application and interpretation requires expert knowledge.[16] Finally, early attempts to control risk, by modifying the worker by selecting only the fit, and then training them in lifting techniques, have not been proven successful. The sensitivity and specificity of pre-placement examinations for estimating the future risk of injury is low;[17,18] and issues of disability and equal opportunity legislation underscore this method as generally inappropriate. The training of workers, in lifting, back care or exercise programs, has not been demonstrated to reduce the incidence of injury.[10,19-23]

The emphasis of risk control is now on the modification of workplaces to suit the worker; and there is some evidence that this can be effective.[10,24,25] There is also recent workplace-based evidence that certain manual handling tasks (involving repetition, force and/or posture) are qualitatively associated with an increased likelihood of injury.[12] Consequently, where there is an intent within workplaces to reduce the risk of injury from manual handling, the issue is to determine who should undertake the risk assessment and what processes should be followed. The professional person recommended to advise on the control of manual handling risk in the workplace is a specialist in ergonomics.[26] However, surveys in 1995 and 1996,[27] indicate there are few ergonomists around the world, and only half practice in the workplace setting.[27] Furthermore, an ergonomist, despite professional expertise, does not necessarily understand the nuances of a particular job.

The emergence of ergonomics over the past 50 years,[26] has been parallelled by western governments and workplaces becoming more participative in their practices.[28] The interface between the two developments led, in the 1980's, to the concept of participatory ergonomics. Participatory ergonomics is a loose term, and there are varying definitions and levels of application; but, essentially, it is a process for the application of worker input into the design of work. When applied to occupational safety and health, it can include worker participation in the assessment of the risk of injury. Although not well validated as an effective approach to the reduction of the risk of injury, the concept of participatory ergonomics has been implicitly adopted in the ergonomic regulations and codes of practice of many countries and statutory authorities. Some of these regulations and codes of practice deal with manual handling; where it is a requirement of employers to manage risk and involve at-risk employees in the process.[29-31]

1.1 STATEMENT OF THE STUDY PROBLEM

In 1989, the management of a 600-bed Western Australian adult teaching hospital identified a need to reduce the risk of occupational injury among its staff. This was due in part, to a high number of injuries associated with extremely high workers' compensation premium costs. As well, new occupational safety and health legislation had just been introduced within the State. This imposed on the hospital, for the first time, explicit responsibility for the safety and health of its employees; and a requirement to consult with employee representatives in relation to safety and health matters.

In response, the hospital created a Department of Occupational Health to assist it to better identify and address the risk of injury to its staff. In 1991, that Department, utilising a newly released Australian Standard for the reporting and recording of occupational injuries,[32] identified that the rate of injury for all staff was 25% higher than the overall injury rate for the State for the 1990/91 financial year (1 July 1990-30 June 1991). Manual handling was the mechanism of injury in over 60% of cases; twice the proportion for the State.[33] Analysis of injuries by occupation, revealed that staff from 'Cleaning Services' and 'Orderly Services' had experienced an injury rate more than double that of staff within 'Nursing Services'; and for these two groups, manual handling was the mechanism in two thirds of cases.

A reduction in the risk of injury from manual handling was seen as the key to reducing overall risk of occupational injury within the hospital. However, a method for doing so was not apparent. Within Western Australia, manual handling remained the most common mechanism of work-related injury; and the proportion of injuries associated with manual handling had not declined for many years.[34] Research literature indicated that neither fitness-based worker selection,[22] nor the training of staff in lifting techniques,[35] were effective methods of controlling the risk of injury from manual handling. There was, however, some indication that work redesign had the potential to reduce injuries from manual handling.[22]

In November 1992, the hospital, under the recommendation of the author, selected Cleaning Services, a group at high risk of injury from manual handling, to trial a manual handling Workplace Risk Assessment Team (WRATs) program. The aim of the Team was to achieve a sustained reduction in injuries, from manual handling in particular, for all staff within the Department of Cleaning Services. The intervention was the application of an iterative 3-stage manual handling injury risk identification, assessment and control process, to the workplace of cleaners, by a consultative team of management and employee representatives and an ergonomist. The Workplace Risk Assessment Team commenced in November 1992 and their activities were studied until October 1995.

1.2 AIM, OBJECTIVES AND EXPERIMENTAL HYPOTHESES

The aim of this thesis is to evaluate the effectiveness of the manual handling Workplace Risk Assessment Team (the intervention) in reducing the risk of injury among staff working within the Department of Cleaning Services. There are two objectives in this aim.

The first objective is to determine whether the occurrence of injury within the Department of Cleaning Services reduced after the introduction of the intervention.

Experimental hypotheses:

H_0: The pre-intervention occurrence of injury = the post-intervention occurrence of injury.

H_1: The pre-intervention occurrence of injury > the post-intervention occurrence of injury.

The second objective is to determine whether the severity of injury, as measured both by workers' compensation claims cost and by hours lost from injury, reduced after the intervention.

Experimental hypotheses:

H_0: The pre-intervention severity of injury = the post-intervention severity of injury.

H_1: The pre-intervention severity of injury > the post-intervention severity of injury.

1.3 SIGNIFICANCE OF THE STUDY

Workplace manual handling injuries are a major cost to society. Traditional approaches to reducing the risk of injury due to manual handling tasks have not been successful. Increasingly, organisations are turning to participatory ergonomics to help reduce the risk. This thesis adds to the body of knowledge of participatory ergonomics, by evaluating the effectiveness of a participatory intervention to control the risk of injuries, where the majority of injuries are associated with manual handling. The available literature dealing with the capacity of non-ergonomists to assess their work for the risk of injury due to manual handling is contradictory.[36-39] There is also a paucity of research evaluating the effectiveness of participatory ergonomics interventions in reducing the frequency and severity of injury.

In addition to the wider relevance, the thesis is of direct interest to the safety and health of cleaners. An overview of the occupational safety and health performance of the estimated 180,000 people employed as cleaners throughout Australia in 1992/93,[40] indicated an injury frequency rate that was 1½ times the *All Occupations* rate; and an average duration of absence from work after occupational injury/disease occurrence of 1½ times the *All Industry* average. 'Body stressing' accounted for half the cases; and almost 70% of all injuries were musculoskeletal in nature. It was determined that, if in 1992/93 the injury/disease incidence rates for full time employees could be reduced to the same level as the *All Industries* rate, the total savings would amount to $50 million per annum. The imbalance in the rate of injury for cleaners in Australia is also evident elsewhere. Cleaners in Quebec hospitals, for example, suffered almost twice as many occupational accidents and illnesses as the average healthcare worker.[41]

1.4 OUTLINE OF THE THESIS

This thesis is divided into seven chapters. This first Chapter has introduced the aims and objectives of the study. The following chapter focuses on the global burden of occupational injury and disease, and identifies manual handling as a global hazard that needs urgent attention. It then explores the difficulties associated with traditional approaches to manual handling risk assessment and control. Next, an introduction to the concept of participatory ergonomics is provided. Finally, Chapter 2 examines the literature dealing with the effectiveness of participatory ergonomics in reducing the risk of injury from manual handling.

The background to the intervention hospital, and the need to address manual handling hazards as a priority, is provided in Chapter 3. The Chapter also explains the rationale for the selection of the Cleaning Services Department as the intervention group for the application of a manual handling Workplace Risk Assessment Team (the intervention). The purpose of the Workplace Risk Assessment Team, and the details of the intervention, are provided in Chapter 4.

Chapter 5 describes the methods used in the study. The research design is that of a longitudinal pre-post intervention study, with one intervention and three comparison groups. The process for recruitment of the groups is explained, and details of the primary outcome measure (lost-time injury) and the observational period are provided. Issues related to data collection, data management and ethics are then considered. Finally, the statistical methods utilised for the aggregate-level data analysis and the individual-level data analysis are provided.

Chapter 6 provides the results obtained from both the aggregate and individual-level analyses, and the final chapter, Chapter 7, provides a discussion of the results, conclusions, limitations of the study, and suggestions for further research.

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CHAPTER TWO

A REVIEW OF THE LITERATURE

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2.0 INTRODUCTION

This Chapter provides the context for the need to determine the effectiveness of a participatory ergonomics approach to the reduction of the risk of injury.

The global significance of manual handling as a hazard is first emphasised. Next, traditional approaches to the assessment and control of the hazard are examined to explain why they fail to be effective in reducing the risk of injury. An introduction to participatory ergonomics is then provided; including its recent application to the management of the risk of injury from manual handling. Finally, the paucity of rigorous studies evaluating the effectiveness of participatory ergonomics interventions, in terms of injury outcome measures, is emphasised.

2.1 THE IMPORTANCE OF MANUAL HANDLING AS A HAZARD

This section overviews the burden of occupational injury and disease to nations, to workers, and to the organisations for which they work. A discussion of the contribution to this burden, from work-related disorders[a] associated with manual handling, highlights why the control of the risk of injury in the workplace is important. It should be remarked that there are difficulties in quantifying injuries and disease caused by work. Many such disorders cannot be confidently ascribed in the individual case (because the clinical features are no different in those cases caused by work and those not caused by work) and accurate estimation of attributable numbers depends upon more sophisticated epidemiological analysis than simply counting cases.

2.1.1 The Burden of Occupational Injury and Disease

2.1.1.1 The burden to nations

In 1992 in the United States of America (USA), where the average 25-65 year old spent 40% of his/her time at work, there were approximately 6500 job-related deaths due to injury; 60,300 deaths from disease; 13.2 million non-fatal injuries; and 862,200 illnesses in the civilian work force.[2] The total (direct and indirect) cost of occupational injury and disease was conservatively estimated at $US171 billion (injuries $US145 billion and illnesses $US26 billion). This compares with the total costs for that year of cancer at $US170 billion, cardiovascular disease at $US164 billion, Alzheimer's disease at $US67 billion and AIDS at $US30 billion.[2]

Within the European Union (EU), in 1996, it was estimated that there were 4,757,611 injuries requiring more than 3 days absence from work. Of these injuries, approximately 50% resulted in absence of between 2 weeks and 3 months from work.[3] The rate of 'over 3-day injuries per 100 workers' in 1996 varied between 1.6 in the United Kingdom (UK) to 6.9 per 100 workers in Portugal;[4] and the calculated economic cost of work-related ill health between European member states ranged

[a] A *work-related disorder* covers the terms work-related injury and work-related disease.[1]

between 2.6% and 3.8% of the Gross National Product.[5] In the UK, the cost of work-related injuries and ill health in 1991 was estimated at £UK11-16 billion.[6] By 1995/96, over 1 million work-related injuries at work were recorded in the UK; resulting in a loss of 24.3 million working days and 27,000 people giving up work.[7]

In Australia, the total annual economic cost of serious workplace injury has been estimated at $AUS20 billion;[8] with a decline in the rate of lost-time injuries (defined as 5 or more days lost from work), from 2.9 to 2.4 per 100 workers between 1994/95 and 1997/98.[9]

2.1.1.2 The human burden

Being at work is not safer than being at home,[10] but the full cost from occupational ill-health or injury to the worker, which may include pain and suffering, and emotional and social incapacity, is difficult to estimate. It is calculated that, globally, 2.7% of disability-adjusted life years (DALYs) are due to occupational factors. This compares with 15.9% of all DALYs from malnutrition (the highest risk factor), 2.6% from hypertension and 0.6% from illegal drug use.[11] In 1996, the attributable burden of occupational exposures in Australia was 44,000 DALYs; or 1.7% of the total burden of disease and injury.[12] A survey in 1995, estimated that 2 million individuals in UK were suffering from an illness, which they believe was caused by their work (current or past)[13] Seven hundred and twelve thousand of those affected were no longer in work. For the 1.3 million remaining, 575,000 had taken no time off work, and 545,000 had lost an estimated 19.5 million days because of work-related illness. Musculoskeletal disorders were by far the most common self-reported illness (affecting an estimated 1.2 million individuals).

From an economic perspective alone, the injured worker is placed at a significant disadvantage A North American study estimates that for employees losing more than 8 weeks from work, workers' compensation benefits cover less than 40% of their losses.[14] A UK Labour Force Survey,[7] estimated that in 1995, workers suffering work-related injury and disease directly lost £558 million in reduced income and additional expenditure. If loss from pain, suffering, and grief to them and their families were included, a cost of £5.5 billion was estimated.

2.1.1.3 The burden to organisations

To organisations that employ staff, the main apparent cost of occupational injury and illness is that of workers' compensation. However, additional 'hidden' costs are estimated at between 0.5 and 20 times the workers' compensation cost.[15 16] The highest indirect payments generally relate to compensatory overtime, extra staffing, training, recruitment of new staff, and loss of production time associated with the injured employee being off work. Other indirect economic costs can include additional management and supervision time, reduced productivity from employment of lower skilled replacement workers, and equipment down time associated with the accident.[17] In 1995/96 for example, the total cost of workplace injury was estimated at 4-8% of all UK industrial and commercial companies' gross trading profits; averaging between £143 and £297 per person employed.[7] Injury experience within an organisation may also be associated with secondary adverse outcomes such as reduced worker morale, liability to prosecution and poor public relations.

Occupational safety and health outcomes, both positive and negative, are increasingly seen as a direct and indivisible consequence of human involvement in the production of goods and services. Given the negative impact of work-related disorders, the imperative of countries and workplaces is to manage major hazards[b] such that the risk of disorders is reduced. Risk management[c] involves an explicit analysis and determination of an acceptable level of risk.[19] Injury risk management, which subsumes risk identification, risk assessment and risk control, has now become the dominant paradigm in occupational health and safety law and codes in many countries around the world.[20]

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[b] A hazard being defined as anything that may result in injury to the person or harm to the health of the person.[18]
[c] Risk management "The management of the working environment to control those aspects of work that will lead to undesirable health and safety outcomes".[19]

2.1.2 Manual Handling as a Major Hazard

2.1.2.1 The magnitude of injuries from manual handling – incidence and severity

Manual handling[d] (usually classified as within the *Ergonomic* grouping[e] of hazards) not only has the potential to produce injury,[21-25] but outperforms any other hazard as a source of work-related disorders.

In 1994, 705,800 injuries due to overexertion or repetitive motion, and resulting in time off work, were sustained by workers in the USA.[26] These injuries, representing 32% of all lost-time injuries in the USA, had a direct cost of $US13-20 billion. Five hundred and thirty thousand of these cases were associated with manual materials handling activities such as lifting, pushing, pulling and carrying. The median time away from work, for cases of manual materials handling injury, was six days; and the total costs (direct and indirect costs) were estimated as high as $US100 billion.[27]

Within the EU, the percentage of injuries associated with categories of manual handling are; 'lifting/moving heavy loads' 34%; 'repetitive movements' 57%; and 'strenuous working postures' 45%.[3] As an example, injury data from the UK indicate that, for the 1997/98 and 1998/99 financial years, the most frequent association with injury (requiring more than 3 days off work) was 'handling, lifting or carrying'.

In Australia, 47,000 body stressing lost-time injuries were sustained by employees during the 1996/97 financial year; contributing 39% of total lost-time workplace injuries. In contrast, the next highest mechanisms of injury being 'falls, trips and slips' at 21.1%, and 'being hit by moving objects' at 14.4%.[9] Injuries from manual handling were also more severe than others on average; the total economic cost of injuries attributable to body stressing at $AUS9.5 billion,[28] being nearly half the total figure for all workplace injury and disease.

In Western Australia (total population of 1.6 million), 9,000 lost-time injuries[f] from manual handling were reported for the 1996/97 financial year; accounting for 30% of

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[d] Alternative names for manual handling include 'manual materials handling', 'body stressing', and 'overexertion'.

[e] Hazards are classified according to type; for example, 'physical', 'ergonomic', 'chemical', 'biological' or 'psychological'.

all occupational injuries.[29] In 1995/96, the workers' compensation cost of manual handling injuries was over $60 million.[30] The average time lost from manual handling injuries was 36 days at an average cost of $12,300; in comparison to $8,900 for 'All injuries'. For 'severe injuries', classified by the Western Australian Government as those requiring 60 days or more off work, the average workers' compensation cost of injuries associated with manual handling was $64,000.

2.1.2.2 The nature of manual handling injuries

One reason for the greater cost, is that the nature[g] of the injury from manual handling is usually that of a musculoskeletal disorder[h], which can be slow to resolve. In the USA the lower back is the most common site of injury associated with materials handling activities, followed by injury to the shoulders.[26] Ninety percent of manual handling injuries to Western Australian workers in 1995/96, for example, resulted in sprains, strains or dislocations (89.6% for males and 89.7% for female workers). The majority of the remainder of manual handling disorders for males were described as the result of 'musculoskeletal disease' (4.4%) or hernias (3.7%), and for females as 'musculoskeletal disease' (7.3%). The trunk (which includes the back) and the upper limbs were the parts of the body most affected by manual handling injury.

2.1.2.3 The industrial demography of manual handling injuries

A variety of inter-related demographic factors influence the risk for occupational injury from manual handling.

(i) Heavy physical work

Reviews of low-back pain in industry have found that workers with 'heavy' manual jobs are more likely to develop compensable injuries than other workers, and the severity of symptoms is greater in this group.[33-35]

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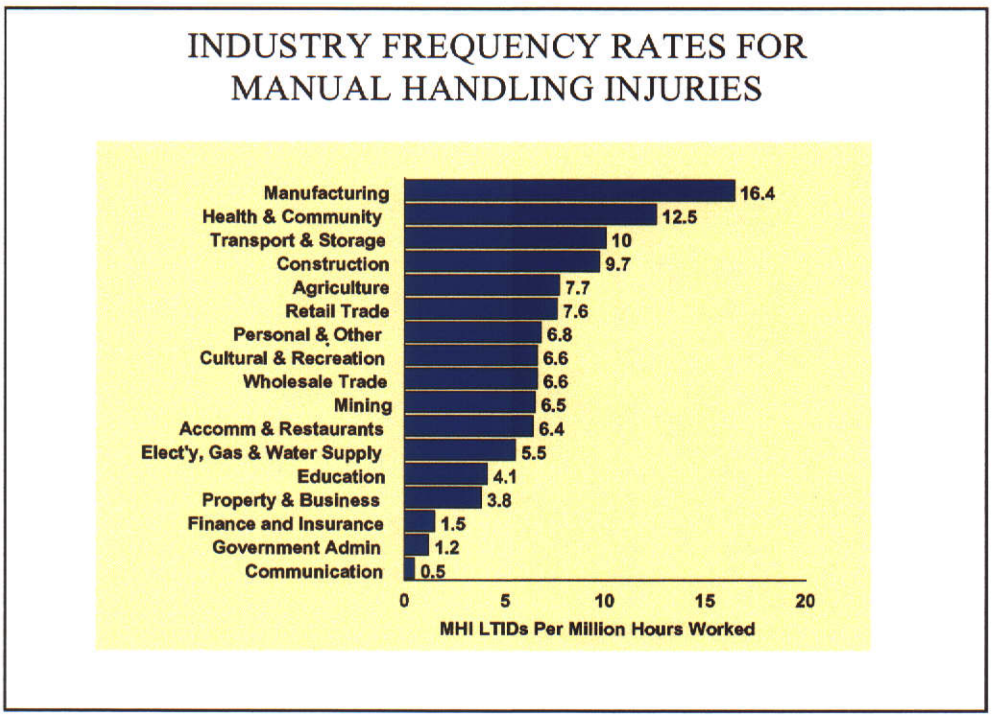
[f] Lost-time injury an occupational injury or disease resulting in the loss of a shift or more from work.
[g] The nature of injury is defined as the type of hurt or harm that occurred to the worker.[31]
[h] *Musculoskeletal disorders* refers to conditions that involve the nerves, tendons, muscles and supporting structures of the body.[32]

(ii) Industry

Variation between industries in injury rates may, in part, reflect differences in completeness of reporting or in the handicap produced by the same level of disease in different jobs. For example, it may be easier to continue working with a back disorder in a sedentary job than in a physically demanding position. Nevertheless, the magnitude of injury from manual handling is borne unevenly between industries.[28 33 36] In Western Australia, for example, the frequency rate for manual handling injury is highest in the 'Manufacturing' and 'Health and the Community' sectors[i] (see Figure 2.1[j]). Within the 'Health and Community Services' sector, nearly half of the injuries are associated with manual handling (see Figure 2.2), and the injuries are more severe than for most industries (See Figure 2.3).

Figure 2.1 *Manual handling injuries (MHI) by industry in Western Australia (1995/96)*



[i] 'Health' includes hospitals and nursing homes.

[j] It is noted that Figures 2.1-2.7 are presented using the layout and abbreviations supplied to the author by the WorkSafe Western Australia Commissioner. LTI/Ds = lost-time injuries/diseases.

Figure 2.2 *Manual handling injuries (MHI), as a proportion of all lost-time injuries and diseases (LTI/Ds), by industry in Western Australia (1995/96)*

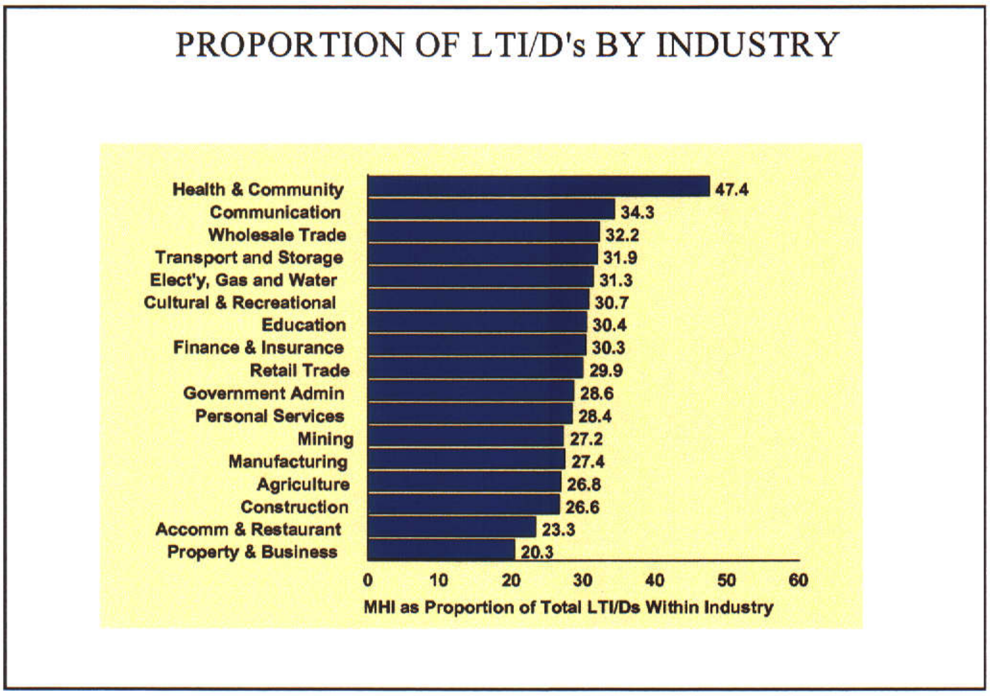
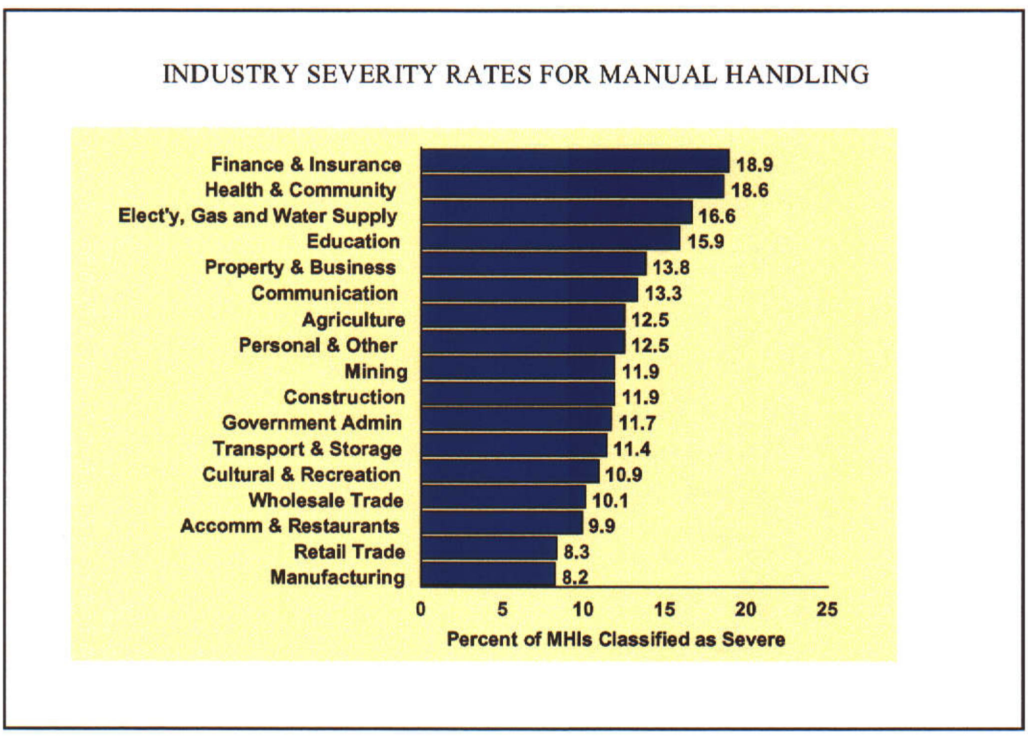


Figure 2.3 *The proportion of manual handling injuries (MHI) classified as severe (requiring 60 days or more from work), by industry in Western Australia (1995/96)*



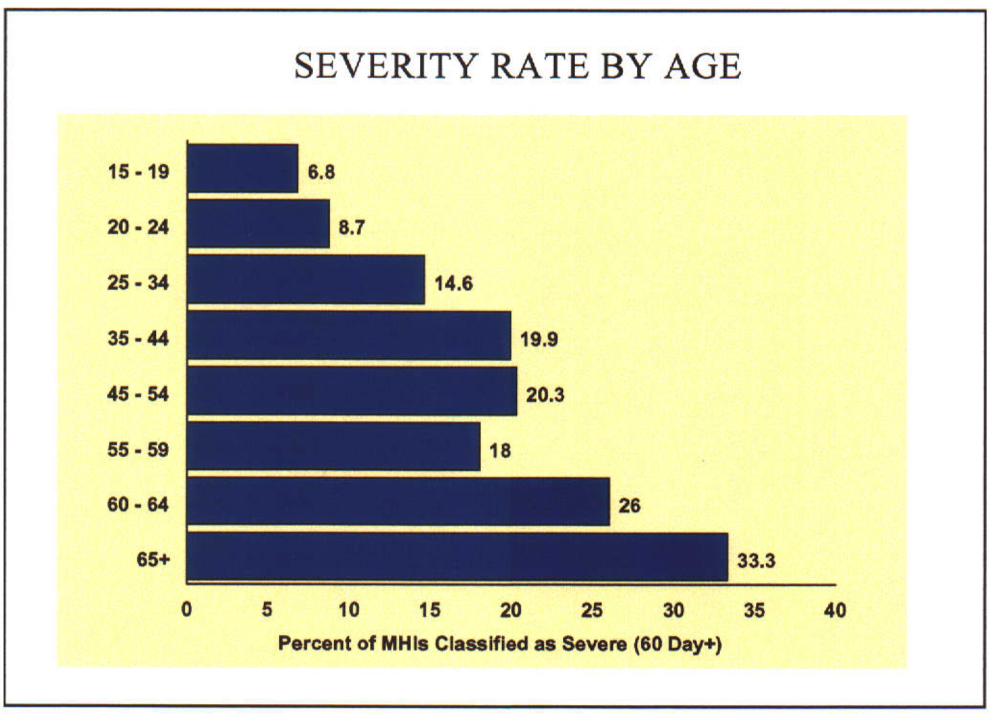
(iii) Job classification

The risk of injury from manual handling varies greatly according to occupation and skill.[34] In Australia, as elsewhere, the broadest occupational category accounting for the largest rates of manual handling injuries in both men and women is that of 'Labourer'.[28] Even within an industry where many occupations are at high risk of injury, this differential risk tends to occur. For example, within the 'Health Industry' workforce in Australia, the rates of injury among 'ward helpers' (such as orderlies and cleaners) are double the average for the whole population (including nurses).[37]

(iv) Age

In contrast to injuries from other causes, there is evidence that as workers get older the risk of injury from manual handling increases.[38 39] Also, as noted in the Western Australian data (see Figure 2.4), the severity of injury from manual handling increases as the age of the injured worker increases.

Figure 2.4 *The percentage of manual handling injuries (MHI) classified as severe, by 5-year age group, in Western Australia, (1995/96)*



(v) Gender

Women undertaking similarly physically heavy jobs as men tend to report more claims than men.[33] Within the total workplace, more men than women sustain injuries from manual handling but, as exemplified in Western Australia (see Figure 2.7), on average women take much longer to recover.

(vi) Work experience

A positive relationship between lack of work experience and increased risk of injury from manual handling has been suggested, but not clearly demonstrated.[33]

2.1.2.4 The resistance of manual handling injury rates to change

The need to reduce the attributable risk of work-related disorders from manual handling has been apparent to most countries for many years. However, there is no global evidence of success in this regard, and in some areas the incidence may be increasing.[40] In 1992, the National Institute for Occupational Safety and Health (NIOSH) recognised the importance of injuries from manual handling.[41] This importance continues, with NIOSH, in 2001, setting their priority areas for research to include musculoskeletal disorders, risk assessment methods and intervention effectiveness research.[42] For most member states of the EU, manual handling/work postures remain workplace risk factors requiring attention.[43]

In Australia, the proportion of all injuries from body stressing rose from 39% in 1996/97 to 41.5% in 1998/99. Between 1988/89 and 1996/97, the total injury Frequency Rate[k] reduced in Western Australia, but by a greater amount for injuries not associated with manual handling (see Figure 2.5) As a consequence, over that time, manual handling injuries increased as a proportion of all injuries (see Figure 2.6). Over the same period, the average number of working days lost from manual handling injuries increased (see Figure 2.7). A reduction in manual handling injuries was one of 6 priority areas for the State Government. In 1996/97, WorkSafe Western Australia (the State Government's occupational safety and health authority) issued 423 improvement notices requiring improvements in work practices, and prosecuted

[k] The Frequency Rate is described, in Western Australia, as the number of lost time injuries and diseases for each million hours worked by a group of workers over a given period.

4 organisations, relating to manual handling. This focus continued the next year also. However, in 1998/99, the percentage of lost-time injuries associated with manual handling remained at the 1996/97 level of 30%.

Figure 2.5 *Manual handling and non-manual handling lost-time injury and disease (LTI/Ds) Frequency Rates, by financial year in Western Australia*

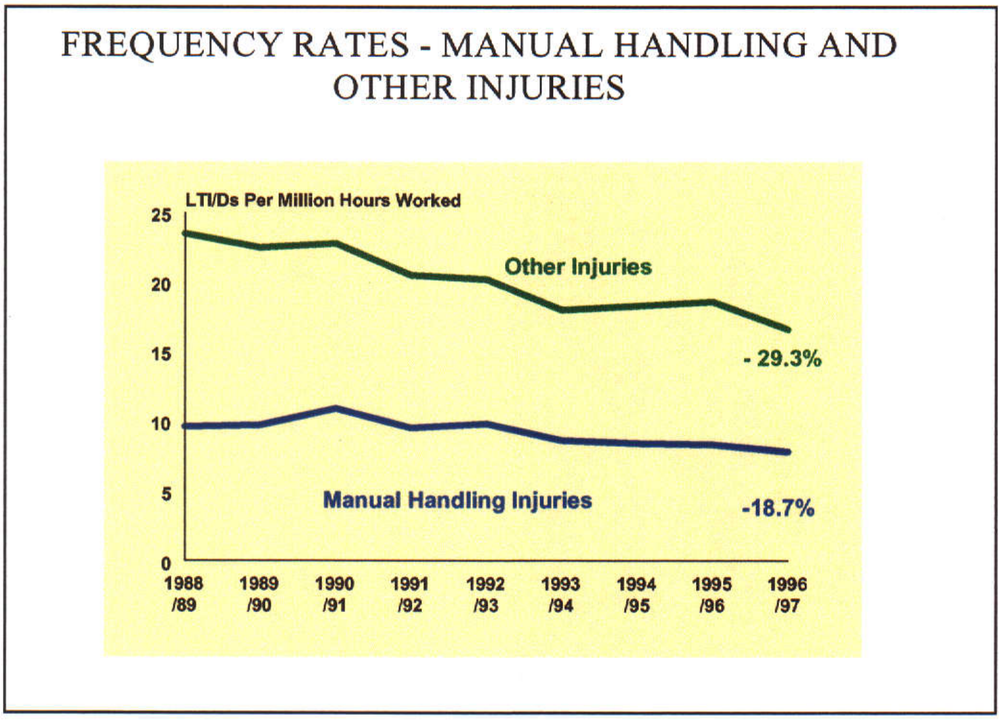


Figure 2.6 *Manual handling lost-time injuries and diseases (LTI/Ds), as a proportion of all LTI/Ds, within Western Australia by financial year*

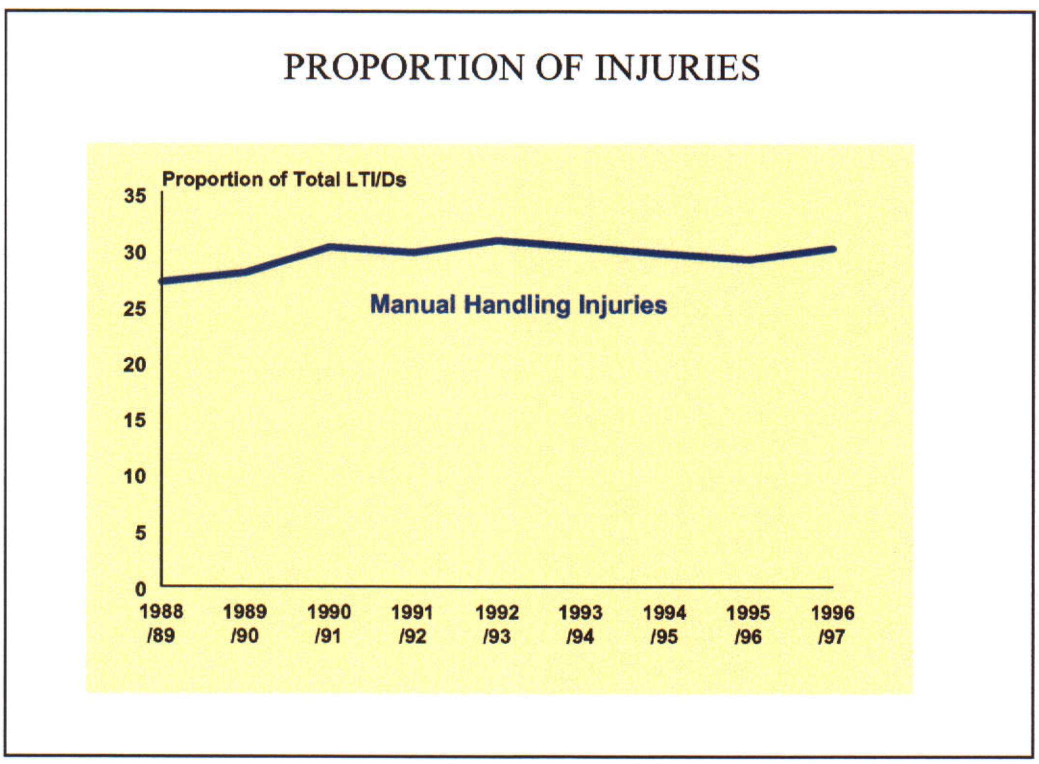
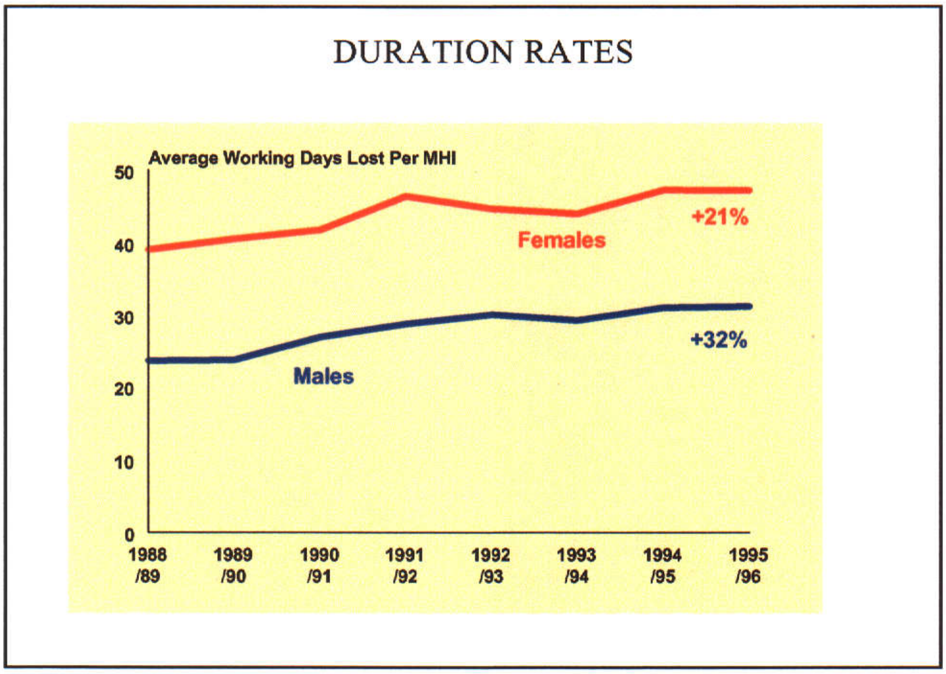


Figure 2.7 *The average number of working days lost (Duration Rate) for manual handling injuries (MHI) in Western Australia, by financial year*



2.2 ISSUES WITH TRADITIONAL APPROACHES TO MANAGING MANUAL HANDLING AS A HAZARD

The accurate identification and assessment of manual handling tasks with high risk of producing injury are considered the initial strategic steps to effective programmes for the control of the risk of injury.[20 44] However, as indicated in the previous section, a global reduction in the risk of injury from manual handling has not been experienced.

This section argues that one reason for the lack of success in reducing the incidence of injury in existing workplaces lies within the definition of manual handling. Most definitions of manual handling are similar to that utilised in Chapter 5. That is, manual handling is 'any activity requiring the use of force by a person to lift, lower, push, pull, carry or otherwise move, hold or restrain a person, animal or thing'.[45] In this case, 'manual' refers to part or all of the energy of force being created by the worker and 'handling' includes actions, like lifting, lowering, pushing, pulling, carrying and holding either singular or in combination.[46]

The focus on the forces involved in manual handling tasks, has led to simplistic and ineffective approaches to the assessment and control of the risk of injury. In particular, the scientific base informing ergonomics has, unsuccessfully, concentrated on the forces involved in certain tasks. At the same time, employers have attempted to modify workers; either by pre-placement selection of workers who they think are capable of withstanding the forces required by the tasks, and/or by training workers to be able to more efficiently deal with the forces involved.

It is first shown in this section that the scientific approaches to the assessment of force have not been validated, that workplace assessment tools are complex and conflicting, and that work and worker characteristics (including the propensity to report injury) confound simple assessment.[47]

Next, problems with worker selection and training are considered. This section concludes by indicating that modifying the workplace, rather than the worker, does have the potential to reduce the risk of injury from manual handling; particularly if the workers themselves are involved in the implementation of the risk controls.

2.2.1 Assessment of the Risk of Injury from Manual Handling

Traditional injury models infer exposures are external factors (hazards) that imply risk.[40] Conceptually, in such models, a dose corresponds to the amount of external factor received by the body. The dose may be measured, for example, by the concentration of injurious substances, or in the case of manual handling, the forces applied to the body. Bodily responses to the internal dose received by target tissue may include tissue damage, with subsequent symptoms and/or dysfunction. As will be shown, however, there are many limitations to the application of this model in relation to the hazard of manual handling. Limitations noted in this section include the narrow focus on 'force' as being the major exposure associated with the risk of injury. Within this narrow focus, another limitation is the adoption of certain empirical methods, initially used to inform the design of efficient workplaces, to inform the assessment of the risk of injury. Fundamentally, these approaches assume that fatigue is associated with an increased risk of injury;[48] yet the pathophysiology of injury or disease from manual handling remains poorly understood.

2.2.1.1 *The scientific basis of manual handling risk assessment*

Scientific approaches to the assessment of the risk of injury involve quantifying the frequency, duration and intensity of manual handling; and then assessing the data in relation to its potential to cause injury. The data used are often initially obtained to design tasks that maximise the efficiency and productivity at work, and then later applied to the assessment of the risk of injuries. The main approaches to the assessment of the risk of injury from manual handling involve the biomechanical, the physiological, the psychological, the psychophysical and the epidemiological approaches, or a combination of approaches.[46] Results from these approaches are largely informed by observation, questionnaires/interviews/surveys, empirical studies, or by epidemiological studies.

(i) The biomechanical approach

The biomechanical approach is concerned with measuring and/or modelling the 'internal' mechanical responses of body tissue to the 'external' physical demands of work activity.[27] It is argued that all musculoskeletal occupational injuries, at least, are biomechanical in nature.[49] The goal of the biomechanical approach is to allow the design of tasks that do not exceed the capacity of the musculoskeletal system.[48] A secondary aim is to identify the risk of injury from manual handling by measuring or estimating the biomechanical stresses within the worker performing the task.

Measures include peak joint moment, peak compression and shear forces on the lumbar spine, mechanical energy transfer, and average integrated moments of forces. Data is obtained either by stress testing (static or dynamic) a population in relation to the strength required for a particular job (e.g. by looking at the percentage capable); by tissue failure studies using cadavers to which forces are applied to body tissues (particularly in the lumbar spine); or by epidemiological studies in which models of spinal forces using workplace data (generally obtained by estimation from biomechanical modelling forces through the body based on workers' posture and forces used) are related to injury patterns.[46] The models, however, can only estimate loads through real tissue. Models cannot accommodate all parts of the body,[50] and they also assume that the body behaves according to the laws of Newtonian physics.[51] To be realistic, in addition to the external load (the force on the body from the object to be manipulated by the worker), models also have to be able to estimate the internal load[1], which frequently can be 10 times greater than that of the external load. To counter some of the problems of *in vitro* methods, recent methods for reviewing the risk of back pain, for example, include near infrared spectroscopy to measure the low-back extensor oxygenation during prolonged contractions; analysis of endplate fractures *in vivo* or quantification of the fluid redistribution in the spinal motion under stress; and laser-Doppler flowmetry to analyse myalgia of muscle fibres.[5]

The biomechanical approach mainly provides information for infrequent handling, and is usually used in attempts to quantify the suspected imposition of large forces on a particular structure of the body (e.g. back or shoulder). However, there is no complete consensus on what forces are injurious.[52] The approach is of limited use where manual handling is a dynamic activity. This is because static models ignore forces due to inertia of load and body segments, and may underestimate tissue stresses associated with dynamic movements.[48] Evidence of any relationship between the information gathered from biomechanical methods and the risk of injury is limited.[53-55]

(ii) The physiological approach

This approach compares measured or estimated physiological responses to the stress of performing a task, with the levels of physiological responses considered reasonable.[46] The physiological approach is considered useful in the assessment of the risk of repetitive tasks at moderate to high frequency and which involve large muscle groups; although the methods are resource intensive. Factors such as blood pressure, heart rate and aerobic capacity have been utilised. In this regard, a relationship between body fatigue and increased risk of injury is assumed. However, there is no agreement between researchers on methodology, or the quantitative relationship between aerobic capacity and risk of injury from manual handling.[48] Importantly, no epidemiological evidence of a relationship between physiological stress and injury outcomes exists.[56]

[1] Internal Load: the load supplied by muscles of the body to tendons and bones etc., to maintain equilibrium.

(iii) The psychological approach

The psychological approach attempts to measure subjective evaluation of work stresses and compare them with allowable psychological stresses. Discomfort, exhaustion and satisfaction are commonly used measures, with subjects reporting on tasks via a variety of tools (e.g. visual analogue scales, rating scales, and questionnaires). A relationship between the subjective feeling of stress and injury, however, has not been demonstrated.[46]

(iv) The psychophysical approach

Psychophysics bridges psychology and physics, by examining the relations between physical stimuli and the environment and the sensation perceived by humans who are exposed to the stimuli.[27] It is a subjective approach, reliant on self-reports from subjects.[57] Usually, psychophysical methods are used to assess how asymptomatic individuals respond to work demands over a work shift (compared with say biomechanical approaches which are more often concerned with predicting how body tissues will react during a single exertion[27]) and the main focus has been on the back and upper extremities.[57] Empirical methods are used to determine acceptable levels of work intensity through subjects adjusting their workloads (the force or frequency of a manual handling situation) to their resulting discomfort or fatigue that they perceive is acceptable,[54] or until it represents their maximum acceptable work load.[58] The work to be undertaken is then judged against this limit. The limit is generally the Maximum Acceptable Weight Limit (MAWL); although Maximum Acceptable Frequencies and Maximum Acceptable Forces have been occasionally established.[46 59 60]

To understand psychophysical factors impacting on MAWL, it is necessary to take into account the ability of an individual to make a psychological connection to his or her job, thus formulating the relationship between the person and the job.[61] In this regard, psychophysical work factors have been described as "the 'perceived' characteristics of the work environment that have an emotional connotation for workers and managers, and that can result in stress and strain".[62] Examples of psychophysical factors include job control, social support, job overload, the significance of the task, the enjoyment of the task,[63] autonomy, skill variety, technology issues, and participation. A variety of physical factors (e.g. metabolic, cardiac etc.)[64] and social factors (e.g. pay incentives, personality etc.)[65] have therefore been suggested as modifying the potential MAWL. However, to control for confounding factors, empirical studies are usually of single tasks only, conducted under laboratory conditions, and undertaken by a small number of fit 'non-workers' (e.g. college age students[41]).

The psychophysical approach in the workplace involves the direct measurement of MAWL in a work situation;[66] or an indirect application. The direct measurement of MAWL is situation specific, and it requires expert resources. One indirect and inexpensive application is the use of tables taking into account anthropometric variables (e.g. the capacity of workers to push an object such as a trolley according to the frequency and duration of the pushing, and the age, gender and height of the person undertaking the pushing) which are empirically informed and then applied to specific workplace situations.[60] Another indirect application of the psychophysical approach is the use of a Job Severity Index (JSI), which is based on the ratio of the estimated work lifting demands to worker lifting capability (using worker strength and anthropometric variables) to predict the MAWL (the assumption being the higher the JSI the higher the risk of injury).[67] The JSI assumes straight up and down lifting, and is not useful for pushing, carrying or pulling.

While the applications within psychophysical approach vary,[52] overall, they are insensitive to bending and twisting.[57] In particular, despite early research indicating that MAWL and JSI could predict risk,[68 69] there has been no verification that psychophysical risk assessment informs the control of incidence or severity of manual handling injuries.[46 54 57 70]

(v) The combination approach

The variety of approaches outlined above, is based on different principles and empirical results.[52] Combinations of measures outlined are also used to determine the risk of injury from a manual handling task. The most well known combination approach to manual handling, primarily designed for North American workers, is the 'Revised 1991 NIOSH Lifting Equation' (revised from the initial 1981 NIOSH guide[71]), designed to enable control of musculoskeletal injuries.[44] The equation provides recommended maximum weights to be lifted given various work characteristics; to be used for assessment as well as job design purposes.[72] The equation assumes that spinal compression is the most important force. The Recommended Weight Limit (RWL) (based on biomechanical, physiological and psychophysical research) is designed to represent a load that most healthy workers can perform for up to eight hours without increased risk of related low back pain.[46] The data required include the weight to be lifted, the horizontal distance between load and body, the vertical position of the lift, the distance travelled vertically, the angle of twist, coupling with other loads and frequency of lifting.

The NIOSH equation, however, cannot be used readily for combination tasks as an assumption is that manual handling activities other than two-handed lifting are minimal. Also, the tool does not allow for 'unpredicted' actions (such as holding, carrying, or pushing/pulling) or unfavourable environments (such as excessive heat and humidity, cramped conditions, moving loads or slippery floors). Importantly, there is no evidence that composite criteria, such as the NIOSH equation, protect the workers intended.[52 44]

(vi) The epidemiological approach

This approach attempts to confirm associations between particular manual handling activities and certain injuries, as there is increasing evidence for a causal relationship between physical work factors and work-related musculoskeletal disorders.[21 24 25] A review of over 600 studies suggests that repetition, force and/or posture are qualitatively associated with disorders of the neck, shoulder, elbow, hand, wrist and back.[21]

It has not been possible, however, to derive quantitative links between personal and job-related risk factors and injury; such as the difference in asymmetry of the back during a task and the likelihood of a back injury.[48] Many studies are of poor study design,[73] including the lack of control or comparison groups,[74] a lack of definition of exposure and outcome criteria,[22 75-79] the use of cross-sectional data[80] and reliance on univariate analysis.[48] Inappropriate methodology, in this area of research, can bias exposure estimates and subsequent estimates of risk.[81]

In summary of the assessment of the risk of injury from manual handling, the empirical approaches arise from different disciplines,[52] and their primary purpose has been to contribute to the design of productive or safe work for new workplaces. In regard to existing workplaces, the epidemiological approach can provide qualitative information on the types of injury that may be associated with manual handling tasks; but no other approach has been validated as having predictive value for the risk of injury. Ultimately, no simple metric exists that represents a quantitative relationship between exposure to manual handling over a period of time and the intensity of the effects present at the end of that time interval.[78] For this reason, and reasons discussed next, it is found that quantitative sets of guidelines for the application to manual handling, based on biomechanical, physiological, psychological, psychosocial criteria or a combination of those, are difficult to apply in industrial situations.[82]

2.2.1.2 The ability of scientific tools to measure the risk of manual handling injury in the workplace

Practitioners who assess the risk of injury from manual handling, aim to determine exact levels of exposure to the hazard, in terms of distance, force, frequency and duration.[40] The implication being that exceeding these risk levels implies a substantial risk of musculoskeletal disorders developing among a certain proportion of the exposed population. Workplace assessment tools and measures are designed to assist the practitioner in three ways. They are intended to identify jobs with high risk of injury, to be useful in developing solutions for workplaces with increased injury risk, and/or to evaluate the effectiveness of potential ergonomic solutions.[44]

Assessment of physical exposure to risks for potential work-related musculoskeletal injuries is undertaken by a variety of methods,[77] using guidelines or tools which refer to databases, indices,[83] and equations.[84] Depending on the method of assessment, factors examined are the postures, force, frequency and/or duration involved in an activity. Consideration is then given to the impact of these factors upon body parts or the whole body. Selecting the appropriate tool for assessment can be difficult, as the practitioner has to determine *prima facie* how the manual handling tasks will physically stress a worker.[85] For example, if infrequent but heavy exertions are assumed, a kinematic tool based on the biomechanical approach may be used. Where the job is highly repetitive (e.g. an activity performed continuously for more than fifteen minutes) a physiological approach maybe undertaken. If the job is only moderately repetitive, and forces are not great, a psychophysical tool maybe adopted.

Assessment surveys depend on clear definitions of jobs and tasks to identify major manual handling risks. In turn, this assumes a homogeneity and simplicity of tasks. However, the more sensitive the tool used in order to obtain information, the less generalisable it is to a real workplace situation. This is especially so where non-repetitive, multi-functional tasks are undertaken at heterogeneous workstations.[77]

Tools include (singly or in combination); pen and paper based observation methods (including writing, drawing or photographing); video taping and computer analysis; direct or instrumental techniques (e.g. electromyography or electronic inclinometers {electrogoniometers} to provide continuous kinetic measurement of posture of a worker's body or joints); and approaches to self-reports assessment of fatigue or discomfort (e.g. questionnaires or interviews). Usually, capacity, versatility, and generality decrease, whereas exactness and cost increase, from self-report to observations to direct measurements.[80]

In addition to concerns about their scientific validity, all workplace risk assessment methods have inadequacies. Direct observational methods can lack precision,[86 87] are less reproducible in dynamic workplace situations,[88 89] and are subject to intra- and inter-observer variability.[90 91] Direct measurements are also usually not feasible for large studies as they generate considerable amounts of raw data. In relation to questionnaires about physical and psychosocial job exposure, studies suggest low validity and reliability in relation to the needs for ergonomic interventions.[92] Where a variety of measurement techniques are used, to describe different exposure profiles in populations under study,[47] a common metric does not exist. That is, there is no way to convert inputs from disparate measurement methods to present a consistent measure for exposure across different jobs.[85]

As potential confounders for risk assessment, work characteristics that can influence the way manual handling is undertaken should be considered when assessing levels of exposure in terms of distance, force, frequency and duration.[25] However, these factors are generally ignored.[58 93] Work characteristics include; the nature of the load/object (e.g. mass, height, dimensions, distribution, stability); the type of action (e.g. lifting, lowering, pushing, pulling, carrying or holding); the nature of the task (e.g. the work environment, pace, complexity of task, posture required [94] etc.); and the nature of the work practices (e.g. staffing, time demands, team work, administrative systems etc.).

Traditional assessment also fails to account for worker characteristics (alone or in combination) that have the potential to influence the risk of an individual to injury when undertaking manual handling.[40 95] Examples of worker characteristics include physical, sensory, motor, psychomotor and personality characteristics, training and experience,[96] health status (including genetic predisposition[22]), and leisure time activity.[93] Within each of these, a range of sub-characteristics exists. For example, 'physical' may include gender, age, height, weight, and the postures adopted at work.

Despite the difficulties of risk assessment, workplace guidelines for the reduction of the risk of injury from manual handling have been produced. Guidelines, with quantitative outputs have the appearance of accuracy, but can be conflicting in their determination of risk. In relation to the risk of back injury, for example, Garg considers that to maximise the safe weight of a load the biomechanical approach would suggest the avoidance of lifting near floor level (keeping the weight at knuckle height),[97] whereas the psychophysical model would indicate lifting from near the floor because strength decreases with height. Similarly, the biomechanical approach would suggest lifting lighter weights more frequently; in contrast to the physiological approach of lifting heavier weights less often.

Overall, the underlying logic, complexity and cost of the risk assessment tools varies greatly.[98] Few tools have been assessed for their capacity to validly predict the risk of injury due to manual handling;[47 98 99] and despite some claims,[100] suitable analytical methods are still not available for quantifying and reducing physical exposure.[82] Kilbom[40] considers such risk estimates would require an immense number of epidemiologic studies in a large variety of different but specific exposure conditions studied over a long period of time. This approach is difficult where workplace exposures change continuously and the exposed population is rarely stable enough to allow long term prospective studies. Consequently, scarcity of epidemiologic data in addition to lack of sufficient knowledge of pathophysiology remain serious problems in attempts to design quantitative relationships. Given that only experts (with high levels of knowledge and experience),[40] who know the underlying assumptions and limitations, can realistically use them, caution has been urged in the indiscriminate use or overdirect application of guidelines.

Summary

The assessment of risk attempts to determine whether manual handling tasks impose physical stresses on the worker, beyond which levels of fatigue will result in injuries to the musculoskeletal and other body systems. Although limits to the forces that can be safely applied to the human body must exist, the assessment of the ratio of task demands to worker capacity is difficult and always incomplete. This is because task demands also include organisational, material, task, workplace, and environmental factors. Further, worker capacity includes personal characteristics and biomechanical, physiological and psychological capacity.[48] Consequently, there is no valid metric which predicts the risk of injury. However, where the results of epidemiological studies can be applied, a qualitative *a priori* indication of the nature and bodily location of potential injuries associated with a manual handling task can be indicated. Otherwise, as in the case history of this thesis,[101 102] the identification and assessment of jobs at high risk of injury within a specific workplace is retrospective and reliant on the reporting of injury.

2.2.2 Issues with Traditional Approaches to the Control of the Risk of Injury from Manual Handling

Controls to reduce the risk of injury due to manual handling are placed into two major categories.[103] The first involves 'modifying' the worker. This occurs either by attempting to select only those who are physically capable of undertaking the manual handling duties, and/or by training those who are selected in manual handling techniques. The second category of control involves modifying the workplace to make it a safer place in which to work. As will be discussed below, there is little evidence that worker modification is effective. There is some evidence that workplace modification can reduce the risk of injury.

2.2.2.1 Modifying the worker

(i) Pre-placement assessment of medical fitness for work

Medical examinations to identify those at risk of musculoskeletal injury have low specificity and sensitivity; and some, particularly those including x-rays of the back have an associated radiation health risk, and are no longer ethically acceptable.[104 105] Garg, in discussing back pain at work, notes that gender, age and anthropometry affect risk, but that variability between workers and within workers over time precludes the use of such factors to assign risk to any particular individual.[106] The only other relatively consistent indicator of risk acknowledged in the literature, although not unanimously,[107] is that a history of back pain indicates a future risk of back pain.[13] However, it cannot be assumed that all applicants for positions (on which their livelihood may depend) will provide a full history.[106] Further, under equal opportunity and/or disability legislation, many governments now require employers to provide cogent reasons why a worker should not be employed at a particular job or task. That is, unless a demonstrated risk exists between task demands and worker incapacity, an employer may be legally liable for not employing a person who applies to undertake the task.[108]

A potentially effective way to assess the capacity of staff to safely undertake manual handling tasks is through Functional Capacity Evaluations (FCEs). The FCE is an extensive set of tests that purports to assess an individual's ability to perform work at the present and in the future. However, a review of the literature on FCEs,[109] reveals that professionals that conduct, report and interpret FCEs are concerned about the absence of formal standards, outcomes and specific guidelines for these assessments. Issues include the number of measurements obtained, the degree of standardisation, the clarity of the concepts and underlining theories, variety in the choice of measuring instrument, adequacy of measurement, the use and availability of normative data and the ability to predict work capacity. The authors of the review quote another researcher, who examined the 10 most commonly used FCE types. Issues included interrater and intrarater reliability, report writing, qualifications of examiners, examination training, and the capacity to be able to project FCE findings to an 8-hour day and to safety Of the 10 FCEs, only one had had validation in a peer-reviewed scientific journal. Of practical limitation is that FCEs may take a number of hours to complete and are expensive. They are therefore generally limited to those people known to have a history of disability, rather than as a general screening tool.

A truncated form of FCE is that of isometric strength testing. This is on the basis that a small number of studies show that job-specific isometric strength testing has some predictive value for the risk of injury. However, no prospective studies have been reported on isokinetic or isoinertial strengths,[106] and not all manual handling involves a great deal of strength (that is, other body requirements may be twisting, asymmetric loading etc.).

(ii) Training

(a) Worker Training

Traditionally, worker training to reduce the risk of injury from manual handling has consisted of the teaching of lifting techniques; although physical conditioning training and risk assessment training are offered to workers on occasions.[110]

(b) Lifting Technique Training

As noted by Garg,[111] there is no 'natural' way of lifting that is universal. In 1978, Snook indicated that training in lifting did not reduce the risk of back injury.[103] This finding has been comprehensively reinforced on numerous occasions since.[112-116]

Straker postulates a number of reasons for the lack of success.[110] These include; the aetiology of work-related musculoskeletal disorders is not well understood; workers may revert to prior behaviour habits after training; workers may not be able to learn the movement patterns that are taught; techniques that are 'correct' in terms of reduced risk in the laboratory may not be applicable in workplace situations; techniques that reduce risks in laboratory may not reduce the risk in the workplace; and contradictions between lifting methods depending on their scientific origins.

Presumably, some tasks also involve forces that overwhelm human capacity, no matter how well the workers are trained.

(c) Physical Conditioning Training

This training is designed to improve muscular strength, muscular endurance, cardiovascular endurance and/or flexibility; and some studies indicate that it can reduce the likelihood of back and neck pain and improve workers' sense of well being.[117-119] However, in addition to the costs, practicability and sustainability of physical conditioning training, a clear association with reduced injury risk has not been demonstrated.[113 116]

(d) Manual Handling Risk Assessment Training

Such training teaches workers how to identify and assess manual handling hazards in the workplace. The assumption is that this type of education will lead to a reduction in their risk of injury. Straker considers that despite the probable benefit of such training, there are no studies to demonstrate its effect on reducing manual handling injuries; and given the apparent ineffectiveness of other control strategies, this needs to be tested.[110]

2.2.2.2 Modifying the work

Primary prevention aims at removal of the causal agents of injury; or where this is not possible, a reduction of risk by modifying the work physical environment or processes. The potential benefit of modifying the work is that the reduction of risk is 'permanent' and not critically dependent upon the modification of worker behaviour.[60] That is, the hazard has been eliminated or reduced and consequently the associated risk is eliminated or reduced. Workers do not have to worry about performing a task in a specially prescribed way and management does not have to worry that a small deviation in worker behaviour will result in poor organisational performance[46] Designing the job to fit the worker is increasingly the preferred option of legislation, and underlies the philosophy of ergonomics.[103 110 120] A wide range of potential controls to reduce the risk of injury from manual handling exist. Examples include the elimination of the need for manual handling, engineering controls (e.g. lifting equipment) and administrative controls (e.g. job rotation to reduce the dose of manual handling per person per shift).

A review by Zwerling et al, indicates that, despite methodological problems with many papers, the implementation of engineering and administrative controls, either singly or in combination, can reduce exposure to ergonomic risk factors for musculoskeletal and other work-related disorders.[79] In the most extensive review to date of literature on ergonomic interventions relating to improved musculoskeletal health,[121] it is considered essential that there be a multi-faceted approach to risk control, with active participation of workers. That is, for intervention strategies to have the best chance of success it is necessary for there to be high commitment of stakeholders using multiple interventions to reduce identified risk factors, and to focus on workers at risk, using measures that actively involve the worker. Conversely, it is considered that strategies focusing on generic intervention measures, based upon concepts of causal mechanisms for musculoskeletal disorders (eg. exposure level above a certain limit), were less likely to have successful outcomes. In summary, ergonomic job redesign, involving workers undertaking the manual handling tasks, offers the most potential for preventing injuries.

2.2.3 Limitations to Reducing Workplace Disorders Associated with Manual Handling

It is unlikely that reported workplace disorders can be eliminated solely by controlling physical exposure to manual handling. Some of the reasons are given below.

2.2.3.1 Not all manual handling is hazardous

The physical relationship between exposure to manual handling and the risk of injury is not clear,[122] and the pathomechanism of injury is not well understood.[80] Even where there are high rates of injury associated with manual handling tasks, most persons undertaking the task do not report injury. Neither manual handling exposure, nor doses, have been accurately identified to correlate with work related musculoskeletal disorders. Physiologically, it is known that muscles and tendons become stronger and joint cartilage thickens in response to physical training, while the reverse happens in inactivity.[40] It is argued that the dose-response is more likely to be a U shaped curve rather than a linear function.[40] For example, back pain and parameters of spinal pathology, have been related to the highest and lowest degree of the physical loading; that is, results indicate that the least pathology arises from moderate or mixed physical loading.[123] Therefore a lack of manual handling has the potential to produce weakness within the musculoskeletal system, which in itself is hazardous; and conversely, a reasonable amount of manual handling may be beneficial by maintaining strength of muscle, bone and other tissues. A paradox highlighting the lack of knowledge of the dose-response relationship is that while legislators aim to reduce exposure to physical stress in the workplace, clinicians incorporate physical challenges to the musculoskeletal system in their rehabilitation programs.[124]

2.2.3.2 There is no clinical distinction between work-related and non work-related disorders

Clinical pathology, associated with manual handling in workers using spinal disc degeneration as an example, is indistinguishable from spinal disc degeneration either in workers who do not undertake significant manual handling or persons who are not in paid employment. Further, work has only a moderate impact on disc degeneration compared with the influence of age and familial factors.[125] Confounding both dose-response assessment, and work relatedness, is the fact that not all manual handling occurs at work. It is plausible that the lack of recovery from non work-related manual handling may predispose to an injury at work.[47 78] However, paradoxically, it is reported that a sedentary lifestyle outside of work may predispose to musculoskeletal injury at work.[126]

2.2.3.3 Attribution of cause

Although the link between manual handling and injury is well established,[21 23 25] the strength of association is not. Back pain, for example, is one of the most studied work-related disorders. In one large household survey, two-thirds of persons with low back pain attributed their complaint to manual handling. However, back pain is prevalent in populations, employed or not, and up to 80% of people will experience an episode of significant back pain in their life.[33] The prevalence of low back pain in 16 year olds, for example, is estimated at 50%.[124]

While a number of workers within a given workplace may succumb to injuries such as musculoskeletal disorders, most workers do not report problems. One interpretation of this paradox is that symptoms, such as regional back pain, are usually just a part of life and not a disorder. Those persons with the symptoms, may either tolerate them and do nothing, or seek care outside the context of the workplace, or seek help in the context of the workplace (e.g. ergonomic remedies or workers' compensation). It is argued that psychosocial factors explain more than ergonomic factors why people seek help in the context of the workplace.[63 115 127-130] Some even suggest a synergistic pathway can exist between psychosocially stressful environments and the risk of musculoskeletal disorder.[131]

Interestingly, the one year prevalence of back pain (directly standardised to the age and sex distribution of the combined samples) rose 12.7 percent in Britain over the 10-year interval 1987-1997,[132] yet the amount of manual handling undertaken in the workplace during the intervening period is stated to have declined.[133]

2.2.4 Summary and discussion

The reason for the global failure to reduce the burden of work-related injuries associated with manual handling is multifactorial. Manual handling is causally related to certain work-related disorders, particularly musculoskeletal, but the dose-response and pathomechanisms are not clear. The scientific bases used in the ergonomic design of new workplaces, aim to predict fatigue but are not validated as useful in predicting the risk of injury from undertaking manual handling tasks. Psychosocial and other factors, internal and external to the workplace, confound the experience and reporting of work-related disorders, and make it difficult to associate injury outcomes solely with the physical demands of the manual handling tasks. Finally, the traditional approach to controlling the risk of injury, by modifying the worker, is not effective.

Notwithstanding the problems relating to the validity of their scientific base, over 700 published or draft standards/regulations/directives/codes of practice relating to ergonomics require workplace action to assess and control the risk of injury. Many of these documents directly consider manual handling. The emphasis is on assessing and modifying the workplace to manage risk. Despite the proliferation of standards/regulations/directives/codes of practice on manual handling, there is a lack of evaluation of their aim to reduce morbidity.[40 121] Criticisms of quantitative regulations, in particular, are that they imply an exposure (or dose) response curve for manual handling exists when none has ever been published. They also require a relatively high level of knowledge and experience by those who apply them, but the duty in interpreting the requirements falls on the employer; increasingly with the participation of the employees at risk.[40 45 134-136] In seeking professional assistance, there is a global lack of ergonomists.[137]

Despite these limitations, epidemiological studies provide qualitative information relating to the nature and location on the body of the musculoskeletal injury associated with manual handling tasks. Importantly, there is some evidence that modification of the workplace can reduce the risk of injury to those performing manual handling tasks. Where this occurs, success is most likely when a multifaceted approach to control is undertaken with worker participation.

2.3 PARTICIPATORY ERGONOMICS AS AN APPROACH TO THE REDUCTION OF THE RISK OF INJURY FROM MANUAL HANDLING

2.3.1 Introduction

The term 'participatory ergonomics' was proposed in 1983, in relation to workers active involvement in implementing ergonomic knowledge and procedures in their workplace.[138] Participatory ergonomics results from the convergence of aspects of worker participation, and of ergonomics, that began 30-40 years earlier.[120]

2.3.1.1 *Worker participation*

A rise in the organised participation of workers in the industrial setting largely occurred in response to Taylorism (also called the 'Scientific Method' or

'Productivity Model'). Taylor, in 1911, applied a scientific approach to the intent of designing efficient work, providing the correct tools, motivating individuals, sharing of responsibilities between management and labour, and sharing of profits. The scientific methods used to improve efficiency, however, include dividing tasks into small components so that work requirements and performance evaluations are easy to define and monitor. Taylorism includes; the separation of the 'thinking' and 'doing' parts of a work process into different jobs; self contained work areas performing only small parts of the whole work process; large numbers of so-called 'unskilled' workers whose jobs only involve the 'doing' part of the work process; a small number of highly skilled specialist staff; a hierarchical management structure; and rigid job structures with strict demarcation of work. Using these methods, work is simplified and standardised. However, skill variety is minimal, workers have no control over the work process and jobs are highly repetitive and monotonous.[61] It is considered this form of work and job design has had many adverse consequences for organisations and their employees and resulted in occupational safety and health problems. The lack of control for workers in the Taylorist work system is considered to make most hazards worse;[139] manual handling in particular, because work systems split jobs into repetitive tasks. However, such work systems still exist in many workplaces.[61]

One response to Taylorism has been the application of Sociotechnical Theory. Formalised in 1981,[61] this theory recognises that the two major systems within an organisation are the 'social system' and the 'technical system'. The social focuses on the workers' perception of the environment, and the technical emphasises the technology and work processes. The origins of the theory stem from a 1950's study in UK coal mines, in which it was shown that the two systems impact on each other.[139] In this study, semi-autonomous work groups were established, and workers were given opportunities to make decisions that affected their work.[61] As a result, improved worker interaction, and feelings of job completion and satisfaction were experienced. The theory calls for flattened management structures that increase worker participation, interaction between workers and the enrichment of jobs.

Worker participation is now well described in the literature on management, organisational behaviour and industrial psychology. The rationale for worker participation includes enhanced worker motivation/job satisfaction, added problem solving capabilities, gradual acceptance of change and greater knowledge of the work/organisation. Each has potential benefits to the worker and to the organisation (and risks if not managed correctly).[140] Different levels and forms of participation exist. These include; quality circles (small groups of worker volunteers from the same work area who, with their supervisor, identify, analyse and solve quality and related problems in their area of responsibility); labour-management committees that address specific problems in their job tasks and generally cover wider areas of an organisation; and work teams which are in effect 'self-regulating' work groups. At the latter extreme, there are intact groups of employees responsible for a 'whole' work process or segment that delivers produce or service to an internal or external customer;[141] responsible for not only getting the work done, but also managing themselves.

Although laying the foundation for worker participation, and for an understanding of how psychosocial factors can be related to ergonomic factors, Sociotechnical Theory *per se* has not been widely applied to worker safety.[139]

2.3.1.2 *Ergonomics*

Ergonomics, the scientific study of human work, emerged as a specialty around the time of the Second World War through individuals working on military systems in various countries around the world.[137] In its most general sense, 'ergonomics' is used to describe the entire spectrum of the human-machine-equipment relationship in which humans interact with physical objects within the work system.[142] In contrast to the Procrustean[m] approach of fitting the person to the job, ergonomics seeks to match work demands with human biological characteristics.[143] As its starting point, ergonomics takes the constitution of individuals (anatomical, biomechanical, physiological, psychological, and social). From an early stage, ergonomics was seen as having the potential advantage of providing a more permanent engineering solution to manual handling problems, to reducing the workers' exposure to risk, and to reducing the medical and legal problems of selecting workers for the task.

[m] Procrustes the name of a legendary robber who fitted victims to a bed by stretching them or cutting off parts of them – Oxford dictionary.

Ergonomics was also seen as placing less emphasis upon workers' willingness to follow established training procedures, such as 'lifting properly'.[144]

During its evolution, ergonomics has broadened its scope from 'microergonomics', with a focus on individual workload, to include that of influencing systems of work. The latter, 'macroergonomics', emphasises the redesign of jobs and organisational change.[145] Intrinsic to macroergonomics, is that ergonomists must obtain an understanding of the roles of the organisation, technology and individuals in producing the product of the system under review; and have dialogue with parties within the system. In turn, many ergonomists have changed their role from that of a pure specialist to become an agent of change.[146]

However, while ergonomists seek to design work so that it will better fit the needs of the individual, their numbers are low relative to the number of workplaces that exist.[120] Surveys in 1995 and 1996 estimated that only 25,000 persons eligible to belong to an ergonomics society existed world-wide, and less than half practiced in industry. A North American survey is quoted as estimating that only 14% of ergonomists are employed in 'safety assurance'.[137]

2.3.2 Participatory ergonomics

The aim of participatory ergonomics is to improve working conditions, productivity and/or product quality.[147] The goal of participatory ergonomics is problem-solving; ranging from the design and planning of a completely new installation, to more commonly attempting to find solutions to an existing problem and redesigning work systems. Participatory ergonomics is used in many countries, and its applications are dependent upon the social, organisational and industrial context.[146] It is applied in a wide range of industries and workplace situations; from offices, to vehicle production, to nuclear plants.[140 148-151]

It is claimed that participatory ergonomics is one intervention strategy capable of simultaneously addressing both ergonomics and psychosocial risk factors in the work environment.[152] Expanding on this, the benefits of participation in the workplace are stated to include increased employee motivation and job satisfaction, enhanced performance and employee health, reductions in work-related musculoskeletal disorders, more rapid implementation of technological and organisational change and more thorough diagnosis and solution formation for ergonomic problems.[152]

There is no agreed single definition of participatory ergonomics, rather it is a mixture of concept and tools.[140] Nagamachi considers participatory ergonomics as the workers' active involvement in implementing ergonomic knowledge and procedures in their workplace.[153] Kuorkina views participatory ergonomics as "practical ergonomics with participation of the necessary actors in problem solving".[146] Noro and Imada view participatory ergonomics as a procedure that allows ergonomists and non-experts to work together.[148] Noro, in 1991, also stated it was a new technology for disseminating ergonomic information.[148] Haines and Wilson define participatory ergonomics as "the involvement of people in planning and controlling a significant amount of their own work activities, with sufficient knowledge and power to influence both processes and outcomes in order to achieve desirable goals".[140]

2.3.2.1 The method of participatory ergonomics

In participatory ergonomics, 'end-users' of ergonomics take an active role in the identification and analysis of ergonomic risk factors, as well as the design and implementation of ergonomic solutions.[148] To do so, participatory ergonomics relies on many factors, including the commitment of management and the motivation of the workers, the training of management and the work force in ergonomics and group process skills, the sharing of information, and the monitoring and evaluation of process and outcomes.

There is no single best way to run a participatory project,[147] but participatory ergonomics is usually commenced by the organisation of a project team. Teams may address specific projects ('selective'), or be 'continuous' and aim for continuous improvement.[152] There is little guidance or empirical evidence on the preferred composition of teams,[140] but all levels of the hierarchy who may have first-hand experience about the problem in question can be involved. Team composition includes representatives of all affected parties (especially workers),[139] and worker effort is supported by supervisors and managers.[153] Recommended team size varies between 6 and 15, but with general agreement that group interaction will be impaired if the team becomes too large. Team building and team training in the principles of ergonomics, communications and/or management will often occur before the team commences activity. The first stage after that is identifying the problem, then searching for ideas on possible solutions, developing and evaluating alternative solutions and, finally, ending up with an action proposal. The definition of the nature of the problem and the goal of the project are usually contained within the project itself.[147]

Tools utilised by participatory ergonomic teams vary, according to the situation and the phase that the group is in. Haines and Wilson have enunciated the major techniques.[140] Brainstorming and group discussions are used widely for problem analysis and ideas generation, as are Pareto analyses[n] and cause-and-effect diagrams (or 'fish bone charts').[154] Surveys and checklists are also considered helpful in helping participants approach problem solving in a structured way.[155] Visualising of problems or solutions is sometimes used to share experience and communication of ideas, particularly when meetings are outside the workplace of interest. Measures include videorecording, small-scale modelling or mock-ups of work areas, and computer aided design; even virtual reality technology has been proposed. Focus groups, or questionnaires,[149] involving the broader group of workers are sometimes used to identify and assess ergonomic problems.

The challenge of 'ergonomics devolution' is to motivate people to become their own ergonomist and provide them with the necessary tools, techniques and training and to recognise when specialist assistance is needed.[140] As the problem-solving converges towards the design and solutions, the participatory process generally becomes more technical; usually requiring a specialist's contribution. Although some literature expresses concern about the balance of the provision of expert services and the potential for the monopolisation of team process, most participatory ergonomic initiatives involve input from an ergonomist. Ergonomist input will vary in scope and

[n] The Pareto Principle states that most (80%) problems are produced by a few (20%) key causes. If these key causes are addressed, then there is greater probability of success.

intensity, and may be from in-house or contracted. Most often, the team has a facilitator. This person is usually, but not necessarily, the ergonomist.[147]

The creation of solutions is rarely straightforward, and usually non-linear, in that phases may be run in parallel[147] or be iterative [146] There is usually some prioritisation involved, which involves the team balancing expert advice with the experience and ideas of team members. Importantly, a solution must be able to be 'sold' to management if it is to be considered for implementation.

It is argued that the potential effectiveness of solutions from participatory ergonomics teams may not be much different to those resulting from sole ergonomist intervention. However, the ownership and acceptance of the solutions, and the confidence and willingness of workers to implement the required change benefits all parties.[156] Conversely, participatory experiences can end in disappointment if results are not achieved, if there are delays in start-ups, or if working conditions are not improved (in particular, if staff perceive knowledge is 'expropriated' only for the benefit of the company).[140]

Project processes or outcomes can be evaluated, depending on the project.[140] Evaluation of participatory ergonomic initiatives is important to enable adjustments to ongoing initiatives, and to examine the effectiveness of the process, and to help the team or the organisation determine whether the team continues or repeats it s exercises.[140]

2.3.2.2 The application of participatory ergonomics to the reduction of the risk of injury from manual handling

Following the establishment of a direct relationship between human motivation and responsibility for outcomes,[157] the use of participatory ergonomics is now widespread.[138, 140] Although the initial focus was on quality and production, participatory ergonomics is increasingly being applied to the sharing of ownership for the management of occupational safety and health risks between employers and employees;[147] to the extent that participatory ergonomics, in relation to ergonomic safety, is now promoted as applicable in all industries around the world.[120 158]

Within organisations, this is undertaken by incorporating the iterative steps of injury risk identification, assessment and control into management systems.[19] In turn, this means that the setting of priorities for occupational safety and health action in participatory ergonomics has to account for both technical and lay concepts of risk.[159] Not all commentators, however, are convinced of the capacity of non-professionals to assess risk. For them, scientific and technical data sources are seen to offer more credible means of risk identification for priority setting than the lay identification of risk. The scientific and technical data sources being considered universal and untainted by social, cultural or cognitive biases that may influence lay groups. Holmes, Triggs and Gifford note that the identification of risk in technical literature is seen as a rational, objective process of hazard identification and risk assessment that arrives at a quantified and unidimensional measurement of risk.[159] Lay people in industry may hold different conceptualisations of risk and hence derive different views on priorities for risk reduction than those determined by professionals utilising technical data. In particular, concern has been expressed about non-expert involvement in manual handling risk assessment.[20 160 161]

Surprisingly, few studies examine for the effectiveness of participatory ergonomics in reducing the risk of occupational injury and disease.[46 140 147 162] The majority of the literature that does exist consists of workplace case studies that describe the implementation phase of participatory ergonomics; sometimes reaching a conclusion that a reduction in the risk factors that can lead to work-related musculoskeletal disorders has occurred.[143 145 149 152 163-169] Fewer studies actually attempt to determine the effectiveness of participatory ergonomics in reducing the occurrence or severity of injury from manual handling among the population at risk.

Where injuries are considered as an outcome, most studies are of inadequate design to determine an effect. A major review of ergonomic intervention research in 1997,[121] identified only sixteen papers that related to ergonomic teams. Many of these had dual aims of improving musculoskeletal health and increasing productivity. The intervention duration of the studies ranged from 6 months to 8 years, a number of studies had no pre-intervention data, and all studies were of dynamic (open) cohorts. Few studies included a control group, and outcome data were generally not associated with specific jobs. Three population case studies among USA workers in meat packing plants,[170-173] did thoroughly describe the participatory process, but the lost-time injury rate results were mixed (although there was a reduction in workers' compensation costs) and again there were no control groups.

More recent literature continues to reveal methodological difficulties. For example, Halpern and Dawson (1997) discuss the impact of a participatory ergonomics program among machine sewing workers.[154] The number of claims actually increased, although the cost per claim reduced, over the three year period. No control group was used, and no statistical analysis was provided. Koda and O'Hara (1999) describe a participatory ergonomics program to reduce injuries amongst Japan's waste management employees. A reduction in work-related injuries from 7.7/100 full time workers to 6.0/100 over 13 years was observed,[162] but again no control group was used, no statistical analysis was undertaken and the severity of injury was not measured.

The most comprehensive outcome assessment in recent literature is that of a participatory ergonomics program for staff at high risk of musculoskeletal injury from manual handling within the Orderly Department of a USA hospital.[174] A team of 3 orderlies and a supervisor, with some assistance from the occupational physician, conducted an assessment of the risk of injury on behalf of the 100 orderlies in the department. The resulting injury risk reduction measures implemented included an improvement in the range of patient handling equipment used, and a revision and training of orderlies in patient handling techniques. Injury incidence and severity were measured for 3 years pre-intervention and for 2 years post-intervention. In addition, at the commencement and on two occasions during the intervention, questionnaires were provided to staff to measure both job satisfaction and musculoskeletal symptomatology.

Injury incidence and severity were assessed by Chi square analysis, after allowing for changes in injury incidence and severity within the whole hospital. Per hundred full-time equivalent orderlies, a significant reduction in the post/pre relative risk of injury of 0.4, and a statistically significant reduction of 70% in the number of days lost from injury, was attained. A large, but non-significant reduction in workers' compensation costs per hundred full-time equivalent workers was also noted. These reductions were associated with a statistically significant increase in job satisfaction indicators and a reduction in reported musculoskeletal symptoms. Individual-level data, however, were not analysed, and the authors noted a high employee turn over within the group. This indicates that the statistical analysis was not appropriate given the complexity of the data.

2.4 CHAPTER SUMMARY

Manual handling is associated with at least one third of all cases of occupational injury. The majority of injuries are musculoskeletal in nature. Because traditional approaches to controlling this major contributor to the burden of work-related disorders have been unsuccessful, manual handling remains an occupational health priority for authorities world-wide. Examination of the reasons for failure of the traditional approaches, however, does indicate opportunities for more effective approaches to the assessment and control of the risks from manual handling; but these interventions require evaluation.

Traditional scientific approaches to the assessment of risk assume a relationship between the forces used in manual handling, fatigue and the risk of injury. However, the pathomechanism of injury has not been established, and the validity of empirical studies focusing on the 'safe' forces that workers can sustain has not been demonstrated. Further, the scientific base of risk assessment is disparate, incomplete, conflicting and lacks generalisability. Consequently, the workplace tools utilised to assess the risk of injury from manual handling fail to be applicable to the variety of tasks and environments that exist in most workplaces, and cannot account for the range of individual characteristics of workplaces and workers. Because there is no common metric for workplace exposure to manual handling (or the dose of forces received by the body from manual handling) and since the pathomechanism of injury is uncertain, no practical occupational exposure limits have been set or validated as useful in informing the control of the risk of injury from manual handling.

In terms of traditional controls, worker modification has been unsuccessful in reducing the risk of injury. Methods for medical selection of those workers best able to sustain physical forces lack sensitivity and specificity. These methods are also generally inappropriate from an equal opportunity perspective. Training of workers in manual handling, so that they can more safely deal with the forces inherent in manual handling tasks, is also rarely successful.

Despite limitations to the quantitative aetiological approaches to the assessment of the risk of injury, there is considerable qualitative evidence that certain manual handling tasks, e.g. those that are considered 'heavy' or 'very repetitive' are associated with an increased risk of injury. These risks may be modified if associated with other qualitative 'non-force factors', such as the psychosocial environment of the worker. Recent evidence, also indicates that modification of the workplace to suit worker capacity can be effective in reducing the risk of injury. Further, since the 1990's, there is increasing evidence that groups of committed worker and employers, with ergonomic and technical advice where required, have the capacity to positively influence the ergonomic characteristics of the tasks and environments of the employees they represent. Participatory ergonomics, initially employed to improve general worker conditions, productivity and quality of product, is increasingly being applied to the reduction of risk of injury; including injury from manual handling. A participatory approach to manual handling risk assessment and control is now adopted in many regulations and codes of practice around the world. However, there has been little evaluation of the effectiveness of participatory ergonomics in reducing the risk of injury from manual handling. Of the studies that exist, most look for a reduction in risk factors *per se*, rather than the injury outcomes, and are generally of poor design.

The few studies that examine an association between participatory ergonomics teams and change in the injury incidence or severity, either lack control groups and/or adequate statistical analysis. Furthermore, despite the importance for the validation of approaches to designing safe manual handling tasks,[48] of the studies identified in the literature, none examine the change in injury outcome at the level of the individual. It is important that future intervention studies adequately examine whether a reduction in injury incidence and severity from manual handling occurs following participatory ergonomics, if it is to be promoted as a workplace strategy.

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CHAPTER THREE

ANTECEDENTS TO THE ESTABLISHMENT OF THE INTERVENTION

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3.0 INTRODUCTION

This Chapter describes the factors that led the intervention hospital to consider the need to control the risk of injury from manual handling among its staff. It then provides the rationale for the selection of the staff of the Cleaning Services Department as the group to trial the intervention – the intervention being the implementation of a manual handling Workplace Risk Assessment Team.

3.1 THE NEED FOR THE INTERVENTION HOSPITAL TO ADDRESS OCCUPATIONAL SAFETY AND HEALTH

In 1988, the intervention hospital identified two imperatives for the improvement of its performance in safety and health; namely, economic and legislative. Both imperatives were underpinned by high numbers of injuries to workers.

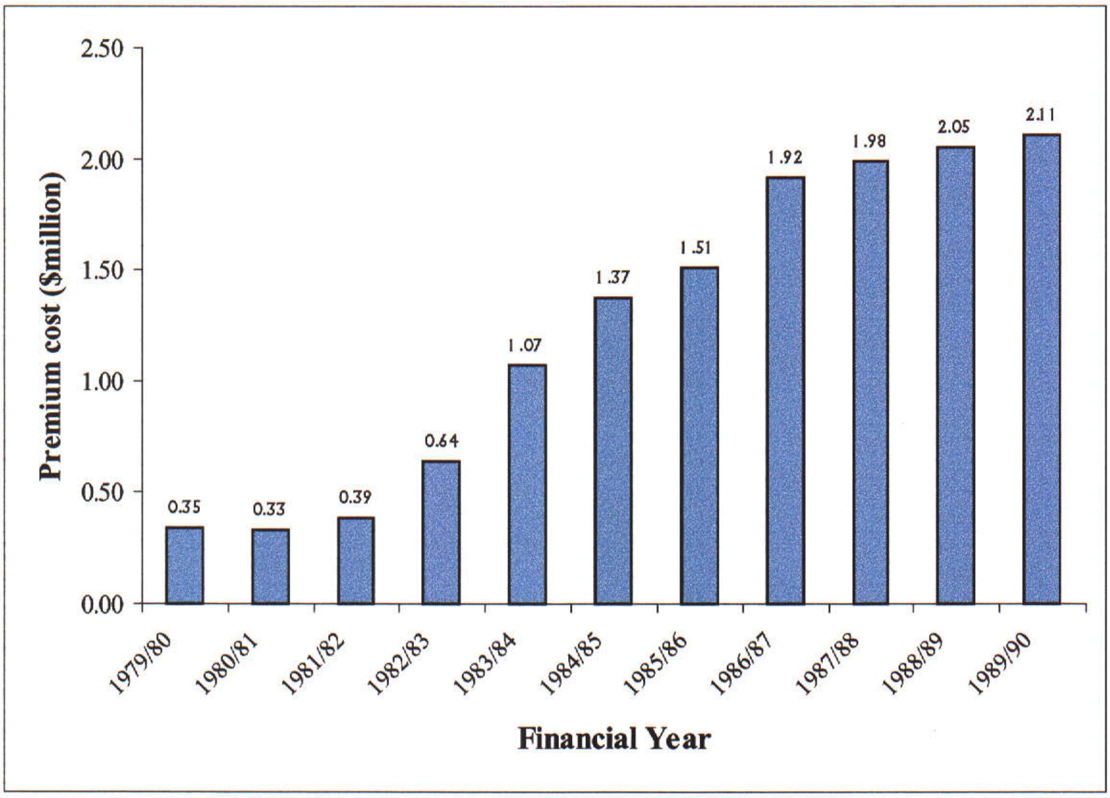
3.1.1 The Economic Imperative – Liability for the Workers' Compensation Premium

The intervention hospital received its annual financial budget from the Health Department of Western Australia; but the budgetary process provided no direct financial incentive to manage workers' compensation claim performance. Traditionally, unlike most other items, the hospital had no constraint placed on the workers' compensation premium component of its budget allocation (the premium being the dollar amount charged to insure all hospital employees). The premium was determined after averaging the hospital's workers' compensation claims performance over the previous 3 financial years. At the conclusion of each financial year, the insurer notified the hospital of the workers' compensation premium required to be paid for the ensuing financial year. If the premium exceeded the monies allocated, the Health Department of Western Australia provided supplementary funding to the hospital.

Between the 1979/80 and 1987/88 financial years, the intervention hospital experienced a 40% increase in the annual number of claims for injury and a 6-fold increase in premium (see Figure 3.1). These increases greatly exceeded increases in staff numbers and the consumer price index over the same period. In 1979/80 the workers' compensation premium equated to $1.20 for every $100 of salary paid to hospital staff. By 1988/1989 the figure had risen to $2.61.

In 1988, the Health Department of Western Australia determined that it would no longer provide supplementary workers' compensation premium funding to hospitals. The 1989/90 budget allocation for the intervention hospital was fixed at an amount slightly higher than the actual 1988/1989 premium, and so provided an immediate incentive to the hospital to reduce the number and severity of work-related injuries.

Figure 3.1 *Non-CPI adjusted workers' compensation premiums for the intervention hospital for 1979-1989 financial years*



3.1.2 The Legislative Imperative

The impact of occupational safety and health legislation upon the hospital, in 1989, had its origin in 1984. Until then, in Western Australia, no unifying occupational health and safety legislation applied to all workplaces; and no single government agency monitored adherence to requirements. The most wide-ranging of occupational health and safety legislation, The Factories and Shops Act, was prescriptive in nature and covered only 40% of industries. In effect, no safety and health law applied to hospitals.

In 1984, the State Government proclaimed the Occupational Safety, Health and Welfare Act (the Act). Components of the Act were introduced in a step-wise manner over four years; such that full compliance with the Act, and attendant regulations, was required by 1988[1,2] The new Act covered most industries in the State, including the health industry.

The Act imposed a prospective general duty of care upon employers for the safety of employees. It also encouraged the involvement of employees, through representatives and committees, to be involved in their own safety and welfare. The objectives of the Act were:

a) to promote and secure the health, safety and welfare of persons at work;

b) to protect persons at work against hazards;

c) to assist in securing safe and hygienic work environments;

d) to reduce, eliminate and control the hazards to which persons are exposed at work;

e) to foster co-operation and consultation between and to provide for the participation of employers and employees and associations representing employers and employees in the formulation and implementation of safety and health standards to current levels of technical knowledge and development;

f) to provide for formulation of policies and for the co-ordination of the administration of laws relating to occupational health, safety and welfare;

g) *to promote education and community awareness on matters relating to occupational health, safety and welfare.*

The general duties of employers were, so far as practicable, to provide and maintain workplaces, plant, and systems of work such that employees were not exposed to hazards. This included the use, cleaning, maintenance, transportation and disposal of plant; and the use, handling, processing, storage, transportation and disposal of substances. Where it was not practicable to avoid the presence of hazards, adequate personal protective clothing and equipment was provided to employees. To meet these obligations employers were required to provide employees with the information, instruction, training, and supervision necessary to enable them to perform their work safely. Importantly, employers were required to consult and co-operate with safety and health representatives, if any, and other employees at the workplace, regarding occupational health and safety.

A single inspectorate, via a new government body titled WorkSafe Western Australia, was created to enforce the Act. Breaches of the Act could be dealt with in three ways; an improvement notice (a requirement to comply within a specified period); a prohibition notice (a requirement to cease the unsafe activity immediately until compliance occurred); or prosecution under criminal law. The government made it clear, publicly, that the enforcement focus would be directed to those with control of the workplace; that is, the employer rather than the employee. In 1989, WorkSafe WA inspectors visited the Chief Executive Officer of the intervention hospital, to inform him that that as the hospital was experiencing high injury numbers the organisation's performance would be monitored by them.

3.2 CREATION OF A DEPARTMENT OF OCCUPATIONAL HEALTH

In September 1989, the intervention hospital established a 5-member Department of Occupational Health to assist the hospital in meeting its increased accountability for safety and health performance. The author was the inaugural Director of Occupational Health.

The major role of the Department of Occupational Health was to advise and support the hospital in its efforts to reduce the risk of injury to staff. Injury prevention activities of the Department included the development of occupational health guidelines and policies; involvement in the planning of safe facilities and work processes; assessment and safety advice for established workplaces; the education and training of hospital staff; the facilitation of occupational health and safety consultative processes (i.e. safety and health representatives and committees); assistance with the resolution of safety and health issues; promotion of incident reporting and investigation; and the collation of injury data for the purpose of monitoring of hospital performance and for informing injury prevention strategies.

3.3 INJURY RECORDING AND REPORTING

In regard to injury data collation, hospital injury records were inconsistent in quality and completeness. This reflected the prior lack of resources committed to occupational injury data collection and the absence of a standardised approach for the recording of injury events. Historical injury data, therefore, could not be reliably utilised to help determine priority areas for preventative action.

Coincidental with the establishment of the Department of Occupational Health, however, injury recording capacity improved with the release of the national *Workplace Injury and Disease Recording Standard AS 1885.1-1990* (the use of the Standard is described in more detail in Chapter 5).[3] Advantages of the new Standard included the capacity to categorise injuries in a systematic manner, and to establish what it referred to as a 'Frequency Rate'; this being an injury frequency rate per million hours worked. Potentially, the frequency rate allowed comparison between groups, or within a group over time. Injuries could also be classified by type. The Department of Occupational Health applied the Standard to major occupational groupings within the hospital in 1991/92; the first financial year after the Standard's release.

3.3.1 Awareness of Manual Handling as a Safety and Health Priority

Initial analysis of the mechanism of injury revealed that 62% of all injuries resulting in a day or more off work (i.e. a lost-time injury) were associated with manual handling (see Table 3.1); this contrasted with a figure of 30% for the state of Western Australia.[4]

Table 3.1 *Lost-time injuries within the intervention hospital, by mechanism of injury, July 1991-June 1992 (as at August 1992)*

Injury Mechanism	Number of lost-time injuries	Percentage of lost-time injuries
Manual handling	**117**	**61.9%**
Falls and slips	22	11.6%
Contact with objects	18	9.5%
Involving equipment	5	2.6%
Biological	0	0%
Miscellaneous	27	14 3%
Total Hospital	**189**	**100%**

3.3.2 The Identification of Cleaners and Orderlies as being of High Risk of Injury

In 1991/92, even before the full accumulation of the first 12 months of injury data according to the new Standard,[3] it became apparent that certain occupational groups were sustaining a large number of injuries relative to their population size. These groups, such as Cleaning Services and Orderly Services, had not traditionally been considered at high risk of injury (compared with nursing staff, for example). In response, the Department of Occupational Health initiated a number of consultative (i.e. in conjunction with the management and safety and health representatives) workplace assessments and interventions to reduce the risk of injury within these smaller groups.

The full 1991/1992 year analysis (summary at Table 3.2) confirmed disparities in injury frequency rates (i.e. in their risk of lost-time injury per million hours at work) between occupational groups. In particular, Cleaning Services, Orderly Services and HealthCare Foods had experienced frequency rates greater than 3 times that of the overall hospital rate. The manual handling component of the injury frequency rates for Orderly Services and Cleaning Services was approximately 4 times that of the hospital average.

Table 3.2 *Lost-time injury frequency rates (LTI per million hours worked) for major occupational groups July 1991-June 1992 (as at August 1992)*

Occupational group	Manual handling lost-time injury frequency rate	Total lost-time injury frequency rate
Admin & Clerical	7 20	10 79
Allied Health	2.90	5.80
Catering Distribution	36.75	65.33
Cleaning Services	**94.69**	**147.29**
Engineering Services	27.35	54.70
Garden and Grounds	49.17	49.17
HealthCare Foods	**24.65**	**123.26**
Medical	0.00	0.00
Nursing Services	30.89	47.67
Orderly Services	**106.38**	**138.75**
Other	38.05	63.41
Storepersons	24 65	73 67
Total hospital	**24.94**	**40.29**

3.4 THE CREATION OF A HOSPITAL POLICY FOR MANUAL HANDLING

In response to the 1991/92 injury data, the author drafted a manual handling policy for consideration by the Hospital Safety and Health Committee. The aim of the draft hospital policy was to prevent, as far as practicable, the occurrence of injury resulting from manual handling activities in the workplace. The policy was based on the then just released Western Australian Government *Code of Practice for Manual Handling.*[5] The qualitative code of practice focussed on three key activities to reduce the risk of injury from manual handling; risk identification, risk assessment and risk control (sic). The components of these areas are outlined in Table 3.3. The Hospital Safety and Health Committee, chaired by the Chief Executive Officer and with membership comprising of safety and health representatives and senior management representatives, approved the manual handling policy in July 1992. The policy was then forwarded to the hospital executive, where it received endorsement a month later.

Table 3.3 *The three key activity areas of the West Australian Code of Practice for Manual Handling (1992), and a summary of their components*

Risk Identification	Risk Assessment	Risk Control
1 Analysis of workplace injury records	1 Action and movements	1 Job redesign
2. Consultation with employees	2. Workplace and workstation layout	2. Modify workplace layout
3. Direct observation	3. Working posture and position	3. Different actions, movements, forces
	4. Duration of loads and distances moved	4. Rearrange materials flow
	5. Weights and forces	5. Modify task - mechanical assistance
	6. Characteristics of loads and equipment	6. Modify task - team lifting
	7. Work organisation	7. Mechanical handling equipment
	8. Work environment	8. Training
	9. Skills and experience	9. Particular training
	10 Age	10. Training in the principles of correct manual handling and lifting
	11. Clothing	11. Other administrative controls
	12. Special needs	12. Special needs
		13. Clothing

3.5 RECOMMENDATION FOR THE TRIAL OF THE WORKPLACE RISK ASSESSMENT TEAM

The *Code of Practice for Manual Handling*, referred to in the intervention hospital's new manual policy and instruction, promoted that risk identification, risk assessment and risk control be undertaken by employers in consultation with their employees. However, the Code was non-specific on the mechanisms for the consultative process.

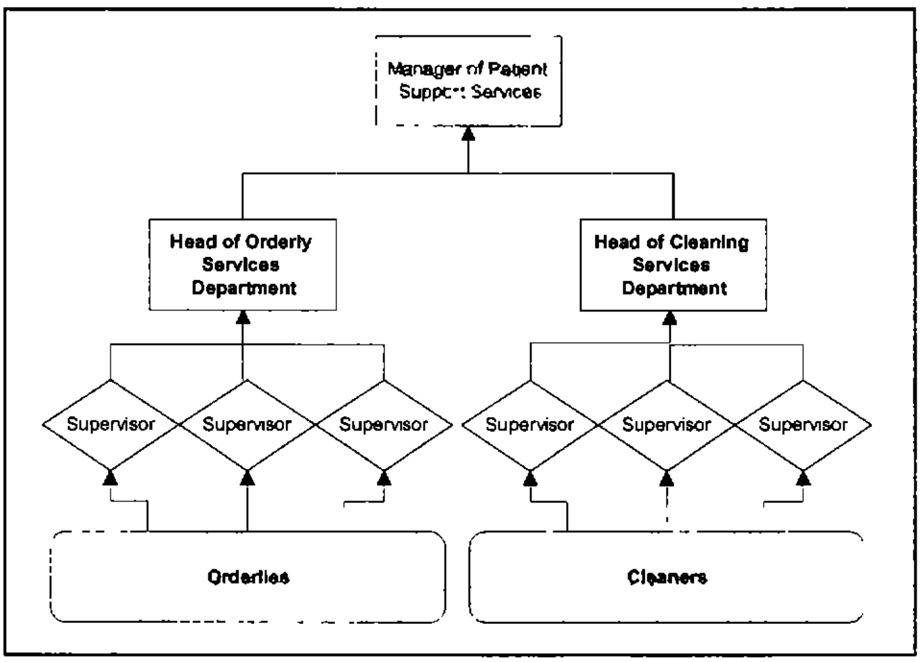
The author became aware, in 1992, of a 1990 report on a pilot programme, to reduce the risk of manual handling injury, undertaken in three Victorian hospitals.[6] The programme was created in response to the introduction, in that State, of a manual handling regulation and code of practice requiring employers to identify, assess and address manual handling hazards within their organisations. The report noted that multiple risk assessment teams had been created from a variety of workplaces within the three institutions. The teams were referred to by their acronym *RATS* (Risk Assessment Teams). RATS comprised management and staff, and their role (after receiving training) was to undertake the manual handling risk identification, assessment and control in a consultative manner. Only a 3-month period had been allocated for the RATS to complete their tasks and details of the *modus operandi* for RATS were not documented. However, the report commented that RATS were accepted within their institutions, and seen as a useful vehicle to address manual handling issues without having to resort to conflict.

After becoming aware of the Victorian report, the author recommended to the safety and health committee of the intervention hospital, the establishment of risk assessment teams to assist with the implementation of the new manual handling policy. In doing so, the author suggested risk assessment teams, would be more likely to be efficient and effective if they operated at a single workplace level (as opposed to the creation of teams that attempted to assess all manual handling across the hospital). That is, a team or teams should be formed from within, and cover, a well-defined group of at-risk staff that reported to one manager. The word *Workplace* was, therefore, placed in front of the term *Risk Assessment Teams* to create the acronym *WRATs*. Ultimately, the Hospital Safety and Health Committee endorsed the establishment of risk assessment teams as a trial within a priority area. A method for the establishment and evaluation of the trial WRATs program, was not determined at the time of endorsement; however, this provided flexibility of process.

3.5.1 The Choice of Cleaning Services as the Trial Area for WRATs

The two departments with the highest manual handling frequency rates were both located within a larger grouping named Patient Support Services. A simplified representation of the line management structure of Patient Support Services is represented at Figure 3.2.

Figure 3.2 *Line management structure for Patient Support Services*



The author approached the Manager of Patient Support Services, responsible for both the Orderly Services and Cleaning Services departments, with a recommendation that the trial WRATs program be undertaken in one area. For two reasons, the Manager tentatively nominated Cleaning Services. The first reason was to maintain control of the implementation process. Changes in work practices or procedures could be made with minimal impact upon the activities of non-cleaner staff. In contrast, the work of orderlies directly involved groups beyond the control of the Patient Support Services Manager Patient handling, for example, would commonly involve both an orderly and a nurse; and was always under the direction of a nurse. Secondly, the Manager considered that Orderly Services had ongoing industrial relations issues that might distract from a focus on WRATs.

The Manager of Patient Support Services provided full commitment to WRATs after the Head of Department, supervisors, and the safety and health representatives from within Cleaning Services' revealed strong enthusiasm for the initiative. The Head of Department of Cleaning Services initially considered the establishment of three teams to be appropriate; two teams to cover the day shift and one the afternoon shift. Each team would comprise a supervisor, a safety and health representative and a general staff member. In September 1992, the Hospital Safety and Health Committee was informed that three WRATs would be created within Cleaning Services.

3.6 THE WORK WITHIN CLEANING SERVICES

3.6.1 Introduction

The average number of cleaners employed was 145, and most were female (details provided in Chapter 6). Approximately two thirds of cleaners worked on day shift and one third on the afternoon shift. An overlap of one hour occurred between the end of the day shift and the beginning of the afternoon shift for the purposes of inter-shift staff communication.

3.6.2 Job Selection Criteria for Cleaners

All cleaning staff were employed under the same industrial award. The job was unskilled, with the three *Essential* hospital criteria for consideration of employment of an individual as a cleaner being:

1. *Conversant with the English language;*
2. *Able to work as part of a team; and*
3. *Able to work with limited supervision.*

The single *desirable* selection criterion was that potential staff had *experience in the health care environment.* Successful applicants were required to undertake an assessment demonstrating medical fitness to undertake cleaning duties, before being considered for placement.

3.6.3 The Workplace

The cleaners' overall workplace encompassed most areas of the 600-bed tertiary institution hospital. Work areas included patient rooms, bathrooms and toilets, reception areas, store rooms and utility rooms, recreation rooms, offices, laboratories, workshops, corridors and passageways, stairwells and courtyards, and a large range of miscellaneous areas. The work demands within a particular type of area could vary considerably according to environment (lighting, surfaces to be cleaned etc.), equipment/furniture density and placement, and occupancy at the time of cleaning (e.g. staff, patients and public).

3.6.4 Cleaners' Duties

The typical duties of a cleaner are detailed at Appendix 3.1. The proportion of time on each duty was mainly dependent upon the area of work and the time of shift. In addition to the routine servicing of areas, staff were required to clean up after unplanned events (e.g. a food spill). Most staff were on a rotating roster, such that every three months their work area placement within the hospital would change. Consequently, most long-term staff undertook the full range of cleaning duties within the hospital (although cleaners servicing specialised areas, such as operating theatres, generally did not share in the rotation).

3.6.5 Functional Requirements of Cleaners' Duties

The physical requirements of cleaning tasks were complex (examples are given at Appendix 3.2). At a broad level, the manual handling components included:

a) Pulling/pushing/lowering, eg equipment such as mop buckets, trolleys, floor buffers/polishers, mops and brooms;
b) Carrying/lifting, e.g. buckets of water/detergent, bins, mattresses, furniture and vacuum cleaners;
c) Holding/restraining, e.g. floor buffers/polishers and steam hoses; and
d) Reaching and bending; e.g. to dust, sweep, wipe and empty bins.

3.6.6 Manual Handling Aids

Equipment used to assist with manual handling included:

a) Metal trolleys to carry most cleaning equipment (e.g. mop bucket, mops, cloths, detergents, polishing agents etc.);
b) Wheeled mop buckets;
c) Dusters with extended handles for high dusting; and
d) Ladders/step ladders

3.6.7 Injuries Sustained by Cleaners

Data collected just prior to the establishment of the WRATs revealed a total of 22 compensable (i.e. lost-time and no lost-time) injuries incurred by cleaners during the 10-month period July 1991-May 1992. The types of injury identified from the *ad hoc* analysis are listed at Appendix 3.3.

3.7 APPENDICES

Appendix 3.1 *Typical Cleaning Duties Undertaken During the Study Period*

1. Floors (including stairs). Surfaces varied, for example, linoleum, carpet and concrete
2. Walls (including air vent grills)
3. Doors (including grills)
4. Ceilings (including air vents)
5. Beds, and mattresses (which had protective plastic covers over them)
6. Toilets, showers, hand basins and mirrors
7. Rubbish bins
8. Patient chairs
9. Commode chairs
10. Intravenous stands and infusion pumps
11. Patient lockers
12. Soap containers
13. Vases and flowers
14. Curtains and curtain rails
15. Televisions
16. Refrigerators
17. Toilet roll holders and replacement of toilet rolls
18. Shelving
19. Tables and trolleys
20. Miscellaneous office and ward furniture and equipment

Appendix 3.2 *Examples of Physical Activities Undertaken When Cleaning*

1. Mopping (using a mop head that had been inserted in water and detergent, squeezed between rollers and then applied to a floor surface)

2. Dry dusting, or wet dusting (using a damp cloth), of either high or low surfaces. Dusting above head height was known as 'high dusting'

3. Wiping and scrubbing (using a cloth and/or scourer with water and detergent) - such as in bathrooms and showers

4. Sweeping, polishing and buffing of floors; including the rhythmical moving of heavy electrical buffing machines (with a rotating head) from side to side in front of the body.

5. Steam cleaning, where appropriate, of soiled (e.g. by faeces) equipment such as commode chairs.

6. Pulling rubbish bags from bins; and carrying the bags to, and placing the bags within, larger bins.

7. Tidying or rearranging objects (including furniture).

Appendix 3.3 *Workers' Compensation Injuries Sustained by Cleaners July 1991-May 1992 (Based on an **Ad Hoc** Report Format as Presented in June 1992)*

The nature of injury in 86% of cases was "sprains and strains of joints and adjacent muscles"

The bodily locations of injury were:

Back	54.5%
Wrist	18 2%
Shoulder	13 6%
Neck	9.1%
Knee	4.5%

The mechanisms of injury were:

Manual handling	55%
Falls and slips	12.5%
Contact with objects	7.5%
Other causes	25%

For manual handling injuries, the associated agencies were:

Brooms and mops	27.3%
Beds	18.2%
Seating/furniture	13.6%

Nine other agencies were each associated with a single injury (4.5% each).

3.8 REFERENCES

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CHAPTER FOUR

THE INTERVENTION AND ITS IMPLEMENTATION

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4.0 INTRODUCTION

This Chapter details the intervention (WRATs) and its implementation, using three case histories to illustrate the process.

4.1 THE INTERVENTION

The intervention was the application of an iterative 3-stage manual handling injury risk identification, assessment and control process, to the workplace of cleaners within the intervention hospital, by a consultative team of management and employee representatives (WRATs) and an ergonomist. WRATs commenced in November 1992, and their activities were studied until October 1995 (see Methods, Chapter 5).

4.1.1 Aim and Objectives of the Intervention

The aim of the intervention was to achieve a sustained reduction in injuries, manual handling injuries in particular, for all staff within the Department of Cleaning Services. In achieving the aim, the first objective, was to foster workplace ownership of solutions to manual handling issues; by the involvement both of those at risk of injury and those with control over the workplace (management). The second objective, was the retention of injury risk management skills within the workplace.

4.2 THE IMPLEMENTATION OF THE INTERVENTION

4.2.1 Introduction

Upon hospital commitment to a trial of WRATs, a group of people determined an implementation process for the team. This group involved the author, the management and the safety and health representatives of Cleaning Services, and the ergonomist from the hospital's Department of Occupational Health. The terms of reference are outlined in the next section.

A 9-member WRATs was established, rather than the initially proposed three teams of three members. It was considered that a single team would maximise communication between parties within Cleaning Services, provide consistency in the risk management process, and provide sufficient personnel for effective team operation. Although only a single team was created, the acronym '*WRATs*' was retained; as the plural term sounded better than the singular, and because it was possible other teams would be formed elsewhere in the hospital in the future.

4.2.2 Terms of Reference

WRATs required a quorum of supervisors[a], safety and health representatives[b] and general Cleaning Services staff[c]. WRATs members, who were selected by the

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[a] Supervisors were cleaners with responsibility (to the Cleaning Services Head of Department) during their shift for the work undertaken by cleaners in their area.

[b] Safety and health representatives were elected by their peers (through a process prescribed under safety and health legislation) for a two-year period, to represent them in safety and health matters. At the time of WRATs commencement, approximately forty safety and health representatives (for all occupations) were in existence throughout the hospital. All safety and health representatives, as required under the Act, attended a comprehensive 5-day accredited training program (which included the process of hazard inspection) at the beginning of their term.

[c] General staff from Cleaning Services were cleaners that were neither a safety and health representative nor a supervisor.

Cleaning Services Head of Department, were required to be committed to safety and health. They were also required to be familiar with the physical environment, processes, equipment, and policies and procedures relating to the work of cleaners. The membership of WRATs initially comprised two safety and health representatives, two supervisors, and four general staff. WRATs first met in September 1992. During the three-year intervention period a small turnover of members occurred; such that membership numbers varied between seven and nine.

The hospital's Department of Occupational Health ergonomist (a physiotherapist, with postgraduate qualifications in ergonomics) sat *ex officio* on WRATs. Guests, such as representatives from Engineering Services, were invited to meetings as required. A 'sunset' clause in the terms of reference, which allowed WRATs to disband if members considered their group efforts were unproductive in reducing the risk of injury, was not exercised.

Regular agenda items for the bimonthly meetings included; feedback from previous meetings; risk identification, either from statistics available from the Department of Occupational Health's injury surveillance system, workplace observations and or reports from general staff; injury risk assessments; recommendations for the control of hazards and reviews of their implementation; and general business.

Where possible, decisions on actions for the control of the risk of injury were made within WRATs. Items requiring management approval were forwarded, in writing to the Head of Department of Cleaning Services. Issues or items requiring an even higher level of resource, or management consideration, were taken by the Head of Department to the Manager of Patient Support Services.

The role of WRATs was explained to all cleaners by presentations at routine staff meetings. Minutes of WRATs meetings were posted on the notice board of the Cleaning Services' Staff Room. The team also reported monthly to the Head of Department of Cleaning Services both verbally (via the supervisor-members) and by forwarding the minutes of meetings.

4.2.3 Risk Identification and Assessment Tool

The author considered it important to provide WRATs with a generalisable, comprehensive yet relatively simple workplace guide, that allowed a given manual handling task to be deconstructed into its major component parts such that those components could be assessed for the risk of injury. The checklist initially provided to WRATs was a 5-page proprietary product. This checklist was subsequently modified by the hospital's ergonomist, in consultation with WRATs members and the author. The modified checklist made reference to the Western Australian Code of Practice for Manual Handling,[1] and also revised some questions to increase their relevance to the hospital environment.

The revised checklist had ten headings relating to the following; actions and movements; workplace and workstation layout; working posture and position; duration and frequency of manual handling, and location of loads and distance moved; weight and forces; characteristics of loads and equipment; work organisation; work environment; skills and experience; and age and clothing. Under each heading was a list of yes/no questions. Depending on whether the checklist was used to assess a work practice, equipment or an environment, either some, or all, of the questions required responses from those undertaking the risk identification process.

4.2.4 Training

Training provided to WRATs was designed to focus the enthusiasm and knowledge of the individual members into effective teamwork for the identification and the assessment of the risk of injury. The goal of training was to equip team members with the capacity to recommend to their management practicable controls for workplace injury risk. Training objectives included WRATs members acquiring an understanding of occupational health principles, with particular regard to manual handling, the ability to identify manual handling hazards in the workplace; the capacity to prioritise manual handling hazards in order of severity; the ability to recommend controls on such hazards; the ability to develop an action plan for implementation of hazard controls; and the ability to evaluate the effectiveness of hazard controls.

The ergonomist, after liaison with WRATs, developed a training program, which took into account the unskilled background of most members. All WRATs attended the program, and received a certificate upon completion. Prior to training, WRATs members were provided with a copy of the Code of Practice for Manual Handling,[1] the Occupational Health, Safety and Welfare Act 1984,[2] and the hospital's 'Manual Handling Policy' and 'Operating Instructions'.

The training program was divided into three 2-hour sessions, and presented by the ergonomist on a weekly basis. The first session described manual handling (using a definition and examples), the rationale for addressing manual handling as a hazard (including the prevalence and costs of injuries, and legislation), information on the manual handling code of practice, and an explanation of the intended roles of the risk assessment team. The second session dealt with simple biomechanical principles (including overviews of anatomy and ergonomics), common work injuries, and the risk identification process (including how to analyse injury data, consult with fellow employees, and observe work practices and processes, and how to use the checklist instrument). The final session detailed the risk assessment process (including prioritising risk), the recommendation of injury risk control measures (introducing the hierarchy of controls; emphasising workplace design, equipment and work organisation, and indicating that lifting techniques were lower down the hierarchy), the planning of action to implement the control strategy within the workplace, and the evaluation of injury controls (utilising the same steps as in risk identification).

4.2.5 Meetings

WRATs meetings considered injury/hazard reports, checklists, the determination of areas of risk, recommendations for the control of hazards, future risk management strategies, and action to be undertaken from previous meetings. The duration of each meeting was approximately one hour. The average attendance for all meetings was 6.3 members (range 4 to 7). In addition to regular meetings, WRATs members undertook a variety of other activities. These ranged from informal liaison with general cleaning staff, ad hoc meetings, and working parties to deal with difficult issues or the evaluation of potential new equipment. Some activities involved liaison with parties external to Cleaning Services, such as personnel from Engineering Services.

4.2.6 The Risk Identification, Risk Assessment and Risk Control Process

The intervention comprised three steps; risk identification, risk assessment and risk control. A description of each step is given below. The descriptions are followed by three case histories to exemplify the iterative process.

4.2.6.1 Risk identification

Items for the identification of risk, namely workplaces, equipment and tasks were determined at regular WRATs meetings. An item was selected either because a duty was common, or because injury data indicated an ongoing risk of injury, or there existed a perception from occupational experience that a duty was dangerous. A wide range of potential manual handling risks were identified for further analysis. Examples include; prolonged mopping, vacuuming and buffing of floors; difficult to clean floor surfaces (requiring repetitive movements); the moving and cleaning of patients' beds; the lifting of heavy vases from high shelves; frequent dusting of objects above head height; and even the replacement of toilet rolls from metal dispensers that were difficult to access. Items were allocated to individual members, or sub-groups of WRATs, according to their knowledge of areas.

The next phase of the identification of risk involved the application of the checklist tool to the selected items. The author audited the first 30 completed checklists; 2 were completed by a single WRATs member, 27 by two members and 1 by three members. The time taken for checklist completion was reported as between fifteen and sixty minutes.

When undertaking checklist assessments, WRATs frequently identified the risk of injury of a non-manual nature. On some occasions, the risk of non-manual handling injury was intrinsically associated with the manual handling activity/process being assessed. For example, the difficult to access metal toilet roll containers also had sharp edges that had resulted in lacerations to the cleaners when replacing the rolls. On other occasions, the risk of non-manual handling injury was noted coincidentally. For example, when WRATs were assessing a staff accommodation block for the risk of injury from moving heavy beds, it was independently noted that frayed carpets represented a trip hazard throughout the building. WRATs therefore decided to assess all risks of injury when they became apparent; whether manual handling or non-manual handling in nature.

4.2.6.2 Risk assessment

WRATs meetings considered the completed checklists in concert with other information; such as injury data, or communication from other cleaners or with non-cleaning staff (e.g. engineers). When requested, the ergonomist provided technical information and comment on the risk of injury. Risk was finally assessed on the likelihood (low, medium or high) and severity (minor, moderate or severe) of injury to a cleaner, and the number of cleaners at risk of injury. This aspect of assessment assisted in the determination of priorities for action. Once assessment was complete, controls that would minimise the risk of injury were considered.

4.2.6.3 Risk controls

WRATs usually made recommendations on the controls that they considered would minimise the risk of injury, at their regular meetings. Exceptions to waiting for meetings were when obvious and simple risk reduction strategies could be enacted at the time of conducting the checklist assessment. For example, changing the storage of regularly accessed heavy containers of detergent from above shoulder-height to thigh-height shelving.

Measures to reduce the risk of injury were considered according the hierarchy of hazard control. The hierarchy is described below, but it is first noted that hazard controls were not considered to be mutually exclusive. That is, more than one type of control could apply to a single item.

Elimination of a hazard was the preferred method of reducing the risk of injury (i.e. top of the hierarchy). For example, the emptying of rubbish from patients' bins involved the pushing of cleaners' trolleys for considerable distances over a shift. Assessment demonstrated that when within a ward, while cleaning around each patient's bed, cleaners emptied rubbish from each patient's bin into a small plastic bag situated on their trolley. When the bag was full, the cleaners pushed their trolley, which contained equipment (such as a water-filled full mop bucket, and mop) and cleaning materials to a large bin centrally located away from the wards. After placement of the bag in the central bin, the cleaner returned to the ward to continue cleaning until the new bag was full; and the disposal process was repeated. To eliminate the manual handling hazard of repetitive long-distance pushing of trolleys, cleaners were provided with rubbish skips (wheeled light-metal receptacles). All rubbish collection for the ward then took place as a single round; after the rest of the cleaning duties had been completed. Consequently only one return trip between the ward and the bin was required.

Substitution was the next most preferred hazard control. For example, the difficult to reach (because they were situated low, adjacent to the toilet pedestals) metal dual-packet toilet tissue holders with sharp edges, were replaced by smooth-edged plastic holders that were easy to open. The new holders were placed higher on the wall to reduce the back flexion required, and having 4-roll holders halved toilet roll replacement frequency.

Engineering controls were next in the hierarchy. Some were simple. For example the 'dolly mop', used by all cleaners for dry or damp dusting of high or awkward places, comprised a long tubular aluminium handle with a small mop head at the far end. Held much like a feather duster, many cleaners experienced hand discomfort when using the mop. The problem was assessed as the slippery narrow (15 mm diameter) handle requiring a strong clenched fist grip to prevent it rotating during use. The 'trial' control was the application of 10 mm thick tubular foam to a small number of mop handles. After cleaner feedback that the handles were much easier to grip, and that the foam stayed in place, the foam was applied to all dolly mops at a cost of $1.75 per metre purchased.

A variety of administrative controls were also implemented. Examples include; a revised general induction training program for cleaning staff (incorporating a manual handling component); increased rotation of duties during any given day to reduce repetitive manual handling; and the education of cleaners and supervisors in the completion and follow-up of incident/hazard reports. The controls that were implemented were unlikely to have impacted on other staff (such as those within Orderly Services).

4.2.7 Case Histories

4.2.7.1 Floor buffing

(i) Risk identification

Floor buffing was selected for risk assessment because it was a ubiquitous duty. Much of the hospital's floor covering was made of linoleum, and 25 buffer machines were utilised to keep the surface clean. To wash and scrub an area of floor, the operator moved a water and detergent-filled machine from side to side by pulling, preferentially, on either end of a handlebar while flat circular pads (attached to a drive plate) in the machine head rotated rapidly on the floor. When scrubbing was complete, the pads were changed and the buffers were used as floor polishing machines.

The amount of floor buffing undertaken by a cleaner varied on a given day and over a shift cycle. That is, a cleaner might buff for their entire shift, or do little or none. General discussions with cleaners revealed that the use of buffing machines required considerable force, particularly by the operators' upper limbs and trunk, to move and control them. Novice users considered training inadequate, and the machines unwieldy and hard to control. Experienced users found buffing tiring and difficult to sustain for long periods. Additionally, machines were poorly maintained and many vibrated excessively.

Injury data revealed nine injuries, including to the shoulder, neck, back, elbow and wrist, associated with buffing had occurred in 1992. One injury was an upper limb fracture.

(ii) Risk assessment

WRATs concluded that that there was a medium risk of a moderate musculoskeletal injury from buffing to a cleaner over a year; and that most cleaners were exposed to the risk.

(iii) Risk controls

Firstly, skills training was formalised (in contrast to previous 'on the job' training) to formally cover the theoretical and practical aspects of safe buffing Secondly, cleaning duties were restructured to reduce the risk of injury due to the repetitive nature of the task. Although this resulted in more cleaners undertaking buffing each day, the duration of buffing duties was reduced to a maximum of two hours per shift. Thirdly, the buffing machines were numbered and entered onto a Engineering Services planned maintenance program. Finally, the Head of Cleaning Services was given authority, and a budget by the hospital's executive committee, to select new floor surfaces across the hospital as old floor surfaces became worn and required replacing Consequently, after consultation with other stakeholders, new floor surfaces began to be purchased that required less cleaning *per se* and less buffing (for example, low pile carpet instead of easily scuffed linoleum).

4.2.7.2 Steam Cleaning

(i) Risk identification

Consultation of WRATs members with cleaners consistently revealed perceptions that steam cleaning of furniture from the wards was hazardous work, and *prima facie* a risk for injury from manual handling. A review of the process identified that certain ward furniture could sustain steam cleaning (e.g. metal/plastic chairs). When this furniture became dirty or soiled it was transported to, and stacked, in a designated outside area of the hospital. When the stack was large enough (once or twice a week), steam cleaning was undertaken by experienced cleaners working in pairs for a number of hours. The workplace comprised a concrete floor, five by three metres in area, bounded on one side by a wall (i.e. open at the sides). Prior to steam cleaning each cleaner donned a pair of earmuffs, facemask, plastic apron and rubber boots. Personal protective equipment (including gowns gloves and boots) was provided in only one size (large). Cleaners would then connect a wide-diameter heavy-duty canvas hose, of approximately four metres in length, to a wall outlet (see Figure 4.1). The outlet was connected to a source of super-heated water. Once connected, because the other (nozzle end) was initially closed, the hose would fill with water and steam. The cleaner would hold the nozzle with one thick-gloved hand, while reaching for stacked pieces of furniture with the other gloved hand. An item of furniture was lifted off the stack and placed against the wall. Rotation of a lever on the nozzle then resulted in a high flow of boiling water and steam in the form of a jet or spray. The jet/spray was directed at the article to be cleaned. The hose was heavy and inflexible and had to be held for prolonged periods. The nozzle was difficult to restrain, and was hot. Skin contact with the nozzle had resulted in three burns in the six weeks prior to the checklist evaluation. The smooth concrete floor, upon which the furniture and cleaners stood, became soaked in water and slippery.

The checklist assessment highlighted the risk of injury from manual handling. This risk was primarily from abnormal and sustained postures required, the heavy hose, and the lifting of furniture single-handedly. However, the overall risk of injury was increased by the awkward nature of the clothing required to worn and the uneven floor surface. Noise, too, was identified as a potential hazard at the time of checklist completion (the sound from the water jet emission could be readily heard one hundred metres away), and WRATs requested further assessment by the Senior Scientific Officer of the Department of Occupational Health. The Senior Scientific Officer measured the sound level at the hose nozzle as between 100-105 dB (A) (with a peak 124dB (A)); exceeding the noise reduction action level required by legislation.

Figure 4.1 *The steam cleaning environment during the risk identification phase*

(ii) Risk assessment

WRATs concluded that the main risks were for musculoskeletal injuries from manual handling and slipping, burns (including concern that misdirection of the steam jet, through distraction, slipping, inappropriate aiming, dropping the hose or 'kick back' could result in severe burns to the user, co-worker or a passer by) and noise induced hearing loss. Overall, WRATs assessed the steam cleaning process as a moderate risk of severe injury to a small number of cleaners.

(iii) Risk controls

WRATs created a working party to generate steam cleaning hazard control recommendations. Six formal meetings, and many informal meetings, were conducted. Membership included a sub-group of WRATs, the Senior Scientific Officer, and a representative from the Supply Department, Patient Appliance Centre (responsible for the equipment to be cleaned), the waste disposal unit (an area initially considered the for relocation of the steam cleaning process), and Engineering Services.

Controls were implemented over an 18-month period. Firstly, after examining many alternatives, the steam hose was substituted with a new electric "high pressure water cleaning machine" (manufacturer's description). The machine contained two reservoirs; one continually filled via a hose with warm water and the other filled with detergent. With the electric motor 'on', water was mixed with detergent as it exited the machine through a narrow hose connected to a 'trigger gun'. The gun was a thin, comfortably held, thermally-insulated hollow metal lance. The shaped exit end of the lance allowed the water/detergent mixture to be readily directed at the furniture (see Figure 4.2). A trigger at the base of the lance allowed the operator to turn the water flow on or off; and with minimal 'kick'. The lance, when 'off' could be easily placed on top of the machine, to then enable the furniture to be moved with two hands. The maximum temperature of the water was 60°C. The maximum noise at source was measured at 85 dB (A). From a customer perspective (the wards), the machine cleaned the furniture as effectively as the steam hose.

Figure 4.2 *The new electric "high pressure water cleaning machine"*

Secondly, after trials elsewhere, it was decided to retain the original location for furniture cleaning. In conjunction with Engineering and Building Services, the cleaning area was restructured to produce a slip resistant floor with water drainage away from the operator, more space (and hence less need of furniture stacking), and side scaffolding to prevent unintended access by passers by. Thirdly, as an administrative improvement, furniture cleaning was rostered more frequently to reduce the need for stacking and the duration of cleaning per episode. Finally, staff were supplied with appropriate and properly fitting personal protective equipment (including earmuffs/plugs). Following the implementation of the controls, no injuries were reported from the furniture cleaning process during the remainder of the intervention period. The $14,000 cost of the controls was provided from the budget of the Manager of Patient Support Services.

4.2.7.3 Cleaners' Trolleys

(i) Risk identification

WRATs identified the trolleys as a potential risk, because all cleaners regularly used them. Cleaners' trolleys carried equipment (such as mop buckets, mops and brushes), cleaning products (such as detergents, powders, polishes), water and cleaning cloths. It is noted that the mop bucket, containing a water/detergent mixture was located on the floor of the trolley. The mop head comprised multiple strands of string-like material secured to a metal cap at the far end of the mop handle. During the mopping process the head was regularly dipped in the bucket for rinsing. The top of the mop bucket had two rollers situated on the inside circumference. The rollers could be moved horizontally towards each other (and the centre of the top) by pushing down on a plastic-coated lever on the outside of bucket. The lever was attached to gearing, which in turn was attached to the rollers. To squeeze excess fluid from the mop head after rinsing, the mop was pulled up from the water with one hand so that the head was situated between the rollers. Then the lever was pushed down with the other hand, to entrap and squeeze the mop head.

Checklist assessment revealed that the trolleys had small wheels. The trolleys were therefore difficult to push, particularly on carpet. Further, trolley space constraints did not allow the storage of dolly mops, so that dolly mops had to be carried in one hand as cleaners pushed the trolleys. Also much of the gearing of the mop buckets had become tight with long term usage; requiring considerable force to be applied to the lever for movement of the rollers to occur. The application of force could be painful, because the handgrips of the levers were made of thin plastic and some were broken.

Many cleaners reported to the WRATs team members that the trolleys were difficult to use, push and steer. However, no injuries requiring time away from work were identified as having occurred in the previous 12 months.

(ii) Risk assessment

WRATs considered that the trolley usage represented a low risk of a minor manual handling injury, but that all staff were exposed to the risk.

(iii) Risk controls

Substitution of the old trolleys with new ones was considered too expensive, so engineering and administrative solutions were recommended. Engineering Services modified the trolleys to include a raised platform for the mop buckets. The stiff gearing on the buckets was replaced, and a wider handgrip added to the wringer levers, to make squeezing of the wet mop heads easier. A hook was fitted on one end of the trolleys to hold the dolly mop. The rear wheels were enlarged and made non-swivel; to make pushing of the trolleys easier. The cost of alterations was approximately $100 per trolley. The trolleys were placed on an annual Engineering Services maintenance program, and staff were informed they should report any trolleys that developed mechanical problems between checks.

4.3 SUMMARY

The Workplace Risk Assessment Team was a small trained consultative group of cleaners and supervisors, and an ergonomist, who employed an iterative process of risk identification, risk assessment and risk control with the aim of reducing the risk of all injuries, particularly manual handling, among all staff who worked in the

Cleaning Services department of the intervention hospital. The intervention commenced in November 1992 and the observation of the intervention ceased in October 1995. More detail on the observational period is provided in Chapter 5.

4.4 REFERENCES

1. Occupational Health Safety and Welfare Commission. *A code of practice: manual handling*. Perth: State Government Printing, 1992.
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CHAPTER FIVE

METHODS

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5.0 INTRODUCTION

This study design is a longitudinal pre-post-intervention study with one intervention and three comparison groups. The intervention (WRATs) involved the application of a manual handling risk identification, assessment and control process, for cleaners within the intervention hospital. The observational period of the study is 1 July 1988 – 31 October 1995

This chapter describes the methods used to determine if the Intervention Group (the staff from the Cleaning Services Department) experienced a change in the occurrence or severity of lost-time injuries when compared to three comparison groups.

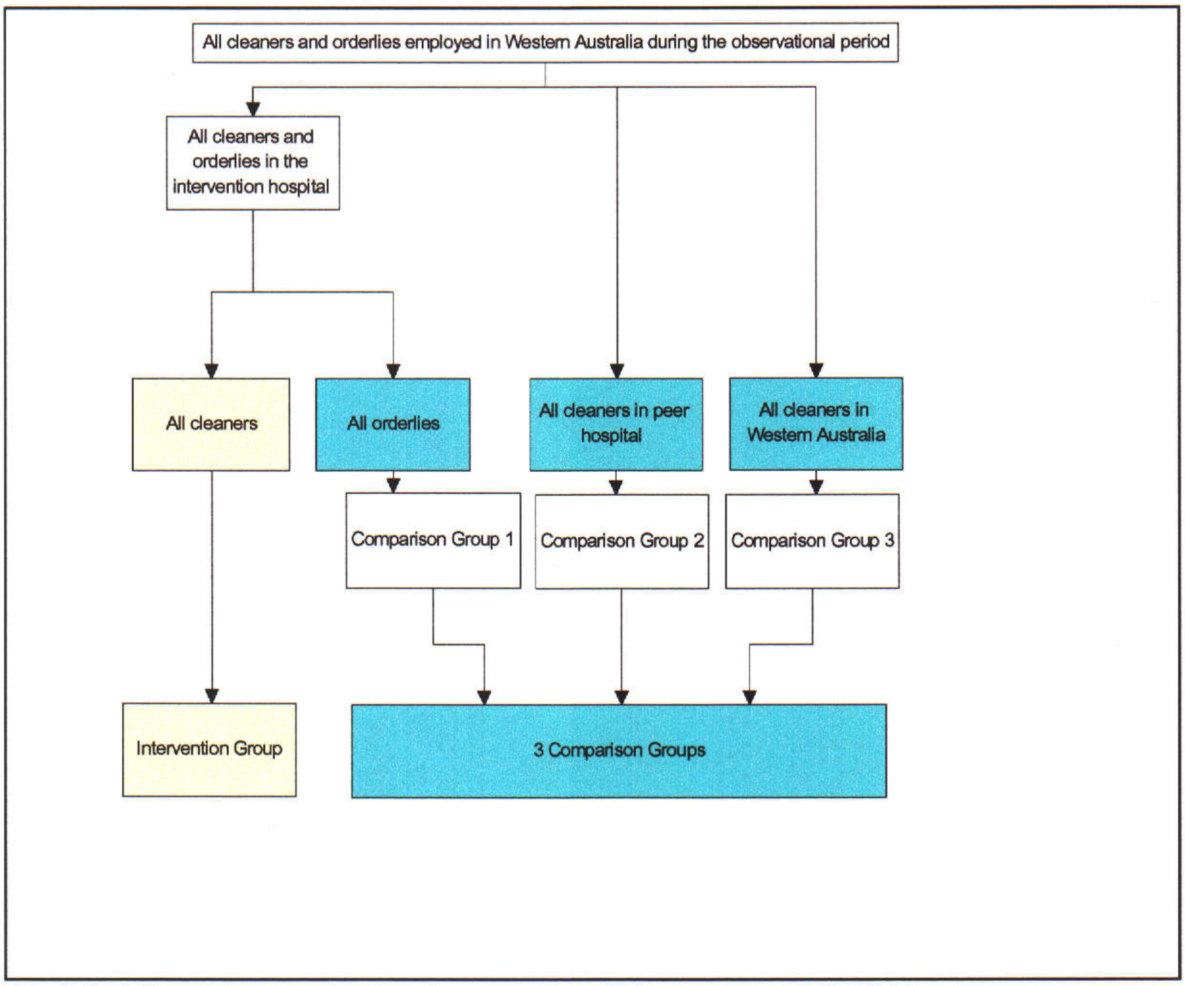
In this thesis, *manual handling* is defined as *'any activity requiring the use of force by a person to lift, lower, push, pull, carry or otherwise move, hold or restrain a person, animal or thing.'*,[1] where *manual* refers to part or all of the energy of force being created by the worker and *handling* includes actions, like lifting, lowering, pushing, pulling, carrying and holding either singular or in combination.[2]

5.1 SELECTION OF THE GROUPS FOR STUDY

All cleaners employed after the intervention, at the intervention hospital, were exposed to injury risk control measures recommended by WRATs. Consequently, all those employed during the observational period were included in the Intervention Group. Three working populations, not exposed to the intervention, were recruited as comparison groups. The groups, namely; orderlies from the same hospital as the Intervention Group; cleaners from a peer public hospital of similar size to the Intervention Group; and all cleaners from within the state of Western Australia are called Comparison Groups 1, 2 and 3, respectively. The outline of the selection process is given in Figure 5.1.

Subjects were not recruited; rather, groups were selected for study, and individual and aggregate data then obtained from a variety of data sources. This section describes the features of the four groups. It is noted that the categories 'Cleaner' and 'Orderly' (i.e. all four groups) both fall within the category of 'Labourer' within the Australian Bureau of Statistics classification of occupations.

Figure 5.1 *Recruitment of groups to the intervention study*



5.1.1 Intervention Group

This group comprised all cleaners employed by the intervention hospital during the observational period. The number of individuals employed during the observational period averaged 145, and were predominantly female (see results in Chapter 6). As outlined in Figure 3.2, the Head of the Cleaning Services Department and the Head of the Orderly Services Department both reported to the Manager of Patient Support Services. Each Department shared the same line management pathway to the Chief Executive Officer.

5.1.2 Orderly Services Staff - Comparison Group 1

This group comprised all orderlies employed by the intervention hospital during the observational period. Coincidentally, as for the Intervention Group, the number of individuals employed at any time during the observational period averaged 145. However, Comparison Group 1 experienced less turnover of staff and nearly all of the staff were male (see Chapter 6). Both groups were employed under an industrial award covered by the same union, their workplace encompassed the entire hospital, and their duties predominantly required manual handling. However, the manual handling duties for subjects in Comparison Group 1 were of a different nature than those for subjects in the Intervention Group; primarily involving courier work (e.g. carrying packages and patient samples) and patient handling duties (e.g. including moving patients in bed, transferring patients between the bed and chair, and pushing beds and patient trolleys). Unlike the Intervention Group, where the supervisor determined most duty requirements for a particular shift, the workload of subjects within Comparison Group 1 was generally determined by nursing staff.

It is to be noted that two years prior to the end of the observational period, the Hospital Board commenced an efficiency review (using external consultants) of all hospital departments. A year later, one of the recommendations of the review was that Cleaning Services and Orderly Services be contracted out. Eventually, only Orderly Services were contracted out. The period leading to this event was subject to industrial dispute between the hospital and the union covering both the orderlies and cleaners.

5.1.3 Peer Hospital Cleaning Services Staff - Comparison Group 2

The peer and intervention hospitals are the two largest public adult teaching hospitals in Western Australia. Cleaners in both hospitals were employed under the same industrial award; that is, their salary and industrial conditions were identical, having been negotiated by the same union. The peer hospital cleaning duties were similar to those of the Intervention Group and, likewise, the population was predominantly female. The workers' compensation insurer was the same for both hospitals.

The peer hospital's Department of Occupational Health was created in 1992. Safety and health initiatives had occurred within the peer hospital since that time, but the Head of Department of Occupational Health reported that none involved WRATs or WRATs-like consultative structures. No major industrial relations issues impacting on the Comparison Group 2 during the observational period had taken place.

5.1.4 State Cleaners - Comparison Group 3

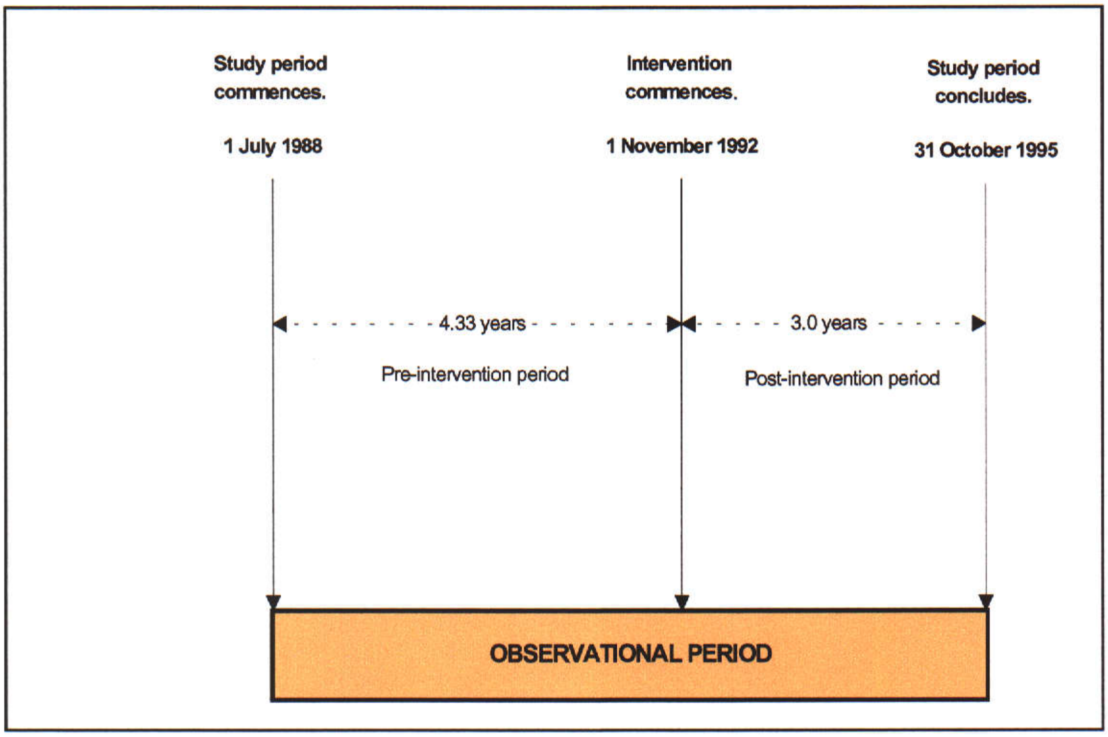
Comparison Group 3 comprised all cleaners (hospital and non-hospital) in Western Australia. Workers' compensation data for cleaners are not published by State government authorities. However in 1998, the executive management of WorkCover Western Australia, the State Government's workers' compensation and rehabilitation authority, permitted the release of data, via that organisation's senior statistician, to the author.

Strictly speaking, the Intervention Group, Comparison Group 1 and Comparison Group 2, were sub-groups of Comparison Group 3. However, as injuries from the first three groups contributed to less than 5% of the Western Australian total, and because it was not possible to remove these groups' contributions to the aggregated data of Comparison Group 3, all 4 groups were treated as separate for the purposes of the thesis. No changes to safety and health legislation, or workers' compensation legislation, that were specific to cleaners or orderlies, occurred during the observational period.

5.2 THE OBSERVATIONAL PERIOD

The financial year 1989/1990 was the first year for which hospital records could be located for the Intervention Group and Comparison Group 1 (Orderly Services). On 31 October 1995 Orderly Services staff ceased to be direct employees of the hospital, and from 1 November 1995 their employment records were unavailable. Consequently, the observational period was determined as between 1 July 1988 and 31 October 1995 inclusive (see Figure 5.2).

Figure 5.2 *Observational period by pre and post-intervention injury duration*



Although the intervention period comprised the 3-year period between the commencement of WRATs and the end of the observational period, for simplicity the intervention period is referred to as the post-intervention period. As will be detailed in the following section, to allow lost-time injury compensation claims to mature, data were obtained 3 years after the observational period.

5.3 PRIMARY OUTCOME MEASURE

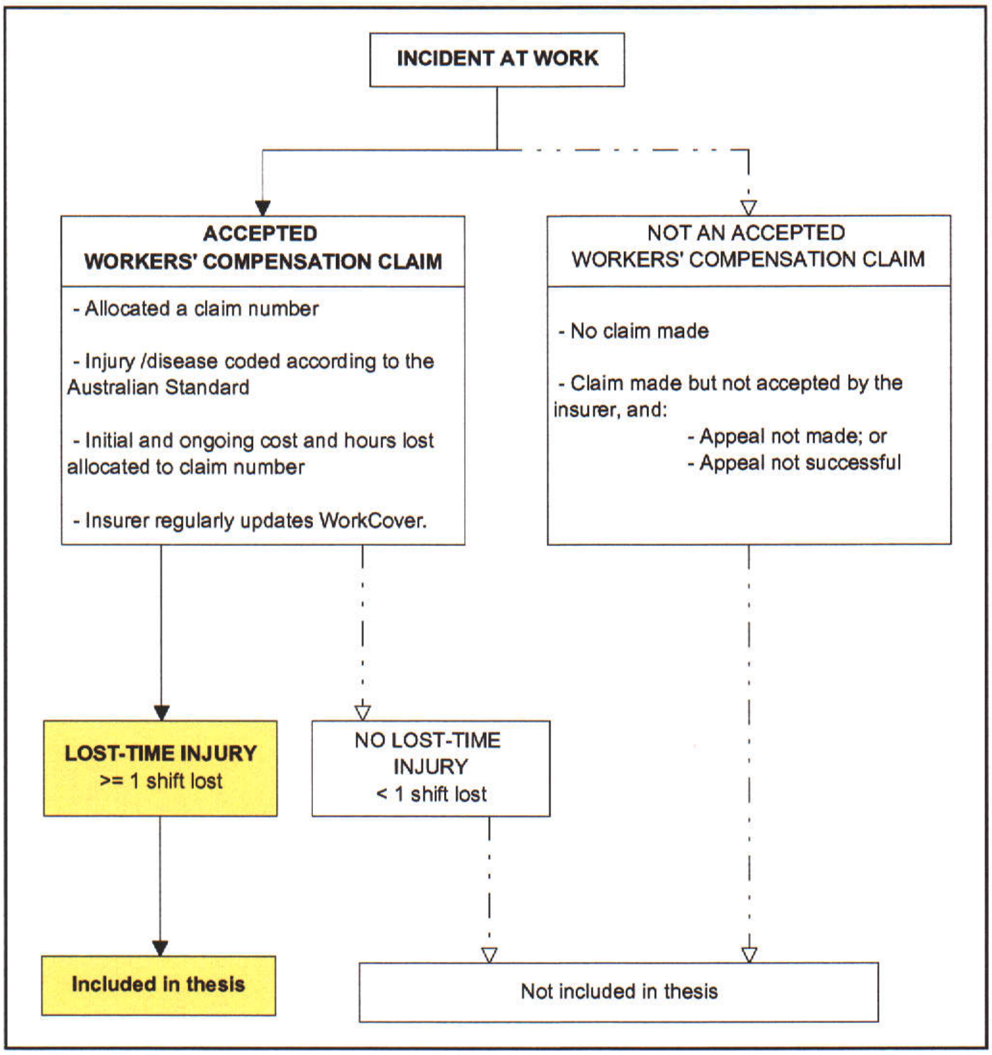
The primary outcome of interest was the lost-time injury. A lost-time injury is classified as a new workers' compensation injury, resulting in the loss of one shift or more from work.[3] By obtaining the number of lost-time injuries over time, measures of counts or occurrence for a group or individual, were able to be determined. In turn, obtaining the workers' compensation cost (i.e. injury claim cost) and hours lost from work (i.e. injury duration) for those lost-time injuries provided data for the determination of injury severity. The following overview of lost-time injury determination and other aspects of the Western Australian workers' compensation process are provided for reference when considering lost-time injury outcomes.

5.3.1 Lost-time Injury

All four groups were covered by Western Australian workers' compensation legislation (Workers' Compensation and Rehabilitation Act 1981), requiring employers to insure their employees against work-related injury or ill health. Whenever an employee made a claim for compensation, the employer was required to forward a properly completed claim form to their insurer. The legislation did not apply fault for the injury to either the employer or injured worker. However, the insurer had to decide whether to accept, or decline, the claim as work-related. Government conciliation and appeals processes were available to all parties in the event of a disagreement as to the veracity of the claim or costs. Any claim accepted by the insurer as compensable was allocated a unique claim number. An ongoing account of any costs and working hours lost (including recurrences of the injury after a worker's return to work) were recorded by the insurer against the claim number.

Accepted workers' compensation claims were classified as a lost-time injury if one shift or more was ever lost from work, or as a no lost-time injury if less than a shift was lost from work. Should the accrued compensable hours lost from work, for a no lost-time injury, eventually equal or exceed the equivalent of a working shift for the injured person it was reclassified as a lost-time injury. An outline of the claims process and lost-time injury determination is given at Figure 5.3.

Figure 5.3 *Overview of the workers' compensation claims process*



5.3.2 Reporting of Claims by Insurers to State Government

From July 1991, each insurer has been required to inform, and regularly update, the State government compensation authority (WorkCover Western Australia) of all lost-time injuries being dealt with by them. Insurer-provided claim data includes details of the injured worker's occupation, industry, injury mechanism and type, total compensation cost and time lost. Where cases are not finalised, the insurer is still required to provide government data on the total cost, and time lost, for each lost-time injury. The total cost of a non-finalised claim comprises the sum of the incurred costs to date, plus the insurer-estimated remaining lifetime costs for the claim (i.e. the remaining liability). With the elapse of time from a claim year, more lost-time injuries are finalised; and for non-finalised claims actuarial estimation of remaining cost and time lost from the injury becomes more accurate. Since 1991, Australian State governments have forwarded de-identified compensation data to the 'National Occupational Health and Safety Commission (Australian Federal Government). In turn this is used to contribute to a standardised 'National Data Set for Compensation-based Statistics',[4] to enable the production of national and nationally comparable workers' compensation-based data.

5.3.3 Injury Claim Cost and Duration

Injury claim cost is taken as the total workers' compensation cost (including insurer estimates of liabilities where a case is not closed) attributable to a lost-time injury. These costs may include the worker's lost salary, medical costs, legal costs, travel costs, rehabilitation costs, settlement and common law costs and sundry minor costs.

It is relevant to note that under the ordinary workers' compensation pathway, a legislated limit applied to the amount of money that could be paid against a claim (it is also noted that this ceiling incrementally increased from $80,000 to $100,000 during the 7-year observational period, in accordance with consumer price index movements). Within the no-fault workers' compensation system (where no party is blamed for the incident leading to the claim), where an individual had a permanent incapacity from the injury, and both the insurer and injured worker agreed, it was open to the parties to settle the claim with a lump sum of money (not exceeding the above limit). Titled a 'Second Schedule' settlement, this closed the case and extinguished further access to the monies relating to that injury. Separate to Second Schedule settlement, it was open to an employee to sue their employer for negligence under common law. This could occur if the employee considered they could demonstrate that a duty of care was owed, but breached by the employer, and that harm had eventuated (i.e. fault-based). Unlike the workers' compensation system, a common law remedy could include damages for pain and suffering and past and future economic loss and costs. There was no ceiling to common law costs, and an employer could be required to pay the employee hundreds of thousands of dollars. The parties generally settled common law cases, for a large sum relative to total costs within the routine workers' compensation pathway, before reaching court. Eventual common law costs, whether settled before court or determined in court, were still required to be formally attributed to the respective workers' compensation claim number. Although less than 5% of all claims, common law cases skew the average workers' compensation claim cost.

Injury duration was recorded as the total number of working hours ever lost (including, as for claim cost, insurer estimates where the case is not closed) from a lost-time injury.

5.3.4 Finalisation of Claims, and the Timing of Workers' Compensation Data Collection

Claims were finalised formally under statutory processes, or informally by the insurer. A claim was formally finalised after a 'Second Schedule' or common law settlement occurred, or the claimant exhausted the monies available under the workers' compensation system, or the insurance company declared the claimant fit for work (after first seeking independent specialist opinion) and the declaration was either not challenged or the challenge was not upheld on appeal.

Informally, insurers had internal methods for 'finalising' a claim. Most commonly, a claim was finalised where a treating doctor had certified the individual fit, or the claimant had failed to provide ongoing treating doctor certification, and no injury recurrence had been reported after many months. However, a 'finalised' claim could be re-opened, if subsequent medical certification demonstrated that a recurrence of incapacity was related to the original injury. Actuarial advice to the author indicated that over 95% of claims were finalised, and never re-opened, after 2 years.

For the purposes of the thesis, total claim cost and duration were obtained in October 1998 (3 years after the observational period), in order to increase the likelihood that claims had reached maturity. If a claim accrued costs or hours lost (or had remaining estimates) after the observational period, the accumulated data were included in the study. Costs were adjusted, by the author, to the July 1998 Australian consumer price index prior to analysis (see Data Collection section and Data Management section below).

5.4 ETHICAL CONSIDERATIONS

Ethics approval was sought and obtained from the Ethics Committees of Curtin University, the intervention hospital (Intervention Group and Comparison Group 1's hospital) and the peer hospital (Comparison Group 2's hospital). To ensure that the author, or others, could not identify individuals, the data for Comparison Group 2 were supplied by the peer hospital without names attached. Confidentiality of all individual level data records was maintained.

State government data on cleaners were provided in aggregate form, in a manner in which individuals or organisations could not be identified. Although cleaner-specific data are not usually published, the data set provided to the author was not different in nature to annual injury information made public by the government on larger industry groups (for example, in the State government publication 'State of the Work Environment'[5]).

The executive committee, and safety and health committee of the intervention hospital were informed of, and sanctioned, the study. They have since been informed of the results to date, and of the associated literature published.[6 7]

5.5 DATA COLLECTION

Data collection was obtained to allow analysis of the incidence and severity of lost-time injury for person time at risk within the four groups.

It is first noted that the data used in the thesis excluded 'journey claim' lost-time injuries, arising in either the pre-intervention period or post-intervention period. A 'journey claim' occurred, up until 1992, when a person travelling between work and home (or vice versa) sustained an injury (e.g. in a motor vehicle accident) and successfully claimed workers' compensation for that injury. In 1992 (late in the pre-intervention period) changes to workers' compensation legislation precluded employees making 'journey claims'. The legislative changes were made on the basis that the employer had no control over environments unrelated to work. For the intervention hospital, the author directly removed the journey claim lost-time injury from the database. For Comparison Groups 2 and 3 the author requested, and was supplied, lost-time injury with journey claims already removed.

5.5.1 Intervention Group

5.5.1.1 Employment data

It is relevant to note that the intervention hospital allocated each person a unique employee number upon employment. If a worker maintained continuity of employment, even if they changed department, they retained their employee number. If employment was terminated (e.g. resignation or retirement), the employee number was never re-used by the hospital. If an individual was re-employed, they were provided with a new employee number. Also, each department had a unique hospital-allocated cost centre number. All cleaners were required to complete time cards at the end of each shift of work. Every fortnight, the hours worked by each cleaner (or taken as leave) were accounted for and wages paid were attributed against the Cleaning Services cost centre number. The hospital allocated each 2-week (i.e. fortnightly) pay period a sequential number, based on the financial year and its temporal placement within that year.

Computer printouts of every fortnightly pay record of the observational period, for Cleaning Services, were obtained by the author. Each fortnightly record contained information on all cleaners employed; including the employee's number, first names, surname, hours worked (e.g. ordinary hours, overtime) or their type of leave (e.g. sickness absence, recreation, workers' compensation).

Approximately 25,000 individual cleaner fortnightly pay records were then entered into a database established by the author. Each entry, therefore, contained the fortnightly record number, employee number, cost centre number, first names and surname and actual hours worked. 'Hours paid', but not actually worked, were not included in the study for the purpose of any analysis. If, for example, a person worked ten hours of 'overtime' at a pay rate of 'time and half' then he/she would be paid the equivalent of fifteen hours salary; but only the ten hours were counted as hours worked for the purposes of this thesis. As a further example, paid leave (e.g. holiday leave or workers' compensation leave) was not included as work.

Next, separate paper records (cards) held by the Department of Cleaning Services and Human Resource Services were examined to confirm that employees did work as cleaners. These records also usually provided the date of birth, date first employed by the hospital and the gender of each employee. These data were added to the author's employee database. The date of birth was to be used to help confirm the identity of an employee. It was also used as a base for certain calculations, for example, age at time of injury. Similarly, the date of first employment was entered to later estimate job experience.

From the departmental cost centre number and fortnightly pay period number, it became possible to identify which individuals were employed by a department for a given period. As a corollary, if a person was redeployed to a different department this could be tracked, as the employee number would remain the same, but the cost centre number would change. Termination of employment was identifiable because no ongoing fortnightly record was available for a subject. Re-employment was identifiable because fortnightly records would resume but the individual would acquire a new employee number (it was assumed that a combination of the same first names, surname and date of birth meant it was the same individual). A change in name could be similarly handled.

5.5.1.2 Workers' compensation data

Paper records held by the hospital, of all workers' compensation claims occurring during the observational period, were examined for lost-time injury data. These files contained a copy of the original employee incident report form (a form devised by the hospital), the employee's workers' compensation claim form, the workers' compensation claim number, the employee number and department, and ongoing medical certificates. The incident and claim forms, in turn, provided the date, and a brief narrative description, of the incident and associated injury.

Over 3000 workers' compensation claims records, for all workers in the hospital during the observational period were examined, and those relating to lost-time injuries for cleaners were retained. From the retained files, the cleaners' names, claim number and date of injury were recorded. The de-identified injury narratives were then categorised, by a person employed by the author with experience in the use of the Australian Standard,[3] as to whether or not the mechanism of injury was from manual handling (examples of non-manual handling mechanisms included trips, burns, chemical exposures and cuts). That is, the mechanism of each injury was categorised as either 'manual handling' or 'non-manual handling'.

Next, the author requested, and obtained, from the hospital's workers' compensation insurer, a copy of that part of the insurer's workers' compensation claim database, containing all hospital claims during the observational period. The database verified that the claims identified from hospital records had been approved and classified by the insurer as lost-time injuries. The insurer's information also provided data on the injury claim cost and injury duration (hours lost from work), which was then added to the author's workers' compensation database. The lost-time injury data were collected in October 1998, to allow the severity of claims to mature (that is, the lost-time injuries had occurred at least 3 years previously). The author sought intervention hospital lost-time injury data from the insurer again in October 1999. The later data revealed that none of the injury claim cost or injury duration data had changed since October 1998. This indicated that the claims were almost certainly finalised, and that no change in injury claim cost or injury duration was expected.

5.5.2 Comparison Group 1 (Orderly Services)

The data availability and the process of data collection for Comparison Group 1 were the same as for the Intervention Group.

5.5.3 Comparison Group 2 (Peer Hospital Cleaners)

Although the peer hospital cleaning services population was considered to have averaged around 200, and to have been relatively stable in number during the observational period, accurate historical employment data (such as hours worked) on all cleaners, whether injured or not, could not be located by the peer hospital. Consequently, data were only obtainable for injured cleaners. The de-identified individual-level data were supplied, via the peer hospital's Head of Department of Occupational Health, on an Excel spreadsheet. The data available, were the gender of the injured person, the date of the lost-time injury, and the injury claim cost and the injury duration. There were no missing injuries, but the mechanism of injury was not recorded.

5.5.4 Comparison Group 3 (State Cleaners)

In contrast to the Intervention Group, Comparison Group 1 and Comparison Group 2 (who all used the same insurer), injury data for Comparison Group 3 were aggregated from data supplied from all insurers within the State of Western Australia. As noted earlier, the Intervention Group, Comparison Group 1 and Comparison Group 2 contributed less than 5% of Comparison Group 3's lost-time injury count.

Data were only available from July 1991. Data availability from this time reflected both a change in the Australian Bureau of Statistics' classification of occupations to include the sub-category 'Cleaner' within the category of 'Labourer', and the introduction of compulsory reporting of workers' compensation claims by insurers to WorkCover WA. It is noted that denominator data for Comparison Group 3, such as the number of persons employed as cleaners, were not kept by WorkCover. Such employment data were not available from the Australian Bureau of Statistics either, as the lowest occupational level surveyed by them for this purpose was that of 'Labourer' (i.e. not the 'Labourer' sub-grouping of 'Cleaner').

The information, provided on a spreadsheet by WorkCover, was aggregate data on the lost-time injury count, injury claim cost and injury duration for all claims for each month between July 1991 and the October 1995; as at July 1998.

5.6 DATA MANAGEMENT

5.6.1 Data Storage And Retrieval

Data to be analysed were transferred from their original, paper or computer, formats to two databases (Microsoft Access) and two spreadsheets (Microsoft Excel).

The databases were utilised for the Intervention Group and Comparison Group 1. As noted earlier, data for these two groups were available for all individuals, whether injured or not The information stored in the first database included the first names, surname. gender, date of birth, employee number, departmental cost centre number, date first employed, and the hours worked (if any) for each fortnightly pay period during the observational period. The second database contained information on each lost-time injury claim; including the claim number, date of injury, mechanism of injury (manual handling or non-manual handling), first names and surname, date of birth, gender, injury claim cost, injury duration, and cost centre at the time of injury.

The spreadsheet for Comparison Group 2 included data on the gender, date of injury, injury claim cost and injury duration for each lost-time injury. The spreadsheet for Comparison Group 3 stored the aggregated injury count, injury claim cost and injury duration for all cleaners in the State for each calendar month between 1 July 1991 and the cessation of the observational period at the end of October 1995.

5.6.2 Data Cleaning

The data in the two databases and two spreadsheets, were examined in a range of ways, including against the primary data sources, to minimise the chance that they had been spuriously recorded, omitted, double counted, or inadvertently altered. As an example, 22 individuals within Intervention Group and Comparison Group 1 were identified as having changed their name during the observational period. Identification of name change was undertaken by creating a database query comparing employee numbers with employee names. If two surnames were held against one employee number, the first names and date of birth were scrutinised on the original records to confirm that the surnames belonged to the same person. If a surname change had occurred, the name was reverted to the original surname – so that person-time at risk could be properly estimated.

5.6.3 Data Security

Retained paper files were contained in locked filing cabinets within the author's department. The databases and spreadsheets resided in a password-secured personal computer held within the author's office. The office and department were locked after hours or in the author's absence. Hospital security staff patrolled the grounds regularly.

5.7 STATISTICAL ANALYSIS

5.7.1 Overview

Aggregate and individual-level data were used to answer the study objectives, namely, to determine if the intervention was associated with a reduction in the occurrence or severity of lost-time injury.

Injury occurrence, as will be detailed in the next section, was analysed in a variety of ways; including as lost-time injury counts, as a rate per million hours worked by a group, or as a rate per hour worked by an individual. Injury severity was assessed by examining injury claim cost and injury duration (hours of work lost from injury). This included analysis of average injury claim cost and injury duration, injury claim cost and injury duration per million hours worked by a group, and injury claim cost and injury duration per hour worked by an individual.

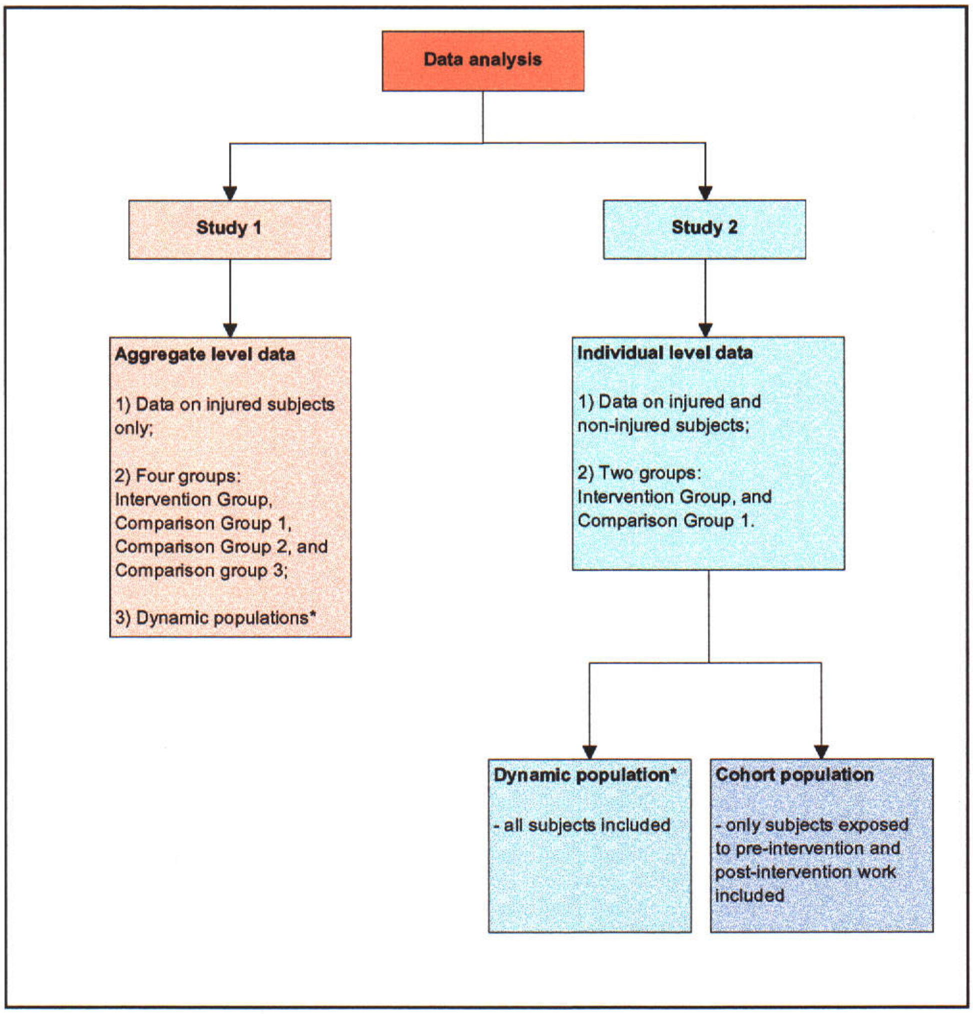
It is recalled that lost-time injury counts, injury claim cost and injury duration data were available for all four groups. For the Intervention Group and Comparison Groups 1 and 2 these data were available for each lost-time injury for the whole observational period (i.e. from July 1988). For Comparison Group 3, the data provided were from July 1991, and aggregated by month. Additionally, for the Intervention Group and Comparison Group 1, individual level data were available on each person who worked at any time during the observational period (i.e. not just those injured). These data included the hours worked per fortnight, their date of birth, date first employed by the hospital, and gender. Where a subject incurred a lost-time injury, and after studying the narratives within the incident and claim reports and then referring to the Australian Standard for workplace injury recording, the mechanism of injury was categorised as either manual handling or non-manual handling.

For convenience, analyses were undertaken within two studies. Study 1 analysed aggregate lost-time injury data from all four groups. The groups were considered as dynamic populations; that is, as a population that can gain or lose members. Study 2 analysed individual level data from within the Intervention Group and Comparison Group 1 (as individual level data were not available for the other groups).

Further, in Study 2, the Intervention Group and Comparison Group 1 were considered in two ways. The first way, continued to consider the groups as dynamic populations; that is, all subjects were included. The second way, considered only those subjects within the Intervention Group and Comparison Group 1 that worked for some time in both pre-intervention period and post-intervention period. These sub-groups were called the 'cohorts'. Analysis of cohort injury occurrence and severity was able to be undertaken after allowance for variables such as age, gender, experience and hours worked per individual.

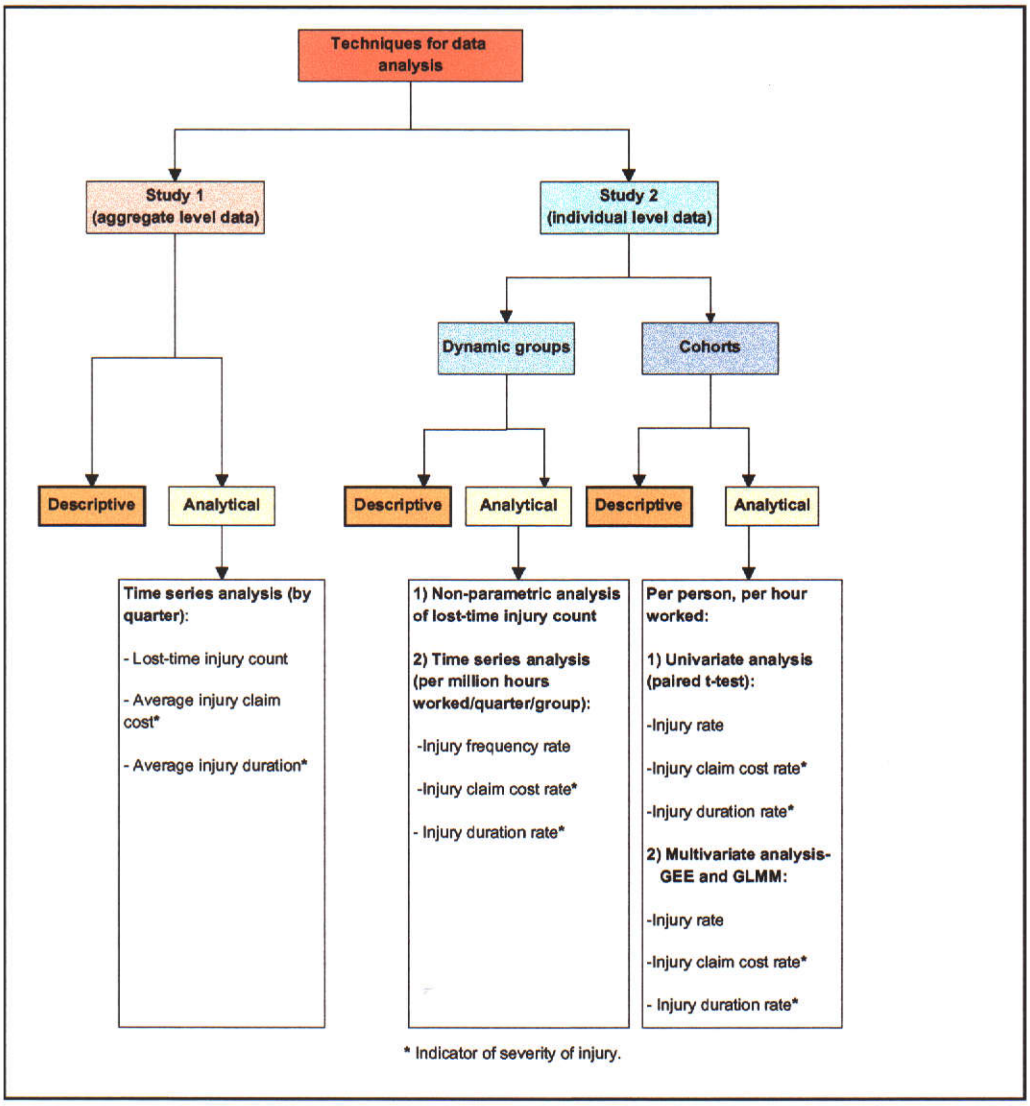
An overview of the approach to the outcome data analysis, and subjects, for each Study is depicted at Figure 5.4. A summary of the analytical techniques used in Study 1 and Study 2 is presented at Figure 5.5. The remainder of this Chapter describes these techniques in more detail.

Figure 5.4 *Study 1 and Study 2 – overview of data and study characteristics*



* Subjects can move in and out of the groups

Figure 5.5 *Overview of analytic techniques used in Study 1 and Study 2*



5.7.2 Study 1

Descriptive statistics were undertaken for the four groups. This was to first report on the pre-intervention and post-intervention period lost-time injuries, injury claim cost and injury duration; and then to describe the average injury claim cost and injury duration for those periods, respectively.

Two analytical approaches were then utilised. First, quarterly lost-time injury counts over time were analysed. The pre-intervention period comprised seventeen quarters (1, …. ,17) and the post-intervention period twelve quarters (18, …., 29). Due to the rare events, particularly for the Intervention Group and Comparison Group 1, Poisson regression was utilised.[8] As quarterly count data were in chronological order, a trend effect and two seasonal terms were added as covariates to adjust for the possible systematic trend (29 quarterly periods) and seasonal pattern (4 seasons each year) on the lost-time injury counts. That is, trend and seasonal covariates were added to the model to indicate if time or season affected lost-time injury counts independently of the intervention. For example, employees may have needed to work harder in Winter (when hospital beds are seasonally loaded with patients with respiratory conditions), and been exposed to a seasonal increase in manual handling injury risk.

The following Poisson regression model was therefore used to analyse lost-time injury counts:

$$Log\, \mu_t = \beta_0 + \beta_1 I_t + \beta_2 \cos(2\pi(t+2)/4) + \beta_3 \sin(2\pi(t+2)/4) + \beta_4 t$$

where μ_t is the expected injury count at t^{th} quarter;

$I_t = 0$ when $t = 1,\ldots,17$ (pre-WRATs), $I_t = 1$ when $t = 18,\ldots, 29$ (post-WRATs);

$\cos(2\pi(t+2)/4)$ and $\sin(2\pi(t+2)/4)$ represent seasonal terms;

$t = 1,\ldots,29$ (trend).

If the β coefficient for the I_t term is significant, it is indicative that the intervention (WRATs) has had an effect. The Poisson regression model was used for each of the four groups separately, rather than for a single analysis including all the groups.

After the lost-time injury counts analysis, quarterly average injury claim cost and average injury duration data were analysed, in chronological order, to gain an indication of any change in injury severity over time. Quarterly average cost and average injury duration were taken as the total injury claim cost and the total injury duration respectively within a 3-month period, divided by the number of lost-time injuries experienced by a group during that period. Following assessment for skewness and kurtosis and subsequent logarithmic transformation, the average cost and average injury duration variables were found to have approximately normal distributions. Multivariate analyses were then undertaken by fitting a linear regression model on the log-transformed injury claim cost and injury duration variables, with seasonal, trend and intervention terms added. Additionally, as observations may not be independent, autocorrelation function and partial autocorrelation functions were used to identify the underlying structure[9] and test whether or not the error term exhibited independence. The model that was applied was:

$$Log\ Y_t = \beta_0 + \beta_1 I_t + \beta_2 \cos(2\pi(t+2)/4) + \beta_3 \sin(2\pi(t+2)/4) + \beta_4 t + \varepsilon_t$$

where Y_t denotes the average cost or average injury duration;

$I_t = 0$ when $t = 1,...,17$, $I_t = 1$ when $t = 18,..., 29$;

$\cos(2\pi(t+2)/4)$ and $\sin(2\pi(t+2)/4)$ represent seasonal terms and ε_t's were normally distributed random errors.

5.7.3 Study 2

5.7.3.1 Overview

As noted earlier, in order to analyse lost-time injuries and their severity, the Intervention Group and Comparison Group 1 were approached in two ways.

In the first approach, the groups continued to be treated as dynamic populations; and for the purpose of Study 2 they were categorised as 'dynamic groups'. It is noted that if a subject switched between the Intervention Group and Comparison Group 1, or vice versa (n = 38), they were counted as a member of the group they were in, for the period of time that they worked with that group. For example, if an orderly worked as a cleaner for 4 pay periods, the hours worked for those 8 weeks were attributed to the Intervention Group. If a lost-time injury occurred during that time it, and all subsequent claim cost and duration relating to that injury, were attributed to the Intervention Group.

In the second approach, only individuals who had worked for at least one fortnight, both before and after the intervention, were analysed. As noted earlier, these sub-groups of the Intervention Group and Comparison Group 1 were categorised as 'cohorts'. To minimise any potential between-group contamination from the intervention, subjects who ever worked in both the Intervention Group and Comparison Group 1 were excluded from the cohorts (n = 20).

For the dynamic populations, the mechanism of each lost-time injury was examined to determine whether it was manual handling or non-manual handling in origin. Descriptive data were first presented. Next, individual lost-time injury counts were categorised to determine, using a range of non-parametric testing, any pre-intervention period/post-intervention period change. Following this, three time series analyses were undertaken to assess the injury frequency and injury severity rates per million hours worked for each of the dynamic groups.

To maintain statistical power in the cohorts, data were not analysed separately for manual handling and non-manual handling lost-time injuries. Descriptive data for the cohorts were determined for sample size, gender, age, and work experience; and the average hours worked per person before and after intervention. Days of work experience since the time of first employment were categorised for the pre-intervention and post-intervention periods. Four categories were used, where 1 = worked less than or equal to 90 days, 2 = worked between 91 and 180 days, 3 = worked between 181 and 364 days, 4 = worked at least 365 days. Pre-intervention period and post-intervention period lost-time injuries per person were then explored using non-parametric methods. Univariate, and finally multivariate analyses utilising Generalised Estimating Equations (GEE) and Generalised Linear Mixed Models (GLMM), were then applied to examine lost-time injuries and severity (injury claim cost and injury duration) per hour worked by the cohorts.

5.7.3.2 Analysis as dynamic populations

(i) Descriptive data

The number of subjects in each group, described by gender were presented; as were the total number of hours worked by each group. Next the lost-time injury, injury claim cost and injury duration data were summarised. Then lost-time injury, injury claim cost and injury duration per million hours worked were presented; including the quantification of the pre-intervention period/ post-intervention period differences.

(ii) Statistical analysis

(a) Non-parametric Analysis - Individual Lost-time Injury Counts

The data were assessed, for every individual who ever worked during the study period, to determine if and when they had a lost-time injury. Individual's lost-time injury counts were then cross-tabulated for the periods before and after intervention. The counts were then subjected to a range of non-parametric tests. The Chi-square test was first used to test whether the row and column variables were independent. The Kolmogorov-Smirnov Z test was then used to test whether the two groups came from the same distribution. Next, Kendall's Tau B and C tests were used to measure the association between the intervention and the ordinal lost-time injury counts. The Gamma test and Somer's d were then used as a measure of association between the two ordinal variables and between the groups respectively.

Initial calculations indicated some pre-intervention period and post-intervention period differences within the Intervention Group and the Comparison Group. Although the results could not strongly indicate a change in person-risk, they encouraged further analysis of risk for those subjects who worked both before and after intervention.

(b) Multivariate Analysis of Injury Frequency, Injury Claim Cost and Injury Duration Rates

Injury frequency, injury claim cost and injury duration rates were taken as the lost-time injuries, injury claim cost and injury duration respectively per million hours worked by each of the groups. Regression analyses were undertaken on sequenced 16-week periods. Log transformation of injury claim cost and injury duration was reasonably effective in attaining the normality assumption. Autocorrelation function and partial autocorrelation functions were used to tentatively identify the error structures of the series.

The linear regression model used was:

$Y_t = \beta_0 + \beta_1 I_t + \beta_2 t + \varepsilon_t$

$I_t = 0$ when $t = 1, \ldots, 14$, $I_t = 1$ when $t = 15, \ldots, 24$;

I_t is the intervention variable, ε_t follows the error process being identified, and t represents the trend term. The Poisson regression model was used for each of the four groups separately, rather than for a single analysis including all the groups.

5.7.3.3 Analysis of cohorts

(i) Descriptive data

The number of subjects in each group was cross-tabulated by gender. Then, the mean hours worked were displayed and work experience described. Next, the lost-time injury counts per subject were categorised. Lost-time injury, injury claim cost and injury duration totals were then tabulated by group. The lost-time injuries were further categorised by mechanism of injury.

(ii) Statistical analyses

(a) Injury counts

Pre-intervention period and post-intervention period injury counts per person (zero, one or greater than equal to two) were presented and subject to the Pearson Chi-square statistic. The Fisher's exact test was then applied to the reduced 2 x 2 table after combining adjacent cells due to small observed counts. The purpose of this analysis was to test the association between post-intervention and pre-intervention within individuals, and consequently injury proneness. The method does not rely on parametric distribution assumptions.

(b) Univariate Analysis of Injury Rate, Injury Claim Cost Rate and Injury Duration Rate

Since the lost-time injury counts analysis did not account for differences in hours worked by individuals in the pre-intervention and post-intervention periods, univariate analyses (paired t-tests) were then applied to explore potential changes in injury rate. The injury rate was taken as the number of lost-time injuries per hour worked by an individual. The injury count also did not address the severity of injury; so this was explored, through univariate analyses, by the injury claim cost rate and the injury duration rate. The injury claim cost rate was taken as the CPI-adjusted workers' compensation claim cost per hour worked by an individual. Similarly, the injury duration rate was the number of hours lost from lost-time injury per hour worked by an individual. Because the injury claim cost and injury duration rates were skewed, a log transformation was undertaken prior to analyses. A 'one' was added to the zeros prior to applying the log transformation. The log-transformed rates were found to follow an approximately normal distribution.

(c) Multivariate Analysis

The covariates of age, gender and experience were included in Generalised Estimating Equations (GEE) and Generalised Linear Mixed Models (GLMM) to adjust for the effect of these potential confounding variables upon pre-intervention and post-intervention injury rate, injury claim cost rate and injury duration rate. The two approaches to analysing longitudinal data have been widely adopted in the statistical literature to analyse correlated observations.

The GEE method[10 11] extended the concept of quasi-likelihood for parameter estimation for non-Gaussian responses. In particular, estimation of the covariate effects is based on the marginal expectation of the response, where the response follows an exponential family of distributions. Such a formulation extends the generalised linear models[8] to adjust correlation between observations of the same subject. In the current context, observations were obtained in pre-intervention period and post-intervention period for the same subject, therefore, the anticipated correlation would be modelled by the exchangeable correlation structure.

The GLMM method[12 13] extends the generalised linear models to allow, in addition to the usual fixed effects, normally distributed random effects u in the linear predictor for the modelling of correlated observations. It features models with a probabilistic formulation of correlated responses within subjects. The fitting of the model uses penalised likelihood as a criterion to be maximised. Variance of the random effects is typically estimated by the restricted maximum likelihood approach to reduce the bias due to maximum likelihood estimation. Furthermore, a dispersion parameter can be used to assess the potential extra error variations. To model injury duration rate, Poisson distribution with logarithmic link function was used. As a convention, the identity link function was chosen to relate the covariates to the log-transformed injury duration and claims cost rates.

5.8 SUMMARY

The intervention study was of pre-post design employing an Intervention Group and three comparison groups. To allow outcome data to mature, lost-time injury data were collected 3 years after the 7.25-year observational period. The data for the groups were available in different forms, and analysed at aggregate or individual-level accordingly. Results of the data analyses are presented in Chapter 6.

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CHAPTER SIX

RESULTS

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6.0 INTRODUCTION

The results presented in this chapter determine whether there is a difference in lost-time injury occurrence and severity (injury claim cost and injury duration) between the pre-intervention and the post-intervention periods. The aggregate-level analysis investigates the association between the Intervention Group, Comparison Group 1 (orderlies from the same hospital as the Intervention Group), Comparison Group 2 (cleaners from the peer hospital) and Comparison Group 3 (all cleaners in the State of Western Australia). Using individual-level data, Study 2 then investigates differences between the Intervention Group and Comparison Group 1. Two approaches are used. The first considers the two groups as dynamic populations, whereas the second approach considers only those subjects within the Intervention Group and Comparison Group 1 that had exposure to work in both the pre-intervention and post-intervention periods.

It is important to note, that the pre-intervention period and post-intervention period are not of the same duration. However, this is not an issue when considering rates or averages. Further, for quarterly and 16-week regression analyses, the different time spans of the pre-intervention and post-intervention periods are adjusted for this.

6.1 STUDY 1 - AGGREGATE LEVEL ANALYSIS

6.1.1 Descriptive Data

(i) Lost-time injuries, injury claim cost and injury duration

Pre-intervention period and post-intervention period lost-time injury, injury claim cost and injury duration data are summarised in Table 6.1. A post-intervention period lost-time injury reduction of 78% was observed for the Intervention Group. Reductions for Comparison Groups 1 and 2 were less (17% and 47% respectively). In contrast, lost-time injuries for Comparison Group 3 increased by 125%. In relation to injury claim cost, respective post-intervention period reductions of 70% and 48%, for the Intervention Group and Comparison Group 2, mirrored reductions in their injury counts. However, Comparison Group 1 and Comparison Group 3 experienced increases of 157% and 159%, respectively. Injury duration reductions of 77% and 47%, respectively, for the Intervention Group and Comparison Group 2 reflected their post-intervention period reductions in lost-time injury count and injury claim cost. In contrast, respective increases in injury duration of 60% and 189% were observed for Comparison Group 1 and Comparison Group 3.

Table 6.1 *Pre-intervention period and post-intervention period lost-time injuries, injury claim cost and injury duration data for all groups*

	Pre-intervention	Post-intervention
	Number of lost-time injuries	
Intervention Group	112	25
Comparison Group 1	106	88
Comparison Group 2	143	76
Comparison Group 3	1,297	2,913
	Injury claim cost ($)	
Intervention Group	1,506,544	451,993
Comparison Group 1	559,525	1,436,562
Comparison Group 2	3,339,755	1,725,437
Comparison Group 3	15,410,992	39,927,996
	Injury duration (hours)	
Intervention Group	75,861	17,760
Comparison Group 1	27,282	43,739
Comparison Group 2	18,723	9,917
Comparison Group 3	603,533	1,746,934

Note: the time span of the post-intervention period is 31% shorter than that of the pre-intervention period.

(ii) Average injury claim cost and average injury duration

As observed in Table 6.2, for the Intervention Group, the average injury claim cost increased 34% in the post-intervention period; although there was minimal change in average injury duration In contrast, the average injury duration almost doubled for Comparison Group 1 and the corresponding average injury claim cost tripled. Comparison Group 2 was the only group not to experience a change in either average injury claim cost or average injury duration between periods; Comparison Group 3's average injury claim cost and average injury duration increased by 15% and 29%, respectively.

It is noted (data not shown) that, due to two main reasons, injury claim cost data had a non-normal distribution. First, the majority of subjects did not experience a lost-time injury. Secondly, a minority of lost-time injury claims was subject to common law settlements, which vastly exceeded the average claim cost of the remainder of lost-time injuries. For example, the maximum injury claim cost for a lost-time injury in the pre-intervention period for the Intervention Group and Comparison Group 1 was $153,727 and $46,024 respectively. In the post-intervention periods the maximum injury claim costs were $242,287 and $340,443, respectively. Injury duration data, too, exhibited a non-normal distribution.

Table 6.2 *Pre-intervention period and post-intervention period average injury claim cost and average injury duration for all groups*

	Pre-intervention	Post-intervention
	Average injury claim cost ($)	
Intervention Group	13,451	18,080
Comparison Group 1	5,279	16,325
Comparison Group 2	23,355	22,703
Comparison Group 3	11,882	13,707
	Average injury duration (hours)	
Intervention Group	677	710
Comparison Group 1	257	497
Comparison Group 2	131	130
Comparison Group 3	465	600

6.1.2 Statistical Modelling

(i) Poisson regression analysis of quarterly lost-time injury count, quarterly average injury claim cost and quarterly average injury duration

To determine whether there was a significant change in lost-time injury count, average injury claim cost and average injury duration between the pre-intervention period and post-intervention periods, four regression models (i.e. one for each group) were run for each variable. The results of regression modelling, adjusted for trend and season, are summarised at Table 6.3.

Table 6.3 *Adjusted post-intervention versus pre-intervention ratios for quarterly lost-time injury count, average injury claim cost and average duration*

	Adjusted post-intervention versus pre- intervention ratio (95% confidence interval)		
	Quarterly lost-time injury count	Quarterly average injury claim cost	Quarterly average duration
Intervention Group	0.486* (0.241, 0.979)	1.929 (0.145, 25.617)	2.102 (0.190, 23.270)
Comparison Group 1	1.149 (0.654, 2.018)	0.606 (0.074, 4.995)	0.543 (0.090, 3.286)
Comparison group 2	1.224 (0.720, 2.081)	2.445 (0.601, 9.949)	3.313* (1.037, 10.591)
Comparison Group 3	0.948 (0.890, 1.123)	1.005 (0.691, 1.462)	1.088 (0.802, 1.476)

* p-value < 0.05

For quarterly lost-time injury count, only the regression for the Intervention Group was significant. It is evident that the WRATs program was associated with an adjusted lost-time injury incidence reduction of 51%. Although not significant, Comparison Group 1 experienced a 15% increase, and Comparison Group 2 a 22% increase, in lost-time injuries in the post-intervention period. Minimal change (- 5%) was noted for Comparison Group 3.

Post-intervention, the Intervention Group and Comparison Group 2 experienced increases in quarterly average claims cost. The increases were 93% and 145%, respectively. In contrast, there was a 39% reduction for Comparison Group 1. However, none of these changes were statistically significant. Comparison Group 3 experienced no post-intervention period change.

On modelling quarterly average injury duration, the Intervention Group experienced doubling in average injury duration, although this was not significant. In contrast, Comparison Group 1's average injury duration reduced by 46%; but this too was not significant. Comparison Group 2 experienced a statistically significant tripling in average injury duration. Comparison Group 3 evidenced minimal change.

6.1.3 Summary

For the Intervention Group, the intervention (WRATs program) was associated with a statistically significant 51% reduction in lost-time injury count, but no significant change in the injury severity (as measured by average injury claim cost or average injury duration). Within the comparison groups no significant changes in any measures were identified; with the exception of a post-intervention period increase in average injury duration for Comparison Group 2.

6.2 STUDY 2 – INDIVIDUAL LEVEL ANALYSIS

As Study 2 refers only to the Intervention Group and Comparison Group 1, the latter will simply be referred to as the Comparison Group for the remainder of this Section.

6.2.1 Dynamic Groups

6.2.1.1 Descriptive data

(i) Subjects, and pre-post lost-time injuries, injury claim cost and injury duration

The average number of subjects employed per fortnight, by both Cleaning Services (Intervention Group) and Orderly Services (Comparison Group) was 145. Although the Intervention Group employed a greater total number of subjects during the observational period compared to the Comparison Group (see Figure 6.1), they worked fewer hours (see Figure 6.2). This reflects that the Intervention Group experienced greater staff turnover and employed more part-time workers than did the Comparison Group.

The gender balance of the two groups was markedly different. 67% of the pre-intervention subjects (n = 230) and 60% of the post-intervention subjects (n = 128) in the Intervention Group were female. In contrast, respectively, 94% (n = 191) and 96% (n = 173) of the Comparison Group were male.

Figure 6.1 *Number of subjects ever employed within the dynamic populations by pre-intervention and post-intervention periods*

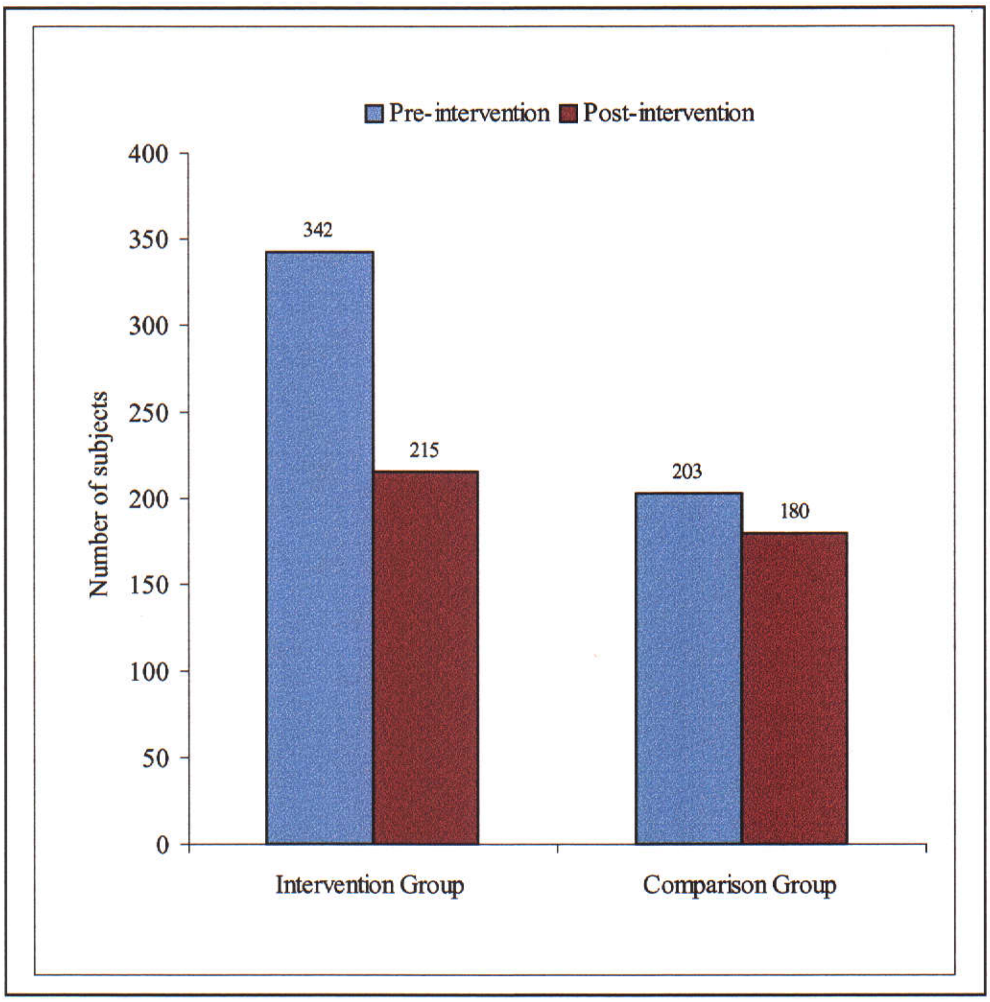
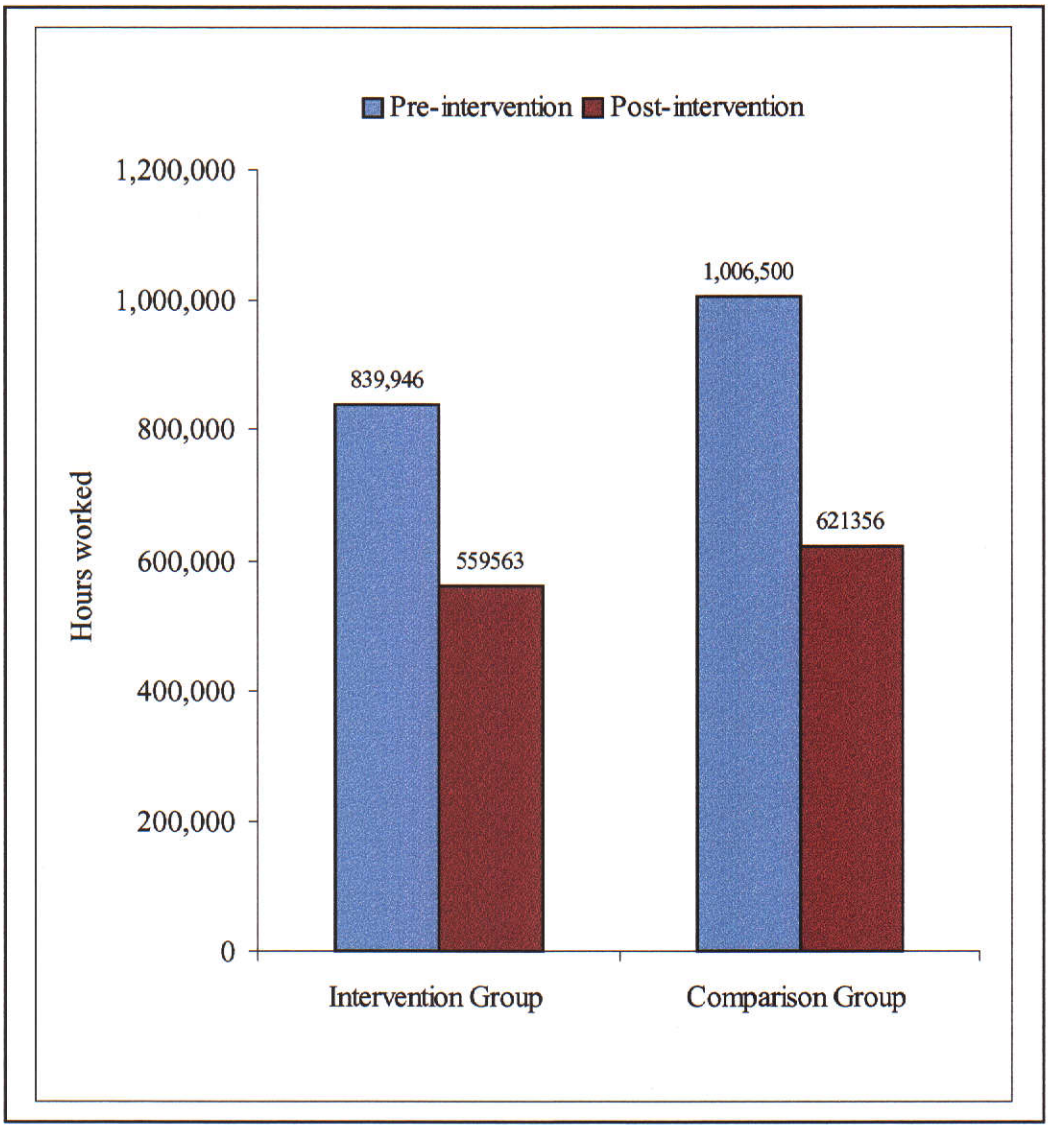
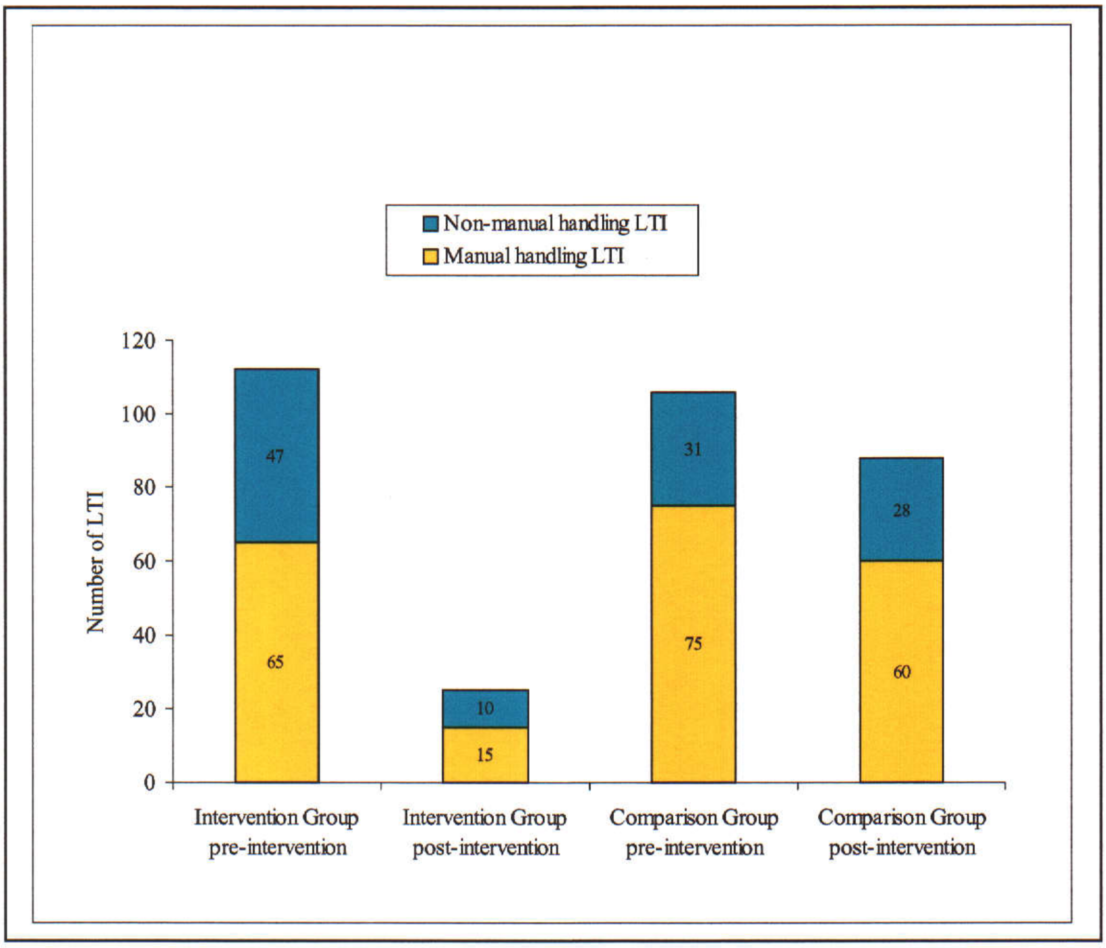


Figure 6.2 *Pre-intervention period and post-intervention period hours worked by dynamic populations*



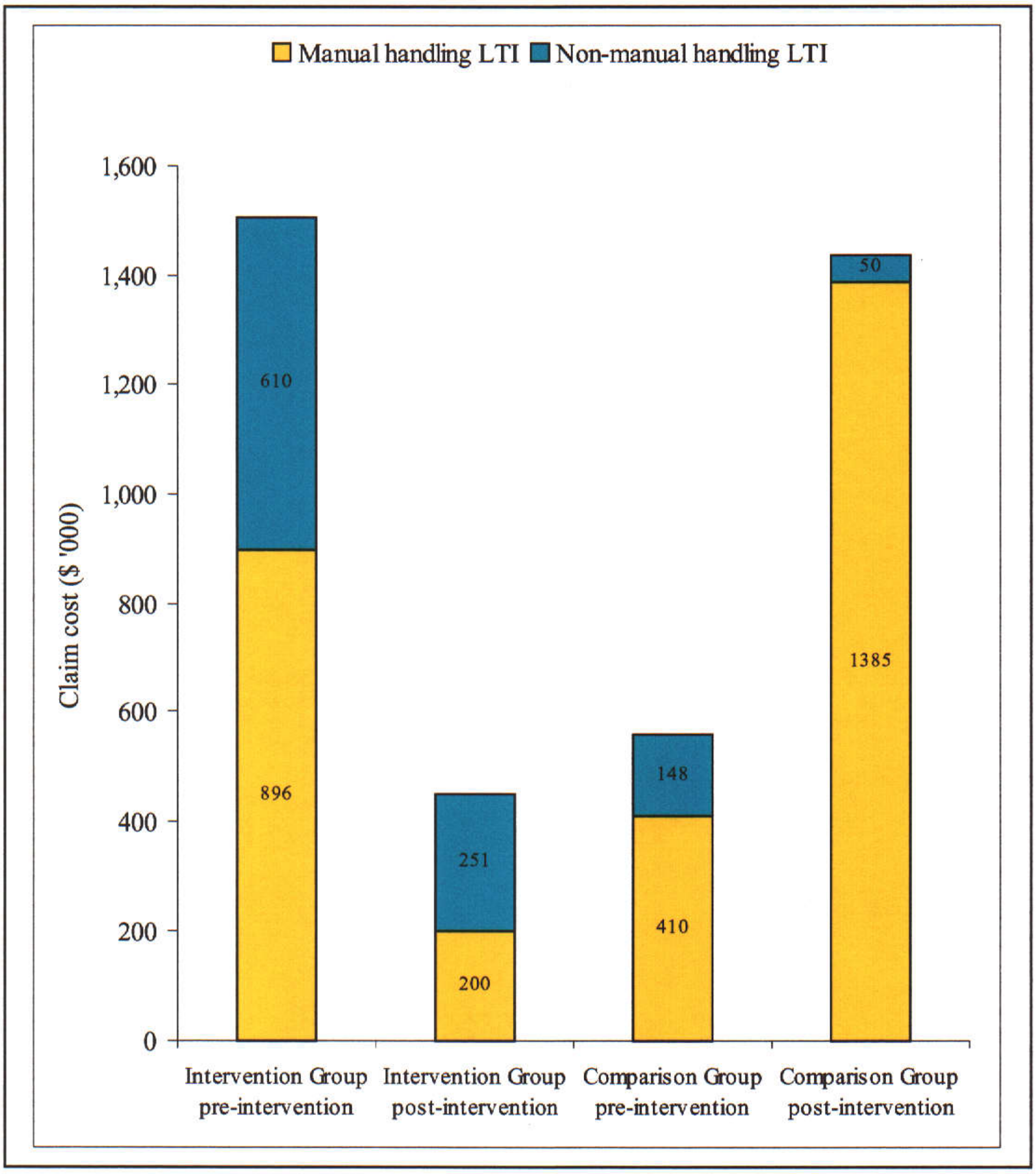
Notwithstanding that the post-intervention period was shorter than the pre-intervention period, the Intervention Group experienced large, and similar, post-intervention reductions in manual handling and non-manual handling lost-time injury (77% and 79%, respectively). In contrast, after allowing for the shorter time span of the post-intervention period, the Comparison Group experienced small increases in both manual handling and non-manual handling lost-time injuries (see Figure 6.3).

Figure 6.3 *Pre-intervention period and post-intervention period lost-time injuries, by mechanism of injury, for dynamic populations*



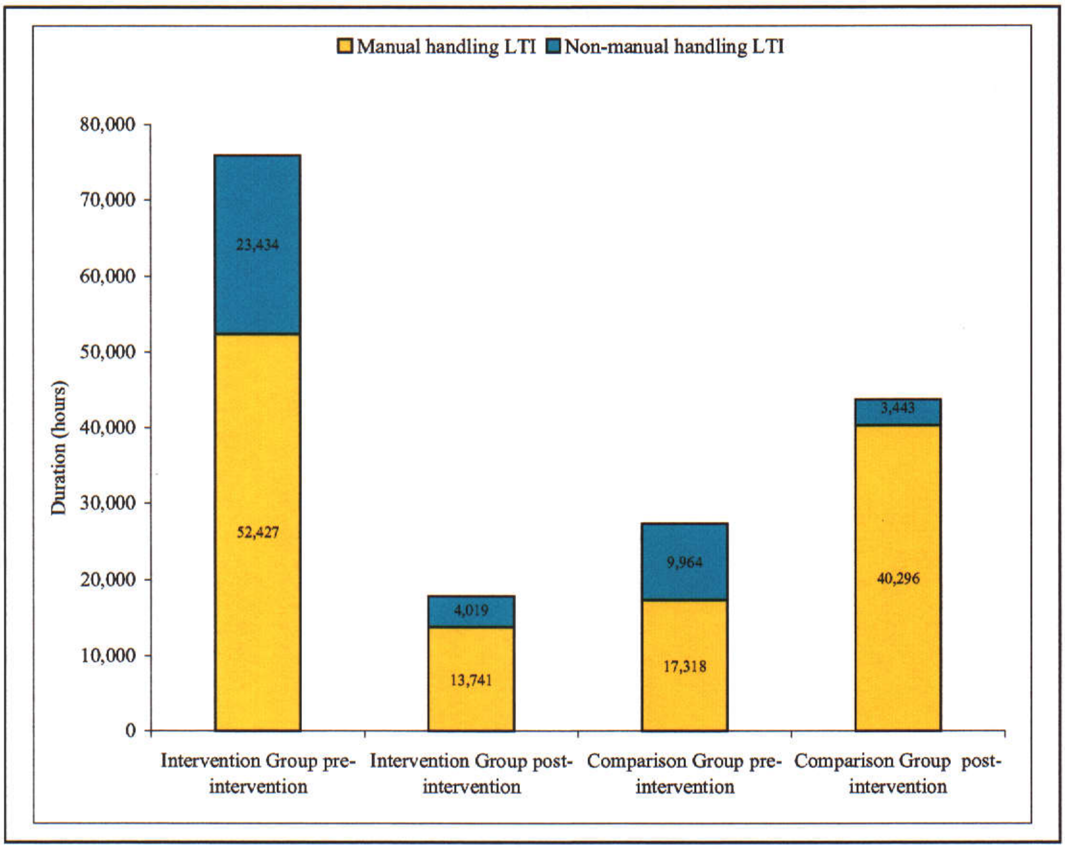
The post-intervention injury claim cost for the Intervention Group was only 30% of the pre-intervention total. The contribution to this reduction was greater for manual handling lost-time injuries (78% less post-intervention) than for non-manual handling lost-time injuries (59% less). In contrast, the injury claim cost for the Comparison Group increased by 157% in the post-intervention period; the 237% increase from manual handling lost-time injuries being partly offset by a 65% reduction in non-manual handling injury claim cost (see Figure 6.4).

<u>Figure 6.4</u> *Pre-intervention and post-intervention period claim cost ($ thousand), by mechanism of injury, for dynamic populations*



The Intervention Group's 77% post-intervention reduction in injury duration matched its reduction in injury claim cost, although in this case, the contribution from non-manual handling lost-time injuries (83%) slightly exceeded that of manual handling lost-time injuries (73%). Injury duration for the Comparison Group increased by 60% in the post-intervention period; the 133% increase in the manual handling component being ameliorated by a reduction of 65% in the non-manual handling injury component (see Figure 6.5).

Figure 6.5 *Pre-intervention and post-intervention injury duration (hours lost), by mechanism of injury, for dynamic populations*



(ii) Injury claim cost and injury duration, per million hours worked

The Intervention Group experienced a large post-intervention reduction in both manual handling and non-manual handling lost-time injuries per million hours worked; resulting in a reduction of the total post-intervention rate to one third that of the pre-intervention rate (it is noted that no statistical significance can be attributed to the numbers). In contrast, the post-intervention total lost-time injury rate of the Comparison Group increased by 28%; contributed to by increases in both manual handling and non-manual handling injury rates (see Table 6.4).

Table 6.4 *Pre-intervention and post-intervention lost-time injuries per million hours worked, by mechanism of injury, for dynamic populations*

	Pre-intervention	Post-intervention	**Rate difference**
Manual handling lost-time injuries per million hours worked			
Intervention Group	76	27	**-49**
Comparison Group	75	97	**22**
Non-manual handling lost-time injuries per million hours worked			
Intervention Group	57	18	**-39**
Comparison Group	31	45	**14**
Total lost-time injuries per million hours worked			
Intervention Group	133	45	**-88**
Comparison Group	105	142	**37**

The post-intervention total claim cost rate per million hours worked by the Intervention Group reduced to less than 50% that of the pre-intervention rate; contributed to by a two-thirds reduction in manual handling claim cost rates, and a 38% reduction in non-manual handling injury claim cost rates. For the Comparison Group, the post-intervention claim cost per million hours worked more than quadrupled; the rate increase entirely due to the manual handling component (see Table 6.5).

Table 6.5 *Pre-intervention and post-intervention injury claim cost per million hours worked, by mechanism of injury, for dynamic populations*

	Pre-intervention	Post-intervention	**Rate difference**
Manual handling injury claim cost per million hours worked			
Intervention Group	$1,066,913	$357,431	**-$709,482**
Comparison Group	$408,277	$2,230,213	**$1,821,936**
Non-manual handling claim cost per million hours worked			
Intervention Group	$726,706	$450,331	**-$276,376**
Comparison Group	$147,635	$81,766	**-$65,869**
Total injury claim cost per million hours worked			
Intervention Group	$1,793,620	$807,762	**-$985,858**
Comparison Group	$555,912	$2,311,979	**$1,756,067**

The two-thirds reduction in post-intervention total injury duration per million hours worked by the Intervention Group mirrored that of claim cost. In contrast, the injury duration per million hours worked for the Comparison Group, by 2.6 times; again, entirely due to increases in the manual handling component (see Table 6.6).

Table 6.6 *Pre-intervention and post-intervention injury duration per million hours worked, by mechanism of injury for dynamic populations*

	Pre-intervention	Post-intervention	**Rate difference**
Manual handling injury duration per million hours worked			
Intervention Group	62,417	24,557	**-37,860**
Comparison Group	17,206	64,852	**47,646**
Non-manual handling injury duration per million hours worked			
Intervention Group	27,899	7,182	**-20,717**
Comparison Group	9,900	5,541	**-4,359**
Total injury duration per million hours worked			
Intervention Group	90,317	31,739	**-58,577**
Comparison Group	27,106	70,393	**43,287**

6.2.1.2 Statistical modelling

(i) Non-parametric analysis

The number of lost-time injuries per individual for the Intervention Group showed a significant reduction between the pre-intervention and post-intervention periods (χ^2=14.479, df = 2, p = 0.001). Similarly, ordinal measures of Somer's d, Kendall's tau-b, Kendall's tau-c and Gamma were all negative with a p-value of $<$0.001, implying significant negative association. The Comparison Group revealed no association between the pre-intervention and post-intervention lost-time injury categories (χ^2=0.708, df = 2, p = 0.702). Ordinal measures of association, such as Somer's d, Kendall's tau-b, Kendall's tau-c and Gamma, were all positive with a p-value of 0.904.

(ii) Regression analysis: Injury frequency, injury claim cost and injury duration rates (per million hours worked)

Tables 6.7-6.9 report the effects of the intervention, after adjusting for potential seasonal and trend effects, on the injury frequency rate (lost-time injury per million hours worked), the log-transformed injury claim cost rate (injury claim cost per million hours worked) and log-transformed injury duration rate (injury duration per million hours worked). The regression model was applied to all lost-time injuries and their manual handling and non-manual handling components. It is to be noted that the term 'intervention' is applied as a convenience term in presenting the results of the Intervention and Comparison Groups. In reality, the intervention applied to the Intervention Group only.

The intervention, was associated with a significant reduction in both manual handling and non-manual handling lost-time injury frequency rates in the Intervention Group. In contrast, for the Comparison Group, the post-intervention period was associated with increases in both rates; although significance was reached only when manual handling and non-manual handling injuries were combined (see Table 6.7).

Table 6.7 *Adjusted effect of intervention based on the lost-time injury rate, by mechanism of injury, for dynamic populations*

	Effect of intervention (95% confidence interval)	
	Intervention Group	Comparison Group
Manual handling lost-time injuries	-51.7* (-82.8, -20.6)	19.0 (-8.0, 46.0)
Non-manual handling lost-time injuries	-38.7* (-56.5, -20.8)	13.2 (-1.1, 27.6)
Total lost-time injuries	-93.3* (-123.2, -63.4)	35.0* (7.0, 62.9)

*p-value < 0.05

The Intervention Group experienced a reduction in injury claim cost rate for both manual handling and non-manual handling injuries. However, even when totalled, the 47% reduction (1-*exp*{-0.64}) did not achieve significance (see Table 6.8). The

Comparison Group, however, experienced a significant post-intervention increase of 418% in manual handling injury claim cost rate and 282% in total injury claim cost rate (1-*exp*{1.340}).

Table 6.8 *Adjusted effect of intervention based on log injury claim cost rate, by mechanism of injury, for dynamic populations*

	Effect of intervention (95% confidence interval)	
	Intervention Group	Comparison Group
Manual handling lost-time injuries	-0.062 (-1.843, 1.719)	1.645* (0.374, 2.917)
Non-manual handling lost-time injuries	-1.029 (-3.180, 1.122)	0.770 (-0.426, 1.965)
Total lost-time injuries	-0.640 (-2.111, 0.831)	1.340* (0.222, 2.459)

*p-value < 0.05

In relation to injury duration in the log scale, the intervention was associated with a 29% increase in rate for manual handling injuries and an 81% reduction for non-manual handling injuries for the Intervention Group; with a net reduction in total injury duration rate of 43%. However, none of the changes reached significance. The Comparison Group experienced a post-intervention increase total injury duration rate of 157%, but only the 274% increase in the manual handling component was significant (see Table 6.9).

Table 6.9 *Adjusted effect of intervention based on log injury duration, by mechanism, by group*

	Effect of intervention (95% confidence interval)	
	Intervention Group	Comparison Group
Manual handling lost-time injuries	0.255 (-1.735, 2.245)	1.318* (0.181, 2.455)
Non-manual handling lost-time injuries	-1.684 (-3.506, 0.139)	0.629 (-0.652, 1.909)
Total lost-time injuries	-0.560 (-2.029, 0.909)	0.942 (-0.031, 1.915)

*p-value < 0.05

6.2.1.3 Summary

There were an approximately equal average number of subjects within the groups. However, the Intervention Group was predominantly female and the Comparison Group almost entirely male.

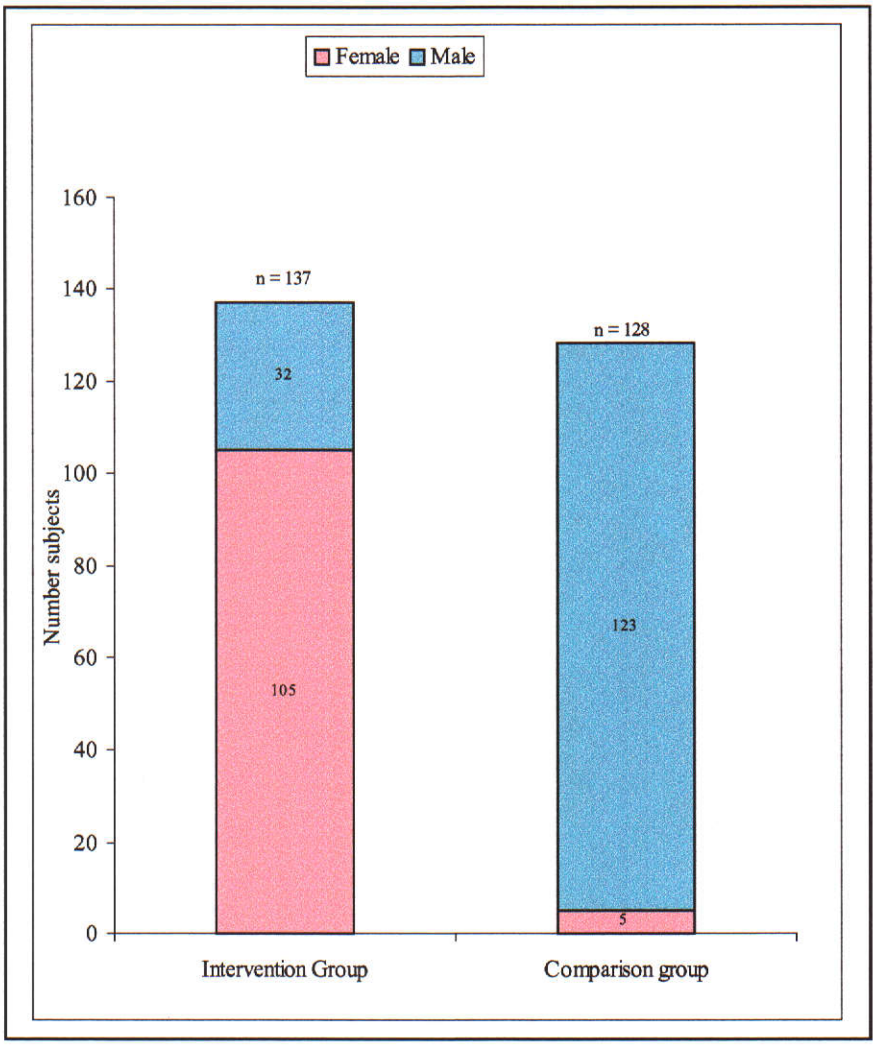
Regression analyses reveal a significant association between the intervention and a reduction in injury frequency rate for the Intervention Group; but reductions in injury duration and injury claim cost rates (severity measures) were not significant. In contrast, the injury frequency rate, injury claim cost rate and injury duration rate all increased significantly in the post-intervention period for Comparison Group 1.

6.2.2 Cohorts

6.2.2.1 Descriptive data

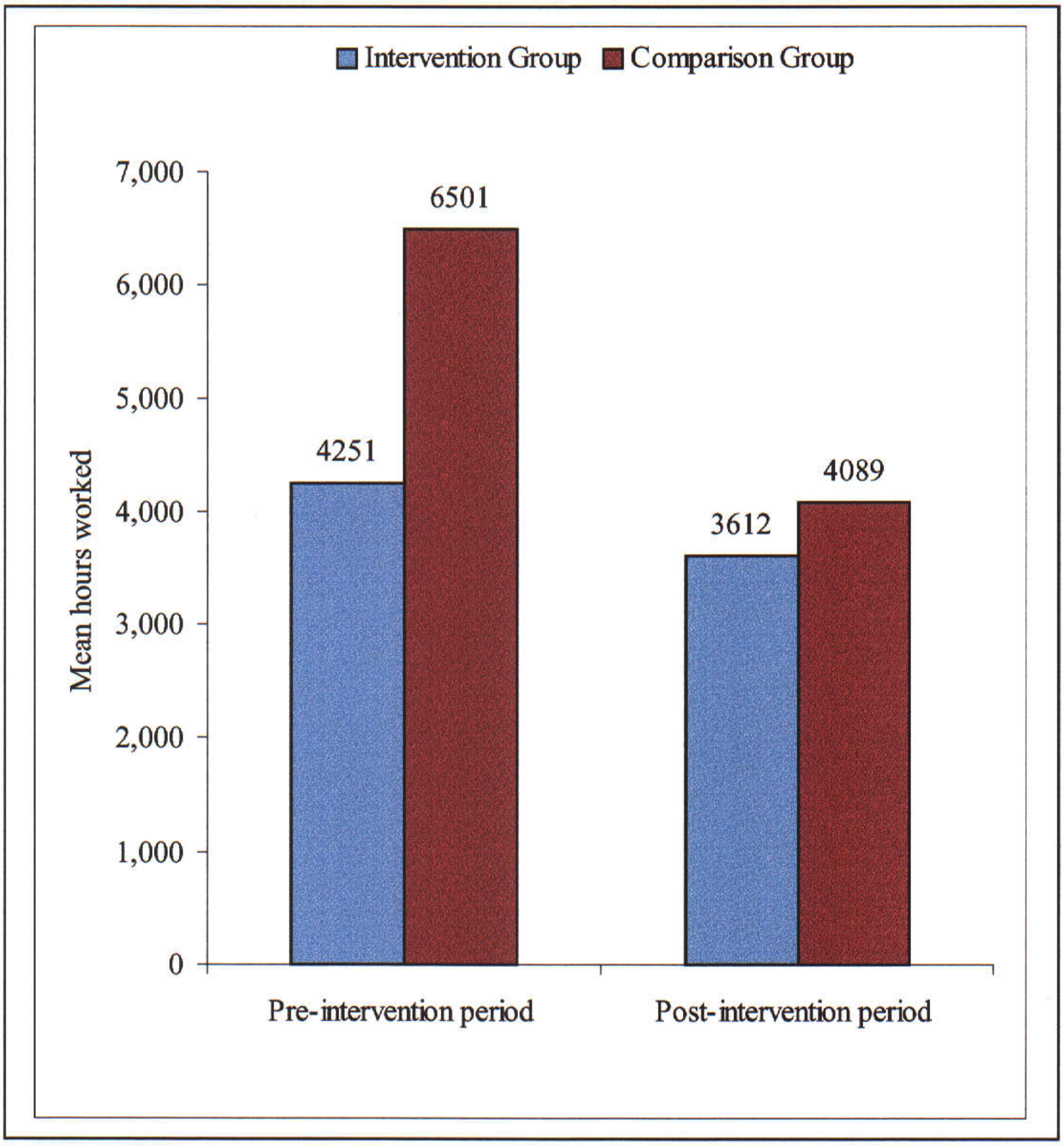
The number of subjects in each group was similar, and the average age of subjects in each group was almost identical (the mean age for the Intervention Group being 37.4 years with a standard deviation 9.7; the mean age for the Comparison Group being 37.6 years with a standard deviation 10.6). However, the female:male ratio for Intervention Group was almost 3:1, whereas for the Comparison Group the ratio was 1:24 (see Figure 6.6).

Figure 6.6 *Subjects by gender for cohorts*



More Comparison Group subjects were full-time employees, relative to Intervention Group subjects; consequently the average number of hours worked by subjects in the Comparison Group was greater (see Figure 6.7).

Figure 6.7 *Pre-intervention period and post-intervention period average hours worked by subjects within the cohorts*



It is recalled, that for regression purposes, work experience was grouped into 4 categories, based on the number of days worked since first employment and the commencement of the observational period and also the commencement of the intervention period. At the commencement of the observational period, 56% of all subjects in the Intervention Group had worked less than 91 days and only 37% had worked at least 365 days; implying that the Comparison Group, with 70% having worked at least 365 days, had greater work experience at the time the study was initiated. However, at the time the post-intervention period commenced, 89% of the Intervention Group and 93% of the Comparison Group, respectively, had worked at least 365 days.

For both the pre-intervention period and post-intervention period, approximately 60% of the Comparison Group were uninjured. However, for the Intervention Group the proportion of cleaners uninjured increased from approximately 70% in the pre-intervention period to 90% in the post-intervention period (see Table 6.10).

Table 6.10 *Pre-intervention and post-intervention number of lost-time injuries per individual*

Number of LTI	0	1	2	3	4	5
Intervention Group						
Pre-intervention	97 (70.8%)	27 (19.7%)	9 (6.6%)	3 (2.2%)	1 (0.7%)	0 (0%)
Post-intervention	123 (89 8%)	12 (8 8%)	2 (1 5%)	0 (0%)	0 (0%)	0 (0%)
Comparison Group						
Pre-intervention	78 (60.9%)	29 (22.7%)	13 (10.2%)	3 (2.3%)	3 (2.3%)	2 (1.6%)
Post-intervention	76 (59.4%)	34 (26.6%)	11 (8.6%)	6 (4.7%)	0 (0%)	1 (0.8%)

The Intervention Group experienced a 72% reduction in lost-time injuries in the post-intervention period (see Table 6.11); with the reduction in manual handling and non-manual handling injuries being of similar proportion (see Table 6.12). In contrast, there was minimal post-intervention change in the Comparison Group's lost-time injury count. The Intervention Group experienced a small (4%) increase in injury claim cost in the post-intervention period, although there was a 47% reduction in injury duration. The Comparison Group, however, experienced a 460% increase in injury claim cost and a tripling of injury duration.

The large post-intervention period change in injury count, with respect to minimal change in injury claim cost and injury duration, meant that the average injury claim cost increased by almost four-fold ($6,394 to $24,033), and the average injury duration almost doubled (397 to 762 hours), for the Intervention Group. For the Comparison Group, the average claim cost increased by more than six-fold ($2,728 to $16,925) and the average injury duration increased by over three-fold (146 hours to 483 hours), respectively. It is noted that, despite the proportionately larger increases for the Comparison Group, the average injury claim cost and average injury duration remained less than those of the Intervention Group.

Table 6.11 *Pre-intervention and post-intervention summary data for lost-time injuries, injury claim cost and injury duration for cohort*

Group	Pre-intervention	Post-intervention
	Number of lost-time injuries	
Intervention Group	58	16
Comparison Group	86	79
	Injury claim cost ($)	
Intervention Group	370,835	384,524
Comparison Group	234,621	1,337,053
	Injury duration (total hours lost)	
Intervention Group	23,017	12,192
Comparison Group	12,550	38,145

Table 6.12 *Pre- post lost-time injury, by mechanism, for cohort*

	Pre-intervention	Post-intervention	Total
	Manual Handling lost-time injuries		
Intervention Group	36	9	45
Comparison Group	60	54	114
	Non-manual Handling lost-time injuries		
Intervention Group	22	7	29
Comparison Group	26	25	51
	Total lost-time injuries		
Intervention Group	58	16	74
Comparison Group	86	79	165

6.2.2.2 *Statistical modelling*

(i) Non-parametric analysis

The pre-intervention period and post-intervention period lost-time injury pattern for the Intervention Group is shown at Table 6.13. A positive association is found between the categories of lost-time injury (namely none, 1, and 2 or more) at pre-intervention and the categories post-intervention; with few injuries evident in the post-intervention period among the Intervention Group. (Pearson χ^2= 5.891, df =1, p = 0.015; Fisher's exact test, for reduced 2x2 table, p = 0.026; Somer's d, Kendall's tau-b, Kendall's tau-c and Gamma were all positive with p = 0.044).

Table 6.13 *Individual pre and post lost-time injury (LTI) count pattern for the Intervention Group*

Intervention Group lost-time injury count – pre-intervention period	Intervention Group lost-time injury count - post-intervention period			
	0 LTI	1 LTI	≥ 2 LTI	Total LTI
0 LTI	91	4	2	97
1 LTI	23	4	0	27
≥ 2 LTI	9	4	0	13
Total	123	12	2	137

The pre-intervention period and post-intervention period lost-time injury pattern for the Comparison Group is shown at Table 6.14. A positive association is evident between the categories pre-intervention and the categories post-intervention; but with more injuries occurring in the post-intervention period among this Group. (Pearson χ^2= 10.269, df =1, p = 0.001; Fisher's exact test, for reduced 2x2 table, p = 0.002; Somer's d, Kendall's tau-b, Kendall's tau-c and Gamma were all positive with p = 0.001).

Table 6.14 *Individual pre and post lost-time injury (LTI) count pattern for the Comparison group*

Comparison group lost-time injury count – pre-intervention period	Comparison group lost-time injury count-post-intervention period			
	0 LTI	1 LTI	≥ 2 LTI	Total LTI
0 LTI	55	18	5	78
1 LTI	15	11	3	29
≥ 2 LTI	6	5	10	21
Total	76	34	18	128

(ii) Univariate analysis

Using paired t-tests, the pre-intervention period and post-intervention period injury rate, injury claim cost rate and injury duration rate were examined for each group. It is noted that the injury claim cost rates and injury duration rates met assumptions of normality after being log transformed. A 'one' was added to the zeros prior to applying the log transformation. The reductions in all three rates were significant for the Intervention Group (see Table 6.15). In contrast, all three rates increased significantly for the Comparison Group.

Table 6.15 *Paired t-tests for pre-intervention period and post-intervention period injury rate, injury claim cost rate and injury duration rate, by group*

	Pre-WRATs Mean (standard error)	Post-WRATs Mean (standard error)	Difference *95% CI*
	Injury rate		
Intervention Group	0.892 (0.148)	0.399 (0.125)	(-0.863, -0.124)
Comparison Group	1.048 (0.158)	1.450 (0.197)	(0.022, 0.784)
	Injury claim cost rate (log transformed)		
Intervention Group	3.285 (0.286)	2.058 (0.228)	(-1.855, -0.599)
Comparison Group	3.263 (0.323)	4.364 (0.365)	(0.211, 1.791)
	Injury duration rate (log transformed)		
Intervention Group	2.419 (0.186)	1.765 (0.163)	(-1.069, -0.239)
Comparison Group	2.273 (0.210)	3.112 (0.237)	(0.334, 1.344)

(iii) Multivariate analysis of injury rate, injury claim cost rate and injury duration rate per hour worked

GEE

GEE models were fitted for injury rate, injury claim cost rate and injury duration rate per hour worked per person, for each group. In each case, adjustment was made for age, gender and work experience. In none of the cases was there evidence of overdispersion. To illustrate GEE analysis, full results (Tables 6.16 and 6.17) and a summary (Table 6.18) are presented for the injury rate. For brevity, the results for injury claim cost and injury duration rates are presented as summaries only (Tables 6.19 and 6.20, respectively).

(a) Injury Rate

After covariate adjustment, the injury rate for the Intervention Group in the post-intervention period was significantly reduced to approximately one-third that experienced in the pre-intervention period (see Tables 6.16 and 6.18). In contrast, the post-intervention injury rate for the Comparison Group increased significantly increased by over 1.5 times (see Tables 6.17 and 6.18).

Table 6.16 *Poisson Generalised Estimating Equations for Intervention Group lost-time injuries*

	Coefficient	Standard Error	p-value	Incidence Density Ratio	95% CI	
Constant	-9.371	0.667	0.000	*	*	*
Intervention	-1.086	0.291	0.000	0.338	0.191	0.597
Gender	-0.026	0.300	0.930	0.974	0.542	1.752
Age	0.006	0.016	0.693	1.006	0.975	1.038
Exp2	-0.227	0.446	0.611	0.797	0.333	1.909
Exp3	-1.126	0.761	0.139	0.324	0.073	1.442
Exp4	-0.079	0.288	0.784	0.924	0.525	1.626

n = 136. s = 1.122. Estimate of common correlation = 0.149

Table 6.17 *Poisson Generalised Estimating Equation fit for Comparison Group lost-time injuries*

	Coefficient	Standard Error	p-value	Incidence Density Ratio	95% CI	
Constant	-8.053	0.823	0.000	*	*	*
Intervention	0.450	0.164	0.006	1.569	1.137	2.165
Gender	-0.528	0.602	0.381	0.590	0.181	1.921
Age	-0.018	0.012	0.138	0.982	0.959	1.006
Exp2	0.138	0.393	0.724	1.149	0.532	2.479
Exp3	0.522	0.809	0.519	1.686	0.345	8.230
Exp4	0.059	0.358	0.870	1.060	0.525	2.141

n = 124. s = 1.220. Estimate of common correlation = 0.455

For Table 6.17, a strong correlation between pre- and post observations for individuals is indicated by the estimate of common correlation. This intra-class correlation provides an endorsement for the use of analysis by GEE.

Table 6.18 *Summary. Lost-time injury intervention incidence density ratios by group, based on GEE analysis*

	Incidence density ratio	**p-value**	**95% confidence interval**
Intervention Group	0.338	0.000	0.191-0.597
Comparison Group	1.569	0.006	1.137-2.165

Intervention Group: n = 136. s = 1.122. Estimate of common correlation = 0.149
Comparison Group: n = 124. s = 1.220. Estimate of common correlation = 0.455

(b) Injury Claim Cost Rate

After covariate adjustment, the post-intervention period, for the Intervention Group, was associated with a significant reduction of 73% in the injury claim cost rate. The Comparison Group, however, experienced a significant rate increase of 167% (see Table 6.19).

Table 6.19 *Summary of injury claim cost intervention incidence density ratios by group based on GEE analysis*

	Incidence density ratio	p-value	95% confidence interval
Intervention Group	0.274	0.005	0.110 - 0.683
Comparison Group	2.675	0.028	1.114 - 6.425

Intervention Group: n = 136. s = 3.051. Estimate of common correlation = 0.251
Comparison Group: n = 124. s = 3.912. Estimate of common correlation = 0.354

(c) *Injury Duration Rate*

The rate reduced by 43% in the post-intervention period, relative to the pre-intervention period, for the Intervention Group; although the change did not quite attain statistical significance at the 0.05 level. In contrast there was a significant increase of 135% for the Comparison Group (see Table 6.20).

Table 6.20 *Summary of injury duration intervention incidence density ratios by group based on GEE analysis*

	Incidence density ratio	p-value	Confidence interval
Intervention Group	0.569	0.058	0.318 - 1.019
Comparison Group	2.349	0.003	1.331 - 4.147

Intervention Group: n = 136. s = 2.051. Estimate of common correlation = 0.278
Comparison Group: n = 124. s = 2.541. Estimate of common correlation = 0.375

GLMM

The results of GLMM analyses are presented at Tables 6.21-6.23. Variations of random worker effects are generally large; especially for injury claim cost rate and duration rate within the Comparison Group. This phenomenon demonstrates the usefulness of the GLMM approach to accommodate the within subject correlation. An exceptionally large variance is also observed in Comparison Group's claims cost rate, suggesting substantial heterogeneity in the data.

Table 6.21 *Injury rate by group by GLMM analysis*

	Intervention Group	Comparison Group
Coefficients (SE)		
Intervention	-1.039 (0.229)*	0.429 (0.137)*
Gender	0.133 (0.400)	-0.141 (0.679)
Age	0.006 (0.019)	-0.018 (0.012)
Exp2	0.405 (0.727)	0.186 (0.490)
Exp3	-0.608 (0.800)	0.511 (0.497)
Exp4	0.047 (0.282)	0.254 (0.267)
Var(u)	1.963	1.282
Dispersion	0.360	0.504

*p-value < 0.05

Table 6.22 *Injury claim cost rate by group by GLMM analysis*

	Intervention Group	Comparison Group
Coefficients (SE)		
Intervention	-1.292 (0.436)*	0.986 (0.448)*
Gender	-0.066 (0.502)	0.983 (1.486)
Age	-0.005 (0.022)	-0.030 (0.028)
Exp2	0.902 (1.110)	1.804 (1.630)
Exp3	-0.673 (0.923)	0.145 (1.939)
Exp4	0.188 (0.535)	0.680 (0.809)
Var(u)	2.371	5.326
Dispersion	6.995	9.998

*p-value < 0.05

Table 6.23 *Injury duration rate by group by GLMM analysis*

	Intervention Group	Comparison Group
Coefficients (SE)		
Intervention	-0.557 (0.289)	0.859 (0.287)
Gender	-0.155 (0.340)	0.446 (0.971)
Age	-0.016 (0.015)	-0.012 (0.019)
Exp2	0.270 (0.739)	1.024 (1.048)
Exp3	-0.781 (0.614)	-0.333 (1.246)
Exp4	-0.008 (0.357)	0.105 (0.521)
Var(u)	1.150	2.371
Dispersion	3.044	4.076

Overall, however, as can be seen in the summary table (Table 6.24), outcomes mirror those of GEE analyses. That is, the Intervention Group, after allowing for covariates, demonstrated a significant reduction in injury frequency rate in the post-intervention period, to approximately one third of the pre-intervention period rate. In contrast, the Comparison Group exhibited a significant 54% increase. The injury claim cost rate significantly reduced by 78% in the post-intervention period for the Intervention Group, and significantly increased by 168% for the Comparison Group. Finally, the Intervention Group experienced a 43% reduction in injury duration rate; but, as for GEE analysis, the change did not quite reach statistical significance. In contrast, the Comparison Group's injury duration rate significantly increased by 136%.

Table 6.24 *Summary table of intervention parameter ratios (95% confidence intervals) by group by GLMM analysis*

Injury rate		Injury claim cost rate		Injury duration rate	
Intervention Group	Comparison Group	Intervention Group	Comparison Group	Intervention Group	Comparison Group
0.354*	1.536*	0.275*	2.680*	0.573	2.361*
(0.226, 0.554)	(1.174, 2.009)	(0.117, 0.646)	(1.114, 6.450)	(0.325, 1.009)	(1.345, 4.143)
1.963 †	1.282 †	2.371 †	5.326 †	1.150 †	2.371 †

*p-value < 0.05 † Variance of random effects

6.2.2.3 Summary

The number and age of subjects in each cohort was similar, although the gender ratios were even less balanced than for the dynamic groups. Two approaches to multivariate analysis, GEE and GLMM, after allowing for age, gender and work experience revealed the same results. Per hour worked, the intervention (WRATs) was associated with a reduction in lost-time injuries and injury claim cost, but the reduction in injury duration rate failed to reach statistical significance. In contrast for Comparison Group 1, injury rate, injury claim cost rate and injury duration rate all increased in the post-intervention period.

6.3 CHAPTER SUMMARY

As noted in Chapter 1, the first objective of the thesis was to determine whether the occurrence of injury within the Department of Cleaning Services reduced after the introduction of the intervention. The second objective was to determine whether the severity of injury, as measured both by workers' compensation claims cost and by hours lost from injury (duration), reduced after the intervention. The null hypotheses being that, both injury occurrence and severity remained the same after the introduction of the intervention. Tables 6.25-6.27 summarise the results of Study 1 and Study 2, by displaying for each group analysed, whether or a not a statistically significant change in the respective measure of injury incidence or severity was experienced.

Table 6.25 displays the results of the quarterly time series modelling of the injury count, and the average cost and the average time lost per injury, for all four groups.

Table 6.25 *Study 1: Summary of time series analyses of aggregate level LTI data by quarter*

	Intervention Group	**Comparison Group 1**	**Comparison Group 2**	**Comparison Group 3**
Measure of injury occurrence				
LTI count	↓	-	-	-
Measure of injury severity				
Average injury claim cost	-	-	-	-
Average injury duration	-	-	↑	-

↓ = statistically significant reduction

↑ = statistically significant increase

- = no statistically significant change

Table 6.26 tabulates the results of quarterly time series modelling of the number, the total cost and the total duration of lost-time injuries per million hours worked by the Intervention Group and Comparison Group 1.

Table 6.26 *Study 2: Summary of quarterly time series analyses, by dynamic group*

	Intervention Group	Comparison Group 1
Measure of injury occurrence		
Injury frequency rate	↓	↑
Measure of injury severity		
Injury claim cost rate	-	↑
Injury duration rate	-	-

↓ = statistically significant reduction

↑ = statistically significant increase

- = no statistically significant change

Table 6.27 summarises any significant pre-post change in the number, or the cost, or the duration of injuries, per hour worked by individuals (after allowing for age, gender and work experience).

Table 6.27 *Study 2: Summary of pre-post changes in injury occurrence or severity in the cohort groups, analysed by GEE and GLMM (univariate results in brackets)*

	Intervention Group	Comparison Group 1
Measure of injury occurrence		
Injury rate	↓ (↓)	↑ (↑)
Measure of injury severity		
Injury claim cost rate	↓ (↓)	↑ (↑)
Injury duration rate	- (↓)	↑ (↑)

↓ = statistically significant reduction

↑ = statistically significant increase

- = no statistically significant change

Overall, subsequent to the intervention, every measure of lost-time injury occurrence indicates a statistically significant reduction within the Intervention Group. No change is noted for the comparison groups; with the exception of Comparison Group 1, which has experienced an increase in all measures of injury occurrence.

Two approaches to measuring injury severity were utilised; firstly the average cost or duration of injury, and secondly the cost or duration of injury per hour worked over time. Adopting the first approach, no reduction in the average cost or the average duration of injury is noted for the Intervention Group. That is, for Intervention Group, the severity of each injury has not significantly changed (although for Comparison Group 2 an increase in average duration is noted). Where severity is examined as a change in the claim cost or duration per million hours per dynamic group, the Intervention Group does not demonstrate any significant post-intervention reduction. However, using either GEE or GLMM analyses (the results are consistent) and allowing for covariate factors, a significant reduction in the claim cost per hour worked is demonstrated for the Intervention Group cohort. The large reduction in duration per hour worked by the cohort, however, just fails to reach significance (despite univariate analysis initially suggesting otherwise). Comparison Group 1, however, reveals a significant post-intervention increase in the claim cost and duration per hour worked.

CHAPTER SEVEN

DISCUSSION AND CONCLUSION

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7.0 INTRODUCTION

Manual handling has been described in the literature as the use of physical force by a worker to undertake a task.[1 2] Manual handling tasks are associated with one third of all occupational injuries,[3-6] and most injuries associated with manual handling are musculoskeletal in nature.[3] Traditional approaches to the assessment of the risk, assume that as fatigue increases with the frequency, duration or intensity of force used in a task, so too does the risk of injury.[7] However, the literature fails to demonstrate a quantitative relationship between the use of force by a worker undertaking manual handling tasks and the risk of injury,[7] or the pathomechanism of injury.[8] Further, the literature now demonstrates that a multiplicity of factors, other than force, contribute to workers experiencing and reporting workplace injury from manual handling.[9] These important factors may be intrinsic to the worker, or be workplace and non-workplace environmental elements associated with workers who undertake manual handling. However, neither the definition nor the specific contribution of each factor or combination of 'non-force' risk factors is able to be determined for any group of workers at risk of injury.

There is no evidence over the past 50 years, despite efforts to reduce the risk of injury from manual handling, that the incidence of injury is declining.[10 11] For example, there is no evidence that selecting and training workers to be more capable of physically managing the forces involved in manual handling is effective in lowering the incidence of injury.[12] It is also apparent that neither a determination of the aetiology of injury from manual handling, nor the establishment of practical occupational threshold limit values for safe manual handling, is imminent. It is therefore reasonable to question whether a reduction in the risk of injury is achievable. If the potential for immediate reduction does exist, then strategies will need to be based on evidence of effective interventions rather than awaiting further research to yield answers on causation.

There is recent evidence to inform intervention strategies. The demonstration that certain tasks, demanding factors such as 'heavy physical work', 'repetition' of manual handling, or 'awkward postures' while lifting, are qualitatively associated with an increased risk of injury[13] provides a focus for the identification and assessment of some of the physical components of the risk of injury. There is evidence, also, that the implementation of microergonomic and macroergonomic controls within the workplace (rather than focusing on the worker), are effective in reducing the likelihood of injury from manual handling.[14] The literature also indicates that a potentially useful strategy to determine these controls, is the employment of participatory ergonomics;[15 16] whereby the workers and management involved in the manual handling (with appropriate professional assistance) identify and assess the risk of injury, and then recommend risk reduction strategies.[17]

To date, there has been only minimal evaluation of participatory ergonomics interventions in reducing the rate or severity of injury associated with manual handling.[17-20] Existing studies mostly lack comparison groups.[15 20-25] Of these studies, the majority fail to adequately analyse the data, and furthermore, none assess change in the individual's level of risk although this is considered necessary.[7] This thesis evaluates the effectiveness of a participatory ergonomics intervention within a group of workers who predominantly undertake tasks of a manual handling nature.

Specifically, the aim of the thesis, as stated in Chapter 1, was to evaluate the effectiveness of the manual handling Workplace Risk Assessment Team (the intervention) in reducing the risk of injury among staff working within the department of Cleaning Services at the intervention hospital. Before the results are discussed, it is necessary to examine a number of threats to the validity of this study. The next section, discusses the results reported in Chapter 6, in relation to the two objectives stated in Chapter 1. The first objective being to determine whether the occurrence of injury reduced after the introduction of the intervention. The second objective being to determine whether the severity of injury, as measured by both workers' compensation claim cost and hours lost from injury reduced after the intervention. The implications of the findings are then discussed in the context of participatory ergonomics. Finally, general conclusions are presented.

7.1 VALIDITY OF THE RESEARCH

The ideal study is that of a Randomised Controlled Trial (RCT), as opportunities for confounding are minimised.[26] However, studies in which individuals or whole working populations are randomly exposed or not-exposed to interventions are rarely feasible. For this particular study, an RCT could not have been undertaken, even if ethically appropriate, as rostering, job relief arrangements and socialisation would have resulted in contamination between groups of cleaners in the intervention hospital. Although the Intervention Group in this study experienced a two thirds reduction in the rate of injury, the quasi-experimental nature of the study means there are many potential threats to validity. This section discusses these threats.

7.1.1 Historical Events

A major threat to validity within pre-post studies is the occurrence of historical events during the intervention which independently affect the outcomes of interest. In this study, the objectives were to evaluate any post-intervention change in the occurrence and severity of injury. Thus, historical threats include any independent change in the propensity of subjects to report injury, or a change in the time off work or the cost per injury once a worker was injured. Considerations include alterations to the psychosocial environment (e.g. management style), the industrial and employment environment, or to the workers' compensation system. To reduce the likelihood of bias not being recognised, three comparison groups were utilised (the nature of manual handling duties was different for Comparison Group 1 compared with the Intervention Group, but Comparison Group 2's duties were similar).

Comparison Group 1 (orderlies) were from the same Patient Support Service as the Intervention Group. It was not possible to allow for the management environment relating to their immediate supervisors, but the Intervention Group and Comparison Group 1 shared the same line management personnel thereafter – from the manager of Patient Support Services up to the chief executive officer of the hospital. As noted in Chapter 5, the Intervention Group, Comparison Group 1 and Comparison Group 2 (cleaners from a peer hospital) were employed, via their hospitals, by the same government health department, shared the same insurer and had the same state union representation. Comparison Group 3, all cleaners employed in the State of Western Australia, were utilised to reduce the risk of bias occurring from changes to state industrial occupational health or workers' compensation legislation, as well as differences associated with the task of cleaning. In terms of a proxy for educational status, all subjects in the four groups were classified as 'Labourer' under standardised national data recording.[27] However, it should be noted that leading up to the end of the observational period both the Intervention Group and Comparison Group 1 were under consideration by the government for contracting out. This led to some industrial unrest. Eventually, only Orderly Services was contracted out, and this may help explain the post-intervention increase in the reporting of injuries among that group.

7.1.2 Regression-to-the-mean

Regression-to-the-mean is another consideration for bias, whereby post-intervention reductions in injury rates are possibly independent of the intervention. That is, the pre-intervention outcome data are chance extremes within a range of data over time for that population. It is possible, but unlikely, that regression-to-the-mean is a threat to this study. From a high pre-intervention risk for all four groups, none of the three comparison groups demonstrated a significant post-intervention reduction in injury occurrence or severity. Further, trend analysis failed to identify seasonal variation in any of the four groups.

7.1.3 Aggregate Data

Another issue for consideration in this study was that Study 1 compared four groups, rather than individuals, over time. This was to accommodate for the fact that, for Comparison Group 2 and Comparison Group 3, only aggregate-level data were available. Study 1 therefore is, in effect, a time-trend ecologic study. This introduces additional threats to validity, particularly the heterogeneity of exposure within the Intervention Group as well as possible within and between-group differences in potential confounding variables. One method for ameliorating such a threat is to incorporate both individual-level and ecologic measures in the same analysis.[28 29] As noted in Chapter 2, no studies in the literature analyse individual-level data to study the impact of participatory ergonomics on injury outcomes. To help reconcile this problem, Study 2 analysed individual-level data for subjects in the Intervention Group and Comparison Group 1, who worked for some time both before and after the intervention. It is noted, however, that although the major independent variables considered for occupational musculoskeletal disorders, namely age, gender and work experience, were included in the analyses, other potential confounders, particularly a history of injury or smoking, and anthropometry, were not accounted for because the data were not available.[30-33]

7.1.4 Measurement Bias

In this study, the intervention involved the application of a manual handling risk identification, assessment and control process, by a consultative team (WRATs) of management and employee representatives and an ergonomist. For the Intervention Group, the exposure measurement is therefore a factor of job category (cleaner) and hours worked during the post-intervention period. In addition to the heterogeneity of exposure within the aggregate data, it is not possible to define in detail what specific risk factors were reduced. However, this is an intervention study, not an aetiological study. And, as noted in the review of the literature, it is not currently possible to identify or quantify the variety of factors that lead to the risk of injury from manual handling. In this context, it is argued in particular, that potential impact of any 'Hawthorne Effect'[a] should not be removed from the outcome determination in the study. Indeed some consider that the term 'Hawthorne Effect' should be avoided; and rather view the effect as a complexity of psychological and social variables affecting the outcome but not monitored.[35] If the intervention positively impacts upon these variables, and these variables, in turn, influence the reporting or the severity of injury, it is important to include their effect.

Errors of dependent and independent variable measurement are unlikely to have been a source of bias in this study. The quality of the data sources make it unlikely that there were missing subjects in any of the groups. Injury outcome data were compiled by the insurers under legislative and actuarial systems of scrutiny and accountability. Severity data (claim cost and duration) for aggregate and individual level data were allowed to mature after the observational period. For the Intervention Group and Comparison Group 1, individual-level data were complete, with the exception of a few missing data for work experience and age Statistical techniques allowed for the latter. Data recorded during the observational period were recorded by persons who were effectively 'blinded'. That is, they collected the data for other purposes, unaware that they were to be used in a study. Where there were two sources for the same information, the author checked that the data were the same. Quantitative variables, such as hours worked per fortnight, would have been previously checked, by hospital audit systems as any error would have resulted in subjects receiving incorrect fortnightly payments. To increase confidence in the likelihood that claims were finalised for the Intervention Group and Comparison Group 1, the author was able to confirm that the estimates of total claim cost and duration for each injury had not changed between the time of the initial post-observation period data collection and on review one year later.

Although WRATs was primarily established to address the risk of injury from manual handling, it was not possible to quarantine the team's activities addressing the risk of injury from non-manual handling hazards. Consequently, the aim of this

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[a] Hawthorne effect: a term used for the effect that might be produced in an experiment simply from the awareness from subjects that they are participating in some form of scientific investigation.[34]

thesis is to assess all lost-time injuries. However, for interest, in the first section of Study 2, both manual handling and non-manual handling data are analysed. To enable this to occur, interpretation of injury narrative information was required to categorise lost-time injuries as 'manual handling' or 'non-manual handling'. To reduce the opportunity of measurement error, the author utilised the services of an individual experienced in the coding of occupational injury according to the Australian standards.[27 36]

7.1.5 Statistical Analysis

A further consideration in studies of this nature (and for all studies) is that of appropriate statistical analysis. For the aggregate-level data, repeated measures (i.e. time series data) were utilised. The autocorrelation function utilised did not reveal any measurement-to-measurement correlation effect or seasonal effect that could have influenced the results. Individual-level data analysis took into account repeated measures, and utilising GEE and GLMM modelling produced the same results. The value of the multivariate analysis[7] was demonstrated, when the exploratory univariate analysis produced a Type I error; indicating a significant reduction in duration rate when none existed. However, in this case it should also be noted that one disadvantage within Study 2, was that the selection only of those subjects who worked for some time both before and after the intervention greatly reduced the power of the study. The most likely effect of small sample size is that of a Type II error. It is noted that the duration rate reduction for the Intervention Group just failed to reach significance. It is also noted that the likelihood of a Type II error would have increased, further, had only manual handling LTI data (rather than total LTI data) been utilised.

7.2 DISCUSSION OF THE RESULTS

7.2.1 Occurrence of Injury

This study demonstrates a large, and statistically significant, post-intervention reduction in all measures of injury numbers and rates for the Intervention Group. In contrast, no reduction in the number or rate of lost-time injuries was observed in any of the comparison groups. Thus, the null hypothesis, that there was no reduction in injury occurrence in the intervention group after the intervention, is rejected.

Importantly, the intervention was associated with a significant reduction, of approximately equal proportions, in both manual handling and non-manual handling lost-time injury frequency rates in the Intervention Group.

7.2.2 Severity of Injury

7.2.2.1 Claim cost

For the Intervention Group, the claim cost per injury increased after the intervention, but the increase was not significant. Although the claim cost per hour worked did reduce significantly; this reduction was due solely to the overall reduction in the total rate of injury per hour.

7.2.2.2 Duration

For the Intervention Group, the duration per injury increased after the intervention, but the increase was not significant. The duration per hour worked did reduce, but this reduction did not reach statistical significance and is due solely to the total reduction in the rate of injury per hour.

As the claim cost and duration per injury did not change for the intervention group after the intervention, the null hypothesis, that the severity of injury did not change after the intervention, is accepted.

In summary, WRATs was associated with a reduction in the occurrence of injuries among members of the Intervention Group. The severity of each injury did not change, although the overall reduction in injury rate resulted in a reduction in the claim cost, and probably the duration, per hour worked. As was noted in Chapter 6, no reduction in outcome measures occurred in the comparison groups. In contrast, Comparison Group 1 experienced a large increase in the rate injury. Although the severity of each injury did not increase, the high injury rate resulted in Comparison

Group 1 experiencing an increase in the claim cost and the duration per hour worked. Comparison Group 2 (cleaners from a peer hospital) experienced an increase in average injury duration.

7.3 IMPLICATIONS OF THE FINDINGS

As revealed in the review of the literature, despite a lack of knowledge on the pathomechanism of injuries or sufficient evidence on safe exposure levels for forces used in manual handling tasks, hundreds of standards on ergonomics have been promulgated or incorporated into legislation around the world; many of which incorporate principles of participatory ergonomics. Their primary intention is to guide or mandate on the reduction of risk for occupational injury, musculoskeletal disorders in particular. Despite this plethora of documents, there is no indication that any have been evaluated to determine if their aim of reducing the risk of injury has been achieved.[37] The absence of the evaluation of interventions, based on standards and regulations, is not just of academic concern; for it can no longer be assumed that business or governments will have confidence in their effectiveness and continue to support their existence. For example, on 20 March 2001, newly-elected President Bush signed a joint resolution of Congress repealing OSHA's Ergonomics Standard (29 CFR Part 1910) that had been effected during the Clinton administration only 2 months earlier.

WRATs is an example of a participatory ergonomics intervention which reduces the risk of injuries, manual handling in particular, for a group at high risk of injury. This study indicates that a participatory ergonomics team, by assessing and addressing risk, can substantially reduce injuries in the workplace. As not all risk factors for injury are attributable to the workplace (e.g. aging),[38] the two thirds reduction in measures of injury occurrence in this study is both large and significant. The significance is enhanced, given that this study appears to be the first to analyse individual-level data. Further, the reductions were contributed to by a fall in both manual handling and non-manual handling injury risk. This reflects, despite the focus on manual handling, WRATs concurrently addressed many non-manual handling hazards. Given the global burden of occupational disorders, of which a resistant one third is from manual handling, these findings are encouraging.

The post-intervention fall in the total claim cost experienced by the Intervention Group was due to the reduction in injury count and not injury severity. Thus, the intervention did not reduce the consequence of an injury once it occurred. Nevertheless, the reduced claim cost per hour worked is positive information for employers. For them, unplanned labour cost per unit of service/production is generally an important consideration in their business. This study indicates that investment in a participatory ergonomics approach to the reduction of the risk of injury can return economic dividends.

As a reinforcing secondary gain for business, participatory ergonomics, by bringing together managers and general employees to mutually influence the work environment, can produce other benefits for organisations.[39] These benefits include improved morale and enhanced industrial relations. Such improvements are likely to influence the psychosocial environment, which in turn may further reduce the risk of injury.

This study indicates that the iterative process of participatory ergonomics *per se* is not complex, that relatively unskilled personnel can assess risk, and that the majority of risk management processes may be able to be undertaken by the employees themselves. In turn, a small group of people can positively influence the health and safety of many. Depending on the risk being addressed, expert assistance and support may only be intermittently required, rather than an ergonomist undertaking all the work as a project. Also, as opposed to a consultant alone providing 'one off' recommendations on risk control, in participatory ergonomics there is ownership of solutions to problems. Much of the work undertaken by WRATs, for example, was undertaken outside of formal meetings by the non-ergonomist members of the team. WRATs were later extended to other areas of the hospital at high risk of injury from manual handling, including many areas of nursing services. These teams were supported by a single ergonomist, who additionally had other duties not involving WRATs. This suggests that participatory ergonomics could be readily adapted to a large number of workplaces, with teams availing of expertise only when required.

Given the paucity of ergonomists, relative to the number of workplaces worldwide, participatory ergonomics provides an opportunity for ergonomists to greatly extend their professional coverage

The iterative process of participatory ergonomics, as studied in WRATs, also implies that valuable knowledge and skills relating to the identification, assessment and control of risk can be retained in the workplace. It is of anecdotal interest, that in 2001, four of the original eight WRATs members still worked in Cleaning Services; one of whom is now the manager.

Standards and legislation which indicate that employees should be involved in injury risk management, are usually silent on the detail of the process. A feature of this study, is that it describes the process of participatory ergonomics. This description and assessment of the WRATs process, as an example of participatory ergonomics, is of interest to the workplace community. For example, after the conclusion of the observational period, the peer hospital (Comparison Group 2) adopted the risk assessment team approach to a number of its workplaces with a high risk of manual handling injury. WorkSafe Western Australia (the State Government occupational safety and health authority), and the local Western Australian Manual Handling Centre, invited the author to present on WRATs at separate seminars; to which many work organisations were invited. Both institutions considered that WRATs provided a useful case history to promote the use of the Western Australian Code of Practice for Manual Handling.[1] An article on WRATs,[40] by the author, in a Western Australian safety and health journal was well received[b]. In addition, the results of the aggregate[41] and individual level studies[42] have been accepted for publishing in peer-reviewed international journals.

It is not possible to generalise widely from a single study, and limitations to the internal validity of this study need to be considered when interpreting the findings. However, the results encourage further evaluation of the capacity of participatory ergonomics interventions to reduce the incidence and severity of manual handling

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[b] The article, 'WRATS - in a hospital!', was awarded the 'Most useful Journal Article Award' in 1995 by the Safety Institute of Australia (WA).

and non-manual handling injuries. Randomised controlled trials, involving several separate workplaces, larger populations and the collection of more data on potential confounders, are necessary if threats to internal and external validity are to be minimised.[14] Preferably, the observational period would be of longer duration, particularly to demonstrate the sustainability of any effect; although ethical considerations would dictate cessation of the trial if the intervention was effective at an early stage. Qualitative pre-post data, from team members and subjects in the groups, would complement quantitative findings on injury incidence and severity. These data could include perceptions about the risk of injury from work, and psychosocial variables such as job satisfaction. If such studies confirm the effectiveness of participatory ergonomics, then cost-benefit studies could be considered to further persuade business and governments of its value as a tool for implementing workplace changes to control hazards and the reduction of the risk or the severity of occupational disorders.

7.4 CONCLUSION

This present study indicates that the Workplace Risk Assessment Team (WRATs) was successful in reducing the risk of manual handling and non-manual handling injury within the Intervention Group. As a consequence the workers' compensation claim cost per hour worked by individuals of the intervention group also reduced. However, the severity of injury *per se*, as measured by claim cost or time lost per injury, did not change after implementation of the intervention.

The WRATs process and results indicate that a participatory ergonomic approach to a reduction in the likelihood of injury is generalisable to a wide range of workplaces in which employees are at risk of injury. In turn, participatory ergonomics has the potential to contribute to global strategies for the reduction of the risk of injury from manual handling and from other hazards. However, more extensive research, using appropriate methodology, in a variety of workplace settings, is required to validate participatory ergonomics for incorporation into general occupational safety practice for the purpose of the reduction of risk of injury.

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