Improving Clinical Outcome through Trauma System

YEUNG, Hiu Hung

A Thesis Submitted in Partial Fulfillment

of the Requirements for the Degree of

Doctor of Philosophy

in

Surgery

The Chinese University of Hong Kong

September 2010

Thesis/Assessment Committee

Professor POON Wai Sang (Chair)
Professor RAINER Timothy H (Thesis Supervisor)
Professor GRAHAM Colin A (Committee Member)
Professor COATS Timothy J (External Examiner)

Abstract of thesis entitled:

Improving Clinical Outcome through Trauma System

Submitted by **YEUNG, Hiu Hung**

For the degree of **Doctor of Philosophy**

at The Chinese University of Hong Kong in July 2010

Background Injury is a major public health problem that creates an enormous social burden. Although Hong Kong has tried to build up a trauma care system according to the criteria employed by the American College of Surgeons Committee on Trauma, there are a number of differences between the two. The effectiveness of the key components of trauma care processes and their clinical outcomes are unclear, and the final outcome in terms of survival rate is unknown.

Aim The aims of this project were to (i) evaluate whether the trauma care system established in Hong Kong has improved the survival rate among trauma patients; (ii) evaluate the effectiveness of trauma teams and their coordinators, primary trauma diversion, and performance improvement programmes, and assess the influence of gender and age on patient outcomes; and (iii) compare clinical outcomes before and after the establishment of a trauma system in Hong Kong and measure them against those achieved in an established regional trauma system in Australia.

Methods Retrospective analysis of data collected prospectively from the trauma registries in Hong Kong and Australia. The Trauma and Injury Severity Score (TRISS), the W score, the Z score, the M score, and W_s statistics are employed to evaluate the mortality rate.

Results The W score for Hong Kong improved significantly from - 4.79 in 1997 to 0.51 in 2009 after the trauma system was established ($P<0.05$). The improving trend observed in the W_s score (- 4.86 ± SE 1.24 Vs 1.06 ± SE 0.74) over the same period indicates that the survival rate increased from 1997 to 2009 ($P < 0.01$). The time taken to deliver the patient from the scene to definitive care was reduced by 97 minutes ($P < 0.001$) using a primary trauma diversion strategy. Proficient trauma teams are associated with reduced mortality in patients with a moderately poor probability of survival ($p = 0.007$) and trauma nurse coordinators play an essential role in conducting trauma audits and maintaining trauma registries. The introduction of guidelines and staff education could result in significant improvements to the trauma care process. Advancing age is associated with an increased mortality rate, whereas gender is not. Injury prevention programmes in Hong Kong are inadequate.

Conclusion Proficient trauma teams, primary trauma diversion, and clinical guidelines are key components of the trauma system that contribute to improved outcomes.

摘要

論文題目： 通過創傷系統改善病人的臨床成效

背景: 創傷是一個重要的公共衛生問題，它對病人及社會造成了的巨大的負擔。香港建立了一個創傷系統，但其臨床成效和對病人的存活率有否正面的影響還未確知。

目的: 評估創傷系統是否能提高創傷病人的存活率，比較創傷系統建立之前和之後的臨床成效，並直接與澳大利亞創傷系統的臨床成效作比較。

方法: 回顧性分析創傷登錄前瞻性收集到的數據，利用創傷嚴重程度評分法（TRISS 法），W 評分，Z 評分和 M 評分，及 W_s 統計法等數據來評估存活率及臨床成效。

結果: W 評分成績顯示創傷系統建立後的存活率有顯著改善, W 評分從 1997 年的 -4.79 升至 2009 年的 0.51 ($P <0.05$)。W_s 顯示創傷病人的存活率得以改善（-4.86 ± 1.24 對比 1.06 ± 0.74）。另外，院前創傷的分流使傷者從現場到接受手術或其他治療的時間減少 97 分鐘 ($P <0.001$)。創傷隊也顯著減少降低嚴重創傷病人的死亡率（$P = 0.007$）。創傷統籌員及臨床教育及指引均能提升創傷護理過程的質量。病人方面，年齡越大相應的死亡率越高，性別對死亡率沒有影響。但是，香港預防創傷方面措施要加強。

結論: 創傷系統有助於改善創傷病人的臨床成效。

ACKNOWLEDGEMENTS

I wish to express my sincere gratitude and thanks to:

My supervisors, **Professor Wai Sang Poon** at the Division of Neurosurgery, Department of Surgery, Prince of Wales Hospital (PWH), The Chinese University of Hong Kong (CUHK) and **Professor Timothy H Rainer** at the Accident & Emergency Medicine Academic Unit, PWH, CUHK, for their expert guidance and interesting interpretations of my research results, for broadening of my field of thought, for their enduring patience and encouragement, and for the enormous support they gave me throughout this research project.

Professor Colin A Graham at the Accident and Emergency Medicine Academic Unit Prince of Wales Hospital, The Chinese University of Hong Kong for his professional guidance, encouragement, and enormous help in having the papers from this project published.

Dr Cheung Nai Kwong, Professor Anthony MH Ho, Professor Peter Cameron, Dr Ning Tang, Professor Paul Lai, Dr Cheung Wai Lun, Dr Cheng Chi Hung, Dr George Wong, and other colleagues on the NTEC Trauma Advisory Committee for their expert opinions and endless support. Their professional attitude, their efforts to improve trauma care, and their kindness are deeply appreciated and will always be remembered.

Katherine Lam, Stella Wong, Sarah Leung, and Brenda Chow for their friendship and support over the last 10 years throughout my career in A&E at the PWH.

All the co-authors and co-investigators in the papers described in this thesis, trauma nurse coordinators in other trauma centers, Dr H F HO, and Ms Annice Chang for the opportunity they have given me to learn and work with them and for their significant contributions to this field of study.

All the medical, nursing, and support staff at the Prince of Wales Hospital, especially the staff in the Emergency Department, for their help, support, and contribution to trauma services.

Last but not least, to my parents Yeung Ming Ching and Ngai Kwan I, my husband Liu Chun Shing, my daughter Gloria Liu, my sister Candy Yeung, and her husband Kwok Siu Wing and to Professor Colin W Evers and all my friends for their unwavering love and constant support, tolerance, endless encouragement, and understanding.

Table of Contents

List of Tables

List of Figures

List of Appendices

Definitions of Terms and Abbreviations

AAAM	Association for the Advancement of Automotive Medicine
ACS	American College of Surgeons
AEMAU	Accident and Emergency Medicine Academic Unit
AHNH	Alice Ho Nethersole Hospital
A&E	Accident and Emergency
AIS	Abbreviated Injury Scale 1990 version
CTACS	Committee on Trauma, American College of Surgeons
CUHK	The Chinese University of Hong Kong
Comorbidity	Presence of pre-existing disease prior to injury. Pre-existing disease includes heart disease, respiratory disease, neurological disease, hypertension, diabetes mellitus, liver disease, renal disease, malignancy, psychiatric illness, chest disease, gastrointestinal disease, endocrine disease, and immune dysfunction.
ED	Emergency Department
CT	Computed tomography
Fall-high	Fall ≥ 2 meters
Fall-low	Fall < 2 meters

FIM	Functional independence measure
GCS	Glasgow coma score
HA	Hospital Authority
HAHO	Hospital Authority Head Office
HI	Head injury
HK	Hong Kong
HK SARG	Hong Kong Special Administrative Region Government
HKSAR	Hong Kong Special Administrative Region
ICU	Intensive care unit
ISS	Injury severity score
Isolated trauma	AIS ≧ 2 injuries in 1 body region
LOS	Length of stay
MAIS	Maximum abbreviated injury score
MRI	Magnetic resonance imaging
Major trauma	Injury severity score (ISS) ≥ 15.
Multiple trauma	Has AIS ≧ 2 injuries in two or more body regions
MTOS	Major trauma outcome study
NTDB	National Trauma Data Bank
Older patient	Patient's age ≥ 55
PR	Pulse rate
Ps	Probability of survival
PWH	Prince of Wales Hospital
QEH	Queen Elizabeth Hospital

QMH	Queen Mary Hospital
RR	Respiration rate
RTS	Revised trauma score
SF 12	Short form 12 (12 items)
SF 36	Short form 36 (36 items)
SBP	Systolic blood pressure
SPSS	Statistical Package for Social Sciences
SD	Standard deviation
TBI	Traumatic brain injury
TEC	Trauma and Emergency Centre
TNC	Trauma nurse coordinator
TMH	Tuen Mun Hospital
TRAN	Trauma Audit and Research Network
TRISS	Trauma and injury severity score
UK	United Kingdom
US	United States
VSTORM	Victorian State Trauma Outcome Registry and Monitoring
WHO	World Health Organization

Chapter 1 Introduction

Trauma is a global public health problem that is the dominant cause of morbidity and mortality and has been a constant feature of human life throughout history (Borse & Hyder, 2009). It is the leading cause of death in those aged 15 to 44 and is the sixth leading cause of death among all age groups in 2008 (Hospital Authority, 2009). Trauma systems involving organised approaches and coordinated response mechanisms have therefore been established to cater for major and potential major trauma patients.

Although a number of studies in the literature show that trauma systems reduce mortality rates (Oakley et al., 2004; Pelege et al., 2004; Lansink & Leenen, 2007; Cameron et al., 2008, Twijnstar et al., 2010), a population-based study shows that trauma systems are not independent mortality rate predictors (Shafi et al., 2006). The authors find that trauma patients with injuries of a similar level of severity who are treated in similarly designated trauma centres may not achieve similar outcomes, suggesting the existence of a wide disparity in the standard of trauma care.

The trauma system in Hong Kong is different from those in other parts of the world. The main question arising in the Hong Kong setting is how we can improve various aspects of the clinical outcomes of trauma care at different levels of the trauma system. The dissertation is thus aimed at exploring the ways in which trauma management, trauma care, and injury prevention can be improved in Hong Kong. In doing so, the studies reported in this thesis investigated various aspects of trauma care and prevention at various levels of the Hong Kong trauma system such as trauma centres and multiple trauma centres in different parts of the territory. Where appropriate, an international comparative study approach was adopted, the argument being that there is a need to explore all possibilities for improvement. Furthermore, although the studies forming part of this thesis represent only a limited selection of the potential areas for enhancement, they indicate the range of evidence that may be used to justify improvements.

The thesis starts from the premise that various aspects of trauma care, ranging from injury prevention and pre-hospital care to emergency department resuscitation, definitive care, and performance monitoring, all play a vital role in optimising trauma patient outcomes, assuming that better trauma care practice, prevention measures, and follow-up improve the clinical outcomes of trauma patients.

This thesis represents an attempt to study the effectiveness of key components of the trauma system. While the main aim of this dissertation is to evaluate the outcomes of the trauma system, it is also aimed at evaluating the effectiveness of primary trauma diversion, trauma teams, and performance improvement programmes, exploring the influences of gender and age on patient outcomes, and comparing the Hong Kong trauma system with the system established in Victoria, Australia to identify its strengths and weaknesses. A total of nine studies were conducted to achieve the aims of this thesis.

Various research methods and approaches were employed to tackle problems at different levels and to answer research questions arising from the Hong Kong trauma system. The first study reported in this thesis evaluated whether the trauma care system in the Prince of Wales Hospital (PWH), a regional trauma centre in Hong Kong, has improved clinical outcomes among trauma patients. The main outcome measure employed in this study was the trauma patient survival rate. The study examined a longitudinal cohort and compared the outcomes of trauma care before and after the Hong Kong trauma system was established. The W score was used to compare the PWH mortality rate with the benchmark from the Major Trauma Outcome Study (MTOS) conducted in the US, and W statistics were used to compare the performance of the PWH with that of other institutions. The conclusion reached is that trauma systems improve patients' clinical outcomes and the rate of improvement in performance is steady after the trauma centre is set up. Nevertheless, the evidence reveals that the injury prevention measures currently in place in Hong Kong are inadequate. Apart from its main outcomes, this study confirms that a trauma team improves the trauma patient survival rate. The percentage of major trauma admissions has increased over the years, implying that although the trauma system in Hong Kong has reduced the mortality rate, further improvements in trauma centre development, injury prevention, and geriatric trauma care are required. The conclusion reached in this study and its implications provide evidence that can be employed in strategic planning for and the future development of the trauma system in Hong Kong.

In connection with this key question, the following important research questions concerning various aspects of trauma care are asked:

- What are the clinical impacts of primary trauma diversion?
- Do trauma teams make a difference to the patient survival rate?
- What is the role of trauma nurse coordinators?
- What are the effects of clinical protocols and education programmes?
- What are the epidemiological features and risk factors of bicycle-related injuries?
- What impact does age have on patient outcomes?
- Do females have better outcomes in traumatic brain injuries?
- Is there any performance difference between the local trauma care system and trauma care systems in other countries?

The answers to these questions are important for patient care improvement, injury prevention, quality control, and the advancement of trauma care standards. Studies conducted as part of this thesis were undertaken at various levels and on a variety of aspects of the trauma care systems in place in Hong Kong and elsewhere. Four single centre studies were conducted to look into the details of pre-hospital care, acute care, and quality control at the regional trauma centre level. These studies investigated the clinical impacts of primary trauma diversion at the pre-hospital level and concluded that primary trauma diversion significantly reduces the time taken to deliver the patient to definitive care. Another issue examined is whether trauma teams make a difference to patient outcomes. The evidence gathered shows that that the presence of a trauma team improves the survival rate among major trauma patients. Furthermore, the study investigating the effect of a clinical protocol on early removal of the spinal board shows that guidelines of this type significantly reduce the time the trauma patient is required to remain on the uncomfortable spinal board and minimises the unnecessary discomfort it causes. The results of these studies show that trauma systems improve not only the survival rate, but also the quality and standard of care.

Injury prevention programmes are a necessary part of all trauma systems. However, a limited number of studies on the epidemiology of trauma and injury prevention have been carried out in Hong Kong. An understanding of the unique characteristics of trauma patients and their epidemiological patterns is essential for planning trauma care, patient management, and injury prevention measures. Three studies examining these aspects were therefore conducted.

First, a multi-centre study was conducted to investigate the characteristics of elderly trauma patients. Four out of the five trauma centres in Hong Kong participated in the study, the results showing that advanced age causes a higher mortality rate and that the main causes of elderly trauma are falls and pedestrian injuries. These findings have important implications for injury prevention among the elderly.

Second, an international study investigated the influence of the patient's gender on treatment outcomes and was conducted in conjunction with trauma centres in Victoria, Australia. It is believed that females have better traumatic brain injury outcomes due to the protection they receive from their sex hormones. However, the study found that gender does not make a difference to traumatic head injury outcomes. This finding has implications for trauma management and treatment.

Third, a single centre study on cycle-related injuries was conducted in the New Territories, the most popular area of Hong Kong for cycling. The study found that helmets are not commonly used to prevent head injuries.

Finally, an international study jointly conducted with trauma centres in Victoria, Australia compared their performance with that of the trauma system in Hong Kong and showed that Victorian trauma centres achieve better outcomes than those in Hong Kong. The results help to identify the strengths and weaknesses of the two systems and have major implications for further improvement of the Hong Kong trauma system.

This thesis comprises 12 chapters that are outlined as follows.

Chapter 1 outlines the main theme of the thesis and gives a brief introduction to the thesis as a whole.

Chapter 2 explores the epidemiology of trauma worldwide with a specific focus on the United States, the United Kingdom, Europe, Australia, and Hong Kong to give the reader a better understanding of the public health issues arising in trauma cases. The history and components of trauma systems are also described and analysed, and the methods used to evaluate trauma systems and their limitations are explored. This chapter also traces the development of the Hong Kong trauma system and identifies the research questions arising from the trauma setting.

Chapter 3 describes the main study conducted as part of this thesis in which the effectiveness of the Hong Kong trauma system was evaluated using the trauma injury severity score (TRISS) methodology. The adjusted mortality rate before and after the establishment of a trauma system was compared. The W score was used to monitor whether the trauma system reduced the mortality rate and the W statistic was employed to compare the outcomes with those of other institutions. The same scores were also used to evaluate the annual mortality rate and to establish whether the survival rate improved further as the trauma system matured over time.

Chapter 4 describes a study monitoring the initial outcomes of a field triage strategy - primary trauma diversion. Integrating all facilities into a trauma system is expected to limit the duplication of effort, enabling potentially salvageable patients with significant injuries to receive the appropriate level of care without delay. However, there is no universally accepted mechanism for pre-hospital triage. The consequences of an inadequate system included over and under triage, which may affect the patient's final outcome. Therefore, the study reported in Chapter 4 assessed the clinical impacts of primary and secondary trauma diversion and the time taken to deliver the patient to definitive care.

Chapter 5 evaluates the impacts of trauma teams. Although the trauma team is one of the key components of a trauma system, there is no global guideline defining its components. Different hospitals have trauma teams composed of different personnel. Prior studies have noted the importance of trauma teams to the wider system (Davis et al., 2008) and have shown that the presence of a trauma surgeon on the trauma team reduces resuscitation time, but has no measurable impact on mortality (Khetarpal et al., 1999). Chapter 5 therefore reports on a study exploring whether the presence of trauma teams makes a difference to mortality.

Clinical guidelines and quality improvement programmes enable health care institutes to improve the monitoring of trauma care services and the detection of problems and to enact and evaluate corrective measures more effectively. Chapter 6 investigates the characteristics of trauma nurse coordinators and their role in the trauma system in Hong Kong. Chapter 7 reports on a study examining the effect of an educational programme for a clinical protocol on early removal of the spinal board.

Chapter 8 gives an overview of a study of elderly trauma, an important issue in the Hong Kong context. After describing the epidemiology of major injury patterns in older trauma patients in Hong Kong, the chapter reports on an attempt to identify the predictors of mortality and improve future outcomes.

In Hong Kong, over 50% of patients with major trauma present with traumatic brain injuries, the leading cause of post-traumatic death and disability (Cheng et al., 2007; Poon et al., 1992; Poon & Li, 1991). Prior studies have suggested that gender and sex steroids influence the pathophysiology of injury and outcome for these patients (Vagnerova et al., 2008, Stein et al., 2008).

Chapter 9 reports the results of a study aimed at determining (i) whether there is any association between gender and mortality in TBI patients aged between 12 and 45; and (ii) whether there is any association between gender and brain edema in the same group of patients.

Chapter 10 focuses on the issue of injury prevention. This chapter summarises a study exploring bicycle-related injuries and risk factors to aid trauma care planning and injury prevention programme implementation.

Chapter 11 describes a study directly comparing the performance of trauma systems with distinct characteristics established in Victoria, Australia and Hong Kong. Although direct comparison of the performance of trauma systems helps to identify the strengths and weaknesses of each system and assists in identifying further improvements to the standard of care delivered in each system, no prior international comparison of trauma system performance using patient level data from different registries has been published. Chapter 12 gives a brief overview of the conclusions reached in this study.

Chapter 2

Background and Current Knowledge

The purpose of this chapter is to introduce the epidemiology of trauma, the conceptual framework used to manage trauma patients under a systematic approach, and the background to trauma systems. The key components of trauma systems and the methods used to evaluate them are then discussed more fully. This thesis draws on prior literature and research findings on the epidemiology of trauma to give a better understanding of this public health problem. The background and characteristics of the Hong Kong trauma system are also described and discussed.

2.1 Traumatic Injuries as a Public Health Problem

Trauma is one of the leading causes of death worldwide and is a major health problem for modern society (Peden, 2000; Center for Disease Control and Prevention, 2007; Hospital Authority, 2009). Mankind has suffered from different types of traumatic injuries including falls, burns, drowning, and intended injures as a result of interpersonal conflict. While the injury mechanisms and incident rates for specific types of injuries may have changed over time, trauma remains one of the leading causes of death among the young worldwide (World Health Organization, 2002). Between 5.4 and 5.8 million people die every year as a result of injury and projections for

2020 show that 8.4 million traumatic deaths are expected annually (Krug et al., 2000; Murray and Lopez, 1997; Borse & Hyder, 2009).

Death registrations in 111 countries show that the injury mortality rate is the highest in Southeast Asia, Latin America, and the Eastern Mediterranean region (Mathers et al., 2009). In sub-Saharan Africa, injuries are responsible for more deaths and disability-adjusted life years than are AIDS and malaria combined (Bergman et al., 2008).

Injuries account for 14% of the number of lives lost and disabilities sustained (World Health Organization, 2002). In the Netherlands, for example, the direct cost of injuries represents 5% of the health care budget (van Beeck et al., 1997). In Spain, the total cost associated with road traffic crashes alone accounts for 1.35% of gross national product (Bastida et al., 2004).

Studies examining the burden of disease show that road traffic accidents are the fourth most common cause of mortality (Mathers & Loncar, 2006; Murray et al., 1997). In particular, the global pattern of death shows that road traffic accidents are one of the major causes of mortality among people aged between 10-24 years. Approximately 2.6 million young people die as a result of such accidents each year, with 97% of these deaths taking place in low- and middle-income countries (Patton et al., 2009). An estimated total of 227,835 pedestrians die in low-income countries each year, as opposed to 161,501 in middle-income countries and 22,500 in high-income countries (Naci et al., 2009).

In the United States (US), trauma is the number one killer of US residents under the age of 44 and was the fourth leading cause of death among all age groups in 2005. In 2005, 121,599 of the deaths recorded were due to unintentional injuries (Heron et al., 2009).

Approximately 30 million emergency department visits made annually relate to trauma. These visits result in 1.9 million hospital admissions and direct medical costs of approximately $80 billion (Bergen et al., 2008).

In 2002, the five leading injury death mechanisms were motor vehicle traffic accidents, firearms, poisoning, falls, and suffocation, accounting for 81% of all injury-related deaths. Thirty percent of injuries resulting in death were to the head and neck region (Miniño et al., 2006).

According to the 2009 annual report of the National Trauma Data Bank, the leading injury mechanisms were falls (217,743 incidents and 7,715 deaths), motor vehicle traffic accidents (199,566 incidents and 9,023 deaths), and striking (47,565 incidents and 551 deaths). Firearms were the sixth most common injury mechanism and led to a very high fatality rate (5,061/31,499, or 16.07%).

In terms of years of productive life lost, prolonged or permanent disability, and cost, trauma is recognised as one of the most important threats to public health and safety in the United States (Committee on Trauma, American College of Surgeons, 2006). Unintentional injury was the sixth leading cause of death in 2005. For persons aged 15 years and above, deaths due to injury at work accounted for a total of 5,113 deaths reported on death certificates (Kung et al., 2008).

In the United Kingdom, there are at least 20,000 cases of major trauma each year in England resulting in 5,400 deaths, and many of them result in permanent disabilities requiring long-term care (National Audit Office, 2010). Although around 28,000 trauma patients do not meet the precise definition of major trauma, they still require similar care. It is estimated that major trauma costs between £0.3 and £0.4 billion a year in immediate treatment costs and that the annual value of lost economic output is between £3.3 and £3.7 billion (National Audit Office, 2010).

In Australia, 12,591 patients died due to external causes of injury in 2003 (McKenzie et al., 2009). The assault-related major trauma rate increased significantly from 2001 to 2007, particularly for blunt assaults in Victoria (O'Mullane et al., 2009). High-energy traumatic deaths occur among 12.3 out of every 100,000 people each year, and 8.6 people out of every 100,000 die from low-energy trauma per annum (Balogh & Evens, 2010). The standardised death rate for injuries was 39.2 per 100,000 people in 2008 (Australian Bureau of Statistics, 2010). Transport accidents accounted for 1,402 deaths, representing 16% of all deaths due to injury. In 2008, there were 2,191 deaths due to intentional self-harm, accounting for 25% of all deaths due to injury (Australian Bureau of Statistics, 2010).

In Canada, injury is the leading cause of death among those under the age of 35 and unintentional injury is the fifth leading cause of death (Statistics

Canada, 2010). Unintentional injuries account for more than 200,000 hospitalisations each year and the major causes of multiple trauma include motor vehicle crashes and falls from heights. There were 8,626 deaths due to unintentional injury in 1997, increasing to 9,506 in 2007. The mortality rate for unintentional injuries was 25.6/100,100. The motor vehicle accident death rate increased from 8.3/100,000 in 1997 to 9.2/100,000 in 2005. The death rate from falls increased from 4.6/100,000 in 1997 to 5.4/100,000 in 2005 (Statistics Canada, 2010). The injury death rate for Canadian males was 60.1/100,000 in rural areas, in comparison with 40.9/100,000 in urban areas; for females, the respective rates were 31.5 and 23.6/100,000. Transportation incidents and suicide were the most important contributors to higher death rates among rural residents aged 15 years or above in 2005.

In China, accidents were the sixth leading cause of death in 1999 and 2000 , and the mortality rate was 564/100,000 (He et al., 2005). The road traffic death rate increased by 95% from 3.9/100,000 in 1985 to 7.6/100,000 in 2005. The highest mortality rates were found in provinces with lower population density (Hu et al., 2008).

The Chinese Ministry of Health estimates that 750,000 citizens are killed and approximately 3.5 million people are hospitalised per annum as a consequence of trauma-related injuries (The George Institution for International Health, 2010), but no detail can be found on this report.

In 2005, the total number of traffic accidents reported in China was 450,000 and the number of deaths was 99,000. Drivers and passengers accounted for

33.2% and 26.6% of death casualties, respectively. Most traffic accidents were caused by drivers, especially those with driving experience of less than 3 years (Zhou et al., 2008). Road traffic accidents due to drink driving accounted for between 0.29% and 1.48% of traffic accident deaths and about 70% of road traffic accidents were bicycle-related (Wang & Jiang, 2003).

In Hong Kong, trauma is the leading cause of death in people aged 15 to 44 and is the sixth leading cause of death for the whole population. A total of 1,854 patients died due to external injuries in 2008 (Hospital Authority, 2009). According to AEIS records held at the Hospital Authority, a total of 329,177 injured patients attended accident and emergency departments in 2009.

There were 500,000 vehicles registered in Hong Kong in 2001, with 165 people dying due to motor vehicle crashes. Most of these cases involved pedestrians (59%) and most individuals died as a result of a major head injury alone or multiple injuries. Hong Kong has a very low motor vehicle death rate relative to its population (2.4 per 100,000), but the mortality rate per registered motor vehicle was 33 per 100,000 vehicles in 2001 (Cameron et al., 2004a).

According to a traffic report issued by the Hong Kong Police Force (2008), 14,576 traffic accidents occurred in 2008, of which 143 were fatal. Road junctions and pedestrian crossings remained the locations in which traffic accidents were most likely to occur (4,032 cases or 28%). Those in which a driver was at fault accounted for 83% or 12,115 of all accidents.

2.2 The Development of Trauma System

The epidemiology of trauma illustrates that injury remains a huge risk and a major cause of death across the world. However, morbidity and mortality resulting from injuries to individuals go relatively unnoticed from day to day. Trauma remains the “silent epidemic” (Committee on Trauma and Committee on Shock, Division of Medical Sciences, National Academy of Sciences, National Research Council, 1966). This report characterises trauma as the "neglected disease of modern society.” Accidental Death and Disability: The Neglected Disease of Modern Society identifies a lack of suitable facilities, triage, and other problems associated with the care of trauma victims.

It was only recently that traumatic injuries were no longer viewed as an “accident”, but came to be regarded in a public health model context (Maggio, 2008). Traumatic injury is viewed as a disease that can be predicted and prevented. Military experience has demonstrated that rapid triage and transportation of injured patients to definitive care save lives (Arroyo & Crosby, 1995). The concept of a trauma system has developed substantially in recent years.

England’s Birmingham Accident Hospital was the world’s first trauma centre and was opened in 1941. By 1947, there were three trauma teams operating in the hospital, each consisting of two consultant surgeons and a consultant anesthetist, as well as a burn team comprising three consultant surgeons (American College of Surgeons 2006, Trauma Org, accessed in 2010).

The American College of Surgeons recognised the need for a systematic approach to trauma and provided a conceptual framework for a trauma system (Committee on Trauma American College of Surgeons, 2006). This systematic approach to trauma care had wartime origins. Military experience reflected the need for in-field trauma care, more rapid transportation of trauma patients to definitive care, and a team of experts working smoothly together (Committee on Trauma, American College of Surgeons, 2006).

Trauma systems are designed to promote optimum care along a continuum running from injury prevention, public access to the system, pre-hospital care, timely triage, and transportation to definitive acute care through rehabilitation to provide patients with the best outcome possible (MacKenzie et al., 2003a; Hoff et al., 2004; Leppäniemi, 2008a). These goals are aimed at optimising the use of resources and ensuring that trauma patients are treated in the right place at the right time by the right specialists.

The first specialised trauma units in the United States began to appear between 1966 and 1972. The organised approach taken to major trauma care in the United States from the late 1960s resulted in the creation of trauma centres, trauma systems, and the surgical specialty of trauma surgery and surgical critical care (Leppäniemi, 2008). In 1971, the state of Illinois established the first trauma system with the support of state legislation (American College of Surgeons, 2006). The designation process adopted in this and other systems is designed to ensure that designated centers have similar personnel, supplies, equipment, and procedures (Cinelli et al, 2009).

In 1976, the American College of Surgeons Committee on Trauma developed criteria for categorising hospitals according to the level of trauma care available. States are using these guidelines as a basis for designating or certifying hospitals as trauma centres. Individuals are transported to trauma centres after sustaining serious injuries rather than being taken to the hospital they might normally choose or to the nearest hospital.

2.2.1 The Trauma System in the United States

Trauma centres are classified into four levels in the US (American College of Surgeons, 2006). There were 1,154 adult trauma centres in the US in 2002, including 190 level I centres and 263 level II centres. The number of level I and II centres per million people ranges from 0.19 to 7.8 by state. In comparison with non-trauma centre hospitals, trauma centres are larger, more likely to be teaching hospitals, and more likely to offer specialised services (MacKenzie[b] et al., 2003).

According to information available on the American College of Surgeons Web site (accessed on 24 April, 2010), there were 328 verified trauma centres with the resources listed in "Resources for Optimal Care of the Injured Patient". Among these centres, 135 are level I trauma centres, 149 are level II, and 44 are level III. There are a total of 170 verified pediatric trauma centres and 24 candidate pediatric trauma centres in 41 states. An estimated 71.5% of pediatric patients live within 60 minutes of a verified pediatric trauma centre by air or ground transport. Access ranges from 22.9% of the population in the most rural areas of the United States to 93.5% in the most urban. Pediatric trauma centres have increased their coverage to 77.4% of the pediatric population (Nance et al., 2009).

Although almost 90% of Americans believe that state trauma systems and hospitals should have a coordinated trauma response, this has not been made a national priority. Only eight states have fully developed trauma systems, and most states have no federal funding or infrastructure in place for managing the aftermath of a natural disaster or terrorist event (Champion et al., 2006). Between 10 and 15% of the US population does not have access to basic emergency medical care. Moreover, the presence of key trauma system components continues to vary throughout the country, most likely because of growing economic constraints (Edlich et al., 2004).

A prior study finds that an estimated 69.2% of US residents have access to a level I trauma centre and 84.1% have access to a level II trauma centre within 60 minutes of their residence. Most of the 46.7 million Americans who have no access to trauma care within an hour live in rural areas, whereas the majority of the 42.8 million Americans who have access to 20 or more level I or II trauma centres within an hour live in urban areas (Branas, 2005).

2.2.2 The Trauma System in the UK and Europe

In the UK, a pilot trauma system was started in 1991 in Stoke-on-Trent (Oakley et al., 2004). There are currently 193 hospitals in England that provide major trauma services within their emergency departments. Consultants in the emergency department are most likely to be present only between 8am and 8pm from Monday to Friday, with night-time and weekend cover provided on an on-call basis. Only one hospital has a 24-hour consultant presence seven days a week.

Trauma teams have been established in around 78% of hospitals in the UK (National Audit Office, 2010). However, a study has shown that only 21% of the 24 hospitals in Scotland with emergency departments have trauma teams. The most common reasons given for not having one were that there was no problem with the current system in eight cases (44%) and an inability to include sufficiently senior staff on the team in six cases (24%) (Hornsby et al., 2010).

The composition of trauma teams varies between hospitals. Trauma teams generally have between six and ten members including representatives from the emergency department, anesthesia, nursing, radiography, and relevant surgical disciplines. The trauma team is activated following receipt of a 'pre-alert' from the ambulance service and before the patient arrives at the emergency department (National Audit Office, 2010). Orthopedic surgery is commonly available in hospitals. However, neurosurgery and cardiac surgery are not always available, with 36% of patients requiring a transfer to a more specialised facility for such treatment (National Audit Office, 2010).

The results of another study show that the severity-adjusted odds of death after trauma declined gradually from 1989 (Lecky et al., 2000). However, the time between the call to the emergency services and arrival at hospital increased from 32 minutes in 1989 to 45 minutes in 1997. The proportion of severely injured patients seen first by a senior doctor increased from 32% to 60% over the same period.

Only 114 hospitals (59% of the hospitals delivering trauma care) voluntarily submitted trauma data to the Trauma Audit & Research Network (TARN) for analysis and comparison (National Audit Office, 2010). TARN data include pre-hospital times, injury mechanisms, injury severity, time to treatment, length of stay, and outcomes based on mortality. The database uses a model to calculate the likely rate of survival for particular injuries or combinations of injuries, taking into account age, gender, and the patient's physical response to their injuries. However, Alexandrescu et al. (2009) find that no major trauma population-based rates are available within well-defined populations across the UK over recent periods. They suggest that new methodological approaches be developed to deal with the study design inconsistencies and knowledge gaps they identify in their review.

In Europe, trauma systems vary greatly from country to country. Three main models are practiced in most central European countries: major trauma care (the US model), a single regionalised system combining trauma care and emergency surgery, and the orthopedic surgery-orientated all-inclusive trauma care model (Leppäniemi, 2008).

A 2002 survey of 12 European countries shows that eight had trauma centers, although in many cases university hospitals managing all surgical emergencies including trauma were labeled as trauma centers (Uranüs et al., 2002).

A study conducted in Finland shows that only one hospital had established multidisciplinary and systematic trauma team training. About 20% of the hospitals surveyed had a trauma team, and 25% had a systematic trauma education program. The case load of severe trauma patients was low and too many hospitals admitted too few patients (Handolin et al., 2006).

Italy had no state trauma system or trauma registry until 2005 (Di Bartolomeo et al., 2006). The emergency medical system is organised according to regional rules and five hospitals provide a high level of care for trauma patients. Many attempts have been made to increase the quality of trauma care in the pre-hospital and hospital phases (Padalino et al., 2006).

While only 52% of Norwegian hospitals had a trauma team in 2000, such teams had been established in 88% of hospitals by 2004. Norwegian trauma centres use paging criteria for trauma teams, trauma manuals and protocols, and designated patient charts. Eighty eight percent of hospitals offer trauma training and 54% hold regular practical drills for trauma teams. Systematic audits are performed in only 27% of hospitals (Isaksen et al., 2006). In recent years, Norwegian hospitals have gradually established trauma teams and criteria for their activation. Of the 49 hospitals that admit severely injured patients, 48 (98%) have a trauma team. A variety of activation criteria are employed and the number of such criteria in each hospital ranges from 8 to 40. Injury mechanisms are commonly used as criteria despite a well-known, large over-triage rate (Larsen et al., 2010).

2.2.3 The Trauma System in Australia

Australia has a public medical service provided by the state and federal governments that is financed both by taxes and a universal "Medicare" levy on the public. The capacity to manage level I trauma is dependent on the presence of specialties such as general surgery, neurosurgery, orthopedics, thoracic surgery, plastic surgery, urology, and intensive care medicine (Croser, 2003).

In 1998, Australia established a Ministerial Taskforce on Trauma and gradually introduced a new trauma care system in Victoria. The percentage of Victorian hospitals with major trauma services increased from 34% to 62% in the 2002- 2004 period, and more patients were attended by advanced trauma life support paramedics. The new Victorian trauma care system has resulted in a significant decrease in deficiencies and the preventable or potentially preventable death rate fell from 36% to 28% between 2002 and 2004 (McDermott et al., 2007).

A prior study finds that among the 111 Australian public hospitals with emergency and surgical services in 2003, 56% had an established trauma team. Ninety five percent of trauma teams were potentially activated by pre-hospital paramedics. For 92% of trauma teams, a combination of anatomical, physiological, and mechanistic criteria were required for activation. Fifty eight percent of trauma team leaders were emergency medicine specialists/registrars, while 8% of trauma teams were led by surgeons/registrars (Wong & Petchell, 2003).

2.2.4 Trauma Systems in Developing Countries

Although there are trauma centres in developing countries such as India, but the level of information available on these centres is limited. In India, ambulances are owned by private companies and operate on a fee-for-service basis, often with only limited equipment such as oxygen cylinders. There is a lack of pre-hospital care and triage, and very few victims arrive at hospital within the critical "golden hour". The caregiver to patient ratio in ICU is 1:5, and some care is provided by relatives. A study conducted by Murlidhar & Roy (2004) shows that the Indian mortality rate was much higher than in the US, with a W statistic of -10.416 (10 excess deaths per 100 patients in comparison with the US norm) in Indian level I trauma centres.

A study conducted in Brazil in 2000 reports that university hospitals provide ambulances with nurses and physicians, advanced trauma life support training to trauma teams, and ICU care. The mortality rate in major trauma patients were 31.25% to 36.84% and the W statistic was between -1.28 and -3.52 (Scarpelini et al., 2006).

China is the most populous nation in the world, yet trauma systems and trauma care are confined to very few hospitals. The network of emergency centres is directly led by the Ministry of Civil Administration, the Ministry of Health, and the Chinese Hospital Association. In 2006, there were 160 emergency medical centres (first aid stations) in China (China Emergency Medical Service System, 2008). The ambulance service has established close links with police, fire departments, and traffic departments. Due to the significant differences in the economic power and size of cities and in the management style adopted for emergency services in China, the emergency services have adopted different models (Dai et al., 2003).

Chinese hospitals are divided into three grades (Ministry of Health of the People's Republic of China, 2008). Grade I hospitals, most of which are community and/or township hospitals, are the most basic facilities and mainly function to promote primary healthcare. Grade II hospitals, most of which are prefecture- and/or county-level institutions, are local technical centres of disease prophylaxis and provide medical treatment to several local communities. Grade III hospitals, most of which are provincial- or municipal-level facilities or are affiliated with a medical university, are the medical centres responsible for providing the highest level of service including the full range of medical sub-specialties, education, and scientific research (Ministry of Health of the People's Republic of China, 2008).

Although the national or local government is theoretically responsible for giving financial support for the running of hospitals, hospitals are in practice often supported in part by loans from commercial banks and other sources of funding. Most hospitals in China must make money to pay staff salaries. Most trauma care services are provided in the surgery departments of hospitals at grade II level or below (Ma et al., 2008).

No orthopedic and/or trauma sub-specialty license is available to establish and maintain quality trauma care services (Ma et al., 2008). China has not established a trauma system similar to that in place in the US. Although there are trauma centres in China, they do not adopt a trauma team approach and there are no trauma registries or trauma nurse coordinators in acute hospitals (personal communications, 2009; 2010).

2.3 The Components of Trauma Systems

The components of trauma systems include public health, injury prevention, and emergency medical services, hospitals that receive all trauma patients, trauma centres, rehabilitation services, research, education, and systems governance (Committee on Trauma, American College of Surgeons, 2006; The Royal College of Surgeons of England, 2009).

2.3.1 Injury Prevention

"Injury does not occur by accident" and prevention may be the best means of dealing with injuries (Committee on Trauma, American College of Surgeons, 2006). The long-term solution to trauma is prevention. Trauma centres play an important role in reducing the impact of injury by participating in injury programmes. Injury prevention programmes designed to reduce the overall burden of injury for a population and ongoing research and education activities are important aspects of trauma systems.

According to the 2009 annual report of the National Trauma Data Bank, of the 627,644 admissions to US trauma centres in 2008, falls were the most common injury mechanism. There were 217,743 (34.7% of the total) fall patients and 7,715 fall-related deaths. The fatality rate among fall patients was 3.54%.

Falls are a common injury mechanism and are a leading cause of injury costs among the elderly (National Trauma Data Bank, 2010). Moreover, they place a significant economic burden on society. National fall-related costs identified in prevalence-based studies range between 0.85% and 1.5% of total health care expenditure and from 0.07% to 0.20% of gross domestic product (GDP). Mean costs per fall victim, per fall, and per fall-related hospitalisation range from US$2,044 to US$25,955; US$1,059 to US$10,913, and US$5,654 to US$42,840 in purchasing power parity (PPP) terms, respectively, and depend on fall severity. Efforts should be directed to economic evaluations of fall-prevention programmes aimed at reducing fall-related fractures, which contribute substantially to fall-related costs (Heinrich, 2010).

Motor vehicle traffic injuries are the second most common injury mechanism in the US, with 199,566 patients (31.8% of the total) sustaining motor vehicle traffic injuries in 2009 and 9,023 deaths. The fatality rate among motor vehicle traffic injury victims was 4.52% (National Trauma Data Bank, 2009 annual report).

In England, the most common cause of injury among trauma patients is motor vehicle crashes (National Audit Office, 2010). In Italy, 55.5% of injuries among trauma patients admitted in Milan are due to motor vehicle and road incidents (Padalino et al., 2006).

Another study reports that motor vehicle traffic was the most frequent injury mechanism treated at National Trauma Data Bank trauma centres and ranked as the highest injury prevention priority (Wiebe, 2006).

The distribution of road traffic fatalities varies dramatically across different parts of the world (Haci et al., 2009). Forty five percent of road traffic fatalities in low-income countries are among pedestrians, in comparison with an estimated 29% of such fatalities in middle-income countries and 18% in high-income countries. Context-appropriate and effective prevention strategies that protect particular at-risk road user groups should be carefully investigated (Haci et al., 2009).

Research shows that 61% of the American public do not know that injury is the leading cause of death for those aged 1 to 34 (Champion et al., 2006). Health care professionals should help to prevent trauma by detecting and reporting health hazards and identifying the role of human behavioral, physical, emotional, and mental defects in accident liabilities (Committee on Trauma and Committee on Shock, 1966). The American College of Surgeons (2006) recommends that trauma centres use their trauma registries to identify the pattern, frequency, and risks of injury within the community.

2.3.2 Pre-hospital Care

Major or potential major trauma patients should be identified at the scene and rapidly dispatched to an appropriate trauma centre for surgical management and critical care. Major trauma patients should be treated at trauma centres, while minor trauma patients can be treated at other hospitals. This requires the optimisation of pre-hospital triage and bypass protocols that primarily divert major or potential major trauma patients to an appropriate trauma centre instead of to the closest hospital. Management protocols and capabilities for rapid inter-hospital transfers of major trauma patients are also required for secondary trauma diversion (Committee on Trauma, American College of Surgeons, 2006; The Royal College of Surgeons of England, 2009).

Pre-hospital notification protocols appear to be most associated with decreased risk-adjusted odds of death (Liberman et al., 2005). Sampalis et al.

(1999) show that reduced pre-hospital time is one the primary factors contributing to a reduced mortality rate. Their results show that tertiary trauma centres and reduced pre-hospital time are the essential components of an efficient trauma care system.

2.3.3 Trauma Centres

The effective functioning of trauma systems requires that trauma centres—a group of related injury-oriented facilities, personnel, and organisational entities—operate in an organised, coordinated manner. Trauma centres generally have trauma directors, trauma surgeons or general surgeons, orthopedic surgeons, anesthetists, neurosurgeons, cardiothoracic surgeons, trauma nurses, and trauma nurse coordinators. Outside reviews have categorised hospitals on the basis of their ability to provide trauma care (Amercian College of Surgeons, 2006).

Trauma centres may be classified from level I to level V or as adult and pediatric centres (American College of Surgeons, 1999, 2006). The American College of Surgeons (1999) criterion for level I trauma centres is an annual volume of at least 1,200 trauma cases per year, of which at least 240 are ISS > 15.

Verifying the status of trauma centres may require the use of outcome measures (Shafi et al., 2008). A prior study shows that accreditation is beneficial regardless of level, the volume of patients treated has a direct impact on survival outcomes, and the presence of a surgical residency programme may confer survival benefits (Pasquale et al., 2001).

Mackenzie et al. (2003) report that the hospital mortality rate is significantly lower at the trauma centre level than at non-trauma centres. Lansink & Leenen (2007) show that mortality is reduced by 15-25% when severely injured patients are treated at a trauma center.

Shafi et al. (2008) identify forty seven American College of Surgeons-verified level I trauma centres that contributed to the National Trauma Data Bank from January 1999 to December 2003. Their study finds that when treating patients with similar injury severity, similarly designated level I trauma centres may not achieve similar outcomes, suggesting the existence of a quality chasm in trauma care.

Cudnik et al. (2009) find that patients taken to level I centres have more severe injuries, more penetrating injuries, and more complications, yet have a similar unadjusted mortality rate in comparison with level II centres. An adjusted analysis shows that patients taken to level I hospitals have an improved chance of survival in comparison with their counterparts taken to level II centres.

A long line of studies in the prior literature show that regionalised trauma systems improve outcomes among seriously injured patients. The study of Cooper et al. (2000) examines the volume-mortality relationship for New York State trauma centres. Their results show that the 35 New York State trauma centres that did not meet the American College of Surgeons criteria had lower, but not significantly lower, mortality rates than the 8 trauma centres that met the criteria. However, other studies demonstrate that patients treated in a high-volume trauma centre have better outcomes (Smith et al., 1990; Konvolinka et al., 1995; Liberman et al., 2005; Simons et al.,1999). Increased patient volume is associated with a reduction in risk-adjusted mortality (Liberman et al., 2005).

A retrospective analysis of prospectively collected data from 1992 to 1996 on patients older than 14 from 24 accredited trauma centres in Pennsylvania suggests that low volume is a significant mortality risk factor in seven of the nine injuries studied (Pasquale et al., 2001).

The trauma system initiated in Delaware in 2000 involved establishing four level III trauma centres in counties that previously did not have them. After implementation, mortality rates fell significantly from 5.3% to 2.8% (Tinkoff et al., 2007). Tinkoff (2007) shows that an inclusive state trauma system including the establishment of level III trauma centres in previously underserved counties led to a decrease in trauma-related mortality rates in those counties.

2.3.4 Trauma Team

The initial care of critically injured patients has profound effects on ultimate outcomes. Adequate management of severely injured patients requires optimal personal and structural conditions. When major or potential major trauma patients are sent to trauma centers, they should be promptly assessed by a multispecialty trauma team.

Trauma teams are composed of various staff in different trauma centres and generally include general surgeons or trauma surgeons, emergency physicians, orthopedic surgeons, nurses, and allied health personnel. Some trauma centres have a two-tier trauma team, while some have only a one-tier trauma team (Wong et al., 2008; Davis et al., 2010).

Trauma teams are activated when certain physiological or anatomical criteria are met (Tinkoff & O'Connor, 2002; Wong & Petchell, 2003). Some trauma teams are activated when significant injury mechanisms are present. However, previous studies have found that mechanism-related trauma team activation criteria are not useful in predicting the need for an immediate multidisciplinary response (Kohn et al., 2004; Tinkoff, 2002; Wong & Petchell, 2003).

Trauma teams have been associated with improved trauma patient outcomes (Wong et al., 2008; Oakley et al., 2004). High costs and additional personnel are justified by improved quality of treatment. However, no prior study has reported on the impact of under-triage on patient survival.

2.3.5 Trauma Nurse Coordinators, Trauma Registries, and Performance Improvement Programmes

An integral part of any trauma system is a trauma registry. A trauma registry is a database that documents acute care delivered to patients hospitalised with injuries. It is “an essential management tool that contains details, reliable and readily accessible information needed to operate a trauma centre” (Committee on Trauma, American College of Surgeons, 2006).

Trauma registries are designed to provide information that can be used to improve the efficiency and quality of trauma care (Morre et al., 2008) and hold injury data coded using the Abbreviated Injury Scale (Association for the Advancement of Automotive Medicine, 2005). Trauma registries provide data used to determine the pattern of trauma, trauma workloads, audit filters, patient outcomes, and research issues.

Trauma nurse coordinators maintain the trauma registry, collect data, and analyse data for overall trauma service performance and potential research application. Trauma nurse coordinators play an important role in the trauma system. They work in conjunction with the trauma director and all departments involved in trauma services to facilitate team interaction and improve service quality.

The United States has established a nationwide National Trauma Data Bank that holds the largest body of trauma registry data ever assembled. In 2009, 567 hospitals submitted data to the National Trauma Data Bank (National Trauma Data Bank, 2009). In Australia, a statewide trauma system has also been established and provides data for ongoing monitoring and trauma care feedback (Cameron et al., 2005). The study of Katsaragakis et al. (2009) shows that trauma registries are feasible even in health care systems where funding for medical research is sparse.

Trauma centres are clinically and administratively structured to oversee system activities. For example, a central trauma committee is required to evaluate governance and performance and to maintain the commitment of senior clinical staff and executives to the care of major trauma patients. The committee develops and implements new policy and guidelines to improve trauma services on an ongoing basis. A prior study has shown that the presence of a performance improvement programme in such a hospital had a positive effect on the quality of care and survival (Liberman et al., 2005).

2.3.6 Rehabilitation

Rehabilitation is an integral part of trauma management, and rehabilitation services are important for trauma patients (American College of Surgeons, 2006). Multiple trauma patients not only require physical rehabilitation, but also need psychosocial support and time to work through the emotional trauma. They need to recover their physical and emotional strength and to rebuild their self-esteem and confidence as they prepare to return to the community.

The ultimate goal of trauma care is to restore patients to their pre-injury status (American College of Surgeons, 2006). This is not only the best objective for the patient, but is also less costly. Patients receive care from an interdisciplinary team of skilled physicians, nurses, social workers, physiotherapists, and occupational therapists. When rehabilitation results in independent patient function, there is a 90% cost saving in comparison with the cost of custodial care and repeated hospitalisation (American College of Surgeons, 2006). Each patient should be assessed for their rehabilitation needs. Patients requiring rehabilitation should be evaluated in detail by the rehabilitation team as early as possible in their hospital stay (American College of Surgeons, 2006).

2.4 Evaluation of Trauma System Outcomes

There are very large discrepancies in the survival rate among trauma patients in different countries. Evaluation of trauma care must be an integral part of any system designed for the care of seriously injured patients (Maldini et al., 2003). Studies have shown that seriously injured patients in low-income countries are twice as likely to die as those in high-income countries (Mock et al., 1998).

Care processes should be evaluated to determine whether they are adequate to achieve the desired outcome. Ineffective processes should be identified, revised, and reevaluated to determine whether revisions have been effective. Mortality, morbidity, length of stay, cost, and quality of life are examples of outcome measures that can be used in this context (American College of Surgeons, 2006).

2.4.1 Trauma and Injury Severity Score (TRISS)

Performance monitoring has gained increasing attention as a tool for evaluating the delivery of health care services. The evidence gathered is used to improve or modify proactive steps taken daily to enhance patient care (World Health Organization, 2009). Evaluation of trauma care must be an integral part of any system designed to care for seriously injured patients. Outcome reviews should compare results achieved to national standards or norms (Boyd et al., 1987).

There are numbers of ways to measure the quality of trauma care, such as through the survival rate, patient's functional outcome under Short Form 36 (SF-36), the functional independence measure (FIM) M score, quality of life, and length of stay. The survival of severely injured patients remains the primary objective of treatment. The mortality rate can be regarded as a quality indicator monitored as a means of measuring and assessing quality (Boyd 1987; World Health Organization, 2009; American College of Surgeons, 2006). Mortality is one of the most commonly used indicators of performance. It is a simple measure for comparing hospital performance and avoids spurious ranking of hospitals (Kirkham & Bouamra, 2008).

The trauma and injury severity score (TRISS) was developed in 1981 and gave clinicians a way to identify major trauma patients with unexpected outcomes and to compare patient outcomes among institutions (Champion, 2002).

Boyd (1987) proposed the trauma and TRISS methodology incorporating the injury severity score (ISS), the revised trauma score (RTS) on admission to the emergency department, and the injury mechanism to quantify the probability of survival (Ps). The TRISS methodology examines W, Z, and M statistics (Boyd et al., 1987; Hollis et al., 1995, 2002) on the basis of the major outcome study methodology.

The Z statistic quantities the differences between the actual number of survivors in the test subsets and the predicted number of survivors based on the baseline. It compares the number of survivors in a study population to that expected from a baseline population r norm. An absolute value of Z in excess of 1.96 is required for the 0.05 significance level (Boyd et al., 1987; Hollis et al., 1995; Champion, 2002).

The M statistic measures the similarity of the injury severity mix to the prediction database. M ranges from zero to one, and the closer the value is to one, the better the match of injury severity. $M < 0.88$ indicates a disparity in the severity match between groups. The low value of M does not explain whether the study group is more or less severely injured than the baseline population (Boyd et al., 1987; Hollis et al., 1995; Champion, 2002).

W is the difference between the predicted number of survivors and the actual number of survivors, divided by the total number of patients divided by 100. W is the number of excess survivors per 100 patients in comparison with the prediction (Hollis et al., 1995; Champion, 2002).

The American College of Surgeons major trauma outcome study (MTOS) provided the first large, multi-institutional database used to drive TRISS norms. The MTOS database was created by the American College of Surgeons over 20 years ago to establish national norms for trauma care (Muller et al., 1990; Champion et al., 1995; Champion 2002).

In 1986, data from 25,000 major trauma outcome study patients were used to relate TRISS values to survival probability using AIS-85 (Champion et al., 1987). The TRISS coefficient was updated in 1996 on the basis of AIS-90 (Champion et al., 1995). The TRISS is a means of case identification for quality assurance reviews conducted on a local basis, and also serves as a means of comparing outcomes among different populations of trauma patients. It offers a standard approach for evaluating trauma care outcomes and is now the model most commonly used to evaluate trauma outcomes. It is also a valid approach for screening trauma patients for unexpected survival/death.

Schluter et al. (2009 a) assess the predictive capabilities of a statistical model that relates routinely collected TRISS variables to length of hospital stay (LOS) in traumatic injury survivors. The results show that the TRISS model is capable of accurately and reliably predicting LOS. The TRISS method can also be used as a tool to identify areas for improvement in the trauma care system.

The probability of survival depends on the severity of trauma, patient factors, and the quality of care received. An earlier study has shown that even though outcome predictions are insufficient for individual decision-making in clinical situations, they might serve as a quality assurance tool in the comparison of trauma care systems. While indicators do not represent perfect measurement devices, they may serve as useful tools for improving patient safety and meeting community expectations (Willis et al., 2007).

2.4.2 Application and Limitation of TRISS

Schluter et al (2009) developed local contemporary coefficients for the trauma injury severity score in New Zealand—TRISS(NZ)—based on a study of 1,735 eligible patients. The accurate predictions of survival for blunt mechanism trauma obtained from both models suggest that TRISS(NZ) coefficients are statistically superior to TRISS coefficients and that the former should replace the latter in New Zealand. However, their sample is relatively small and is drawn from only one hospital in Auckland. The TRISS (NZ) may be a benchmark applicable in Auckland, but is also useful as an international benchmark.

A Thailand study conducted by Siritongtaworn & Opasanon (2009) seeks to validate the accuracy of the TRISS methodology in predicting the survival of trauma patients admitted to the Siriraj Hospital in comparison with actual mortality outcomes (discharged or dead) over a 1-year period. The study confirms the accuracy of the TRISS methodology for predicting survival in Thailand.

Maldini et al. (2003) conducted a retrospective review of 586 children with major trauma admitted to the Children's Hospital in Zagreb to analyse the validity of the TRISS methodology in evaluating traumatised children admitted to the ICU. The results show no statistically significant differences between the predicted and actual number of children who died. Their study documents and confirms the TRISS methodology as an effective predictor of both severity of injury and potential for mortality in children with major trauma.

A study of the rate of preventable deaths in a Spanish hospital shows that it was higher than expected (Koo et al., 2009). Mortality is strongly associated with head injuries and age, and the TRISS model is shown to be an objective means of identifying preventable deaths.

Although the TRISS methodology has become a standard tool for evaluating the performance of trauma centres and identifying cases for critical review, several limitations have been identified, and the validity of the methodology in certain types of trauma has been questioned (Demetriades et al., 1998).

There have been conflicting reports regarding the applicability of the TRISS methodology in evaluating trauma care in developing countries. Hariharan et al. (2009) claim that the TRISS is a fair discriminator in the study case mix with an area under the curve of 0.82 (95% confidence interval 0.69-0.96). There is a considerable disparity between predicted and observed outcomes when trauma patients are evaluated by the TRISS methodology in such settings.

In intubated patients, RTS is not available for the calculation of probability of survival (Ps). For this group of patients, they are either excluded from the TRISS or there is a need to use the modified score or pre-hospital vital signs (Voskresensky et al., 2009).

The TRISS method has the disadvantage of a low sensitivity of 60% for blunt trauma, resulting in a high rate of unexpected deaths. The reasons for this are the underestimation of head injuries, multiple injuries to one body region, and a failure to take full account of the individual patient's age (Oestern & Kabus, 1994).

The probability of survival among the patients examined by Michiue et al. (2009) was estimated at 0.60-0.99, suggesting that their deaths were preventable. However, there are difficulties in the clinical diagnosis of potentially fatal injuries, and autopsy reports may not be available for deceased patients.

Demetriades et al. (1998) measure the performance of the TRISS by the percentage of misclassifications, including false positives and false negatives, in comparing the survival status predicted by the TRISS with the patients' true status. The study finds that the overall misclassification rate was 4.3 per cent. However, in many subgroups of patients with severe trauma, the misclassification rate was very high.

In a later study, Demetriades et al. (2001) also evaluate the role of the TRISS in comparing outcomes between a small and a large trauma centre and assess its usefulness in various groups of patients. The evaluation of the

TRISS survival predictions in various subgroups of patients show a high misclassification rate in patients with severe trauma, with the rate being higher than 25% for some groups. The authors conclude that the TRISS methodology is not a reliable tool for comparing outcomes between trauma centres and leads to an unacceptably high misclassification rate in patients with severe trauma.

2.4.3 A Severity Characterization of Trauma (ASCOT)

The shortcomings of the TRISS method are well-known and a number of scholars have attempted to modify the model by stratifying for age and adding other parameters such as comorbidities, alcohol consumption, gender, and serious injury scores (Begeron et al., 2006, Millham et al., 2004, Champion et al., 1996).

Over the years, many different modifications have been made to the original trauma scores. The A Severity Characterization of Trauma (ASCOT) measure (Champion et al., 1996), the Trauma Audit Research Network database, and the National Trauma Data Bank provide various international standards for comparing data from contributing hospitals.

Based on data for 14,296 patients admitted to four well-recognised trauma centres, Champion et al. (1996) developed the ASCOT measure, which more precisely describes anatomic injuries and improves the degree of calibration with actual outcomes. The ASCOT measure is calculated on the basis of the

Glasgow coma score (GCS), systolic blood pressure (SBP), the respiration rate (RR), an abbreviated injury scale (AIS) score of > 2, and age. The ASCOT method, in which the ISS is replaced by the patient's anatomic profile and the age of the patient is given more consideration, produces results that are hardly better in spite of the somewhat time-consuming nature of the method (Oestern & Kabus, 1994). Some studies show that the ASCOT method is considered to be superior to the TRISS in evaluating Ps (Hou & Tsai, 1996; Zhu & Jiang, 1998; Rabbani & Moini, 2007).

A retrospective cohort study based on data for 91,112 patients admitted to 69 hospitals between 2000 and 2001 held in the National Trauma Databank (Glance, 2005) uses the TRISS and ASCOT methods to calculate the ratio of the observed to expected mortality rate (the O/E ratio) for each hospital. The TRISS and ASCOT measures disagree on the outlier status of 35 of the 69 hospitals and exhibit substantial disagreement on the identity of quality outliers within the NTDB.

2.4.4 W Statistic

An institution's trauma survival rate can be compared with that predicted by the TRISS method using a definitive outcome-based evaluation protocol. Younge et al. (1997) claim that comparison of trauma survival rates between institutions and reference databases is hampered by different injury severity mixes. Hollis et al. (1995) point out that the M statistic fails to identify any mismatch in injury severity. The W statistic is clearly inappropriate for comparing the performance of institutions with different injury severity mixes, and the M statistic is not adequate for detecting potentially important differences in injury severity mixes. The authors introduced W_s, a measure standardised with respect to injury severity mix, to allow for more accurate comparisons between different institutions.

The trauma and injury severity score methodology over-predicts survival in certain Ps intervals. To overcome this problem, a standardised comparison using a stratified W statistic (W_s) has been proposed (Hollis et al., 1995). W_s enables comparison, but does not represent the actual survival rate at an institution, although it is useful for comparing the performance of different centres.

W_s is a standardisation method that allows for comparison between hospitals and employs a prediction database. W_s represents the W score that would have been observed in the institution if the case mix of injury severities were identical to that of the prediction database. The significance of W_s can be assess using Z_s. Z_s can be compared to a standard normal distribution; hence, $Z_s < -1.96$ indicates that W_s is significantly less than zero and $Z_s > 1.96$ indicates that W_s is significantly greater than zero.

A 95% confidence interval can be calculated for W_s by using W_s and its standard error (SE).

$$95\% \text{ CI for } W_s = W_s \pm 1.96 \text{ SE } (W_s)$$

Confidence intervals are used to graphically illustrate the magnitude of W_s and its direction, accuracy, and statistical significance.

2.5 The Impact of Trauma Systems

Experience and research have shown that trauma-related morbidity and mortality can be reduced by the introduction of organised trauma systems (Sampalis et al., 1999).

In 1995, states in the US with trauma systems had a 9% lower mortality rate than those without (Nathens et al., 2000). The effect of trauma systems is evident in the analysis of MVC deaths, in which a 7% reduction in the death rate was identified (Nathens et al 2000). Population-based evidence supports a 15 to 20% improvement in the survival rate among seriously injured patients as a result of trauma system implementation (Mullins et al., 1999).

The results of a meta-analysis of 14 published articles show that trauma systems improved the odds of survival in 8 of the 14 studies examined. The presence of a trauma system led to a 15% reduction in mortality (Celso et al., 2006).

Shafi et al (2009) find that similarly designated trauma centres do not achieve similar outcomes despite the presumed availability of similar resources and that not all designated trauma centres achieve similar results. Considerable variations in risk-adjusted mortality rates exist across similarly designated trauma centres. The adjusted OR of survival was significantly different from the crude OR of survival at 6 of the 14 trauma centres investigated. Such variability in outcomes may reflect variations in quality of care, and reasons for this discrepancy should be explored.

In an earlier study, Shafi et al. (2008) find that for mild injuries, the survival rate at five centres (11%) was significantly worse than that achieved at their counterparts. With increasing injury severity, the percentage of outcome disparities increased (in 15% of centres for moderate injuries and 21% of centres for severe injuries) and persisted in subgroups of patients with head injuries, patients sustaining penetrating injuries, and older (> 55 years) individuals.

Trauma systems improve survival rates in injured patients in Norway (Lansink & Leenen, 2007). Mortality was reduced by 15-25% when severely injured patients were treated at a trauma center (Lansink & Leenen, 2007).

Liberman (Liberman et al., 2005) surveyed 59 hospitals in the province of Quebec, Canada, finding that tertiary trauma centres were associated with a reduction in risk-adjusted mortality in comparison with both primary and secondary centres.

Peleg (Peleg et al., 2004) examine a retrospective cohort for the impact of Israel's national trauma system from 1997 to 2001. They find a steady but significant reduction in the inpatient death rate among major trauma patients (ISS $\geqq$ 16) hospitalised at level I trauma centres in Israel, falling from 21.6% to 14.7%.

A study of the statewide system of trauma care introduced in Victoria, Australia in 2000 finds that there was a significant overall reduction in the risk of death for patients treated in the trauma system (Cameron et al., 2008).

After the trauma system in the Netherlands was implemented, in-hospital mortality for all injured patients decreased from 2.6% to 2.3% (OR: 0.89 with 95% CI: 0.80-0.98). Implementation of an inclusive trauma system in the Netherlands resulted in a more efficient triage system for trauma patients among hospitals and was associated with a substantial and statistically significant reduction (16%) in the risk of death (Twijnstra et al., 2010)

2.6 The Development of the Hong Kong Trauma System

Hong Kong did not have a trauma care system in the 1990s (Ho & Yuen, 2003). In 1994, American Professor Donald Trunkey was invited to review the trauma service in Hong Kong. He suggested that Hong Kong needed to develop a trauma system, establish trauma centres, enhance intensive care unit (ICU) facilities, and provide resources to develop trauma services.

In 1996, the Queen Elizabeth Hospital (QEH) established the first trauma care system in Hong Kong that included a trauma team, trauma team activation criteria, a trauma high dependence unit, a trauma registry, performance improvement programmes, trauma service audit committees, and monthly morbidity and mortality meetings on trauma care (Ip & Ho, 2000). The Queen Mary Hospital (QMH) also established a similar trauma system in 1997 and employed the first trauma nurse coordinator in Hong Kong in 1998 (Ho & Yuen, 2000). In the same year, the Prince of Wales Hospital (PWH) also developed as a trauma centre (Rainer & De Villiers, 2003; Trauma Advice Committee of Prince of Wales Hospital, 2003).

In 2000, the Hospital Authority conducted a major review of trauma services and surveyed 14 acute hospitals in Hong Kong (Hospital Authority, 2000). It found that multi-disciplinary trauma teams provided trauma care in 10 of the 14 acute care hospitals operated by the Hospital Authority (HA). In 2000, the number of trauma admissions in each hospital ranged from 1,099 to 6,605 and the number of trauma deaths per hospital was between 2 and 71. The HA also invited a group of visiting expert panelists from the US, the UK, Canada, and Australia to advise on trauma services. They suggested that a system of trauma care comprising a functioning network of trauma care organisations and facilities was required to provide the full spectrum of definitive care to all trauma patients. The volume of trauma patients in Hong Kong justified only two or three level I trauma centres due to the density of the local population and the resources available (Hospital Authority, 2000).

In response to the surgical review, the Hospital Authority Head Office (HAHO) set up a Trauma Working Group to lead the development of trauma services in Hong Kong. It formulated a blue plan on the short-term, medium–term, and long-term development of the Hong Kong trauma system (Hospital Authority, 2000).

The Trauma Working Group also reviewed surgical services in Hong Kong as a whole. With reference to the concepts proposed by the Committee on Trauma of the American College of Surgeons (1998), it recommended that the trauma system begin with an emergency medical system and later be extended to include a rehabilitation facility. It also advised that each trauma centre should develop and conduct a trauma prevention programme (Hospital Authority 2001). The development of pre-hospital trauma care also mandated the introduction of a fully integrated emergency medical system with personnel trained to implement protocols to guide patient care, direct triage, and ensure the prompt transportation of patients to the nearest appropriate trauma centre. Moreover, it underlined the necessity of maintaining a trauma registry and of regularly analysing and reporting on patients' functional outcomes, quality of life, and mortality (Hospital Authority, 2001).

In 2002, the HA conducted a paper survey of all trauma patients brought to accident and emergency departments (AEDs) by ambulance. This was aimed at assessing the caseload impact of bypassing AEDs and at testing the accuracy of ambulance crew diversions. The results, finding that the over-triage rate was 56.5% and the under-triage rate was 1.7%, were reviewed by senior emergency physicians. The caseload projection was that 8% of trauma patients would be diverted. In the following year, the HA and the Fire Service Department (FSD) conducted a pilot ambulance diversion programme in the New Territories East Cluster (NTEC).

The Hospital Authority designated five trauma centres in 2003. These five trauma centres are the PWH, the QEH, the QMH, the Tuen Mun Hospital

(TMH) and the Princess Margaret Hospital (PMH). Individual hospitals established their own trauma care systems and formed a multi-disciplinary trauma advisory committee or trauma service committee. They sought to improve trauma care outcomes by the introduction of multi-disciplinary trauma teams, trauma call activation protocols, the employment of trauma nurse coordinators, the establishment of trauma registries, advanced trauma life support training, the development of trauma management guidelines, regular tertiary surveys, multidisciplinary trauma audit meetings, and the implementation of primary trauma diversion strategies.

In 2004, the HAHO Central Committee was established and comprises representatives from the departments of anesthesia, accident and emergency, diagnostic radiology, intensive care, neurosurgery, orthopedic surgery, and surgery, as well as representatives of the 5 trauma centers, the medical director of the ambulance service, and trauma nurse coordinators.

Although Hong Kong has attempted to build up its trauma care system according to the criteria suggested by Committee on Trauma of the American College of Surgeons, there are some difference between the systems in place in Hong Kong and the US. The first is that Hong Kong does not have an accreditation system for trauma centres. Instead, trauma centres are designated by the Hospital Authority. Second, there are no trauma surgeons in Hong Kong. Trauma patients are first resuscitated in the trauma room by an ED physician and the trauma team. Relevant specialists become involved according to the injuries sustained by the patient.

2.6.1 Issues Arising from the Hong Kong Trauma System

The Clinical Outcomes of the Trauma System

Hong Kong's trauma care system has been established since 2003; there is a need to monitor trauma care outcomes. To improve the quality of care, it should be possible to compare performance data from different institutions based on an internationally accepted standard. The trauma registry system was set up to secure quality assurance in trauma care. It provides data for continuous monitoring, quality assurance, and trauma-related research. Trauma scores also serve as instruments of quality control for the systematic comparison of patients and institutions. The reviews undertaken attempt to demonstrate that the trauma care system improves patient outcomes. The TRISS method is the approach most commonly adopted and serves as the benchmark for outcome measurement and international comparison.

As noted above, although Hong Kong has sought to build up its trauma care system according to the criteria proposed by the Committee on Trauma of the American College of Surgeons, the Hong Kong system is somewhat different from its US counterpart. Hong Kong does not have an accreditation system for trauma centres. Hong Kong's trauma centres are designated by the Hospital Authority and their criteria, infrastructure, levels, and trauma volumes are different to those of the US or Australian system. In addition, there are no trauma surgeons in Hong Kong and trauma patients are first resuscitated in a trauma room by an ED physician and the trauma team before being seen by the relevant specialist(s). The characteristics of the trauma population may also be different to those of other countries. Patients' age, gender, and causes of injury have consequences for comorbidity and may affect patient morbidity. Administrative and clinical components also have a great impact on the outcomes of trauma care. The outcomes of the Hong Kong trauma care system remain unclear despite the strong need to monitor them.

Primary Trauma Diversion

In Hong Kong, the Hong Kong Government provides the ambulance service through the Fire Service Department. Ambulance crews generally deliver patients to the nearest hospital. There is also a lack of direct communication between ambulance crews and the receiving hospital. Other than in mass casualty incidents, there is no field triage. In 2003, a primary trauma diversion strategy was implemented in Hong Kong. Prior studies have shown that the reduction in pre-hospital times achieved by transporting severely injured patients from the scene directly to a trauma centre is associated with a reduction in mortality and morbidity (Sampalis et al., 1997; Sampalis et al., 1999; Mackenzie et al., 2003; Hoff et al., 2004; Leppaniemi, 2008). Neither the clinical impact of primary and secondary trauma diversion in Hong Kong nor their influence on the time taken to deliver the patient to definitive care is known.

Trauma Teams

Trauma teams in Hong Kong are not activated by the ambulance crew before the patient arrives at the hospital. When a trauma patient arrives at a trauma centre, the AED doctor in charge decides on the necessity of activating a trauma call according to the activation criteria. The trauma team generally includes an emergency physician, a surgeon, an orthopedic surgeon, an anesthesiologist, an intensive care physician, a trauma nurse coordinator, and nurses from the emergency department (ED). However, the members of trauma teams and trauma call systems vary across different hospitals. For example, the QEH team includes a radiographer and the TMH team includes a neurosurgeon. There is no trauma surgeon specialist who acts as team leader and the trauma team leader is not necessarily a surgeon. For example, the TMH trauma team leader is an on-call ICU physician and the PWH trauma team leader is an ED specialist in charge or general surgeon. Prior studies have associated trauma teams with improved trauma patient outcomes (Wong et al., 2003; Oakley et al., 2004). Trauma teams are regarded as one of the key components of a trauma system. However, whether the presence of a trauma team makes a difference to mortality is unknown.

The Role of Trauma Nurse Coordinators

All trauma centres in Hong Kong have established a trauma registry to monitor and collect feedback on the management processes for and outcomes of major trauma patients across all healthcare providers. The trauma nurse coordinator is responsible for data collection and analysing trauma registry data and trauma quality improvement programmes.

For the first time, Hong Kong has full-time trauma nurse coordinators responsible for maintaining trauma registries and conducting trauma audits. However, the role of the trauma nurse coordinator is new and is not clear to others.

Effectiveness of Clinical Guidelines

In Hong Kong, many new trauma guidelines and educational programmes have been initiated to improve the quality of care. The aim is not only to improve the trauma patient's chance of survival, but also to improve the process of care. For example, spinal boards have been widely used for spinal immobilisation in significant blunt injuries. Some studies have addressed patient discomfort and the potential harmful consequences of the prolonged use of a spinal board (Chan et al., 1996; Lovell & Evan, 1992; March et al., 2002; Morris et al., 2004; Porter & Allison, 2003). Guidelines on early removal of the spinal board have been implemented and educational programmes have been conducted. However, the outcomes of these programmes are unknown and their effects have yet to be measured.

Elderly Trauma

The elderly population is growing rapidly in Hong Kong, with the proportion of the Hong Kong population aged 55 or older increasing to 22.1% in 2006 (Hospital Authority, 2006). Life expectancy in Hong Kong is 79.4 years for males and 84.3 years for females (Census and Statistics Development, 2006). The aging population in Hong Kong presents a challenge to the health care system, yet there is little local data on older trauma patients. A better knowledge of the spectrum and epidemiology of older trauma patients is needed to guide prevention programmes and the evaluation of trauma management.

Gender Impacts in Traumatic Brain Injuries

Traumatic brain injuries (TBI) are the most common form of life-threatening injury after trauma and are a major cause of disability and mortality worldwide (Utomo et al., 2009, MRC Crash Trial Collaborators, 2008; Tagliaferi, 2006; Wong et al., 2010; Yates, 2006). Head injuries are common in Hong Kong (Poon et al., 1992; Hsiang et al., 1996; Poon & Li, 1991) and 49% of trauma patients have sustained head injuries (Cheung et al., 2007). However, it is not clear whether women with TBI have better outcomes than men or whether there is any association between gender and brain edema.

Injury Prevention

Cycling is both a popular leisure activity and an important means of transport in Hong Kong, mostly in the New Territories (Hong Kong Police Force, 2006). Data from the Transport Department of the Hong Kong Government show that 1,500 to 1,800 bicycle-related accidents are recorded annually, with school age children and young adults being the groups most frequently involved in bicycle accidents (Transport Department, 2008). However, the severity and pattern of bicycle injuries and the mortality rate among cyclists remain unknown in Hong Kong.

2.7 Research Questions

Based on the foregoing discussion of the background to this thesis and the literature review, a number of important questions concerning the trauma system arise:

1. Is there any significant difference in the survival rate before and after the trauma care system was set up?
2. Does the trauma system result in progressive improvement in the survival rate?
3. What are the clinical impacts of primary and secondary trauma diversion?
4. Do trauma teams make a difference to the patient survival rate?
5. What is the role of trauma nurse coordinators in the trauma system?

6. What are the effects of an educational programme for ED staff and a clinical protocol for early removal of the spinal board?
7. Is there any association between gender and mortality in traumatic brain injury patients aged between 12 and 45?
8. Is there any association between gender and brain edema in the same group of patients?
9. What is the epidemiology of major injury patterns and predictors of mortality in elderly patients in Hong Kong?
10. What is the epidemiology of bicycle-related injuries in patients presenting to the Prince of Wales Hospital?
11. Is there any difference in the outcomes of bicycle-related injuries between patients aged > 15 years and patients aged ≤ 15 years?
12. Is there any difference in the clinical outcomes of major trauma patients between Hong Kong, China and Victoria, Australia?

Chapter 3

An Evaluation of the Effect of a Trauma System on Mortality

3.1 Introduction

Hong Kong is an international city with a population of 7,026,400 people (Census and Statistics Department, 2010). Trauma is the leading cause of death in those aged 15 to 44 and is the sixth leading cause of death across the whole population (Hospital Authority, 2008). In 2009, a total of 329,177 injured patients attended an accident and emergency department and a total of 1,854 patients died due to external injuries in 2008 (Hospital Authority Statistical Report, 2009). Apart from those who died from trauma, a significant proportion of these patients may have suffered permanent disabilities. In terms of years of productive life lost, prolonged or permanent disability, and cost, trauma is recognised as one of the most important threats to public health and safety (Committee on Trauma, American College Surgeons, 2006).

Hong Kong is seldom hit by natural disasters such as earthquakes, tsunamis, or hurricanes, but its populace does experience serious incidents such as falls, motor vehicle crashes (MVC), burns, and other domestic injuries. Prior investigations have shown that motor vehicle crashes and falls are the most common causes of trauma (Cameron, 2004; Rainer et al., 2000). Head injuries are very common, with more that 9,000 patients with such injuries being admitted to a single hospital between 1989 and 1993 (Poon et al., 1992; Hsiang et al., 1996). However, neurosurgery and some other specialties such as cardiothoracics and burns are not available in all acute hospitals. In hospitals without such specialist services, trauma patients are not admitted and are instead directed to the closest acute hospital (Rainer & Smit, 2003).

Prior investigations show that delayed traumatic extradural hematomas are not a rarity (Poon et al., 1992) and find a significant increase in mortality and morbidity among secondary referred patients with traumatic extradural hematomas (Poon & Li, 1991; Härtl , 2006). Other studies (Kam et al., 1998; Rainer, 1998) show that too many preventable deaths occur and that the mortality rate in Hong Kong is much higher than the norm observed in the major trauma outcome study (MTOS) in North America.

As noted earlier in this thesis, Hong Kong has tried to build up a trauma care system on the basis of the criteria of the American College of Surgeons Committee on Trauma, although there are some differences between the Hong Kong system and that in place in the US. These differences are seen in Hong Kong's lack of an accreditation system for trauma centres, in the designation of centres by the Hospital Authority, and in the criteria, infrastructure, pre-hospital care, levels, and volume of trauma patients treated. The members of trauma teams are completely the same as their United States or Australian counterparts.

Experience and research has shown that trauma-related morbidity and mortality can be reduced by the introduction of organised trauma systems

(Sampalis et al., 1999; Nathens et al., 2000; Oakley et al., 2004; Mackenzie et al., 2006; Celso et al., 2006). On the other hand, a population-based study (Shafi et al., 2006) claims that trauma systems are not independent predictors of mortality. Many factors cause the mortality rate to fall and a reduced mortality rate cannot be attributed solely to the presence of a trauma system. Clay (2001) finds that overall mortality rates were higher in the post-system period (8.3%) than in the pre-system period (6.7%), but not significantly. However, Clay's study monitored level-3 and level-4 trauma centres rather than major trauma centres.

In most countries, systematic trauma registries were not available until their trauma systems had been set up. Only a few studies have analysed the outcomes of trauma systems before and after their implementation. A recent study (Twijnstra et al., 2010) monitored an inclusive trauma system in The Netherlands. However, it evaluates both severely and less severely injured patients and their outcomes are not compared with the MOTS benchmark.

No published investigation has formally examined mortality before and after the implementation of a trauma system in Hong Kong. The effects and outcomes of the newly developed trauma service in Hong Kong are unknown and there a very limited number of studies consider trauma services in Hong Kong. If the trauma system has been successful, its outcomes should demonstrate that the overall survival rate has improved.

A recent study (Leung et al., 2010) monitored the outcome of the trauma system in Queen Mary Hospital. The authors use the W score to monitor the survival rate, but this measure uses the coefficients of the injury severity score (TRISS) of the MOTS database compiled 20 years ago. Even the authors were aware of the "vastly different case-mix" reflect in the W_s standard with respect to injury severity mix, but did not produce more accurate comparisons between different institutions to overcome this problem.

3.2 Aim and Hypotheses

The aim of this study was to evaluate whether the trauma care system in Hong Kong improves trauma care.

Two hypotheses were proposed:

Hypothesis 1. The mortality rate did not change after the PWH set up its trauma care system;

Hypothesis 2. The trauma system did not result in progressive improvement in the survival rate.

We expected to reject the null hypotheses.

3.3 Methods

3.3.1 Setting

The PWH is a university teaching hospital with 1,450 beds and is the regional major trauma centre for the New Territories East Cluster in Hong Kong. The emergency department (ED) has an annual attendance around 160,000 patients per annum. The trauma registry and trauma system of the PWH were established in 2001. The inclusion criteria for the trauma registry are listed in Appendix 1. Approximately 500 trauma patients per annum are included in the trauma registry. This was a single centre trauma registry study for which the data used were collected prospectively from the trauma registry database of the Prince of Wales Hospital (PWH).

3.3.2 Patients

Two groups of patients were recruited for the study.

The first group of patients comprised trauma patients who attended the PWH ED between January 1997 and June 1997 before implementation of the trauma system. The second group of patients was made up of trauma patients who attended the PWH ED between January 2001 and December 2009 after the trauma system was established. The inclusion criteria for both groups were the same as the trauma registry inclusion criteria.

Ethical approval was obtained from the local institutional Research Ethics Committee.

3.3.3 Data and Analysis

The data from January to June 1997 of all trauma cases presenting to the resuscitation room at the Prince of Wales Hospital were retrospectively collected by a doctor who was a university lecturer who was interested in trauma care. Comprehensive patient characteristic information and injury severity data were collected for each consecutive patient for analysis. Resuscitation room logbooks were checked for the entire six month period to ensure no cases were missed (Rainer et al., 2000). Anatomical injuries were categorized according to the Abbreviated Injury Scale (AIS) 1990 revision. The Injury Severity Score (ISS) scoring system was employed to determine the severity of injury. The Ps, W score and Ws score of the 1997 cohort were calculated based on the 1995 MTOS coefficients which are same as 2001-2009 cohorts. The sample size of 1997 cohort is much smaller than the 2001-2009 cohorts as the trauma registry was not yet developed at that time.

Demographic data collected included age, sex, comorbidity, and injury mechanism. The initial Glasgow coma score (GCS), systolic blood pressure (SBP), and respiratory rate (RR) were all determined from the first emergency department (ED) measurements.

The mode of patient transfer, either primary or secondary transfer, was included in the analysis, as was length of intensive care unit (ICU) stay and overall hospital length of stay (LOS). Trauma call activation, admitting specialty, operative procedure, length of stay (LOS) in the intensive care unit (ICU) and in the hospital, injury severity score (ISS), revised trauma score (RTS), mortality, and probability of survival (Ps) were also analyzed.

The injury severity scores (ISS) and abbreviated injury scores (AIS) for different body regions were used to determine injury severity. The probability of survival (Ps) for each patient was calculated according to the TRISS method using American data coefficients (Boyd et al., 1987; Champion, 1995) and under the ASCOT methodology (Champion et al., 1996).

The TRISS coefficients for equation were based on the 1995 update of the MTOS (Champion et al., 1995, Champion, 2002) and AIS 98 was used in this study.

The Z statistic was used to indicate statistical differences between the actual number of survivors and the predicted number of survivors based on the baseline. An absolute value of Z exceeding 1.96 indicated a significant difference at the 95% confidence level. The M statistic was used to measure the similarity of the injury severity mix to the prediction database. $M < 0.88$ indicated a disparity in the severity match between groups. The W statistic indicated the number of excess survivors per 100 patients in comparison with the prediction. The W score was used to compare the mortality rate in time periods with an organised system of trauma care with the rate in time periods in which so such system existed. The results were expressed as the W score for each year after system implementation in comparison with expected mortality in a period in which no trauma system existed.

W_s is the standardisation method that allows for comparison between hospitals and in which a prediction database is used to compare the outcome of the study population with the MTOS. A 95% confidence interval can be calculated for W_s by using W_s and its standard error (SE). A 95% confidence interval is calculated on the basis of the equation

95% CI for $W_s = W_s \pm 1.96$ SE (W_s)

Graphically displaying the standardised distribution with a 95% confidence interval illustrates the magnitude of W_s in terms of its direction, accuracy, and statistical significance.

3.4 Results

3.4.1 Age and Gender

A total of 4,458 patients had their details recorded in the trauma registry between 2001 and 2009. The numbers of patients per year is shown in Figure 3.1. There were 1,262 (28.3%) female patients and 3,196 (71.7%) male patients during this period. The ratio of males to females over the years did not differ significantly ($p = 0.683$). The average number of trauma patients per year was 495. Three hundred and sixty (28.5%) female patients and 661 (20.7%) male patients had comorbidity on admission ($p < 0.001$).

The mean age of the overall sample was 41.54 years, ranging from 0 years to 99 years. The mean age of female patients was 44.69 ± 25.16 years, older than the average male patient who was 40.29 ± 19.21 years old ($P < 0.001$). More female (57.2%) than male patients were older than 74 ($P <0.001$). The distributions of age and gender are shown in Figure 3.2. There was a correlation between the percentage of elderly patients (age ≧ 65 years) and year ($p = 0.007$).

Figure 3.1 Number of patients per year

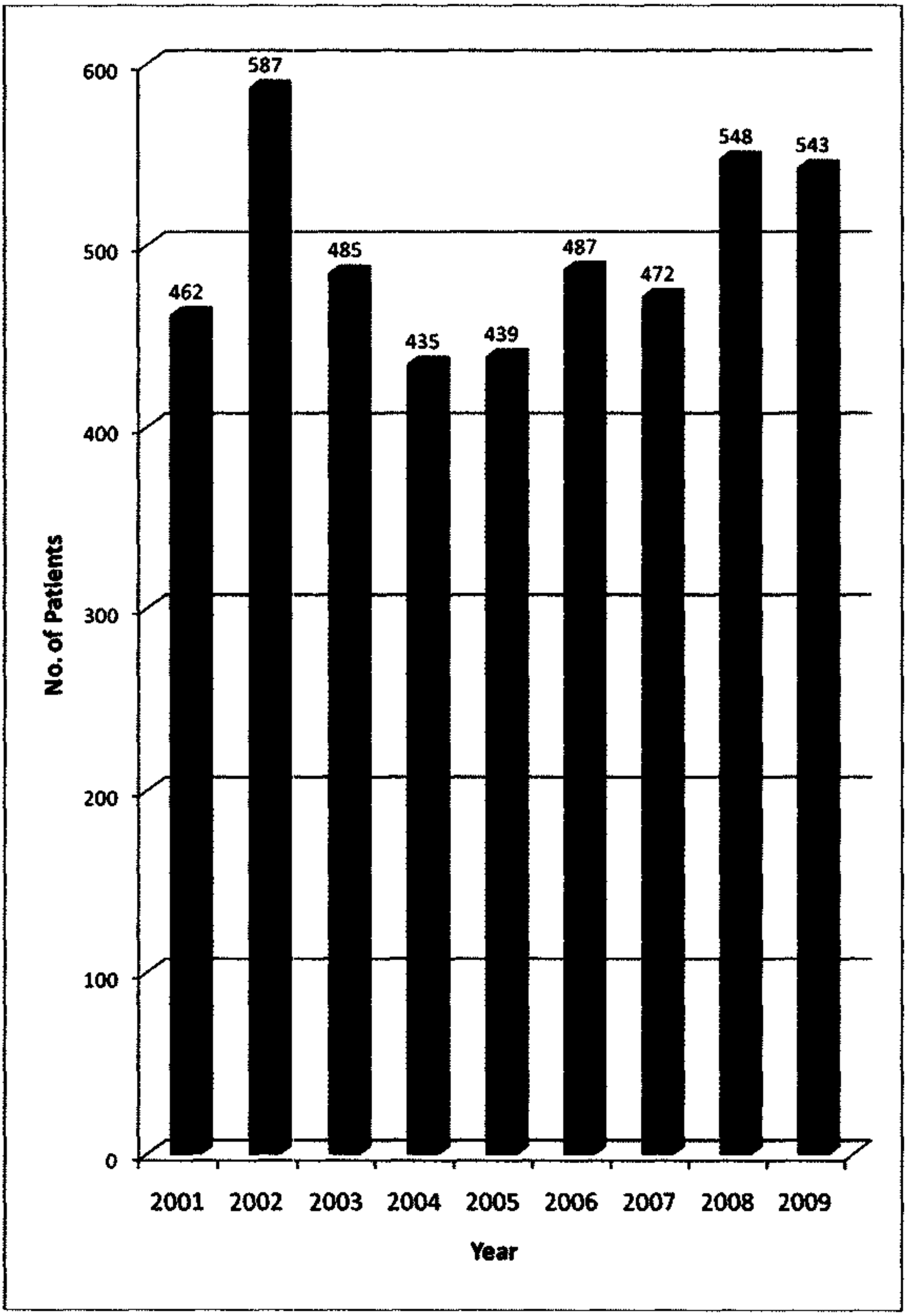
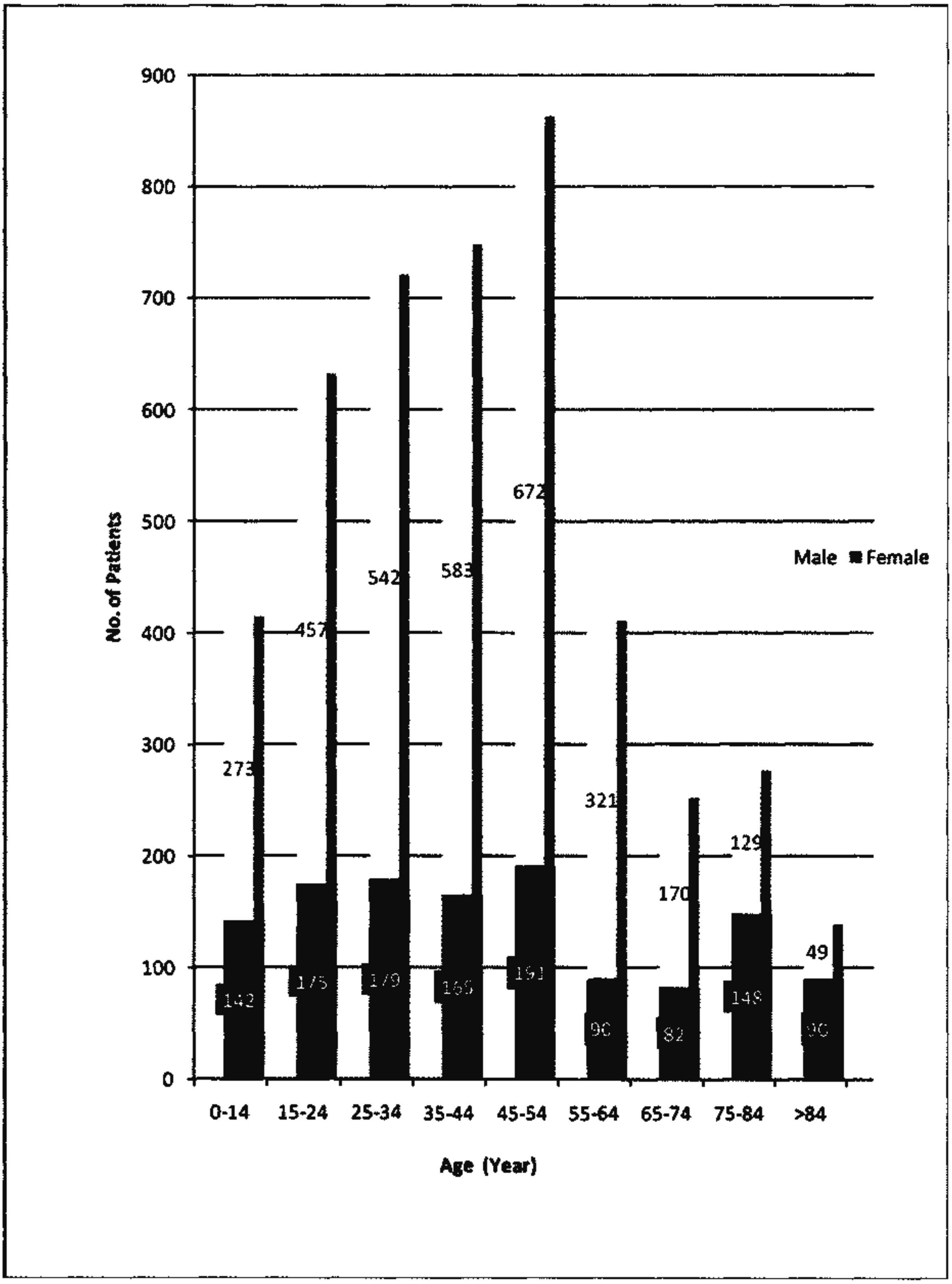


Figure 3.2 Age and gender distributions



3.4.2 Types and Mechanisms of Injury

The most common type of injury was blunt injuries (3,908, 87.7%), followed by burns (285/445, 6.4%) and penetrating injuries (265, 5.9%). Motor vehicle crashes were the cause of 1,738 injuries, or 39.0% of the total; 1,293 (29.0%) patients were injured in falls. Three hundred and four (6.8%) patients had suffered bicycle-related injuries and 291 (6.5%) were burn patients. The patients' injury mechanisms are shown in Figure 3.3.

The injury mechanisms among each age group were significantly different ($P < 0.001$). There were more burn patients among those aged 0-14 (17.8%). Low falls were the most common injury mechanism in patients aged 55 or above. Pedestrians hit by motor vehicles were the second most common injury mechanism in patients aged 65 or above (Figure 3.4).

Injury mechanisms changed significantly between 2001 and 2009 ($P < 0.001$). The percentage of passenger injuries gradually decreased from 13.2% in 2001 to 8.3% in 2009. However, the percentage of patients injured in low falls increased from 67/462 (14.5%) in 2001 to 102/543 (18.8%) in 2009. In 2009, more patients were injured due to high falls. The number of pedestrian injuries was higher in 2001 and 2002 than in other years (Figure 3.5).

Differences were apparent in the injury mechanisms of males and females ($P < 0.001$). In females, 27% sustained their injuries because of a low fall, 17.4% were motor vehicle passengers, and 16.7% were pedestrians. In males, the most common injury mechanism was low falls (15.1%), followed by motor vehicle drivers (14.4%) and high falls (11.4%) ($p < 0.001$). The details are shown in Figure 3.6.

3.4.3 Injury Severity Score (ISS)

The injury severity score (ISS) ranged from 1 to 75. A total of 3,084 (69.2%) patients suffered minor trauma (ISS < 15) and 1,374 (30.8%) suffered major trauma (ISS > 15). The ISS distribution is shown in Figure 3.7. The distribution of scores on the abbreviated injury scale (AIS) is shown in Figure 3.8.

3.4.4 Injury Severity and Head Injuries

The distribution of injuries across different body regions showed that head injuries were the most common severe injury in the study population (Figure 3.9). A total of 1,749 (39.2%) patients suffered a head injury. The number and percentage of head injuries increased, but did not reach a statistically significant level ($p = 0.31$). The details are shown in Table 3.1.

Figure 3.3 Injury mechanisms

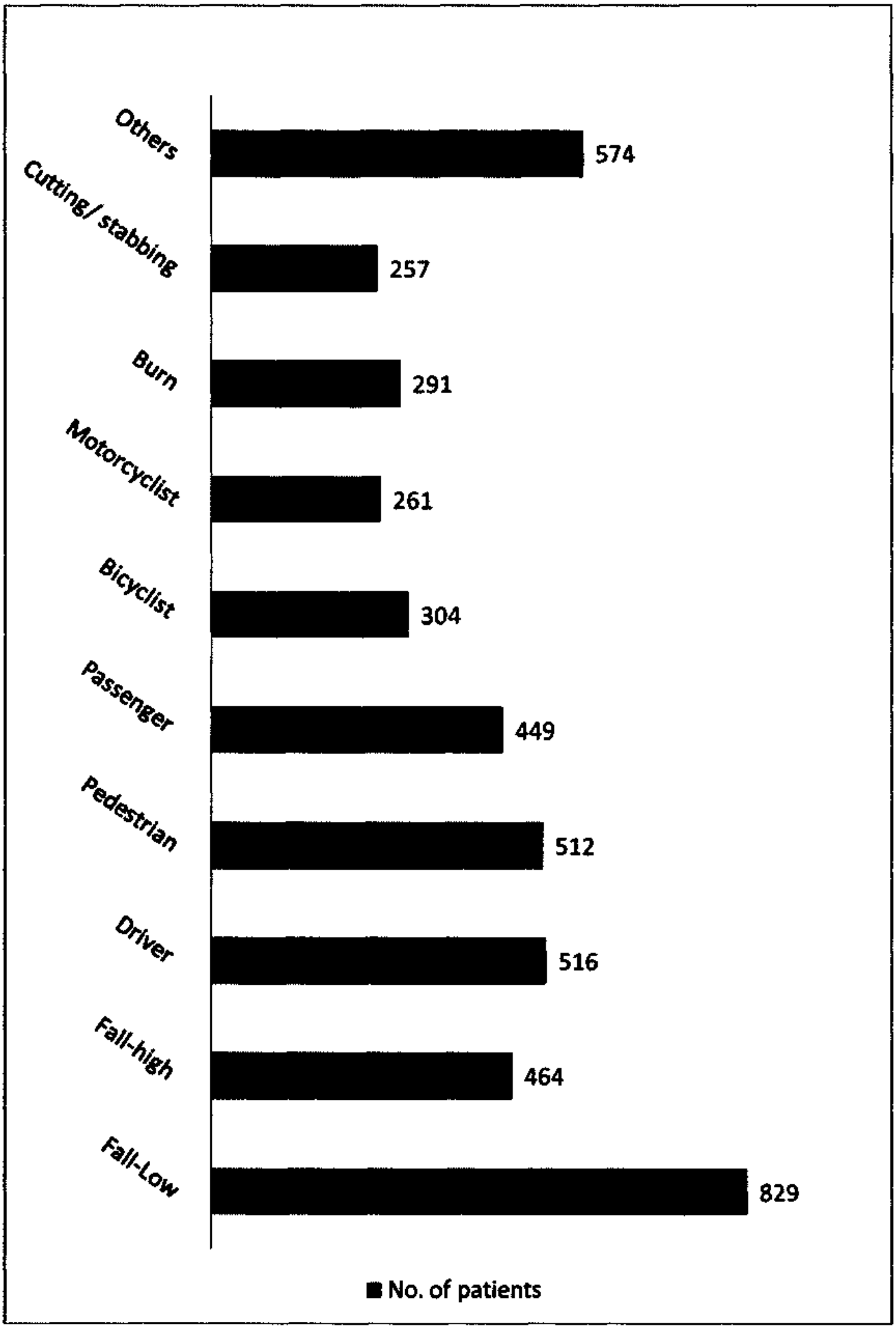


Figure 3.4 Injury mechanisms and age groups

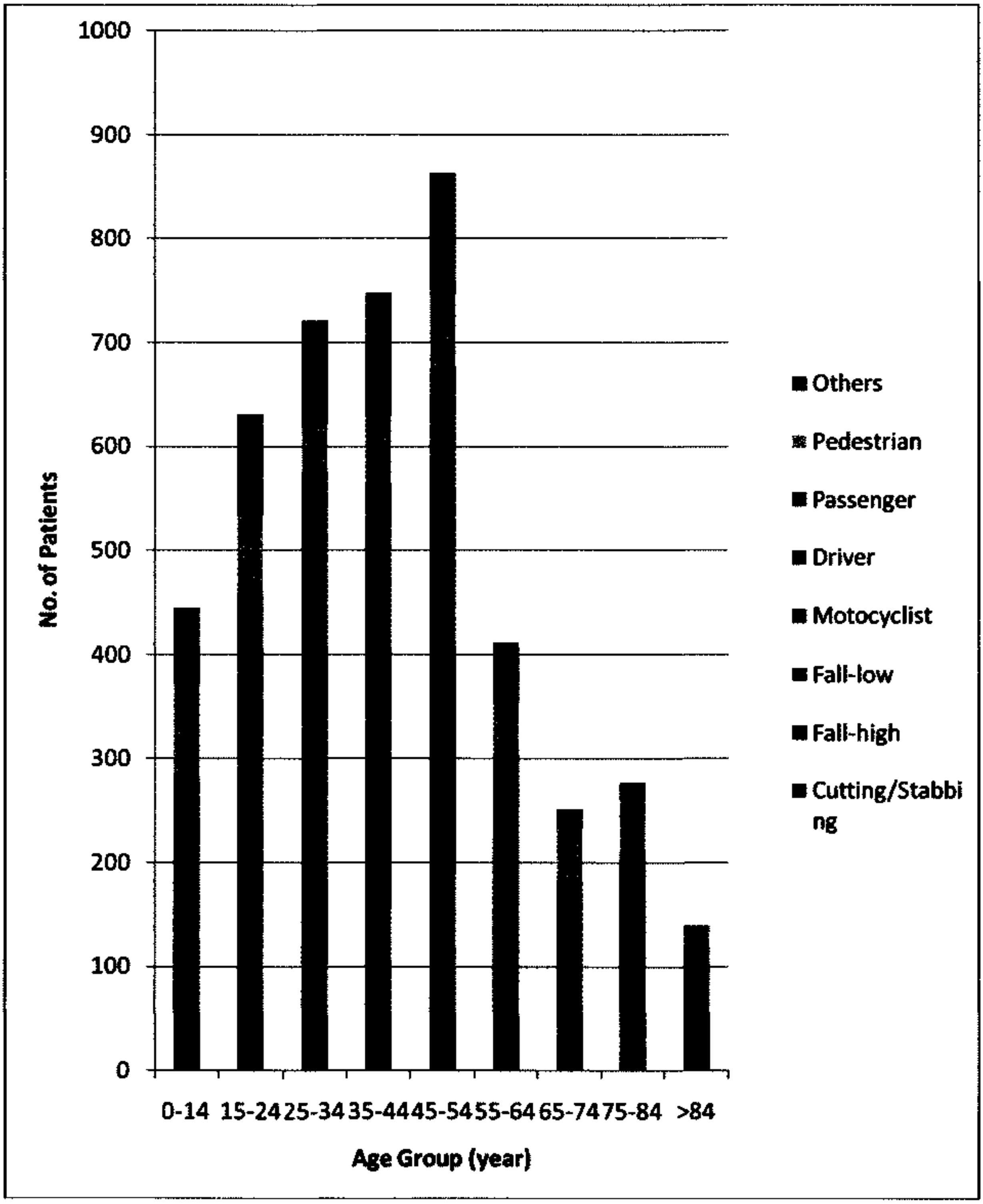


Figure 3.5 Injury mechanisms (2001-2009)

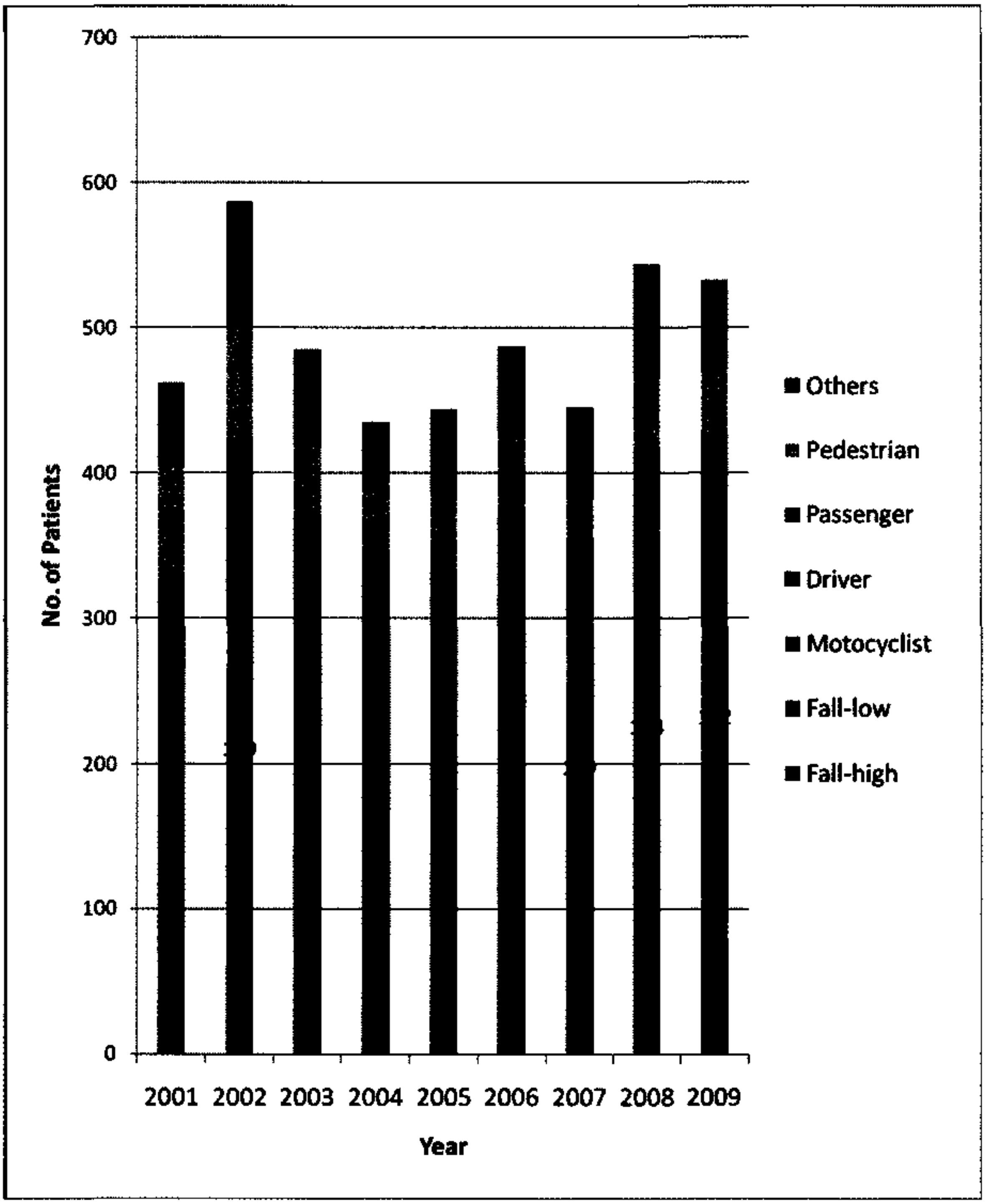


Figure 3.6 Injury mechanisms in males and females

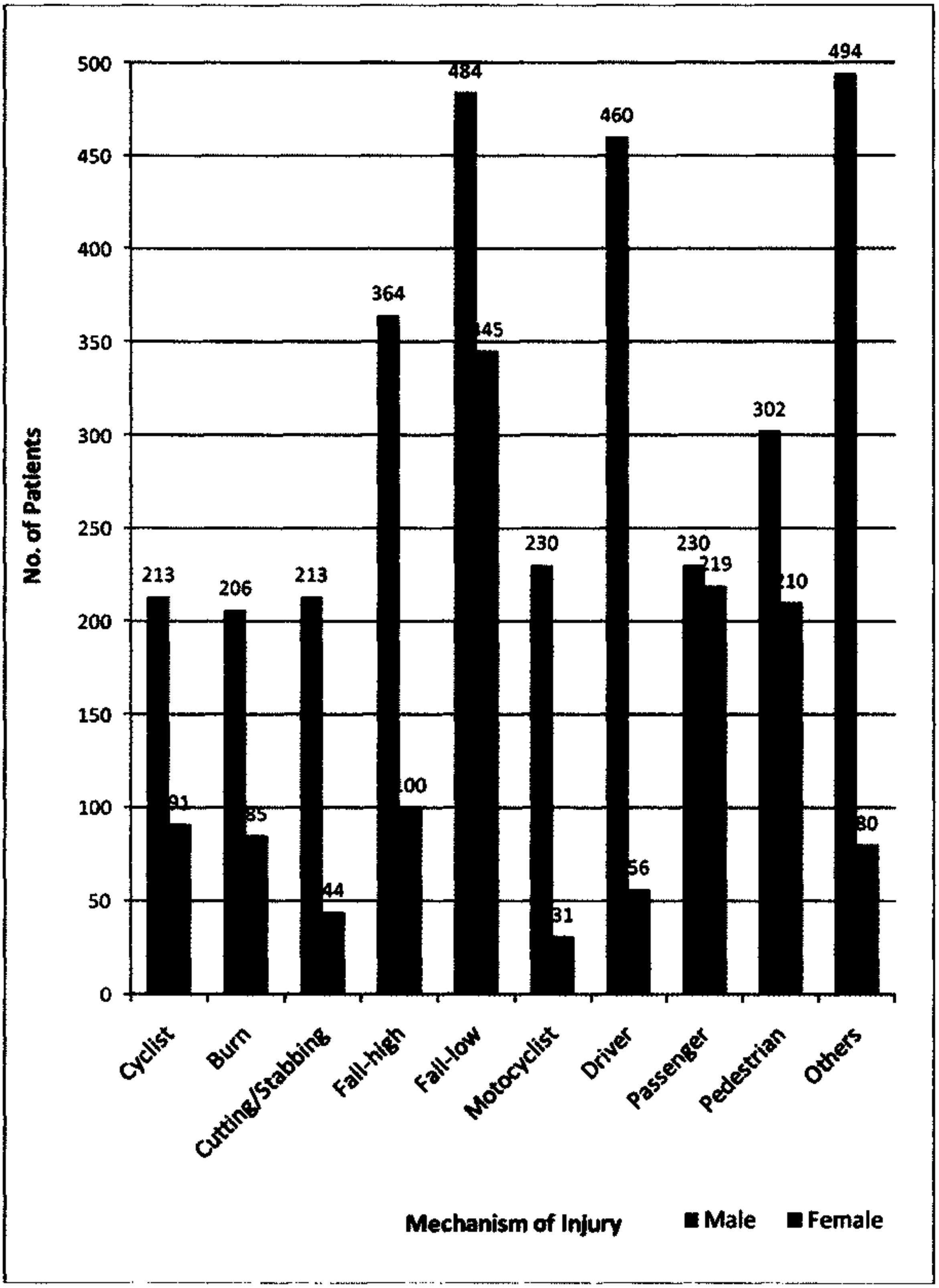


Figure 3.7 Distribution of injury severity scores (ISS)

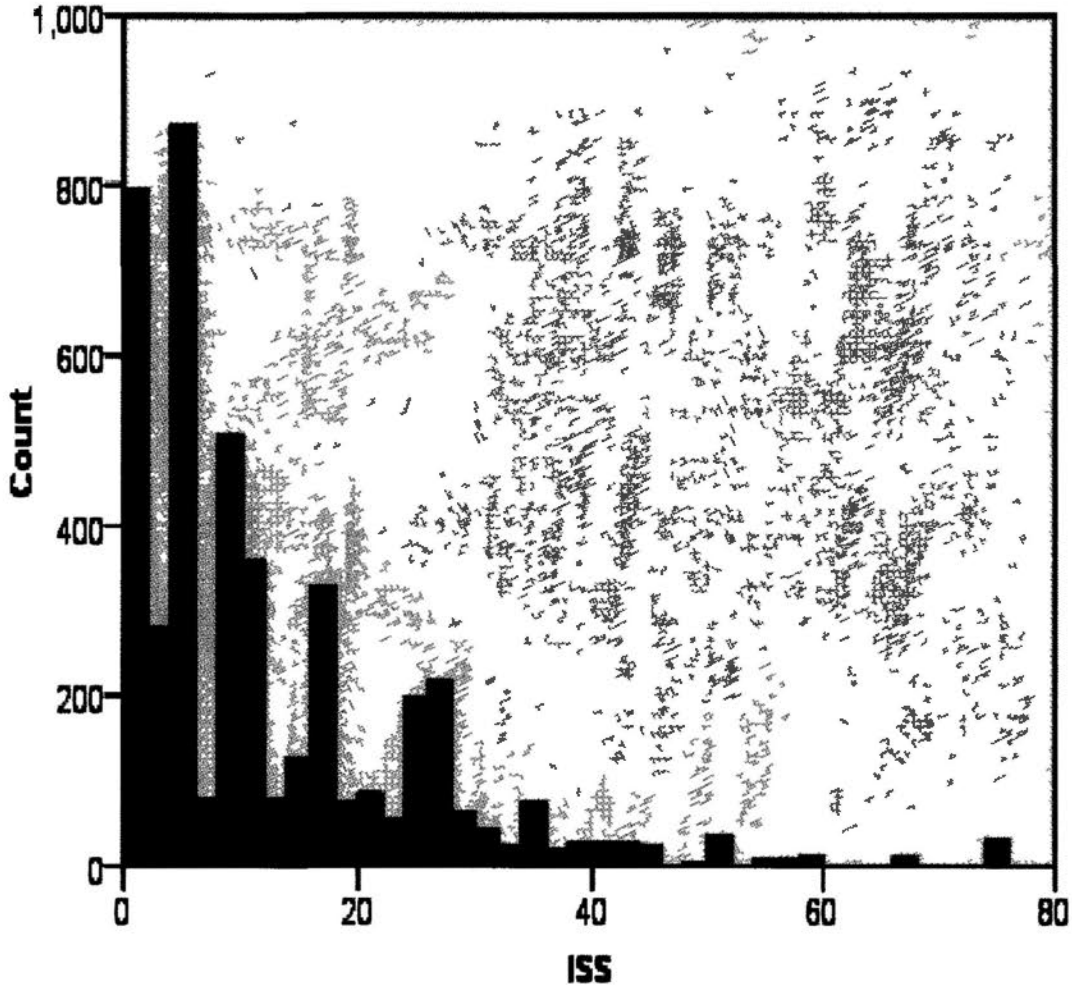


Figure 3.8 Distribution of scores on the abbreviated injury scale

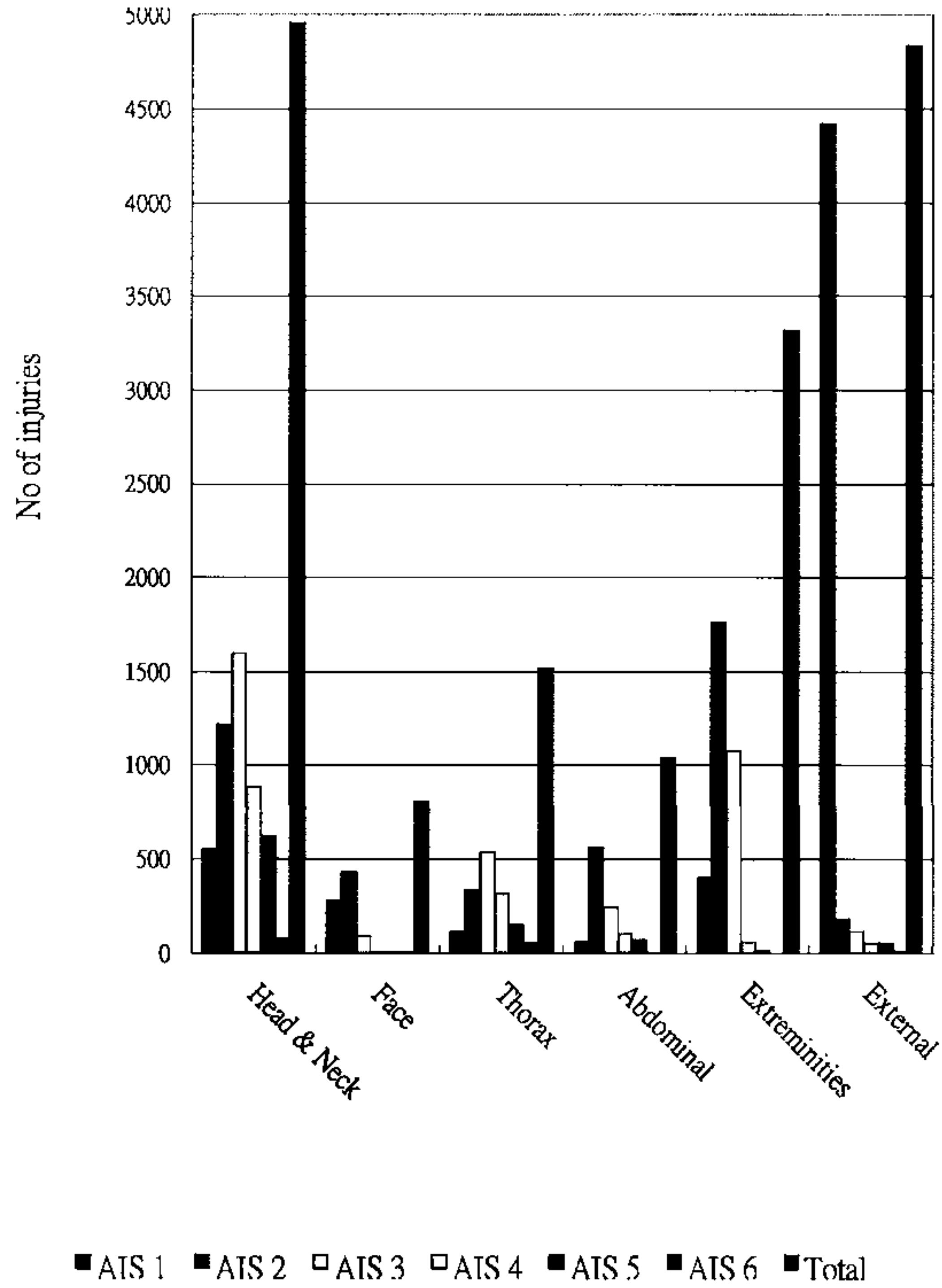
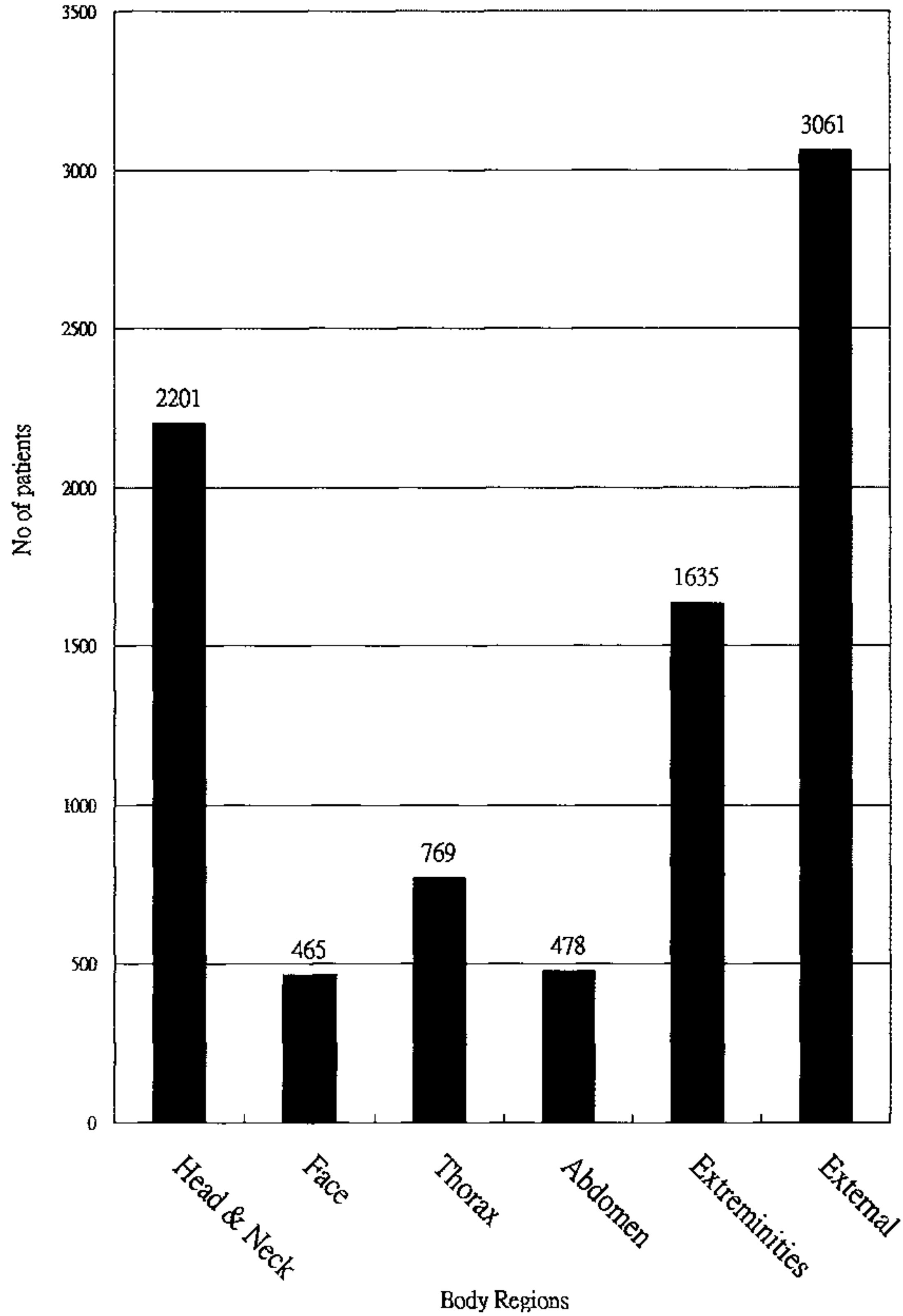


Figure 3.9 Distribution of injuries in different body regions



3.4.5 Major Trauma

Between 2001 and 2009, there were 1,373/4,458 (30.8%) major trauma patients, an average of 153 major trauma patients per year. The percentage (number) of major trauma patients has gradually increased from 26% (120/342) in 2001 to 30.8% (167/376) in 2009 ($P < 0.001$). There were 178/472 (37.7%) trauma patients in 2007 and 212/548 (38.7%) in 2008, more than in other years (Figure 3.10).

The most common injury mechanisms causing major trauma were high falls (194/464, 41.8%), burns (121/291, 41.6%) and pedestrians hit by a motor vehicle (209/303, 40.8%). The details are shown in Figure 3.11.

ISS was correlated to age, such that older patients had a higher ISS ($P < 0.001$). Of the 668 patients aged ≥ 65, 316 (47.3%) were major trauma patients. The details are shown in Figures 3.12 and 3.13.

Figure 3.10 Percentage of major trauma patients between 2001 and 2009

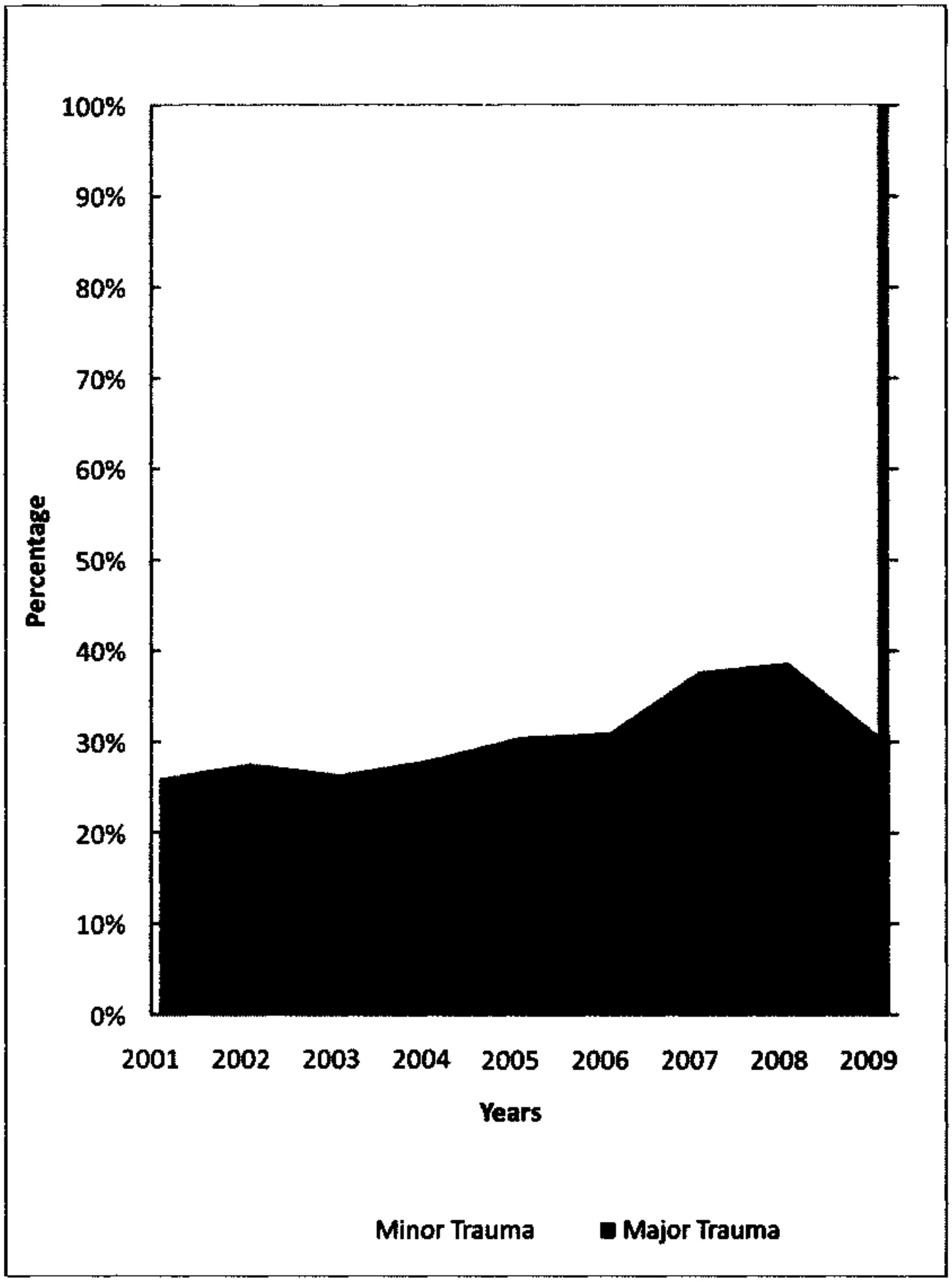


Figure 3.11 Major trauma and injury mechanisms

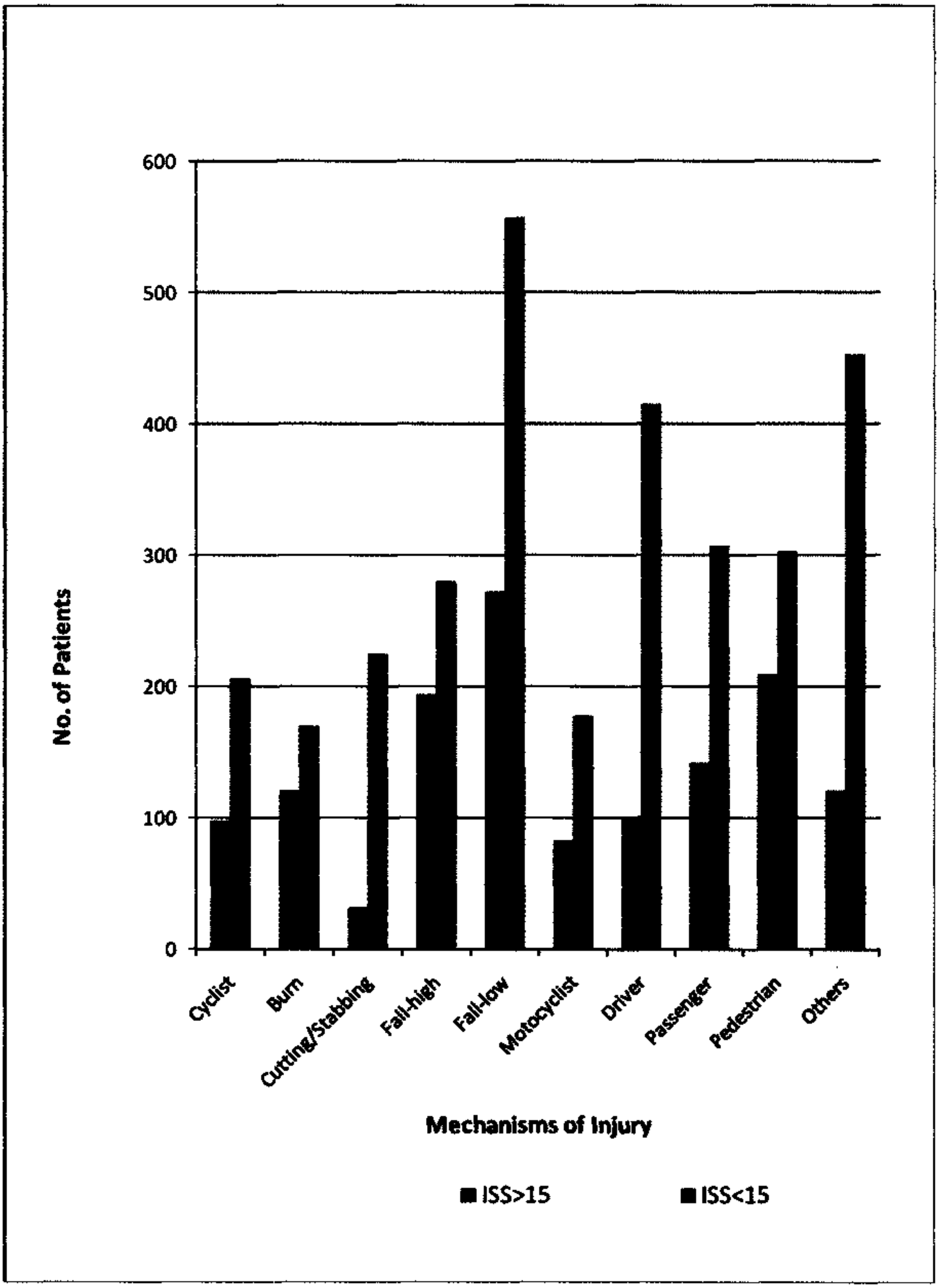
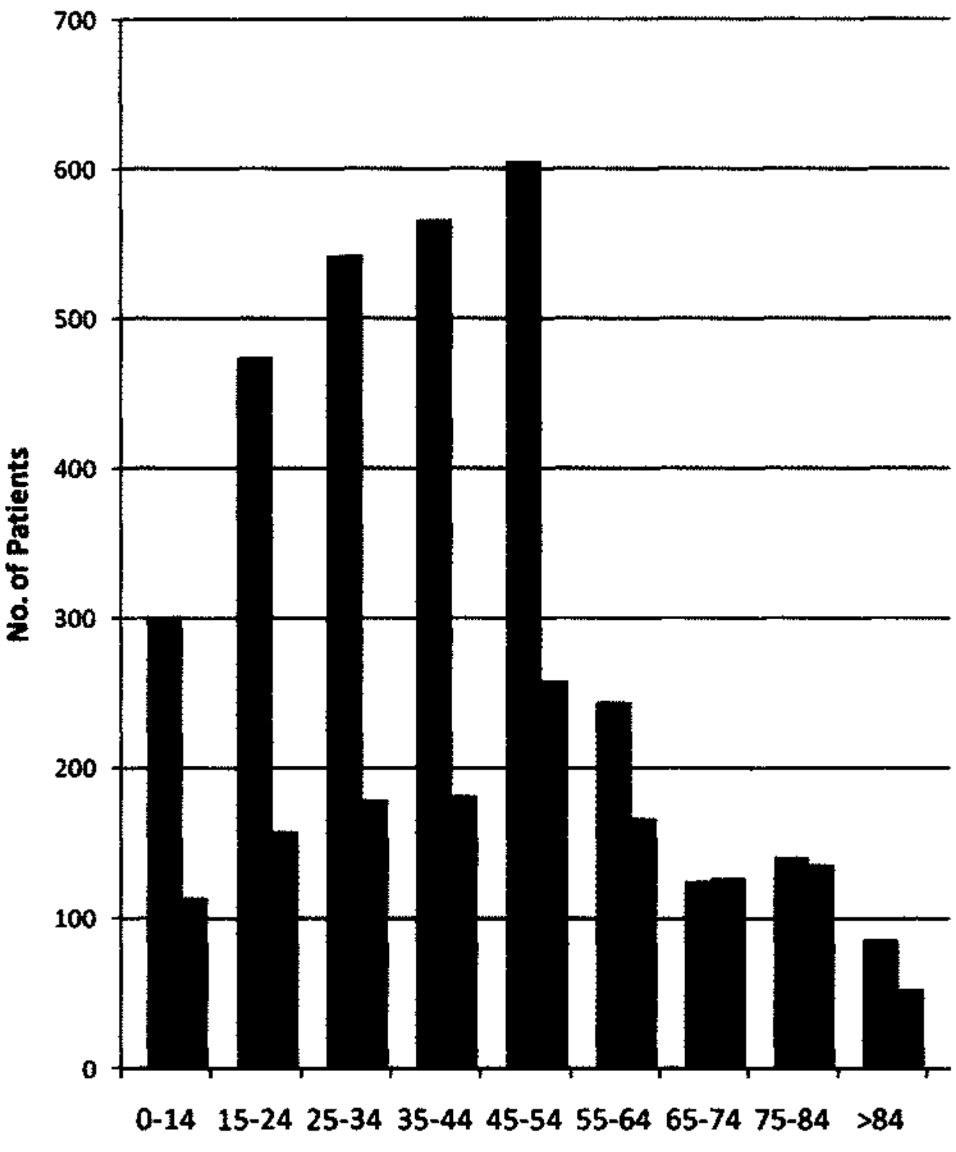


Figure 3.12 Major trauma and age groups

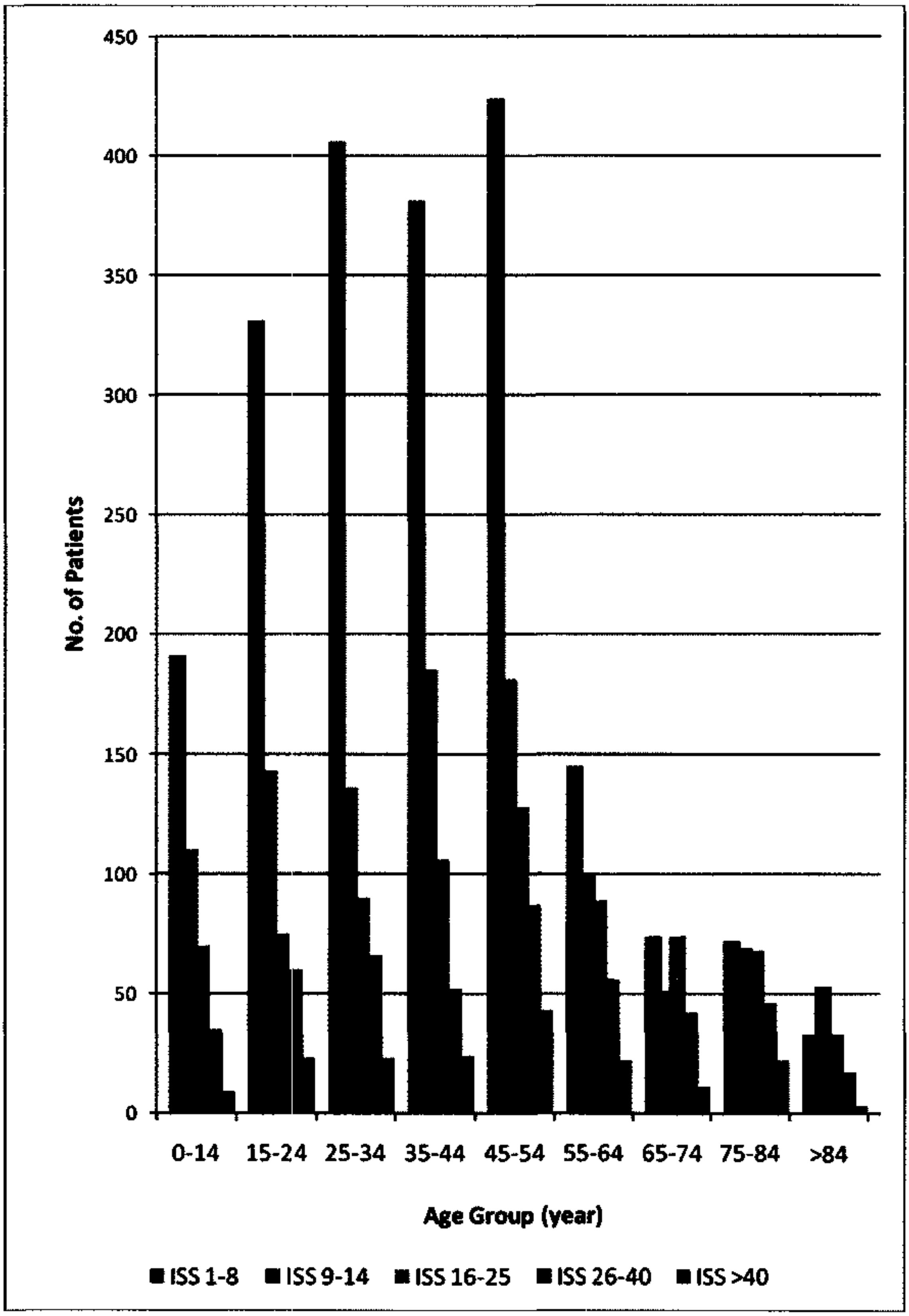


	0-14	15-24	25-34	35-44	45-54	55-64	65-74	75-84	>84
Minor trauma	301	474	542	566	605	244	125	141	86
Major trauma	114	158	179	182	258	167	127	136	53

Age Group (year)

■ Minor trauma ■ Major trauma

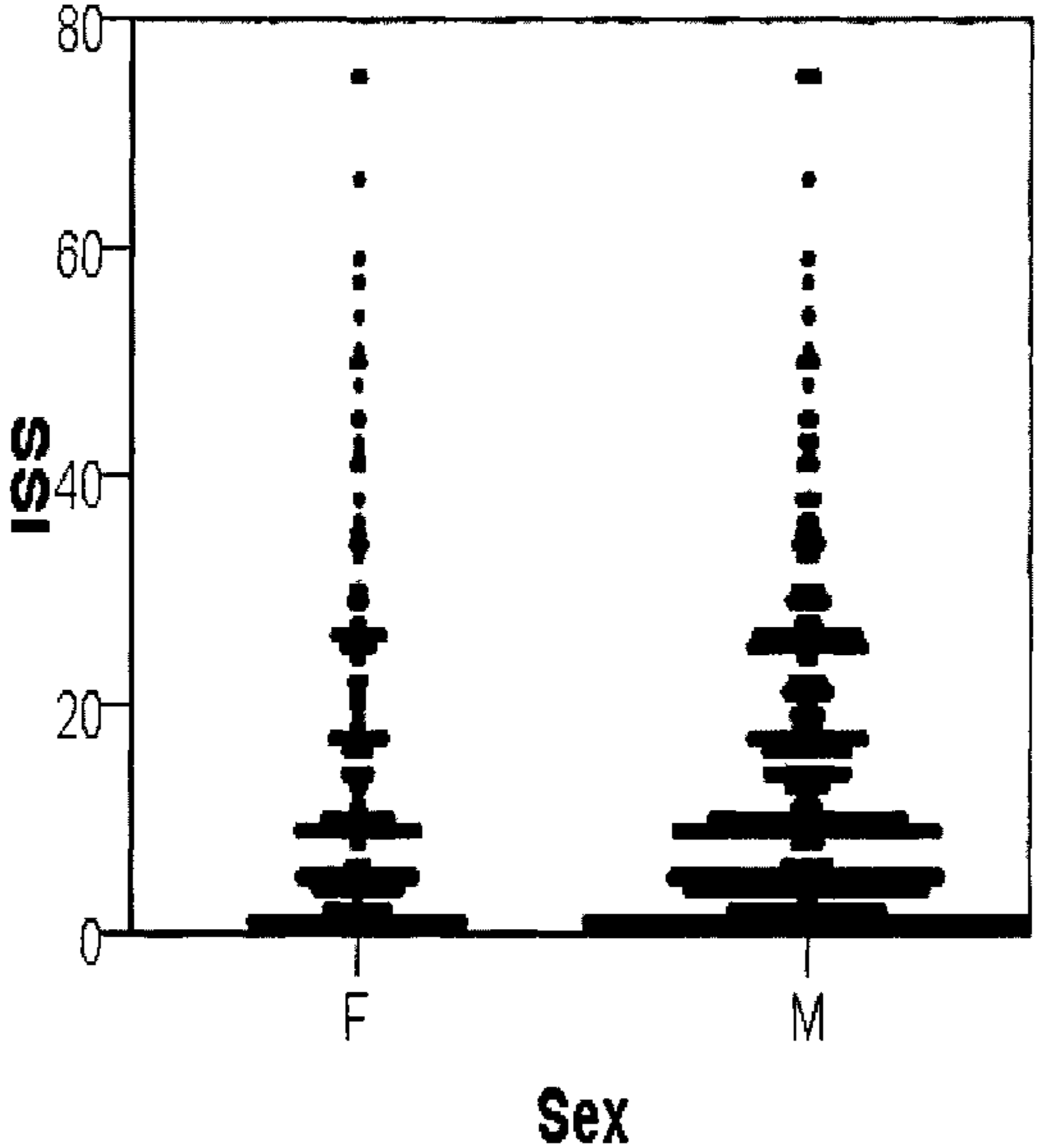
Figure 3.13 Injury severity scale and age groups



3.4.6 Injury Severity Score and Gender

The chance of undergoing major trauma (ISS > 15) was not significantly different between males and females ($p = 0.114$) (Figure 3.14). However, while 827 (25.9%) males underwent multiple trauma, only 278 (22.0%) females did so ($p = 0.007$). The mean ISS ± SD was 11.94 ± 13.1 among females and 12.29 ± 12.4 among males, with no statistically significant difference between the genders ($p = 0.40$). Female patients were more likely to have an ISS of 1-8 or an ISS > 40 than males. Male patients were more likely to have an ISS in the 16-25 range ($p = 0.022$).

Figure 3.14 ISS distribution among males and females



3.4.7 Hospital Length of Stay (LOS) and ICU (LOS)

Hospital LOS ranged from 0.1 to 716 days. The mean LOS ± SD was 11.4 ± 24.5 days. Hospital LOS increased steadily from 2001 to 2009 ($P < 0.001$). The mean age of patients admitted in 2007, 2008, and 2009 was significantly higher than in the 2001-2006 period ($p = 0.01$). The average LOS in 2007 and 2008 was significantly longer than in 2003. Age, ISS, and LOS correlated to year ($p < 0.001$). The data show that patients became older and their ISS scores became higher between 2001 and 2009 (Table 3.1).

Of the 724 patients admitted to the ICU, 182 (14.4%) were female, 542 (17.0%) were male, and 500 (81.5%) were major trauma patients. The maximum ICU LOS was 94 days. The ICU mean LOS ± SD was 6 ± 9.4 days and the median was 2.5 days. Females were less likely to be admitted to the ICU than males ($p = 0.039$). The ICU admission rate gradually increased from 8.3% in 2001 to 13% in 2009 ($p < 0.001$) (Figure 3.15). There was a correlation between ICU admissions and year ($P < 0.001$). The average ICU admission rate was 16.2%. Although older patients with a higher ISS were no more likely to be admitted to the ICU ($p = 0.083$), the ICU admission rate was 11.3% (82 patients) for patients aged 65-74. Only 56 (7.7%) ICU admission patients were older than 74 (Figure 3.16).

Figure 3.15 2001-2009 ICU admission rates

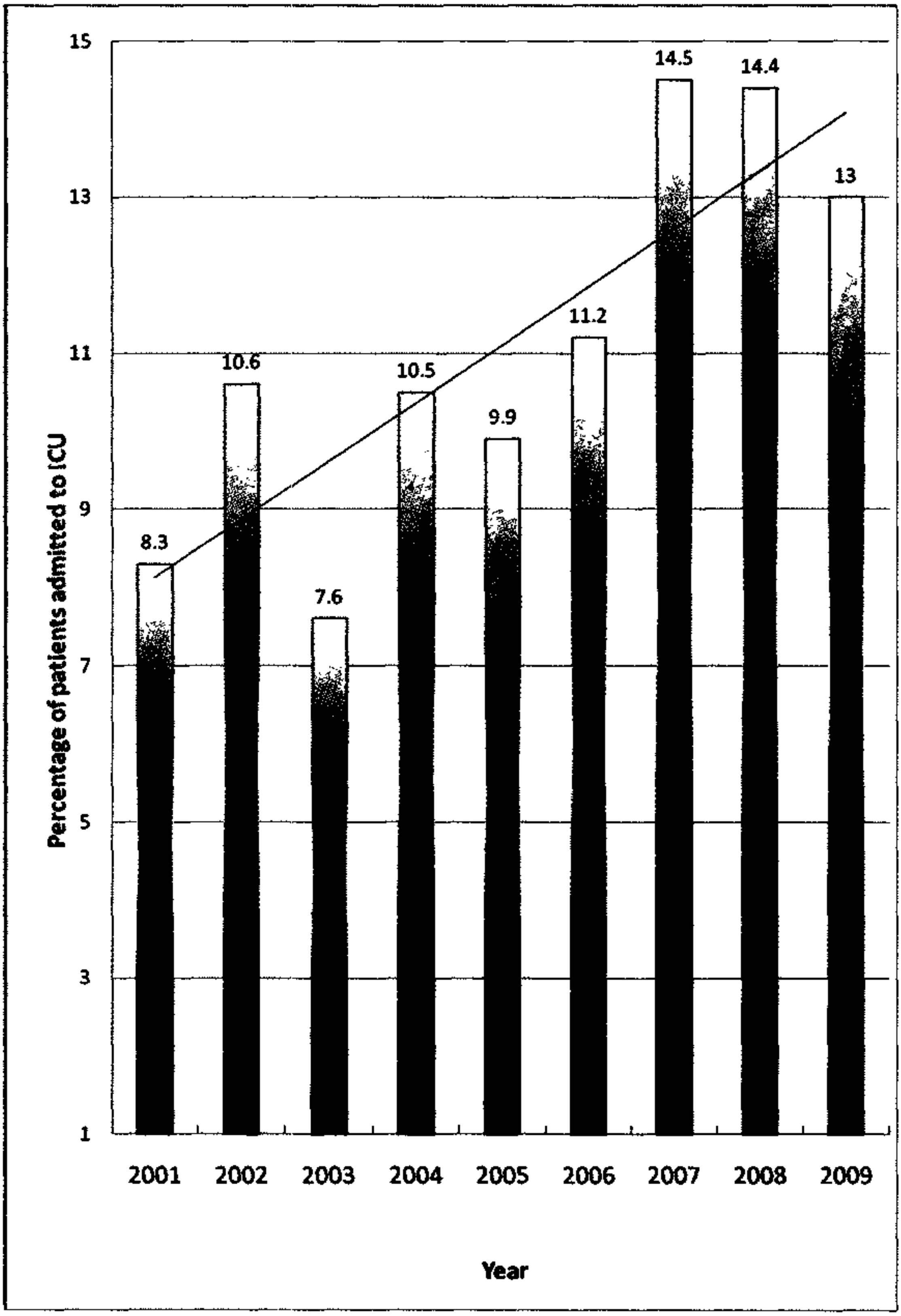
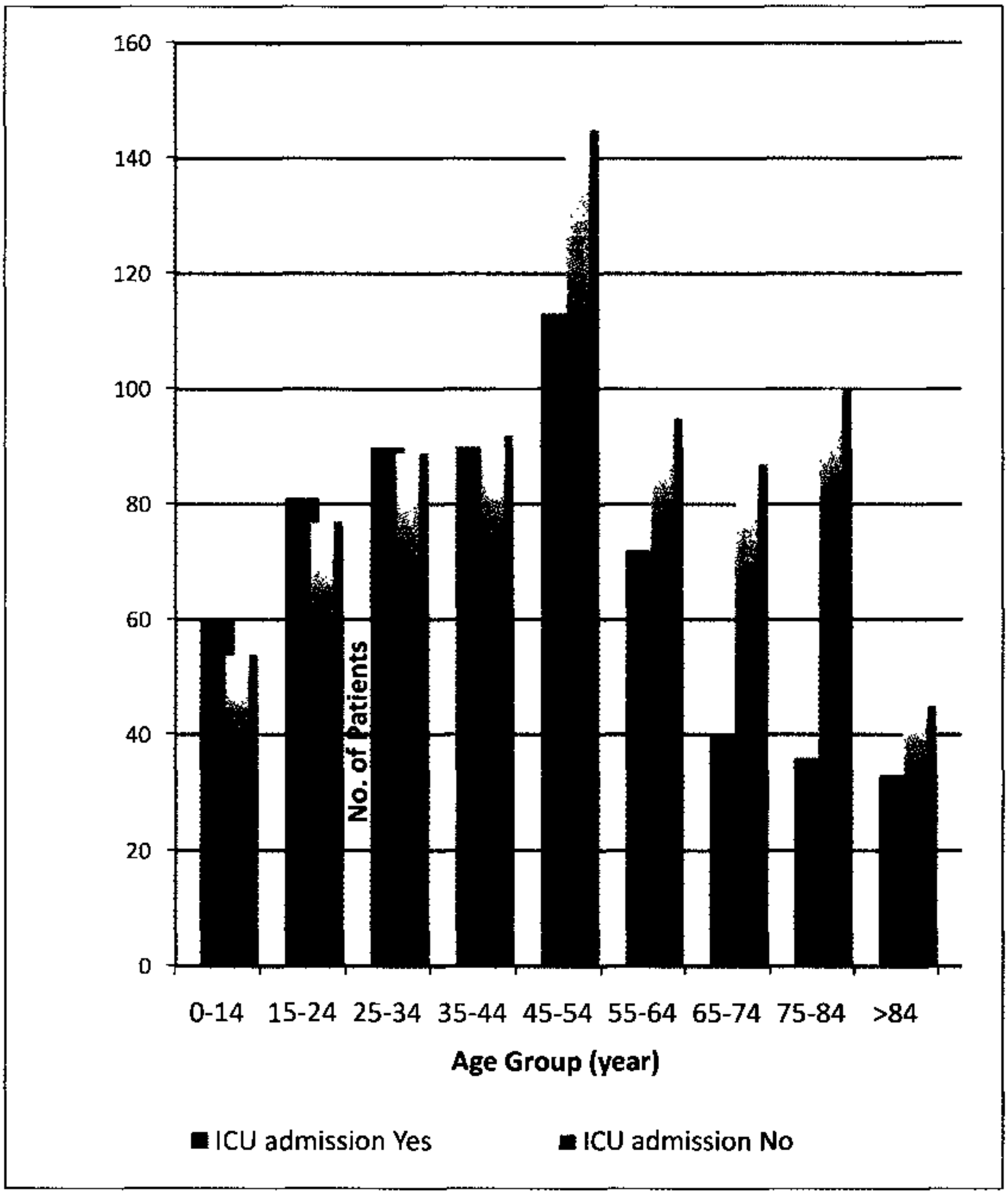


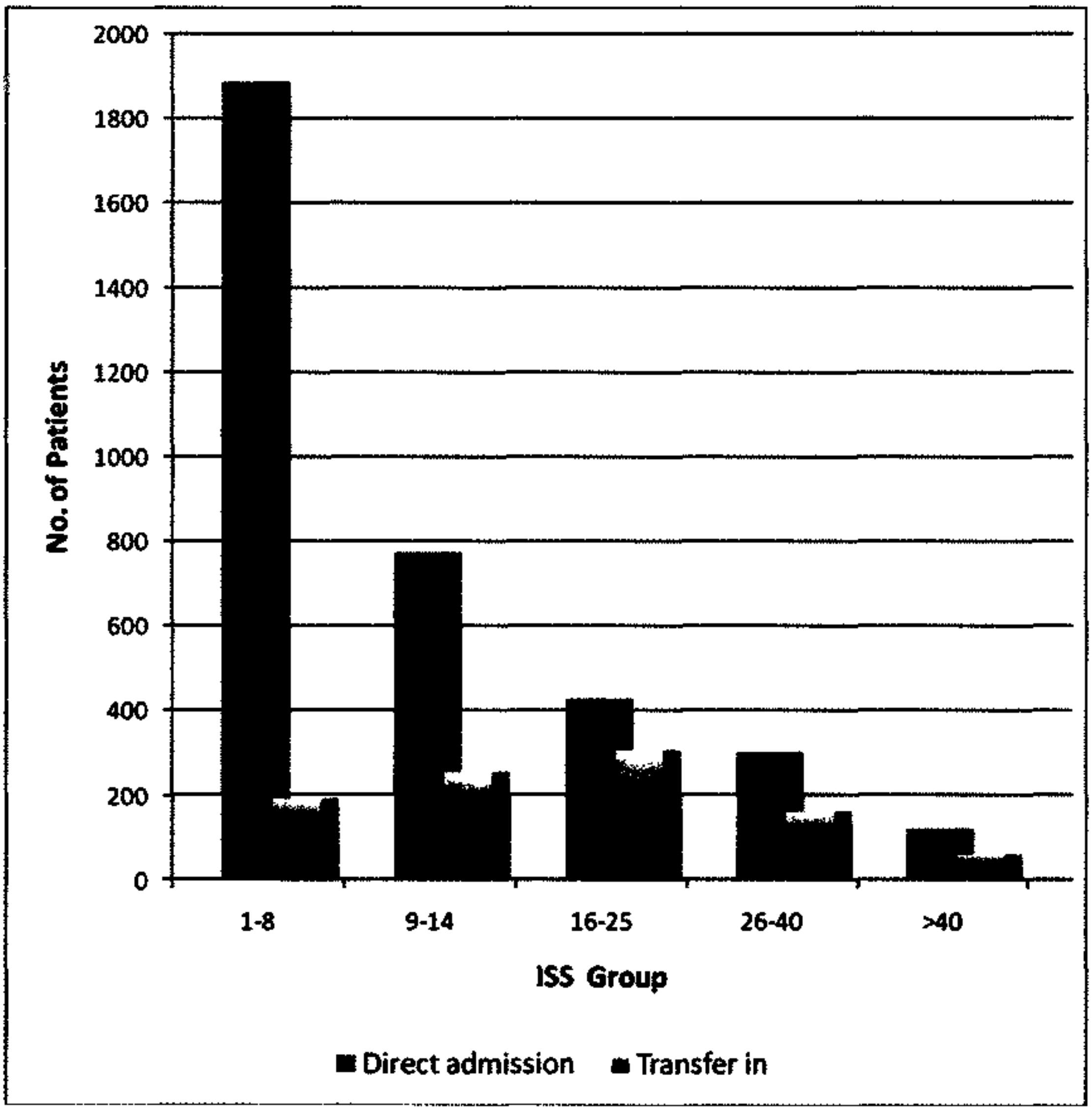
Figure 3.16 Major trauma patients admitted to ICU



3.4.8 Patients transferred from other hospitals

Nine hundred and seventy five (21.9%) patients were transferred from China and other Hong Kong hospitals. The mean ISS among patients transferred in (17.85 ± 13.05) was higher than that among directly admitted patients (10.6 ± 12.0) ($P < 0.001$). Of the 975 patients transferred in, 528 (54.2%) were major trauma patients, whilst 846/1374 (24.3%) directly admitted trauma patients underwent major trauma. The details are shown in Figure 3.17.

Figure 3.17 Transferred in patients and ISS



3.4.9 Mortality

The overall mortality rate was 6.2% (277/4,458). The non-adjusted mortality rate for females was 8.1% (102 deaths), higher than the 5.5% for males (175 deaths) ($p = 0.001$). An increased ISS resulted in a higher mortality rate ($p < 0.0001$); the details are shown in Figure 3.18.

The mortality rate differed significantly for different injury mechanisms ($p < 0.001$). Pedestrians had the highest mortality rate (12.5%). Mortality among patients who suffered low falls was even higher than that among high fall victims. Figure 3.19 details the relation between injury mechanism and the mortality rate.

An increase in age resulted in a higher mortality rate and required more rehabilitation services (Figure 3.20). The mortality rate was 0.3% in those aged below 14 and rose to 36.5% among patients older than 74. Mortality differed significantly among different age groups ($p < 0.001$). There was a correlation between age and mortality rate ($p < 0.0001$; Pearson correlation = -0.217) and the percentage of trauma patients requiring rehabilitation increased in line with age ($p = 0.005$; Pearson correlation = 0.877) (Figure 3.20).

Figure 3.18 ISS and mortality

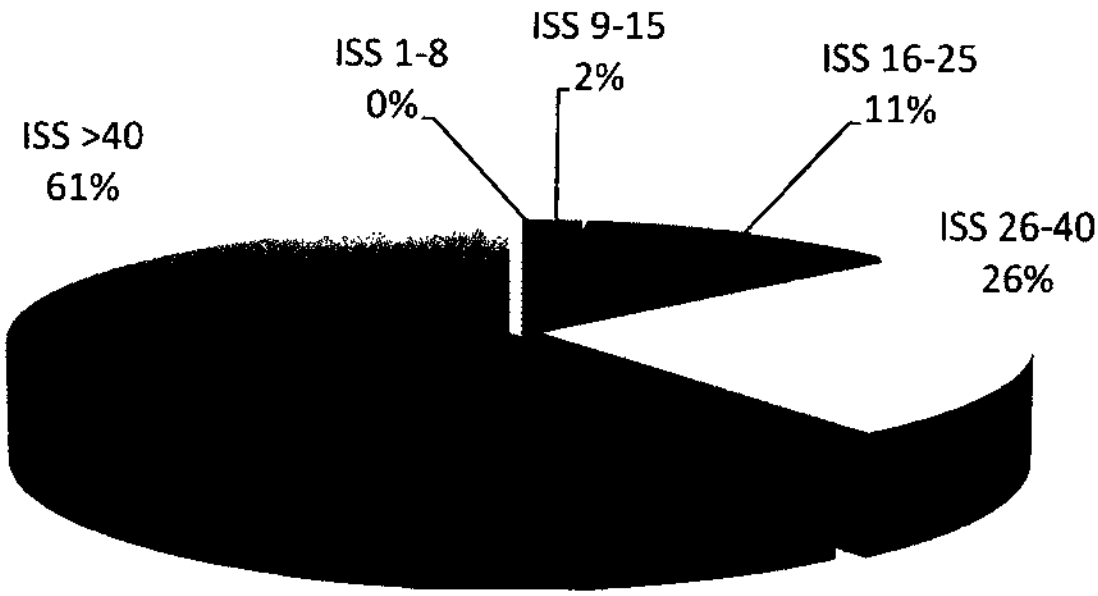


Figure 3.19 Injury mechanism and the related mortality rate

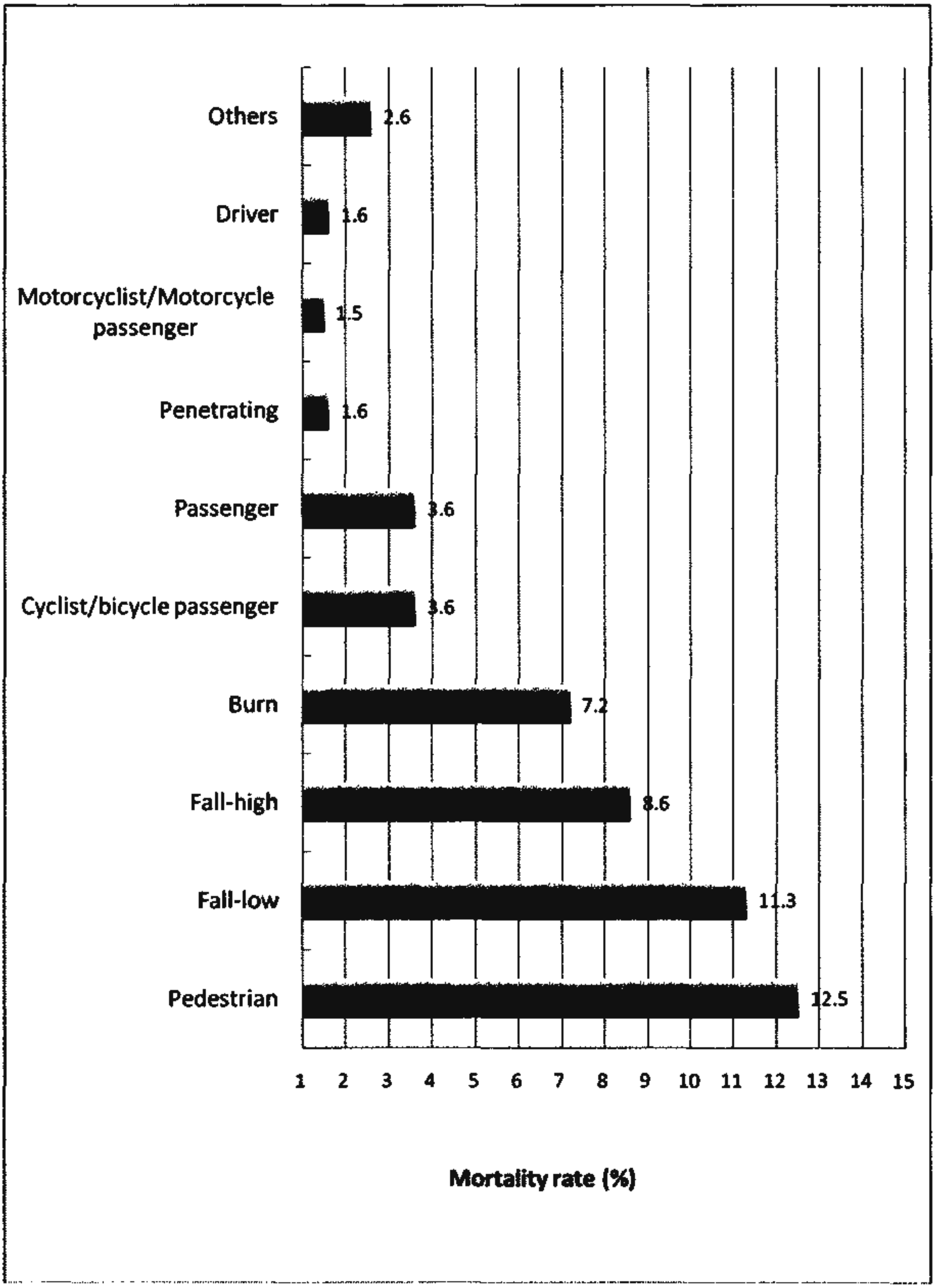
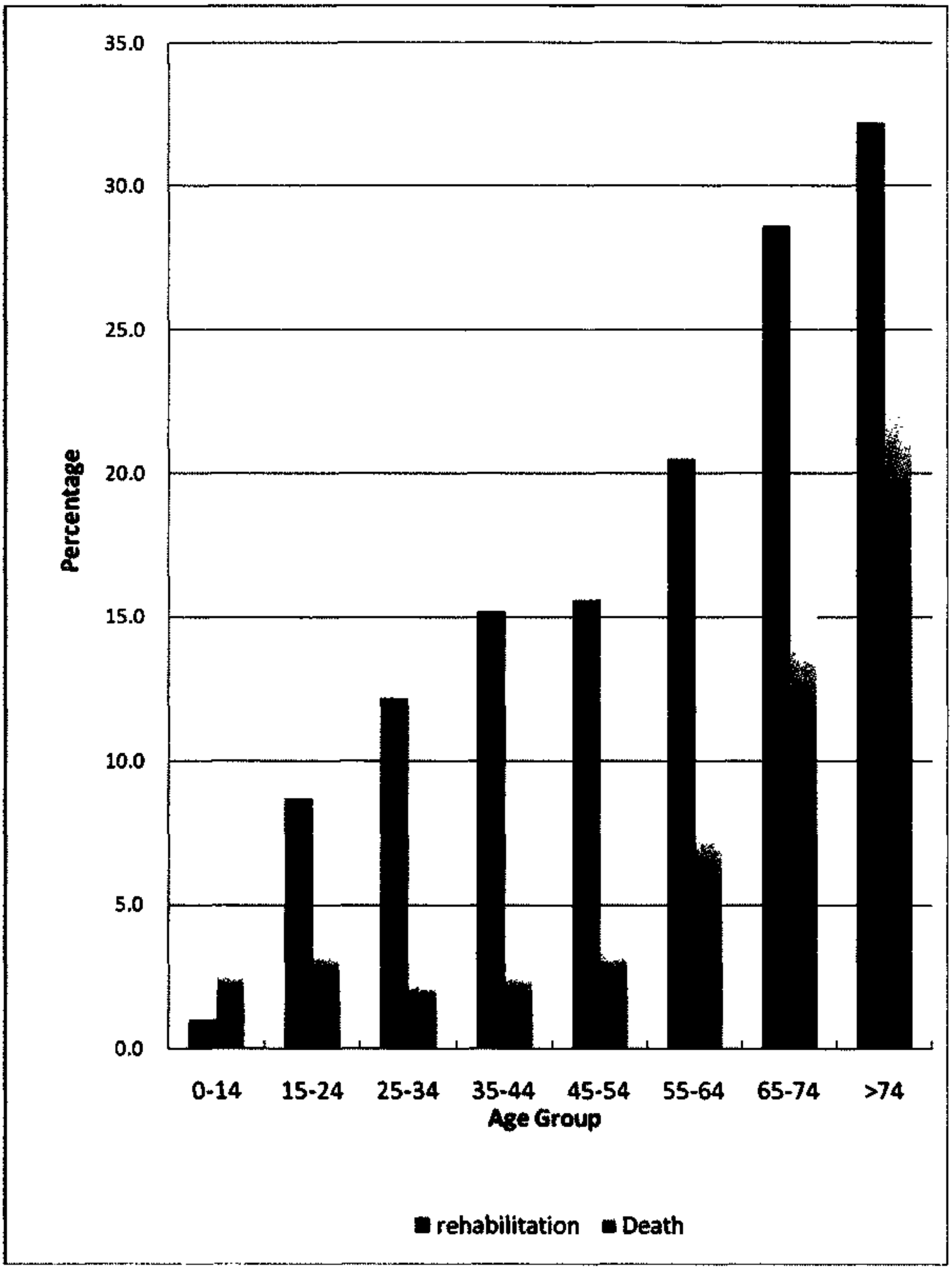


Figure 3.20 Age-related mortality rate and rehabilitation



3.4.10 W score, Z score, M score, and W_s statistic

W Score

The W score indicates the difference between the actual and predicted survival rates. The W score increased steadily from -0.16 in 2001 to 0.51 in 2009, indicating that the performance of the PWH improved from 0.16 excess deaths to 0.51 excess survivors (Figure 3.21). In 2006, the W score was 1.98 and the M score was 2.31, indicating that performance was better than the US norm.

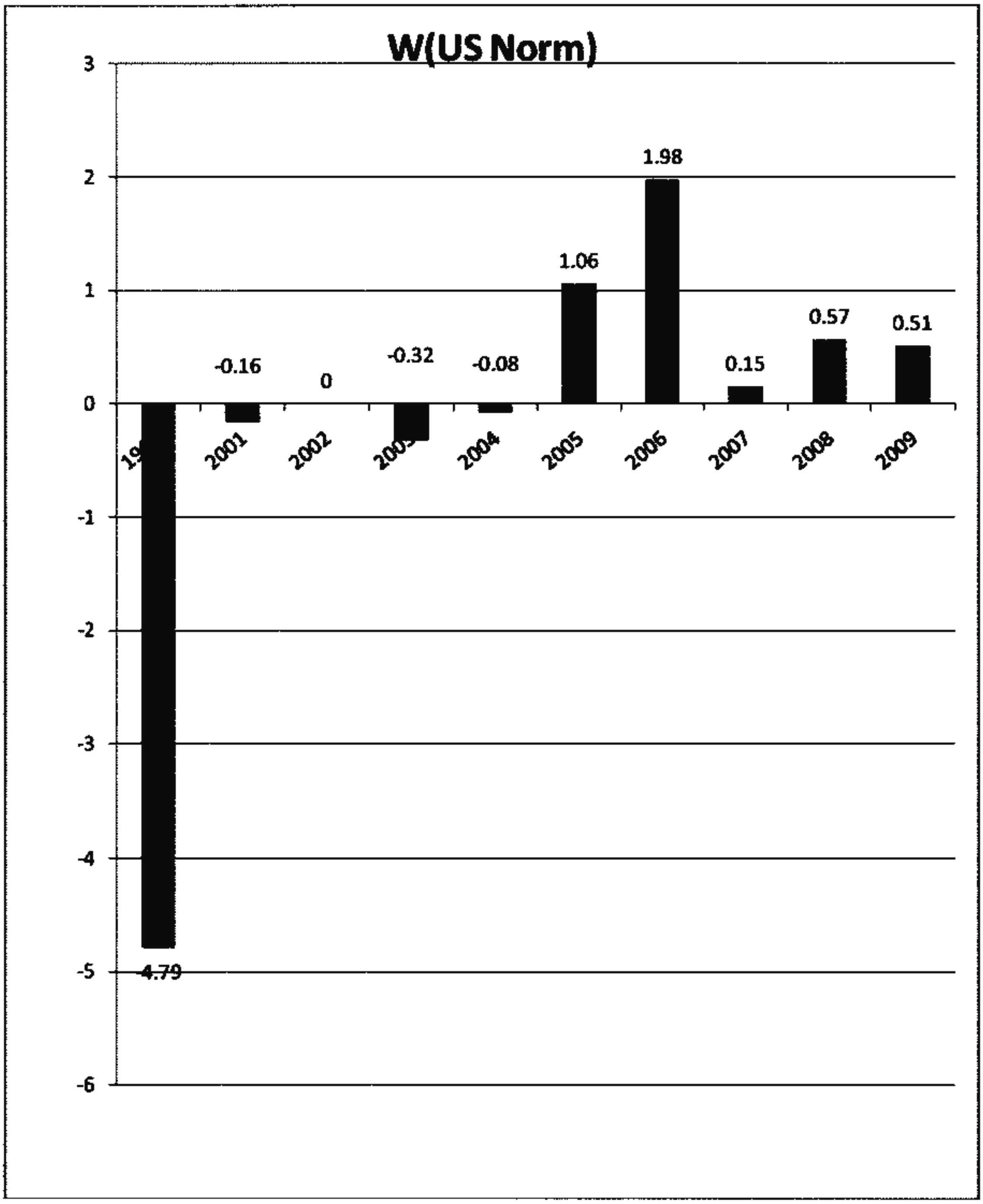
Z score

The Z score is used to assess whether the W statistic is significantly different from zero, with $Z < -1.96$ indicating performance significantly worse than the norm in the US prediction database and $Z > 1.96$ indicating significantly better performance. The Z score ranged from -0.42 to 2.31 in this study population (Table 3.2), indicating that PWH performance was not significantly different from the S standard.

M score

The M score is a measure of the similarity of the injury severity mix to that of the prediction database. A value of less than 0.88 is deemed unacceptable for the purpose of comparison with the US database The M score in the sample observed ranged from 0.89 to 0.99, indicating that the case mix in the study population was compatible with that of the MTOS population.

Figure 3.21 W score trend: excess survivors per 100 patients (2001-2009)



W_s Statistic

The W score is an inappropriate measure for comparing the performance of institutions with different injury severity mixes. W_s represents the W score that would have been observed in the institution if the case mix of injury severity was identical to that of the prediction database. Figure 3.21 clearly shows that the standard of care at the PWH gradually improved over time. Figure 3.22 shows a 95% confidence interval for Ws that contains zero and indicates that Ws was not significantly different from that in the US prediction database. Performance was better than the US norm in 2006, with a 95% confidence interval. The confidence interval crossed the zero line in other years, indicating there was no significant difference between the observed W_s and that defined by the TRISS methodology.

Table 3.1 Demographic data and outcomes

Variable	1997 (1/2 year)	2001	2002	2003	2004	2005	2006	2007	2008	2009	Total	P-value
No of Patients	225	462	587	485	435	439	487	472	548	543	4458	
Mean Age	36 86	38 36	39 57	41 2	40 9	41 0	39 7	44 7	43 9	44 1	41 5	0 001
± SD	± 20 57	± 20 6	± 20 3	± 21 3	± 21 2	± 21 1	± 20 5	± 20 8	± 21 2	± 22 4	± 21 2	
age ≥ 65 no (%)	29 (13 2%)	61 (13 2%)	73 (12 4%)	79 16 3%)	63 14 5%)	57 13 0%)	62 12 7%)	85 (18 0%)	92 (16 8%	96 (17 7%)	697 (14 9%)	0 007*
Mean ISS ± SD	10 79 ± 10 67	10 11 ± 12 3	11 36 ± 12 5	11 05 ± 12 3	12 06 ± 12 2	12 46 ± 11 8	12 93 ± 13 0	13 60 ± 12 7	14 46 ± 14 5	11 57 ± 11 1	12 19 ± 12 6	<0 001
Multiple trauma no (%)	48 (23 4%)	120 (26 0%)	162 (27 6%)	128 (26 4%)	122 28 0(%)	134 (30 5%)	151 (31 0%)	178 (37 7%)	212 (38 7%)	167 (30 8%)	1422 (30 5%)	<0 0001
Mean NISS ±SD	N/A	13 9±17 3	15 4±18 0	14 6±16 4	16 0±16 4	16 1±15 3	16 9±17 2	19 4±19 1	20 6±20 4	16 4±17 3	16 4±17 3	<0 001
Head & Neck AIS ≥ 2	77/203 (34 3%)	111 (24 0%)	223 (38 0%)	179 (36 9%)	183 (42 1%)	180 (41 0%)	200 (41 1%)	212 (44 9%)	247 (45 1%)	214 (39 1%)	1749 (39 2%)	0 31
GCS group												0 001
3-8	20 (10 3%)	34 (7 4%)	56 (9 5%)	37 (7 6%)	38 (8 7%)	29 (6 6%)	28 (5 7%)	51(10 8%)	48 (8 8%)	37 (6 8%)	358 (8 0%)	
9-13	15 (7 7%)	29 (6 3%)	24 (4 1%)	19 (3 9%)	26 (6 0%)	26 (5 9%)	29 (6 0%)	38 (8 1%)	55 (10 0%)	42 (7 7%)	288(6 5%)	

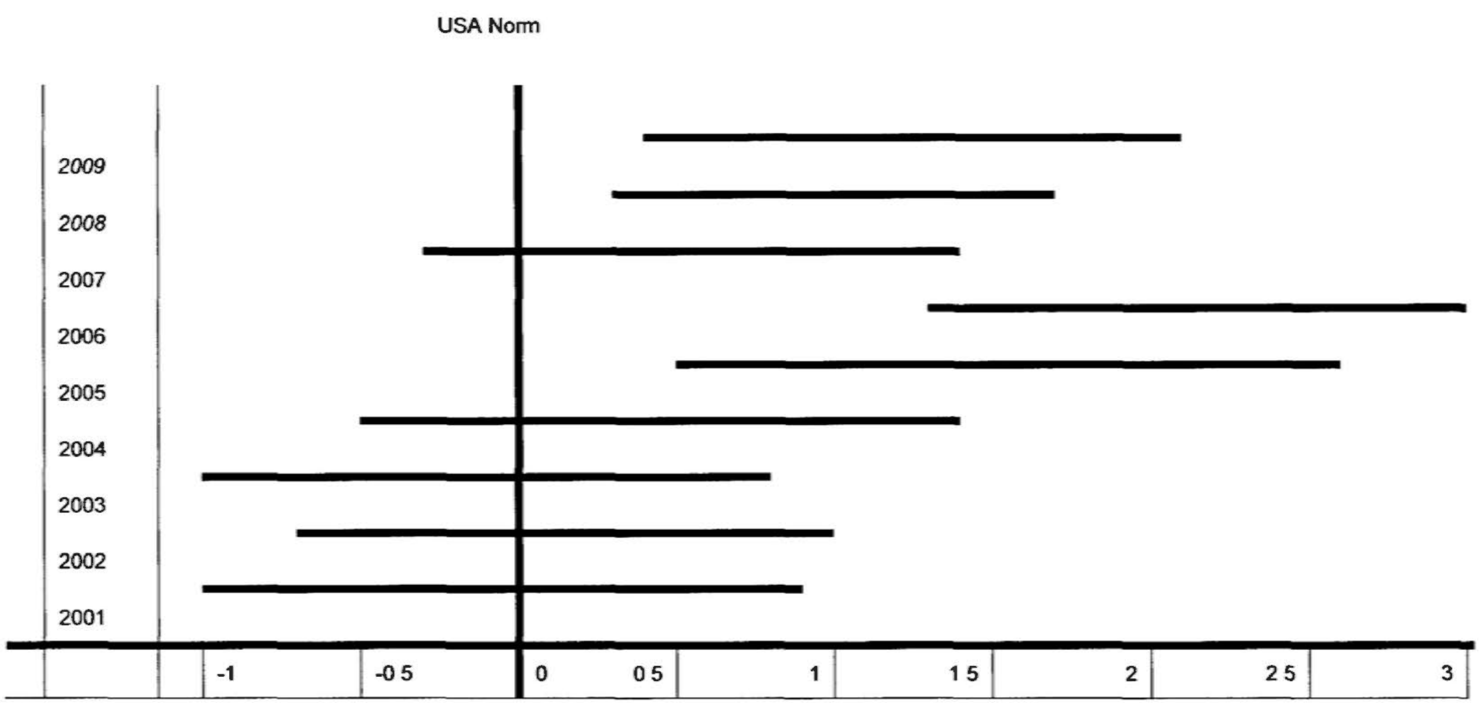
14-15	159 (81 5%)	399 (86 4%)	507 (86 4%)	428 (88 4%)	371 (85 3%)	384 (87 5%)	430 (88 3%)	383 (81 1%)	445 (81 2%)	464 (85 5%)	3811 (85 5%)	
ED RR												<0 001
> 10	2 (6 4%)	23 (5 3%)	35(6 4%)	9(1 9%)	5(1 3%)	4(1 0%)	6(1 3%)	3(0 7%)	6(1 1%)	5(0 9%)	96(2 3%)	
10-28	188(92 6%)	381(%)	480(%)	434(%)	377(%)	397(%)	434(%)	433(%)	497(%)	198(%)	3931(%)	
> 29	13 (6 4%)	27(6 3%)	31(5 7%)	30(6 3%)	18(4 5%)	18(4 3%)	20(4 3%)	21(4 6%)	30(5 6%)	28(5 3%)	223(5 2%)	
LOS ± SD	11 8 ± 30 4	9 7± 19 3	10 0±18 0	8 3±14 0	11 4±22 3	13 0±22 4	12 0±25 8	13 6±36 8	14 2±32 3	10 4±20 8	11 4±24 5	0 001
ICU admission	24(12 5%)	60(13 0%)	77(13 1%)	55(11 3%)	77(17 7%)	72(16 4%)	82(16 8%)	105(22 2%)	104(19 0%)	94(17 3%)	750(16 1%)	<0 001
Transferred	N/A	74(16 0%)	135(23 0%)	71(14 6%)	95(21 8%)	94(21 4%)	112(23 0%)	131(27 8%)	145(26 5%)	118(21 7%)	975(21 9%)	<0 001
Outcome												0 001
Alive	192 (85 3%)	430 (93 1%)	556 (94 7%)	454 (93 6%)	405 (93 1%)	418 (95 2%)	467 (95 9%)	436 (91 1%)	499 (91 1%)	516 (95 0%)	4373 (93 4%)	
Dead	33 (14 7%)	32 (6 9%)	31 (5 3%)	31 (6 4%)	30 (6 9%)	21 (4 8%)	20 (4 1%)	36 (7 6%)	49 (8 9%)	27 (5 0%)	277 (6 6%)	

Remarks Ps group (p = 0 083), SBP (p = 0 142), RTS (p = 0 272)

Table 3.2 W score, Z score, M score, and W statistic

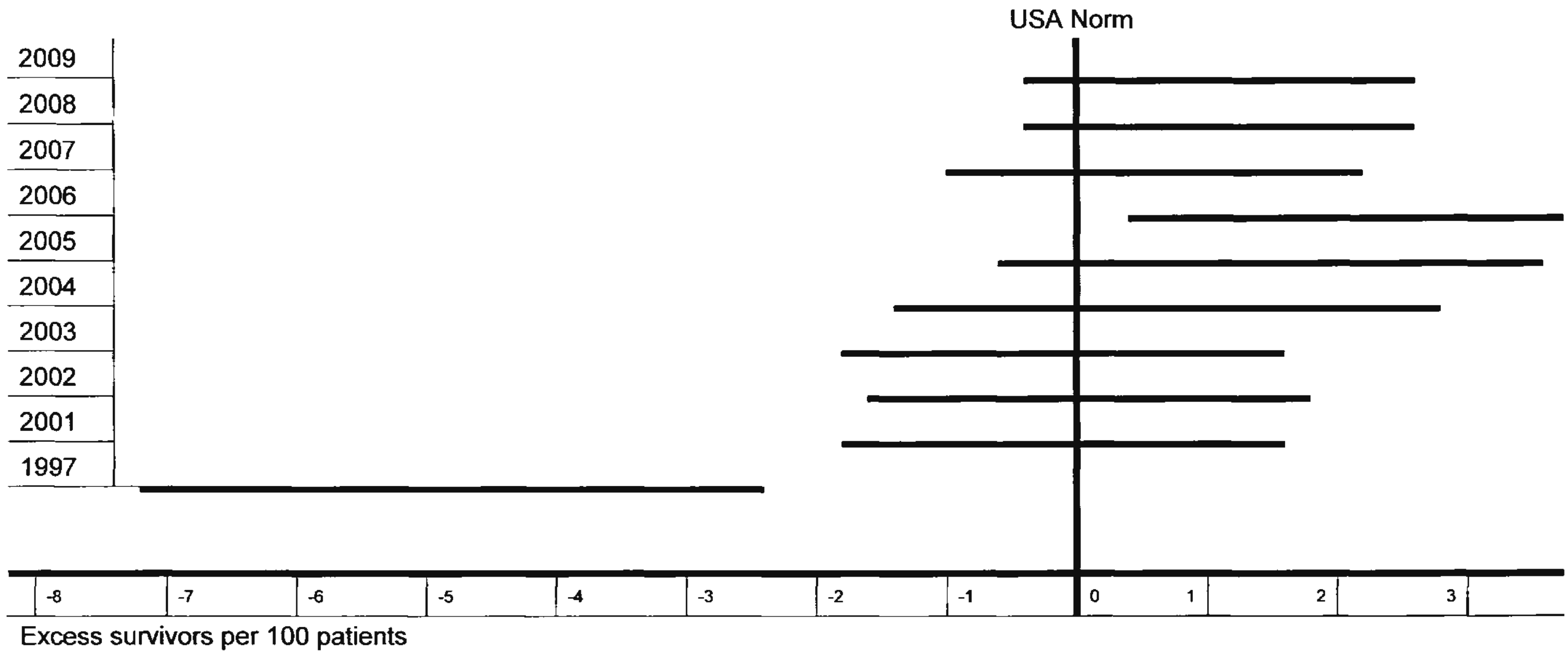
Variables	1997	2001	2002	2003	2004	2005	2006	2007	2008	2009
TRISS										
W	-4.79	-0.16	0	-0.32	-.008	1.06	1.98	0.15	0.57	0.51
Z	-3.89	-0.19	0	-0.42	-0.08	1.26	2.31	0.16	0.62	0.6
M	0.98	0.99	0.96	0.96	0.97	0.96	0.97	0.92	0.89	0.91
ASCOT										
W	N/A	0.22	0.06	-0.34	0.07	0.48	1.54	0.31	0.82	0.59
Z	N/A	-0.28	0.09	-0.45	0.09	0.61	1.89	0.32	0.91	0.73
M	N/A	0.98	0.97	0.96	0.98	0.96	0.98	0.94	0.92	0.95
Ws	-4.86	-0.07	0.15	-0.11	0.42	1.52	2.11	0.58	1.06	1.23
SE(W_s)	1.24	0.88	0.82	0.87	0.95	1.07	0.85	0.82	0.74	0.86
Zs	-3.92	1.48	0.18	-0.13	0.44	1.42	2.5	0.7	1.42	1.43
1.96XSE	2.43	1.72	1.61	1.71	1.86	2.10	1.67	1.61	1.45	1.69
95% CI W_s	-2.37,	-1.79,	-1.56, 1.76,	-1.81	-1.44	-0.58	0.44,	-1.03	-0.39	-0.46
	-7.29	1.65,		1.60	2.81	3.62	3.78	2.198	2.51	2.92

Figure 3.22 Graphic display of Ws ± SE (Ws)



W_s represents the W score that would have been observed in the institution if the case mix of injury severities was identical to that of the US prediction database.

Figure 3.23 Graphic display of 95% CI for W_s 【$W_{s,} \pm 1.96$ SE ($W_{s,}$)】



3.5 Discussion

The results of this study demonstrated that the existence of a trauma system was associated with a reduction in the risk of death caused by injury. The results are supported by other studies (Oakley et al., 2004; Sampalis et al., 1999; Nathens et al., 2000; Oakley et al., 2004; Mackenzie et al., 2006; Celso et al., 2006) showing that trauma systems reduce mortality. There was a clinically important improvement in the survival rate after the trauma system was implemented. The adjusted mortality rate improved from about five excess deaths per 100 trauma patients in 1997 to one excess survivor per 100 trauma patients in 2009. Each year saw about 500 trauma patients admitted, among whom there were an average of 152 major trauma patients. The trauma system therefore saved 30 more patients per year.

The best performance was achieved in 2006, in which there were 2 excess survivors per 100 patients and the survival rate was statistically significantly better than that predicted by the MTOS. This result demonstrates that trauma systems improve the survival rate among injured patients. Primary trauma diversion, trauma teams, ATLS training programmes and trauma team training, advanced diagnostic radiology, advances in medical technology, trauma registries, trauma audits, and peer reviews of trauma deaths may contribute to the improvement in the survival rate.

The W score in the study population was -4.8 and increased to -0.16 after the trauma system was established in 2001. The W score was slightly below or equal to zero from 2001 to 2005, indicating that the survival rate improved significantly and was steadily maintained at this higher level for a few years. This cap on the improvement seen in the survival rate might be due to several reasons, one being that it takes time to mature and develop trauma guidelines, trauma triage protocols, trauma team training, inter-hospital transfer agreements, trauma centre organisation, and ongoing quality assurance arrangements after establishing the trauma system. The study conducted by Nathens (2000) shows that the effect of a trauma system becomes apparent after 10 years.

The second reason for the one-off improvement seen in the survival rate might be that the reduced manpower in the ED (Wai et al., 2010) limited further improvement in patient outcomes. A third factor may have been the severe acute respiratory syndrome (SARS) outbreak in 2003. The PWH was one of the major hospitals involved in the SARS crisis and fighting SARS took first priority.

From 2007 through 2009, the survival rate among trauma patients was maintained at around 0.15 to 0.57 and was not statistically significantly different from the MOTS norm. In this period, the ED installed a computed tomography (CT) scanner and developed a fast track CT scan protocol (Lee et al., 2009) and a massive blood transfusion protocol to enhance patient outcomes. Another reason for the absence of any further improvement in the survival rate may have been the effect of the age of trauma patients.

The results tell us that the mean age of trauma patients admitted to the PWH gradually increased over the study period. The elderly population (≧ 65 years) grew rapidly from 12.7% in 2006 to 17.7% in 2009. Elderly patients have more complex conditions due to comorbidity, which in turn may account for the increase seen in the mortality rate. Although age is adjusted for in the TRISS methodology by dichotomising patients into two age groups of < 55 and ≥ 55, it is known that the mortality rate among elderly patients increases with age (Demetriades et al., 2005). The older the patient, the higher the mortality rate, even where patients have minor or moderate injuries. The fact that the TRISS methodology does not categorise elderly patients into a greater number of sub-groups is a well-known limitation and we need to be aware of it when interpreting research results.

The number of patients and the severity of injury increased rather than decreased from 2001 to 2009. This indicates that the role of the health care profession in reducing the incidence and seriousness of injury is underdeveloped. Although advances have been made in the management and quality of medical care, injury prevention efforts still lag. The number and percentage of major trauma incidents gradually increased over the study period, especially between 2006 and 2009. That the trauma system did not reduce the number of severely injured patients may be a result of the redistribution of a small number of seriously injured patients through primary trauma diversion or inadequate injury prevention efforts.

The two most common causes of death in the study population were falls and motor vehicle crashes in which pedestrians were killed. This result indicates that injury prevention programmes have been inadequate or unsuccessful. Elderly people are at high risk due to their impaired awareness of environmental hazards, decreased mobility, reduced cognitive function, and greater number of comorbidities (McMahon et al., 1996; Perdue et al., 1998; Grossman et al., 2002; Cheng et al., 2009). The focus on prevention needs to be intensified. Accidents are seldom random events and consist of numerous factors that can be modified to reduce the risk of injury. Preventing injury requires that changes be made to the root behavioral causes. Fall prevention programmes and road safety education are essential elements of such an approach.

Trauma centres should not only focus on treatment, but also need to extend their role to injury prevention (Amercian College of Surgeons, 2006). Acute medical treatment and rehabilitation will reduce the burden of injury, but prevention programmes and injury controls are likely to have an even greater impact. Therefore, task groups should be established at the HA level and in individual hospitals to look into the organisation, experience, and achievements of trauma prevention programmes in Hong Kong.

This study shows that head injuries are not only the most common injuries, but are also the most serious. Head injuries are the most frequent causes of long term disability, suggesting that more research should be undertaken and more resources provided to minimise the degree of injury and improve the outcomes of head injury patients (Pape et al., 2006).

The American College of Surgeons (1998, 2006) criteria for level I trauma centres are an annual volume of at least 1,200 trauma cases per year, of which at least 240 are ISS > 15. According to the HA (2001), Hong Kong would be justified in having 3 designated trauma centres to concentrate major trauma patients, but there are currently five trauma centres in Hong Kong. It is necessary to streamline the five existing trauma centres to a maximum of three to concentrate resources and ensure trauma teams have sufficient experience. Integrating all facilities into a trauma system limits the duplication of services and directs the most severely injured patients to a few high-volume institutions. Studies demonstrate that patients treated in a high-volume trauma centre have better outcomes (Smith et al., 1990; Konvolinka et al., 1995; Liberman et al., 2005; Simons et al., 1999). Moreover, increased patient volumes are associated with a reduction in risk-adjusted mortality (Liberman et al., 2005). On the other hand, low volume was a significant risk factor for mortality in seven of the nine injuries studied by Pasquale et al. (2001).

A central trauma registry should be developed to deal with the knowledge gaps in existing facilities. It is essential to conduct trauma audits and quality assurance programmes and to gain a better understanding of the strengths and weaknesses of both the current trauma system and trauma prevention programme planning.

3.6 Limitations and Future Study

The number of the patient included in this study was small, especially in the sample used for the period before the PWH trauma centre was established. More representative results are likely to be obtained if all trauma centres were to participate in future studies. It is hoped that this can be achieved once the Hong Kong central trauma registry has been established.

Knowledge of the long-term and functional outcomes associated with major trauma is important to define the overall impact of trauma centres more accurately. There is a need to monitor morbidity and functional outcomes, as such information helps in the planning and utilisation of health resources and justifies the appropriate allocation of healthcare and research resources (Laupland et al., 2010). Therefore, further research is warranted to reveal the long-term and functional outcomes, quality of life, and morbidity rate among major trauma patients.

One measure of how well a trauma centre functions is its ability to critically examine care process outcomes within the institution. Yet the TRISS methodology employed in this study does not provide information gathered through a peer-review process. Critical and systematic in-depth reviews of the performance of the trauma care process and its outcomes are required in the future to identify areas for improvement.

Chapter 4

Primary Trauma Diversion

4.1 Abstract

Background: Trauma is a leading cause of death and the loss of workdays in Hong Kong. Reports have suggested that the timely provision of care in dedicated trauma centres can improve patient outcomes. Until recently, ambulances were required to take trauma patients to the emergency department of the nearest hospital. The study reported here examined the initial experience of primary trauma diversion from the scene to a dedicated trauma centre in Hong Kong.

Methods: This prospective study involved the establishment of a primary trauma diversion strategy in the area served by the Alice Ho Nethersole Hospital (AHNH), a general hospital in the New Territories. Trauma patients who fulfilled the diversion criteria were taken directly to the Prince of Wales Hospital (PWH) in Shatin, a university teaching hospital and the trauma centre for the area. Data were collected to determine the change in the time taken to deliver trauma patients to definitive care and an impact analysis of PWH services was performed.

Results: The study considered 60 patients who underwent primary trauma diversion and 35 patients who underwent secondary trauma diversion after receiving initial treatment at the AHNH. This represents two extra trauma

patients per week at the PWH. The median injury severity score (ISS) among the subjects was 9 and 52% of the patients had been involved in a traffic accident. Of the eligible patients, 76% (69 out of 91) were correctly diverted according to protocol. Primary diversion patients reached definitive care 97 minutes faster than patients undergoing secondary diversion.

Conclusion: Primary trauma diversion is feasible in Hong Kong and means that patients reach definitive care 97 minutes faster than they would by going to the nearest hospital. Primary trauma diversion protocols should be extended throughout Hong Kong.

4.2 Introduction

Trauma remains one of the leading causes of death and the loss of workdays in Hong Kong (Department of Health HKSAR, 2002), especially among younger people. In 2000, a Hospital Authority (HA) trauma working party report identified a number of deficiencies in trauma care (Medical Services Development Committee, HA, 2001). One significant pre-hospital care issue was identified: ambulances could transport trauma patients only to the nearest hospital instead of to the nearest appropriate hospital. In addition, the lack of direct communication between ambulances and receiving hospitals made appropriate triage of patients difficult.

Evidence suggests that trauma patients should be transferred directly from the scene to a dedicated trauma centre to improve both morbidity and mortality (Young et al., 1998; Kam et al., 1998; Sampalis et al., 1997). Short pre-hospital times, early recognition of severe injuries, and adequate initial resuscitation and management in a trauma centre are important determinants of good outcomes (Roy, 1987; Cooper et al., 1998; Smith et al., 1990; HA, 2002).

The HA trauma working group decided that trauma patients should be transferred directly from the scene to the nearest appropriate hospital. Five hospitals in Hong Kong were designated as trauma centres to provide timely definitive care for trauma patients (Medical Services Development Committee, HA, 2001).

This pilot study was conducted in the New Territories East Cluster (NTEC) to test the feasibility, practicality, and impact of primary trauma diversion (PTD) in Hong Kong. The NTEC serves the population of Shatin, Tai Po, and the North District, which is estimated at 1.33 million people (HA, 2001). There are three acute hospitals in this cluster: the PWH, the AHNH, and the North District Hospital NDH. The PWH is a university teaching hospital and is designated as the trauma centre for this cluster.

The aim of this study was to assess the clinical impact and the time taken to deliver patients to definitive care under the primary and secondary trauma diversion protocols adopted in this region of Hong Kong.

4.3 Materials and Methods

This prospective observational study started in November 2003 and the data collection process was complete by the end of August 2004. Two hospitals were involved in this study: the PWH in Shatin and the AHNH in Tai Po. These two hospitals are about 10 km apart. In the PWH, around 520 trauma patients per annum are triaged to the trauma rooms according to whether or not they present with a high-risk mechanism, of whom around 160 are injury severity score (ISS) > 15 patients. The PWH ED has 180,000 patients per annum. The third hospital in the cluster, the NDH, was not included in this initial study.

Primary trauma diversion (PTD) was defined as the transport of adult (> 12 years of age) trauma patients from the normal AHNH catchment area directly from the scene to the PWH trauma centre with or without prior communication with the emergency medicine specialist at the PWH according to protocol. Secondary trauma diversion was defined as the transfer of trauma patients from the scene to the AHNH ED followed by a transfer, after initial resuscitation, from the AHNH ED to the PWH trauma centre for definitive care. Children were initially excluded from the PTD strategy to allow ambulance staff to become familiar with the concept before the staged expansion of the programme to include children under the age of 12.

All trauma patients whose condition satisfied one of the inclusion criteria (Table 4.1) underwent primary trauma diversion to the PWH trauma centre. Trauma patients initially excluded by the PTD criteria (Table 4.2) received emergency treatment in the AHNH ED, with some being transferred to the PWH and therefore being classified as secondary trauma diversion cases.

Table 4.1 Inclusion criteria for primary trauma diversion

Anatomical Criteria
Flail chest
Two or more long-bone fractures
Amputation proximal to wrist or ankle
All penetrating trauma to head, neck, or torso
Limb paralysis
Pelvic fracture
Combined trauma and burn (partial or full thickness, > 20% of total body surface area)
Physiological Criteria
Glasgow coma scale < 14
Systolic blood pressure < 90 mm Hg
Respiratory rate < 10 or > 29 per min

Table 4.2 Exclusion criteria for primary trauma diversion (ambulance crew should take to the nearest hospital)

Exclusion Criteria
Patient cannot maintain own airway and/or breathing AND
Ambulance crew unable to establish and maintain patent airway and effective ventilation
Patient in cardiac arrest
Child under 12 years old (or < 130 cm in height)
Mass casualty incident (4 seriously injured patients in one incident)
Patient handled by ambulance staff who have been deployed from other areas under special circumstances and have not yet been trained on trauma diversion

Ambulance crews serving these two hospitals were given written information on the introduction of PTD and in-service training. Ambulance crews in Hong Kong usually work as a two-person team, with at least one trained to paramedic emergency medical assistant level II (EMAII). Paramedics are capable of performing endotracheal intubation (without drugs), intravenous cannulation, and fluid administration. A dedicated proforma in the form of a four-step decision flow chart (Appendix 2) was designed to allow ambulance crews to determine whether or not the patient was a candidate for PTD according to the inclusion and exclusion criteria. The proforma used by each crew was collected and audited to ensure decision-making was consistent.

All ED doctors at the PWH were introduced to the PTD protocol through in-service training. A 24-hour telephone 'hotline' was made available to allow ambulance crews to consult with the ED specialist on duty at the PWH. A form was designed to facilitate consistent ED decision-making with respect to PTD and to collect data about telephone consultations.

Data were collected from a variety of sources. Ambulance crew report forms, trauma diversion decision forms, and telephone data forms were all collected by the PWH trauma nurse coordinator for review by the NTEC Trauma Advisory Committee. Given the pre-hospital nature of the decision-making process, the clinical findings of the ambulance crew at the scene were taken to be the best available when assessing the appropriateness or otherwise of the PTD process.

Data were collected on demographic details, timing of incident and call, injury description, and injury severity. Length of stay was recorded, along with specialty and level of care, utilisation of computed tomography or magnetic resonance imaging scans, surgical procedures, and mortality at 30 days. The primary outcome measures employed for the study were the proportion of correctly diverted trauma patients and the reduction or increase in time to definitive care for these patients. A "trauma call" was defined as the activation of the hospital trauma team, a multidisciplinary team led by a specialist emergency physician. For the purpose of this study, the time the patient reached definitive care was defined as the time of departure from the trauma room in the emergency department, whether the destination was the operating room, the intensive care unit (ICU), or the general ward.

4.4 Results

During the 46-week study period, 95 patients underwent trauma diversion to the PWH, of which 60 were primary trauma diversions and 35 were secondary trauma diversions. This represents an additional trauma workload of two patients per week for the PWH ED. Basic data are given in Table 4.3. Ambulance crews used the trauma hotline in three cases over the study period, resulting in two primary trauma diversions and no diversion in the remaining case. Traffic-related injuries (52%) and falls > 1 m (22%) were the predominant injury mechanisms among the diverted patients. Traffic-related injuries were the most common injury mechanism in the secondary transfer group (34%) along with penetrating trauma (20%). The median ISS was 9 for the PTD patients and 10 for the secondary diversion patients. The median ISS for the overall sample was 9, indicating predominantly moderate trauma, and the probability of survival was correspondingly high among both primary and secondary diversion patients.

Table 4.3 Basic data for diverted cases

Variables	PTD n = 60	STD *n* = 35	Total *n* = 95	P-value
Mean age (SD)	39 (19)	44 (21)	41 (20)	0.69*
Gender M:F	38:22	26:9	64:31	0.27#
Causes of Injury				
Motor vehicle crash	24 (40%)	11 (31.4%)	35 (36.8%)	0.40*
Bicycle crash	7 (11.7%)	1 (2.8%)	8 (8.4%)	0.25**
Fall > 1meter	13 (21.7%)	4 (11.4%)	17 (17.9%)	0.27**
Fall < 1meter	4 (6.7%)	5 (14.3%)	9 (9.5%)	0.28**
Struck by object	3 (5%)	5 (14.3%)	8 (8.4%)	0.14**
Penetrating assault	4 (6.7%)	7 (20%)	11 (11.6%)	0.092**
Burn/scald	2 (3.3%)	2 (5.7%)	4 (4.2%)	0.62**
Others	3 (5%)	0	3 (3.1%)	0.29**
Trauma Call	18 (30%)	12 (34%)	30 (32%)	0.66**
Injury Severity Score				
1-8	21	10	31	
9-15	25	14	39	
> 15	14	11	25	
Median	9	10	9	
Mean ± SD	11.7 ± 10.8	13.2 ± 10.4	12.2 ± 10.6	0.49*
Range	1-51	1-50	1-51	
Revised Trauma Score				
7.84	50	29	79	
< 7.84	10	6	16	
Mean ±	7.47 ± 1.26	7.69 ± 0.65	7.55 ± 1.09	0.29*
Range	0-7.84	4.22-7.84	0-7.84	
Probability of Survival				
0-0.49	2	1	3	
0.50-0.89	3	3	6	
0.90-0.94	5	1	6	
0.95-1.0	48	28	76	
Mean ± SD	0.94 ± 0.17	0.93 ± 0.19	0.93 ± 0.17	0.81
Range	0.076-0.997	0.006-0.997	0.006-0.997	

SD, standard deviation; #Independent samples *t* test ; *χ^2 test ; **Fisher exact test.

Of the 95 initial cases, four patients were excluded from further analysis as primary trauma diversion was impossible: three patients attended the AHNH ED using non-ambulance transport and were subjected to secondary trauma diversion (STD), but obviously could not have been primarily diverted; one patient specifically requested to be taken to the PWH and was therefore also excluded from the assessment of correct application of the primary diversion protocol.

Of the remaining 91 cases, 69 (76%) were diverted correctly in accordance with the written protocol, seven cases (8%) were under-diverted, that is, they were taken to the AHNH when they fulfilled the PTD criteria, and 15 cases (17%) were brought to the PWH using the PTD protocol when they did not fulfill the PTD criteria.

Of the 35 cases who underwent secondary diversion, two were taken to the AHNH because of immediate airway or breathing problems, 21 patients did not meet the PTD criteria but required specialty treatment not available in the AHNH, four were under 12 years of age, three were involved in a mass casualty incident (MCI), three patients attended the AHNH of their own accord, one patient was treated by an ambulance crew with no PTD training, and one patient was transferred from a local psychiatric hospital to the AHNH without reference to PTD as the crew did not recognise the case as one of trauma.

The time difference between the point at which each patient was injured and delivered to definitive care (defined as the time the patient left the ED at the PWH) is shown in Table 4.4. PTD saved an average of 97 minutes from the time ambulance control received the emergency call to the time the patient was delivered to definitive care. Table 4.5 details the impact analysis of PWH services as a result of the diversion policy in the cluster. There were seven deaths, one from a burn and one case where no data were available. Analysis of the remaining five deaths using TRISS methodology revealed three patients with Ps > 0.5 and two patients with Ps < 0.5; there was also one unexpected survivor (Ps < 0 5)

Table 4.4 Time intervals from injury to definitive care

Time Interval (average, minutes)	Primary Diversion n = 58	Secondary Diversion n = 30	Mean Difference	95% CI or Difference	P value
Injury to call time	5 5	6 2	-0 64	-4 1 to +2 8	0 7
Ambulance times					
Call to arrival at scene	7 6	7 0	+0 6	-2 1 to +3 3	0 7
Scene to patient's side	4 0	2 2	+1 8	-0 7 to +4 3	0 2
On scene time	16 6	11 8	+4 7	+1 0 to +8 4	0 014
Scene to hospital	18 3	11 4	+6 9	+3 5 to +10 3	<0 001
Subtotal	46 4	32 6	+13 8	+8 0 to +19 6	<0 001
Total ED time					
AHNH to PWH	0	101 5	-101 5	-116 0 to -87 0	<0 001
(ED transfer)					
PWH ED time	90 0	94 7	-4 7	-50 9 to +41 5	0 8
Subtotal	90 0	195 1	-105 1	-155 2 to -55 0	<0 001
Time to definitive care	13 63	233 1	-96 7	-153 9 to -39 6	0 002

P-value independent samples *t* test Detailed ambulance data were missing for two patients in each group Three patients in the secondary transfer group were not transported to the AHNH by ambulance, so there are no times available

Table 4.5 Impact analysis: morbidity and length of stay

Variables	Primary Diversion n = 60	Secondary Diversion n = 35	Total n = 95	P value
ICU Service				
Number of ICU admissions	10 (16.7%)	6 (17.1%)	16 (16.8%)	1.0*
Mean ICU LOS (days) ± SD	11.2 ± 15.9	5.2 ± 6.1	8.9 ± 13.1	0.3#
Surgical procedure	32 (53%)	15 (43%)	47 (50%)	0.4*
CT/MRI	23 (38.3%)	21 (60%)	44 (46.3%)	0.055*
Special Care				
Neurosurgery	25 (14.7%)	15 (42.9%)	40 (42%)	1.0*
Orthopedics and trauma	14 (23.3%)	6 (17.1%)	20 (21%)	0.6*
Other surgical specialty	6 (10%)	11 (31.4%)	17 (17.9%)	0.012*
Burns surgery	2 (3.3%)	2 (5.7%)	4 (4.2%)	0.62*
Mean hospital LOS ± SD	12.3 ± 21.2	6.9 ± 7.0	10.3 ± 17.5	0.074#
Outcome				
Discharge	15 (25%)	25 (71%)	63 (66.3%)	<0.001*
Died	4 (6.7%)	3 (8.6%)	7 (7.4%)	0.71*
DAMA	2 (3.3%)	0	2 (2.1%)	0.53*
Rehabilitation	39 (65%)	7 (20%)	23 (24.2%)	<0.0001*

DAMA: discharge against medical advice; #Independent samples *t* test ; *Fisher exact test.

4.5 Discussion

There has been considerable disagreement about the feasibility of introducing PTD to Hong Kong despite favorable evidence from other parts of the world. The initial experience of primary trauma diversion in Hong Kong reflected in the results of this study suggests that patients receive definitive care a mean of 97 minutes earlier with PTD in comparison with the conventional approach of taking the patient to the nearest hospital. There did not appear to be any adverse events resulting from PTD in the 14-minute delay the protocol imposed on patients in this study. Specifically, the two patients taken to the AHNH with airway and breathing problems both had severe respiratory compromise and these decisions were appropriate. There did not appear to be any patients who clinically deteriorated in transit to the PWH as a result of PTD.

The fact that PTD saved an average of 97 minutes from the time the ambulance received the call to the time of definitive treatment may have saved the lives of major trauma victims, although we cannot demonstrate this given the small number of cases observed. The additional workload (0.3 cases per day) is reasonable for the PWH and does not appear to have impacted on the other core activities of the ED. The definition of definitive care varies between studies, but our decision to define it as the time of departure from the ED (to the operating room, ICU, or ward) allowed for consistency as it is easily defined and recorded. In the PWH, major trauma is given priority for imaging studies such as computed tomography, and delays are usually no more than 5 to 10 minutes. Likewise, there is a dedicated trauma theatre and the hospital protocol provides for the operating suite to be alerted at an early stage during trauma resuscitation, with delays being a rarity.

The number of patients included in this study is too small to speculate on whether an improvement of 97 minutes impacts on survival, but it is likely that this is a clinically significant difference in the time to definitive care. The

AHNH transfers all patients with significant trauma requiring inpatient care to the PWH as it does not have onsite surgical and orthopedic services, so all potential study patients will have been captured. Around one third of the patients in each group had an ISS of 1 to 8, representing minor injuries. This may reflect over-triage on the part of the ambulance crews in the PTD group, and further review of the triage criteria may reduce this proportion. However, a reasonable degree of over-triage is to be expected in any trauma system, and this is especially so during the early stages of introducing a new concept such as PTD.

Some patients with minor injuries will have been transferred from the AHNH to the PWH and classified as secondary trauma diversions as they required inpatient specialist care for their injuries despite their minor nature. Two seriously injured trauma patients (ISS 26 and 50) who subsequently died were not diverted to the trauma centre using PTD because they were thought to require life-saving interventions for severe airway or breathing difficulties.

Given that time to definitive care is critical, patients who were taken to the nearest hospital (AHNH) rather than to the trauma centre (PWH) are perhaps the very patients who may have benefited most from PTD, although the small number of cases does not allow for further comment. This aspect of potential under triage warrants further review of the triage criteria and operational issues. Although the two hospitals that participated in this study are 10 km apart, they are connected by 6 km of high-speed highway that allows for patients to be transferred between the two hospitals in around 8 minutes under optimal conditions.

During busy traffic periods or after a road collision on this highway, these times will increase considerably. These factors will also impact on implementation of the PTD protocol among individual ambulance crews. PTD for severely injured patients with airway and breathing problems requires a high level of risk assessment on the part of the ambulance crew and a high degree of skill in managing the airway and ventilation. Further training may be required for ambulance crews before PTD can be extended to include these patients.

Given the lack of surgical facilities at the AHNH, all of these trauma patients would have been transferred in any event. In addition, the proportion of patients requiring operative intervention or ICU care was similar in each group, so the principal impact on services is on the two EDs at the AHNH and the PWH. The PWH admitted the equivalent of two extra trauma patients per week (an extra 0.0006% assuming a weekly ED attendance of 3,462 patients). Anecdotal evidence suggests this had a minimal impact on the care of other ED patients. The impact on the AHNH in terms of reducing workload in a smaller department could also be helpful, but is unlikely to have a major impact on the care of other patients.

There was an excess of transfers for other surgical specialties that mainly represent plastic and reconstructive surgery referrals. However, the mean length of stay was lower in the secondary transfer group, which may reflect the smaller number of patients who required a formal operative procedure.

In addition, the smaller proportion of secondary transfers who were discharged to a rehabilitation facility may reflect the higher number of primary diversion patients requiring surgery. Some patients were excluded from PTD as they were part of a mass casualty incident (MCI) or were a pediatric trauma patient (defined as age < 12). Motor vehicle crashes and penetrating assaults because of fights between groups were the two leading causes of trauma in this study and are types of incidents that commonly involve multiple casualties.

The PWH has the capacity to deal with four seriously injured patients simultaneously in accordance with the regional disaster plan. The PTD protocol specifically defines MCI as an exclusion criterion for using PTD, which seemed reasonable until PTD was well-established. However, as local crews become more familiar with PTD, it is suggested that even during an MCI situation, up to four seriously injured patients should be taken to the PWH trauma centre in accordance with PTD criteria.

The PWH is the only hospital providing 24-hour pediatric surgery, pediatric ICU, neurosurgical, otorhinolaryngology, and cardiothoracic surgical services in this region of Hong Kong. All major trauma patients including children will eventually be referred to the PWH for further management and definitive care. It may be more efficient to send all pediatric trauma patients who meet PTD criteria to the PWH directly. It is unlikely that the small number of children injured in this region (around one severely injured child per month) would add significantly to the PWH workload if they were all triaged to the PWH.

The evolution of these guidelines in light of the initial results of this study suggests that both MCI patients and pediatric trauma patients should be included in PTD protocols. Ambulance personnel may require further training to be able to identify children suitable for PTD and the physiological criteria may require revision by, for example, including capillary refill time instead of blood pressure measurement for small children. The introduction of PTD has significantly decreased the time taken to deliver patients to definitive care in this region of Hong Kong. The number of patients considered in this study does not allow us to comment on the effect of PTD on mortality at this stage. Further study of the effects of extending primary trauma diversion throughout Hong Kong is warranted to assess its effect on morbidity and mortality throughout the region.

Chapter 5

Do Trauma Teams Make A Difference?

5.1 Abstract

Objective: To evaluate the association between trauma team activation according to well-established protocols and patient survival.

Methods: A single-centre registry study of data collected prospectively from trauma patients (who were treated in a trauma resuscitation room, died, or were admitted to the ICU) in a tertiary referral trauma centre emergency department (ED) in Hong Kong. A 10-point protocol was used to activate rapid trauma team response to the ED. The main outcome measures were mortality, need for ICU care, or an operation within 6 h of injury.

Results: Two thousand five hundred and thirty nine consecutive trauma patients admitted between 1 January 2001 and 31 December 2005 were included in our trauma registry, of whom 674 patients (mean age 43 years, S.D. 22; 71% male; 94% blunt trauma) met trauma call criteria. Four hundred and eighty two (72%) correctly triggered a trauma call and 192 (28%) were not called ('undercall'). Patients were less likely to have a trauma call despite meeting the criteria if they were aged over 64 years, had sustained a fall, had a respiratory rate of < 10 or > 29 per minute, had systolic blood pressure of between 60 and 89 mmHg, or a GCS of 9-13. In a sub-group of patients with a moderately poor probability of survival (probability of survival, *P*s, 0.5-0.75),

the odds ratio for mortality in the undercall group in comparison with the trauma call group was 7.6 (95% CI, 1.1-33.0).

Conclusions: In the institution studied, undercalls accounted for 28% of patients who met trauma call criteria, and in patients with a moderately poor probability of survival, undercall was associated with a decreased chance of survival. Although trauma team activation did not guarantee a greater likelihood of survival, better compliance with trauma team activation protocols optimised care processes and may have translated into a higher probability of survival.

5.2 Introduction

Trauma is a leading cause of death worldwide, including in Hong Kong (Murray & Lopez, 1997; Department of Health HKSAR, 2002), and the development of an effective trauma system is a vital strategy to optimise patient morbidity and survival (Lecky et al., 2000; Demetriades et al., 2002; Celso et al., 2006). Trauma systems involve a multitude of different pre-hospital and hospital based components, each of which contributes in varying degrees of importance to improving patient care (Ip & Ho, 2000; Lau & Lau, 2000; Young et al., 1998; Sampalis et al., 1997; Roy, 1987; Cooper et al., 1998; Smith et al., 1990).

When a severely injured trauma patient arrives at hospital, one important aspect of a good trauma system is the early and rapid assembly of experienced clinical decision makers who can plan and implement early life- and limb-saving procedures (Plaisier et al., 1998; Khetarpal, 1999; Lossius & Langhelle, 2000; Eastes et al., 2001; Kohn et al., 2004; Dattani et al., 2005; Smith et al.; 2005). Multiple levels for trauma team activation have been described according to the triage protocols adopted in individual system, but whichever system is used, a trauma team is assembled in the trauma resuscitation room in response to a trauma activation call. Such a system has been in place in Hong Kong since 1994 (Sampalis et al., 1997; Smith et al., 2005).

Previous studies have shown that a good trauma system is likely to improve the patient survival rate (Ip & Ho, 2000; Lau & Lau, 2000; Young et al., 1998; Sampalis et al., 1997; Roy, 1987; Cooper et al., 1998; Smith et al., 1990), that certain activation criteria may predict outcomes better than others, and that some factors absent from trauma team protocols should be included such as age, gender, previous illness, or injury mechanism (Lossius et al., 2000; Kohn et al., 2004). Some studies also report under-triage and over-triage rates (Smith et al., 2005). However, no prior investigation has reported on the impact of under triage on patient survival. Does it really make a difference to patient survival if trauma calls are not activated?

The aim of this study was to evaluate the association between trauma team activation according to well-established protocols and patient survival.

5.3 Materials and Methods

5.3.1 Study Design, Patients, and Setting

This single-centre registry study of data collected prospectively was conducted on all consecutive major trauma cases included in our trauma registry database at the emergency department (ED) of the Prince of Wales Hospital (PWH) between January 2001 and December 2005. The PWH is a university teaching hospital with 1,200 beds and is the regional major trauma centre for the New Territories East Cluster in Hong Kong. The ED has an annual attendance of 160,000 patients per annum. Approximately 520 trauma patients per annum are triaged to the designated trauma resuscitation rooms according to specific predetermined protocols, and approximately 160 patients per annum have an injury severity score (ISS) > 15 (Baker et al., 1974; AAA, 1990). Ethical approval for this study was waived by the local institutional Research Ethics Committee as the data were collected from a large trauma registry and patient data were anonymous (Appendix 1). Health care was provided free at the point of access to the ED between January 2001 and October 2002, and during this period charges were levied only if the patient was admitted to a hospital ward or referred for outpatient follow up. From November 2002, a HK$100 (US$13, GBP 7, EUR 10) charge was made for each ED attendance. The local trauma system has been set up according to well-established evidence-based recommendations, international standards, and local trauma needs (Plaisier et al., 1998; Khetarpal et al., 1999; Lossius et al., 2000; Eastes et al., 2001; Kohn et al., 2004; Dattani et al., 2005; Smith et al., 2005; Hospital Authority of Hong Kong, 2005). In this two-tier system, the first response involves a team of three emergency physicians, at least one of whom is a specialist, and three nurses, at least one of whom is trained in trauma care. The second tier is the hospital trauma team that responds to a "trauma call" and includes two general surgeons (one trainee and a specialist), an orthopaedic surgeon, and an intensive care unit physician (usually an anaesthetist). The purpose of the trauma team is to enable rapid assessment, resuscitation, and operative or intensive care intervention for patients who have suffered potentially major trauma that is highly likely to involve life-threatening or life-disabling injury. The trauma registry of the PWH was established in December 2000. Information is collected prospectively on trauma patients who sustain injuries that warrant resuscitation or close monitoring in a trauma resuscitation room, patients who die, or patients admitted to the ICU. Data from the trauma database were analysed retrospectively. The data analysed included demographic variables; mechanism of injury; anatomical and physiological trauma scores (including abbreviated injury scores for each body region (AIS), the injury severity score (ISS), and the revised trauma score (RTS)) and patient mortality and complications (Baker et al., 1974; AAA, 1990).

5.3.2 Definitions

Trauma was defined as a blunt external or penetrating injury. Adults were defined as those aged ≥ 18. Pre-injury morbidity was defined as the presence of any pre-injury chronic systemic disease that may or may not limit normal activity (e.g. stroke, hypertension, diabetes mellitus, malignancy, psychiatric illness, respiratory, gastrointestinal, cardiovascular, hepatic, neurological, renal, endocrine or metabolic disease, chronic alcohol intake, or active smoking).

The trauma call activation criteria applied in the PWH are described in Appendix 3. For the purpose of this study, if any single criterion was met, then a trauma call should have been activated. Haemodynamic instability was defined as a single systolic blood pressure reading of < 90mmHg at any time from the time of injury to leaving the ED. Respiratory distress was defined as a single respiratory rate of > 29 or < 10 breaths per minute at any time from the time of injury to leaving the ED. A "trauma call" was defined as activation of the multidisciplinary hospital trauma team. For the purpose of this study, a "correct call" was defined as activation of the trauma call when indicated according to predetermined guidelines. An "undercall" was deemed to have occurred when it was indicated that a call was made according to the guidelines but was not activated. An independent audit group (the Trauma Advisory Committee) judges the appropriateness of each trauma call, but for the purpose of this study, only objective criteria were applied. The probability of survival for each patient was calculated using the well-established TRISS methodology (Baker et al., 1974; AAA, 1990; Boyd et al., 1987).

5.3.3 Outcome measures

The primary outcome measure was mortality (defined as death within 28 days of injury). The secondary outcome measures included an operation within 6 hours or a need for ICU (Smith et al., 2005).

5.3.4 Statistical analysis

Baseline characteristics were analysed using Fisher's exact test, the χ^2-test, the *t*-test, the Mann-Whitney *U*-test, ANOVA, and the Kruskall-Wallis test where appropriate. To identify variables associated with undercall, data were initially analysed by univariate analysis. Significant "independent" variables were then entered into a multiple logistic regression model with undercall as the dependent variable. To determine whether undercall was associated with mortality (the dependent variable), undercall and probability of survival groups (independent variables) were analysed by logistic regression. However, undercall is unlikely to affect patients with a high probability of survival who are likely to live anyway, or to affect patients with a very low probability of survival who are likely to die anyway. Therefore, patients were further divided into probability of survival sub-groups and the logistic regression model was repeated for each group.

5.4 Results

Between 1 January 2001 and 31 December 2005, 150,593 patients attended the ED with an injury. Of these, 2,539 consecutive trauma patients were included in our trauma registry. After excluding a further 1,865 patients who did not meet the criteria for a trauma call (131 dead before arrival, 1,719 patients who were correct cases of no call, and 15 overcall patients), 674 patients remained for analysis (mean age 43, S.D. 22; 71% male; 94% blunt trauma), of whom 482 (72%) were cases of correct trauma calls and 192 (28%) were undercalls according to objective criteria. Of the 192 undercalls, the consensus committee judged that 148 (76%) were appropriate decisions.

Table 5.1 Patient characteristics (n = 674)*

Variable	Correct trauma call n =482	Undercall n = 192	P value
Age (years), mean ± SD	42 ± 21	45 ± 25	0.0407
≥ 65, no. (%)	67 (14)	52 (27)	<0.0001
Male sex, no. (%)	354 (73)	124 (65)	0.0243
Type of injury, no. (%)			
– Blunt	453 (94)	183 (95)	0.5820
– Penetrating	29 (6)	9 (5)	
Cause of injury, no. (%)			
– Motor vehicle crash	292 (61)	74 (39)	<0.0001
– Fall	117 (24)	86 (45)	<0.0001
Pre-injury morbidity status, no. (%)	94 (20)	64 (33)	0.0002
ISS > 15, no. (%)	324 (67)	78 (41)	<0.0001
Site of injury and AIS > 2			
– Head and neck, no. (%)	253 (53)	73 (38)	0.0006
– Thorax, no. (%)	182 (38)	18 (9)	<0.0001
– Abdomen, no. (%)	84 (17)	11 (6)	<0.0001
– Limbs, no. (%)	138 (29)	26 (14)	<0.0001

* Percentages are presented with the denominator of 482 or 192 as appropriate; the χ^2 test or Fisher's exact test is used for categorical data.

The patient characteristics of the correct trauma call and undercall groups are shown in Table 5.1. Despite meeting trauma call activation criteria, trauma calls were not activated in 52 of the 119 (44%) patients aged > 64, 48 of the 176 (27%) females, 78 of the 402 (19%) patients with major trauma (ISS > 15), 73 of the 326 (22%) patients with a head injury of AIS > 2, 26 of the 164 (16%) patients with AIS > 2 extremity injuries, 18 of the 200 (9%) patients with AIS >

2 chest injuries, 11 of the 95 (12%) patients with AIS > 2 abdominal injuries, 64 of the 158 (41%) patients with a pre-injury illness, and 86 of the 203 (42%) patients with a fall history. Univariate analysis revealed that the following factors were associated with undercall: age > 65, female, injury resulting from a fall, and pre-injury comorbidity.

Of the 10 trauma call activation criteria, the three criteria most associated with undercalls were GCS ≤ 13, respiratory distress, and haemodynamic instability (Table 5.2). Despite meeting trauma call activation criteria, trauma calls were not activated in 22 of the 68 (30%) patients with systolic blood pressure between 60 and 89 mmHg, 59 of the 61 (97%) patients with a respiratory rate of > 29 breaths per minute, and 98 of the 260 (38%) patients with a GCS ≤ 13. The undercall group left the ED on average 10 min sooner than the correct trauma call group. However, patients who required an urgent operation or ICU care waited an average of 23 min longer to leave the ED if they were in the undercall group in comparison with those in the correct call group (Table 5.3).

Table 5.2 Evaluation of trauma call criteria (n = 674)*

Variable	Correct trauma call n = 482	Undercall n = 192
1. Haemodynamic instability (SBP < 90mmHg)	42 (9)	22 (12)
2. Respiratory distress (RR < 10 or > 29 per minute	2 (<1)	59 (31)
3. Glasgow coma score ≤ 13	162 (34)	98 (51)
4. Penetrating injury of head to groin	27 (6)	2 (1)
5. Blunt injury to chest/abdomen	157 (33)	8 (4)
6. Flail chest	0	0
7. Spinal injury with paralysis	22 (5)	1 (<1)
8. ≥ 2 proximal long bone fractures	13 (3)	0
9. Open/depressed skull fracture	26 (4)	1 (<1)
10. Unstable pelvis fracture	30 (5)	1 (< 1)

* Percentages are presented with the denominator of 674

Table 5.3 Processing time (minutes) in the emergency department (n = 674)*

Variable	N	Correct trauma call n = 482	N	Undercall n = 192	P value†
Arrival to ED discharge	474	59 (43 – 85)	189	72 (51 – 105)	<0.0001
Require urgent operation or ICU care	251	51 (39 – 72)	38	63 (48 – 115)	0.0003
Arrival to trauma room discharge	474	56 (41 – 78)	189	65 (45 – 93)	0.0018
Require urgent operation or ICU care	227	50 (38 – 68)	32	67 (41 – 120)	0.0119

Medians, interquartile range, and range; † Mann-Whitney test

The adjusted odds ratios of significant variables associated with undercall are shown in Table 5.4. Patients were less likely to be the subject of a trauma call despite meeting trauma call criteria if they were aged over 64, had sustained a fall, had a respiratory rate of < 10 or > 29 per minute, had systolic blood pressure between 60 and 89 mmHg, or had a GCS of 9-13. The probability of survival was generally higher in the undercall group than in the correct call group, and this in turn was associated with a lower mortality rate and less of a need for an urgent operation and ICU care (Table 5.5). Nevertheless, of the 674 patients meeting trauma call activation criteria, 24 (4%) were undercalls and died, 23 (4%) were undercalls yet required an urgent operation, and 30 (5%) were undercalls requiring ICU care.

Table 5.4 Adjusted odds ratios for undercalls*

Criteria	Odds Ratio	95% CI	P value
Age > 64 years	1.9	1.1 – 3.2	0.0208
Age ≤ 64 years		reference	
Falls	1.8	1.1 – 2.8	0.0121
No falls		reference	
Respiratory rate > 29	21.6	8.3 – 55.4	<0.0001
Respiratory rate 10 – 20		reference	
Systolic blood pressure 60 – 89 mmHg	3.0	1.3 – 6.6	0.0076
Systolic blood pressure ≥ 90 – 119 mmHg		reference	
GCS 13	5.7	2.4 – 13.2	<0.0001
GCS 12	6.6	1.9 – 23.2	0.0030
GCS 11	3.8	1.7 – 8.6	0.0016
GCS 10	4.0	1.5 – 10.6	0.0047
GCS 9	3.4	1.1 – 10.0	0.0274
GCS 15		reference	

* Only variables meeting statistically significant odds ratios are included.

Table 5.5 Relationship between trauma call activation and life-threatening status (N = 674)

Variable	Correct trauma call n = 482	Undercall n = 192	P value**
Ps*, no. (%)			0.0003
0 – 0.25	41 (8)	3 (2)	
0.26 – 0.50	25 (5)	2 (1)	
0.51 – 0.75	36 (7)	13 (7)	
0.76 – 0.95	71 (15)	34 (18)	
0.96 – 1.00	255 (52)	129 (67)	
Using raw data: †			
W score	4.93	0.97	
Z score	3.83	0.52	
M score	0.69	0.81	
Using adjusted data‡			
W score	0.04	-3.59	
Z score	0.03	-2.13	
M score	0.71	0.84	
Life-threatening status			
Mortality – no. (%)	93 (19)	24 (13)	0.0421
Operation < 6 hours – no. (%)	147 (30)	23 (12)	0.2242
ICU – no. (%)	219 (45)	30 (16)	<0.0001

* Ps, probability of survival; ** chi-square test or Fisher's exact test; † Using only raw data and making no adjustment for missing variables; ‡ Using complete data where normal values are used in place of missing data

Analysis of raw data showed that there were 4.93 excess survivors in the trauma call group and no excess survivors in the undercall group. The case mix of each group was clearly different. After replacing missing values with normal values, further analysis of 'complete' data showed that there were but 3.59 excess deaths in the undercall group. The case mix of each group was again different.

Table 5.6 Adjusted odds ratios for mortality, ICU admission, and urgent operation

Variables	Odds Ratio	95% CI	P value
Mortality			
Undercall	1.9	1.0 – 3.0	0.0539
1 – Ps *	530	175 – 1605	<0.0001
ICU admission			
Undercall	0.2	0.2 – 0.4	<0.0001
1 – Ps *	5.1	2.6 – 10.0	<0.0001
Urgent operation			
Undercall	0.9	0.5 – 1.9	0.8165
1 – Ps *	13.0	3.5 – 49.1	0.0001
Ps groups			
0 – 0.25	152000	0 - α	0.9776
0.26 – 0.50	0.6	0.03 – 10.1	0.6963
0.51 – 0.75	7.6	1.7 – 33.0	0.007
0.76 – 0.95	1.4	0.5 – 4.1	0.5181
0.96 – 1.00	0.5	0.1 – 4.4	0.41

* Ps, probability of survival

In comparison with the correct trauma call group, the undercall group had a low odds ratio for mortality of 1.9 (P = 0.054), a small value in comparison with the other independent variable (probability of survival) for which the odds ratio was 530 (Table 5.6). Undercall appeared to have little association with mortality in the high and low probability of survival groups. However, the odds ratio for death was 7.1 in the undercall group for patients with a moderate to low probability of survival (*Ps*, 0.5-0.75).

5.5 Discussion

This study shows that there was a 28% undercall rate in the Hong Kong trauma system despite the use of protocol-driven trauma call activation. Despite meeting trauma call activation criteria, trauma calls were not activated for a significant proportion of patients aged > 64, patients with falls, patients with respiratory compromise, patients with moderate degrees of hypovolaemic shock, and patients with depressed conscious levels with a GCS of between 9 and 13. Patients for whom no trauma call was made were likely to undergo a mean delay of 20 min in the ED before admission to the ICU or for an urgent operation. The impact of undercall is seen most clearly in patients with a probability of survival of between 0.5 and 0.75.

The undercall rate in the local context may be explained by a number of factors. First, trauma team leaders have initially been encouraged not to follow guidelines rigidly, but to use their judgment in interpreting their application. Second, a significant proportion of cases are elderly females who have sustained low-energy falls and it may be difficult to differentiate a blunt external head injury from acute stroke. Third, some of the trauma call criteria originally presented are non-specific and qualitative, e.g. haemodynamic instability, respiratory distress. These criteria are clearly open to interpretation. Fourth, many of the criteria may be met for only a short period, e.g. one physiological reading, such that doubt is cast on the seriousness of the case. Fifth, some of the anatomical criteria are ambiguous, e.g. blunt injury to chest or abdomen. Sixth, the trauma team leader may have made the judgment that although criteria were met, it was unlikely that a trauma call would result in any significant change in management.

In the absence of a randomised design and groups with equal probability of survival, it is not possible to determine the cause and effect of undercall on patient survival and morbidity. Such a randomised study would require withholding a trauma team from activation for one group, which would not be ethically justified. Nevertheless, a 28% undercall rate appears to be quite high, and there was a strong association between undercall and mortality in the group with a moderately low probability of survival. It is reassuring to note that only five (3%) of the undercall patients had a probability of survival of less than 50%. On peer review, none of these cases were considered avoidable deaths. Although peer review adjudged that the decision not to activate a trauma call was reasonable in 75% of these undercall cases, there remains a concern that a small proportion of these cases may not have received optimal care.

Our data suggest that that there were fewer excess survivors in the undercall group than in the correct trauma call group (W statistic). Does this mean that undercall results in unexpected deaths, or that correct trauma calls result in more unexpected survivors, or does the case mix render the data uninterpretable? To adjust for the case mix, we initially used multivariate logistic regression and included trauma call and probability of survival variables to assess their relative contribution. The regression analysis suggested that although undercall may have increased the odds of death, its contribution was extremely small in comparison with that of patient factors and it did not reach statistical significance. If so, then this suggests that the trauma team leaders' judgment may have been appropriate, at least in that a trauma call would have had little impact on the patient outcome. However, does the analysis of the undercall and correct trauma call groups as a whole mask a critical sub-group?

To adjust further for case mix, we analysed each group according to distinct probability of survival sub-groups. This analysis revealed that undercall made little difference in patients with a very low probability of survival (*P*s, 0-0.5) who were likely to die regardless of the intervention and that undercall made no difference to patients with a high probability of survival (*P*s, 0.75-1.0) who were likely to live whichever intervention was implemented. The real impact was in the group with a moderate probability of survival (0.5 -0.75). In this probability group, our data show that the odds ratio for mortality in the undercall versus the correct trauma call group was 7.6, i.e. in this group, undercall increased the probability of death more than seven-fold. In retrospect, it appears that although our trauma team leaders used a high level of clinical acumen to assess patients, undercall was strongly associated with mortality in the moderately severe injury group and should therefore be minimised.

We recommend that trauma call criteria be made as quantitative and specific as possible. For example, haemodynamic stability should be defined as a single measurement of systolic blood pressure < 90mmHg at any time from injury to leaving the ED, a single respiratory rate of < 10 or > 29 breaths per minute should result in trauma call activation, and a single reading of GCS < 14 in the presence of probable trauma should result in trauma call activation. Although single readings may occasionally be erroneous, modern equipment is usually accurate and even isolated abnormal readings suggest significant physiological disturbance. In conclusion, this study shows that in the institution studied, undercalls accounted for 28% of patients who met trauma call criteria, and that in patients with a moderate probability of survival, failure to activate a trauma call was strongly associated with increased mortality. Trauma team leaders need to comply closely with departmental trauma team activation protocols to optimise the chances of survival.

Chapter 6

The Role of Trauma Nurse Coordinators

6.1 Abstract

Background Trauma is one of the leading causes of death among all age groups in Hong Kong. In 2003, the Hospital Authority designated five hospitals as trauma centres. Five trauma nurse coordinators (TNCs) were employed to facilitate multidisciplinary care and to coordinate all aspects of quality improvement for injured patients. This study investigated the characteristics and role of TNCs in Hong Kong.

Methods A questionnaire was developed and sent to all TNCs in HK to ascertain their demographic characteristics, educational background, job training, role, and position within the organisational structure.

Results The TNCs were 30-40 years of age (four females); were experienced registered graduate nurses; held post-registration certificates or diplomas in emergency/critical care; and had 11 to 18 years of nursing experience. All of the TNCs had pursued masters degrees and two had completed their studies. Four of the TNCs had received formal training on computerised data management, abbreviated injury scale coding, and trauma nurse coordination. The TNCs had an average of 2.5 years' experience in their post. TNCs managed the trauma registry and were involved in clinical patient

management, quality assurance activities, professional and public education, and research.

Conclusion TNCs play an important role in trauma management in Hong Kong.

6.2 Introduction

Trauma is one of the five leading causes of death for all age groups in Hong Kong (HA, 2004). Experience and research has shown that trauma-related morbidity and mortality can be reduced by the introduction of organised trauma systems (Sampalis et al., 1999). A system of trauma care has recently been proposed and developed in Hong Kong. The development of trauma care and trauma nurse coordinators has been ongoing in Hong Kong and elsewhere for some time (Table 6.1).

In 2003, the Hospital Authority of Hong Kong designated five hospitals as trauma centres: the Prince Margaret Hospital, the Prince of Wales Hospital, the Queen Elizabeth Hospital, the Queen Mary Hospital, and the Tuen Mun Hospital. These centres deal with 150,000 trauma cases annually.

In an effort to provide optimal care for trauma victims, five trauma nurse coordinators (TNC) were employed to facilitate multidisciplinary care and to coordinate all aspects of quality improvement for injured patients. The American College of Surgeons recognises trauma nurse coordinators as central to the development and function of trauma care systems (American College of Surgeons, 1999).

The American College of Surgeons (1999) defines a trauma coordinator as "a designated individual with responsibility for coordination of all activities on the trauma service and works in collaboration with the trauma service director".

Despite this clear definition, the role of TNCs in Hong Kong is unclear at the present time. The aim of this study was to investigate the characteristics of the trauma nurse coordinators and their role in the Hong Kong trauma system.

Table 6.1 Trauma developments

Year	Developments
1971	First trauma nurse coordinators appointed in level 1 trauma centers in Illinois, USA
1982	Advanced trauma life support (ATLS) for nurses taught in conjunction with physician course in USA
1985	First trauma nurse coordinator appointed in Australia
1991	First trauma nurse coordinator appointed in Scotland
1994	Donald Trunkey's report suggests the development of a trauma system in Hong Kong
1997	ATLS starts in Hong Kong
1998	First trauma nurse coordinator in Hong Kong appointed at Queen Mary Hospital
1999	International Trauma Symposium held in Hong Kong
2003	Five hospitals designated as trauma centres in Hong Kong

References: Beachley et all.,1988 and Nocera, 2003

6.3 Methods

A questionnaire (Appendix 4) was developed and sent to the five TNCs in Hong Kong to ascertain their demographic characteristics, educational background, job training, role, and position within the organisational structure. Consent was obtained from all TNCs and data were anonymised for analysis. The survey was carried out in the autumn of 2004.

6.4 Results

The five TNCs in Hong Kong all completed the questionnaire. One was male and the other four female, and their ages ranged between 30 and 40. The average time they had worked in nursing was 14 years (ranging from 11 to 18 years). Their previous work experience and experience as TNCs are shown in Table 6.2.

Table 6.2: Demographic data for TNCs

Nursing experience (years)	TNC experience (years)	Area of work before TNC
13	2	ICU, AED
13	3	Surgery, Education, Medicine
18	< 1	ICU, Surgery
14	6	AED
11	1	AED

Qualifications of TNCs All of the TNCs in Hong Kong were registered nurses. They had at least a bachelor's degree in nursing and a post-registration certificate in either emergency or critical care nursing. Two of them also held a post-graduate diploma. All five TNCs had pursued master degrees, with two having already completed their degrees. They had also received trauma-related training on subjects such as basic cardiac life support, advanced trauma care nursing, and pre-hospital trauma life support and through participation in the trauma nursing core course. Three of them were qualified instructors for some of these courses.

TNC training Three TNCs began their jobs without specific formal training. Four TNCs had received formal training in courses on computerised data management, abbreviated injury scale coding, and trauma nurse coordination. Most of these courses were delivered in the United States.

Position of TNCs in the hospital hierarchy TNC positions were assigned either to the central nursing division (n = 3) or the accident and emergency department (n=2). Three TNCs equated their position in the administrative hierarchy to that of an advanced practice nurse (APN), one to that of a nurse specialist (NS), and one to that of a nursing officer (NO). Three coordinators were supervised by the trauma service director (chief of service or consultant) and the nursing administrator (general nursing manager or departmental operations manager). One TNC worked solely under nursing supervision, while another worked solely under medical supervision.

Role of the trauma nurse coordinators in the trauma system All TNC respondents reported that they had an active role in clinical matters, quality assurance, the trauma registry, education, and research.

Clinical activities All of the TNCs were actively involved in the initial management of trauma patients, including the resuscitation phase. These activities could involve clinical rounds, patient care follow-up, supervision of care plans, and the monitoring of trauma nursing care throughout the hospital. They identified cases for subsequent focused review and clarified issues among different specialties. They acted as a point of contact for liaison to facilitate multidisciplinary communications and anticipated the rehabilitation needs of patients. Moreover, the TNCs assisted families and patients in understanding their injuries and treatment progress. They also played an invaluable role in helping patients and their families to come to terms with their injuries.

Quality assurance The TNCs were responsible for the design, development, and implementation of trauma care quality assurance and local audit activities. They assisted the trauma lead clinicians in developing clinical guidelines and checking on adherence to resuscitation protocols. They monitored decision-making priorities in trauma care and investigated unusual events such as iatrogenic injuries and delays in performing interventions. Trends in complication rates, system errors, and epidemiological patterns were also monitored.

The TNCs in Hong Kong coordinated monthly trauma audit meetings and worked with doctors to conduct concurrent interdisciplinary patient reviews. They identified potential problem cases for discussion during trauma audit meetings and were also responsible for trauma data and case presentations.

Trauma registries The TNCs all had direct responsibility for the maintenance of the hospital-based trauma registry. The registry is a computerised database containing information about the condition, care, and outcome of trauma patients, as well as details of the injuries involved. Each TNC was responsible for data collected through the trauma registry and their quality. They reviewed clinical notes, radiology reports, surgeons' operation notes, and post-mortem findings to identify injury diagnoses. These injuries were then recorded and coded using the abbreviated injury scale (AIS); the injury severity score (ISS) and probability of survival (Ps) were then calculated. Data from trauma registries were used in regularly scheduled quality of care reviews. Based on these data, statistical reports were provided to the hospital for regular review and to the Hospital Authority for annual review.

Education and research Education was an essential component of the TNC role. It was important for TNCs to identify areas of educational need and coordinate appropriate educational sessions to deliver essential information. This entailed activities such as introducing new equipment and protocols, teaching trauma care education (such as advanced trauma care nursing), and teaching outreach programmes to pre-hospital organisations and the public. The TNC also gave feedback to doctors concerning current clinical guidelines and policies, directly participated and served as a role model during trauma resuscitations, and delivered debriefings after critical trauma resuscitations.

Furthermore, TNCs identified specific trauma research topics from areas of interest such as clinical questions and gaps in the literature. The TNCs assisted with trauma-related research projects by facilitating the effective use and analysis of the trauma registry data.

6.5 Discussion

The results of this small survey indicate that the role and responsibilities of Hong Kong TNCs are very similar to those of TNCs in cities in the United States, the United Kingdom, and Australia (Nocera, 2003; DeKeyser et al., 1993; Blansfield, 1996). Before the TNCs established trauma registries, the standards and outcomes of the Hong Kong trauma care system could not be compared with international benchmarks. TNCs have also contributed to the setting up of the trauma system in areas such as trauma audits, guidelines, and trauma call activation systems. Their posts can be justified by decreases in complications, length of stay, and early discharge planning (DeKeyser et al., 1993).

As all five Hong Kong trauma centres developed their own trauma registry databases in various systems, it would be difficult to merge the data together as a Hong Kong-wide trauma registry. This is similar to the situation in the United States; a US national survey of trauma coordinator positions conducted in 1996 indicated that 97% used a hospital-based trauma registry (Gantt et al., 1996). Combining all the existing databases into a single database is now a great challenge. It is essential to create a central trauma registry that allows for more efficient and accuracy prediction of trauma epidemiology and patient and health care provision needs.

Local training for TNCs is limited as there are no TNC courses, injury severity scale coding courses, or trauma registry courses available in Hong Kong. Local training and educational programmes for trauma registries, trauma system development and quality improvement, and for the various skills required for trauma nurse coordination should be considered to provide training to nurses interested in trauma nursing and those who wish to prepare for the TNC role for the purpose of career development.

6.6 Conclusion

The post of trauma nurse coordinator is a challenging position that has helped to elevate the profile of trauma and improve the standard of care provided to seriously injured patients in Hong Kong. Apart from participating in the resuscitation phase, trauma nurse coordinators play a pivotal role in later phases of care and in the overall planning and auditing of trauma services. Although no formal published study has demonstrated the "effectiveness" of trauma coordinators, experience from many trauma centres in Hong Kong and around the world suggests that it is necessary for one role to oversee the trauma system and bring all members of the trauma team together. The trauma coordinator fulfils this role for the primary purpose of encouraging optimal care for victims of trauma.

Chapter 7

Effects of an Educational Programme and Clinical Guideline on Early Removal of Spinal Board

7.1 Abstract

Aim The introduction of an education programme and trauma clinical guidelines may improve the quality of patient care. Although pre-hospital spinal immobilisation is usually accomplished with a spinal board, prolonged immobilisation on a spinal board in the emergency department (ED) can be detrimental. This study was aimed at investigating whether a staff education programme can reduce the time patients spend on spinal boards.

Methods An observational study conducted in a trauma centre ED with 180,000 attendances per year. The trauma nurse coordinator recorded the time each patient was immobilised on a spinal board. Guidelines on the removal of spinal boards were issued after recording period 1 (January–June 2001) and were reinforced several times. The post-training period (period 2) ran from May to October 2003. Medians were compared using the Mann-Whitney U test for non-parametric data and the chi-square test was used for categorical data.

Results There were 122 eligible patients in period 1 and 104 in period 2. Median time to removal from the spinal board was reduced by 18.5 minutes, falling from 50 minutes to 31.5 minutes (Mann-Whitney U test, $p < 0.0001$, 95% CI for difference in medians 13–29 minutes). In period 1, 44 of the 122 patients (36%) were removed from the spinal board before leaving the ED, compared to 78 of the 104 patients (75%) in period 2 ($p < 0.0001$, chi-square test).

Conclusion The introduction of guidelines, reinforced by ED staff education, can significantly reduce the time patients spend on spinal boards after trauma and can increase the proportion of patients who can be removed from the board before leaving the ED.

7.2 Introduction

Pre-hospital personnel assume that patients who are victims of significant blunt trauma have potential spinal injuries. The immediate care of blunt trauma patients therefore involves early immobilisation of the entire spine (Morris et al., 2004). The spinal board is widely used for spinal immobilisation to allow for efficient transportation during pre-hospital trauma management.

Some studies have addressed patient discomfort and the potential harmful consequences of spinal board use in trauma patients (Chan et al., 1996; Lovell & Even, 1992; March et al., 2002; Morris et al., 2004; Porter & Allison, 2003). Concerns have recently been raised that prolonged immobilisation of the patient on a hard spinal board could itself cause harm (Morris et al., 2004).

The spinal board is used by the majority of pre-hospital care providers in the United Kingdom, North America, and Hong Kong. Recent research has shown that 44% of UK hospitals remove the spinal board after the primary survey and that 53% remove the spinal board as part of the secondary survey [6]. However, 3% remove the spinal board after transferring the patient to the ward. Another paper describes the lack of ongoing audits or defined protocols governing spinal board use in the UK (Malik & Lovell, 2003), reporting that 43% of emergency departments (EDs) routinely keep the patient on a spinal board until all relevant radiology has been performed.

This study was aimed at investigating both the length of time and the proportion of trauma patients who remain on a spinal board in the Prince of

Wales Hospital (PWH) ED. The effects of both an educational programme for ED staff and a clinical guideline on early removal of the spinal board on the number of patients who spend time on spinal boards and the length of time they spend on the board were also studied.

7.3 Methods

This observational study included all trauma patients transported to the Trauma and Emergency Centre at the PWH who had been immobilised on a spinal board in the pre-hospital phase. Total ED spinal board time was defined as the time from arrival of the ambulance at the ED until the patient was removed from the spinal board or left the ED. The length of time each patient was immobilised was retrieved from ED records and reviewed by the trauma nurse coordinator. The first period of recording ran from January 2001 to June 2001 (period 1). Patients were excluded if insufficient data were recorded or if complete records were unavailable from the ED and the ambulance journey record.

The hospital trauma committee subsequently issued a clinical guideline on the removal of spinal boards to remind all staff of the potential problems of spinal boards and advise that spinal boards should be removed before patients left the ED. This guidance was reiterated to all staff 4 months and 8 months later. In addition, a continuing education programme was instituted for medical and nursing staff in the ED with an emphasis on the early removal of the spinal board. Informal staff feedback was collected and concerns were clarified.

Further data were then collected in a second six-month period from May 2003 to October 2003 (period 2). For statistical analysis, medians were compared using the Mann-Whitney U test as the data were non-parametric. The chi-square test was used to compare categorical data.

7.4 Results

There were 122 eligible patients in period 1 and 104 in period 2. Ten patients were excluded due to insufficient data (eight in period 1 and two in period 2). Median time to removal from the spinal board was 50 minutes in period 1 (range: 1-295 minutes) and 31.5 minutes in period 2 (range: 0-201 minutes), $p < 0.0001$ (Mann-Whitney U test). The 95% confidence interval for the difference in medians was 13-29 minutes. This equates to an absolute reduction of 18.5 minutes and a relative reduction of 37% for the median time patients spend on the spinal board.

The mean time spent on the spinal board in the ED was shortened from 69 minutes to 23 minutes. In period 1, 44 of the 122 patients (36%) were removed from the spinal board before leaving the ED, in comparison with 78 of the 104 patients (75%) in period 2 ($p < 0.0001$, chi-square test).

7.5 Discussion

The introduction of an education programme and a clinical management guideline led to a statistically and clinically significant decrease in the length of time patients remained on spinal boards in the PWH ED. There was also an increase in the proportion of patients for whom the spinal board was removed prior to leaving the ED.

The data suggest that the clinical management guideline and ongoing ED staff education can significantly improve the clinical care of patients on spinal boards. The materials for the ATLS course run by the American College of Surgeons state that patients may stay on a spinal board for up to two hours from the time of injury. The shortening of the time spent immobilised on the spinal board has led to the PWH ED meeting this recommendation in a higher proportion of patients.

Prolonged immobilisation can lead to significant complications. Patients who have sustained spinal cord injuries with paralysis below the level of the lesion are at high risk of skin breakdown due to pressure sores. Evidence is mounting that prolonged immobilisation can lead to skin breakdown within hours. The mean interface pressure between the sacrum and the spinal board is as high as 147mmHg, a high level of pressure that is a potential cause of ischaemic pressure sores (Lovell & Evan, 1992).

Healthy people with intact sensation complain of pain and discomfort within 30 minutes of being placed on a spinal board. The pain is most concentrated in the occiput, the lumbar spine, and the sacrum (Chan et al., 1996). A prior study has reported an increase in false-positive clinical examinations due to pain induced by prolonged immobilisation on a spinal board (Marcy et al., 2002). In addition, the spinal board, being entirely flat, gives no support to the physiological lumbar lordosis (Lovell & Evan, 1992). Immobilisation on a flat-back board places the majority of people into relative cervical extension, which may itself be deleterious (Schriger et al., 1991).

The spinal board adversely affects the quality of spinal radiographs. This can lead to diagnostic difficulties and unnecessary duplicate radiological exposure (Vickery, 2001).

However, 25% of the patients examined in this study continued to leave the ED on a spinal board. While this is an undesirable situation, it may relate to rigid interpretation of advanced trauma life support (ATLS) guidelines stipulating that "any patient with a suspected spinal injury must be immobilised above and below the suspected injury site until injury has been excluded by radiographs." It could be argued that this recommendation in the ATLS guidelines should be changed as prolonged spinal board immobilisation can lead to all the problems previously discussed.

Despite the success of the educational programme and clinical management guideline, further improvement is required and is being actively pursued through ongoing audit of the trauma service. The limitations of this study include the difficulty experienced in measuring the total time spent on the spinal board (the pre-hospital time plus the ED time). The outbreak of SARS in Hong Kong during the study period also delayed the recruitment of patients in the second period for nearly one year. However, we have no reason to suspect that the two time periods chosen for comparison were adversely affected by SARS or any other material change in the local trauma system.

Chapter 8

The Impact of Gender on Traumatic Brain Injuries

8.1 Abstract

Background: Prior research has suggested that females with traumatic brain injuries (TBI) have more favorable outcomes then men due to their higher levels of circulating estrogen and progesterone, which may reduce brain edema.

Objectives: To determine whether there is any association between gender and mortality in TBI patients and whether there is any association between gender and brain edema.

Design: A retrospective cohort study using data taken from a trauma registry in Hong Kong and the Victorian State Trauma Registry for the 2001 to 2007 period.

Setting: Two regional trauma centres in Hong Kong and two adult major trauma centres and one pediatric trauma centre in Victoria, Australia.

Main Outcome Measures: Mortality and brain edema.

Patients: Trauma patients aged 12 to 45 with an abbreviated injury scale (head) score of ≥ 3 were included in the study. Patients with minor head injuries and undisplaced closed skull fractures were excluded.

Results: Both the Hong Kong and Victorian data showed no significant difference in gender-related mortality. The odds ratio of increased mortality was associated with decreased systolic blood pressure and a lower Glasgow coma scale, and with an increased new injury severity or injury severity score. In Hong Kong, brain edema was associated with the female gender ($p = 0.017$) and the odds of brain edema were greater for females than for males. However, this association was not found in Victorian patients.

Conclusion: This study found no significant association between gender and mortality in either Victoria or Hong Kong and does not support the concept that females have better outcomes after suffering a TBI.

8.2 Introduction

Traumatic brain injury (TBI) is the most common form of life-threatening injury after trauma and is a major cause of disability and mortality worldwide (Utomo et al., 2009; MRC CRASH Trial Collaborators, 2008; Tagliaferri et al., 2006; Yates, 2006). In Hong Kong, over 50% of patients with major trauma have TBI, the leading cause of post-traumatic death and disability (Yeung et al., 2008; Cheng, 2008). Prior research has suggested that females with brain injuries after trauma have more favorable outcomes and appear to recover better than their male counterparts (Wolthmann et al., 2001). Other studies have postulated that females may be protected due to their higher levels of circulating estrogen and progesterone (Stein, 2001; Roof & Hall, 2007; Sayeed & Stein, 2009; Hu et al., 2009; Stein & Sayeed, 2010).

Although some animal studies (Roof & Hall, 2000; Wright et al., 2001; Guo et al., 2006; Gilbson et al., 2008; Kasturi & Stein, 2009; Roof et al., 1996) have that found that progesterone reduces cerebral edema after TBI, others (Coughlan et al., 2009) have not confirmed this finding. Progesterone appears to have a neuroprotective action and may have potential as a treatment for brain edema in patients with TBI (Stein et al., 2008; Vagnerova et al., 2008).

Clinical studies on the potential benefits of progesterone have been inconclusive. Some suggest that progesterone improves outcomes in patients with TBI (Wright et al., 2007; Xiao et al., 2008), while others (MRC CRASH Trial Collaborators, 2008; Steyerbuery et al., 2008; Demertriades et al., 2006;

Foreman et al., 2007; Rappold et al., 2002) indicate that gender is not related to the severity of TBI and that females do not have better outcomes then men (Ponsford et al., 2008; Coimbra et al., 2003; Gannon et al., 2002; Farace & Alves, 2000). Some of these studies are based on samples with women of non-child bearing age, even including women 80 years of age and above, while others do not focus on TBI. One population-based study (Deitch et al., 2007) indicates that hormonally active women may have a better physiologic response than males. The authors use serum lactate as a marker of the hemodynamic response to injury but do not report on mortality or functional outcome. This line of literature does not provide clear guidance on whether women with TBI have better outcomes than men or whether there is any association between gender and brain edema.

The aims of this study were to determine whether there is any association between (i) gender and mortality in TBI patients aged between 12 and 45 years; and (ii) gender and brain edema in the same group of patients.

8.3 Methods

8.3.1 Study design

Ethical approval to conduct a retrospective study of high-quality administrative trauma databases in which patients with TBI were to be selected for analysis was obtained from the joint CUHK-NTEC Clinical Research Ethics Committee in Hong Kong, the Standing Committee on Ethics in Research Involving Humans at Monash University, and all participating institutions in Australia.

8.3.2 Setting

Data were taken from the Victorian State Trauma Registry (VSTR) (2004) in Australia, from the Prince of Wales Hospital (PWH) Trauma Registry, New Territories East Cluster, Hong Kong, and from the Queen Elizabeth Hospital (QEH) Trauma Registry, Kowloon East Cluster, Hong Kong. The period of study was from 1 January 2001 to 31 December 2007.

Victoria

Victoria is a state in southern Australia and the VSTR (2004) is a state-wide population-based trauma registry developed in 2001 based at Monash University, Melbourne. In an integrated trauma system with level 1, 2, 3, and 4 services, 139 health service facilities contribute data to one trauma registry in the same state. The system includes two adult major trauma centres and one pediatric trauma centre. The VSTR includes data on patients with *any* of the following: death due to injury, an injury severity score (ISS) > 15, an intensive care unit (ICU) stay > 24h requiring mechanical ventilation, and urgent surgery. The registry enables tracking of cases across the system by collecting identifiable information.

Hong Kong

In Hong Kong, 95% of the population is Chinese. The PWH and QEH trauma registries are hospital-based registries. The inclusion criteria for the PWH and QEH registries include information on trauma deaths, patients triaged as 'critical' or 'emergency' in the emergency department (triage categories 1 and 2), all ICU admissions, and major trauma patients transferred from another acute hospital.

8.3.4 Data collection

The data collected included age, gender, pre-existing diseases, injury mechanism, injury type, primary or secondary transfer from hospital, trauma call activation, admission specialty, arrival at accident and emergency department (ED), discharge time, intubation time in the ED, arrival to first head CT, surgical operation time, ICU length of stay, and hospital length of stay. Version 98 of the abbreviated injury scale (AIS) was used to determine the severity of injury in different body regions. The injury severity scale (ISS) and new injury severity scale (NISS) scores were calculated from the AIS scores. Each patient's Glasgow coma scale (GCS) score, respiratory rate (RR), and systolic blood pressure (SBP) were recorded.

As the type and severity of the brain injury may affect the patient outcome, brain injuries were grouped into different subgroups: penetrating injury, brain stem injury, cerebral contusion, cerebellum injury, diffuse axonal injury (DAI), extra axial hemorrhage/epidural hemorrhage (EDH), cerebral hematoma, subdural hemorrhage (SDH), subarachnoid hemorrhage (SAH), brain edema, skull base or displaced skull fracture, and others. The AIS (head) score was used to indicate the severity of the brain injury. Patients with AIS(head) $\geqq$ 3 were defined as isolated head injury patients, while patients with AIS(head) $\geqq$ 3 and at least one AIS $\geqq$ 2 in another body region were defined as multiple trauma patients.

8.3.5 Subjects

Trauma patients aged 12 to 45 years with AIS $\geq$ 3 in the head region, irrespective of whether or not there were other major injuries, were classified as having a traumatic brain injury and were included in the study. The study focused on this age group so that only premenopausal females were included in the study. Patients with minor head injuries and those who had lost consciousness without suffering a brain hemorrhage or an undisplaced closed skull fracture were excluded.

8.3.6 Outcomes

The primary outcome measure was in-hospital mortality. Mortality is a hard outcome that is the same across jurisdictions. Even in patients who die with an isolated head injury, it is not always possible to say that death was due to the head injury. The secondary outcome measure was the presence of brain swelling or edema.

8.3.7 Statistical Analyses

SPSS v17.0 was used for data analysis. It was decided that data from Hong Kong and Australia should be presented and analysed separately for a number of reasons. First, there are significant differences between trauma care and adjusted mortality outcomes between the two regions. Second, race may have an impact on mortality from trauma (Shafi et al., 2007). The dataset from Hong Kong was predominantly drawn from the ethnic Chinese population, whilst that from VSTORM was based on a predominantly non-Chinese population. The separate analysis of the Hong Kong and Victoria datasets may have partially allowed for this difference.

Descriptive data were expressed as means and standard deviations or medians and inter-quartile ranges (IQR) for continuous variables and were analysed using the t-test or the Mann-Whitney test depending on data distribution. Categorical data are presented as frequencies and percentages and were analysed using the chi-square test, Fisher's exact test, or unadjusted odds ratios.

As data for the two countries were analysed separately, a separate univariate analysis was conducted on data from each country. Significant variables were selected for entry into a multiple logistic regression model and separate models were generated for Hong Kong and Victoria. Variables showing significance ($p < 0.05$) in these models were entered into the final model. Gender was included in each model.

8.4 Results

8.4.1 Study population Characteristics

From January 2001 to December 2007, a total of 18,804 (13,376 male and 5,428 female) patients were entered into the VSTR, PWH, and QEH trauma registries. Of these, 2,979 patients comprising 698 in Hong Kong and 2,281 in Victoria met the inclusion criteria and were included in this study. The ratio of males to females was 3.8 to 1.

Table 8.1 Patient characteristics

	Hong Kong (n = 698)			Victoria (n = 2281)		
Variable	**Male 529**	**Female 169**	**P-value**	**Male 1823**	**Female 458**	**P value**
Injury Count			0 829			0 047
Isolated HI	236 (44 6%)	77 (45 6%)		391 (21 4)	79 (17 2%)	
Multiple trauma	293 (55 4%)	92 (54 4%)		1432 (78 6%)	379 (82 8%)	
Age (years) Mean ± SD	29 6 ± 9 6	27 9 ± 9 7	0 049	27 2 ± 8 7	26 3 ± 9 3	0 044
Causes of injury			<0 001			<0 001
Motor vehicle driver	60 (11 3%)	1 (0 6%)		414 (22 7%)	134 (29 3%)	
Motor vehicle passenger	39 (7 4%)	24 (14 2%)		181 (9 9%)	90 (19 7%)	
Pedestrian	66 (12 5%)	68 (40 2%)		175 (9 6%)	83 (18 1%)	
Motorcycle driver & passenger	64 (12 1%)	9 (5 3%)		245 (13 4%)	9 (2%)	
Bicycle-related	39 (7 4%)	18 (10 7%)		81 (4 4%)	8 (1 7%)	
Cutting	14 (2 6%)	3 (1 8%)		14 (0 8%)	0 (0%)	
Fall	154 (29 1%)	35 (20 7%)		271 (14 9%)	60 (13 1%)	
Others*	93 (17 6%)	11 (6 5%)		442 (24 2%)	74 (16 2%)	
SBP Group			0 072			<0 001
< 90mmHg	32 (6 0%)	12 (7 1%)		78 (4 3%)	33 (7 2%)	
90-140mmHg	340 (64 3%)	124 (73 4%)		797 (44%)	287 (62 9%)	
140-160mmHg	109 (20 6%)	21 (12 3%)		660 (36 4%)	110 (24 1%)	

> 160mmHg	48 (9 1%)	12 (7 1%)		278 (15 3%)	26 (5 7%)	
Multiple system injury	92 (54 4%)	292 (55 3%)	0 863	1432 (78 6%)	379 (82 8%)	0 047
ISS groups			0 788			0 297
< 16	109 (20 6%)	34 (20 1%)		79 (4 3%)	23 (5%)	
16-25	212 (40 1%)	62 (36 7%)		825 (45 3%)	188 (41%)	
26-40	131 (24 8%)	48 (28 4%)		614 (33 7%)	157 (34 3%)	
> 40	77 (14 6%)	25 (14 8%)		305 (16 7%)	90 (19 7%)	
Time Median (IQR)						
Arrival to 1st CT (min)	53 (37-82)	48 (34-71)	0 062	64 (36-119)	73 (37-132)	0 097
Arrival to intubation (min)	19 (10-32)	15 (8-25)	0 045	12 (4-37)	11 (2-26)	0 380
LOS (days)	9 (5-19)	10 (5-19)	0 194	8 (4-17)	9 (4-19)	0 019
ICU LOS (days)	1 (0-5)	1 (0-6)	0 472	2 (0-7)	2 (0-10)	0 051
HI-related Operation	164 (31 0%)	56 (33 1%)	0 603	712 (39 1%)	180 (39 3%)	0 924
Other Operation	234 (44 2%)	58 (34 3%)	0 023	1276 (70%)	333 (72 7%)	0 255

*Other causes of injury include fire, flames, smoke and scalds, horse and other animal-related injuries, machinery, other transport-related circumstances, struck by or collision with object, struck by or collision with person, submersion or drowning, and unspecified external cause SBP, initial emergency department systolic blood pressure, ISS, injury severity score, ICU, intensive care unit, LOS , length of stay, HI, head injury

Baseline characteristics for Hong Kong and Victoria are shown in Table 8.1. In Hong Kong, males were older than females ($p = 0.049$). More females were injured as motor vehicle passengers or pedestrians, but more males were injured as motor vehicle drivers, motorcycle drivers, and passengers and as a result of falls ($p < 0.001$). Females had shorter ED arrival to intubation times ($p = 0.045$) and fewer surgical operations ($p = 0.023$).

In Victoria, there were significant gender differences in age, cause of injury, blood pressure, injury count, and length of stay, with females being significantly younger ($p = 0.044$). More females than males were injured while driving or being a passenger in a motor vehicle or as a pedestrian and more males were injured while riding a bicycle or motorcycle ($p < 0.001$). Victorian females also had a significantly lower systolic blood pressure ($p < 0.001$), more multiple system injuries ($p = 0.047$), and a longer hospital stay ($p = 0.019$).

Regarding injury severity in injured body regions, males had more severe abdominal injuries in both Hong Kong ($p = 0.046$) and Victoria ($p < 0.001$). There were no significant gender differences in AIS head, neck, face, thorax, extremities, or external score in both the Hong Kong and Australian samples. The only difference between the genders was that Hong Kong male patients suffered serious abdominal injuries more frequently, while females had a higher frequency of moderate abdominal injuries ($p = 0.046$). Abdominal injuries sustained by Australian females were also more minor than those of males ($p < 0.001$).

8.4.2 Gender and Mortality

Table 8.2 shows the gender-related mortality rates in Hong Kong and Victoria. In Hong Kong, females were less commonly admitted to the ICU despite having a lower SBP. No female who died had a GCS > 9 on arrival at the ED. More females died with an RR < 12/min while more males died with an RR > 24/min ($p < 0.001$). Females had a higher mortality rate then males when they presented with a small to moderate haematoma ($p = 0.003$), but males with a large SDH had a higher mortality rate then females ($p = 0.026$). In Victoria, females aged 12 to 19 had the highest mortality rate of all male and female age groups.

In Hong Kong, the all-cause mortality rate among patients with isolated HI was 8% (25/313), with the female mortality rate being 5.2% (4/77) and a male mortality rate of 8.9% (21/236). The odds ratio for male to female mortality was 1.784 (95% CI 0.592, 5.364; $p = 0.298$). In Victoria, the all-cause mortality rate among patients with isolated HI was 4.7% (22/470), with the female mortality rate being 3.8% (3/79) and a male mortality of 4.9% (19/391). The odds ratio for male to female mortality was 1.29 (95% CI 0.37, 4.48; $p = 0.68$).

Table 8.2 Gender-related mortality rates in Hong Kong and Victoria

	Hong Kong			Victoria		
	Male	Female		Male	Female	
	N = 529	N = 169		N = 1823	N = 458	
Variable	Mortality	Mortality	P	Mortality	Mortality	P
	N = 68	N = 21	value	N = 185	N = 56	value
	(12.8%)	(12.4%)		(10.1%)	(12.2%)	
Injury Count			0 407			0 175
Isolated HI	21 (30 9%)	4 (19 0%)		19 (10 3%)	3 (5 4%)	
Multiple Trauma	47 (69 1%)	17 (81 0%)		166 (89 7%)	54 (96 4%)	
Age			0 742			0 014
12-19	10 (14 7%)	3 (14 3%)		37 (20%)	23 (41 1%)	
20-29	22 (32 4%)	8 (38 1%)		68 (36 7%)	13 (23 2%)	
30-39	15 (22 1%)	6 (28 6%)		51 (27 6%)	12 (21 4%)	
40-45	21 (30 9%)	4 (19 0%)		29 (15 7%)	8 (14 3%)	
ISS			0 401			0 034
< 16	0	0		4 (2 2%)	0 (0)	
16-25	16 (23 5%)	3 (14 3%)		36 (19 5%)	4 (7 1%)	
26-40	18 (26 5%)	4 (19 0%)		59 (31 9%)	15 (26 8%)	
>40	34 (50 0%)	14 (66 7%)		86 (46 5%)	37 (66 1%)	
GCS at ED			0 031			1 000
<9	50 (73 5%)	21 (100%)		180 (97 3%)	55 (98 2%)	
9-13	12 (17 6%)	0		3 (1 6%)	1 (1 8%)	
>13	6 (8 8%)	0		2 (1 1%)	0 (0)	
RR (per min) at ED			0 001			0 134
<12	15 (22 1%)	14 (66 7%)		108 (58 4%)	40 (71 4%)	
12-24	26 (38 2%)	5 (23 8%)		72 (38 9%)	14 (25%)	
>24	27 (39 7%)	2 (9 5%)		5 (2 7%)	2 (3 6%)	
SBP at ED			0 224			0 002
<90mmHg	17 (25 0%)	9 (42 9%)		40 (21 6%)	18 (32 1%)	
90-139mmHg	31 (45 6%)	10 (47 6%)		72 (38 9%)	30 (53 6%)	

140-160mmHg	8 (11 8%)	1 (4 8%)		47 (25 4%)	8 (14 3%)	
>160mmHg	12 (17 6%)	1 (4 8%)		26 (14 1%)	0 (0)	
Brain injury						
SDH large	22 (32 4%)	3 (14 3%)	0 026	14 (7 6%)	3 (5 4%)	0 769
Cerebral haematoma small to moderate	4 (5 8%)	7 (33 3%)	0 003	71 (38 4%)	22 (39 3%)	1 000
Skull fracture	38 (55 9%)	14 (66 7%)	0 381	118 (63 8%)	27 (48 2%)	0 037
ICU admission			0 002			0 943
Yes	63 (92 6%)	13 (61 9%)		156 (84 3%)	47 (83 9%)	
No	5 (7 4%)	8 (38 1%)		29 (15 7%)	9 (16 1%)	
OT-head			0 803			0 231
Yes	33 (48 5%)	9 (42 9%)		106 (57 3%)	27 (48 2%)	
No	35 (51 5%)	12 (57 1%)		79 (42 7%)	29 (51 8%)	

OT-head, emergency operation-related head injury, SDH, subdural hemorrhage SDH large, SDH AIS ≥ 5, > 50cc, > 1cm thick, bilateral, massive, extensive, cerebral haematoma small to moderate, cerebral haematoma AIS < 5, < 30cc, < 4cm diameter All figures refer to % (95% CI) unless otherwise indicated

In Hong Kong, the all-cause mortality rate among patients with multiple trauma was 16.6% (64/385), with the female mortality rate being 18.5% (17/92) and a male mortality rate of 6% (47/293). The odds ratio for male to female mortality was 0.84 (95% CI 0.46, 1.55; p = 0.584). In Victoria, the all-cause mortality rate among patients with multiple trauma was 12.1% (220/1,811), with the female mortality rate being 14.2% (54/379) and a male mortality rate of 11.6% (166/1,432). The odds ratio for male to female mortality was 0.79 (95% CI 0.57, 1.10; p = 0.16).

Table 8.3 shows the adjusted and non-adjusted odds ratios for gender-related mortality Univariate analysis showed no significant differences in the mortality rate between males and females either registry (HK: p = 0.884, VSTR: p = 0.196). Both the Hong Kong and the Victorian data showed that the odds ratio of mortality increased with a reduction in SBP and the GCS score and an increase in the NISS and ISS scores. The Hong Kong data showed that RR < 12/min and RR > 24/min were also independent predictors of hospital mortality in trauma.

Table 8.3 Adjusted and non-adjusted odds ratios for gender-related mortality

Hong Kong			Victoria		
Variables	**OR (95% CI)**	**P value**	**Variables**	**OR (95% CI)**	**P value**
Non-adjusted			**Non-adjusted**		
Male	1 04 (0 62, 1 75)	0 884	Male	0 81 (0 59, 1 11)	0 196
Female	Reference		Female	Reference	
Adjusted*			**Adjusted****		
Male	2 07 (0 67, 6 39)	0 204	Male	0 72 (0 35, 1 45)	0 357
Female	Reference		Female	Reference	

OR, odds ratio *Adjusted for isolated HI and multiple trauma, causes of injury, comorbidity status, transferred patients, trauma call, LOS, SBP, RR, GCS, ICU admission, head injury-related operation, ISS NISS, SDH, EDH, SAH, haematoma, contusion, brain stem injury, cerebellum injury, skull displaced fracture, and brain edema were not input into the model as ISS already incorporated the brain injury

8.4.3 Gender and brain edema

Overall, 167 Hong Kong patients (115 male and 52 female) and 254 VSTR patients (193 male and 61 female) were diagnosed with brain edema. Comparisons of trauma-related variables and brain edema rates between males and females were carried out. For Hong Kong, the only gender difference was that female pedestrians were more likely to have brain edema ($p < 0.001$). For Victoria, brain edema was more likely to be associated with females aged 12-19 and males aged 20-29 ($p = 0.034$), female motor vehicle drivers or passengers ($p < 0.001$), and females with a low RR ($p = 0.031$) or low BP ($p = 0.006$).

In Hong Kong, brain edema was associated with the female gender ($p = 0.017$); trauma call activation, longer ICU LOS, more surgical procedures for the head injury, higher ISS and NISS, lower GCS, RR, RTS, and Ps (all $p < 0.001$); and with SBP < 90mmHg or SBP > 160mmHg ($p = 0.029$). Brain edema was also related to SDH ($P < 0.001$), cerebral contusion ($p = 0.013$), and brain stem injury ($p = 0.007$).

In Victoria, brain edema was associated with shorter LOS, longer ICU, more surgical procedures for the head injury, higher ISS and NISS, lower GCS, RR, BP and RTS, as well as with the presence of other injuries to the brain (including SDH, SAH, haematoma, contusion, brain stem injury, cerebellum injury, DAI, skull fracture, and other brain injuries) (all $p \leq 0.001$).

Table 8.4 shows the adjusted and non-adjusted odds ratios for gender-related brain edema. The odds of brain edema in females were greater than for males. However, this association was not found in Victorian patients. Victorian indicators for brain edema were GCS, NISS or ISS, brain stem injury, and cerebral contusion.

Table 8.4 Adjusted and non-adjusted odds ratios for gender-related brain edema

	Hong Kong		Victoria		
Variables	**OR (95% CI)**	**P value**	**Variables**	**OR (95% CI)**	**P value**
Unadjusted		0.017	**Unadjusted**		
Male	0.63 (0.43, 0.92)		Male	0.77 (0.56, 1.05)	0.097
Female	Reference		Female	Reference	
Adjusted*			**Adjusted****		
Male	0.62 (0.39, 0.99)	0.043	Male	0.85 (0.61, 1.18)	0.326
Female	Reference		Female	Reference	

8.5 Discussion

This is the first study to specifically investigate any gender differences in survival and brain edema in patients with traumatic brain injuries among hormonally active age groups. There was no apparent statistically significant difference in gender-related mortality after head injury in either the Victorian sample or the Hong Kong sample. The assumption that female patients benefit from better neuroprotection, possibly because of their elevated levels of circulating estrogen and progesterone, was not supported by our study.

However, clinically, females had higher mortality rate (female mortality rate 18.5% Vs male mortality rate 6% in Hong Kong; female mortality rate 14.2% Vs male mortality rate 11.6% in Victoria). In both Victoria and Hong Kong, females were clinically more likely to have brain oedema (female rate of brain edema 30.8% Vs male rate of brain edema 21.7% in Hong Kong; female rate of brain edema 13.3% Vs male rate of brain edema 10.6% in Victoria) but only the Hong Kong data shows a statistically significant difference with females being more likely to develop traumatic brain oedema. These clinically significant differences are not statistically significant which may reflect a Type II error due to a smaller than ideal sample size.

8.6 Limitations

This study used a gender-age combination as a surrogate for hormonal status. Clearly, hormonal changes occur on a monthly basis, meaning this study could evaluate only overall gender differences and not the effects of high or low levels of estrogen and progesterone. Second, the treatments and protocols employed in the participating healthcare facilities are bound to have varied and the confounding effect of such differences cannot be ruled out. Third, race may have an impact on mortality from trauma and may therefore be a confounding factor. Neither participating registry collected specific data on race. The closest we came to allowing for such possible racial differences was in using one dataset predominantly drawn from an ethnic Chinese population and the other predominantly based on a non-Chinese cohort. The separate analysis of the Hong Kong and Victoria datasets may have partly allowed for this. Other than this, it was not possible to analyse the effects of race on mortality in this study. Some variables considered in our study had many missing values (e.g. comorbidity). The results showed that females had poorer outcomes but these were not statistically significant. Further study with a larger sample size may be required to minimize the chance of having a Type II error. Finally, there were fewer patients in the Hong Kong group than in the Victorian group, thus reducing the power of this part of the study. Despite these limitations, our study was based on large datasets.

8.7 Conclusion

This study, which was unique in investigating post-traumatic brain outcomes in men and women in age groups associated with female fertility, found no significant association between gender and mortality in either Victoria or Hong Kong and does not support the concept that females have better outcomes after TBI.

Chapter 9

Elderly Trauma

9.1 Abstract

Background Trauma is the eighth leading cause of death in Hong Kong. In 2002, 18.5% of the population of Hong Kong were aged 55 or above, and the percentage increased to 22.1% in 2006. The aging population in Hong Kong presents a challenge to the health care system, yet there is little local information on older trauma patients.

Objectives The objectives of this study were to describe the epidemiology of high risk trauma in older patients in Hong Kong and to identify predictors of trauma mortality.

Methods Retrospective analysis of prospectively collected data from a centralised trauma database. Data covering the 2002 to 2004 period were collected from four trauma centres in Hong Kong.

Results Between 2002 and 2004, the four trauma centres had a total of 2,124,175 emergency department attendances of whom 376,021 (17.7%) were trauma patients and 80,827 (3.8%) were aged 55 or older. Eight hundred and ten injured older patients met the inclusion criteria for this study and 380 (46.9%) patients had comorbidity at the time of injury.

Common causes of injury were falls (50.0%; 405/810) and motor vehicle crashes (33.6%; 272/810), with 77.2% (210/272) of the latter group being pedestrians. Mortality was 24.4% (198/810) and increased with age ($p < 0.0001$). Of all patients, 53.5% (433/810) had major trauma (ISS > 15).

Head injuries contributed to 80.3% (159/198) of deaths and 38.4% (311/810) of patients required operations. Patients were discharged home in 40.5% (328/810) of cases and one-third (270/810) required rehabilitation. Significant predictors of mortality included comorbidity, injury severity score, age, and decreasing Glasgow coma score.

Pedestrians struck by motor vehicles and patients suffering falls are the principal causes of trauma in older patients in Hong Kong. Mortality increases with age. The independent indicators of trauma mortality in older patients are comorbidity, age, ISS, and GCS.

9.2 Introduction

The elderly population is growing rapidly in Hong Kong and elderly trauma patients have a significantly higher mortality rate than younger adults. Trauma is the eighth leading cause of death in Hong Kong (HA, 2006), a special administrative region of the People's Republic of China, and is one of the most densely populated areas in the world. In 2002, 18.5% of the population of Hong Kong were aged 55 or older, and this proportion increased to 22.1% in 2006. Life expectancy in Hong Kong is 79.4 years for male and 84.3 years for females (Census and Statistics Development, HKSAR, 2006)

The Hospital Authority in Hong Kong oversees five designated trauma centres that are all government-funded. From 2002 to 2004, these five trauma centres received 2,484,329 emergency department attendances of whom 442,240 (17.8%) were trauma patients. The aging population in Hong Kong presents a challenge to the health care system, yet there is a scarcity of local data on older trauma patients. A better knowledge of the spectrum and epidemiology of older trauma patients may guide prevention programmes and the evaluation of trauma management. It is also unclear whether the mortality associated with increasing age is a feature of age itself or a feature of any associated comorbidity. The TRISS methodology does not take into account the effects of increasing age (above 55 years) or of comorbidity as factors affecting mortality.

The objectives of this study were (i) to describe the epidemiology of major injury patterns in older trauma patients in Hong Kong; and (ii) to identify predictors of mortality and improve future outcomes.

9.3 Patients and Methods

9.3.1 Study design, patients, and setting

This study was conducted as a retrospective analysis of prospectively collected data from a centralised administrative trauma database. Data were collected over three years (1 January 2002 to 31 December 2004) from four trauma centres in Hong Kong. These four trauma centres were the Prince of Wales Hospital (PWH), the Queen Elizabeth Hospital (QEH), the Queen Mary Hospital (QMH), and the Tuen Mun Hospital (TMH). The QMH covers Hong Kong Island, the QEH serves Kowloon, the PWH serves the Eastern New Territories, and the TMH covers the Western New Territories.

The inclusion criteria for entry into the trauma databases are described in Appendix 1. The TRISS methodology usually divides patients into two groups according to age: < 55 or ≥ 55. The reason for this division is that the major trauma outcome study (MTOS) in the USA shows that at ages greater than 55, for comparable levels of physiologic derangement and anatomic injury severity, there are significantly higher mortality rates in comparison with those among patients aged less than 55 (Cameron et al., 2004; Census and

Statistics Development, HK 2006). All patients aged 55 or older were included in this study.

The trauma registries were developed by individual trauma centres and capture specific clinical data relating to high-risk trauma patients. Patients who had drowned or suffered asphyxia or poisoning, as well as trauma patients who had died before arrival at the emergency department, were excluded from the study. All of the data in each trauma registry were collected and coded by trained trauma nurse coordinators.

The data collected included age, sex, comorbidity, and injury causes. The initial Glasgow coma score (GCS) and initial systolic blood pressure (SBP) and respiratory rate (RR) were all determined from the first emergency department (ED) measurements. Trauma call activation, admitting specialty, operative procedure, length of stay (LOS) in both the intensive care unit (ICU) and the hospital, injury severity score (ISS), revised trauma score (RTS), mortality, and probability of survival (Ps) were also recorded.

9.3.2 Definitions

Injury data were coded using the abbreviated injury scale developed by the Association for the Advancement of Automotive Medicine (1998). TRISS coefficients were used to calculate the P values (Champion, 1989, 1995). In this study, a body region was considered to be injured if AIS was ≥ 2. Major trauma was defined as an ISS > 15 and minor trauma as an ISS < 16. Patients aged 55 or above were defined as older patients.

Comorbidity was defined as the presence of pre-existing disease prior to the injury. Pre-existing diseases included heart disease, respiratory disease, neurological disease, hypertension, diabetes mellitus, liver disease, renal disease, malignancy, psychiatric illness, chest disease, gastrointestinal disease, endocrine disease, and immune dysfunction.

9.3.3 Primary outcome measure

The primary outcome measure was all-cause mortality, defined as death during admission to any of the trauma centres.

9.3.4 Statistical analysis

The chi-square test, linear-by-linear association, and Fisher's exact test were used as appropriate for categorical data, and the t-test was used for continuous data. To identify variables associated with mortality, data were initially analysed by univariate analysis. Continuous and/or categorical variables with p values of < 0.10 were then entered into a multiple logistic regression model with mortality as the dependent variable. Non-significant variables in the multivariate analysis were then removed stepwise until only significant variables remained. Statistical significance was set at $p < 0.05$.

9.4 Results

Between 1 January 2002 and 31 December 2004, the four trauma centres had a total of 2,124,175 emergency department attendances of whom 376,021 (17.7%) were trauma patients and 80,827 (3.8%) were aged 55 or older. Eight hundred and ten injured older patients met the inclusion criteria for this study.

By type, the vast majority of trauma in Hong Kong was blunt trauma (93.7%; 759/810). Penetrating trauma and major burns each accounted for 3.0% of cases. Patient characteristics, causes of injury, and mortality are shown in Table 9.1. The overall mortality rate was 24.4% (198/810) and increased with age ($p < 0.0001$, chi-square).

Among older adults, 50.0% (405/810) of trauma cases were due to a fall. The most common site of injury after a fall was the head and neck region (66.7%, 270/405) followed by the limbs and pelvic area (25.2%, 102/405). Thoracic injuries accounted for 11.6% (47/405) of cases and facial injuries for 7.2% (29/405).

Table 9.1 Patient characteristics, causes of injury, and mortality (N = 810)*

Characteristic	Total N = 810	Survived N = 612	Died N = 198	p-value
Age (years)				
Mean ± S D	71 8 ± 10 7	70 6 ± 10 6	75 6 ± 10 2	<0 001**
55-74	471 (58 1)	390 (63 7)	81 (40 9)	<0 001***
75-84	221 (27 3)	145 (23 7)	76 (38 4)	
84 or above	118 (14 6)	77 (12 6)	41 (20 7)	
Sex				0 606***
Male	470 (58 0)	352 (57 5)	118 (59 6)	
Female	340 (42 0)	260 (42 5)	80 (40 4)	
Injury Mechanism				0 015
Fall				
• Fall ≤ 2 meters	331 (40 9)	245 (40 0)	86 (43 4)	
• Fall ≥ 2 meters	74 (9 1)	47 (7 7)	27 (13 6)	
MVC				
• Pedestrian	210 (25 9)	156 (25 5)	54 (27 2)	
• Motor vehicle passenger	32 (4)	30 (4 9)	2 (1 0)	
• Motor vehicle driver	24 (3 0)	23 (3 8)	1 (0 5)	
• Motorcycle driver or passenger	6 (0 7)	5 (0 8)	1 (0 5)	
Bicycle-related	31 (3 8)	25 (4 1)	6 (3 0)	
Major burn or scald	27 (3 3)	19 (3 1)	8 (4 0)	
Penetrating	24 (3)	20 (3 3)	4 (2 0)	
Others	51 (6 3)	42 (6 8)	9 (1 8)	

* Data are presented as numbers and percentages unless stated otherwise **T-test, *** Fisher's test, linear-by-linear association or chi-square test, **** Mann-Whitney U test

A motor vehicle crash (MVC) was the cause of trauma in 33.6% (272/810) of older patients, of whom 77.2% (210/272) were pedestrians. Among MVC victims, 53.6% (146/272) sustained head injuries. Limb and pelvic girdle injuries accounted for 47.1% (128/272) of cases, thoracic injuries for 36.0% (98/272), and facial injuries for 12.1% (33/272).

There was no overall relationship between comorbidity and mortality among the 788 patients with recorded comorbidity data (Table 9.2). However, if patients were divided into minor and major trauma groups, then comorbidity was associated with a higher mortality rate in patients with minor trauma (p = 0.020).

Table 9.2 Comorbidity, trauma severity groups, and mortality (N=788)

	Comorbidity	Total N = 788	Survived N = 610	Died N = 178	p-value
Overall	Yes	380 (48.2)	284 (46.6)	96 (53.9)	0.083
	No	408 (51.8)	326 (53.4)	82 (46.1)	
Minor Trauma	Yes	178 (22.6)	164 (26.9)	14 (7.9)	0.020
	No	195 (24.7)	190 (31.1)	5 (2.8)	
Major Trauma	Yes	202 (25.6)	120 (19.6)	82 (46.1)	0.352
	No	213 (27.0)	136 (22.3)	77 (43.3)	

Fisher's test or chi-square test. Data are given as numbers and percentages. Twenty two cases were excluded because there was no comorbidity information.

Table 9.3 shows the relationship between physiological variables and mortality. On admission, 60.0% (486/810) of older trauma patients had a GCS of 15 and 4.6% (37/810) had hypertension. The respiratory rate was deranged in 9.1% (74/810) of older patients. There was a very strong inverse correlation between mortality and GCS, a significant relationship between blood pressure group and mortality, and a significant relationship between respiratory rate and mortality.

Table 9.4 describes the subjects' anatomical injuries. Major trauma was suffered by 53.6% (434/810) of older patients, while head injuries were the most common form of injury (58.4%, 473/810) and the most life-threatening. Major head injuries accounted for the deaths of 33.5% (159/474) of older patients and contributed to 80.3% (159/198) of deaths.

Table 9.3 Physiological characteristics and mortality (N = 810)*

Characteristic	Total N = 810	Survived N = 612	Died N = 198	p-value
GCS				
Median (IQR)	15 (11, 15)	15 (14, 15)	7 (3, 14)	< 0.001**
3-5	99 (12.2)	21 (3.4)	78 (39.4)	< 0.001***
6-8	61 (7.5)	24 (3.9)	37 (18.7)	
9-12	79 (9.8)	50 (8.2)	29 (14.6)	
13-15	571 (70.5)	517 (84.5)	54 (27.3)	
SBP mm Hg				
Mean ± S.D.	153.6 ± 39	154.2 ± 34.5	151.9 ± 50.5	0.4784****
0-75	18 (2.2)	4 (0.7)	14 (7.1)	< 0.001***
76-89	19 (2.3)	14 (2.3)	5 (2.5)	
90-119	97 (12.0)	66 (10.8)	31 (15.7)	
120-160	352 (43.5)	290 (47.4)	62 (31.3)	
161-199	223 (27.5)	169 (27.6)	54 (27.3)	
> 200	101 (12.5)	69 (11.3)	32 (16.2)	
RR				
Mean ± S.D.	19.6 ± 6.0	20.0 ± 4.7	18.1 ± 8.6	< 0.001****
0	29 (3.6)	8 (1.3)	21 (10.6)	< 0.001***
1-5	1 (0.1)	0	1 (0.5)	
6-9	4 (0.5)	1 (1.5)	1 (0.2)	
10-29	736 (90.9)	577 (94.3)	159 (80.3)	
> 29	36 (4.4)	23 (3.8)	13 (6.6)	
RTS				
Median (IQR)	7.84 (6.90, 7.84)	7.84 (7.84, 7.84)	5.97 (4.09, 7.55)	< 0.001**
0-3.00	19 (2.3)	2 (0.3)	17 (8.6)	< 0.001***
3.01-4.00	7 (0.9)	2 (0.3)	5 (2.5)	
4.01-5.00	40 (4.9)	7 (1.1)	33 (16.7)	
5.01-6.00	85 (10.5)	29 (4.7)	56 (28.3)	
6.01-7.84	85 (10.5)	54 (8.8	31 (15.7)	
7.841	570 (70.4)	516 (84.3)	54 (27.3)	

* Data are presented as numbers and percentages unless stated otherwise. ** Mann-Whitney U test; *** Fisher's test, linear-by-linear association or chi-square test; **** T-test

Table 9.4 Anatomical injury severity scores and mortality (N = 810)

Characteristic***	Total N = 810	Survived N = 612	Died N = 198	p-value
ISS				
Mean ± S.D.	17.6 ± 14.4	13.4 ± 10.4	30.4 ± 16.3	<0.001*
1-14	377 (46.5)	355 (58.0)	22 (11.1)	
16-24	187 (23.1)	164 (26.8)	23 (11.6)	
25-39	184 (22.7)	77 (12.6)	107 (54.0)	
> 50	62 (7.7)	16 (2.6)	46 (23.2)	
AIS Head & Neck				< 0.001**
2-3	167(20.6)	150 (24.5)	17 (8.6)	
4-5	302(37.3)	165(27.0)	137 (69.2)	
6	5(0.6)	0 (0)	5 (2.5)	
AIS Face				0.962**
2-3	73 (9.0)	58 (9.5)	15 (7.6)	
4-5	2 (0.2)	0 (0)	2 (1.0)	
AIS Thorax				< 0.001**
2-3	87 (10.7)	62 (10.1)	25 (12.6)	
4-5	76 (9.4)	42 (6.9)	34 (17.2)	
6	2 (0.2)	0 (0)	2 (1.0)	
AIS Abdomen & Pelvic Contents				< 0.001**
2-3	69 (8.5)	53 (8.7)	16 (8.1)	
4-5	16 (2.0)	4 (0.7)	12 (6.1)	
AIS Extremity				< 0.001**
2-3	239(29.5)	202 (33.0)	37 (18.7)	
4-5	21 (2.6)	9 (1.5)	12 (6.1)	
AIS External				0.845**
2-3	36 (4.4)	36 (5.9)	0 (0)	
4-5	13 (1.6)	8 (1.3)	5 (2.5)	
6	4 (0.5)	1 (0.2)	3 (1.5)	

* T-test; ** Fisher's test, linear-by-linear association or chi-square test; *** no. (%) except mean ± S.D and range

The mortality rate was 30.8% (61/165) among older patients with thoracic trauma and was 32.9% (28/85) among those with abdominal injuries. Limb and pelvic injuries were the second most commonly injured area (32.1%, 260/810), but the related mortality rate was relatively low at 18.8% (49/260). Major burns were the least common injury type in older patients (3.3%, 27/810) and the overall mortality rate from all causes was 29.6% (8/27).

Table 9.5 shows that 31.3% (62/198) of patients who died had a Ps of between 0.76 and 0.99, representing a group with a high proportion of potentially preventable deaths (Rainer, 2007). The percentage of patients requiring operative treatment was 38.4% (311/810). The proportion of patients discharged home was 40.5% (328/810) and 1.0% (8/810) of the sample were transferred to other acute hospitals. One-third of patients (270/810) required a transfer to a rehabilitation hospital after discharge from the trauma centre.

Dependent variables with p values < 0.10 from Tables 9.1, 9.2, 9.3, and 9.4 were selected for the multiple regression model. Continuous variables were grouped and entered into the model. The variables included age, injury mechanism, GCS, SBP, RR, ISS, and comorbidity. RTS, AIS, and Ps were not considered because their calculation already included variables entered into the model. LOS is an outcome rather than a predictor and was not used. Non-significant variables were removed, leaving four variables as significant predictors of mortality (Table 9.6). The odds ratios associated with death increased with comorbidity, ISS, and age, and decreased with an increasing GCS.

Table 9.5 Probability of survival and length of stay (N = 810)*

Characteristic	Total n = 810	Survived n = 612	Died n = 198	P value
Ps				
Median (IQR)	0.94 (0.79, 0.94)	0.95 (0.91, 0.97)	0.57 (0.26, 0.80)	< 0.001***
Range	0 – 0.983	0.039 – 0.983	0.0 – 0.966	
0.00-0.25	48 (5.9)	7 (1.1)	41 (20.7)	< 0.001***
0.26-0.50	62 (7.7)	13 (2.1)	49 (24.7)	
0.51-0.75	60 (7.4)	23 (3.8)	37 (18.7)	
0.76-0.95	307(37.9)	252 (41.2)	55 (27.8)	
0.96-0.999	303 (37.4)	296 (48.4)	7 (3.5)	
Excluded	30 (3.7)	21 (3.4)	9 (4.5)	
ICU LOS (days)****				
Mean ± S.D.	5.8 ± 9.0	5.7 ± 7.4	5.9 ± 11.0	0.066
Median (IQR)	0 (0, 2)	0 (0, 2)	1 (0, 2)	< 0.001****
Range	0-76	0 - 41	0 - 76	
Hosp. LOS (days)				
Mean ± S.D.	14.1 ± 25.3	15.6 ± 25.2	9.5 ± 25.0	0.0030**
Median (IQR)	6.7 (2, 15)	8 (4, 17)	2 (1, 8.2)	< 0.001****
Range	0-306	0 - 306	0 - 298	

* Data are presented as numbers and percentages unless stated otherwise; **T-test; *** Fisher's test, linear-by-linear association or chi-square test; **** Mann-Whitney U test

Table 9.6 Adjusted odds ratios for mortality

Variables	Odds Ratio	95% Lower	95% Upper	P value
Comorbidity: Yes	2.404	1.433	4.032	< 0.001
Comorbidity: No	Reference			
GCS 3-5	23.184	10.699	50.239	< 0.001
GCS 6-8	6.228	3.157	12.287	< 0.001
GCS 9-12	3.175	1.644	6.129	< 0.001
GCS13-15	Reference			
Age 75-84	3.526	2.034	6.113	< 0.001
Age > 84	4.230	2.188	8.180	< 0.001
Age 55-74	Reference			
ISS 16-24	2.170	1.077	4.376	0.0303
ISS 25-39	14.297	7.591	26.928	< 0.001
ISS 41-49	37.120	11.725	117.514	< 0.001
ISS > 50	57.941	18.008	186.433	< 0.001
ISS 1-15	Reference			

Binary Logistic Regression

9.5 Discussion

This study shows that in adults above 55 years of age, both age and comorbidity are independently associated with mortality after trauma. Males predominate among trauma patients up to the age of 75. Blunt injury from falls and pedestrian MVC are the main causes of trauma in Hong Kong.

Comorbidity alone is a significant factor contributing to mortality. This important finding suggests that it is not simply increasing age that affects outcomes, but that comorbidity also independently affects the chance of survival or death. In some trauma centres, age and comorbidity are not trauma team activation criteria. Therefore, trauma team activation criteria may have to be adjusted to include advanced age and the presence of comorbidity; this issue requires further study.

MVC is the most common cause of major trauma in all age groups in Hong Kong (Cameron et al., 2004; Rainer et al., 2000). It is the second leading cause of injury among older people and two-thirds of MVC victims are pedestrians. In 2003, there were 14,436 traffic accidents reported in Hong Kong (Hong Kong Police Force, 2004), with 173 fatal MVC incidents. Older patients were most the common victims, with up to 65% of fatal incidents involving people aged 60 or above in 2004. Pedestrians accounted for 58% of motor vehicle deaths and their mean age was 59 (Cameron et al., 2004).

The aging process impairs older peoples' postural stability, balance, motor strength, vision, hearing, and overall coordination. Injury prevention strategies must be emphasised to both pedestrians and drivers. Effective interventions for road traffic injury prevention can be enhanced by health education and awareness, legislation, improved vehicle design, and environmental modifications (Ghaffar et al., 2002).

Falls are the most common source of morbidity and mortality among older people. In this study, one in three patients died if they fell from ≥ 2m and one in five patients died if they fell from a low level (< 2m). Our study confirms the results of a previous investigation suggesting that even simple low-level falls among the elderly lead to a high mortality rate and that mortality increases progressively with age (Bergeron et al., 2006).

Falls are seven times more likely to be the cause of death among older people than in the younger age group (Sterling et al., 2001). More primary health education, particularly fall prevention programmes, may help to increase awareness of the risks of falls in the older population (Bergeron et al., 2006).

Although the most common injuries observed in this study were head and extremity injuries, the most common lethal injuries occurred in the head, neck, and chest regions. Head injuries were extremely common in older patients and the associated mortality rate was high. The injury pattern observed was different from that seen in a previous study of the elderly population in Germany (Richter et al, 2005) indicating that limb injuries were the most common type of injury and that head injuries were present in only 29% of elderly patients.

In our study, almost half of the head injured patients presented to the ED with a normal GCS. The findings are similar to those of another study (Reynolds et al,, 2003) suggesting a probability of at least 25% of intracranial haemorrhage in elderly, anticoagulated, head-injured patients initially assessed as having a normal GCS. Neurological deterioration occurred within 6 hours of the time of injury.

While appropriate triage, aggressive treatment, close observation, and monitoring are frequently recommended in the management of the elderly trauma patient, there is little evidence to show that these measures improve patient outcomes, and the primary prevention of head injuries appears to be the best strategy for the elderly.

A local Hong Kong study (Kam et al.,1998) shows that unexpected trauma deaths are reduced by improving multi-disciplinary cooperation, making earlier diagnoses of injuries, and encouraging senior participation in trauma care. Our results suggest that older trauma patients with thoracic trauma, especially where associated with other injuries, should be aggressively managed to avoid preventable morbidity and mortality.

Although TRISS results are dichotomised into age groups of < 55 and ≥ 55, we found that the mortality rate among elderly patients increased with advancing age. This study confirms the finding of Demetriades (2005) that the older the patient, the higher the mortality rate, even where patients have minor or moderate injuries. The TRISS methodology may need to be adjusted by categorising those in the > 55 age group into more sub-groups to address this issue. Further studies with bigger sample sizes are required to identify appropriate local age-specific regression coefficients for the calculation of Ps.

In this study, pre-existing medical problems were not taken into consideration when calculating the probability of survival (Champion et al., 1989). Elderly minor trauma patients with comorbidity had a higher mortality rate and the calculated probability of survival may have been unreliably high in this group of patients.

Increasing age, the presence of comorbidity, higher injury severity (measured by the ISS) and a lower GCS all independently predict a higher risk of mortality. These factors should be taken into account when deciding on trauma call activation and in performing mortality audits. A significant proportion of deaths may be preventable, especially in patients with a probability of survival greater than 0.75 (Rainer et al., 2007).

In sum, injuries are common among older patients in Hong Kong and are likely to increase in frequency. Pedestrians struck by motor vehicles and falls are the principal causes of trauma in older patients in Hong Kong and both are amenable to primary prevention strategies. Head and chest injuries are associated with a high mortality rate despite the aggressive emergency care provided to patients with such injuries. Mortality increases with age and comorbidity, age, ISS, and GCS are independent indicators of trauma mortality in older patients.

Chapter 10

Injury Prevention: Bicycle-Related Injuries

10.1 Abstract

Background One of the key components of any trauma system is injury prevention. Trauma centres play an important role in reducing the impact of injury by participating in prevention efforts, e.g. identifying specific injuries and risk factors in patients and the community. Cycling is both a popular leisure activity and an important means of transportation in Hong Kong. Riding behaviour causes and injury patterns may differ between young and older riders.

Aims The aims of this study were to (i) describe bicycle-related injuries among patients presenting to a regional trauma centre in Hong Kong; and (ii) compare patients aged > 15 with patients aged ≤ 15.

Methods This retrospective observational study examined all bicycle-related injury patients presenting to the ED of the Prince of Wales Hospital (PWH) in 2006.

Results The results show that the rate of bicycle helmet use is low in Hong Kong, suggesting that helmet wearing should be promoted among cyclists. Bicycle-related injuries are common in children, but the injuries suffered by

adults are more serious. Head and limb injuries are common and limbs on the left side of the body are 2.5 times more likely to be injured than those on the right. Older people are more likely to be involved in a motor vehicle collision and to sustain more severe injuries than their younger counterparts. Older patients suffer more serious injuries to the head and neck, the face, the thorax and the abdomen in comparison with the younger cohort.

Conclusion Prevention strategies should include more widespread helmet use and increasing bicycle lane provision to enable traffic separation in Hong Kong. The three 'E' approaches (education, enforcement, and environment) should be implemented to prevent bicycle injuries in Hong Kong.

10.2 Introduction

Cycling is both a popular leisure activity and an important means of transportation in Hong Kong, especially in the New Territories (Hong Kong Police Force, 2006). Around 2% of the Hong Kong population ride bicycles to work or school, particularly in rural areas and the outlying islands (Transport Department, Government of the Hong Kong Special Administrative Region, 2008). Data from the Transport Department of the Hong Kong Government reveal that 1,500 to 1,800 bicycle-related accidents are recorded annually, with school age children and young adults being the groups most frequently involved in bicycle accidents. In 2006, bicycle-related events accounted for 7.4% of all traffic incidents and 6.3% of all traffic-related fatalities. In 2008, 1,462 (87.7%) bicycle-related traffic incidents occurred in the New Territories (Transport Department, Government of the Hong Kong Special Administrative Region, 2008). The PWH is one of two designated trauma centres for this region and serves the Eastern New Territories.

In Hong Kong, patients with suspected major trauma undergo either primary diversion from the scene directly to the trauma centre or secondary transfer via a district hospital to a regional trauma centre (Cheung et al., 2006). Previous local studies (Lee et al., 2003, Ng et al., 2001) conducted in two district hospitals in the New Territories describe the epidemiology of bicycle-related trauma and focus on triage, treatment, and mortality in the ED. Neither study uses the abbreviated injury score, the injury severity score, the revised trauma score or the TRISS methodology to describe and evaluate care (Association for the Advancement of Automotive Medicine, 1990; Baker et al., 1974; Boyd et al., 1987).

Children below 15 years of age account for the majority of bicycle-related injuries (Coffman, 2003; Hansen et al., 2005; Moyes, 2006; Powell et al., 1997; Shah et al., 2007). Most young children are inexperienced cyclists and their cycling behaviour and causes and patterns of injury may differ from those of older riders. While identifying general epidemiological patterns of bicycle-related injuries could lead to the identification of local injury prevention strategies, comparing adult- and child-related incidents may reveal potential age-specific prevention strategies.

10.3 Aims

The aims of this study were to (i) describe bicycle-related injuries among patients presenting to a regional trauma centre in Hong Kong; and (ii) compare patients aged > 15 with patients aged ≤ 15.

10.4 Setting, Materials, and Methods

This retrospective observational database study identified all trauma patients presenting to the ED of the PWH between 1 January 2006 and 31 December

2006. The PWH is a regional trauma centre and university teaching hospital located in Shatin in the Eastern New Territories.

The trauma attendance records of all patients presenting to the PWH ED were reviewed, with patients who had sustained bicycle-related injuries being analyzed. Data collected included patient characteristics, injury mechanisms, treatment and care received in hospital, abbreviated injury score (AIS), injury severity score (ISS), revised trauma score (RTS), hospital admission or discharge, hospital length of stay (LOS), intensive care unit (ICU) admission and LOS, patient disposal details, and mortality. Patients were classified into two groups: those aged ≤ 15 and those aged > 15.

10.5 Definitions of terms

Bicycle-related injuries were defined as any injury involving a bicycle including those sustained by riders, bicycle passengers, and pedestrians struck by a bicycle, as well as injuries suffered in bicycle-bicycle collisions and bicycle-motor vehicle collisions. If the patient attended on more than one occasion for the same incident, only the first attendance was counted. Injury days were divided into workdays and holidays. Holidays included public holidays, Saturdays, Sundays, and school holidays. In 2006, the ratio of holidays to working days was 155:210. Each new day was deemed to begin at midnight. Patients aged ≤ 15 were defined as younger patients and patients aged > 15 were defined as older patients.

The primary outcome measure was the Glasgow outcome scale (Jennett & Bond, 1975) in which the categories are good recovery, moderate disability, severe disability, vegetative state, and death.

The study was approved by the joint CUHK-NTEC Clinical Research Ethics Committee.

10.6 Statistical analysis

Patients' baseline characteristics in the two age groups were analysed using Fisher's exact test, the χ^2-test, and the t-test as appropriate. Relative risks (expressed as odds ratios with corresponding 95% confidence intervals [CI]) were used for comparison. Statistical significance was set at $p < 0.05$.

10.7 Results

Between 1 January and 31 December 2006, 143,852 patients attended the PWH ED, of whom 23,777 (17%) were trauma patients. Of the trauma patients, 698 (3.0%) had suffered bicycle-related injuries. Of those with a bicycle-related injury, 473 (67.8%) were cycling for exercise or recreation and 225 (32.2%) were cycling for transportation purposes.

Of the total patient sample, 457 (65.5%) were male (mean (SD) age 27.3 (±18.5)) and 241 (34.5%) were female (mean (SD) age 26.4 (± 16.2)). Their ages ranged from 1 year to 90 years. The number of younger patients (aged ≤ 15) was 223 (31.9%); 203 (29.1%) patients were aged 16 to 25; 246 (35.2%) patients were aged 26 to 64; and 26 (3.7%) patients were aged 65 or above.

Table 10.1 shows the baseline characteristics and age group comparison of the 698 patients recruited for the study. Four hundred and eighty four (69.3%) of the bicycle-related injuries occurred during holidays, three times more than those occurring on weekdays (odds ratio 3.06, 95% CI 2.36-3.98).

Table 10.1 Baseline characteristics and age group comparison

Variables	**Age ≤ 15 (n = 223)**	**Age >15 (n = 475)**	**P**
	No (%)	**No (%)**	**value**
Sex			0 232
Male	153 (68 6%)	304 (64 0%)	-
Female	70 (31 4%)	171 (36 0%)	-
Date of Injury			0 262
Weekday	62 (27 8%)	152 (32 0%)	-
Holiday	161 (72 2%)	323 (68 0%)	-
Injury Mechanism			**0.022**
Only one cycle involved	199 (89 2%)	418 (88 0%)	
Crashed/knocked down by cycle	23 (10 3%)	38 (8 0%)	
Crashed/knocked down by motor vehicle	1 (0 4%)	19 (4 0%)	-
Wearing Helmet	2 (0 9%)	1 (0 2%)	**0.002**

P Fisher's test or chi-square test

Six hundred and seventeen (88.4%) bicycle-related injuries involved only one bicycle Sixty one (8.7%) patients were injured after a collision with a bicycle.

Twenty (2.9%) patients were struck by a motor vehicle on the road. Patients in the older group were 9.3 times (95% CI 1.23-69.5) more likely to be involved in a crash with a motor vehicle than were those in the younger group.

Only three (0.4%) of the 698 cyclists wore a helmet at the time of injury. Among these three patients, one sustained a small traumatic subarachnoid haemorrhage, one had a displaced fracture of the radius, and one sustained multiple abrasions.

Figure 10.1 shows that the peak incidence of bicycle injuries occurred during months with prolonged holidays, e.g. April (Easter holiday), July and August (summer holiday), October (three public holidays), and December (Christmas).

Figure 10.1 Incidence of cycle-related injuries by month

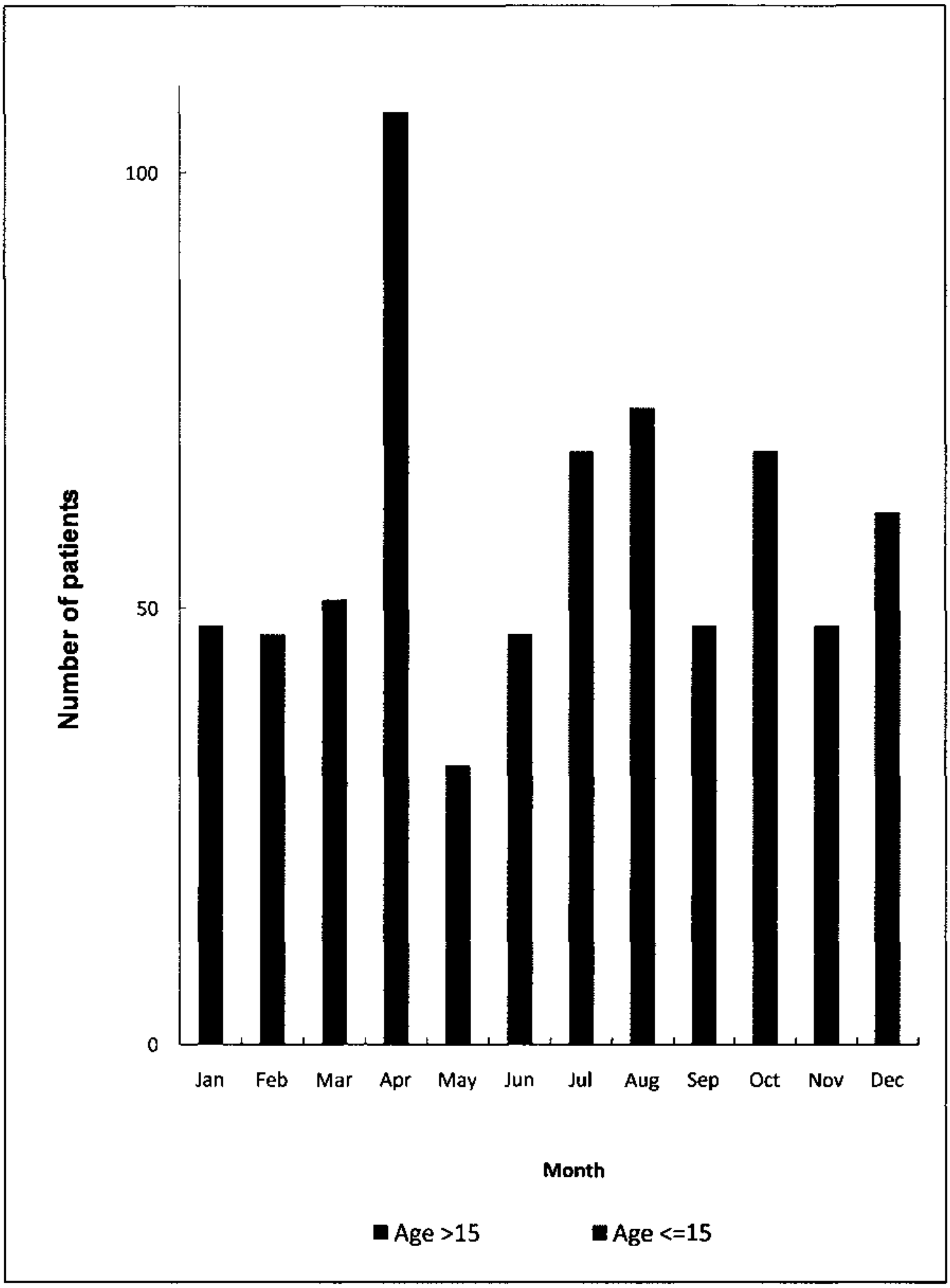


Table 10.2 shows the injury mechanisms, ED triage categories, specialties consulted, and investigations and treatments performed among the participating patients. More younger patients were triaged as category 3 (urgent). Older patients had higher triage grades, required more radiological investigations, and stayed in hospital longer. The seven patients requiring ICU care were all in the older group and ranged in age from 21 to 65. The ICU LOS ranged from 0.2 to 5 days.

Table 10.3 shows the injury severity scores, revised trauma scores, abbreviated injury scores, and outcomes among the sample. The bicycle-related injuries suffered were relatively minor in that only 17 (2.1%) patients were major trauma cases. They were all cyclists and 15 of them were older patients. Eight (47.1%) of the major trauma patients were knocked down by a motor vehicle and nine (52.9%) had lost control and skidded. The younger group had more moderate trauma (ISS 9-14), while the older group had more major trauma (ISS > 15) ($p = 0.038$).

Table 10.2 Hospital management for cycle-related injuries

Variables	Age ≤ 15 (n = 223) No (%)	Age > 15 (n = 475) No (%)	p-value
Triage			**0.002**
Critical and Emergency (Category 1 & 2)	3 (1.3%)	32 (6.7%)	-
Urgent (Category 3)	51 (22.9%)	76 (16.0%)	-
Semi/Non-urgent (Category 4 & 5)	169 (75.8%)	367 (77.3%)	-
Specialties Consulted			0.120
Trauma Team	2 (0.9%)	11 (2.3%)	-
Orthopaedic Surgery	53 (23.8%)	88 (18.5%)	-
Neurosurgery	14 (6.3%)	43 (9.1%)	-
Dental	6 (2.7%)	16 (3.4%)	-
Plastic Surgery	2 (0.9%)	15 (3.2%)	-
Others	2 (0.9%)	7 (1.5%)	-
ED only	144 (64.6%)	295 (61.6%)	-
Treatment in Hospital			
Radiography	157 (70.4%)	369 (77.7%)	**0.037**
Dressing	121 (54.3%)	284 (59.8%)	0.168
Suture	44 (19.7%)	107 (22.5%)	0.403
Closed Reduction in ED	4 (1.8%)	9 (1.9%)	0.927
POP	8 (3.6%)	25 (5.3%)	0.400
CT Scan	7 (3.1%)	45 (9.5%)	**0.002**
Hospital Admission	56 (25.1%)	133 (28.0%)	0.423
Hospital LOS (days)	2.4 ± 3.2	4.0 ± 5.2	**0.005***
ICU Admission	0	7 (1.5%)	N/A
ICU LOS (days)	-	2.9 ± 1.9	N/A
Operation	19 (8.5%)	62 (13.1%)	0.081

P: Fisher's test or chi-square test; *T-test; OP: Plaster of Paris

Table 10.3 ISS, RTS, and AIS

Variables	Age ≤15 (n = 223) No (%)	Age > 15 (n = 475) No (%)	p-value
ISS			0.038
1 - 3	169 (74.4%)	367 (77.3%)	
4 - 8	28 (12.6%)	60 (12.6%)	
9 - 14	27 (12.1%)	33 (6.9%)	
>15	2 (0.9%)	15 (3.2%)	
RTS < 7.841	2 (0.9%)	7 (1.5%)	0.397
AIS Head & Neck			**0.02**
1	1 (0.4%)	1 (0.2%)	
2	10 (4.5%)	31 (6.5%)	
3	1 (0.4%)	10 (2.1%)	
4	2 (0.9%)	5 (1.1%)	
5	0	6 (1.3%)	
AIS Face			**0.063**
1	10 (4.5%)	30 (6.3%)	
2	0	4 (0.8%)	
3	0	2 (0.4%)	
AIS Thorax			**0.037**
1	0	3 (0.6%)	
2	0	1 (0.2%)	
3	0	3 (0.6%)	
4	0	4 (0.8%)	
AIS Abdomen			0.086
1	0	2 (0.4%)	
2	0	3 (0.8%)	
3	0	1 (0.2%)	
5	0	1 (0.2%)	
AIS Extremity			**0.003**
1	7 (3.1%)	24 (5.1%)	
2	19 (8.5%)	42 (8.8%)	
3	27 (12.1%)	22 (4.6%)	
AIS External			0.068
1	223 (100%)	468 (98.5%)	

P: Fisher's test or chi-square test; *T-test

Almost all patients with bicycle-related injuries presented with external injuries including abrasions, contusions, and lacerations. Other than external wounds, limb injuries were the most common type of injury, followed by head injuries and facial injuries. In this study, 67 (9.6%) of victims had sustained a head injury and 11 of the 67 (16.4%) head injuries were serious or critical. Head injuries were also the main cause of death after trauma.

The older group had more serious head and neck, face, thorax, and abdominal injuries than the younger group. Thoracic and abdominal injuries were rare in the younger patient group. Younger patients had higher percentage of limb injuries than the older group ($p = 0.003$). A total of 141 (20.2%) patients had limb injuries of which 95 (67.4%) were left-sided injuries. The odds ratio for left-sided limb injuries was 2.5 (95% CI 1.14-5.56). Upper limb fractures were common (104/141, 74.5%) and the most common fracture site was the radius (48/104, 46.1%). Nineteen patients (13.5%) had lower limb injuries and 17 (12.1%) had a joint sprain or dislocation.

All the patients in the younger group survived and were discharged directly to their homes. The longest LOS was 19 days. In the older group, 15 patients (2.1%) were transferred to rehabilitation hospitals. Table 10.4 shows the outcomes according the Glasgow outcome score.

Table 10.4 Outcome by Glasgow outcome score (n = 698)

Outcome	Age ≤15 (n = 223) No (%)	Age >15 (n = 475) No (%)	P value
Good recovery	223 (100%)	469 (98.7%)	0.242
Moderate disability	0	4 (0.8%)	
Severe disability	0	0	
Vegetative state	0	0	
Death	0	2 (0.4%)	

P: Fisher's exact test

10.8 Discussion

Bicycle-related injuries were three times more likely to happen in holidays than on weekdays. The incidence and severity of injuries in the older group were higher than in the younger group. Older cyclists were more likely to ride on the road and be involved in incidents with motor vehicles.

A previous study (Enrlich et al., 2004) shows that most adult cyclists claim they are experienced and never think they will get hurt, and never feel in danger while cycling. Some people do not believe that helmets offer meaningful protection (Bungum & Bungum, 2003). In Hong Kong, adults have accounted for over 87% of bicycle-related deaths since 2000 (Transport Department of HK, 2008). This is important, as riders' perceptions and attitude to bicycle safety are not related to their experience, skills, or maturity.

In our study, the main cause of death and moderate disability after a bicycle related-incident was head injuries. Other common injuries included musculoskeletal injuries and chest and abdominal trauma. A properly fitted helmet may reduce the severity of a traumatic brain injury. A case-controlled study (Thomas et al., 1994) demonstrates that wearing a helmet reduces the risk of head injury by 63% and lowers the risk of loss of consciousness by 86% among children.

A review of controlled studies (Thomas et al., 1999) suggests that wearing a helmet leads to a 63%-88% reduction in the risk of head and brain injuries and severe brain injuries for cyclists in all age groups. Injuries to the upper and mid-facial areas are reduced by up to 65%. Helmets also provide an equal level of protection for all types of accidents including incidents involving motor vehicles (Thomas et al., 1999).

It is not mandatory to wear a helmet when riding a bicycle in Hong Kong. This study suggests that the prevalence of helmet usage is extremely low in Hong Kong. Prior studies (Coffman, 2003; Ji et al., 2006; Lee et al., 2005) show that legislating to make it compulsory for cyclists to wear a helmet reduces traumatic brain injuries. A population-based study in Canada shows that the bicycle-related head injury rate declined more significantly (45%) in provinces where such legislation had been adopted than in provinces and territories that did not adopt legislation (27%) (Macpherson et al., 2002). Wearing a helmet when riding a bicycle is now mandatory in many states in the United States, Canada, and New Zealand.

Although the Hong Kong Government has conducted numerous health programmes to promote bicycle safety, there are no compulsory helmet laws for cyclists, whereas it is mandatory for motorcyclists to wear a helmet. Prior studies have shown that helmet legislation is the most cost-effective and easy way to increase the rate of bicycle helmet use (Ji et al., 2006; Lee et al., 2005). Although there is an argument that helmet legislation may discourage cycling, previous studies demonstrate that such legislation uniformly reduces the severity and incidence of head and facial injuries (Britt et al.,1998; Gilchrist et al., 2000; Ji et al., 2006; Lee et al., 2005).

The results of this study show that the most severe bicycle-related injuries were sustained as a result of a motor vehicle collision. There are insufficient cycling paths in Hong Kong and people often ride bicycles on busy roads shared by high-speed motor vehicles. This practice is very dangerous both for cyclists themselves and for other road users in the congested Hong Kong road network. It may be necessary to provide sufficient bicycle lanes and consider the introduction of a penalty system to encourage cyclists to use specific bicycle lanes.

Another factor present in the New Territories may be that many cyclists hire bicycles for leisure activities rather than buying one of their own. This means they may have less experience and ability, potentially making them more prone to injury. One method that could be used to improve the situation is to insist that bicycle hire shops make it compulsory for bicycle hirers to hire a helmet as well. While this may increase the cost to the cyclist, the overall effect of this measure in reducing the incidence of injuries may be worthwhile.

Approaches to prevention of cycle injuries Injuries are preventable and predictable and are one of the major issues in public health care. Three 'E' approaches should be implemented to prevent bicycle injuries: education, enforcement, and environment (Coffman, 2003; Enrlich et al., 2004; Finnoff et al., 2001; Gilchrist et al., 2000; Heng et al., 2006; World Bank, 2008).

Education Educational programmes can raise awareness of bicycle safety and may have a positive impact on behavioural changes through increased knowledge, skills, and awareness of road safety. It is important to conduct educational programmes involving events such as workshops or road safety programmes broadcast on television to teach guidelines, skills, and safety measures and encourage the use of helmets among cyclists. Interactive interventions such as discussions and video shows not only improve the knowledge and skills of cyclists immediately, but also lead to knowledge retention with respect to bicycle safety for a period of time (Celements, 2005).

Enforcement Apart from education, implementing a degree of enforcement in the form of helmet legislation for all bicycle users may be required to reduce the overall burden of injury and possibly prevent some fatal injuries. The Hong Kong Government should seriously consider legislating for compulsory helmet use among bicycle users.

Environment Many factors affect the severity of injury in a collision, with speed being one of the most important factors. Limiting speeds in bicycle lanes should be considered to reduce the severity of injuries suffered by cyclists. Sufficient cycling paths should be provided to prevent bicycle-motor vehicle crashes.

10.9 Study limitations

Because this study was based on data from a single regional hospital, the findings may not be representative of bicycle-related injuries in other health care settings. Some injured cyclists may not attend an ED, and patients who died before hospitalisation were not included in this study. This study may therefore underreport the true incidence of bicycle-related injuries.

10.10 Conclusion

Head and limb injuries are common forms of bicycle-related injuries. The bicycle helmet use rate is low in Hong Kong and wearing a helmet when cycling should be promoted. Although bicycle-related injuries are common in children, the injuries in adults observed in this study were more serious. Prevention strategies should include more widespread helmet use and an increased number of bicycle lanes to enable the separation of cycle and vehicular traffic.

Chapter 11

A Comparison of Trauma Care in Victoria, Australia and Hong Kong, China

11.1 Abstract

Background: Despite the high incidence of major trauma, few studies have directly compared the performance of trauma systems. This study compared the performance of trauma systems in Victoria, Australia (VIC) and Hong Kong, China (HK).

Methods: Data collected prospectively from the 2 trauma systems over 5 years from January 2001 were compared using univariate analysis. Variables were then entered into a multivariate logistic regression to assess outcome differences between the systems and were adjusted for the effects of clinically important factors.

Results:

A total of 5,536 cases from VIC and 580 cases from HK were taken for analysis. The HK group was older, but the injury mechanisms in both systems were similar. Thoracic and abdominal trauma was more common in VIC, while

head injuries were more prevalent in HK. More patients were admitted to intensive care in VIC and patients stayed in intensive care for one day longer on average despite a higher rate of comorbidity in HK patients. The overall mortality rate was 20.2% for HK and 11.9% for VIC (χ^2 =32.223, $P < 0.001$).

Conclusion: The HK trauma system performed at a level comparable to international standards, but there was a significant difference between the two systems in the probability of survival among major trauma patients. Possible modifiable factors may include criteria for the activation of trauma calls and improved ICU utilisation.

11.2 Introduction

Trauma accounts for 1 in 10 deaths globally and ranks as the sixth most common cause of death in Hong Kong (Census and Statistics Division, HKSARG, 2007). Trauma registries have become increasingly widespread since they were first developed in the US in the 1970s. One of the major aims of registries is to monitor major trauma care processes and outcomes for individual communities (Cameron et al., 2005). However, registries can also guide the allocation of health care resources and help to assess the performance of trauma systems, as well as providing a means to compare national and international standards (Jurkovich & Mock, 1999).

The increasing use of trauma registries, along with the development of the major trauma outcome study (MTOS) databank in the United States (Champion et al., 1990) and the National Trauma Data Bank (NTDB) (American College of Surgeons, 2007), have facilitated comparisons of the performance of individual trauma systems with international standards. A systematic review and meta-analysis (Celso et al., 2006) has compared the performance of various trauma systems with such benchmarks. However, the inherent limitations of this approach are well documented (Joosse et al., 2005; Glance et al., 2005; Jones & Redmond, 1995). Using the reference data set, differences between systems can be determined through comparisons of the M score, the Z score, and the W score (Cameron et al., 2005; Jurkovic & Mock, 1999; Joosse et al., 2005). However, in many cases, factors contributing to the differences identified cannot be established from these scores alone. To date, no international comparison of trauma system performance using patient level data from registries has been published. The trauma registries of Hong Kong, China and Victoria, Australia provided an ideal opportunity for direct comparison of the performance of 2 different trauma systems. The aim of this investigation was to compare the outcomes of major trauma patients in Hong Kong and Victoria over a 5-year period.

11.3 Patients and Methods

11.3.1 Setting

Victoria has a population of approximately 5 million, accounting for 24% of the Australian population. Two thirds of the Victorian population live in metropolitan Melbourne (Cameron, 2005). Definitive care of major trauma patients is centralised in 1 pediatric and 2 adult major trauma centres that together capture more than 80% of major trauma patients (Cameron, 2005).

The New Territories East region of Hong Kong has a population of approximately 1.2 million, accounting for 18% of the Hong Kong population. The PWH is the only designated trauma centre in the New Territories and serves a relatively large proportion of the New Territories East region (Cheung et al., 2006). It records data on all presenting trauma cases through a hospital-based registry.

11.3.2 The Registries

The Victorian State Trauma Registry based at Monash University is funded by the Victorian Trauma Foundation and the Victorian Department of Human Services. It was developed in 2001 and serves as a population-based statewide data collection tool. The registry collects a comprehensive range of parameters from all trauma patients including measures from the pre-hospital and in-hospital settings. In addition, the registry has the unique ability to assess outcomes at hospital discharge as well as at 6 months following discharge (VSTORM, 2004).

In Hong Kong, trauma registries are currently used in the 5 designated trauma centres covering the territory. Although the 5 trauma centres merge their datasets annually for administrative purposes, there is currently no territory-wide central data collection device. The PWH trauma registry has been actively collecting data since 2000 and is funded by the Hospital Authority of Hong Kong.

11.3.3 Data

This analysis used prospectively collected data from both trauma registries for the 5-year period from January 2001 to December 2005. The management approaches adopted by the two systems for victims of trauma are similar, with severely injured patients transferred to dedicated trauma centres for immediate treatment. Anonymised data restricted to blunt trauma with an injury severity score (ISS) > 15 were classified as major trauma cases and included in the analysis. Patients suffering penetrating injuries and burns (accounting for less than 10% of the total number of trauma patients) were excluded from the study. Demographic data including age, sex, and comorbidities were analysed. The mode of patient transfer, either primary or secondary transfer, was included in the analysis, as was length of intensive care unit (ICU) stay and overall length of hospital stay. The ISS and the abbreviated injury score (AIS) for different body regions were used to determine the patterns of injury in both Victoria and Hong Kong, while the mechanism of injury (including the type of injury and the cause of the injury) was also evaluated. The TRISS methodology was used to derive probabilities of survival (Ps) using standard techniques. MTOS and NTDB coefficients were used throughout. Ethical committee approval was obtained from both sites for the study.

11.3.4 Analysis

Descriptive data were expressed as means (standard deviations) or medians (interquartile range) for continuous variables. Comparison of the trauma systems was performed using two-sample *t* tests for continuous variables and χ^2 tests for categorical data. Multivariate logistic regression was used to assess the probability of the outcomes of interest (e.g. survival/death) and adjusted for key differences between the two trauma systems. Data were initially managed using a Microsoft Excel database (Microsoft Corporation, Redmond, WA) worksheet before being transferred to SPSS v12.0 (Statistical Package for Social Sciences, Chicago, IL) and Statview for Windows v 5.0 (Abacus Concepts, SAS Institute, Cary, NC) for further analysis.

11.4 Results

The analysis included 5,536 cases from Victoria and 580 cases from Hong Kong. Patient age ranged from 1 to 99 (Table 11.1). The mean age of patients injured in Hong Kong was 45.3, with a median of 45 and a standard deviation (SD) of 22 years. The mean age in Victoria was 42.0, with a median of 38 and a SD of 18 years. Age differences were statistically significant (two-sample *t* test, $p < 0.001$).

The sex distribution was similar between the 2 locations (Table 11.1). In Hong Kong, 71% of patients (412 of 580) were male, whereas men accounted for 72% of major trauma patients (3986 of 5536) in Victoria ($\chi^2 = 0.252$, $p = 0.615$).

Table 11.1 Profile of major trauma patients

Variable	Hong Kong n = 580	Victoria n = 5536	P-value
Sex			0 615
Male	71 (67 3, 74 7)	72 (70 8, 73 2)	
Female	29 (25 3, 32 7)	28 (26 8, 29 2)	
Age (years)	45 3 (43 4, 47 7)	42 0 (41 4, 42 6)	< 0 001
Causes of injury			< 0 001
Motor vehicle	22 4 (19 0, 25 8)	34 3(33 0, 35 6)	
Motorcycle	8 1 (5 9, 10 3)	11 7 (10 9, 12 5)	
Pedestrian	18 8 (15 6, 22 0)	9 9 (9 1, 10 7)	
High fall	14 8 (11 9, 17 7)	11 5 (10 7, 12 3)	
Low fall	18 6 (5 4, 21 8)	15 1 (14 2, 16 0)	
Others*	17 2 (14 1, 20 3)	17 5 (16 5, 18 5)	
Trauma call	53 4 (49 3, 57 5)	57 3 (56 0, 58 6)	0 078
Comorbidity	24 7 (21 2, 28 2)	12 7 (11 8, 13 6)	< 0 001
ICU admission	41 9 (37 9, 45 9)	51 1 (49 8, 52 4)	< 0 001
ICU length of stay (days)	3 0 (2 44, 3 52)	3 9 (3 71, 4 08)	< 0 001
Length of stay (days)	18 0 (15 7, 20 3)	13 2 (12 8, 13 6)	< 0 001
Operative rate	57 9 (53 9, 61 9)	75 0(73 9, 76 1)	< 0 001
ISS			< 0 001
16-25	50 1 (46 0, 54 2)	62 6 (61 6, 64 2)	
26-40	36 6 (32 7, 40 5)	27 3 (26 1, 28 5)	
> 40	13 3 (10 5, 16 1)	9 8 (9 4, 10 6)	
AIS			
Head and neck	80 7 (77 5, 83 9)	76 2 (75 1, 77 3)	0 017
Face	23 5 (20 0 27 0)	22 9 (21 8, 24 0)	0 750
Thorax	42 7 (38 7, 46 7)	52 6 (51 3, 53 9)	0 001
Abdomen	24 9 (21 4, 28 4)	29 1 (27 9, 30 3)	0 032
External	72 4 (68 8, 76 0)	55 2 (53 9, 56 5)	0 001
Extremities	44 0 (40 0, 48 0)	48 1 (46 8, 49 4)	0 065
ED-GCS			0 089
< 8	15 0(12 1, 17 9)	13 2 (12 3, 14 1)	
8-13	23 4 (20 0, 26 8)	27 5 (26 3, 28 7)	

> 13	61.6 (57.6, 65.6)	59.3 (58.0, 60.6)	
ED –RR (per min)			0.001
< 15	13.6 (13.2, 15.2)	14.2 (14.1, 20.3)	
15-25	70.9 (67.1, 74.7)	75.6 (74.4. 76.8)	
> 25	15.5 (12.4, 18.6)	10.1 (9.2, 11.0)	
ED-SBP (mmHg)			< 0.01
< 100	14.3 (11.4, 17.2)	8.5 (7.8, 9.2)	
100-200	69.6 (65.8, 73.4)	81.5 (80.5, 82.8)	
> 200	16.1 (14.1, 20.3)	10.0 (16.5, 18.5)	
Transfer	30.2 (26.5, 33.9)	34.0 (32.8, 35.2)	0.064
Outcome			< 0.001
Home	44.0 (40.4, 48.0)	38.5 (37.2, 39.8)	
Death	20.2 (16.9, 23.5)	11.9 (11.0, 12.8)	
Rehabilitation	32.9 (2.91, 36.7)	44.1 (42.8, 45.4)	
Others	2.9 (1.5, 4.3)	5.5 (4.9, 6.1)	

All figures refer to % (95% CI) unless otherwise indicated. *Other causes of injury include cyclist: rider or passenger, cutting, piercing object, fire, flames, smoke and scalds, horse and other animal-related, machinery, other transport-related circumstances, struck by or collision with object, struck by or collision with person, submersion or drowning—other, unspecified external cause. ICU indicates intensive care unit; ISS, injury severity score; AIS, abbreviated injury score; ED-GCS, emergency department Glasgow coma score; ED-RR, emergency department respiratory rate; ED-SBP, emergency department systolic blood pressure.

Patient transfer patterns were similar across the 2 trauma systems, with major trauma patients generally being transferred from smaller hospitals to major trauma centres for definitive management. In Victoria, 34.0% of patients (1882 of 5536) were transferred between facilities, while in Hong Kong, 30.2% of patients (175 of 580) were transferred to the major trauma centre (χ^2 = 3.483, p = 0.064).

In Hong Kong, the most common injury mechanisms were motor vehicle occupants (22.4%), pedestrian injuries (18.8%), and low falls (18.6%). The 3 main causes of injury in Victoria were motor vehicle occupants (34.3%), other causes (17.5%), and low falls (15.1%) (Table 11.1).

Analysis of the AIS codes showed that the patterns of injuries to the face and extremities were similar between the regions. There was a higher rate of chest and abdominal trauma in Victoria. More external injuries and head and neck injuries were reported in Hong Kong (Table 11.1).

Both systems use a team approach for trauma management. The trauma team is activated when a patient's condition fulfils certain criteria (Appendix 2). Trauma calls were activated in 53.4% of patients (310 of 580) in Hong Kong, while 57.3% of patients (3170 of 5536) in Victoria had the full trauma team activated (χ^2 = 27.745, $p < 0.001$). Partial trauma team activations for transferred patients were not included in this analysis.

The proportion (n = 143, 24.7%) of Hong Kong trauma patients with a recorded comorbidity was higher than in the Victorian sample (12.7%; 702 of 4377; χ^2 = 26.891, $p < 0.001$).

During their hospital stay, 41.9% of patients (242 of 580) from Hong Kong and 51.1% of patients (2,817 of 5,536) from Victoria were admitted to the ICU (χ^2 = 17.517, $p < 0.001$). The mean length of the ICU stay was significantly shorter in Hong Kong than in Victoria (3.0 days in Hong Kong vs. 3.9 days in Victoria; two-sample *t* tests, $p < 0.001$). The mean length of the overall hospital stay was longer in Hong Kong than in Victoria (18.1 days vs. 13.2 days; two-sample *t* tests, $p < 0.001$). The proportion of patients who underwent surgery was higher in Victoria (75.0%, n = 4,152) than in Hong Kong (57.9%, n = 336) ($\chi^2 = 78.307$, $p < 0.001$).

In Hong Kong, 44.1% (255 of 580) of patients were discharged to return home directly from hospital, compared with 38.5% (2,130 of 5,536) in Victoria. The number of patients discharged to rehabilitation services in Victoria was higher than that in Hong Kong (44.1% compared with 32.9% in Hong Kong; χ^2 = 53.930, $p < 0.001$).

The overall mortality rate for trauma patients was 20.2% (117 of 580) in Hong Kong and 11.9% (659 of 5,536) in Victoria ($\chi^2 = 32.223$, $p < 0.001$). By applying the coefficients from the MTOS4 from 1995 and the NTDB55 from 2005, the samples were stratified according to TRISS categories and Z and W scores (Jones, 1995) were compared. The performance of the 2 regions as assessed by this method is shown in Table12.2.

Table 11.2 W and Z scores for Hong Kong and Victoria

Variable	W	Z
Hong Kong		
MTOS	-1.3	-1.09
NTDB	-0.9	-0.78
Victoria		
MTOS	-2.3	-6.48
NTDB	-2.3	-6.43

Table 11.3 Odds ratios for survival adjusted for trauma system

Variable	Odds Ratio	95% CI	P Value	R^2
Age	0 975	0 971, 0 978	< 0 0001	0 058
Sex				0 011
Male	1 509	1 287, 1 769	< 0 0001	
Female	Reference			
Causes of injury				0 040
Motor vehicle	2 092	1 642, 2 66	< 0 0001	
Motorcycle	3 55	2 468, 5 119	< 0 0001	
High fall	1 339	1 012, 1 773	0 413	
Low fall	0 851	0 665, 1 090	0 200	
Others	2 865	2 127, 3 853	< 0 0001	
Pedestrian	Reference			
Trauma call				
Yes	0 544	0 454, 0 651	< 0 0001	
No	Reference			
ICU admission				
Yes	0 717	0 598, 0 861	0 717	
No	Reference			
Comorbidity				
Absent	3 509	2 888, 0 770	< 0 0001	
Present	Reference			
ISS	0 927	0 921, 0 933	< 0 0001	
ED_SBP	1 011	1 009, 0 933	< 0 0001	
ED_RR	1 079	1 070, 1 087	< 0 0001	
ED_GCS	1 261	1 240, 1 283	< 0 0001	
ED_SaO2	1 014	1 012, 1 016	< 0 0001	

R2 is the weighting of each factor's contribution to survival ICU indicates intensive care unit, ISS, injury severity score, ED-GCS, emergency department Glasgow coma score, ED-RR, emergency department respiratory rate, ED-SBP, emergency department systolic blood pressure, ED-SaO2, emergency department peripheral oxygen saturation

Table 11.3 shows the odds ratios for survival for each predictor, adjusted for the effect of the individual trauma system. Independent predictors for survival using the model were younger age, male sex, absence of comorbidity, and trauma team activation. Independent predictors for survival for causes of injury included motor vehicle occupants, motorcycle users, and the "others" category. Lower severity of injury as measured by ISS was associated with better survival. Higher emergency department (ED) systolic blood pressure, higher GCS, higher SaO2, and a higher respiratory rate were all independent physiological predictors for survival. Table 11.4 shows the results of the multivariate logistic regression analysis to identify independent predictors of survival. Independent predictors of survival included younger age, absence of comorbidity, and ICU admission. The independent predictors for survival included motor vehicle occupants and motorcyclists; those sustaining a low fall had a significantly higher risk of death compared with the reference group consisting of pedestrians. Physiologic parameters including higher ED systolic blood pressure, higher ED GCS, and higher ED oxygen saturation were also independent predictors for survival. Overall, patients in Victoria were twice as likely to survive as their Hong Kong counterparts.

Table 11.4 Multivariate analysis for survival

Variable	Odds Ratio	95% CI	P Value
Victoria	2 173	1 61 , 2 932	< 0 0001
Hong Kong	Reference		
Age	0 965	0 959, 0 970	< 0 0001
Causes of injury			
Motor vehicle	1 682	1 147, 2 466	0 0078
Motorcycle	2 274	1 233, 4 194	0 0085
High fall	0 831	0 540, 1 279	0 4010
Low fall	0 453	0 687, 2 99	0 0002
Others	1 019	0 645, 1 610	0 9359
Pedestrian	Reference		
Trauma call			
Yes	0 778	0 555, 1 091	
No			
ICU admission			
Yes	1 388	1 038, 1 857	0 0269
No			
Comorbidity			
Absent	1 530	1 155, 2 206	0 0030
Present	Reference		
ISS	0 943	0 932, 0 953	< 0 0001
ED_SBP	1 005	1 002, 1 008	0 0006
ED_GCS	1 274	1 240, 1 310	< 0 0001
ED_SaO2	1 008	1 004, 1 012	0 0002

ICU indicates intensive care unit, ISS, injury severity score, ED-GCS, emergency department Glasgow coma score, ED-RR, emergency department respiratory rate, ED-SBP, emergency department systolic blood pressure, ED-SaO2, emergency department peripheral oxygen saturation

11.5 Discussion

This analysis demonstrates that mortality from major trauma in Hong Kong is comparable with that of the MTOS study group using the MTOS 1995 and NTDB coefficients. In contrast, the same analysis suggests that treatment received in Victorian hospitals for major trauma patients may be associated with significantly improved outcomes. The M statistic for the 2 regions was not calculated as the patient groups examined were clearly different from the whole MTOS/NTDB datasets, not including ISS < 15. After adjusting for differences across the systems and known predictors of survival, patients in Victoria were significantly more likely to survive than patients in Hong Kong. We identified factors related to survival in a multivariate logistic regression model that are potentially modifiable, including the relative amount of ICU utilisation.

ICU use was found to be an independent predictor of survival. Although no prior study has examined ICU usage and trauma patient survival in adults, one investigation demonstrates improved patient survival following ICU admission for pediatric trauma patients (VSTORM, 2004). Increased ICU utilisation in Victoria is reflected by the high proportion of patients admitted to the ICU and their longer mean length of ICU stay. This additional utilisation may be partly attributable to greater resources. Victorian hospitals have been able to designate a specific number of ICU beds for major trauma patients as the traffic injury insurer (the Transport Accident Commission) and the local government health department have made a significant investment in infrastructure. In Hong Kong, the PWH has a general ICU, but one ICU bed is designated for major trauma patients at any given time due to the designation of the hospital as a regional trauma centre. If ICU beds are fully occupied from time to time and a trauma patient requires ICU care, a non-trauma patient will be transferred out to make space for the trauma patient. Increasing the proportion of trauma patients admitted to the ICU and lengthening ICU stays in Hong Kong may be one method of improving trauma outcomes; this would require further prospective study.

Prior research demonstrates that activation of the trauma team has a positive impact on patient care, with some studies suggesting an improvement in trauma survival (Liberman et al., 2004; Osterwalder, 2002). Although the multivariate analysis conducted in this study showed that trauma call activation itself was not an independent predictor of survival, some studies have shown an improvement in survival in certain high-risk patient sub-groups (Rainer et al., 2007). The composition of the trauma teams was similar in the 2 locations, including an experienced emergency physician (acting as the trauma team leader), a general surgeon, an orthopaedic surgeon, and an anesthetist/intensivist, with or without a neurosurgeon. In both settings, trauma team leaders had all successfully completed a standard trauma resuscitation training course. In the Prince of Wales Hospital in Hong Kong, all trauma team leaders had completed an ATLS course, while in Victoria, all trauma team leaders had completed the equivalent Australasian (EMST) course.

Trauma team activation in Victoria occurs well in advance of the patient's arrival at hospital if certain criteria are fulfilled (Appendix 3). In contrast, the Hong Kong team is activated only after a clinical assessment by the specialist emergency physician in charge, and the same specialist takes up the role of trauma team leader once the trauma call is activated. The time from the patient's arrival to trauma team activation is usually less than 5 minutes and local audit data confirm that other team members arrive in less than 10 minutes in over 95% of trauma team activations. Therefore, the delay from arrival to specialist general surgical assessment is less than 10 minutes in almost all cases in Hong Kong.

Although the Hong Kong activation process is not as ideal as that of the system in Victoria, it represents the current best practice that can be achieved in a busy Hong Kong hospital setting. Table 11.3 suggests that trauma team activation may have a significant impact on survival; this key difference, as well as the increased frequency with which the trauma team is activated and the timing of activation of the trauma team in Victoria, may play some role in the higher survival rate among trauma patients treated in the Victorian system. This study suggests that a change in current practice, with earlier activation of the trauma team in Hong Kong, ideally before the arrival of the patient, may further improve the trauma survival rate. This proposal should be the subject of a prospective study in Hong Kong. Pre-hospital care plays an important role in trauma patient care. The SAMU (Service d'Aide Medicale Urgente) in France plays a very active role in onsite resuscitation. The Victorian team adopts is a more active approach to pre-hospital care similar to that taken in

France. In France, physicians are trained to practice rapid sequence induction and intubation at the scene. In Victoria, specially trained paramedics working in mobile intensive care ambulances can also use rapid sequence-induction techniques to achieve pre-hospital endotracheal intubation.

Ambulance care in Hong Kong is protocol-driven and is standardised throughout the territory. In Hong Kong, ambulance personnel are not trained to perform endotracheal intubation in the pre-hospital arena (with or without drugs), and transfer times from the scene to the most appropriate hospital are usually about 32 minutes (Cheung et al., 2006). These reasons explain why Hong Kong continues to adopt the "scoop and run" approach. Although studies examining aggressive pre-hospital airway approaches reveal contrary results (Rainer et al., 2007, Bergeron et al., 2006), some studies suggest that early intubation with appropriate ventilation strategies does improve the chance of survival among patients with severe head injuries. Pre-hospital care focusing on the airway and ventilation in trauma patients is certainly an area that needs further exploration.

Differences in operative rates were marked in the univariate analysis, but were not significant in the multivariate regression. It may be that for certain conditions, an increased operation rate is associated with an improved survival rate. Unfortunately, the small number of patients in different injury sub-groups did not allow for further meaningful analysis.

Age is known to be associated with mortality among trauma patients. Several studies have shown that age itself is a reliable predictor for the outcomes of elderly trauma patients (Macias et al., 2004; Bergeron et al., 2005; Wardle, 1999). In this study, increased age was shown to be associated with decreased survival. Non-modifiable factors such as age and sex play an important role in recovery from trauma. Although patient-specific characteristics are not amenable to clinical treatment, preventive steps can be taken to reduce the risk of injury to this high-risk group. The higher mean age of injured patients among the Hong Kong population appears to reflect the aging population of this region and potentially places an increased burden on the performance of the trauma system. Trauma in the elderly may also be related to the low rate of vehicle ownership in Hong Kong and the predominance of low falls and pedestrian injuries.

The presence of comorbidities has been found to be a predictor of poor outcomes (Davis et al., 2006; Winchell & Hoyt, 1997). Our study also shows that the presence of comorbidities has a negative impact on trauma patient survival. The mean age of injured patients among the Hong Kong sample was higher than that among the Victorian cohort, and there was a greater rate of comorbidities seen in the Hong Kong group that is likely to have contributed to the higher mortality rate.

Improvements in the safety of car design and greater efforts to promote road safety are both likely contributors to the improved outcomes following motor vehicle accidents in comparison with those of high- and low-fall injuries. Strategies to reduce the rate and severity of low falls may translate into positive results for trauma patient survival.

11.6 Limitations

Like other studies using registry-based data, this investigation was limited to an analysis of the parameters available from the Victorian and Hong Kong trauma registries. The lower number of patients in the Hong Kong group may have limited some of our conclusions. Therefore, other significant factors contributing to trauma patient outcomes on which data were not collected by the two registries may provide additional explanations for our results. Furthermore, much of the pre-hospital component of patient care was not explored in this investigation despite marked variations between the 2 systems. For example, most Victorian patients with a GCS of < 9 at the scene were intubated by rapid sequence intubation at the scene, whereas in Hong Kong, trauma intubation at the scene is not undertaken, even in patients with a low GCS.

The number of patients recruited in each of the two locations was significantly different. Because the Prince of Wales Hospital is only one of the five trauma centres in Hong Kong, the number of trauma patients in Hong Kong during the study period should be around five times higher, i.e. around 3,000. This would make the 2 groups more comparable in terms of number of patients. Unfortunately, however, Hong Kong does not currently have a unified trauma registry. It is hoped that a similar, more comprehensive comparison study can be undertaken once the Hong Kong trauma registries have been unified.

Similarly, it is unclear whether the longer length of stay observed in Victoria is too lengthy or the shorter length of stay in Hong Kong is too abbreviated. Given the better outcomes in Victoria, it is likely that Hong Kong is underutilising hospital resources for trauma patients. However, this issue requires further study and a formal cost-effectiveness analysis.

The severity of head injuries sometimes outweighs that of injuries sustained in other body regions and often accounts for the high mortality rate among trauma patients. In practice, this reflects a weakness of using the TRISS score to classify trauma patients. There were more head injury patients in the Hong Kong group than in the Victorian sample. This may have a negative effect on Hong Kong's performance if injury severity is measured by the injury severity score alone. Therefore, a further analysis of this aspect of trauma care in the 2 centres is planned. As this study was restricted to patients with an ISS of > 15 and blunt trauma, the samples differed significantly from that of the original MTOS group. It was not possible to calculate an M score as the inclusion criteria for the registries for less severely injured patients in Hong Kong and Victoria were different. By selecting patients with an ISS of > 15, we hoped to eliminate potential bias as quality assurance procedures for both databases suggested that the proportion of potentially missed patients in this group was likely to be less than 2%.

Although attempts were made to consider all relevant factors contributing to trauma patient survival and outcomes, additional parameters such as the type of diagnostic investigation, the timing of any operation, and the type of intervention each patient received were not analysed in this study.

The difficulties encountered in measuring outcomes following trauma are well documented (Glance, 2004). Many trauma systems have now reduced the immediate incidence of mortality following trauma to relatively stable levels, prompting some to suggest that functional outcomes may provide a more informative measure of successful management than mortality alone (Graham et al., 2007a, 2007b). Incorporating measures of functional outcome in the medium to longer term (i.e. ≥ 6 months) could strengthen future studies and may be a more sensitive and meaningful indicator than the crude measure of mortality. This investigation did not consider the impact of funding or resource allocation on the two systems and their possible effects on patient outcomes. Although greater resources appear to be available in the Victorian system, investigation of the potential impacts this may have had was beyond the scope of this study.

11.7 Future Directions

Using a population-based trauma registry to monitor patterns of trauma and evaluate trauma system performance should be considered an integral part of contemporary trauma care. Currently, the 5 trauma centres in Hong Kong use independent trauma registries to collect data relating to trauma patients, although core data are merged annually. A territory-wide trauma registry for the Hong Kong trauma system would improve the system further by unifying data collection and monitoring overall system performance. Studies directly comparing registry data such as this one allow for analysis of performance differences and provide a means of exploring alternative processes and management structures. This may ultimately lead to improved local service delivery for trauma patients.

11.8 Conclusion

Every trauma system can and should seek to improve its standard of care. This may be achieved by the system benchmarking itself against a comparable or superior system. As this study suggests, the direct comparison of trauma registries allows for the identification of potentially modifiable factors that may be associated with performance differences. This study has shown that the performance of a regional trauma service in Hong Kong is comparable to MTOS standards, but there appears to be a significant difference in mortality from major trauma between Victoria and Hong Kong. Modifiable contributing factors may include different approaches to pre-hospital care, the timing of activation of trauma team calls, and improved ICU utilisation. Future comparisons of these 2 systems would help to evaluate changes in trauma care over the next decade. Further studies in other regions of the world using comprehensive trauma databases would help to extend this work.

Chapter 12

Conclusion

Development of the Hong Kong trauma system has improved the clinical outcomes of trauma patients. The increasing effectiveness of the local trauma system may be a result of the introduction of primary trauma diversion in pre-hospital care, the establishment of trauma centres and trauma teams for acute care, and the initiation of trauma audits, clinical guidelines, and educational programmes. There is a need to place a further emphasis on improving injury prevention programmes. Streamlining the five trauma centres in Hong Kong by reducing their number to a maximum of three may be required to concentrate resources and ensure sufficient experience and patient volumes. A central trauma registry is recommended for better quality assurance, research, planning, and injury prevention programmes. Post-injury functional outcomes and quality of life among trauma patients need to be monitored to provide a more comprehensive picture of clinical outcomes.

Appendix 1: Trauma Registry Inclusion Criteria

1. Injury mechanisms potentially causing major trauma
    - Ejection from vehicle
    - Death of occupant in same vehicle
    - Auto crash with significant vehicular body damage
    - Significant fall (> 20 feet)
    - Significant auto rollover
    - Bent steering wheel
    - Auto-pedestrian impact
    - Significant motorcycle, motor vehicle and bicycle impact
    - Significant assault
2. Multi-system blunt or penetrating trauma with unstable vital signs:
    - Haemodynamic compromised with hypertension or peripheral signs of shock
    - Respiratory compromise with respiratory distress or desaturation
    - Altered GCS 13 or below
3. Significant anatomical injuries:
    - Penetrating injury of head, neck, torso (front or back), groin
    - Significant blunt or crush injury to chest or abdomen
    - Flail chest
    - Spinal injury with paralysis
    - Two or more obvious proximal long bone fractures (upper arm or thigh)
    - Open or suspected depressed skull fracture
    - Unstable pelvis or suspected pelvic fracture
    - 2^{nd} or 3^{rd} degree burn > 20%
    - Blast or gunshot injury
    - Extensive facial injury
4. Trauma deaths and trauma patients admitted to an intensive care unit (ICU) or high dependency area.

5. ED triage category 1 (critical) or 2 (emergency) trauma.

Appendix 2. Trauma Patients Diversion Form (for ambulance)

創傷病人分流表格 Trauma Patients Diversion Form

日期/召喚時間 Date/Time of call	病人姓名 Patient's name	性別/年齡 sex/age	單位/救護車編號 Unit/Amb No	救護車主管階級及編號 Amb Supr Rank/No

---病人資料 Demographic Data Entry---

請在適當的☐中加上√號（可以選擇一個或以上√號）
Put a √ in the appropriate ☐ (can choose one or more√)

在以下適當的√號打圈
Circle one of the appropriate √s below

步驟 Step	檢查 Check	到最近醫院 Go to nearest Hospital	到創傷中心 Go to Trauma Centre	轉到下一步 Go to Next Step
1.	➢ 病人 是 心臟驟停 Patient in Cardiac Arrest	√		
	➢ 病人 不是 心臟驟停 Patient NOT in cardiac arrest	----------	----------	步驟 2
2.	傷者的 氣道 及／或 呼吸 Patient's Airway &/or Breathing			
	➢ 不能 有效地處理 CANNOT be managed	√		
	➢ 能 有效地處理 Can be managed	----------	----------	步驟 3
3.	身體器官所受的傷害 Anatomical Criteria			
	連枷胸 Flail Chest ☐			
	下肢骨折涉及(甲) 2 條大腿 或 (乙) 1 條大腿及 1 條小腿 或 (丙) 2 條小腿 或 (丁) 1 或 2 條大腿及 1 或 2 條小腿 Lower limbs fracture of (a) 2 thighs, or (b) 1 thigh and 1 lower leg or (c) 2 lower legs or (d) 1 or 2 thigh(s) and 1 or 2 lower leg(s) ☐			
	手腕或足踝以上的斷肢 Amputation proximal to wrist or ankle ☐			
	頭部、頸部或身軀有穿透性創傷 Penetrating trauma to head, neck, or torso (trunk) ☐			
	肢體癱瘓 Limb paralysis ☐			
	盆骨骨折 Pelvic Fracture ☐			
	百分之二十或以上的皮膚面積涉及二級或以上的燒傷 Burn of 2nd degree or more & involved 20% body surface area or more ☐			
	➢ 符合 以上任何一種或多於一種的身體傷害 =/>1 of the anatomical criteria met	----------	√	
	➢ 不符合以上任何一種的身體傷害 None of the anatomical criteria met	----------	----------	步驟 4
4.	生理性的範疇 Physiological Criteria			
	格拉斯哥昏迷等級評分 < 14 (</=13) 或 AVPU 等級評分不完全清醒 * — GCS < 14 (</= 13) or VPU / not completely alert * ☐			
	血壓上壓 < 90 mmHg 或 毛細管血液回流灌注需時多於兩秒 * — Systolic BP < 90 mmHg or Cap Refill > 2 sec * ☐			
	呼吸頻率 < 10 or > 29 / min — Resp Rate < 10 or > 29 / min ☐			
	➢ 符合 以上任何一種或多於一種的生理性範疇 =/>1 of the physiological criteria met	----------	√	
	➢ 不符合以上任何一種的生理性範疇 None of the physiological criteria met	√		

(although you may not need to go to the last step in this guide, you need to find and treat)
(雖然並不需一定跟從指引到最後一個步驟，但仍需檢視病人及提供適當處理)

***GCS and BP should be used for an adult. For an older child (8 – 12 years) GCS and BP should be used if easily obtained, but if it is difficult to obtain the GCS and BP or if the child is young (< 8 years), AVPU and CR are used as fallbacks.**

*檢查成人病人或八至十二歲的小童病人時，必須根據格拉斯哥昏迷等級評分及血壓等範疇。當檢查八至十二歲的小童病人的格拉斯哥昏迷等級評分及血壓等範疇遇到困難或該名小童病人少於八歲時，才可使用逐分清醒程度 AVPU 及毛細管血液回流灌注作後備指標。

---知會創傷中心 Notify Trauma Centre---

經由何種途徑知會創傷中心 Trauma Centre Notified by	☐ 消防控制中心 FSCC	☐ 無線電直接聯絡急症室 Radio Direct to A&E	☐ 手電直接聯絡急症室 Mobile Phone to A&E
線上諮詢（如有）On-line consultation (if done) 回覆醫生的姓名 Name of doctor answered Dr		☐ 無線電直接聯絡急症室 Radio Direct to A&E	☐ 手電直接聯絡急症室 Mobile Phone to A&E

已接收病人
Patient received by (創傷中心名稱 Name of Trauma Centre) ______

已由局長查閱／日期
Checked by DepC/Date ______ ______

FSG 332(Revised June2006)

Appendix 3: Trauma Call Criteria

Victoria

Mechanism

Vehicle roll over

Fatality in same vehicle

Ejection from vehicle

Motorcycle accident, cyclist impact > 30 kph

Extraction > 30 min

Fall > 5 m

Explosion

Injuries (this is not an exclusive list)

All penetrating injuries

All significant blunt injuries

Assessed by ambulance with all injuries involving:

- Evisceration
- Explosion
- Severe crush
- Amputation

Suspected spinal injury

Serious burns

Fractured pelvis

Signs

Intubated

Respiratory rate < 10 or > 30

Systolic blood pressure < 100 mm Hg (adult)

Systolic blood pressure < 75 mm Hg (child)

GCS < 15

SpO2 < 90%

Treatment (all patients who have undergone these pre-hospital interventions)

Intubated

Any airway maneuver at any time

Assisted ventilation

Chest decompression

Failure to control external bleeding

Neuromuscular blockade

> 500 mL IV fluid

Sedatives

Other criteria

All interhospital trauma transfers

Significant comorbidity ± warfarin

Pregnancy

<u>**Hong Kong**</u>

Any single episode of the following:

Physiological derangement

Systolic blood pressure ≤ 90 mm Hg

Respiratory rate ≤ 10 or ≥ 29 breaths per minute

Glasgow coma scale 13 or below

Anatomical injuries

Penetrating injury of head, neck, chest, abdomen, groin, or proximal extremities

Spinal injury with neurological signs (eg, limb paralysis)

Significant blunt or crush injury to chest/abdomen (include flail chest)

Major pelvic fracture (e.g. unstable pelvic fracture)

2 or more proximal long bone fractures

Open or suspected depressed skull fracture

Appendix 4: Trauma Nurse Coordinator Survey Questionnaire

Trauma Nurse Coordinator Role

Please tick "✓" or fill in the most appropriate answer in the (   )

A Background Information

Gender ( ) Male ( ) Female

Age ( ) < 30 ( ) 30-40 ( ) > 40

Status of Employment

( ) Contract term ( ) Permanent ( ) Part-time ( ) Full-time

Current working capacity

( ) RN, ( ) APN, ( ) NO, ( ) NS,

TNC position is assigned to

( ) Accident & Emergency Department

( ) Department of Surgery

( ) Department of Orthopaedic Surgery

( ) Central Nursing Division of the hospital

( ) Others, Specify____________

The immediate supervisor of TNC is (Can have more than one choice)

( ) GM(N)

( ) DOM

( ) WM

( ) SNO

( ) Physician

Specify the rank: ( ) MO ( ) SMO( ) Consultant ( ) COS

( ) Hospital administrator; specify________________________

Name of the working trauma centre:

( ) PM H ( ) QEH ( ) QMH ( ) PWH ( ) TMH

Number of years of post-registered working experience: ( ) years

Number of years in the current post ( ) years

Area of work experience before becoming a trauma nurse coordinator (can have more than one answer)

( ) AED ( ) Surg ( ) ICU ( ) Orth ( ) Med

( ) Paed( ) Education ( ) Administration ( ) Oncology

( ) Eye ( ) Gynaecology or OBS ( ) Psy ( ) others

B. Trauma Registry

Does you trauma centre have a computerised registry? ( ) Yes ( ) No

Number of personnel who work on the registry: ( )

Number of full-time registry personnel: ( )

Person responsible for the registry:

( ) Trauma nurse coordinator

( ) Other nurse

( ) Doctor

( ) Records administrator

( ) Records technician

( ) Other

C. **Education**

( ) Hospital-based training

( ) University-based training

( ) Post-graduate certificate, Specify ____________________

( ) Post-graduate diploma, Specify ____________________

( ) Bachelor's degree, Specify ____________________

( ) Master's degree,

Specify ____________________

( ) PhD

( ) Other trauma-related training, Specify ____________________

D. **<u>TNC on-the-job training</u>:**

( ) Computerised data management

( ) ICD-9-CM[a] N coding

( ) ICU-9-CM E coding

( ) Abbreviated injury scale

( ) Trauma nurse coordinator course

( ) No job training

Publications

Publications

The results of this thesis have been published as original articles in the following peer-reviewed journals:

Yeung J. H. H., Mikocka-Walus A. A., Cameron P. A., Poon W. S., Ho H. F., Chang A. M.L , Graham C. A, Rainer T. H. (2010). Hormonally active women are not better protected from traumatic brain injury than men of a similar age: a retrospective international study*. **Archives of Surgery*** (in press).

Yeung J. H. H., Leung C. S., Poon W. S., Cheung N. K., Graham C. A., Rainer T. H. (2009). Bicycle related injuries presenting to a trauma centre in Hong Kong. **Injury,** 40(5), 555-559.

Yeung J. H. H., Chang A. L., Ho W., So F. L., Graham C. A., Cheng B., Cheung N. K., Ho H. F., Yuen W. K., Kam C. W., Rainer T. H. (2008). High risk trauma in older adults in Hong Kong: a multicentre study. ***Injury,*** 39(9), 1034-1041.

Cheng C. H., Graham C. A., Gabbe B. J., **Yeung J. H. H**., Kossmann T, Judson R. T., Rainer T. H., Cameron P. A. (2008). Trauma care systems: a comparison of trauma care in Victoria, Australia, and Hong Kong, China. ***Annals of Surgery,*** 247(2), 335-342.

Rainer T. H, Cheung N. K., **Yeung J. H. H.,** Graham C.A. (2007). Do trauma teams make a difference? A single centre registry study. ***Resuscitation,*** 73(3), 374-381.

Yeung J. H. H., Cheung N. K., Graham C. A. , Rainer T. H. (2006). Reduced time on the spinal board - effects of guidelines and education for emergency department staff, ***Injury***, 37(1), 53-56.

Yeung J. H. H., Cheung N. K., Graham C. A., Chang A. M. L., Ho W., Rainer T. H. (2006). Role of the trauma nurse coordinator in Hong Kong, ***Surgical Practice*** (2006) 10, 97–101.

Cheung N. K., **Yeung J. H. H**., Chan J. T., Cameron P. A., Graham C. A., Rainer T. H. (2006). Primary trauma diversion: initial experience in Hong Kong. ***Journal of Trauma***, 61(4), 954-960.

Trauma-Related Papers Published during PhD (2006-2010)

Ho A. M., Dion P. W., **Yeung J. H. H.**, Ng C. S., Karmakar M. K., Critchley L. A., Rainer T. H., Cheung C. W., Tay B. A. (2010). Fresh-frozen plasma transfusion strategy in trauma with massive and ongoing bleeding. Common (sense) and sensibility. ***Resuscitation***, 2010 Jun 21. [Epub ahead of print]

Lee K. L., Graham C. A., **Yeung J. H. H.**, Ahuja A. T., Rainer T. H. (2010). Occult pneumothorax in Chinese patients with significant blunt chest trauma: incidence and management. ***Injury***, 41(5), 492-494.

Wong GK, Tang BY, **Yeung JH**, Collins G, Rainer T, Ng SC, Poon WS. (2009). Traumatic intracerebral haemorrhage: is the CT pattern related to outcome? ***British Journal of Neurosurgery***, 4, 1-5.

Ho A. M., Graham C. A., Ng C. S., **Yeung J. H. H.,** Dion P. W., Critchley L. A., Karmakar M. K. (2009). Timing of tracheal intubation in traumatic cardiac tamponade: a word of caution. ***Resuscitation***, 80(2), 272-274.

Cheng C. H., Yim W. T., Cheung N. K. , **Yeung J. H. H.**, Man C. Y., Graham C. A., Rainer T. H. (2009). Differences in injury pattern and mortality between Hong Kong elderly and younger patients. ***Hong Kong Journal of Emergency Medicine***, 16(4), 224-232.

Lee K. L., Graham C. A., Lam J. M., **Yeung J. H. H.**, Ahuja A. T., Rainer T. H. (2009). Impact on trauma patient management of installing a computed tomography scanner in the emergency department. ***Injury***, 40(8), 873-875.

Cheung P. S., Lam J. M., **Yeung J. H. H.**, Graham C. A., Rainer T. H. (2007). Outcome of traumatic extradural haematoma in Hong Kong. ***Injury***. 2007, 38(1):76-80.

Yim V. W., **Yeung J. H. H.**, Mak P. S., Graham C. A., Lai P. B., Rainer T. H., (2007). Five year analysis of Jockey Club horse-related injuries presenting to a trauma centre in Hong Kong. ***Injury***. 38(1):98-103.

Bibliography

Alexandrescu R, O'Brien S. J, Lecky F. E. (2009). A review of injury epidemiology in the UK and Europe: some methodological considerations in constructing rates. *BMC Public Healt,* 9(226), 1-22.

American College of Surgeons (2007). What is the National Trauma Data Bank? Online. Retrieved 1 February 2007 from http://www.facs.org/trauma/ntdb.html.

American College of Surgeons (1998). *Resources for Optimal Care of the Injured Patient.* Chicago, Ill: American College of Surgeons.

American College of Surgeons (2006). *Resources for Optimal Care of the Injured Patient.* Chicago, Ill: American College of Surgeons.

American College of Surgeons (2010). *Verified Trauma Centers.* Online. Retrieved 24 April 2010 from http://www.facs.org/trauma/verified.html .

Arroyo J. S., Crosby L. A. (1995). Basic rescue and resuscitation: trauma system concept in the United States, *Clinical Orthopedics and Related Research*, 318, 11-16.

American Geriatric Society (2001). Guideline of the prevention of falls in older persons. *Journal of the American Geriatrics Society*, 49, 664-672.

Association for the Advancement of Automotive Medicine (1998). *The Abbreviated Injury Scale: 1990 Revision Updated 98.* Barrington IL: Association for the Advancement of Automotive Medicine.

Association for the Advancement of Automotive Medicine (2005). *Abbreviated Injury Scale 2005*, Barrington, IL: Association for the Advancement of Automotive Medicine.

Australian Bureau of Statistics (2010). *3303.0 - Causes of Death, Australia, 2008 Quality Declaration Latest ISSUE Released at 11:30 AM (CANBERRA TIME)* 31/03/2010. Online. Retrieved 24 April 2010 from http://www.abs.gov.au/ausstats/abs@.nsf/Products/3303.0~2008~Chapter~National+Health+Priority+Areas+(NHPAs)?OpenDocument.

Baker S. P., O'Neill B., Hadden W., Long W. B. (1974). The Injury Severity Score: a method for describing patients with multiple injuries and evaluating emergency care. *Journal of Trauma*, 14(3), 187-196

Balogh Z.J., Evans J. A. (2010). Epidemiology of trauma deaths: volume, methodology, and comparability - reply to letter. *World Journal of Surgery*, 34(1), 158-63.

Bastida J. L., Aguilar P. S., González B. D . (2004). The economic costs of traffic accidents in Spain. *Journal of Trauma,* 56 (4), 883-889.

Beachley M., Snow S., Trimble P. (1988). Developing trauma care systems: the trauma nurse coordinator. *Journal of Nursing Administration,*18 (8), 34-42.

Bergeron E., Clement J., Lavoie A., Ratte S., Bamvita J. M., Aumont F., Clas D. (2006). A simple fall in the elderly: not so simple. *Journal of Trauma*, 60(2), 268-273.

Bergeron E., Lavoie A., Moore L, Clas D., Rossignol M., et al. (2005). Comorbidity and age are both independent predictors of length of hospitalization in trauma patients. *The Canadian Journal of Surgery*, 48 (5), 361-366.

Bergman S., Deckelbaum D., Lett R., Haas B., Demyttenaere S., Munthali V., Mbembati N., Museru L., Razek T. (2008). Assessing the impact of the trauma team training program in Tanzania. *Journal of Trauma*, 65(4), 879-883.

Bergen G., Chen L. H., Warner M., Fingerhut L. A. (2008). Injury in the United States: 2007 chart book. Hyattsville, MD: National Center for Health Statistics.

Blansfield J. S. (1996). Trauma nurse coordinator: the career spectrum in emergency nursing. *Journal of Emergency Nursing*, 22(6), 486-488.

Borse N. N., Hyder A. A. (2009). Call for more research on injury from the developing world: results of a bibliometric analysis. *The Indian Journal of Medical Research*, 129(3), 321-326.

Boyd C. R., Tolson M. A., Copes W. S. (1987). Evaluating trauma care: the TRISS method. Trauma Score and the Injury Severity Score. *Journal of Trauma*, 27(4), 370-378.

Branas C. C., MacKenzie E. J., Williams J. C., Schwab C. W., Teter H. M., Flanigan M. C., Blatt A. J. , ReVelle C. S. (2005). Access to trauma centers in the United States. *The Journal of American Medical Association.* 293(21), 2626-2633.

Britt J., Sliver I., Rivara F. P. (1998). Bicycle helmet promotion among low income preschool children. *Injury Prevention*, 44(4), 280-283.

Bungum T. J., Bungum N. W. (2003). Predictors of bicycle helmet usage among seniors. *Journal of Community Health*, 28 (3), 221-228.

Cales R. H., Anderson P. G., Heilig R. W. Jr. (1985). Utilization of medical care in Orange County: the effect of implementation of a regional trauma system. *Annals of Emergency Medicine*, 14(9), 853-858.

Cameron P. A., Rainer T. H., Mak P. (2004a). Motor vehicle deaths in Hong Kong: opportunities for improvement. *Journal of Trauma,* 56(4), 890-893.

Cameron P. A., Finch C. F., Gabbe B. J., Collins L. J., Smith K. L., McNeil J. J. (2004). Developing Australia's first statewide trauma registry: what are the lessons? *ANZ Journal of Surgery,*74(6), 424-428.

Cameron P. A. , Gabbe B. J., McNeil J. J., Finch C. F., Smith K. L., Cooper D. J., Judson R., Kossmann T. (2005). The trauma registry as a statewide quality improvement tool. *Journal of Trauma,* 59(6),1469-1476.

Cameron P. A., Gabbe B. J., Cooper D. J., Walker T., Judson R., McNeil J. (2008). A statewide system of trauma care in Victoria: effect on patient survival. *The Medical Journal of Australia*, 189(10), 546-550.

Clements J. L. (2005). Promoting the use of bicycle helmets during primary care visits. *Journal of the American Academy of Nurse Practitioners,* 17(9), 350-354.

Celso B., Tepas J., Langland-Orban B., Pracht E., Papa L., Lottenberg L., Flint L. (2006). A systematic review and meta-analysis comparing outcome of severely injured patients treated in trauma centers following the establishment of trauma systems. *Journal of Trauma*, 260(2), 371-378.

Census and Statistics Development, Hong Kong Special Administration Region (2006). Online. Retrieved 12 December 2006 from http://www.censtatd.gov.hk/.

Census and Statistics Division, Hong Kong Special Administrative Region Government (2007). Online. Retrieved 1 February 2007 from http://www.censtatd.gov.hk/.

Census and Statistics Department, Hong Kong Statistics (2010). Online. Retrieved 30 May 2010 from http://www.censtatd.gov.hk/hong_kong_statistics/statistics_by_subject/index.jsp.

Centre for Disease Control and Prevention. Centre for Disease Control and Prevention Web site (2007). Online. Retrieved 8 January 2010 from http://www.cdc.gov.

Champion H. R. (2002) Trauma scoring. *Scandanavian Journal of Surgery*, 91,12-22.

Champion H. R., Sacco W. J., Copes W. S., Gann D. S., Gennarelli T. A., Flanagan M. E. (1989). A revision of the trauma score. *Journal of Trauma,* 29 (5), 623-629.

Champion H. R., Copes W. S., Sacco W. J., Lawnick M. M., Keast S. L., Bain L. W. Jr, Flanagan M. E., Frey C. F. (1990). The major trauma outcome study: establishing national norms for trauma care. *Journal of Trauma*, 30 (11), 1356 –1365.

Champion H. R., Sacco W. J., Copes W. S., Gann D. S. (1995). Injury severity scoring again. *Journal of Trauma,* 38(1), 94-95.

Champion H. R., Copes W. S., Sacco W. J., Frey C. F., Holcrol M. D., Hoyt D. B., Weigelt J. A. (1996). Improved prediction from a severity characterization of trauma (ASCOT) over trauma and injury severity score (TRISS): results of an independent evaluation. *Journal of Trauma,* 40(1), 42-49.

Champion H. R., Mabee M. S., Meredith J. W. (2006). The state of US trauma systems: public perceptions versus reality--implications for US response to terrorism and mass casualty events. *Journal of American College of Surgeons,* 203(6), 951-61.

Chan D., Goldberg R. M., Chan L. (1996). Backboard versus mattress splint immobilisation: a comparison of symptoms generated. *Journal of Emergency Medicine*, 14, 293- 298.

Cheng C. H., Graham C. A., Gabbe B. J., Yeung J. H. H., Kossmann T, Judson R. T., Rainer T. H., Cameron P. A. (2008). Trauma care systems: a comparison of trauma care in Victoria, Australia, and Hong Kong, China. *Annals of Surgery,* 247(2), 335-342.

Cheng C. H., Yim W. T., Cheung N. K. , Yeung J. H. H., Man C. Y., Graham C. A., Rainer T. H. (2009). Differences in injury pattern and mortality between Hong Kong elderly and younger patients. *Hong Kong Journal of Emergency Medicine*, 16(4), 224-232.

Cheung P. S., Lam J. M., Yeung J. H.H., Graham C. A., Rainer T. H. (2007) Outcome of traumatic extradural haematoma in Hong Kong. *Injury,* 38(1), 76-80.

Cheung N. K, Yeung J. H. H., Chan J. T. S., Cameron P. A., Graham C. A., Rainer T. H. (2006). Primary trauma diversion – initial experience in Hong Kong. *Journal of Trauma,* 61 (6), 954-960.

China Emergency Medical Service System. Online. Retrieved 29 March 2008 from http://www.emss.cn/.

Cinelli S. M., Brady P., Rennie C. P., Tuluca C., Hall T. S. (2009) Comparative results of trauma scoring systems in fatal outcomes. *Connecticut Medicine*, 73 (5), 261-265.

Clay Mann N., Mullins R. J., Hedges J. R., Rowland D., Arthur M., Zechnich A. D. (2001). Mortality among seriously injured patients treated in remote rural trauma centers before and after implementation of a statewide trauma system. *Medical Care,* 39(7), 643-653.

Coffman S. (2003). Bicycle injuries and safety helmets in children. *Orthopedic Nursing,* 22, 9-15.

Coimbra R., Hoyt D. B., Potenza B. M., Fortlage D., Hollingsworth-Fridlund P. (2003). Does sexual dimorphism influence outcome of traumatic brain injury patients? The answer is no! *Journal of Trauma,* 54(4), 689-700.

Committee on Trauma and Committee on Shock, Division of Medical Sciences, National Academy of Sciences, National Research Council (1966). *Accidental Death and Disability: The Neglected Disease of Modern Society* Washington D C: The National Academies Press.

Cooper D. J., McDermott F. T., Cordner S. M., Tremayne A. B. (1988). Quality assessment of the management of road traffic fatalities at a level I trauma center compared with other hospitals in Victoria Australia. Consultative Committee on Road Traffic Fatalities in Victoria. *Journal of Trauma,* 45(4), 772-779.

Cooper A., Hannan E. L., Bessey P.Q., Farrell S.F., Cayten C. G. & Mottley L. (2000). An examination of the volume-mortality relationship for New York State trauma centres. *Journal of Trauma*, 48(1), 16-24.

Coughlan T., Gibson C., Murphy S. (2009). Progesterone, BDNF and neuroprotection in the injured CNS. *The International Journal of Neuroscience*, 119(10), 1718-1740.

Croser J. L. (2003). Trauma care systems in Australia. *Injury*, 34(9), 649-651.

Cudnik M. T., Newgard C. D., Sayre M. R., Steinberg S. M. (2009). Level I versus Level II trauma centers: an outcomes-based assessment. *Journal of Trauma*, 66(5), 321-326.

Dai K., Xu Z., Zhu L. (2003). Trauma care systems in China. *Injury*, 34(9), 664-668.

Dattani R. G., Richards T., Smith C. D., Magee T. R. (2005). Trauma calls: role of the general surgeon and CT scanning. *Emergency Medical Journal*, 22 (5), 339-341.

Davis D. P., Idris A. H., Sise M. J., Kennedy F, Eastman A. B., Velky T, Vilke G. M., Hoyt D. B. (2006). Early ventilation and outcome in patients with moderate to severe traumatic brain injury. *Critical Care Medicine*. 34(4), 1202-1208.

Davis K. A., Cabbad N. C., Schuster K. M., Kaplan L. J., Carusone C., Leary T., Udelsman R. (2008). Trauma team oversight improves efficiency of care and augments clinical and economic outcomes. *Journal of Trauma,* 65(6), 1236-1242.

Davis T., Dinh M., Roncal S., Byrne C., Petchell J., Leonard E., Stack A. (2010). Prospective evaluation of a two-tiered trauma activation protocol in an Australian major trauma referral hospital. *Injury.* 41(5), 470-474.

Deitch E. A., Livingston D.H., Lavery R.F., Monaghan S.F., Bongu A., Machiedo G. W. (2007). Hormonally active women tolerate shock-trauma better than do men: a prospective study of over 4000 trauma patients. *Annals of Surgery,* 246 (3), 447-453.

DeKeyser F. G., Paratore A., Camp L. (1993). Trauma nurse coordinator: three unique roles. *Nurse Manager,* 24(12), 56A, 56D, 56H.

Demetriades D., Chan L. S., Velmahos G., Berne T. V., Cornwell E. E. 3rd, Belzberg H., Asensio J. A., Murray J., Berne J., Shoemaker W. (1998). TRISS methodology in trauma: the need for alternatives. *The British Journal of Surgery,* 85(3), 379-384.

Demetriades D., Sava J., Alo K. (2001). Old age as a criterion for trauma team activation. *Journal of Trauma,* 51(4):754-757.

Demetriades D., Chan L., Velmanos G. V., Sava J., Preston C., Gruzinski G., Berne T.V. (2001). TRISS methodology: an inappropriate tool for comparing outcomes between trauma centers. *Journal of American College of Surgery,* 193(3), 250-254.

Demetriades D., Karaiskakis M., Velmahos G, Alo K, Newton E., Murray J., Asensio J., Belzberg H., Berne T., Shoemaker W. (2002). Effect of outcome of early intensive management of geriatric trauma patients. *The British Journal of Surgery*, 89 (10), 1319-1222.

Demetriades D., Murray J., Brown C., Velmahos G., Salim A., Alo A. and Rhee P. (2005). High-level falls: type and severity of injuries and survival outcome according to age. *Journal of Trauma,* 58(2), 342-345.

Demetriades D., Kuncir E., Brown C.V., Martin M., Salim A., Rhee P., Chan L. S. (2006). Early prediction of mortality in isolated head injury patients: a new predictive model. *Journal of Trauma,* 61(4), 868-872.

Department of Health HKSAR. (2002) *Ten Leading Causes of Death in Hong Kong in 2002 (ICD-10).* Hong Kong, SAR.

Di Bartolomeo S., Sanson G., Michelutto V., Nardi G., *Burba I., Francescutti C,* Lattuada L., Scian F., Regional Study-Group on Major Injury. (2004). Epidemiology of major injury in the population of Friuli Venezia Giulia-Italy. *Injury*, 35(4), 391-400.

Di Bartolomeo S., Nardi G., Sanson G., Gordini G., Michelutto V., Ciminello M., Giugni A., Cingolani E., Cancellieri F. (2006). The first Italian trauma registry of national relevance: methodology and initial results. *European Journal of Emergency Medicine*, 13(4), 197-203.

Eastes L. S., Norton R., Brand D., Pearson S., Mullins R.J., (2001). Outcomes of patients using a tiered trauma response protocol. *Journal of Trauma,* 50 (5), 908 -913.

Edlich R. F., Wish J. R., Britt L. D., Long W. B. (2004). An organized approach to trauma care: legacy of R Adams Cowley. *The Journal of Long-Term Effects of Medical Implants.* 14(6), 481-511.

Emerman C. L., Shade B., Kubincanek J., (1992). Comparative performance of the Baxt Trauma Triage Rule. *American Journal of Emergency Medicine,* 10(4), 294-297.

Emerman C. L., Shade B., Kubincanek, K. (1993). A comparison of EMT judgment and prehospital trauma triage instruments, *Journal of Trauma*, 31(10), 1369-1375.

Enrlich P. F., Helmkamp, J. C., Williams J. M., Haque A., Furbee P. M. (2004). Matched analysis of parent's and children's attitudes and practices towards motor vehicle and bicycle safety: an important information gap. *Injury Control and Safety Promotion*, 11, 23-28.

Fallon W. F. Jr, Barnoski A. L., Mancuso C. L., Tinnell C. A., Malangoni M. A. (1997). Benchmarking the quality-monitoring process: a comparison of outcomes analysis by trauma and injury severity score (TRISS) methodology with the peer-review process. *Journal of Trauma*, 42(5), 810-815.

Farace R., Alves W. M. (2000). Do women fare worse: a metaanalysis of gender differences in traumatic brain injury outcome. *Journal of Neurosurgery,* 93(4), 539-545.

Farin A., Deutsch R., Biegon A., Marshall L.F. (2003). Sex-related differences in patients with severe head injury: Greater susceptibility to brain swelling in female patients 50 years of age and younger. *Journal of Neurosurgery,* 98(1), 32-36.

Finnoff J. T., Laskowski, E. R., Altman K. L., Diehl N. N. (2001). Barriers to bicycle helmet use. *Pediatrics*, 108: E4.

Foreman B. P., Caesar R. R., Parks J, Madden C., Gentilello L. M., Shafi S., Carlile M. C., Harper C. R., Diaz-Arrastia R. R. (2007). Usefulness of the abbreviated injury score and the injury severity score in comparison to the Glasgow Coma Sale in predicting outcome after traumatic brain injury. *Journal of Trauma,* 62(4), 946-950.

Frederick D, Reynolds, M. D., Patrick A., Dietz M. D., Diane H., Timothy S., Whitaker, M. D., (2003). Time to deterioration of the elderly, anticoagulated, minor head injury patient who presents without evidence of neuralgic abnormality. *Journal of Trauma*, 54(3), 492-496.

Füglistaler-Montali I., Attenberger C., Füglistaler P., Jacob A. L., Amsler F., Gross T. (2009) In search of benchmarking for mortality following multiple trauma: a Swiss trauma center experience. *World Journal of Surgery*, 33(11), 2477-2489.

Gannon C. J., Napolitano L. M., Pasquale M., Tracy J. K., McCarter R. J. (2002). A statewide population-based study of gender differences in trauma: validation of a prior single-institution study. *The American College of Surgeons,* 195(1), 11-18.

Gantt D. I., Price J. P., Pollock D. A. (1996) The status of the trauma nurse coordination position: a national survey. *Journal of Trauma,* 40(5), 816-819.

Ghaffar A., Hyder A. A., Bishai D., Morrow R. H. (2002). Interventions for control of road traffic injuries: review of effectiveness literature. *The Journal of Pakistan Medical Association,* 52(2), 69-73.

Gibson C.L., Gary L. J., Bath P. M. W., Murphy S. P. (2008). Progesterone for the treatment of experimental brain injury; a system review. *Brain,* 121, 318-328.

Gilchrist R. A., Schieber S. L., Davidson S. C. (2000). Police enforcement as part of a comprehensive bicycle helmet program. *Pediatrics.* 106, 6-9.

Glance L. G., Dick A., Osler T. M., Mukamel D. (2004). Judging trauma center quality: does it depend on the choice of outcomes? *Journal of Trauma.* 56(1), 165–172.

Glance L. G., Osler T. M., Dick A. W. (2005). Evaluating trauma center quality: does the choice of the severity-adjustment model make a difference? *Journal of Trauma,* 58(6), 1265-1271.

Graham[a] C. A., Gordon M. W. G., Roy C. W., Hanlon P. W. (2007). Long term outcomes of major trauma without head injury in the West of Scotland: case control study. *European Journal of Emergency Medicine,* 14(1), 35-38.

Graham[b] C. A., Craig N., Gordon M. W. G. (2007). Health status following major trauma in the West of Scotland. *Hong Kong Journal of Emergency Medicine,* 14, 29-36.

Grossman M. D., Miller D., Scaff D. W. (2002). When is an elder old? Effect of preexisting conditions on mortality in geriatric trauma. *Journal of Trauma,* 52(2), 242–246.

Guo G., Sayeed I., Baronne L. M., Hoffman S. W., Guennoun R. and Stein D. G. (2006). Progesterone administration modulates AQP4 expression and edema after traumatic brain injury in male rats. *Experimental Neurology,* 198(2), 469-478.

Haas B., Jurkovich G. J., Wan J., Rivara F. P., MacKenize E. J., Nathens A. B. (2009). Survival advantage in trauma centres: expeditious intervention or experience? *Journal of American College of Surgeons*, 208(1), 28-36.

Handolin L., Leppäniemi A., Vihtonen K., Lakovaara M., Lindahl J. (2006). Finnish Trauma Audit 2004: current state of trauma management in Finnish hospitals. *Injury,* 37(7), 622-625.

Hansen K. S., Morild I., Engesaeter L. B., Viste A. (2004). Epidemiology of severely and fatally injured patients in western part of Norway. *Scandinavian Journal of Surgery*, 93(3), 198-203.

Hansen K. S., Eide G. E., Omenaas E., Engesaster L. B., Viste A. (2005). Bicycle-related injuries among young children related to age at debut of cycling. *Accident Analysis & Prevention,* 37(1), 71-75.

Hariharan S., Chen D., Parker K., Figari A., Lessey G., Absolom D., James S., Fraser O., Letsholathebe C. T. (2009). Evaluation of trauma care applying TRISS methodology in a Caribbean developing country. The *Journal of Emergency Medicine,* 37(1), 85-90.

Härtl R., Gerber L. M., Iacono L., Ni Q., Lyons K., Ghajar J. (2006). Direct transport within an organized state trauma system reduces mortality in patients with severe traumatic brain injury. *Journal of Trauma*, 60(6), 1250-1256.

He J., Gu D., Wu X., Reynolds K., Duan X., Yao C., Wang J., Chen C. S., Chen J., Wildman R. P., Klag M. J., Whelton P. K. (2005). Major causes of death among men and women in China. *The New England Journal of Medicine,* 353(11), 1124-1134.

Heinrich S., Rapp K., Rissmann U., Becker C., König H. H. (2010). Cost of falls in old age: a systematic review. *Osteoporosis International,* 21(6), 891-902.

Heng K. W. J., Lee, A. H. P., Zhu S., Tham K. Y., Seow E. (2006). Helmet use and bicycle-related trauma in patients presenting to an acute hospital in Singapore. *Singapore Medical Journal*, 47(5), 367-372.

Henry M. C., Hollander J. E., Alicandro J. M., Cassara G., O'Malley S., Thode H. C. Jr. (1996). Incremental benefit of individual American College of Surgeons trauma triage criteria. *Academic Emergency Medicine: Official Journal of the Society for Academic Emergency Medicine*, 3(11), 992-1000.

Heron M. & Tejada-Vera B. (2009). Deaths: leading causes for 2005. *National Vital Statistics Report: from the centers of disease control and prevention, National Centre for Health Statistic, National Vital Statistic System*, 58(8), 1-97.

Hong Kong Police Force, Traffic Branch Headquarters. (2004). *Half Year Traffic Report 2004*: Hong Kong: Hong Kong Police Force, Traffic Branch Headquarters.

Hong Kong Police Force, Traffic Branch Headquarters. (2006). *Traffic Report 2006: Hong Kong:* Hong Kong Police Force, Traffic Branch Headquarters.

Hong Kong Police Force, Traffic Branch Headquarters. (2008). *Traffic Report 2008: Hong Kong:* Hong Kong Police Force, Traffic Branch Headquarters.

Ho W. K. W., Yuen W. K. (2000). Trauma service in Queen Mary Hospital. *Emergi-News,* 11 (1), 6-7.

Hoff W. S., Schwab C. W. (2004). Trauma system development in North America. *Clinical Orthopaedics and Related Research*, 422, 17-22.

Hornsby J., Quasim T., Dignon N., Puxty A. (2010). Provision of trauma teams in Scotland: a national survey. *Emergency Medicine Journal.* 27(3), 191-193.

Hollis S., Yates D. W., Woodford M., Foster P. (1995). Standardized comparison of performance indicators in trauma: a new approach to case-mix variation. *The Journal of Trauma,* 38(5), 763-766.

Hospital Authority (2000). *Review of Surgical Service in the Hospital Authority: Final Report Submitted to the Coordinating Committee in Surgery.* Hong Kong: Medical Service Development Division.

Hospital Authority (2001). *Medical Services Development Committee Paper* No 126. Hong Kong.

Hospital Authority (2002). *Annual Plan 2002–2003, 74–76.* Hong Kong: Hospital Authority 2002.

Hospital Authority (2004). *Hospital Authority Statistical Report 2002–2003,* Hong Kong: Hospital Authority Statistics and Health Information Section 2004.

Hospital Authority (2005). *Hospital Authority Statistical Report 2003–2004*, Hong Kong: Statistic & Workface Planning Department.

Hospital Authority of Hong Kong (2005). *Triage Guidelines: Accident and Emergency Departments.*

Hospital Authority (2006). *HA Statistical Report 2005-2006.* Hong Kong: Statistic & Workface Planning Department.

Hospital Authority (2009). *HA Statistical Report 2007-2008.* Hong Kong: Statistic & Workface Planning Department.

Hou L. F. & Tsai M. C. (1996). Comparison between of TRISS and ASCOT methods—in Tainan area. Trauma and injury severity. A severity characterization of trauma. *Kaohsiung Journal of Medical Science,* 12(12), 691-698.

Hsiang J. N. K., Cheung T. K. W., Goh K. Y. C., Lam J. M. K., Zhu X. L. and Poon W. S. (1996). Features of head injury at Prince of Wales Hospital, Hong Kong from 1989 to 1993. *Hong Kong Medical Journal*, 2(2), 141-145.

Hu G., Wen M., Baker T. D., Baker S. P. (2008). Road-traffic deaths in China, 1985-2005: threat and opportunity. *Injury Prevention: Journal of the International Society for Child and Adolescent Injury Prevention,* 14(3), 149-53.

Hu G., Baker S. P., Baker T. D. (2010). Urban-rural disparities in injury mortality in China, 2006. *The Journal of Rural Health,* 26(1), 73-77.

Hu Z., Li Y., Fang M., Wai M. S., Yew D. T. (2009). Exogenous progesterone: a potential therapeutic candidate in CNS injury and neurodegeneration. *Current Medical Chemistry,* 16(11), 418-425.

Ip A. O. W., Ho H. F., (2003). Trauma service in Queen Elizabeth Hospital. *Emergi-News* 2000, 11(2), 7-10.

Isaksen M. I., Wisborg T., Brattebø G. (2006). Organisation of trauma services--major improvements over four years. *Tidsskr Nor Laegeforen,* 126(2), 145-147.

Jennett B., Bond M. (1975). Assessment of outcome after severe brain damage. *Lancet*, 1, 480-484.

Ji M., Gilchick R. A., Bender S. J. (2006). Trends in helmet use and head injuries in San Diego County: the effect of bicycle helmet legislation. *Accident Analysis & Prevention,* 38,128-134.

Jones J. M., Redmond A. D., (1995). Templeton J. Uses and abuses of statistical models for evaluating trauma care. *Journal of Trauma*, 38:89 –93.

Joosse P., Smit G., Arendshorst R. J., Soedarmo S., Ponsen K. J., Goslings JC (2009). Outcome and prognostic factors of traumatic brain injury: a prospective evaluation in a Jakarta University hospital. *Journal of Clinical Neuroscience*, 16(7), 925-928.

Jurkovich G. J., Mock C. (1999). Systematic review of trauma system effectiveness based on registry comparisons. *Journal of Trauma,* 47(3 suppl), 46-55.

Kam C. W., Kitchell A. K., Yau H. H., Kan C. H. (1998). Outcome of major trauma patients in a Hong Kong general hospital. *European Journal of Emergency Medicine*, 5(3), 297-306.

Kasturi B. S., Stein D. G. (2009). Progesterone decreases cortical and sub-cortical edema in young and aged ovariectomized rats with brain injury. *Restorative Neurology and Neuroscience*, 27(4), 265-275.

Katsaragakis S., Theodoraki M. E., Toutouzas K., Drimousis P. G., Larentzakis A., Stergiopoulos S., Aggelakis C., Lapidakis G., Massalis I., Theodorou D. (2009). The implementation of a national trauma registry in

Greece. Methodology and preliminary results. *Journal of Trauma,* 67(6), 1421-1425.

Khetarpal S., Steinbrunn B. S., McGonigal M. D., Stafford R., Ney A. L., Kalb D. C., West M. A., Rodriguez J. L. (1999). Trauma faculty and trauma team activation: impact on trauma system function and patient outcome. *Journal of Trauma*, 47(3):576-581.

Kirkness C. J., Burr R. L., Mitchell P. H., Newell D. W. (2004). Is there a sex difference in the course following traumatic brain injury? *Biological Research for Nursing,* 5, 299-310.

Kirkham J. J., Bouamra O. (2008). The use of statistical process control for monitoring institutional performance in trauma care. *Journal of Trauma,* 65(6), 1494-501.

Konvolinka C. C. W., Copes W. S., Sacco W. J. (1995). Institution and per-surgeon volume versus outcome in Pennsylvania's trauma centers. *American Journal of Surgery,* 170(4), 333-340.

Kohn M. A., Hammel J. M., Bretz S. W., Stangby A. (2004). Trauma team activation criteria as predictors of patient disposition from the emergency department. *Academic Emergency Medicine*, 11(1), 1-9.

Koo M., Sabaté A., Bassas E., Lacambra M., López S. (2009) Mortality in patients with multiple injuries: analysis using the trauma and injury severity score in a referral hospital. *Rev Esp Anestesiol Reanim*, 56(2), 83-91.

Krug E. G., Sharma G. K., Lozano R. (2000). The global burden of injuries. *American Journal of Public Health,* 90(4), 523-26.

Kung H. C., Hoyert D. L., Xu J., Murphy S. L. (2008). Deaths: final data for 2005. *National Centre for Health Statistics, National Vital Statistic System,* 56(10), 1-120.

Lansink K. W., Leenen L. P. (2007). Do designated trauma systems improve outcome? *Current Opinion in Critical Care,* 13(6), 686-690.

Larsen K. T., Uleberg O., Skogvoll E. (2010). Differences in trauma team activation criteria among Norwegian hospitals. *Scandinavian Journal of Trauma Resuscitation and Emergency Medicine,* 18(21), 1-10.

Lau P. F. & Lau C. C., (2000). A brief introduction of the trauma care system in PYNEH. *Emergi-News,* 11 (1), 4-8.

Laupland K. B., Svenson L. W., Grant V., Ball C.G., Mercado M., Kirkpatrick A.W. (2010). Long-term mortality outcome of victims of major trauma. *Injury,* 41(1), 69-72.

Lecky F., Woodford M., Yates D.W. (2000). Trends in trauma care in England and Wales 1989-97. UK Trauma Audit and Research Network. *Lancet,* 355 (9217), 1771-1775.

Lee B. H. Y., Schofer J. L., Koppelman F. S. (2005). Bicycle safety helmet legislation and bicycle-related non-fatal injuries in California. *Accident*

Analysis & Prevention, 37(1), 93-102.

Lee L. L. Y., Yeung K. L., Chan J. T. S., Chen R. C. L. (2003). A profile of bicycle-related injuries in Tai Po. *Hong Kong Journal of Emergency Medicine*, 10, 81-87.

Lee K. L., Graham C. A., Lam J. M., Yeung J. H. H., Ahuja A. T., Rainer T. H. (2009). Impact on trauma patient management of installing a computed tomography scanner in the emergency department. *Injury*, 40(8), 873-875.

Leppäniemi A. (2008a). A survey on trauma systems and education in Europe. *European Journal of Trauma and Emergency Surgery*, 34(6), 577-581.

Leppäniemi A (2008). Current status and future options for trauma and emergency surgery in Europe. *Ulus Travma Acil Cerrahi Derg*, 14(1), 5-9.

Leung K. K., Ho W., Tong K. H., Yuen W. K. (2010) Outcome of severely injured trauma patients at a designated trauma centre in the Hong Kong Special Administrative Region. *Chinese Medical Journal*,123(10),1251-1244.

Liberman M., Mulder D. S., Lavoie A, Sampalis J. S. (2004). Implementation of a trauma care system: evolution through evaluation. *Journal of Trauma*, 56(6), 1330-1335.

Liberman M., Mulder D. S., Jurkovich G. J., Sampalis J. S. (2005) The association between trauma system and trauma center components and outcome in a mature regionalized trauma system. *Surgery*, 137(6), 647-658.

Lossius H. M., Langhelle A., Pillgram-Larsen J, Lossius T. A, Søreide E, Laake P, Steen PA. (2000). Efficiency of activation of the trauma team in a Norwegian trauma referral centre. *The European Journal of Surgery,* 166(10), 760-764.

Lovell M. E., Evan J. H. (1992). A comparison of the spinal board and vacuum stretched, spinal stability and interface pressure. *Annals of Emergency Medicine,* 21, 1185-1188.

Ma Z. S., Zhang H. J., Lei W., Xiong L. Z. (2008). Musculoskeletal trauma services in China. *Clinical Orthopedic and Related Research,* 466(10), 2329-2336.

Macias C. A., Clermont G, Watson R. S, (2004). Effect of age and gender on mortality of blunt chest trauma patients. *Critical Care Medicine*, 32 (suppl), A83.

MacKenzie E. J., Morris J. A., Smith G. S., Fahey M. (1990). Acute hospital costs of trauma in the United States: implications for regionalized systems of care. *Journal of Trauma*, 30(9), 1096-1101.

MacKenzie E. J., Rivar F. P., Jurkovich G. J., Nathens A. B., Frey K. P., Egleston B., Salkever D. S. Scharfstein D. O. (2003a). A national evaluation of the effect of trauma-centre care on morality. *The New England Journal of Medicine*, 354, 366-378.

MacKenzie E. J., Hoyt D. B., Sacra J. C., Jurkovich G. J., Carlini A. R., Teitelbaum S. D., Teter H. Jr. (2003). National inventory of hospital trauma centers. *Journal of American Medical Association*, 289(12), 1515-1522.

Macpherson A. K., To T. M., Macarthur C., Chipman M. L., Wright J. G, Parkin P. C. (2002). Impact of mandatory helmet legislation on bicycle-related head injuries in children: a population-based study. *Pediatrics*, 110, e60.

Malik M. H. A., Lovell M. E. (2003). Current spinal board usage in emergency departments across the UK. *Injury,* 34(5), 327-329.

Maggio P. M. (2008). "*Identifying Trauma System Components*" in *Trauma Contemporary Principles and Therapy.* Edited by Flint L, Meredith JW, Schwab CW, Trunkey AA, Rue LW, Taheri PA. Philadelphia: Lippincott Williams & Wilkins.

Maldini B., Skuric J., Visnjic S., Fattorini I. (2003). Authors' own assessment of TRISS method studies in the treatment of major trauma in children. *European Journal of Pediatric Surgery.* 13(4), 260-265.

March J. A., Ausband S. C., Brown L. H. (2002). Changes in physical examination caused by use of spinal immobilisation. *Prehospital Emergency Care*, 6, 421-424.

Mathers C. D., Loncar D. (2006). Projections of global mortality and burden of disease from 2002 to 2030. *PLoS Med*, 3(11), 2011-2030.

Mathers C. D., Boerma T., Ma Fat D., (2009). Global and regional causes of death. *British Medical Bulletin*, 92, 7-32.

McDermott F. T., Cordner S. M., Cooper D. J., Winship V. C. (2007) Consultative Committee on Road Traffic Fatalities in Victoria. Management deficiencies and death preventability of road traffic fatalities before and after a new trauma care system in Victoria, Australia. *Journal of Trauma*, 63(2), 331-318.

McKenzie K., Chen L., Walker S. M. (2009). Correlates of undefined cause of injury coded mortality data in Australia. *The HIM Journal*, 38(1), 8-14.

McMahon D. J., Schwab C. W., Kauder D. (1996). Comorbidity and the elderly trauma patient. *World Journal of Surgery*, 20 (8), 1113-1119.

Medical Services Development Committee, Hospital Authority, Hong Kong (2001). *Organisation and Development of Trauma Care in HA*. Hong Kong: Hospital Authority.

Michiue T., Ishikawa T., Quan L., Zhu B. L., Maeda H. (2008). Forensic pathological evaluation of injury severity and fatal outcome in traffic accidents: five illustrative autopsy cases of clinically unexpected death. *Forensic Science Medicine Pathology*, 4(3), 153-158.

Millham F. H., LaMorte W. W. (2004). Factors associated with mortality in trauma: re-evaluation of the TRISS method using the National Trauma Data Bank. *Journal of Trauma*, 56(5), 1090-1096.

Miniño A. M., Anderson R. N., Fingerhut L. A., Boudreault M. A., Warner M. (2006). Deaths: injuries, 2002. National Vital Statistic Report: from the Centres of Disease Control and Prevention. *National Centre for Health Statistics, National Vital Statistic System,* 54(10), 1-124.

Ministry of Health of the People's Republic of China. *Standards for General Hospital Classification and Administration.* Online. Retrieved 29 March 2008 from http://www.orthochina.org/orthopedic/topic.jsp?className=healtheducation&ID=4605.

Mock C. N, Jurkovich G. J., Nii-Amon-Kotei D., Arreola-Risa C., Maier R. V., (1998). Trauma mortality patterns in three nations at different economic levels: implications for global trauma system development. *Journal of Trauma,* 44(5), 804-812.

Morris C. G., McCoy E. P., Lavery G. G. (2004). Spinal immobilisation for unconscious patients with multiple injuries. *British Medical Journal,* 329 (7464): 495-499.

MRC CRASH Trial Collaborators (2008). Predicting outcome after traumatic brain injury: practical prognostic models based on large cohort of international patients. *BMJ*, 336(764), 425-429.

Murlidhar V., Roy N. (2004). Measuring trauma outcomes in India: an analysis based on TRISS methodology in a Mumbai university hospital. *Injury,* 35(4), 386-390.

Moore L., Clark D. E., (2008). The value of trauma registries. *Injury,* 39(6), 686-695.

Moore L., Lavoie A., Turgeon A. F., Abdous B., Le Sage N., Emond M., Liberman M., Bergeron E. (2009). The trauma risk adjustment model: a new model for evaluating trauma care. *Annals of Surgery,* 249(6), 1040-1046.

Moyes S. A. (2006). Changing pattern of child bicycle injury in the Bay of Plenty, New Zealand. *Journal of Pediatrics and Child Health.* 43(11), 486-488.

Mullins R. J. (1999). A historical perspective of trauma system development in the United States. *Journal of Trauma.* 47(3 Suppl), S8-14.

Mullins R. J., Mann N. C. (1999). Population-based research assessing the effectiveness of trauma systems. *Journal of Trauma*, 47(3 Suppl), S59-66.

Murray C. J., Lopez A. D. (1997) Alternative projections of mortality and disability by cause 1990-2020: Global Burden of Disease Study. *Lancet,* 349(9064), 1498-1504.

Naci H., Chisholm D., Baker T.D. (2009). Distribution of road traffic deaths by road user group: a global comparison. *Injury Prevention,* 15(1), 55-59.

Nance M. L., Carr B. G., Branas C. C. (2009). Access to pediatric trauma care in the United States. *Archives of Pediatrics & Adolescent Medicine.* 163(6), 512-518.

Nathens A. B., Jurkovich G. J., Rivara F. P., Maier R. V. (2000). Effectiveness of state trauma systems in reducing injury-related mortality: a national evaluation. *Journal of Trauma,* 48(1), 25-30.

Nathens A. B., Brunet F.P., Maier R.V. (2004), Development of trauma systems and effect on outcomes after injury. *Lancet,* 363(9423), 1794-1801.

National Audit Office (2010). *Major Trauma Care in England.* London: National Audit Office Press Office.

National Confidential Enquiry into Patient Outcome and Death (2007). *Trauma: Who Cares? A Report of the National Confidential Enquiry into Patient Outcome and Death.* London: National Confidential Enquiry into Patient Outcome and Death.

National Trauma Data Bank (version 5.0) (2005). *Machine Readable Data File and Documentation.* Chicago: American College of Surgeons.

National Trauma Data Bank (2009). *National Trauma Data Bank Report 2009.* Chicago: American College of Surgeons.

Ng C. P., Siu A. Y. C., Chung C. H. (2001). Bicycle-related injuries: a local scene. *Hong Kong Journal of Emergency Medicine,* 8, 78-83.

Nocera N. (2003). Hubs, spokes and trauma nurse coordinators: New South Wales' model of optimal trauma care – part I. *Australian Emergency Nursing Journal*, 6(1), 5-9.

Oakley P. A., MacKenzie G., Templeton J., Cook A. L., Kirby R. M. (2004). Longitudinal trends in trauma mortality and survival in Stoke-on-Trent 1992-1998. *Injury,* 35 (4), 379-385.

Oestern H. J., Kabus K. (1994). Comparison of various trauma score systems. An overview. *Unfallchirurg,* 97(4), 177-184.

O'Mullane P. A., Mikocka-Walus A. A., Gabbe B. J., Cameron P. A. (2009). Incidence and outcomes of major trauma assaults: a population-based study in Victoria. *The Medical Journal of Australia,* 190(3), 129-132.

Osterwalder J. J. (2002). Could a regional trauma system in Eastern Switzerland decrease the mortality of blunt polytrauma patients? A prospective cohort study. *Journal of Trauma*, 52(6), 1030 –1036.

Padalino P., Intelisano A., Traversone A., Marini A. M., Castellotti N., Spagnoli D., Russo R., Zola R., Salvini P. (2006). Analysis of quality in a first level trauma center in Milan, Italy. *Annli Italiani di Chirurgia*, 77(2), 97-106.

Pape H. C., Zelle B., Lohse R., Stalp M., Hildebrand F., Krettek C., Panzica M., Duhme V., Sittaro N.A. (2006). Evaluation and outcome of patients after polytrauma -- can patients be recruited for long-term follow-up? *Injury,* 37(12), 1197-1203.

Pasquale M. D., Peitzman A. B., Bednarski J., Wasser T. E. (2001). Outcome analysis of Pennsylvania trauma centers: factors predictive of nonsurvival in seriously injured patients. *Journal of Trauma,* 50(3), 465-472.

Patton G. C., Coffey C., Sawyer S. M., Viner R. M., Haller D. M., Bose K., Vos T., Ferguson J., Mathers C. D. (2009). Global patterns of mortality in young people: a systematic analysis of population health data. *Lancet,* 374(9693), 881-892.

Peden M.M., McGee K., Krug E. (2002). *Injury: A Leading Cause of the Global Burden of Disease, 2000.* Geneva: World Health Organisation.

Peleg K., Aharonson-Daniel L., Stein M., Kluger Y., Michaelson M., Rivkind A., Boyko V. (2004). Israel Trauma Group. Increased survival among severe trauma patients: the impact of a national trauma system. *Archives of Surgery.* 39(11), 1231-1236.

Perdue P. W., Watts D.D., Kaufmann C.R., Trask A. L. (1998). Differences in mortality between elderly and younger adult trauma patients: geriatric status increases risk of delayed death. *Journal of Trauma,* 45(4), 805-810.

Personal communication with Hospital Authority, 22 December 2006.

Personal communication with Prof Baochi Liu, Head of Emergency Center, First Affiliated Hospital of Zhengzhou University, November 2009.

Personal communication with Hospital Authority and Dr Lin Peiyi, Head of the

Emergency Department, the Second Affiliated Hospital of Guangzhou Medical College, 27 May 2010.

Plaisier B. R., Meldon S. W., Super D. M., Jouriles N. J., Barnoski A. L., Fallon W. F. Jr, Malangoni M. A. (1998). Effectiveness of a 2-specialty 2-tier triage and trauma team activation protocol. *Annals of Emergency Medicine,* 32 (4), 436-441.

Ponsford J. L., Myles P.S., Cooper D. J., McDermott F. T., Murray L. J., Laidlaw J., Cooper G., Tremayne A. B., Bernard S. A. (2008). Gender differences in outcome in patients with hypotension and severe traumatic brain injury. *Injury,* 39(1), 67-76.

Poon W. S., Li A. K.C. (1991). Comparison of management outcome of primary and secondary referred patients with traumatic extradural haematoma in a neurosurgical unit. *Injury*, 22(4), 323-325.

Poon W. S., Rehman S.U., Poon C. Y. F., Li A. K.C. (1992). Traumatic extradural hematoma of delayed onset in not a rarity. *Neurosurgery,* 30(5), 681-686.

Porter K. M., Allison K. P. (2003). The UK emergency department practice for spinal board unloading. Is there conformity? *Resuscitation*, 58(1), 117-120.

Powell E., Tanz R., DiScala C. (1997). Bicycle-related injuries among preschool children. *Annals of Emergency Medicine*, 30(2): 260-265.

Rabbani A. & Moini M. (2007). Application of "Trauma and Injury Severity Score" and "A Severity Characterization of Trauma" score to trauma patients in a setting different from "Major Trauma Outcome Study". *Archives of Iranian Medicine,* 10(3), 383-386.

Rainer T. H., Chan S. Y., Kwok K., Suen D. T. K., Lam W., Cocks R. A. (2000). Severe trauma presenting to the resuscitation room of a Hong Kong emergency department. *Hong Kong Journal of Emergency Medicine*, 7(3), 130-135.

Rainer T. H, Cheung N. K., Yeung J. H. H, Graham C.A. (2007). Do trauma teams make a difference? A single centre registry study. *Resuscitation,* 73(3), 374-381.

Rainer T. H. & Smit D.V.P (2003). Trauma systems and emergency medicine. *Emergency Medicine (Fremantle),* 15(1), 11-7.

Rappold J. F., Coimbra R., Hoyt D. B., Potenza B. M., Fortlage D., Holbrook T., Minard G. (2002). Female gender does not protect blunt trauma patients from complications and mortality. *Journal of Trauma,* 53 (3), 436-441.

Reynolds F. D., Dietz P. A., Higgins D, Whitaker T. S. (2003), Time to deterioration of the elderly, anticoagulated, minor head injury patient who presents without evidence of neurologic abnormality. *Journal of Trauma*, 54 (3), 492-496.

Richter M., Pape H. C., Otte D., Krettek C. (2005). The current status of road user injuries among the elderly in Germany: a medical and technical accident analysis. *Journal of Trauma*, 58 (3), 591-595.

Roof R. L., Duvdevain R., Stein D.G. (1996). Progesterone treatment attenuated brain edema following contusion injury in male and female rats. *Restorative Neurology and Neuroscience,* 138, 246-251.

Roof R. L. & Hall E.D. (2000). Gender differences in acute CNS trauma and stroke neuroprotective effects of estrogen and progesterone. *Journal of Neurotrauma,* 17 (5), 367-388.

Roth R. N. (2001). *Prehospital Care: Trauma Scoring Systems and Trauma Triage.* 2001. In *Trauma Management and Emergency Medicine Approach.* Edited by Ferrers PC, Colucciello SA, Marx JA, Verdile V P & Cibbs M A. St. Louis: Mosby, Inc.

Roy P. D. (1987). The value of trauma centres: a methodologic review. *Canadian Journal of Surgery*, 30(1), 17-22.

Salottolo K. , Settell A., Uribe P., Akin S., Slone D. S., O'Neal E., Mains C., Bar-Or D. (2009). The impact of the AIS 2005 revision on injury severity scores and clinical outcome measures. *Injury,* 40(9), 999-1003.

Sampalis J. S., Denis R., Frechette P., Brown R., Fleiszer D., Mulder D. (1997). Direct transport to tertiary trauma centers versus transfer from lower level facilities: impact on mortality and morbidity among patients with major trauma. *Journal of Trauma*, 43(2), 288-295.

Sampalis J. S., Denis R., Lavoie A., Fréchette P., Boukas S., Nikolis A., Benoit D., Fleiszer D., Brown R., Churchill-Smith M., Mulder D. (1999). Trauma care regionalization: a process-outcome evaluation. *Journal of Trauma*, 46(4), 565-579.

Sayeed I., Stein D. G. (2009). Progesterone as a neuroprotective factor in traumatic and ischemic brain injury. *Progress in Brain Research, 175*, 219-237.

Scarpelini S, de Andrade J. I., Dinis C. P. A. (2006). The TRISS method applied to the victims of traffic accidents attended at a tertiary level emergency hospital in a developing country. *Injury*, 37(1), 72-77.

Schluter P. J., Cameron C. M., Davey T. M., Civil I., Orchard J., Dansey R., Hamill J., Naylor H., James C., Dorrian J., Christey G., Pollard C., McClure R.J. (2009a). Using Trauma Injury Severity Score (TRISS) variables to predict length of hospital stay following trauma in New Zealand. *The New Zealand Medical Journal,* 122(1302), 65-78.

Schluter P. J, Cameron C. M., Davey T. M., Civil I, Orchard J., Dansey R., Hamill J., Naylor H., James C., Dorrian J., Christey G., Pollard C., McClure R.J. (2009). Contemporary New Zealand coefficients for the Trauma Injury

Severity Score: TRISS(NZ). *The New Zealand Medical Journal,* 122(1302), 54-64.

Schriger D. L., Larmon B., LeGassick T., Blinman T. (1991). Spinal immobilization on a flat backboard: does it result in neutral position of the cervical spine? *Annals of Emergency Medicine*, 20, 878-881.

Shafi S., Nathens A. B., Elliott A. C., Gentilello L. (2006). Effect of trauma systems on motor vehicle occupant mortality: a comparison between states with and without a formal system. *The Journal of Trauma,* 61(6), 1374-1378.

Shafi S., de la Plata C. M., Diaz-Arrastia R., Bransky A., Frankel H., Elliott A. C., Parks J., Gentilello L. M., Gentilello L. M. (2007). Ethnic disparities exist in trauma care. *Journal of Trauma,* 63(5), 1138-1142.

Shafi S., Friese R., Gentilello L. M. (2008). Moving beyond personnel and process: a case for incorporating outcome measures in the trauma center designation process. *Archives of Surgery*, 143(2), 115-119.

Shafi S., Stewart R.M., Nathens A.B., Friese R.S., Frankel H., Gentilello L.M., (2009). Significant variations in mortality occur at similarly designated trauma centers. *Archives of Surgery,* 144(1), 64-68.

Shah S., Sinclair S. A., Smith G. A., Xiang H. (2007). Paediatric hospitalizations for bicycle-related injuries. *Injury Prevention.* 13(5), 316-321.

Shorr R. M., Rodriguez A., Indeck M. C. (1989). Blunt chest trauma in the elderly. *Journal of Trauma,* 29(2), 234-237.

Simons R., Eliopoulos V., Laflamme D., Brown D. R. (1999). Impact on process of trauma care delivery 1 year after the introduction of a trauma program in a provincial trauma center. *Journal of Trauma*, 46(5), 811-815.

Siritongtaworn P., Opasanon S. (2009). The use of Trauma Score-Injury Severity Score (TRISS) at Siriraj Hospital: how accurate is it? *Journal of Medical Association of Thailand,* 92(8), 1016-1021.

Smith J. S. Jr., Martin L.F., Young W. W., Macioce D.P. (1990). Do trauma centers improve outcome over non-trauma centers: the evaluation of regional trauma care using discharge abstract data and patient management categories. *Journal of Trauma,* 30(12), 1533-1538.

Smith R. F., Frateschi L., Sloan E. P., Campbell L., Krieg R., Edwards L. C., Barrett J. A. (1990a) The impact of volume on outcome in seriously injured trauma patients: two years' experience of the Chicago trauma system, *Journal of Trauma,* 30(9), 1066-1076.

Smith J., Caldwell E., Sugrue M. (2005). Difference in trauma team activation criteria between hospitals within the same region. *Emergency Medicine Australasia,* 17, 480-487.

Statistics Canada (2010). Age-standardized mortality rates by selected causes, by sex (both sexes). Online. Retrieved 18 April 2010 from http://www40.statcan.gc.ca/l01/cst01/health30a-eng.htm.

Stein D. G. (2001). Brain damage, sex hormones and recovery: a new role for progesterone and estrogen? *Trends in Neurosciences,* 24(7), 386-391.

Stein D.G. & Hoffman S.W. (2003). Estrogen and progesterone as neuroprotective agents in the treatment of acute brain injuries. *Pediatr Rehanil, 6(1), 13-22.*

Stein D. G., Wright D. W., Kellermann A.L. (2008). Does progesterone have neuroprotective properties? *Annals of Emergency Medicine*, 51 (2), 64-72.

Stein D.G. & Sayeed I. (2010). Is progesterone worth consideration as a treatment for brain injury? *American Journal of Roentgenology,* 194(1), 20-22.

Sterling D. A., O'Connor J. A., Bonadies J. (2001). Geriatric falls: injury severity is high and disproportionate to mechanism. *Journal of Trauma.* 50 (1), 94-95.

Steyerbuerg E.W., Mushkudiani N., Perel P., Butcher I., Lu J., McHung G.S., Murray G.D., Marmarou A, Roberts I., Habbema J. D., Mass A.I. (2008). Predicting outcome after traumatic brain injury: development and international validation of prognostic scores based on admission characteristics. *PLoS Medicine,* 5(8), 1252-1261.

Tagliaferri F., Compagnone C., Korsic M., Servadei F., Kraus J. (2006). A systemic review of brain injury epidemiology in Europe. *Acta Neurochir (Wien)*,148(3), 255-268.

Templeton J., Oakley P.A., MacKenzie G., Cook A.L., Brand D., Mullins R.J., Trunkey D. D. (2000). A comparison of patient characteristics and survival in two trauma centres located in different countries. *Injury,* 31(7), 493-501.

The George Institution for Internal Health (2010). *China Trauma Collaboration Background & Aims.* Online. Retrieved 15 July 2010 from http://www.iih.usyd.edu.au/iih/china/china-trauma-collaboration.cfm

The Royal College of Surgeons of England. (2009). *Regional Trauma System Interim Guidance for Commissioners. The Intercollegiate Group on Trauma Standards.* London: Publications Department, The Royal College of Surgeons of England.

Thomas S., Acton C., Nixon J., Battistutta P., Pitt W. R., Clark R. (1994). Effectiveness of bicycle helmets in preventing head injury in children: a case control study. *British Medical Journal,* 308, 1164-1165.

Tinkoff G. H. & O'Connor R. E. (2002). Validation of new trauma triage rules for trauma attending response to the emergency department. *Journal of Trauma,* 52(6), 1153-1158.

Tinkoff G. H., O'Connor R. E., Alexander E. L .3rd, Jones M.S. (2007). The Delaware trauma system: impact of Level III trauma centers. *Journal of Trauma,* 63(1), 121-126.

Traffic Branch Headquarters Hong Kong Police Force (2006). *Traffic Annual Report*, Hong Kong: 2006. Transport Department, The Government of Hong Kong Special Administrative Region (2008). Online. Retrieved 19 February 2008 from

http://www.td.gov.hk/road_safety/road_traffic_accident_statistics/index.htm

Trauma advice committee, Prince of Wales Hospital (2003). *Trauma Service,* Hong Kong: Prince of Wales Hospital.

Trauma Org (2010). Online. Retrieved 24 April 2010 from http://www.trauma.org/archive/history/systems.html.

Twijnstra M. J., Moons K.G., Simmermacher R. K., Leenen L. P. (2010). Regional trauma system reduces mortality and changes admission rates: a before and after study. *Annals of Surgery.* 251(2), 339-343.

Uranüs S, Lennquist S. (2002). Trauma management and education in Europe: a survey of twelve geographically and socioeconomically diverse European countries. *European Journal of Surgery,* 168 (12), 730-735.

Utomo W. K., Gabbe B. J., Simpson P. M., Cameron P. A. (2009). Predictors of in-hospital mortality and 6-month functional outcomes in older adults after moderate to severe traumatic brain injury. *Injury,* 40(9), 973-977.

Vagnerova K., Koerner I. P., Hurn P. D. (2008) Gender and the injured brain. *Anesthesia & Analgesia,* 107(1), 201-214.

van Beeck. E. F, van Roijen. L, Mackenbach J. P, (1997). Medical costs and economic production losses due to injuries in the Netherlands. *Journal of Trauma,* 42 (6), 1116-1123.

van der Sluis C. K., Klasen H. J., Eisma W. H., ten Duis H.J. (1996). Major trauma in young and old: what is the difference? *Journal of Trauma,* 40(1), 78-82.

van der Sluis C. K., Timmer H. W., Eisma W. H., ten Duis H.J.(1997). Outcome in elderly injured patients: injury severity versus host factors. *Injury,* 28(9-10), 588-592.

Vickery D. (2001). The use of the spinal board after the pre-hospital phase of trauma management. *Emergency Medicine Journal*, 18 (1), 51-54.

Victorian State Trauma Outcome Registry and Monitoring (VSTORM). *2004 Fourth Quarter Report*, Melbourne, Victoria, Australia.

Vollmer D. G. (1991). Age and outcome following traumatic coma: why do older patients fare worse? *Journal of Neurosurgery,* 75, 37-49.

Voskresensky I. V., Rivera-Tyler T., Dossett L. A., Riordan W. P. Jr, Cotton B. A. (2009). Use of scene vital signs improves TRISS predicted survival in intubated trauma patients. *The Journal of Surgical Research,* 154(1), 105-11.

Wai A. K., Chor C. M., Lee A. T., Sittambunka Y., Graham C. A., Rainer T.H. (2009). Analysis of trends in emergency department attendances, hospital admissions and medical staffing in a Hong Kong university hospital: 5-year study. *International Journal of Emergency Medicine,* 2(3), 141-148.

Wang Z., Jiang J. (2003). An overview of research advances in road traffic trauma in China. *Traffic Injury Prevention,* 4(1), 9-16.

Wardle T. D. (1999). Co-morbid factors in trauma patients. *British Medical Bulletin,* 55, 744-756.

West J. G., Wiebe D. J., Nance M. L., Branas C. C. (2006), Determining objective injury prevention priorities. *Injury Prevention,* 12(5), 347-350.

Willis C. D., Evans S. M., Stoelwinder J. U., Cameron P. A. (2007). Measuring quality. *Australian Health Review,* 31(2), 276-281.

Winchell R. J., Hoyt D. B. (1997). Endotracheal intubation in the field improves survival in patients with severe head injury. *Archives of Surgery,* 132(6), 592-597.

Wolthmann C. D., Franklin G. A., Boaz P. W, Luchette F. A., Kearney P. A., Richardson J. D., Spain D. A. (2001). A multicenter evaluation of whether gender dimorphism affects survival after trauma. *The American Journal of Surgery,* 81(4), 297-300.

World Bank (2008). *The Significance of Non-motorised Transport for Developing Countries. Strategies for Policy Development.* Online. Retrieved 6 May 2008 from http://www.i-ce.info/download/publications/sign_non_mot_transport.pdf

World Health Organization (2000). *Injury: A Leading Cause of the Global Burden of Disease.* Geneva, Switzerland: World Health Organisation.

World Health Organization (2002). *Global Burden of Disease Estimates, 2002 rev.* Online. Retrieved 30 June 2006 from (http://apps.who.int/whosis/data/Search.jsp or http://www.who.int/quantifying_ehimpacts/global/results/en/index.html)

World Health Organization (2009). *Guidelines for Trauma Quality Improvement Programmes.* Geneva: World Health Organization Press.

World Health Organization (2009): *Violence and Injury Prevention.* Online. Retrieved 25 December 2009 from http://www.euro.who.int/violenceinjury/about/20050208_1

World Health Organization, (2004). http://www.who.int/mediacentre/factsheets/fs310/en/index.html.

Wong K., Petchell J. (2003). Trauma teams in Australia: a national survey. *ANZ Journal of Surgery*, 73(10), 819-825.

Wong G. K., Hung Y. W., Chong C., Yeung J. H.H., Ng S. C.P., Rainer T, Poon W. S. (2010). Assessing the neurological outcome of traumatic acute subdural hematoma patients with and without primary decompressive craniectomies. *Acta Neurochirurgical Supplement,* 106, 235-237.

Wright D. W., Bauer M. E., Hoffman S. W., Stein D. G. (2001). Serum progesterone levels correlate with decreased cerebral edema after traumatic brain injury in male rats. *Journal of Neurotrauma*, 18(9), 901-909.

Wright D. W., Kellermann A. L., Hertzberg V. S., Clark P. L., Frankel M., Goldstein F. C., Salomone J. P., Dent L. L, Harris O. A., Ander D. S., Lowery D. W., Patel M. M., Denson D. D., Gordon A. B., Wald M.M., Gupta S., Hoffman S. W., Stein D.G. (2007). ProTECT: A randomized clinical trial of progesterone for acute traumatic brain injury. *Annals of Emergency Medicine,* 49(4), 391-402.

Xiao G., Wei, J., Yan W., Wang W., Lu Z. (2008). Improve outcomes from the administration of progesterone for patients with acute severe traumatic brain injury: a randomized controller trail. *Critical Care,* 12, R61.

Yates P. J., Williams W. H., Harris A., Round A., Jenkins R. (2006). An epidemiological study of head injuries in a UK population attending an emergency department. *Journal of Neurology, Neurosurgery, and Psychiatry*, 77, 699-701.

Yeung P. Y., Woo J., Yim V.W.T., Rainer T.H., Wong S. (2006). Towards improvement of services for elderly fallers attending accident and emergency department. *Hong Kong Journal of Emergency Medicine*, 13, 250.

Yeung J. H. H., Chang A. L., Ho W., So F. L., Graham C. A., Cheng B., Cheung N. K., Ho H. F., Yuen W. K., Kam C. W., Rainer T. H. (2008). High risk trauma in older adults in Hong Kong: a multicentre study. *Injury*, 39(9), 1034-1041.

Yim V. W., Graham C. A., Rainer T. H. (2009). A comparison of emergency department utilization by elderly and younger adult patients presenting to three hospitals in Hong Kong. *International Journal of Emergency Medicine*, 2(1), 19-24.

Younge P. A., Coats T. J., Gurney D, Kirk C. J. (1997). Interpretation of the Ws statistic: application to an integrated trauma system. *The Journal of Trauma*, 43(3), 511-515.

Young J. S., Bassam D., Cephas G. A., Brady W. J., Butler K., Pomphrey M. (1998). Interhospital versus direct scene transfer of major trauma patients in a rural trauma system. *American Surgery*, 64(1), 88-91.

Zafar H., Rehmani R., Raja A. J., Ali A., Ahmed M. (2002). Registry based trauma outcome: perspective of a developing country. *Emergency Medicine Journal,* 19(5), 391-394.

Zhou J. H., Qiu J., Zhao X. C., Liu G. D., Xiao K., Zhang L., Jiang Z. Q., Wang Z. G. (2008). Road crash in China from 2003 to 2005. *Chinese Journal of Traumatology*, 11(1), 3-7.

Zhu P. & Jiang J. (1998). Employment of trauma and injury severity score and a severity characterization of trauma in the outcome evaluation of trauma care and their research advances. *Chinese Medical Journal (Eng).* 111(2), 169-179.