Rural-Urban TBI Outcomes:
System Design, Experience and Paramedic Intervention

By

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Submitted in fulfilment of the requirements for the
Degree of Doctor of Philosophy

Deakin University August 2013
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Rural-Urban TBI Outcomes: System Design, Experience and Paramedic Intervention

for the degree of: Doctor of Philosophy

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Full Name: Benjamin Fisk

Signed: .................................................................

Date: .................................................................

7th August 2013
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**Thesis Abstract**

**Objectives:**

This research project had two main objectives. Firstly, the project aimed to investigate the relationship between trauma system design and rurality by comparing rural and urban traumatic brain injury (TBI) outcomes. Secondly, the project aimed to determine how decreased paramedic exposure to severely injured patients may impact confidence, performance and the inclination to intervene with high-risk procedures.

**Background:**

Severe TBI is a pattern of injury with dramatic physical, social, financial and quality-of-life ramifications. Trauma systems are known to improve outcomes following severe injury, yet few studies have been undertaken to assess differences in TBI outcomes between geographic locations within a single established trauma system. The effective management of TBI begins in the pre-hospital setting and may require complex intervention strategies. Although it is recognised that clinician performance may suffer in areas of low case load, little is known about the way that exposure and confidence may impact the paramedic management of TBI cases.

**Methods:**

The first section of this project was an epidemiological study of severe TBI patients, using data from the Victorian State Trauma Registry (VSTR), National Coronial Information Service (NCIS), and the Victorian Ambulance Cardiac Arrest Registry (VACAR). The study period for each data source varied, but fell between the 1st October 2006 to 31st December 2011. Univariate analysis provided a rural/urban profile of TBI patient demographics, cause of injury, injury severity and elements of pre-hospital resource utilisation. Multivariate logistic regression compared in-hospital mortality and functional outcomes at 6 months post-injury. Rural and urban groups were defined using the Accessibility and Remoteness Index of Australia (ARIA+).
The second section of this project was a mixed methods analysis of rural/urban differences in clinician experience, exposure and confidence. Data were extracted from the Victorian Ambulance Clinical Information System (VACIS) and a combined dataset of VACIS and Ambulance Victoria Human Resources (AVHR) information. Again, the study period varied between sources but ranged from 1st January 2008 to 31st December 2011. Focus groups were undertaken with rural and urban MICA paramedics to understand factors likely to impact paramedic confidence when required to manage high acuity cases. Univariate analysis was used for rural/urban comparisons relating to paramedic exposure to TBI, and for all cases that required RSI for intubation. Thematic analysis was utilised for interpretation of qualitative data. Rural and urban groups were defined using the Accessibility and Remoteness Index of Australia (ARIA+).

**Results:**

The results provide a comprehensive profile of severe TBI in a region serviced by a mature trauma system, from pre-hospital pre-intervention fatalities through to functional outcomes for survivors at 6 months post-injury. The results also provide a detailed description of paramedic exposure to severe TBI cases, the use of RSI, and factors impacting clinician confidence.

**Key Findings:**

- This study found similar rural and urban outcomes following TBI, suggesting that trauma system design and maturity may counteract the potentially negative aspects of rurality.

- The results show that serious co-morbidities, age and injury severity have a greater influence on in-hospital mortality and functional outcome than rurality.

- The results show that Helicopter Emergency Medical Services (HEMS) are utilised for a greater proportion of rural cases, with possible links to outcomes following severe TBI, and implications for skills maintenance amongst non-HEMS paramedics.

- The results indicate that rural road-based MICA paramedics have lower exposure to cases requiring Rapid Sequence Induction (RSI) for intubation, that confidence can impact clinical
performance, and that skills and knowledge maintenance require a combination of formal and informal strategies.

Conclusions:

The results of this study provide a broad profile of severe TBI outcomes from cases where victims were deceased at the scene prior to any clinical intervention through to those who survived at 6-months post-injury. The results provide an insight into the breadth of exposure that paramedics have to low-frequency high-acuity cases, and the way that confidence may impact decisions to intervene with high-risk procedures.

The design of this study allowed for comparisons within a geographic region serviced by a mature trauma system. Previous studies have suggested poorer outcomes for rural TBI patients. Analysis confirmed that the profile of severe TBI patients in Victoria is similar to that reported in the existing literature, and that patient demographics and injury causation factors, rather than rurality, were more likely to influence functional outcomes for survivors. The collective results show that a holistic approach to trauma system design and development is required in order to achieve optimal patient outcomes across broad geographical areas.

The frequent use of experienced HEMS paramedics in rural areas raises the possibility that paramedic exposure and experience may be important. Analysis indicated that clinical confidence can decrease even amongst experienced paramedics, and that alternative strategies may be required to enhance and maintain skills, knowledge and confidence in rural areas. Lessons gained from understanding the relationship between experience, exposure and confidence are likely to have applications for other high-acuity case types, and may translate well to other craft groups required to manage such cases particularly in rural and remote areas.

These findings have implications in the Australian setting where a large proportion of rural and remote communities remain isolated in regards to access to emergency medical care. Initial intervention strategies may be crucial in these settings, where access to higher level trauma care may be many hours away. These findings may also have implications for developing countries where the high rate and burden of traumatic injuries is evident. Understanding differences between rural
and urban trauma profiles, enhanced pre-hospital intervention strategies, and the process of regionalising trauma expertise provides a framework for development in areas lacking integrated trauma care services. Ultimately, improvements may enhance the standard of trauma care and ensure optimal patient outcomes following severe injury.
## Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Full Form</th>
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<tbody>
<tr>
<td>AAA</td>
<td>Abdominal Aortic Aneurysm</td>
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<td>AAV</td>
<td>Air Ambulance Victoria</td>
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<tr>
<td>AIS</td>
<td>Abbreviated Injury Score</td>
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<td>ALS</td>
<td>Advanced Life Support</td>
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<tr>
<td>AMI</td>
<td>Acute Myocardial Infarction</td>
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<tr>
<td>AOR</td>
<td>Adjusted Odds Ratio</td>
</tr>
<tr>
<td>AP</td>
<td>Ambulance Paramedic</td>
</tr>
<tr>
<td>ASA</td>
<td>American Society of Anaesthesiologists</td>
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<tr>
<td>ASGC</td>
<td>Australian Geographical Classification</td>
</tr>
<tr>
<td>ARIA</td>
<td>Accessibility and Remoteness Index of Australia</td>
</tr>
<tr>
<td>AV</td>
<td>Ambulance Victoria</td>
</tr>
<tr>
<td>AVHR</td>
<td>Ambulance Victoria Human Resources</td>
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<tr>
<td>AVRSD</td>
<td>Ambulance Victoria Research Services Division</td>
</tr>
<tr>
<td>BLS</td>
<td>Basic Life Support</td>
</tr>
<tr>
<td>BVM</td>
<td>Bag-Valve-Mask</td>
</tr>
<tr>
<td>CBF</td>
<td>Cerebral Blood Flow</td>
</tr>
<tr>
<td>CCF</td>
<td>Congestive Cardiac Failure</td>
</tr>
<tr>
<td>CEA</td>
<td>Carotid Endarterectomy</td>
</tr>
<tr>
<td>CI</td>
<td>Confidence Interval</td>
</tr>
<tr>
<td>COAD</td>
<td>Chronic Obstructive Airways Disease</td>
</tr>
<tr>
<td>CO2</td>
<td>Carbon Dioxide</td>
</tr>
<tr>
<td>CPP</td>
<td>Cerebral Perfusion Pressure</td>
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<td>Abbreviation</td>
<td>Full Form</td>
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<tr>
<td>CSO</td>
<td>Clinical Support Officer</td>
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<tr>
<td>DNR</td>
<td>Do Not Resuscitate</td>
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<tr>
<td>DUHREC</td>
<td>Deakin University Human Research Ethics Committee</td>
</tr>
<tr>
<td>EMS</td>
<td>Emergency Medical Services</td>
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<tr>
<td>ESP</td>
<td>Expanded Scope Paramedic</td>
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<tr>
<td>ETCO2</td>
<td>End-Tidal Carbon Dioxide</td>
</tr>
<tr>
<td>ETI</td>
<td>Endotracheal Intubation</td>
</tr>
<tr>
<td>ETT</td>
<td>Endotracheal Tube</td>
</tr>
<tr>
<td>GAP</td>
<td>Graduate Ambulance Paramedic</td>
</tr>
<tr>
<td>GCS</td>
<td>Glasgow Coma Score</td>
</tr>
<tr>
<td>GOS-E</td>
<td>Glasgow Outcome Scale Extended</td>
</tr>
<tr>
<td>HEMS</td>
<td>Helicopter Emergency Medical Service</td>
</tr>
<tr>
<td>HR</td>
<td>Human Resources</td>
</tr>
<tr>
<td>HTS</td>
<td>Hypertonic Saline</td>
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<tr>
<td>ICP</td>
<td>Intracranial Pressure</td>
</tr>
<tr>
<td>ICU</td>
<td>Intensive Care Unit</td>
</tr>
<tr>
<td>ISS</td>
<td>Injury Severity Score</td>
</tr>
<tr>
<td>IFS</td>
<td>Intubation Facilitated by Sedation</td>
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<tr>
<td>IV</td>
<td>Intra-Venous</td>
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<td>Justice Human Research Ethics Committee</td>
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<tr>
<td>MAP</td>
<td>Mean Arterial Pressure</td>
</tr>
<tr>
<td>MFP</td>
<td>MICA Flight Paramedic</td>
</tr>
<tr>
<td>MI</td>
<td>Myocardial Infarction</td>
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<tr>
<td>Abbreviation</td>
<td>Full Form</td>
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<td>--------------</td>
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</tr>
<tr>
<td>MICA</td>
<td>Mobile Intensive Care Ambulance Paramedic</td>
</tr>
<tr>
<td>MOI</td>
<td>Mechanism of Injury</td>
</tr>
<tr>
<td>MTS</td>
<td>Major Trauma Service</td>
</tr>
<tr>
<td>OHCA</td>
<td>Out-of-Hospital Cardiac Arrest</td>
</tr>
<tr>
<td>OOH</td>
<td>Out-of-Hospital</td>
</tr>
<tr>
<td>OOH-ETI</td>
<td>Out-of-Hospital Endotracheal Intubation</td>
</tr>
<tr>
<td>PaCO2</td>
<td>Partial Pressure of Arterial Carbon Dioxide</td>
</tr>
<tr>
<td>PaO2</td>
<td>Partial Pressure of Arterial Oxygen</td>
</tr>
<tr>
<td>PCO2</td>
<td>Partial Pressure of Carbon Dioxide</td>
</tr>
<tr>
<td>PO2</td>
<td>Partial Pressure of Oxygen</td>
</tr>
<tr>
<td>TBI</td>
<td>Traumatic Brain Injury</td>
</tr>
<tr>
<td>NCIS</td>
<td>National Coronial Information Service</td>
</tr>
<tr>
<td>RRMA</td>
<td>Rural, Remote and Metropolitan Areas</td>
</tr>
<tr>
<td>RSI</td>
<td>Rapid Sequence Induction</td>
</tr>
<tr>
<td>SaO2</td>
<td>Saturation of Arterial Oxygen (via arterial blood gas analysis)</td>
</tr>
<tr>
<td>SOPs</td>
<td>Standard Operating Procedures</td>
</tr>
<tr>
<td>SpO2</td>
<td>Saturation of Arterial Oxygen (via pulse oximetry)</td>
</tr>
<tr>
<td>SRU</td>
<td>Single Responder Unit</td>
</tr>
<tr>
<td>VACAR</td>
<td>Victorian Ambulance Cardiac Arrest Registry</td>
</tr>
<tr>
<td>VACIS</td>
<td>Victorian Ambulance Clinical Information System</td>
</tr>
<tr>
<td>VSTORM</td>
<td>Victorian State Trauma Outcomes Registry and Monitoring Group</td>
</tr>
<tr>
<td>VSTR</td>
<td>Victorian State Trauma Registry</td>
</tr>
<tr>
<td>VSTS</td>
<td>Victorian State Trauma System</td>
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Chapter 1: Introduction to the Study

1.1 Introduction

This thesis originated following the identification of gaps in the existing knowledge related to the pre-hospital care of severely brain injured patients from rural and remote areas, and the way in which trauma systems may impact outcomes for this patient group. The following responses from focus group participants capture the essence of this research project:

“...the biggest challenge for me is that complex patient, when you’re a fair way from anywhere and you certainly can be up to an hour even from just a minor treatment centre.......the situation where air support’s not available and so you have not only the situation where you’ve got the complex patient, it might be a TBI or may be others, but where you’ve got the situation where you’re very much on your own.” MICA paramedic, focus group participant (rural).

“..we were just talking about what makes the job difficult.......working in the hospital it’s all very well, you’ve got good conditions and you’ve got like a team around you, I think that ambulance is just so different to that... you’ve got potentially darkened conditions and people out of control, and to me that’s what makes ambulance so much different.” MICA paramedic, focus group participant (urban).

“..the stressful parts of it come with jobs that are disorganised and chaotic. Then once you can get that under control it doesn’t matter if it’s a paed or an adult.... once you can get it under control then you can apply certain systematic practice to it and follow goal driven therapies.” MICA paramedic, focus group participant (urban).

“..there are spectacularly different approaches in geographical places. And it’s absolutely amazing the willingness to intervene, the willingness to use up to and including 100% of your skill set is not present in most places. In some places and this is including major regional centres, it’s probably less than 25% utilization of the skill set.” MICA paramedic, focus group participant (urban).
1.1.1 The Research Problem

People living and working in rural and remote locations are likely to face challenges not encountered by their urban counterparts. Whilst there are numerous benefits associated with a rural lifestyle, there also exist many disadvantages. Decreased access to emergency health services and major trauma expertise has the potential to impact outcomes following severe injury in these locations. Rural clinicians committed to working in rural and remote locations are likely to be faced with difficult medical cases and patient presentations. The challenges in regards to managing these case types may be magnified due to a lack of resources, clinical isolation and low case exposure. This study will address specific aspects relating to the management of severely injured patients in rural and remote locations. The study will focus on the group of patients with severe traumatic brain injuries (TBI), and will consider how such patients are managed at a systems level as well as at a clinician level. The study aims to highlight and address some of the challenges surrounding the management of this patient group, and the way in which strategies differ in the rural and urban settings.

The study is based on previous findings that outcomes following major trauma in rural and remote areas are worse when compared to the same injury sustained in an urban environment\(^1\,^3\). Differences have been reported between rural and urban major trauma groups, as well as patient demographics, lifestyle factors and geographical constraints\(^4\,^6\).

Within the major trauma cohort of patients, those with severe traumatic brain injury are reported to have the highest mortality\(^7\). This patient group in particular may benefit greatly from targeted clinical intervention aimed at reducing the progression of secondary brain injury\(^8\,^10\). Such intervention can be provided at major trauma hospitals, requiring a high degree of efficiency and integration in order to ensure that rural trauma patients receive appropriate treatment and clinical management.

Well-designed trauma systems are more likely to identify, capture and appropriately manage severe TBI cases\(^11\,12\). Such trauma systems need to cater for major trauma cases that occur in a range of locations, from metropolitan areas to remote and isolated locations. Regionalisation is a
characteristic of trauma system design likely to positively impact patient outcomes from rural and remote areas \(^1\), yet studies investigating the impact of trauma system design on outcomes following TBI are limited.

The early identification of major trauma and severe TBI cases is vital to ensure that such cases are managed at centres with high trauma caseload and expertise \(^4\). It therefore becomes apparent that targeted and specific pre-hospital decision making and intervention for particular patient groups may expedite the process of entry into the trauma system. This may then contribute to improved patient outcomes, although controversy and discussion remains regarding the extent of the benefits of pre-hospital care \(^15-17\). The impact of pre-hospital intervention on patient outcomes is gaining interest within the literature, and this particular body of knowledge is likely to continue to grow. It is the intention of this study to contribute to that body of knowledge.

Trauma system design may not always alleviate the dilemma encountered by rural clinicians who may be required to manage severe, complicated, major trauma cases that they encounter infrequently. As a specialised group of rural clinicians, rural intensive care paramedics may be required to utilise high-risk procedures such as RSI \(^18-22\) in a setting where they have minimal or ad-hoc case exposure. This may provide a useful example of the volume-performance relationship \(^23,24\).

Few studies have addressed the relationship between trauma system design, rurality and functional outcomes following severe TBI. In addition to this, there are also few studies that have investigated the relationship between case exposure, clinical confidence amongst paramedics, and the disposition of paramedics to intervene with high-risk procedures in low-frequency high-acuity cases. Considering these points, this project is unique in its aim to address both of these research areas.

Two research areas and a series of research questions were developed to address these topics. The research questions were addressed via seven sub-studies as outlined below:
Research Area 1: Rural-Urban Traumatic Brain Injury Outcomes: The Impact of Trauma Systems

Study 1

1. Is there a difference in the profile of TBI patients between rural and urban areas?

2. Is there a difference in pre-hospital response to severe TBI cases?

3. Is there a difference in the type of hospital that severe TBI patients are first transported to?

4. Is there a difference in in-hospital mortality between rural and urban TBI patients?

5. Is there a difference in functional outcomes at 6 months post injury between rural and urban TBI patients?

Study 2

1. Is there a difference in the proportion of severe TBI cases transported by HEMS between rural and urban areas of a state serviced by an established trauma system?

2. Is there a difference in the injury profile of patients transported by HEMS between rural and urban areas?

3. Does appropriate HEMS utilisation positively impact patient outcomes following severe TBI?

Study 3

1. Is there a difference in the characteristics of pre-hospital, pre-intervention deaths occurring as a result of severe TBI between rural and urban areas in a state serviced by an established trauma system?
Study 4

1. Is there a difference in the proportion of pre-hospital deaths occurring as a result of severe TBI, following attendance and resuscitation by pre-hospital clinicians, between rural and urban areas in a state serviced by an established trauma system?

2. Are there rural and urban differences relating to patient demographics and scene management during pre-hospital resuscitation of severe TBI cases resulting in cardiac arrest?

Research Area 2: Traumatic Brain Injury Management: Paramedic Confidence and Competence

Study 5

1. Is there a difference in the overall number of rapid sequence inductions (RSIs), for all clinical presentations meeting criteria for intervention using this technique, performed by intensive care paramedics working in rural and urban areas within a state serviced by an established trauma system?

Study 6

1. Is there a difference in the number of severe TBI cases that met pre-hospital RSI criteria, but where the procedure was not performed, between rural and urban areas within a state serviced by an established trauma system?

Study 7

1. How do paramedic perceptions of case exposure and experience differ between rural and urban areas?

2. How do rural and urban paramedic perceptions differ regarding skills maintenance and performance?
3. Is there a difference between rural and urban paramedics’ attitudes towards intervention when faced with low-frequency, high-acuity cases?

4. Is paramedic confidence adversely impacted by low acute caseload?

In order to address these research questions the project utilised an iterative, mixed-methods design. The study design focussed primarily on quantitative methods, with qualitative aspects incorporated into the project structure.

1.1.2 Significance of the Study

This study is important as it addresses the nexus between a systems approach and a clinician-centred approach to the management of major trauma in rural areas. This nexus is of particular significance as it represents those occasions when severely injured patients in rural or remote locations require deliberate and focussed intervention yet delays in arrival at major trauma services are likely or inherent. On these occasions, individual clinicians may be required to intervene with procedures that carry both considerable risks and potential benefits to the patients, yet in circumstances where these clinicians may have had minimal recent exposure. A review of the literature shows that there have been few studies relating to the relationship between trauma system design and the impact of rurality on outcomes following severe traumatic brain injury (TBI). In addition to this the investigation aims to contribute to the growing body of knowledge relating to the pre-hospital phase of the management of rural TBI cases, and the way that case volume and exposure impacts clinician confidence and intervention.
1.1.3 Structure of the Thesis

This thesis addressed the research questions identified following a review of the literature via a series of ordered and structured processes. The following section will describe the overall structure of the thesis by outlining the content and intention of each chapter. These details are provided below.

Chapter One: Chapter one provides an overview of the project, its context within the existing literature and the rationale for scientific investigation.

Chapter Two: Chapter two provides an extensive review of the literature relating to severe traumatic brain injury outcomes and the impact of case exposure on clinician confidence. Within these two broad topics, several key subjects are highlighted. These include: the epidemiology and management of severe TBI, major trauma outcomes, trauma system design, the concept of rurality, emergency health in rural communities, knowledge and skill retention amongst rural clinicians, paramedic decision making, and training strategies.

Chapter Three: Chapter three describes the overall conceptual study design, highlighting the connection between the two main study areas and each sub-study that was undertaken to investigate each hypothesis. This chapter explains the methodology used for each separate study. The research questions and hypotheses are presented, along with information describing the data collection processes, inclusion/exclusion criteria, variable definitions and outcome measures. An explanation of the statistical analysis undertaken in each study is provided. Ethics considerations and data storage processes are outlined.

Chapter Four: Chapter four presents the results and key findings for each study.

Chapter Five: Chapter five discusses the key findings from each study in relation to existing literature. Each section within this chapter reiterates the findings related to each hypothesis and
discusses how the findings complemented and differed from the relevant literature, and the implications of the findings.

Chapter Six: Chapter six highlights how the key findings may translate to the management of high-acuity cases in rural areas, as well as implications for maintaining skills and knowledge amongst clinicians with low exposure to high-acuity cases. This chapter discusses the findings in the context of the study limitations. Recommendations for future research are also offered. This chapter also presents the conclusions of the overall study.
Chapter 2: A Review of the Literature

This chapter will review the literature relating to the key themes of severe TBI, trauma system design and effectiveness, rurality, and clinician confidence. The chapter is divided into three sections:

- Traumatic Brain Injury
- Major Trauma Outcomes in Australia
- Clinical Practice in Rural Areas

Each of these sections is divided into topics which correspond with the central themes. This chapter also includes summaries of the literature and outlines the research questions related to each section.

2.1 Literature Search Methods

The literature search was an ongoing process throughout this study. The search and review commenced in March 2010, and the final review was undertaken in June 2013.


Database searches were conducted using MEDLINE, OVID, CINAHL, PubMed, Academic Search Complete and Web of Science. Database searches were conducted between 1970 and 2013, and limited to English language studies only. Database searches listed over 1352 articles, of which 446 were considered directly relevant to this study.
2.2 Traumatic Brain Injury

2.2.1 Introduction

Whilst the focus of this research project is the impact of severe TBI on rural populations in Australia, an understanding of the broader context of this injury pattern is important. The high incidence of TBI in developed nations should be viewed with the knowledge that the impact of TBI is considered greatest in low and middle-income countries\(^{25}\). There has been a sharp increase in the global incidence of TBI due to increasing use of motor vehicles in these countries where approximately 85% of the world’s populations reside\(^{25,26}\). With an estimated 90% of deaths due to injury occurring in these countries\(^{25}\), studies reiterate that TBI presents a clinical problem with significant social and quality-of-life ramifications\(^{27}\). The financial cost for families and caregivers in developing countries has been described as “catastrophic”\(^{28}\).

Explanations for this growing problem in developing countries include rapid industrialisation, urbanization, uncontrolled increases in motorcycle use and lack of safety design or legislation\(^{29,30}\). Such an environment may be seen as a “complex interaction of human, vehicle and environmental factors along with a lack of sustainable preventive programs”\(^{31}\). This suggests a challenge for developed nations with extensive, well-resourced trauma systems and high industrial safety standards with legislative support. Efforts must be continued to reduce the social and economic impact of this injury pattern on a national level, but developed nations may also have a responsibility towards less-developed nations within their region.

Whilst acknowledging the global burden associated with TBI, developed nations must also recognise disparity within their own borders. Depending on one’s perspective, Australia is either blessed or cursed with a broad range of geographical environments with varying population densities. Consideration needs to be given to the impact of TBI across the spectrum of metropolitan, rural and remote areas within the states and territories of Australia. This study aims to investigate rural and urban differences in TBI outcomes between rural and urban areas in the state of Victoria, focusing on clinical management in the pre-hospital environment and the impact of low exposure to TBI cases on paramedic confidence and performance.
2.2.2 Epidemiology and Burden of Injury

It has been suggested that by the year 2020 traumatic brain injury (TBI), which currently results in over 10 million deaths or hospitalisations per year, will emerge as the major worldwide cause of death and disability. Referred to as a “significant injury to the brain following head trauma”, TBI remains the leading cause of mortality and disability in the younger population in high-income countries today. The incidence of TBI in Australia has been stated as 322 per 100,000 head of population, exceeding incidence rates found in the United States and Europe. It has been shown that TBI in Australia is the leading cause of death in those under 45 years of age, accounting for 21% of all deaths in this group, with up to 20% of injury survivors sustaining severe neurologic disability or remaining in a vegetative state. The economic impact of severe TBI in Australia, expressed as the financial cost per case per year, is higher than all comparator conditions except muscular dystrophy.

These figures indicate that although trauma systems in Australia are technologically advanced and staffed by personnel with considerable expertise, TBI remains a serious health concern. The wide-reaching implications following severe TBI suggest that this injury pattern warrants investigation into strategies which may reduce the incidence of these cases, may improve clinical intervention, or may improve patient outcomes following injury. The first section of this project will compare rural and urban TBI outcomes within a region serviced by an established trauma system.

2.2.3 Definitions of Primary & Secondary Injury

The following sections will outline the pathophysiology of TBI, current best practice recommendations for clinical management and the specific implications of pre-hospital intervention. It is important to understand the underlying mechanisms behind severe brain injuries, in order to contextualise appropriate prevention and management practices.

There are two distinct phases in the occurrence of TBI. These are the initial trauma causing structural damage, known as primary injury and considered to be irreversible, and secondary damage caused by potentially reversible pathological changes in the brain itself and surrounding
protective tissues. The high mortality and morbidity associated with severe TBI are due to both the primary insult and secondary complications.

Primary injury may be caused by direct forces, such as blunt or penetrating trauma, or by indirect forces such as those associated with rapid changes in speed or momentum and resulting in movement of the brain within the cranial vault. Direct forces may result from being struck by an object or by the head striking a surface, and indirect forces are often associated with acceleration or deceleration. Primary injury typically involves skull fractures, haemorrhage and direct neuronal damage occurring as a result of a head-strike.

Secondary injury occurs from minutes to days after the initial insult as a result of cellular changes within the brain. Direct cellular damage results in altered cell function, changes in cellular permeability, changes in auto-regulation and oedema. This combination creates increased pressure within the cranial vault, further damaging brain tissue and worsening the condition. This process is explained in more detail below.

This review demonstrates there is a need to research ways in which pre-hospital intervention may be enhanced or improved, with the aim of preventing or minimising secondary brain injury in rural areas.

### 2.2.4 Pathophysiology

Following any significant trauma, major changes occur in “the microcirculation, cell membrane transport and function, energy metabolism, and function of mitochondrial, immunological and cardiovascular systems.” As with major trauma in general, these mechanisms occur in TBI, with secondary injury resulting from two broad groups of mechanisms: intracranial causes and extracranial causes. Intracranial causes include mass lesions, localised or widespread brain swelling, intracranial hypertension, seizures, intracranial vasospasm and infection. Extracranial causes include hypotension, hypoxia, hyper or hypocapnoea, hyper or hypoglycaemia, anaemia, pyrexia, electrolyte imbalance, coagulopathy and infection. An example of one of these secondary complications is
intracranial bleeding, with the frequency of such bleeding varying with severity of injury, age, the site of injury and the presence or absence of a compound skull fracture. At a cellular level, secondary brain injury is complicated by vascular and endothelial damage, both triggering inflammatory mediators and the resulting inflammatory complications. These biochemical mechanisms work in conjunction to protect healthy neurons (neuroprotective effects) and to remove damaged neurons (autodestructive effects). This post-traumatic mediator release affects not only the brain but also other organs, resulting in systemic inflammatory response syndrome (SIRS) and multiple organ failure as well as secondary cerebrovascular injury.

Although a great deal is known about the molecular and cellular mechanisms of TBI, the principles underpinning treatment modalities have changed little over the past 20 years. In acknowledging that the principles of managing secondary brain injury have changed little, the literature shows that the application of these principles may still be lacking even in settings with considerable trauma expertise, advanced technology and progressive trauma system design.

This review of the literature suggests there is a need for research to increase the understanding of two key areas that may contribute to the improved application of known principles: 1) how trauma systems contribute to optimal patient management and outcomes, and; 2) the impact of experience and confidence on individual clinician intervention.

### 2.2.5 Principles for Reducing Secondary Brain Injury

The importance of clinical strategies aimed at reducing secondary brain injury is summarised clearly by Bledsoe and Benner: “Having a high index of suspicion and treating preventively for secondary brain injury is vital to the reduction of overall morbidity and the preservation of neurological function.” The following section will outline the basic principles surrounding the prevention and management of secondary brain injury, and will highlight discussions within the literature regarding such strategies.
The management of TBI traditionally indicates early surgical intervention to relieve intracranial lesions and critical care aimed at avoiding or minimising secondary brain injury\textsuperscript{8-10,47}. Current guidelines indicate that achieving specific levels of the partial pressure of arterial oxygen (PaO2), percentage of haemoglobin saturated with oxygen (SaO2), partial pressure of carbon dioxide (PaCO2), and systolic blood pressure (SBP) are the minimum supportive care aims to reduce or prevent secondary brain injury\textsuperscript{48}. The techniques for achieving or maintaining these parameters include endotracheal intubation and ventilatory support, sedation and analgesia, maintenance of fluid volume and electrolyte balance, nutritional support and prophylaxis for thromboembolism – all aimed at creating an environment where further damage to the brain is reduced and the brain itself can recover\textsuperscript{9}.

When the brain is injured and begins to swell within the skull the pressure gradient that must be overcome to supply oxygenated blood to the brain also increases. When intracranial pressure (ICP) exceeds jugular venous pressure (JVP) the maintenance of cerebral perfusion pressure (CPP) (being the difference between mean arterial pressure (MAP) and ICP), is recognised as being necessary to reduce the impact of secondary brain injury\textsuperscript{9}. When injury to the brain has the combined effect of impaired autoregulation of blood pressure (BP) and increasing ICP, cerebral blood flow (CBF) becomes dependant on CPP. Although it is widely accepted that uncorrected hypotension, or low blood pressure, has adverse effects in the TBI patient, the precise management of CPP is yet to be clearly specified\textsuperscript{9,40,49}. Controversy surrounds the level of CPP that is considered adequate for the TBI patient, and whether increasing CPP beyond this level will have a therapeutic or detrimental effect\textsuperscript{9}.

The need to correct hypotension in order to maintain cerebral blood flow and oxygenation is considered a fundamental principal in reducing the impact of secondary brain injury. Along with this, there is a need to reduce cerebral oedema, which in effect contributes to a continuing process of increased ICP, decreased blood flow and cellular damage within the brain – all of which generate further oedema and worsening ICP. In order to minimise these effects, volume replacement is required to combat hypotension and increase blood flow to the brain, which in simple terms mitigates some of the adverse effects of cerebral oedema and cellular damage.
Hypoxia and hypotension can commonly occur in the less-controlled pre-hospital environment. The paramedic application of RSI, which describes a process of sedating and paralysing a patient in order to secure their airway via endotracheal intubation, in the setting of TBI requires deliberate action to secure the patient’s airway, but in order to minimise the progression of secondary brain injury and achieve optimal patient outcomes the procedure must be undertaken with additional clinical strategies. Pre-hospital RSI is reported to be most effective when combined clinical interventions maximise haemodynamic stability. In order for the pre-hospital management of TBI patients to be effective, individual clinicians require sound psychomotor and cognitive skill sets. The literature suggests that maintenance of these skills is dependent on exposure, opportunities for training and practise. It is unclear from the literature how trauma system design impacts clinician skills maintenance in rural, low-volume locations.

This review of the literature so far indicates that a two-stage process may be required to understand the systems impact on TBI outcomes and the clinician-centred aspects of TBI management. It is therefore proposed that this project will be undertaken in two parts. The first part of this project will focus on the impact of trauma systems on patient outcomes following severe TBI, whilst the second part will investigate the relationship between case exposure and clinician confidence, and how this may translate to standards of clinical care in the pre-hospital environment.

2.2.5(a) Pharmacology

Certain types of fluids, due to their osmolarity, can be used to increase intravascular volume whilst also decreasing intracellular oedema. The choice of fluid for volume replacement in this setting has understandably undergone many investigations. Several studies have investigated the use of hypertonic saline, with the general conclusion that this type of fluid does not improve TBI outcomes. The use of mannitol, an osmotic diuretic, for reducing ICP in severe head injury remains unclear with evidence suggesting that excessive administration may in fact increase brain swelling. Current research has looked at the use of albumin, a water soluble protein that can be used as a volume expander. These studies have raised conflicting results, either associating the use of albumin with higher mortality when compared to saline, or suggesting that protocols including the use of albumin reduce mortality. Investigations in this area will no doubt continue.
Research has also been conducted looking at additional therapies and procedures that may benefit TBI patients. The use of aminosteroids to reduce cell membrane damage following cerebral hypoxia, has not yet been found to provide conclusive benefits\textsuperscript{60}, and the use of corticosteroids for reducing intracranial pressure has been found to be detrimental\textsuperscript{61}. Barbiturates have been found to reduce ICP but there is no evidence to indicate a reduction in mortality\textsuperscript{62}. The use of hypothermia and erythropoietin, a hormone that increases the oxygen carrying capacity in the blood\textsuperscript{57}, as neuroprotective measures for minimising secondary brain injury are also undergoing investigation\textsuperscript{63,64}.

Whilst the range of pharmacological interventions available in the pre-hospital setting may be limited, it is likely that further studies will be conducted into additional practices that may complement RSI and contribute to favourable functional outcomes for TBI patients. Recognising that the pre-hospital management of severe TBI is likely to increase in complexity, part of this study aims to provide an understanding of the amount of experience considered necessary to maintain cognitive and practical skills for paramedics required to manage this injury pattern.

\textbf{2.2.5(b) Airway Management and Ventilation}

This section of the literature review aims to provide an outline of the importance of airway management following TBI. Later sections of the literature review will deal specifically with pre-hospital airway management. This section will outline the current understanding regarding the timing of airway intervention, the parameters of the procedure itself, and ventilation strategies aimed at reducing secondary brain injury. The need for early endotracheal intubation in this patient group, which has particular relevance in the pre-hospital setting, is highlighted below.

Berston and Soni\textsuperscript{65} state:

“All patients with severe head injury (traumatic coma), marked agitation or significant extracranial trauma require early oral endotracheal intubation. Depending on the skill of the operator and available facilities, this should be performed using rapid sequence induction…..”
As mentioned previously, the deliberate management of cerebral oxygen and carbon-dioxide levels is an accepted strategy for minimising the progression of secondary brain injury. In an overview of traumatic brain injury, Heegaard and Biros\textsuperscript{33} reiterate the physiological factors influencing autoregulation and cerebral blood flow (CBF) within the brain. They state: “Hypertension, alkalosis and hypocarbia [hypocapnoea] result in cerebral vasoconstriction; hypotension, acidosis, and hypercarbia [hypercapnoea] causes cerebral vasodilation.” Airway management in TBI patients, which allows for deliberate ventilation, provides an avenue for controlling these physiological parameters. A description of the importance of these factors will follow, and the literature regarding the definitions of physiological parameters will be discussed.

It is important to differentiate between the initial airway and ventilation strategies aimed at minimising the progression of secondary brain injury, and the later strategies aimed specifically at reducing raised intra-cranial pressure (ICP). Maas, Stocchetti and Bullock\textsuperscript{26} reiterate the complexity of the mechanisms that combine to contribute to secondary brain injury: “Secondary processes develop over hours and days, and include neurotransmitter release, free radical generation, calcium-mediated damage, gene activation, mitochondrial dysfunction, and inflammatory responses.” Werner and Engelhard\textsuperscript{66} support this outline of the secondary processes following TBI, highlighting the importance of cerebral blood flow. These authors outline the pathophysiological factors that impact on, or are impacted by, cerebral blood flow as follows:

- Hypoperfusion and hyperperfusion
- Cerebral autoregulation and CO2 reactivity
- Cerebral vasospasm
- Cerebral metabolic dysfunction
- Cerebral oxygenation
- Excitotoxicity and oxidative stress; and
- Oedema
- Inflammation
- Necrosis and apoptosis

These summaries give some indication of the depth and complexity of physiological factors and processes related to TBI and the progression of secondary brain injury. An in-depth analysis and review of the current literature relating to each of these contributing factors is beyond the scope of
this thesis, but the relationship between hypoxia, hypercapnoea and inflammation is important to note.

The significance of these two processes is that early strategies may minimise their effects on secondary brain injury. More precisely, early and appropriate airway management and ventilation can increase cerebral oxygenation while also controlling the partial pressure of carbon-dioxide (PCO2). The literature shows that this has an application in the broader context of the management of TBI, but also has implications in the setting of pre-hospital RSI.

2.2.5(c) Minimising Secondary Brain Injury

This section will outline the strategies aimed at minimising the progression of secondary brain injury. Again, Berston and Soni\textsuperscript{65} indicate that the initial priorities in the management of TBI should include “controlling the airway, ensuring adequate oxygenation and ventilation.”, reinforcing that, “Neurological assessment and brain-specific treatment should only follow once cardiorespiratory stability has occurred.” Tintinalli, Kelen and Stapczynski\textsuperscript{38} state that, “Hypoxia, defined as a Po2< 60 mmhg, increases mortality from TBI”. They further highlight that all patients who have sustained a severe TBI should be intubated and ventilated with 100% oxygen.

Collective guidelines\textsuperscript{8,9,47,67} indicate that the initial management of severe TBI, defined by a GCS of 3 – 8, should aim to prevent secondary brain injury by avoiding hypoxaemia (defined as oxygen saturations below 90%) and hypotension (which will be discussed later). Further to this, in the presence of acute neurological deterioration the guidelines suggest short term hyperventilation aimed at achieving a PaCO2 of 25-30 mmHg. Haddad and Arabi\textsuperscript{68} reiterate that hypoxia should be avoided and that ventilation should aim to maintain pulse oximetry (SpO2) of 95% or greater. Further to this, these authors suggest that hyperventilation should be avoided within the first 24 hours due to the presence of compromised cerebral perfusion, as a result of hypocapnoea and vasoconstriction. Hyperventilation may also lead to hyperinflation of the lungs, increasing intrathoracic pressure and thereby decreasing venous return, cardiac output and cerebral blood flow. These points highlight that Australian and international guidelines share common principles, but that variations in definitions and physiological parameters exist.\textsuperscript{8,47,69-71}
Minardi and Crocco\textsuperscript{72} reiterate the significance of hypoxia following traumatic brain injury, highlighting that episodes of hypoxia may be unnecessarily prolonged due to either lack of recognition or lack of treatment. Studies by Chesnut et al\textsuperscript{67}, and Chi et al\textsuperscript{73} show the association between an episode of hypoxia at any stage during the management of severe TBI and increased mortality. Importantly, Minardi and Crocco\textsuperscript{72} stress the need for early supplemental oxygen during the management of TBI. The authors state that if the patient is unable to maintain their own airway, or if initial attempts to increase oxygenation are unsuccessful, then intubation will be required. Who should be performing the intubation, how it is best achieved, and when it should be instigated will be discussed in further sections.

This section of the literature review reinforces the importance of specific clinical strategies for intervention in severe TBI cases, aimed at reducing secondary brain injury. It also highlights the variability in guidelines despite general consensus regarding these key strategies. This section further clarifies the literature surrounding the use of RSI and how the technique may be best utilised to achieve optimal outcomes following TBI. Later sections of the study will consider the factors that influence the judgement and decision making required by paramedics to utilise RSI effectively in order to achieve recommended end points.

\textbf{2.2.5(d) Pre-Hospital Management Strategies}

Having outlined the existing literature regarding the principles of TBI management and possible future developments, this section will focus entirely pre-hospital management strategies. There is still much debate regarding which pre-hospital interventions, if any, are beneficial in the setting of TBI. Pre-hospital triage and assessment of conscious state, as well as fluid administration and airway management are examples of interventions that continue to generate discussion\textsuperscript{17,21,35,74-82}. More specifically, the paramedic use of RSI continues to generate much discussion\textsuperscript{20-22,52,79,80,82-92}. 
Pre-Hospital Fluid Management

The most appropriate method of pre-hospital volume replacement to maintain blood pressure and prevent hypotension in TBI patients continues to generate discussion. The application of fluid resuscitation in the pre-hospital setting is considered controversial, not only for patients suffering TBI. There are two main points to consider:

- whether there is a role for pre-hospital fluid resuscitation in trauma in general;
- and whether this applies to the TBI patient.

A committee drawn from the Eastern Association for the Surgery of Trauma in the USA undertook a meta-analyses in 2009 to address these and other questions. This committee aimed to answer five key questions:

- Should injured patients have vascular access attempted in the pre-hospital setting?
  - If so, what location is preferred for access?
  - If access is achieved, should intravenous fluids be administered?
  - If fluids are to be administered, which solution is preferred?
  - If fluids are to be administered, what volume and rate should be infused?

The first two questions remain fundamental to many of the arguments against pre-hospital intervention in general. Discussion remains regarding pre-hospital intervention, with some studies suggesting that intervention should never delay transport to appropriate trauma facilities and others indicating that early, appropriate pre-hospital intervention may positively impact long term patient outcomes. Controversy remains, particularly relating to who should be performing pre-hospital procedures and which procedures are of the greatest value.

Cooper et al discussed the insertion of IVs and the administration of fluids to severe TBI patients in the pre-hospital setting. Their paper suggests that:
Hypotension was associated with increased morbidity and doubled mortality rates in TBI patients;

- Pre-hospital hypotension and the presence of hypotension on arrival at the emergency department were associated with increased mortality;

- Pre-hospital hypotension acted as a predictor of higher mortality when compared to normotensive TBI patients.

A randomised control trial was used to study the use of pre-hospital hypertonic saline (HTS) for volume replacement in severe TBI patients. The trial aimed to determine whether pre-hospital resuscitation using HTS improved long-term functional outcomes following severe TBI when compared to the use of conventional fluids, concluding that neurological function at 6 months post-injury was almost identical to between the two groups. The authors reflected that “prehospital hypotension had been corrected by hospital arrival in both groups. Although HTS resuscitation is likely to have been faster, conventional resuscitation protocols were equally effective for prehospital resuscitation of these patients.” The results also indicated that the two groups of trauma patients with either multi-system trauma including TBI, or isolated TBI, had survival rates better than those predicted at the beginning of the study.

One particular study questioned the efficacy of any advanced pre-hospital intervention, let alone the need for specific high-level interventions such as RSI. Research findings also associate fluid resuscitation with worse outcomes in multi-trauma patients, suggesting this may be due to a combination of:

- Tissue oedema
- Compartment syndrome
- Coagulopathy
- Disruption of blood clots

A further consideration surrounds the definition of hypotension. As stated, it is widely accepted that even one episode of hypotension can be associated with an increase in mortality following severe TBI, however a universal definition of hypotension is still lacking. Previous studies have used
a systolic blood pressure (SBP) range of 80 -100mmHg
54,93,104, while one study suggested that ICP, MAP and CPP provide more accurate measures
105.

These points highlight some of the challenges faced by clinicians managing severe TBI patients, when the presence of multi-system trauma is also very likely. Whilst aggressive and early fluid resuscitation may reduce hypotension and maintain cerebral perfusion pressure, this approach to fluid resuscitation may worsen patient outcomes by disrupting the natural clotting process and restarting haemorrhage. Time spent initiating pre-hospital fluid resuscitation may also delay transport to definitive care. This reiterates the need for a cautious and judicious approach to fluid resuscitation in this patient group, particularly when additional pharmacological agents are utilised to achieve RSI. As mentioned earlier, these agents have the potential to worsen hypotension and therefore increase the progression of secondary brain injury. For pre-hospital RSI to be part of a successful strategy aimed at reducing the impact of secondary brain injury, pre-intubation and post-intubation management must also be addressed and given equal importance. The administration of sedative and paralysing agents plus insertion of an endotracheal tube are of little value if physiological factors are not addressed.

In summary, the current literature indicates that a degree of uncertainty remains concerning various aspects of pre-hospital fluid resuscitation in general, as well as the correction of hypotension in the management of severe TBI patients. Generally, it is accepted that hypotension is associated with higher mortality in this patient group, and that early intervention to correct hypotension is an important part of the clinical management of these patients. The current literature also reiterates the importance of blood pressure maintenance in conjunction with pre-hospital RSI, highlighting that the process of minimising secondary brain injury involves a range of strategies unlikely to be successful if undertaken in isolation.

It is likely that a degree of debate will remain regarding the limits of pre-hospital intervention. It is difficult to argue against the premise that seriously ill or injured patients need to be transported to hospital in a timely manner, suggesting that pre-hospital intervention must always be undertaken in manner that does not dramatically increase the timeframe from injury to hospital. However, this argument may be balanced by the emerging acceptance that early, specific, high-level pre-hospital intervention has the potential to impact patient outcomes. Therefore moderate increases in pre-
hospital timeframes may be acceptable. This study will investigate the importance of paramedic intervention in the setting of TBI, recognising the increased potential for adverse events in settings of low case load and exposure.

**Pre-Hospital Airway Management**

The underlying principles of minimising secondary brain injury by reducing periods of hypoxia are applicable to the pre-hospital phase of TBI management, however debate remains regarding the strength of supporting evidence and efficacy of such management practices in this specific environment. As with the pre-hospital management of hypotension in TBI patients, much discussion continues regarding the most appropriate methods to reduce hypoxia, and who should be performing high-level procedures. Essentially the discussions are focussed on whether paramedics should be trained to perform RSI, and whether pre-hospital RSI correlates with improved outcomes for TBI patients.

The technique of RSI requires complete removal of a patient’s airway reflexes in order to minimise increases in intracranial pressure (ICP) during laryngoscopy and to optimise chances of successful endotracheal intubation. Much has been written regarding the relative difficulties associated with performing this technique in the pre-hospital environment when compared to the hospital environment. The finding of an association between favourable functional outcome in severe TBI patients who underwent pre-hospital RSI is a positive finding that remains controversial and has not been reflected in all studies. In reporting the findings the authors of these studies recognise that the mechanism by which outcomes are improved is unclear, with the early administration of 100% oxygen, control of minute ventilation, and a decrease in patient temperature recognised as possible contributing factors.

The risks and potential pitfalls of undertaking the procedure in the pre-hospital environment are widely discussed. The performance of the procedure in a difficult environment is referenced and the need for strict control of end-tidal carbon dioxide levels (ETCO2) is raised. Following this, the use of ETCO2 monitoring is recommended for use by pre-hospital providers to prevent excessive hypoventilation or hyperventilation. The necessity and importance of continuous
monitoring of vital signs, oxygen saturation for major trauma in general are reinforced in other studies\textsuperscript{115}.

Fakhry et al\textsuperscript{18} reinforce the importance of airway management and ventilation in head-injured patients, summarising that:

- Primary brain injury is known to cause hypoventilation
- A decreased level of consciousness may lead to an inability of a patient to protect their airway
- When combined with hypotension, these factors place TBI patients at a very high risk of progressing to secondary brain injury
- Hypoxemia, hypercapnoea, and acidosis contribute to the progression of secondary brain injury and are known to increase mortality\textsuperscript{18}

In the context of existing literature that suggested an association between pre-hospital transport delays and adverse outcomes for trauma patients, Cudnik et al\textsuperscript{95} stated, “the time delay associated with RSI-assisted OOH-ETI [out-of-hospital endotracheal intubation] evident in our study (and therefore potential delayed time to definitive care) is yet another aspect to consider when implementing or modifying prehospital airway protocols”. The authors further suggested that pre-hospital intubation, and therefore pre-hospital RSI, should be considered as a move away from the “fundamental” premise of trauma care, which is to quickly recognise the severity of the injury/injuries and to provide rapid transport to a major trauma centre.

Just as Davis et al\textsuperscript{17,84,116,117} recognised the potential influence of transport delays in cases where pre-hospital RSI was initiated, Cudnik et al\textsuperscript{95} reinforce this premise, stating “Expeditious out-of-hospital (OOH) care and transport to a trauma center are believed to improve outcomes after major trauma. However, OOH interventions may prolong elapsed field time, both on scene and during transport”. This particular study found that pre-hospital times were substantially longer following intubation attempts, and that the greatest difference in pre-hospital times was between the non-intubation and the RSI groups. To strengthen the findings the methodology adjusted for the potential confounding variables of transport distance and injury severity.
Importantly, although this particular study found an association between pre-hospital RSI and increased pre-hospital transport times, there was no attempt made to evaluate differences in mortality or functional outcome. Further limitations were that there was no attempt to evaluate the experience or qualification level of the paramedics who performed the RSIs.

Further studies highlight the ongoing discussions regarding pre-hospital RSI. In a study that compared morbidity and mortality following paramedic intubation in TBI patients compared to TBI patients intubated in the hospital setting, researchers found an association between decreased survival and pre-hospital intubation. This study did not specifically seek to measure pre-hospital RSI, and the authors recognised that there was a “subgroup of patients with more significant injuries who might benefit from field intubation.” The authors also recognised the limitation that the cohort of TBI patients in the study who underwent pre-hospital intubation did so without pharmacological intervention (RSI), and therefore were likely to have a severe TBI and low GCS. Logic would follow that if they had a lesser brain injury and higher GCS, then they would need induction agents to successfully achieve intubation. This should be recognised as a potential confounder and a source of selection bias. In essence, the pre-hospital intubation group was likely to have worse outcomes because the severity of their injuries was much higher.

Following a retrospective trauma database review Ellis et al stated, “We believe that if patients have an immediate need for intubation and ventilation and adequate skills are available on-scene, then they should not have to wait until admission to hospital to have the procedure performed.” Interestingly, the study included only TBI cases that underwent pre-hospital RSI that was administered by pre-hospital doctors rather than paramedics. The focus of the study was to determine the presence of intracranial pathology in trauma patients with a high GCS (13-14), concluding that a decrease of even one or two points on the Glasgow Coma Score following a traumatic mechanism is associated with a “significant rate of intracranial pathology.” The relevance of the study to this project is that the authors recognise some of the problems associated with paramedic RSI programs but still conclude that RSI can be effectively utilised for high GCS TBI patients in the pre-hospital setting when a “robust clinical governance” structure is in place. The issues associated with paramedic RSI programs which were highlighted by Ellis et al include paramedic training and skill retention. Considering these, it can be seen that strategies may be utilised to effectively overcome these deficiencies. Research into strategies regarding paramedic
confidence and effective simulation programs and their potential benefits on patient outcomes is warranted. These strategies may be most effective if based on an understanding of the problems and challenges faced by paramedics, which will be explored in later sections of this project.

A prospective, randomised, controlled trial was undertaken in Victoria over a 4 year period with the aim of comparing functional outcomes for adult TBI patients who underwent pre-hospital RSI administered by paramedics, compared those who underwent RSI in the emergency department. The results indicated that there were a greater percentage of favourable outcomes at 6 months post-injury in the patients who underwent RSI in the pre-hospital setting. Whilst acknowledging the limitations of the study, the authors highlighted that RSI in the pre-hospital setting may have some potential advantages. The suggested advantages were:

1) Following intubation, oxygenation and ventilation can be controlled and delivered precisely;

2) Trauma patients in rural areas may benefit from pre-hospital RSI as the procedure allows the patient to be stabilised at the scene and potentially transported over longer distances.

3) A longer initial transport time to a hospital with a higher level of trauma capability has the added benefit of significantly reducing further delays created by one or more inter-hospital transfers.21

These potential advantages are important when we consider the “bigger picture” of outcomes following TBI. Although pre-hospital RSI allows paramedics to secure the patient’s airway, therefore combatting complications associated with a loss of airway, the technique also allows for control of oxygen and carbon dioxide levels in the blood and brain. As mentioned previously, by improving oxygenation and avoiding both hypocapnoea91,112 and hypercapnoea91, the technique provides an avenue to reduce the progression and severity of secondary brain injury. In combination with fluid replacement and control of hypotension, this appears to have distinct benefits for the severe TBI patient group. Again, it is the combined management of physiological parameters pre and post-intubation that provides the greatest benefit, not just the procedure of RSI alone.
Studies also raise additional considerations regarding paramedic RSI, indicating that this approach is not without risk. The Bernard et al.\textsuperscript{21} recognised three areas related to patient safety and standards of practice:

1) That high standards of paramedic intubation requires thorough and ongoing training;

2) There may be adverse effects to the patient in the setting of a failed intubation with the inability to provide adequate oxygenation via other methods;

3) The high risk of death following an unrecognised oesophageal intubation;

4) There may be a higher likelihood of cardiac arrest prior to, or following, pre-hospital RSI as the administration of sedative agents combined with positive-pressure ventilation may contribute to haemodynamic instability in the presence of an uncontrolled haemorrhage.

As paramedics lack some of the diagnostic techniques and equipment available in the emergency department, they may at best be able to suspect ongoing internal haemorrhage, and attempt to counter this with fluid resuscitation\textsuperscript{21}.

Recognising that existing research clearly highlights the need to aggressively reduce secondary brain injury, the same authors raise the point that, “The issue may thus be who is doing the intubation (and how) and not whether intubation is appropriate”\textsuperscript{21}. This point seems to be central to a sub-group of the literature, with arguments both for and against paramedics performing the procedure.

Studies have indicated that RSI could be undertaken safely, with comparable success and complication rates to those in hospital, by a small, well-trained group of paramedics\textsuperscript{18,21}. Other studies have found variance in pre-hospital timeframes and additional factors impacting the success of pre-hospital RSI\textsuperscript{17,84,95-98,118-120}. Importantly, Fakhry et al highlight that, “in the absence of Class 1 data ascribing to the deleterious effects to the procedure itself and not the circumstances under which it is performed”, there is a strong argument for the continued use of pre-hospital RSI by well-trained, highly experienced providers\textsuperscript{18}. 

27
Several studies have reported low success rates following paramedic RSI. Some success rates have been reported as low as 71.8%\textsuperscript{101}. As mentioned, any appraisal of the literature regarding pre-hospital RSI reveals contrary findings to Fakhry et al. Davis et al\textsuperscript{18,80} indicated that paramedic delivered RSI was associated with increased mortality and worse functional outcomes. A study known as the “San Diego Paramedic RSI Trial” was ceased based on the apparently negative outcome following paramedic RSI, and the authors identified several limitations related to the findings\textsuperscript{80}.

Firstly, although the study group and control groups were matched on age, sex, mechanism of injury (MOI) and injury severity, the researchers acknowledged that other patient parameters may have contributed to the difference in outcomes. One example includes the presence of pre-existing co-morbidities, which was not included as a variable. Secondly, the authors recognised that there was a high incidence of hyperventilation and transient hypoxia following RSI, with the understanding that these occurrences could greatly impact the progression of secondary brain injury. Thirdly, the study identified a higher incidence of transport delays in the RSI group, and although the relationship was unclear, acknowledged that rapid transport to high level trauma care for the RSI group may have improved outcomes. Further to this, the researchers highlighted that currency in training, experience and frequent exposure to the procedure, were vital for avoiding skill erosion. On this note, Fakhry et al’s findings re-iterated that the success of pre-hospital RSI relied on a system that supported a small group of experienced, specially trained paramedics who were able to access ongoing training, and who utilised the procedure on a regular basis\textsuperscript{18}.

Although these examples highlight the significance of training, skills maintenance and experience, they may also be interpreted to suggest there is a connection between clinician confidence, decision making surrounding RSI and patient outcomes. This relationship between exposure, experience and confidence, and how this may impact performance will be a key topic for the second part of this thesis.

As an interim summary, the studies highlighted so far describe several emerging themes in the literature surrounding pre-hospital intubation for TBI patients, and paramedic RSI in particular.
Current research indicates that poor patient outcomes following RSI may be due to clinical and practical problems such as incorrect ETT placement, post-intubation hyperventilation or on-scene times resulting in delays to hospital arrival. The existing literature suggests ongoing debate regarding pre-hospital RSI, with some discussion focussed entirely on which clinician groups should be undertaking the procedure in this setting. There seems to be a great degree of variation in the methodology of the studies conducted, with limitations associated with matching patient groups and correlating the application of RSI by paramedics with patient outcomes following TBI. In contrast to the negative findings regarding paramedic RSI, there also appears to be growing acceptance that the RSI procedure and the management of associated physiological problems is beneficial for patients suffering from severe TBI, and that early intervention using the procedure may have a positive influence on patient outcomes. Despite the inconsistencies in the literature, there is a strong indication that thorough training programs and clinician experience are important factors for ensuring the successful application of RSI.

**Therapeutic Hypothermia and TBI**

The short section of the literature review will discuss the use of therapeutic hypothermia in the management of TBI, and how this may translate to pre-hospital practice in the future. A 2006 study by Adamides et al.\(^40\) highlighted that at the time there was no class I evidence supporting the routine use of therapeutic hypothermia, along with other therapeutic interventions, in the management of TBI. An earlier study by Bernard et al.\(^121\) indicated that there were varying results from clinical trials regarding the use of induced hypothermia for anoxic brain injury, severe stroke and severe traumatic brain injury. A more recent study by Davies\(^122\) reinforces that the topic remains controversial, “despite a strong biological rationale and reasonable evidence from the literature”. Having recognised the controversy, the author reiterates several key points:

1) If applied optimally, therapeutic hypothermia is likely to improve outcomes following TBI

2) Correct application requires that the intervention is delivered “early, long and cool”

3) The optimal group within the severe TBI cohort of patients are those that are young and experiencing an elevation in ICP\(^122\)
If these broad criteria are met, it is suggested that therapeutic hypothermia for TBI does in fact have an application. This must be balanced by the studies that have suggested adverse outcomes in TBI patients managed using therapeutic hypothermia due to complications with the clotting process and increased haemorrhage. Other studies do not support the use of this intervention outside the research setting.

The relevance of this intervention in the setting of this thesis is that elements within the literature indicate that the use of therapeutic hypothermia may provide the greatest benefits if implemented initially in the pre-hospital setting. In this context, an outline of its application provides an insight into targeted strategies that may emerge in future pre-hospital guidelines aimed specifically at improving outcomes following severe TBI. With recognition that time delays to definitive care are inherent when major trauma cases occur in rural and remote areas, it follows that techniques such as therapeutic hypothermia may be of the greatest benefit to that group of major trauma patients who sustain their injuries in locations that are at a considerable distance from major trauma facilities. With this in mind, a short explanation will follow, including the current literature discussing the potential benefits of the procedure when used in the pre-hospital setting.

Therapeutic hypothermia refers to the “controlled lowering of core temperature for therapeutic reasons”, and has physiological effects on the central nervous system, cardiovascular system, gastrointestinal system, hematologic system and acid-base balance. The premise of its use in the setting of severe TBI is the aim of “decreasing oxygen consumption and intracranial pressure” in order to protect the brain against secondary ischaemia.

An editorial letter by Kruger suggests that in regions serviced by pre-hospital providers capable of administering higher level interventions, that allowing “haemodynamically stable TBI patients to ‘self cool’ at the scene” may be a legitimate strategy if it is in fact determined the therapeutic hypothermia improves functional outcome following TBI. This letter makes reference to the underlying premise of preventing hypothermia in major trauma patients and that patients in certain climates are more susceptible to pre-hospital hypothermia regardless of the aetiology of their condition. Within this reasoning, the authors amply that if core body temperature can be moderated and maintained within certain parameters, that it may be beneficial to allow the TBI cohort of trauma patients to become hypothermic prior to attending hospital.
This short summary of literature relating to the use of therapeutic hypothermia for TBI patients in the pre-hospital setting is not intended to be exhaustive. In the context of this study it has been recognised as an important topic that may have implications for pre-hospital intervention in the future, particularly for those patients who sustain such injuries in rural and remote locations. The current literature shows a trend towards the recognition of pre-hospital intervention as the first stage of initiating critical care in a mature trauma system. This highlights the need to understand and address factors that impact the willingness and ability of paramedics to intervene with high-risk procedures, particularly with the challenges faced by paramedics working in rural and remote locations.

2.2.6 Interim Summary of Research Questions

This review of the literature relating to the principles of airway management, reduction in the progression of secondary brain injury, and trends in paramedic practice related to the use of RSI highlight that further studies are required in this area. There is no disagreement that if these procedures are performed the clinician must be experienced, competent and confident. There is however, a need for research to investigate the impact of experience, exposure and confidence on the paramedic utilisation of RSI. It follows that the development and maintenance of both psychomotor and cognitive skills surrounding RSI could ensure high standards of safety and clinical intervention, regardless of the craft group.

This study aims to investigate how pre-hospital management of severe TBI may differ between rural and urban areas, and how trauma system design may influence patient outcomes between geographical locations. Further to this, the study will aim to provide solutions and concepts for training programs in rural and remote locations where clinicians are likely to experience minimal exposure and decreased levels of confidence. This may have the potential to impact intervention, decision making and patient outcomes.


Study 1: Research Questions

1) Is there a difference in the profile of TBI patients between rural and urban areas?
2) Is there a difference in pre-hospital response to severe TBI cases?
3) Is there a difference in the type of hospital that severe TBI patients are first transported to?
4) Is there a difference in in-hospital mortality between rural and urban TBI patients?
5) Is there a difference in functional outcomes at 6 months post injury between rural and urban TBI patients?

2.3 Major Trauma Outcomes in Australia:

2.3.1 Rural and Remote Trauma Profile in Australia

Trauma is a major cause of mortality and morbidity in both developed and developing nations worldwide. It has a significant impact on the health and wellbeing of not only the person or persons injured in a particular incident, but also on the families and wider community as a whole.

There has been considerable discussion regarding the implications of major trauma in rural and remote areas of Australia, with research suggesting patients suffering traumatic injuries in rural areas have worse outcomes than those in urban areas. With one third of the Australian population residing in rural or remote locations, these communities continue to be over-represented in road transport related injury and fatality statistics. Addressing the health needs of rural and remote Australia is not a new concept, however rural communities continue to be adversely impacted by reduced access to a broad range of services, including health services.

When considering the impact and difficulties surrounding the management of major trauma in remote areas, several themes emerge. In a study conducted in Western Australia, it was found that there was a disproportionate amount of trauma deaths occurring in rural areas, with the death rate over 4 times higher in very remote areas when compared to major cities\(^1\). It was also found that
the two most common trauma conditions requiring transfer were head injuries and injuries to the thorax. Similar findings occurred applied to the international context. Further to this it has been observed that trauma care and trauma systems are often studied from urban perspectives. Whilst recognising that the primary need for transporting trauma patients is to access more advanced technology and specialist medical services, the same study acknowledges that there is a degree of risk in transporting critically ill patients and that a risk-benefit analysis must always be considered. The fact that these practical dilemmas exist in the management of major trauma patients highlights that rural and remote residents are impacted by traumatic injuries in different ways to patients in urban areas, but that the focus has often been on improving trauma care services in urban areas.

2.3.2 Motor Vehicle Fatalities: Characteristics and Trends

A recent report prepared by the Bureau of Infrastructure, Transport and Regional Economics indicated the following statistics regarding fatal road crashes and fatalities in Australia over the past 10 years:

- National annual fatalities have decreased by approximately 24% over the past 10 years
- The 17 – 25 year age group has the highest rate of fatalities per population
- All types of fatal crash are decreasing
- Single vehicle crashes account for approximately 44% of the total, which is a similar proportion to that in 2002.

A recent study by Frechede, McIntosh, Grzebieta and Bambach investigated the characteristics of single vehicle rollovers in Australia. Of particular interest was the finding that 61% of the 474 single rollover fatalities between 2000 – 2007 had head injury listed as the cause of death. The results also suggested that head injury was more likely when the occupant was not ejected from the vehicle and a seat belt was worn. Further to this, the findings indicated that most single vehicle rollovers that resulted in a fatality in the Australian setting involved up to two rolls and a pre-crash travel speed of 100 km/h or over.
A study by Chen et al\textsuperscript{133} compliments the above findings. This study considered the characteristics of vehicle crashes involving young drivers that occurred in rural areas. The study highlighted that young drivers were over-represented in road fatalities in Australia, and that while there was a higher risk of single vehicle crashes in rural or regional areas, overall there was a higher risk of crashes in urban areas\textsuperscript{133}. The findings indicated that unique factors in rural areas may have contributed to the higher likelihood of single vehicle crashes in these locations. Such factors included road structure and maintenance, speed, and driver behaviour\textsuperscript{133}.

A study undertaken in San Diego County by Potenza et al\textsuperscript{134} found that motor vehicle crashes were the leading cause of all injuries and the third-leading cause of fatal injury. The study indicated that there were no gender differences for these leading causes of injury and fatal injury. Partly supporting, but also contrasting this was a study by Soreide et al\textsuperscript{135} that investigated the epidemiology of trauma deaths in Europe. This study found that blunt trauma, male gender and pre-hospital deaths predominated in this setting. The study found that the main cause of death was central-nervous system injury, which was closely aligned with high injury severity scores to the head and neck region. Additional findings indicated that motor vehicle crashes accounted for the majority of blunt trauma deaths, and that there were more male deaths across all age groups\textsuperscript{135}. Importantly, the study also indicated that secondary brain injuries contributed to a second peak of trauma deaths and concluded that the profile of fatal trauma victims in Scandinavia was “male, young, severely injured, and dying shortly after (blunt) injury”\textsuperscript{135}. Rosenfeld et al\textsuperscript{136} highlighted the prevalence of head injury amongst road traffic fatalities in Victoria, Australia.

Another Australian study identified patterns in single vehicle rollovers in the Northern Territory, indicating that such incidents were more likely when the following factors were present: increased speed, when the driver was male and if the accident occurred in a rural area\textsuperscript{137}. The study also makes reference to additional factors including road conditions, vehicle defects, the influence of alcohol and whether a seatbelt was worn\textsuperscript{137}.

These reports and studies are important as they provide a picture of road traffic fatalities both here in Australia and overseas. Little has been written regarding differences in rural and urban severe TBI cases where fatalities occurred prior to ambulance attendance. Although this patient cohort is likely to be very small, an understanding of these case types is important for completeness. Rural fatality
rates may be impacted by access to pre-hospital care, which in turn may be influenced by geographical and time constraints. Therefore, there is a need to investigate pre-hospital, pre-intervention fatalities, looking for trends and differences between incidents occurring in rural and urban areas.

2.3.3 Traumatic Cardiac Arrest Associated With Severe TBI

It is well documented that outcomes following traumatic cardiac arrest tend to be poor. Although current literature regarding traumatic arrest with head injury as the primary injury is sparse, this section of the literature review will the existing studies.

Zwingmann et al found that paediatric patients had a higher chance of survival following pre-hospital traumatic arrest when compared to adult patients, however the paediatric cohort tended to have poorer functional outcomes. Cera et al discussed the apparent futility of pre-hospital resuscitation attempts following traumatic cardiac arrest, also suggesting that rapid aeromedical transportation of such patients had little effect on outcome.

Although the literature is limited regarding traumatic cardiac arrest related to severe TBI, outcomes following pre-hospital cardiac arrest warrant some discussion. A key article by Eisenberg, Bergner and Hallstrom written in 1979, indicated that paramedic intervention had a “small but measurable” effect on mortality following cardiac arrest. Since this article was written, other studies have found that targeted guidelines have improved pre-hospital cardiac arrest outcomes in general, and that young people surviving cardiac arrest have good functional and quality of life outcomes. A further study has highlighted the importance of implementing clear guidelines for field termination of resuscitation.

A recent study by Boyd and Perina reiterated that although outcomes from cardiac arrest have typically been poor, there have been significant advances regarding each stage of the “chain of survival”. The authors highlight that pre-hospital intervention has improved drastically, and that with a continued focus on evidence based practice short-term outcomes such as achieving ROSC.
prior to hospital admission are likely to continue to improve\textsuperscript{153}. Importantly, two further articles note regional differences in out-of-hospital cardiac arrest outcomes\textsuperscript{154,155}, which may be partly attributed to differences in the availability of higher level care, the experience of pre-hospital personnel, and the management provided at regional hospitals.

This area of the literature is important as it indicates that discrepancies exist regarding cardiac arrest outcomes between rural and urban locations. Little has been written specifically regarding outcomes following traumatic cardiac arrest with severe TBI as the primary injury, and what influence paramedic intervention may have with this patient group. The literature indicates that further investigation is required regarding pre-hospital post-intervention fatalities, rural and urban differences in the number of paramedics attending such cases, and any differences in intervention provided by the two groups.

2.3.4 TBI Outcomes as Sub-Group of Major Trauma

Knowing that mortality from major trauma in rural and remote areas of Australia is higher when compared to urban areas\textsuperscript{2,3}, and knowing that there are differing impacts on rural ambulance services and trauma systems in general, it seems logical to suggest that the management of traumatic brain injury in rural areas would have different implications and that mortality from these cases in rural areas may be higher.

In the state of Victoria the majority of deaths from major trauma continue to occur within the head and brain injury group\textsuperscript{156,157}, yet there is a lack of research regarding rural and urban differences in TBI outcome. The implementation of state-based regionalised trauma systems has been an important step towards improving trauma outcomes. The literature indicates that most injury deaths occurring in remote rural hospitals could be classified into those who suffered catastrophic injuries and deteriorated rapidly and those who died several days after suffering a traumatic brain injury\textsuperscript{7}. In recognising that rural injury mortality is higher than urban mortality, studies have found that trauma systems should focus on the specific patient group suffering traumatic brain injury\textsuperscript{7}.
Several aspects relating to the management and outcomes of traumatic brain injury have been studied in the Australian/New Zealand setting, and also specifically in Victoria\textsuperscript{158-166}. A 2008 study that looked closely at the neurologic outcomes following traumatic brain injury found that mortality and unfavourable outcomes in Australia and New Zealand remained high and had not differed significantly in a 10-15 year period\textsuperscript{167}. Again, in Western Australia, the number of deaths resulting from head injuries sustained as a result of motor vehicle crashes in rural areas was found to be significantly higher than that in urban areas\textsuperscript{168}.

Further studies have been undertaken in the international context\textsuperscript{70,169,170}, including investigations into differences in rural and urban outcomes for paediatric head injury\textsuperscript{171}, paediatric bicycle related injuries\textsuperscript{172}, and specific rural/urban head injury outcomes\textsuperscript{27,29,173-177}. Additional studies have been conducted looking at the impact of pre-hospital management on traumatic head injury outcomes\textsuperscript{21,22}, one of which was conducted in Victoria, Australia, and found that long term head injury outcomes benefited from paramedic advanced airway management\textsuperscript{21}. It must also be mentioned that specific studies have been undertaken in Victoria, looking for rural/urban differences in cardiac arrest outcomes\textsuperscript{154,178}, the provision of care for conditions that may not need hospitalisation\textsuperscript{170}, the prevalence of asthma\textsuperscript{180}, sports and recreational injuries\textsuperscript{181}, suicide rates\textsuperscript{182}, and the management of congestive cardiac failure\textsuperscript{183}. Each of these has provided an insight into rural/urban health differences and definitions in the Australian context.

It can be seen that major trauma and traumatic brain injury impact our rural communities. Discussions have been undertaken regarding differences in brain injury outcomes, and studies have looked closely at the impact of trauma systems on this specific injury type. Although there have been studies comparing rural/urban differences in Victoria relating to other conditions, an extensive review of the literature has not uncovered a study that has looked specifically at differences in traumatic brain injury outcomes in Victoria by comparing both the extended Glasgow Outcome Scale (GOS-E) and hospital mortality. The maturity of the trauma system in Victoria and the quality of the data available through the Victorian State Trauma Registry (VSTR) create an optimal setting in which to undertake a rural/urban comparison of outcomes following TBI.

Recognising that major trauma outcomes are likely to be worse with increasing rurality, and that severe TBI has the highest mortality within the major trauma cohort, it follows that further
investigation is warranted in order to determine the relationship between rurality and outcomes following TBI. The first section of this study will compare in-hospital mortality and functional outcomes following severe TBI between rural and urban patients managed within a mature trauma system.

2.3.5 Trauma Systems

The purpose of an established trauma system is to improve the collective transport and treatment process of trauma patients to optimise the clinical care, and to minimise the range of burdens associated with traumatic injury\textsuperscript{184}. The concept of trauma systems is based on getting the right patient to the right facility in the most appropriate time frame, which has implications for rural trauma. Many elements are required to establish such a system, and “The delivery of effective trauma care requires a complex system needing trained practitioners with specific expertise and skills, availability of diagnostic and therapeutic resources, and readily available specialty care”\textsuperscript{11}. This section of the literature review will discuss the themes within the current literature relating to differences in trauma system design and maturity, then summarising how different may impact outcomes following major trauma and TBI in rural areas. A key focus will be the application of trauma systems that encompass rural locations.

In practice, trauma systems work to move severely injured patients to highly specialised trauma centres in major cities. When looking specifically at the impact on the timing of patient transfers within regionalized trauma systems in the United States, Svenson\textsuperscript{185} concluded that rural patients were not benefiting as transfer times for smaller rural centres had not improved, suggesting that this was in contrast to the impact of trauma systems on urban trauma patients. Supporting this, other studies found that trauma outcomes from rural areas in the United States were worse overall when compared with urban areas\textsuperscript{186}. Distance and lack of resources might contribute to these findings, but it also follows that trauma system design should in some way be able to counteract aspects of rurality that would otherwise be detrimental to trauma outcomes. An early article by Narad, Becker and Frecceri\textsuperscript{187} highlighted this issue specifically, with the authors articulating that patients in rural areas were located at varying distances from designated trauma centres, but that they may require stabilisation at smaller hospitals that lacked the expertise and facilities to comprehensively manage these cases. The authors concluded that regional hospitals could be integrated with the larger
trauma hospitals through transfer guidelines and inclusion in quality assurance mechanisms that encompassed the entire system. Similar findings were reached by Rogers et al.\textsuperscript{188} who concluded that in the absence of a formal trauma system, rural patients were more likely to die at the scene of an incident despite a lower severity of injury. This finding was attributed in part to age differences of the rural/urban patient groups as well as longer response times and transport times in rural areas.

A study conducted in the United States recognised that although “Timely access to definitive trauma care has been shown to improve survival rates after severe injury”, a large number of rural North American communities continued to lack access to definitive trauma care.\textsuperscript{189} Further studies recognise the differences associated with trauma care in rural areas.\textsuperscript{42,190-193} This is an issue that seems relevant to Australia considering the spread of cities and towns across the states and territories. In relation to Victoria’s trauma system it has been found that there was a “significant reduction in the risk of death among major trauma patients” since its introduction.\textsuperscript{12} Interestingly, at the time of introduction of the State Trauma System, it was suggested that there would not be a significant impact on Victoria’s road ambulance services due to new trauma triage guidelines, but that secondary air ambulance transfers would be expected to increase.\textsuperscript{194} This point is important, as the ambulance and air-ambulance services are likely to play an important role when considering the needs of rural communities and access to high-level trauma care. It seems logical to suggest that rural communities require a link to be able to access the major trauma centres, with road and air ambulance resources providing this capability. Interestingly, there was no reference in the above-mentioned article to differing needs and expectations associated with the management of major trauma cases in rural areas.

A study from the United States raised three key points regarding trauma system effectiveness:

- Most trauma deaths occurred in the period after transport from the rural hospitals;
- The outcome for seriously injured patients depended on multiple providers making multiple decisions at consecutive stages during the process of patient management;
- That although state wide trauma systems are often discussed as one entity, the issues relating to improving outcomes for trauma patients in rural or isolated areas is more complex.\textsuperscript{14}
These points highlight the management of rural major trauma, and the capture of these cases through trauma systems can be challenging and is likely to involve many factors.

**Regionalisation of Trauma Care**

Regionalisation of trauma systems has been linked with patient outcomes. The association between trauma systems and head injury outcome has been investigated\(^{195}\), with one study finding that a regionalised trauma system in Australia contributed to a lower risk-adjusted mortality rate for traumatic brain injured patients when compared to the United Kingdom where a similar trauma system did not exist. In addition to this, it has also been noted that regionalisation of trauma care may bring with it problems related to exposure and skills maintenance of rural clinicians\(^4,196\). From one of these studies, Helling\(^4\) suggests that higher mortality in rural areas may be associated with delayed recognition of major trauma cases and inconsistency in the level of care provided by ambulance personnel, combined with a lack of trauma training for rural physicians and inadequate hospital resources. The author continues by suggesting that the standardisation that is associated with regionalisation of trauma care may go some way to alleviating these factors. The adoption of standardised trauma management and transfer guidelines, in combination with the ability to monitor patient outcomes and system effectiveness, forms the basis of regionalisation of trauma care.

When considering the Australian context, it seems evident that key aspects of rurality are likely to impact the way that trauma services are delivered. When an incident occurs resulting in one or more patients sustaining severe trauma injuries, there are several steps that must occur before the patient receives definitive care. In very simple terms, the patient must be accessed, undergo initial stabilisation, and be transported to medical facility, where further stabilisation or definitive care may be provided. It follows that the further away the initial incident occurs from a major trauma centre, that there is a greater likelihood of more than one sequence of transport and stabilisation. It is preferable that the number of these sequences are minimised, and the integration of a retrieval system within the trauma system may help to achieve this.
It has been reported that although the rural population of Victoria is approximately one third that of the metropolitan regions, there was still a higher incidence of major trauma in the rural regions\(^{197}\). Acknowledging that worse outcomes for rural trauma patients had previously been documented, this study suggests that reasons for such outcomes could include delays in patients being accessed if an unwitnessed event had occurred, longer transport times, and limited resources in the management of major trauma patients in rural areas. This study did not find a significant difference in outcome for those trauma patients first attending rural hospitals in Victoria. At the time of the study the authors also found that Victoria’s trauma system had favourable survival statistics in comparison to overseas models. This study referred to major trauma cases in general, and did not focus on outcomes following severe TBI.

A report by the Royal College of Surgeons of England\(^{198}\) describes regional trauma systems and highlights some of the differences between centralised and regionalised systems:

A regional trauma system serves a defined population to reduce death and disability following injury. The trauma system includes public health, injury prevention, emergency medical services, all trauma-receiving hospitals, major trauma centres, rehabilitation services, research, education and systems governance. The trauma system [regionalised] optimises the use of resources, so a trauma patient is treated in the right place at the right time by the right specialists. Major trauma patients are treated at major trauma centres, while other trauma patients are treated at trauma units.

The same report highlights the key elements deemed essential for a functioning regionalised trauma system as:

- Clear pre-hospital triage guidelines;
- Bypass protocols;
- Development and clarification of trauma capabilities at hospitals other than major trauma centres;
- Rapid inter-hospital major trauma centre transfer capabilities\(^{198}\)

Delprado highlights these very issues when recognising the importance of retrieval systems and discussing the impact of distance to major centres, sparse population distribution in rural areas, and the impact of these two points on the time taken for patients to reach definitive care\(^{199}\). Kristiansen
et al reiterate the link between the pre-hospital and in-hospital stages of trauma management, stating that “regional networks of predictable and accountable pre and in-hospital resources are needed for efficient trauma systems”\(^2\). Both of these studies indicate that the pre-hospital component of a trauma system, whether that be road or air resources, do indeed provide that link between the severe trauma incident in a rural area and the care that is provided at a major trauma centre. It may also be interpreted that the studies indicate a greater significance and reliance on air resources when faced with increasing rurality, a concept that is supported by Croser\(^2\) and Danne\(^1\).

These concepts are important and relevant to this thesis as they demonstrate a link between rurality, trauma systems and outcomes following TBI. Following sections will address the literature directly related to the relationship between TBI outcomes and structured trauma care, and the difficulties surrounding skills maintenance and clinician confidence in rural areas. These additional sections of the literature review support the need to further understand the two key areas of the relationship between trauma systems and rurality, and strategies that may be useful for improving or maintaining clinician confidence in rural areas.

### 2.3.6 The Use of HEMS for Major Trauma Cases

The use of helicopters and fixed-wing aircraft for the transport of critical patients has occurred for several decades. The initial concept, like many other developments in civilian trauma care, was adapted from models utilised during various armed conflicts. The use of helicopters for aeromedical evacuation in particular progressed following the Falklands, Korean and Vietnam wars. “Dustoff” missions, using the iconic Bell 212 or ‘Huey’, to rapidly transport casualties from the battlefield to a frontline surgical unit were credited with saving the lives of many service personnel during the Vietnam conflict in particular\(^2\).

The integration of Helicopter Emergency Medical Systems (HEMS), within established trauma systems provides a capability for accessing patients in rural, remote or isolated locations and transporting to the major trauma centres located in metropolitan areas. HEMS are also often utilised for the inter-facility transfer of critical patients, either from regional hospitals to major metropolitan centres, or between metropolitan hospitals\(^2\). The focus of this section of the
literature review will be to reflect on the efficacy, potential benefits, logistical considerations and the risks associated with HEMS use. A particular focus will be included on the relationship between HEMS utilisation and patient outcomes following severe TBI.

Targeted and specific use of HEMS is vital for ensuring the most appropriate utilisation of this resource. The establishment of, ongoing costs, staffing and maintenance costs associated with HEMS operations are substantial. It is therefore very important that this resource is utilised in a way that aims to balance cost-effectiveness with patient outcomes. A recent study by Brown et al found that patients transferred by helicopter were “more severely injured and use more hospital resources” when compared to patients transferred by road ambulance. This then reinforces the need for judicious use of this resource, and warrants further consideration of how this may relate to rural trauma patients and TBI cases in particular.

Following an extensive review of the literature, Brown et al came to several conclusions regarding the cost effectiveness of HEMS. Firstly, it was noted that although much of the focus is centred on HEMS utilisation in the setting of major trauma, its use also appears to be justified in the setting of non-trauma patients. A further principle highlighted by the review is that a true estimation of cost effectiveness requires considerable detail and its accuracy is subject a range of factors. Brown et al state that the results of a cost-benefit analysis of HEMS is “only as good as the estimates and assumptions (with respect to both costs and benefits).”

There are several key themes related to HEMS utilisation that are shown in the literature. Crew configuration is a topic that generates much discussion, not only referring to the medical crew mix that makes up the team, but also to their clinical capability, scope of practice, and ability to safely perform high-risk procedures in the pre-hospital setting. For example, European HEMS teams are predominantly comprised of a physician or physician/nurse, while HEMS crews in the United States and Canada are likely to be physician/paramedic, paramedic/paramedic or paramedic nurse. In Australia the HEMS crew is likely to be a paramedic/paramedic, physician paramedic or solo paramedic.
This variation in crew configuration should not necessarily impact patient outcomes, however much has been written regarding the clinical scope of the varying models and in particular, who should be performing RSI. Recognising that RSI is a high-risk procedure, some studies have suggested that the procedure should only be performed by physicians\textsuperscript{98,99,107,215}. Further studies suggest that pre-hospital RSI contributes to unfavourable patient outcomes\textsuperscript{79,84,96,97}. Parts of the literature also undertake fiscal analysis of crew mix options, often finding that physicians cost a great deal more than paramedics or nurses, and that the percentage of cases at which they may truly have an impact of patient survival may be minimal\textsuperscript{207,216-218}. Further discussions focus on the background of the crafts groups, the complexities of working in the pre-hospital setting, and standards to ensure safe work practices\textsuperscript{219,220}.

Consistency tends to be lacking in the literature regarding HEMS staffing and pre-hospital RSI. Useful studies highlight the need for appropriate despatch, high standards, regular exposure, and robust clinical auditing processes regardless of the craft group\textsuperscript{18,203,219,220}. This in many ways negates the debate about which clinicians should be working on HEMS, or who makes up the optimal crew mix, and re-focusses the discussion back to the safest and most effective way to deliver the highest standards of care to major trauma patients. Recognising that many of the HEMS crew-mix discussions include some reference to the application of pre-hospital RSI, these discussions are important in the context of patient outcomes following severe TBI.

It is recognised that geographical isolation may be a contributing factor to outcomes following major trauma in rural and remote areas. In this particular setting, HEMS are likely to have greater utilisation rates and may play a key role within the trauma system. A sub-analysis within the rural/urban comparisons undertaken in this project will focus on determining differences in the injury profile of TBI patients transported by HEMS, and will assess the impact of HEMS utilisation on in-hospital mortality and functional outcomes.
2.3.7 HEMS Use in Rural Areas

The literature suggests that HEMS plays an important function within any trauma system. The best use of HEMS resources, the most effective way to staff the service, and the scope of interventions that may be initiated all remain areas of discussion. An additional theme within the HEMS literature is how the capability can be best utilised in rural areas. It seems logical that the greater the distance from an accident scene to a major trauma centre, that more resources and longer transport times will be involved. This may also apply to non-traumatic medical emergencies, such as a patient experiencing an acute myocardial infarction (AMI) who requires specialist intervention. In theory, when these incidents occur in rural areas the patients may also benefit from rapid transport to major centres. HEMS resources may therefore also be useful for this patient group. A discussion of the literature relating to HEMS use in both rural trauma and non-trauma emergencies will be discussed.

An early study by Urdaneta et al attempted to evaluate the impact of HEMS transport on patient outcomes following multi-system trauma. The authors concluded that it was difficult to predict which patients may benefit from HEMS transport, unless information such as objective injury classification and trauma scores where known at the time of HEMS request. Even though this study was undertaken in the 1980s, it still remains unlikely that front-line clinicians will be able to provide specific trauma triage criteria, anatomical injury classification and/or a Total Trauma Score. The authors did however raise some important observations relating to rural trauma patients, and to patients who sustained TBI in particular. In reference to TBI cases that are initially managed at smaller rural facilities, the authors state:

"Many of them were transferred by helicopter because local facilities were poorly equipped to evaluate the extent of their injuries or to care for potential complications", adding that "Rural physicians are always concerned that the correct diagnosis be made and that urgent neurosurgical treatment be initiated as quickly as possible when necessary. Therefore, they often request helicopter transport for patients with head trauma."

The authors add, “the helicopter service provides excellent assistance to those physicians who treat injured victims in small rural community hospitals”. Although this study lacks clear links between
HEMS utilisation and patient outcomes, it does indicate that HEMS may be a useful capability in the overall management of rural trauma cases.

A study undertaken by Shepherd et al\textsuperscript{222} aimed to assess the effectiveness of HEMS utilisation in rural Australia, whilst providing an overview of the injury profile, transport times compared to road ambulance responses, and factors related to crew mix. Although not specifically investigating the impact of HEMS on TBI outcomes in rural areas, this paper is important in the context of this project, which in part is aiming to assess the impact of rurality on TBI outcome. Key findings from the paper include:

- There was no statistically significant time advantage in the use of HEMS to scenes greater than 100 km from a regional trauma centre
- There was a time advantage of using road transport within 50 km of a regional trauma centre\textsuperscript{222}.

This paper is important in regards to the topic of this thesis for several reasons. The study was undertaken in a rural Australian setting, and although other studies looking at rurality and trauma outcomes may draw some parallels, it can also be argued that the Australia setting has its own characteristics and profile. Examples of such characteristics include the geography and spread of towns in rural and remote areas of Australia, the capabilities and smaller hospitals and their function within a broader trauma system, and the configuration and level of clinical intervention provided by retrieval services in a given area. In simple terms, the Australian setting is unique because of the landscape, the use and availability of services, and the way that we approach trauma management.

The findings of Shepherd et al show that the true benefit of HEMS may lie in its utilisation in rural and remote areas, rather than urban settings. Studies\textsuperscript{211,223} show the positive impact of appropriate HEMS utilisation on trauma outcomes in urban areas however it seems logical to suggest that the patients at greater risk of adverse outcomes due to delays in reaching definitive care, are those who sustain their injuries in locations furthest from these facilities\textsuperscript{224,225}. It is important to note that delays in reaching a major trauma centre may not always contribute to worse outcomes for trauma patients\textsuperscript{226} but that rural and remote patients are more likely to undergo multiple transfers if they...
are not transported directly to the highest level of care\textsuperscript{2,227}. This process of multiple transfers is recognised as a factor that may influence outcomes following trauma\textsuperscript{200,228}.

The literature that indicates HEMS resources are often used inappropriately and often have little impact on patient outcomes must be acknowledged. A study undertaken in the United Kingdom by Melton et al\textsuperscript{229} reiterates that, “The helicopter has clear advantages in accessing remote rural areas and areas where traffic congestion is a problem”. However, the same authors conclude by saying that more stringent triage criteria are needed in relation to HEMS utilisation, and that “the helicopter is not a mode of therapy, it is merely a method of transport”\textsuperscript{229}. The authors suggest that HEMS services are often used for low acuity cases where they have no measurable impact on patient outcome. This in itself would not pose a problem if HEMS resources were widespread and cost-neutral to run. However the reality of HEMS operations is that each mission exposes the crew to a range of hazards, that HEMS resources are generally limited within a given system, and that they are expensive to run/operate. This highlights that clear indications are needed to best utilise this resource, and although a degree of over-triage will be inherent in all HEMS operations this should be minimised where possible. Later sections of this chapter will address the aspects of HEMS utilisation likely to impact patient outcomes.

A study by Cummings and O’Keefe\textsuperscript{216} aimed to examine the effect of mode of transport on patient mortality, and how different transport options impacted the total cost of pre-hospital and hospital trauma care. The study focussed specifically rural trauma patients, with the key hypothesis that the mode of transport and scene disposition would have no impact on the overall cost of trauma care for this patient group. The study identified some findings of interest:

1) A cohort of severely injured patients were not recognized by pre-hospital personnel and were taken to rural hospitals;

2) There were no significant differences in scene times between ground ambulance crews and HEMS crews;

3) Total patient costs from scene to discharge were not significantly different between the road-ambulance and HEMS crews, but transfer costs were less when HEMS was utilised to transport the patient from the scene to a major trauma centre rather than multiple transfers after initially attending a rural hospital.
The authors summarise that the transport of major trauma patients to rural hospitals significantly increases the time taken to reach a major trauma centre and increases pre-hospital costs. Further to this, delays in attendance at a major trauma centre may be due to lack of recognition of severely injured patients by pre-hospital personnel and staff at rural hospitals. The authors conclude by stating that the use of HEMS is the most cost effective in regards to total trauma costs when the patient is transported directly from the scene to the major trauma centre. These findings have some importance for this study. In simple terms, the study highlights that the appropriate use of HEMS resources may be financially beneficial. As Melton et al suggested, appropriate triage and activation of HEMS is not straightforward, but is a crucial element in the overall effectiveness of any trauma system that utilises this service. In some ways it is acceptable for a degree of over-triage to result in HEMS transporting patients who do not meet major trauma criteria, but it is undesirable for under-triage to result in HEMS missing patients who should otherwise be transported directly from the scene to a major trauma facility. Over-triage may also result in HEMS resources being unavailable for cases clearly meeting the criteria for intervention at major trauma facilities. This could occur if the helicopter has been tasked to attend what turns out to be a lower acuity case.

The importance of these points in the setting of this project is that if clinician exposure to major trauma, and to severe TBI cases in particular, is lower in rural areas then there may be the possibility of decreased levels of confidence and performance when managing these cases. Recognising that there may not be one single factor within an established trauma system that has the greatest impact on patient outcomes, it still follows that the identification of deficits within individual components of the system and the creation of solutions to address these deficits may contribute to the improvement of the overall effectiveness of the system itself. This may have particular relevance for severe TBI patients in rural areas.

An Australian study looked at the difference in HEMS activation patterns and patient outcomes following a change from physicians tasking and staffing to intensive care paramedic tasking and staffing. The authors, Cameron, Pereira, Mulcahy and Seymour conducted a series of case reviews over a 4 year period comparing length of hospital stay, transfer rates, rates of discharge directly from ED and 30 day mortality. In summary, the study found no difference in patient outcomes between the groups treated by either physicians or paramedics. Further to this, the
authors found that both groups had similar tasking criteria in relation to high-acuity patients, but that the paramedic group had a statistically significant higher rate of taskings for low-acuity patients. These were deemed to be “clinically unnecessary”\textsuperscript{230}. Interestingly, two of the main points in the discussion of this study support the staffing of HEMS by paramedics. The authors state:

Helicopter tasking for primary retrievals can be performed by ambulance or medical personnel. The results show that the activation capabilities are the same for sick patients and that there is no difference in admitted patient outcomes when an ICP [Intensive Care Paramedic] is sent on a primary retrieval instead of an EP [Emergency Physician].\textsuperscript{230}

This suggests that paramedics can develop the same level of knowledge, judgement and expertise as physicians when processing information in order to determine the most appropriate resourcing for a given case. In addition to this the authors also state, “There is no difference in outcome when prehospital care is performed in a helicopter by paramedics or doctors”\textsuperscript{230}.

These points need to be considered in the context of other studies that discuss the most appropriate staffing of HEMS. As mentioned earlier, many papers suggest that physician staffing of HEMS is more beneficial for patient outcomes\textsuperscript{98,99,107,215}. However, many of these studies are lacking in the quality of methodology and tend to make the distinction between who is performing the procedures rather than which procedures are being performed. The argument that is often raised is that physicians have a greater scope of practice, can provide a wider range of interventions, and are not limited by protocols. It is fair to suggest that physicians have received more training in a much broader range of medical procedures and interventions, and that their knowledge base is extensive. However, it must also be acknowledged that the pre-hospital environment brings with a set of unique challenges and circumstances. Discussions regarding whether the benefits of HEMS relate to the skills of the clinical team or the mobility of the transport platform\textsuperscript{231} are important in the context of the overall aims of pre-hospital trauma care\textsuperscript{232,233}. These aspects of literature highlight that regardless of a clinician’s background, expertise can be developed in the pre-hospital retrieval environment. Experience, training and exposure are equally important regardless of whether the clinician comes from a paramedic or emergency medical background.
2.3.8 Interim Summary of Research Questions

The literature suggests rural hospitals and smaller medical resources are not able to provide definitive care for severely head-injured trauma patients. At times, the care provided at such facilities may not prevent the progression of secondary brain injury. Although rural facilities and rural clinicians may only encounter these cases infrequently, studies suggest that they still should be prepared and capable of managing this patient cohort. The problem that is becoming increasingly evident is that a lack of exposure, experience and confidence may decrease a practitioner’s ability to perform high-risk procedures safely and efficiently. Rural clinicians are more likely to experience this lack of exposure, experience and confidence, therefore an alternative strategy may be required to maintain high levels of skill for rural paramedics authorised to perform this procedure. The first section of this study will investigate the way in which trauma system design can impact TBI patient outcomes in rural areas, whilst the second section of this study will look closely at the factors that may adversely impact confidence and competence amongst rural paramedics.

Research Questions

Study 2:

1) Is there a difference in the proportion of severe TBI cases transported by HEMS between rural and urban areas of a state serviced by an established trauma system?
2) Is there a difference in the injury profile of patients transported by HEMS between rural and urban areas?
3) Does appropriate HEMS utilisation positively impact patient outcomes following severe TBI?

Study 3:

1) Is there a difference in the characteristics of pre-hospital, pre-intervention deaths occurring as a result of severe TBI between rural and urban areas in a state serviced by an established trauma system?
**Study 4:**

1) Is there a difference in the proportion of pre-hospital deaths occurring as a result of severe TBI, following attendance and resuscitation by pre-hospital clinicians, between rural and urban areas in a state serviced by an established trauma system?

2) Are there rural and urban differences relating to patient demographics and scene management during pre-hospital resuscitation of severe TBI cases resulting in cardiac arrest?

### 2.4 Clinical Practice in Rural Areas

The previous section of the literature review has highlighted the challenges encountered by rural patients who have sustained severe TBI, and some of the difficulties faced by rural clinicians who may be required to manage these patients. This section of the literature review will further articulate the challenges faced by rural communities and rural clinicians, aiming to identify areas where further research may be beneficial.

#### 2.4.1 Defining Rurality in the Context of Emergency Health

In order to understand rural and urban differences in health care and patient outcomes, the way that rurality is defined and classified first needs to be understood. The aim of this section is to describe the existing rural and remote classifications used in Australia, and to discuss the most appropriate application in the setting of urgent care and emergency health.

Health care needs and accessibility to health services differ in rural and remote areas of Victoria, therefore researchers, planners and service providers must have tools to define boundaries between urban and other localities. Advances in transport and technology may reduce perceived distances, but acute medical emergencies will always require timely intervention and rapid initial stabilisation. In order to meet the urgent care and emergency health needs of rural Victoria, clear definitions of rurality and remoteness must first be considered and justified.
Wakerman demonstrates the importance of having a clear definition, highlighting that the concept of rurality has changed over time. Originally anything other than urban was considered rural, with the classification then developing into a continuum, and eventually a definition that not only encompasses time and place but also social, economic and demographic factors. Further discussions recognise that the concept of what is rural is far from universal, but important for policy development, research and future practices. Importantly it is recognised that rural Australia has a morbidity and mortality profile which is worse than that of urban parts of the country, and that there is a clear link between remoteness and decreased levels of health. Additionally Phillips highlights that regional and remote populations in Australia have poorer risk factor profiles, lower levels of income and education, are exposed to greater physical risks and have less access to health services. Wang and Lou indicate that such non-spatial factors are as equally important as spatial factors when determining influences on health care access.

Rural and remote areas typically have greater distances between medical facilities, with the perception being that time delays in receiving definitive care impact patient outcomes. However, studies have found that longer pre-hospital times were not necessarily associated with higher mortality or longer hospital stays, and that long term functional outcome following brain injury was no different between rural and urban groups in the state of New South Wales, Australia. The essence of the problem is highlighted again, in reference to rural paediatric trauma and the need to have greater access to acute medical resources in rural, remote and isolated communities, and also by the notion that the more remote or isolated a location is the more exposure medical personnel may have to complex acute care. Dukeshire summarises that despite there being significant interest and weight placed on definitions of “rural” in Canada, there is a lack of research looking specifically at the differing definitions of rurality and their implications for health planning, resource allocation and delivery of services. In many ways Canada shares similar characteristics to Australia relating to population density and geographical isolation.

At first glance therefore it seems obvious that access to any type of service is more limited for those who live in rural areas, particularly in the Australian context. When considering access to health services, several more detailed questions need to be investigated, such as:

- How is access measured?
• What is considered to be poor access?
• How is remoteness estimated?\textsuperscript{246}

Further to this, when considering the provision of health care, it is interesting to see the “remote medical context” referred to as being locations that are:

• geographically, professionally and personally isolating;
• where there is limited medical and logistical resources;
• where peer support is limited;
• where climatic, political or cross-cultural environments may be extreme;
• and where health services are being provided to marginalised populations with differing worldviews and differing cultural understandings of health\textsuperscript{247}.

Being able to clearly define rurality and remoteness allows us to measure the differing impacts of trauma and head injury, but reaching such a definition is not straightforward. Ocana-Riola and Sanchez-Cantalejo, recognise that the rural/urban divide is much more than a simple dichotomy\textsuperscript{248}. The authors highlight that traditional methods of defining rurality focus on either the number of inhabitants or population density, but recognise that simplifying the process and reducing rurality to a single variable in this manner does not necessarily accurately represent the degree of remoteness inherent in a particular geographic location. Alternatively a paper looking at access to health care services in rural areas of the United Kingdom, found that drive-time was a more accurate measure of access\textsuperscript{246}. Other studies reinforce the difficulties related to health care access in rural and remote locations\textsuperscript{249,252}, particularly in relation to emergency care\textsuperscript{250,253}.

In Australia, the development of geographical classifications such as the RRMA (Rural, Remote and Metropolitan Areas), ARIA (Accessibility/Remoteness Index of Australia), and the ASGC (Australian Standard Geographical Classification) systems have aimed to address the problem of defining rurality\textsuperscript{254}. 
The ARIA methodology has been used in other studies looking at the impact of rurality on health as well as specific rural/urban comparisons for injury or illness types, and was developed as a way of representing remoteness from goods and services from any location in Australia. ARIA + is a continuous index ranging from 0 – 15 (high accessibility – high remoteness), and is based on road distances to the nearest service centres, of which there are 5 categories based on population size. The five distances to each level of service centre are divided by the mean distance for that category in Australia. The resulting score for each level of service centre are added (with a maximum limit of 3 being applied for any score), and an overall ARIA+ score is generated. The ARIA+ methodology was chosen for this project as it provides a purely geographical measure of remoteness, incorporates a continuum, and the methodology is clear. This classification has been widely used in other studies comparing rural and urban patient outcomes and is useful for comparing trauma outcomes as it defines locations based on road distances to specific facilities and services.

Understanding geographical classification systems is important in the broader context of this study, as it shows that a “perfect” classification tool does not exist. The literature shows that each system has strengths and weaknesses, and that a given definition of rurality may impact findings comparing rural and urban patient outcomes. Later aspects of this study will compare patient outcomes between classification systems to determine whether one system may be more appropriate than another for rural TBI research.

2.4.2 Disparity in Rural and Urban Health Outcomes

Although the focus of this research is specifically rural-urban differences in traumatic head injury outcomes in Victoria, it is important to understand differences in rural-urban health status in Australia. It is intended that this section of the literature review will add to the reader’s understanding of broader differences in health outcomes, and how this translates to differences in outcomes following traumatic injury.

The public perception of rural health in Australia seems to centre on limited access to health care services, worse overall health status for rural populations, and the significantly worse health status of Aboriginal and Torres Strait Islander communities. It has been stated that, “on almost every
indicator of health and social disadvantage residents of rural communities fare worse than their urban counterparts. Research tells us that rural and remote Australian residents have shorter life expectancy, higher rates of injury mortality, particularly from road traffic accidents, as well as higher rates of homicide, communicable diseases, smoking, alcohol consumption and disability. Although a significant proportion of the health status differences are attributable to the Indigenous and non-Indigenous community profiles, mortality for non-Indigenous people living away from major cities remains higher.

As mentioned previously, injuries account for 18% of excess mortality outside major cities in Australia, and diseases of the circulatory system for 40%. The relationship between increased mortality rates and increased remoteness is linked to both differences in health-associated risk factors and socioeconomic implications. Tobacco smoking, high blood pressure, obesity and high cholesterol are each considered to be preventable risk factors associated with poor health status in rural and remote Australian communities. Workforce shortages, limited access to health care facilities, less exposure to health promotion activities, and geographic isolation are all examples of socioeconomic factors that contribute to rural-urban health differences.

The predominance of the agricultural and mining sectors in rural and remote Australia, and the geographical, cultural and environmental challenges faced by those working in these industries, may be closely linked with the rural health deficits associated with occupation and lifestyle. It should also be noted that due to their reliance and direct contact with the environment, rural communities may be more likely to feel the immediate impact of climate change – with recent instances of floods, droughts and severe weather as clear examples. These environmental factors impact our entire population, but the link between environment and health may be closer for those living in rural and remote areas.

Remote health is often viewed, investigated and reported from the ‘deficit’ perspective – meaning that remote health in Australia is defined as sicker and poorer rural populations, the lack and difficult retention of health staff, and lack of rural health career opportunities. This deficit view focuses on the problems facing rural and remote communities and fails to highlight the positive aspects of rural and remote life.
This section of the literature review has shown that many factors are inter-related in contributing to health outcomes in rural areas. Parts of the literature make reference to how these factors may be related to outcomes following traumatic injury. The combined literature showing rural health disadvantage and differences in traumatic injury profiles in rural and remote locations\(^\text{262,263}\) highlight the need for further research. Parts of this study will aim to highlight differences in the underlying patient profiles and demographics when comparing patient outcomes following severe TBI.

### 2.4.3 Social Capital and Access to Health Care

This section of the literature review will highlight some of the background concepts relating to the way in which social factors may impact the incidence and management of traumatic injuries. This section will show that rural communities have differing characteristics to urban communities that influence the way in which health needs are identified and addressed at an individual and community level.

It has been suggested that rural and remote communities are strengthened by well-established social networks, or what is known as social capital\(^\text{261,264}\). Key aspects of social capital include participation in community life, shared values, and trust\(^\text{265}\). The “norms and networks that create trust”\(^\text{264}\), may be particularly important in Australia’s current state of increasing economic pressure and social decline in rural areas. It is reported that “lower population density encourages connections between residents”\(^\text{258}\), as well as network cooperation and voluntary activity\(^\text{258}\).

The benefits of increased social capital in rural areas seem clear, but must also be viewed in the context of rural-urban differences in mental health. The greater likelihood of depression and stress related illness, and specifically suicide amongst male farmers\(^\text{266-268}\), suggests there remains a great need for social bonds and support in rural areas. No doubt, ways of strengthening trust and mutuality in local communities will continue to develop as a means of tackling social disadvantage and individual isolation in rural communities\(^\text{264}\).
It is suggested that there is a significant need for reform within the Australian health system, in order that health care is accessible and equitable\textsuperscript{269}. The key aspects requiring solutions have been identified as continuing health workforce shortages, limited access to health care services in rural areas, and unacceptably lower health status across the rural-urban, Indigenous non-Indigenous divide\textsuperscript{270}. Potential solutions for improving rural health care delivery include increased use of information technology, increased access to research and development opportunities for all health disciplines, and the ability to retain academically inclined clinicians\textsuperscript{271}.

The points raised in this short section are important in the context of this study as they highlight that social capital can play a key role in strengthening relationships and social interaction within rural communities. The studies show that the importance of these relationships seems to increase as geographic isolation increases, that disparities in access to health care exist, and that there is variance in patient outcomes between rural and urban areas in Australia. An increased need for social cohesion, the way in which community relationships can impact health, and continuing health workforce shortages throughout rural and remote areas of Australia are inter-related. It is likely that when combined, these factors influence behaviours and willingness to utilise health services. The following sections of the literature review will outline the current research regarding the way that rural communities perceive pre-hospital services. These topics have relevance to this thesis as they suggest that underlying community behaviours and attitudes have many influences, and that they may contribute to injury causality and outcome.

2.4.4 Rural Communities and How They Perceive Pre-Hospital Providers

This section will build on the concepts outlined in the previous section regarding social capital, and will discuss the sub-set of the literature that outlines rural attitudes towards pre-hospital care.

Existing studies show the relationship between health and place, and the way in which attitudes towards trauma care may differ in rural areas. “Help-seeking” behaviours, or the willingness to seek help, has been reported to be influenced by the tolerance of a given society towards coping mechanisms\textsuperscript{267}. This attitude towards coping mechanisms may differ between geographical regions, and geographical variations in health may be linked to three types of factors: contextual,
compositional and collective. Each of these relate to lifestyle differences, which may also influence attitudes towards rural trauma care. A summary of these factors is shown below:

Table 1: Contextual, Compositional and Collective Influences on Health Behaviours

<table>
<thead>
<tr>
<th>Contextual</th>
<th>Compositional</th>
<th>Collective</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population decline, plus social and economic change in small inland rural towns has contributed to increasing centralisation of infrastructure, including health services. This has had the following effects:</td>
<td>Rural populations have been reported as:</td>
<td>This category includes sociocultural and historical features of a given community. Examples are:</td>
</tr>
<tr>
<td>• Reduced sense of cohesion and community participation</td>
<td>• Having a lower average socio-economic status</td>
<td>• Legal and moral norms</td>
</tr>
<tr>
<td>• Those who leave tend to be better educated with greater job prospects</td>
<td>• Being older</td>
<td>• Traditions</td>
</tr>
<tr>
<td>• Those who move to these towns tend to be from low-income groups</td>
<td>• Having lower health status</td>
<td>• Values and interests</td>
</tr>
<tr>
<td>Lower service utilisation may be related to lack of availability or accessibility of services, combined with community attitudes and perceptions.</td>
<td>• Having higher rates of unemployment</td>
<td>• Shared histories</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Religious affiliation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Political ideology</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Ethnic, regional and national identity</td>
</tr>
<tr>
<td></td>
<td>Demographic and socio-economic factors may correlate with decreased health awareness and service utilisation.</td>
<td>Collective effects include constructs such as social cohesion and social capital. Collective effects may influence the way in which an individual views health problems and utilisation of health services.</td>
</tr>
</tbody>
</table>

Although these concepts have been drawn from literature relating to rural suicide rates in Australia, recognising the significance to trauma care is important in this study. The combination of contextual, compositional and collective factors influencing community attitudes to health care show that patient perceptions towards their own health and how to manage acute problems is multifactorial. The studies into these factors show that there are rural/urban differences towards individual health needs and attitudes towards accessing health services. Understanding the root cause of these differences may not be essential to this project, but appreciating that they exist and that they impact health outcomes for rural residents is important.
Paramedics may have an important role in strengthening relationships and developing more robust attitudes towards accessing health care in rural areas. Via thematic analysis of semi-structured interviews with key community stakeholders, Stirling et al. concluded that expanded scope paramedics (ESPs) were able to strengthen relationships between emergency care providers and rural communities, through deliberate community engagement strategies. The authors indicate that ESPs were able to increase interactions between ambulance services and rural communities, with reported benefits to rural communities in three key areas. It may be argued that the key areas of ESP capacity building in rural communities relate closely to the three factors influencing coping mechanisms and perceptions of health in rural communities. Table 2 shows the four areas of ESP influence and the three broad areas encompassing coping and health perceptions in rural areas identified by Stirling et al.

Table 2: Community Attitudes and Adoption of ESP Models in Rural Areas

<table>
<thead>
<tr>
<th>ESP area of influence</th>
<th>Factors influencing community attitudes and individual perceptions</th>
<th>Link between concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increased community response capacity</td>
<td>Compositional / Collective</td>
<td>By increasing community awareness of pre-hospital emergency and primary care services, individuals within the community may be more willing to utilise services. Increased availability of services may contribute to population retention and reduce population migration.</td>
</tr>
<tr>
<td>Linking of communities with ambulance services</td>
<td>Compositional / Utilisation</td>
<td>Strengthening the relationship between a given community and the ambulance personnel within that community, there is a greater opportunity for direct communication of needs and expectations. Community perceptions of health practitioners directly influence confidence in those practitioners. Perceptions and confidence are strengthened through the building of relationships, understanding of community needs, and understanding the levels of care that are available.</td>
</tr>
<tr>
<td>Increased health promotion and illness prevention at community level</td>
<td>Contextual / Collective</td>
<td>Broadening of traditional paramedic roles provides the opportunity to increase the utilisation of pre-hospital resources in rural areas. Utilisation will only increase as community awareness of the available resources also increases.</td>
</tr>
</tbody>
</table>
Other studies have found that paramedics were responsive to broader community roles, and that engagement in population health activities increased job satisfaction and increased the likelihood of paramedics staying in rural or remote areas\textsuperscript{273}. It should be stated that there is no intention within this literature review to discuss the advantages and disadvantages of extended care paramedic models. However, there are concepts raised with the literature that highlight the differences in community perceptions in rural and remote areas, and how pre-hospital services may impact and influence these perceptions. In this regard, these concepts are also important when aiming to understand how best to access and manage major trauma patients in rural and remote areas. It may be argued that the influence of environment, location and social attitudes\textsuperscript{274} lies at the heart of understanding how best to manage major trauma incidents in this setting.

One study found that there is no difference in service utilisation between rural and urban areas\textsuperscript{275}, although this particular study focussed only on a range of health services and not just emergency care. An additional study found that self-reported health service utilisation was higher in rural areas\textsuperscript{276}. A study by O’Meara, Kendall and Kendall\textsuperscript{277} describes the collaborative approach to developing an urgent care model for a remote community in south-eastern Australia. The implementation of a paramedic model aimed at enhancing emergency response within the community, whilst also strengthening primary health care services and increasing social capital was met with a positive response. Although it is difficult to quantify the contribution of the model to major trauma outcomes, it follows that wider availability of higher levels of immediate clinical care, combined with a refined process of patient stabilisation and transfer is likely to have some impact. It also follows that community perceptions of such services, and community confidence in these services would increase over time.

A study undertaken in the United Kingdom by Simons et al\textsuperscript{43} highlights the specific aspects limiting delivery of trauma care in rural and remote areas, and the strategies to overcome these. Interestingly, none of the aspects raised by Simons et al relate to the way in which a given community utilises its resources, or their attitudes towards and understanding of the services that are available. Studies suggest that ambulance utilisation differs across geographical locations, with utilisation in rural and remote areas being lower than that in urban areas\textsuperscript{278}, and that expanded paramedic models in rural and remote areas can improve urgent care treatment partly through improved community relations\textsuperscript{279}. O’Meara, Burley and Kelly\textsuperscript{280} clearly explain the differing needs of
rural Victorian communities in regards to accessing and maintaining urgent care services. These authors highlight that the approach to the provision of urgent care in rural communities is more holistic and must include decisions made by the community members themselves. The differing needs and utilisation of ambulance service in rural or remote areas has also been discussed\(^{281-285}\). Beillon, Suserand, Kalerg and Herlitz\(^{278}\) found that ambulance service delivery differed across geographical areas, stating that in sparsely populated areas cases were more severe and more pre-hospital intervention was applied. The differing needs and perspectives of rural critical care patients requiring either road or air transportation have also been investigated\(^{286}\), along with patient and health professional perceptions regarding use of ambulance services for the management of acute asthma in rural areas\(^{287}\).

These studies highlight specific differences in the use of, and public perception of, pre-hospital providers in rural locations. In a broader context, this area of the literature indicates that there is an interaction between the types of urgent care and emergency care services available in different geographical regions, and the way that communities perceive the need for and utilisation of such services. This suggests that community attitudes towards health care and the way that they utilise services may differ across locations and that social and cultural factors play an important role in the development of health care strategies. As health care professionals often reside in the same location in which they live, it follows that rural clinicians may have differing attitudes when compared to urban clinicians regarding the health needs and availability of services in rural communities. The literature also shows that the traditional paramedic role may differ in rural and remote locations when compared to urban areas.

These points are important in the context of this study, as little has been written regarding differences between rural and urban paramedics and their willingness to intervene with high-risk procedures. Part of this study will investigate the way that rural paramedics perceive their role within local and wider health systems, and how this may impact their confidence and willingness to manage severely injured, but infrequently encountered patients. The implications of this may be that rural paramedics are required to provide a unique role during the management of severely injured patients.
2.4.5 A Multi-Disciplinary Approach to Major Trauma Management in Rural Areas

This section will outline the literature relating to the way that different craft groups may be required to manage major trauma cases in rural and remote locations. This topic is important for this study as the relative lack of acute care resources in rural areas may dictate that a multi-disciplinary approach to major trauma management is required.

Lessons can be drawn from other medical disciplines that may be required to intubate patients. The maintenance of intubation skills for respiratory therapists has been studied, confirming that occasional performance of this skill did not maintain the skill and that theoretical study as well as practical training were of benefit in a skills maintenance program\(^{288}\). A further study found that simulation-based training improved the performance of techniques to manage a difficult airway by anaesthetists, and concluded that performance improvement lasted 6-8 weeks\(^{289}\). In relation to the performance of cricothyroidotomy, a life-saving technique that may be used as part of a failed intubation procedure, it has been recommended that training on mannequins is beneficial and reduces procedure time, although retraining times for optimal skill retention were not found\(^{290}\).

The importance of teamwork must also be considered in this setting. Although there is growing recognition of the importance of teamwork in the medical professions, the science of implementing teamwork training continues to develop\(^{291}\). Just as the previous example of intubation performance highlights the benefits of simulation training, simulation training is also reported to improve team skills in the medical setting. Ostergaard, Oestergaard and Lippert\(^{292}\) write that “In the field of medicine, team training aiming at improving skills such as leadership, communication, co-operation, and followership at the individual and team level seems to reduce risk of serious events and therefore increase patient safety”. A further Scandinavian study reported that trauma teams from 28 Norwegian hospitals highlighted leadership and communication as major obstacles during the management of actual trauma cases. Training courses were delivered, focussing on improved teamwork, communication skills and building common understanding of treatment priorities and principles. Participant’s course evaluations expressed a high perception of learning and the value of practical simulation, with staff from minor hospitals reporting the same high degree of benefit as staff from major hospitals. The authors concluded that “local team training is a feasible approach and team simulation offers an excellent opportunity to practise demanding and infrequent
challenges”, further highlighting that the use of simulation allows the integration of “interpersonal skills as well as communication and leadership under stress”. In fact, in a previous study, the same authors expressed the finding that leadership, co-operation and communication are the most essential team function components in low-frequency emergencies.

These studies show us that there is more to effective trauma management than simply applying skills or clinical guidelines. Human factors and team dynamics play a vital role in the management of crisis situations in the emergency care setting. These examples highlight that cognitive and interpersonal skills are as equally important as psychomotor skills, but may be more difficult to define, refine and practice. Ostergaard et al state that the educational value of simulation training for improving team performance in the medical setting comes from the ability to trigger emotional involvement. Further to this they suggest that if optimisation of team skills can improve patient safety, then such training should be integrated into the training of healthcare personnel at all levels.

By showing that training which develops cognitive as well as core clinical skills can improved trauma management by teams working in the hospital environment, it is reasonable to suggest that such training would also be of great benefit to teams working in an environment that is less controlled and less predictable. Although many trauma training programs for pre-hospital teams exist, programs that place equal focus on leadership, communication and teamwork as well as clinical skills seem to be lacking. The intention of the second part of this research project is to gain insight into the challenges faced by rural clinicians, and to offer solutions or strategies for ways in which issues relating to exposure and confidence may be overcome.

2.4.6 Knowledge and Skill Retention for Rural Clinicians

This section of the literature review will discuss the studies that have been undertaken in relation to rural pre-hospital care, and the lessons that may apply to other medical disciplines required to manage emergency and critical care patients in this setting.
The frequency of time critical emergencies in rural areas has implications regarding skill erosion and clinician confidence. Low frequency, high acuity cases present challenging clinical situations to practitioners who may have had formal training in their management but low exposure to actual cases. Examples of such cases in the pre-hospital setting would include major trauma, severe critical illness and critical paediatric (obstetric/neonatal) cases.

A study aimed specifically at the training of pre-hospital personnel in the management of spinal injuries, found that skill retention was poor in the absence of practical application or re-training\textsuperscript{299}. Other studies determined that surgical skill development required task-specific training\textsuperscript{300}, and that the development of critical and perishable surgical skills required programs that encompassed rapid skill acquisition followed targeted re-training at certain intervals\textsuperscript{301}. Interestingly, Stefanidis, Acker and Heniford\textsuperscript{302} suggest that some surgical skills were resistant to decay for up to 5 months following proficiency based training. A further study found that simulation has considerable value in maintaining complex procedural skills, with result suggesting that a single session of high fidelity simulation combined with practice and feedback could enhance skills maintenance for up to 12 months\textsuperscript{303}.

Additional studies have highlighted the importance of a specific curriculum for reinforcing Basic Life Support (BLS) skill retention\textsuperscript{304}, and that practical Advanced Life Support (ALS) skills decrease at 6 weeks and 12 weeks following dedicated ALS training\textsuperscript{305}. Another study found that BLS skills in the setting of infant cardiac arrest were less than optimal after a period of 6 weeks following refresher training\textsuperscript{306}. Other studies found that BLS and ILS skills deteriorated after 6 months following training\textsuperscript{307}, that brief “booster” training sessions improved skill retention in paediatric CPR\textsuperscript{308}, that intervals between CPR and AED refresher training for lay responders should not exceed 7 months\textsuperscript{309}, and that the characteristics of the participants may influence the timeframes needed for refresher training\textsuperscript{310}. Each of these findings has implications for the development of initial and refresher training programs that include clinical and practical skills, and provides an insight into the application of simulation training in critical care medicine.

In the pre-hospital setting it is generally accepted that loss of airway patency represents one of the most life-threatening complications of major trauma\textsuperscript{311}. Further to this, the setting in which pre-hospital intubations take place are considered “less than controlled” while presenting “the most
adverse conditions both in terms of environmental factors and patient’s clinical presentations\textsuperscript{311}. Pre-hospital airway management for trauma patients is therefore a good example of a critical care procedure that is susceptible to erosion, and which has implications for patient outcomes.

The role of airway management for severe TBI patients has been discussed in earlier sections of the literature review, and the suite of skills required in this process are susceptible to decay over time. In the absence of actual cases requiring this type of specific management, alternative training strategies may be required. A pilot study conducted in the United Kingdom was undertaken specifically to assess the impact of simulation training on the performance of pre-hospital anaesthesia\textsuperscript{312}. The study was undertaken as the researchers recognised that pre-hospital anaesthesia carried potential risks and could result in unnecessary morbidity and mortality if not performed correctly. Participants were tested on their performance at the beginning and end of a 10 day training package, with the results showing that although the mean time from arrival to tracheal cuff inflation increased in later simulations, the number of critical events per simulation decreased. All participants in the study reported an increase in confidence relating to their pre-hospital anaesthesia skills, and interestingly, there was a trend towards higher team work scores\textsuperscript{312}.

A 2008 study into paramedic skill retention relating to paediatric airway management concluded that targeted training strategies were vital in low-call-volume locations\textsuperscript{313}. The authors reiterated that paediatric airway skills were susceptible to decay, and that the process of endotracheal intubation suffered a more rapid decline when compared to bag-mask ventilation (BMV). Further to this, the authors suggested that a gap existed between paramedic self-efficacy and skill performance, with self-efficacy remaining high while skill performance deteriorated. An additional study in 2011 compared success rates between paramedic intervention and using ETI or supraglottic airway devices. The study found that the success rate for ETI deteriorated at 3 months after initial training while significantly higher success rates were maintained over the same period for supraglottic devices\textsuperscript{314}.

It is important to note that each of these studies has differences and limitations in their methodology, and that a detailed comparison would highlight inconsistencies regarding the findings. However, collectively these studies reinforce the notion that case exposure and “hands-on” application are vital for skills maintenance, and in the absence of regular practical skill application
specific strategies should be implemented in an effort to maintain high standards of clinical management and intervention. These problems are not isolated to particular medical disciplines or professions, and much has been written about the difficulties facing rural doctors and nurses. Little has been written about how these problems impact ambulance paramedics working in rural, remote and isolated communities. There is scope for further research to contribute to the current knowledge regarding the way that rurality impacts paramedic exposure to low-frequency high-acuity cases, and how this translates to decision making and clinical practice. This will be addressed in Part 2 of this overall study.

2.4.7 Caseload and Confidence for Rural Clinicians

This section will outline the literature discussing the relationship between case volume, clinician confidence and competence, and patient outcomes. Later sections of the literature review will discuss the implications of these concepts in relation to paramedic practice and the pre-hospital management of TBI in rural areas.

Several studies make reference to the relationship between case volume and outcomes from complex or less-frequent procedures\textsuperscript{23,315-317}. A study by Holt, Polaniecki, Loftus and Thompson\textsuperscript{318} found that hospitals that performed a higher annual volume of carotid endarterectomy, had lower patient mortality rates and shorter length of hospital admissions. Further studies highlight the inverse relationship between procedural volume and in-hospital mortality. Hannan et al\textsuperscript{319} discuss percutaneous angioplasty volume, Birkmeyer et al\textsuperscript{320} discuss high-volume hospitals and the risk of operative death, while Tu, Austin and Chan\textsuperscript{321} describe a relationship between outcomes following acute myocardial infarction and treatment by a high-volume physician. Findings by Glance et al\textsuperscript{316} suggest that “ICUs treating higher volumes of high-risk patients have lower mortality rates”, while Dudley et al\textsuperscript{21} make reference to the relationship between case volume and quality of care in general. Finlayson et al\textsuperscript{315} reinforce that operative mortality decreases as hospital volume increases, and add that high-volume exposure may be of the greatest benefit for elderly patients and higher-risk procedures or cases.
As an example, carotid endarterectomy (CEA) is considered the gold standard in the treatment of carotid artery atherosclerotic disease, with a recommended annual volume 70-80 procedures per hospital per year considered necessary to archive optimal patient outcomes. In this regard, the procedure may be considered to be low-frequency, high-risk. Similar findings have been described by Killeen et al in relation to invasive vascular procedures, elective and urgent abdominal aortic aneurysm (AAA) repair, oesophagectomy, and the management of sepsis. Collectively, these studies highlight the relationship between caseload and patient outcomes, yet the variety in procedures and case types presents difficulties in creating specific guidelines or recommendations for a set number of exposures applicable to any low-frequency high-risk event or intervention. Metzger et al suggested that more than 20 esophagectomies per year were required to reduce mortality, while Holt et al indicated greater than 43 AAA repairs per year were required to reduce mortality, while another study by Holt et al suggested a minimum of 35 procedures to attain the desired effect. Findings by Hogan and Winter support the correlation between surgical volume and improved clinical outcomes in oncology cases, but also offer some caution regarding the existing literature and previous studies.

Within these studies, it can be seen that there is great variance in the recommended number of procedures or exposures required to optimise patient outcomes. It can also be seen from these studies that a great degree of clarification is required regarding the relationship between overall hospital volume and patient outcomes, or individual clinician exposure and patient outcomes. It must also be noted that the weight of findings and quality of the studies varies greatly, although overall there seems to be a clear trend towards the concept that increased volume and exposure leads to improved performance and patient outcomes.

Killeen et al raise the following important points:

- Speculation on the mechanism underpinning the observed volume outcome correlation is challenging. It may represent a scenario of direct causality or “practice makes perfect”
- The issue is further confounded by the need to clarify if the inferior performance of low-volume providers is a universal phenomenon or whether a few high-volume providers simply overshadow low-volume providers.
• Volume as a surrogate measure of performance is easily determined from readily available data sources

An older study by Soreide et al \(^{325}\) highlighted the importance and need for anaesthetists working in the pre-hospital environment to undertake specific training and preparation in order to safely manage “uncommon but life-threatening” conditions. An additional study by Paal et al \(^{326}\) makes very clear recommendations regarding the advanced airway management and the volume-outcome relationship. This study states the following:

• An experienced health-care provider may consider prehospital anaesthesia induction.
• A moderately experienced health-care provider should optimise oxygenation, initiate hospital transfer and only try to intubate a patient in extremis.
• A lesser experienced health-care provider should completely refrain from intubation, optimise oxygenation, initiate hospital transfer and only in extremis ventilate with an alternative supra-glottic airway or a bag-valve-mask device. \(^{326}\)

Although the study does not offer any definitions relating to clinician experience, the authors suggest that regular training and exposure in the operating room and during simulation exercises is vital for maintaining skills, efficiency and performance \(^{326}\).

A prospective follow-up study of major trauma patients who survived following treatment at a series of emergency departments in the United Kingdom concluded that case volume was related to clinician performance and management of seriously injured patients, particularly those trauma patients with injuries to multiple body systems or a TBI \(^{327}\). This study suggests that case volume, or case exposure, has a direct relationship with clinical management. The way that case exposure impacts performance in the clinical setting remains an area of investigation within the literature, with certain studies highlighting the influence of caseload on clinician confidence.
A study aimed at determining the impact of a modified training program for combat medics highlighted issues very similar to those experienced by rural clinicians. Although the mechanism of injury, types of injury and complexity of the operational environment differ greatly, the authors highlighted several factors that inhibited combat medic confidence and competence. These are:

- Despite advances in training technology, opportunities for practical clinical in-patient assessment and emergency intervention are limited;
- The number of combat medics that require training is large;
- Time constraints surrounding existing training programs;
- There is a finite availability of severely injured patients\(^\text{328}\).

As mentioned, although these factors are raised in the military context they also have an application in the setting of rural practice. For example, an intensive care paramedic working in a quiet rural area may experience long periods of little exposure to major trauma cases, there may be few opportunities for skills maintenance and re-training, and the provision of training packages may be limited by the spread of intensive care paramedics across both rural and urban regions covered by a particular service. If these factors do impact clinician confidence, then it seems logical that rural paramedics may be susceptible to this.

The same authors reiterate that “one of the most important factors associated with increasing self-reported confidence and preparedness among combat medics is active clinical and field experience”, and that specific, deliberate, targeted training programs can shorten the learning curve between training and exposure\(^\text{328}\). An Australian study investigating confidence levels amongst emergency physicians (EPs) found a correlation between the percentages of time spent working in a clinical setting and the level of individual confidence when managing high acuity cases or performing low frequency procedures. The authors state:

EP spending 30-60% of their time on clinical work were more confident in managing sick children, ED orthopaedics and tube thoracotomy than colleagues with a lighter clinical load, but were less confident than colleagues spending more than 60% of their time clinically for central venous access and neonatal emergencies.\(^\text{329}\)
Both of these studies make the connection between recent and frequent clinical exposure and practitioner confidence. A further study in Kuwait reached the same conclusion after assessing self-reported levels of confidence in medical graduates following their intern year. The study found that the majority of interns had minimal exposure to relatively simple emergency resuscitative procedures, and that only a small number suggested they would be confident to perform the procedures without having any previous exposure\textsuperscript{330}.

The way that rurality impacts clinician confidence and performance may be subtle and difficult to pinpoint. Murphy\textsuperscript{331} provides a clear picture of the difference in approaches to TBI management between rural and urban hospitals, indicating that the focus at rural facilities is to provide initial treatment then transport to major centres, while the urban approach is to make a rapid diagnosis, determine the need for emergency intervention, and to provide intensive monitoring. These differences reflect the roles and responsibilities of rural and urban hospitals, but also suggest that levels of intervention and resourcing may differ. The underlying implication is that while the roles may differ, the volume and frequency of such cases may also differ between rural and urban areas. It follows that if urban centres receive TBI patients from multiple rural hospitals, then the urban centres will see a greater volume of TBI patients. This difference in volume, and therefore a difference in exposure for clinicians working in either rural or urban areas, is an important area for discussion within this thesis.

It follows that rural clinicians are particularly susceptible to skill erosion, but the ability to make complex clinical decisions also warrants some discussion. It seems reasonable to suggest that the difficulties associated with acute care, which affect rural populations, also affect rural practitioners. Rural practitioners in this context may be from varied backgrounds such as medicine, nursing or paramedicine. The classic dilemma in Australia is that rural populations desperately want and need competent and experienced clinicians, who have the ability to deal with general medical complaints but also have the ability to manage complex trauma and medical cases. The problem occurs when such practitioners do relocate to rural areas but then encounter minimal exposure to these complex cases. Regardless of a practitioner’s experience and background, skill maintenance becomes a problem. When a given rural practitioner is exposed to these cases, which may occur in a setting with limited support and long patient-care timeframes, although their skills are very much needed
they may feel anxious, lack confidence and perform below par. It is a difficult issue, and often an emotive issue.

In summary, these studies show that there appears to be a relationship between case volume and patient outcomes. Several studies make this correlation based on “institutional exposure” by referring to patient mortality and the volume of higher-risk cases managed at particular hospitals. Other studies make reference to individual clinician exposure, the risk of clinical errors and the potential impact on patient outcomes. These two perspectives perhaps represent opposite ends of the volume-outcome relationship, but both have relevance and importance to this study. This research will address the issue of volume of practice of skills in relation to both the impact of and effectiveness of trauma systems on patient outcomes, and the impact of low case volume on clinician confidence, confidence and performance.

2.4.8 Caseload and Performance in the Pre-Hospital Setting

This section of the literature review will outline the current knowledge specifically regarding the relationship between caseload and paramedic practice, building on the previous section. This section will focus studies related to high-acuity low-frequency cases, volume-outcome relationships and the impact of HEMS on road-based paramedic exposure, and team performance

Tomek\textsuperscript{332} writes, “paramedics often utilize advanced, high-risk, low-frequency clinical procedures” performed in a team environment that is required to operate together but rarely trains together. Such teams are referred to as ad-hoc high performance teams\textsuperscript{333-335}. The nature of these teams is that they are formed in high-consequence situations where the opportunity to develop and refine team processes has not been available. Critical cases in the pre-hospital environment create a need for these teams.

Two Australian studies make clear reference to the perception amongst paramedic students that they lack clinical exposure in their formative years. Lord and McCall\textsuperscript{336} make the important point that the establishment of appropriate clinical placements during student paramedic training requires
close communication between students, universities and ambulance services. Williams, Brown and Winship further highlight that paramedic students understand and value the importance of sound clinical exposure in during certain periods on consolidation. The recognition of this process amongst paramedic students goes some way to supporting the concept that volume, clinician confidence, clinical performance and possibly patient outcomes are connected.

In regards to specific pre-hospital interventions and the volume-outcome relationship in this setting, several studies make reference to lower frequency skills and cases. Chesters et al indicated that although pre-hospital RSI represented only 8–14% of missions attended by a UK HEMS service, that the introduction of SOPS could ensure safe application of this high-risk procedure. The study in fact reports a zero failure rate for this procedure implemented under these circumstances, however the results report on the number of “HEMS RSIs” rather than the number of “clinician RSIs”. Further to this, the study does not make reference to the number of RSIs previously performed by each clinician. A study by Barsuk et al also found that specific airway management focussed simulation training improved overall performance.

Discussions regarding the most appropriate crew configuration and taskings for primary HEMS retrievals are ongoing, yet the Victorian HEMS model utilises a single MICA flight paramedic as the attending clinician for the majority of primary taskings. It follows that if HEMS attend a greater proportion of severe TBI cases in rural areas, then HEMS paramedics are likely to have greater exposure to these case types when compared to the exposure of road-based paramedics. In a broader sense, this may lead to situation where the pre-hospital expertise in managing these cases remains relatively confined to a single group of clinicians, at the expense of those paramedics who may benefit from increased exposure.

A point to consider when discussing pre-hospital team performance is that the nature of such teams may in fact differ from those in the hospital setting. This is important, because when contemplating the best method to develop the less quantifiable skills of such teams (e.g., soft skills), the nature of the teams must first be understood.
The existing literature highlights that clinician confidence may be impacted by the frequency and types of cases attended, as well as the training programs utilised for initial and ongoing skill development. The literature also indicates a relationship between rurality and confidence, providing some indication of the issues faced by rural clinicians. It follows that the identification of deficits in clinical practice should be met with strategies aimed at correcting these problems, and the literature suggests that targeted simulation programs may provide this solution. The usefulness of simulation programs seems to depend on the context, focus, delivery and follow up of the programs, combined with the willingness of the participants to engage. This willingness to engage may be related to the level and accuracy of self-efficacy amongst the target audience. With these points in mind, following sections of the literature review will look more closely at factors specifically effecting paramedic decision making, particularly regarding the need to address low acute case-loads in rural areas. The relevance of such programs will be explored and considered in the context of the pre-hospital management of major trauma and severe TBI.

2.4.9 Factors Impacting Paramedic Decision Making

This section will begin with an outline of the current literature regarding the role of heuristics in clinical decision making. This type of decision making has relevance to paramedic practice, which is primarily governed by the use of guidelines and protocols. This will be followed by a review of the current knowledge surrounding the many factors that influence paramedic decision making in a range of circumstances and situations.

Heuristics and Clinical Decision Making

This section of the literature review will look at the specific influence of heuristics on clinical decision making. Heuristics make an important contribution to clinical decision making in emergency medicine and critical care, and warrant explanation and discussion in this thesis as specific parts of the methodology are aimed at determining factors that influence paramedic decision making and strategies that may be available to enhance this decision making ability for all medical disciplines tasked with managing low-frequency high-acuity cases, particularly in rural areas.
Mohan and Angus\textsuperscript{342} highlight factors impacting decision making in the critical care setting, highlighting that decision making may be influenced by “social, cognitive, and emotional factors”. The authors indicate that decisions in the critical care setting are further influenced by the environment in which a task is defined and the use of mental shortcuts, or heuristics. The authors suggest that heuristics provide “rapid, facile answers to complex questions”, but also that they are balanced by “rule-based” deductions. The authors further indicate that heuristics, or “automatic instinctive systems”, play a key role when clinicians are faced with “fatigue, time pressure, or cognitive overload”\textsuperscript{342}.

Evans\textsuperscript{343} provides a summary of four predominant clinical decision making models and theories, these are: pattern recognition, decision analysis theory, hypothetico-deductive reasoning, and intuition. A full description of each model is beyond the scope of this research, however heuristics fall predominantly under the decision making model of pattern recognition.

A study by Ghafouri et al\textsuperscript{344} articulates clinical decision making processes used by emergency physicians, concluding that rules-based processes such as heuristics were the most frequent tools used by doctors in this environment. Event-driven processes followed by skill-based processes were also used frequently, and used in that order respectively. The authors suggest that rules-based processes, which encompass “rules, heuristics, algorithms and clinical pathways” are useful in complicated situations because they provide a format or guideline that has been established from evidence-based practice\textsuperscript{344}. Such a foundation brings with it a degree of reliability and credibility, and allows the clinician to essentially follow a set of instructions, or a clear pathway.

Eva and Norman\textsuperscript{345} state in their commentary that the use of heuristics by clinicians can introduce bias into the clinical decision making process. The authors indicate that heuristics are very useful in the process of clinical decision making, but that they recognise that although a particular heuristic may be applied in an efficient and apparently appropriate manner, if the heuristic itself is inaccurate than medical errors are likely to occur. In other words, a decision making pathway may be followed correctly, but if the pathway has been incorrectly applied to the clinical presentation then a critical error may occur. The authors suggest that heuristics are necessary in emergency medicine and critical care, because these environments bring with them a mix of high volume routine case presentations and intermittent high-acuity presentations that require rapid assessment and
intervention provides a succinct summary, “Heuristics can be considered to simplify the complexity of clinical judgements”.

It has been recognised and accepted that clinical decision making is undertaken concurrently with, and is complimented and strengthened by, clinical judgement. Elliot discusses the interaction between decision making and judgement, highlighting that “in technical-rational decision-making the focus is on reaching an end-point, which in clinical judgement involves reaching an accurate diagnosis and treatment decision”. The author also reinforces the importance of relationship-building in the process of assisting decision making and supplementing judgement regarding a given clinical pathway. Elliot’s study complements the work done by Pelaccia et al that discusses the dual-process model of clinical reasoning that develops from a combination of analytical and non-analytical process such as intuition.

Studies highlight the positive use of heuristics in emergency medicine and critical care, whilst other reiterated that rational decision making was favoured over experiential decision making. Studies suggested that emergency physicians preferred hypothetico-deductive algorithms over rule-using algorithms (heuristics). Additional studies reinforced the importance of past experience in developing and effectively utilising heuristics, and the need for caution in the application of heuristics. Amin summarises this well by stating, “the success of heuristics-based reasoning is highly context and content-specific and depends on years of deliberate practice and reflection.”

Improvement in clinical decision making requires an understanding of the cognitive processes and influences outlined above, but also of strategies that may enhance this ability amongst clinicians. Alternative decision support strategies for rural clinicians warrant mention. Studies have been undertaken to investigate the application of checklists in clinical practice, as well as the potential benefits of telemedicine in the management of rural trauma and within the pre-hospital environment.

Collectively, these studies reinforce that sound clinical decision making processes are developed over time and rely on the integration of a range of cognitive processes. Several aspects of this
project aim to quantify how experience and exposure impact paramedic confidence, and how this in turn may impact paramedic intervention.

**Paramedic Decision Making**

As a major theme within this thesis is the paramedic application of RSI in areas of low caseload, it is important to understand the range of factors likely to influence paramedic decision making regarding the use of low-frequency high-risk procedures. This section of the literature review will outline the current knowledge regarding factors impacting paramedic decision making.

Ryan and Halliwell offer a concise appraisal of the way that paramedic decision making is made. The authors provide this summary of the key processes:

- The decision making process differs as paramedic experience increases
- Hypothetico-deductive reasoning (ruling in-ruling out) is a safe approach to patient assessment and primary survey
- Intuitive decision making, based on experience if often used but is likely to be less thorough and prone to error
- A mixed approach to decision making may be the most appropriate mode
- Different approaches to decision making between trainers and mentors may create a degree of friction and confusion

The points raised by Ryan and Halliwell indicate that there are many influences on the paramedic decision making process, and that experience over time may modify the way that this group of clinicians makes decisions. This highlights that the decision making process is dynamic, but their paper also suggests that certain influences may be identifiable.

The paramedic decision making process is framed by guidelines and protocols. Taghavi et al state that guidelines clearly assist paramedic decision making in specific circumstances, particularly in complex or less-frequently encountered cases. The case types referred to were cases requiring end-
of-life decisions or the termination of resuscitation efforts in palliative care cases. Although these case types differ considerably to the case types investigated in this study (ie, severe TBI cases requiring intervention with high-risk procedures), there are similarities in the need for clear structure and direction regarding what is required and expected by paramedics attending these cases. A study by Mengual, Feldman and Jones supports the Taghavi paper by indicating that clear “do not resuscitate” (DNR) orders are feasible and acceptable for paramedic practice.

Paramedic decision making in complex tasks has received some attention. Pitt found that paramedic decision making was accurate when choosing whether to administer pre-hospital thrombolysis. This particular procedure carries risks whether administered in the hospital or pre-hospital environment, and the study found that appropriate decisions were made by paramedics when guidelines were followed. The study mentions that there were discrepancies regarding pre-hospital and in-hospital decisions, suggesting that this arose from the use of more stringent inclusion criteria for paramedics. The message however, is paramedic decision making in high acuity cases can be accurate and appropriate, particularly when the boundaries and expectations are clear.

An additional study found that paramedic decision making was complex in the similarly challenging situation of a multi-casualty case. Arbon et al suggest that paramedics use triage tools as a foundation on which to make decisions in conjunction with their own skills and experience, as well as the skills and experience of the other attending crews. A study by Campeau offers further insight to the factors influencing paramedic decision making, including: creating a “what if” strategy, managing scene resources, clinical and non-clinical considerations, and uncertainty of diagnosis. Another study offered an insight into the stages of paramedic decision making, which range from pre-arrival, assessment on immediate arrival, continuing assessment, and making transport decisions. These points in particular will be investigated in later sections of this study.

Parsons and O’Brien discuss the process of paramedic decision making in the setting of mental health emergencies, and again make reference to the importance and influence of prior experience, clinical knowledge and tacit knowledge. Parsons and O’Brien focus on the paramedic management of mental health emergencies, using this as an example of a complex and dynamic case. The authors suggest that the use or protocols or guidelines in such cases is debatable, but that the combination of a clear intervention pathway, prior paramedic experience and underlying clinical knowledge may
offer the most reliable foundation for dealing with these types of emergencies. Without offering a clear solution, this article does raise the point that protocols and guidelines may not be useful in all cases.

A study by Pillay highlights the factors impacting paramedic decision making as they relate to the implementation of RSI. Pillay makes the following points:

- Decision making is based on a foundation of knowledge and judgement
- Clinical learning can be informal and informal
- Feedback and self-reflection are both important in developing clinical decision making skills
- Attitudes of colleagues, mentors and allied health personnel can impact decision making
- The appropriate application of RSI involves practical elements and human factors

It is important to also understand the way in which clinical errors impact decision making and the way in which decision making may lead to clinical errors. Brady suggests that the complexities of managing acute or critical patients in emergency situations, along with several other factors, contribute to the occurrence of clinical errors. The author concludes with two pertinent points: firstly, that mistakes can act as valuable learning tools, and secondly that mistakes must be identified before they can be utilised as learning tools. These points are relevant to this study as they articulate the presence of further factors that may influence paramedic clinical decision making, which in turn relate to the use of heuristics.

Erich offers a slightly different perspective of paramedic decision making, discussing how errors occur in this process, which educational strategies may be best at enhancing critical-thinking abilities, and what kind of support is needed for paramedics to actually practice that level of critical thinking. This article recognises that heuristics, as discussed in a separate section of the literature review, have the potential to bias and limit paramedic decision making. The author suggests that the use of selective rather than comprehensive information may result from repeated exposure to a particular case type, resulting in the clinician jumping to conclusions. The author also suggests that
in-field mentoring and support via medical oversight systems may be a possible solution to helping
paramedics develop more thorough decision making processes.

It is important to recognise the factors that lead to cognitive errors as it highlights the mix of inputs
that lead to both optimal and poor decisions in the field. Stiegler, Neelankavil, Canales and
Dhillon\textsuperscript{375} define cognitive errors as “thought process errors, or thinking mistakes, which lead to
incorrect diagnoses, treatments or both”. The authors highlight that although decision-making has
been studied thoroughly in other settings (such as aviation), it remains a relatively new field of
enquiry in the setting of anaesthesiology and critical care medicine. The findings of this study
highlighted that cognitive errors were frequent in this setting, but that most importantly they were
also identifiable. The authors conclude that, “identification of the most common cognitive errors is
crucial to developing appropriate training strategies for management and prevention”\textsuperscript{375}. These
findings and conclusions from the literature support the need for research aimed at determining the
factors that influence the paramedic decision making process in high-acuity low-frequency cases.

A study by Mohan et al\textsuperscript{376} found that cognitive processes contributed to persistent rates of under-
triage by physicians when managing trauma patients. The authors make reference to difficulty in
making decisions in complex situations and conclude that there has been little research on the way
that decision-making impacts trauma triage in real practice\textsuperscript{376}. Closely related to this is a study by
Mazzocco and Cherubini\textsuperscript{377} that found that a sound decision-making process could rationalise and
outweigh the outcomes from a similar case in the past. This finding again shows the interaction of
heuristics in the clinical decision making process but also indicates that heuristics can be managed.
To clarify this, the authors write, “The results of the present study suggest that a tendency to
overweight the importance of single, previous, poor outcomes may have ill effects on medical
practice”\textsuperscript{377}. An understanding of this process is also closely linked to clinician self-efficacy, which
has been found to vary amongst clinicians required to manage complex tasks\textsuperscript{378}.

Each of these studies are important in providing an insight into the factors that influence clinician
decision making in general, but also more specifically, paramedic decision making in critical
situations. The studies highlight the importance of training, experience and confidence and highlight
that many practical and human factors elements may contribute to sound decision making regarding
the application of high-risk procedures. The literature also suggests that the development of clinical
skills and competence also rely on the same factors. Each of these studies reiterates that further investigation is required to understand the effects of these processes on real practice. Part 2 of this thesis aims to compare levels of confidence and competence amongst rural and urban paramedics, in order to determine whether decision making regarding the application of the RSI procedure may be adversely affected when working in low-volume locations.

2.4.10 Training Modalities: Simulation Training in Low-Volume Settings

The use of simulation in medical practice is well-accepted, with its introduction originating from the aviation sector. Parallels can be drawn between the application of medical skills when managing severe trauma in both the pre-hospital and hospital settings. In both circumstances, practitioners are required to work under stressful conditions, and need to apply a combination of practical skills, clinical skills and theoretical knowledge. This section of the literature review will focus on the application of simulation training designed to develop both cognitive and psychomotor skills in the context of pre-hospital care, ad-hoc-teams and low-volume locations.

In order to develop strategies for improving clinical performance in any setting, cognitive factors impacting clinical-decision need to be understood. The interplay between confidence and competence in emergency medicine has been considered. Kessler and Burton\textsuperscript{379} states; “We believe that better-trained physicians can improve the quality of care and the health of patients. We have also long assumed the correlation between educational intervention and patient benefit to be a true assumption.” This indicates that educational strategies for medical professionals may have a direct relationship with the clinical management of patients. This may seem like a simple concept, yet it raises the point that although educational strategies may be available and are utilised, there is no guarantee that the implementation of these strategies will directly translate to improved practice and patient care. More specifically, this article in particular highlights that although current educational strategies may have been shown to improve clinician competence and confidence, this alone may not improve patient care. There needs to be a further step. The author suggests that step is “clinical outcomes-based medical education research”, which is designed to assess for gaps in patient safety and to identify medical errors\textsuperscript{379}. 

Factors impacting skill and knowledge retention are particularly relevant to the application of high-risk low-frequency skills. Studies have been conducted looking at skill and knowledge retention for medical personnel, with some findings suggesting that psychomotor skills are acquired more easily when access to self-guided instructional material is allowed\(^{380}\). Hallikainen et al\(^{381}\) highlight that the practice of emergency medicine involves multiple teams and disciplines throughout the pre-hospital and hospital phases. The authors further discuss that although this team approach is required, that education for medical students and paramedic students is often done in isolation. With the intention of furthering the combined group’s knowledge of pre-hospital emergency medicine, a course was established using theory sessions, case studies and practical-simulation. High-fidelity simulation was introduced as a new teaching method for the program. Student feedback was positive for the overall combined program and the full-scale simulation aspect rated highly. This further reiterates the importance of simulation training designed specifically to enhance team performance in low-volume settings.

The nature of pre-hospital care is that clinicians are often faced with diverse and physically challenging environments. Three factors that support the use of medical simulation are that simulators are safe, flexible and cost-effective\(^{382}\). In the pre-hospital setting the use of simulation training can expose practitioners to elements associated with stressful or hazardous environments without the risk of actual harm. This seems particularly important for clinicians likely to be faced with managing severely injured patients on an infrequent basis. In addition to this, the type of clinical presentation, the complexity of the case and the duration of the event can be modified and adapted to meet multiple training objectives. This further supports the development of targeted training for clinicians working in ad-hoc teams. The cost-effectiveness of this type of training comes from the ability to expose multiple trainees to a given scenario and for broader learning to occur during debriefs. In fact, the most beneficial learning has been reported to occur during debriefs that include the facilitation of self-reflection\(^{293,294,383}\).

If thoughtfully structured and delivered, medical simulation training may be conducted at a relatively low cost with minimal technology. The effectiveness of any program is likely to be based on its ability to meet clear educational objectives, and these objectives may be tailored to focus on different aspects of clinical practice. If the focus remains on the facilitation of lessons learned, such
programs can remain highly effective\textsuperscript{384,385}. Developing reflective practice amongst clinicians is likely to enhance preparation for the management of low-volume cases.

It seems reasonable to suggest that the maintenance of practical skills, communication skills and team integration skills are vital for optimal performance at low-frequency cases. Therefore if a program is aimed at skill acquisition then any training should focus on the real-time application of techniques, should utilise appropriate and up to date equipment, and should allow for repetition and scaling of complexity\textsuperscript{314}. If a program is aimed at communication, leadership and team performance, then a given scenario may be created with relatively little technology but designed in such a way to generate the desired inter-personal interactions\textsuperscript{293,294,383,386}. Combining the psychomotor or technical skills and the cognitive inter-personal skills would require considerable thought and structure to deliver an effective program\textsuperscript{339,387}. The literature also highlights that some of the greatest benefits reported by participants involved in medical simulation training include the lessons regarding effective teamwork, communication, decision making and leadership\textsuperscript{291,292,381}. This suggests that these cognitive and inter-personal skills play an integral role in the optimal management of high-acuity cases in low-volume settings.

The potential benefits of targeted simulation training in rural areas or regions affected by low caseload seem numerous\textsuperscript{302,388,389}. A mobile facility has the potential to create a “training outreach” service that can travel to small hospitals or ambulance stations within a given region. Such a facility could target specific needs identified by local clinicians and could target training at those cases which may require management by range of health professionals. Programs such as this have been trialled and accepted in rural regions in northern Norway\textsuperscript{293,383}.

Simulation programs aimed at improving the management of high-acuity low-frequency cases may need to include additional educational strategies. Brannan, White and Bezanson\textsuperscript{390} reiterate that lectures and discussions remain a key aspect of clinical learning but that “learner-centred strategies that actively engage students and involve decision making and realistic patient responses may be more useful for students learning complex content”. Further studies highlighted the importance of integrating teamwork into effective clinical practice, indicating that shared mental models, coordination, communication and leadership are all important factors in sound clinical practice\textsuperscript{391}. 
These points by Manser\textsuperscript{391-393} as well as Brannan et al\textsuperscript{390} offer insight into the holistic requirements of effective clinical education aimed at enhancing patient outcomes.

Two articles, one by Bond et al\textsuperscript{394} and one by Biese et al\textsuperscript{395} discuss the use of simulation specifically for more-complex and less-frequently practiced skills. Both articles acknowledge the positive impact of simulation on confidence and competence, but importantly also note that further studies are required to assess the impact of simulation on patient care and patient outcomes. Additional studies highlight the application of simulation training specifically for the maintenance of advanced airway skills\textsuperscript{312,339,396,397}. The studies are relevant to this research project’s interest in determining how confidence and competence may impact actual hands-on practice and clinical intervention.

Gerhardt et al\textsuperscript{328} consider the use of pre-deployment simulation and live-tissue procedural laboratories to train Army medics. The study reported that post-deployment surveys indicated increased levels of combat medic confidence and perceptions of preparedness for dealing with variety of severity levels relating to patient injuries. The most pertinent observation however was that “further research quantifying the objective differences in patient care that result from such training advances is warranted”.

Further to this, an Australasian study designed to detect differences in confidence amongst sub-groups of emergency physicians found the following:

- Men tended to be more confident than women
- Emergency physicians who have been working for longer or who work a lower percentage of clinical hours still maintain their confidence in most clinical procedures and tasks
- Emergency physicians working in private hospitals have less exposure and greater barriers to continuing education\textsuperscript{329}

These studies highlight the importance of including specific goals within targeted simulation programs aimed at enhancing clinical confidence amongst clinicians working in low-volume settings. The mentioned studies suggest that various factors impact clinician confidence, and support the
need for further research into the viability of specific clinical training strategies and programs in this area.

Numerous studies reinforce the benefits of simulation programs in the setting of emergency medicine and pre-hospital care, yet little research has been undertaken regarding the most appropriate training strategies designed to cater for paramedics or other clinicians who may be required to perform high-risk procedures with an ad-hoc team in a low volume setting. The second research area in this project will address these points specifically. The qualitative aspect of this study will investigate paramedic perceptions regarding which strategies they feel are likely to enhance and improve their clinical management of low-frequency high-acuity cases.

2.4.11 Interim Summary of Research Questions

This section of the literature review has brought together several concepts that relate to, and impact, the provision of emergency care in rural and remote locations. It is important to understand the broader concepts relating to defining and categorising rural locations, as this is a key aspect in determining the health and medical needs of non-metropolitan communities. The literature indicates that definitions and categorisation methods each have strengths and weaknesses.

This component of the literature review further highlights the disparity between rural and urban health outcomes and how social factors impact the health needs of communities and the way in which they interact with health care providers. This relationship has been explored in the context of emergency health and the differences surrounding pre-hospital care models in rural and remote locations.

This part of the literature review has further explored the way that clinicians from varying backgrounds may need to work together when managing high-acuity, low-frequency cases in rural locations. This has highlighted the subtleties and difficulties relating to clinician confidence and performance in low-volume settings. The final sub-sections have detailed the literature relating
specifically to paramedic decision making and training strategies, which may benefit paramedics and other rural clinicians working in low-volume settings.

Collectively, the review of the literature in this section has indicated a need for further research aimed at understanding the volume-performance relationship in the setting of rural paramedic practice. The following research questions will contribute to this body of knowledge.

**Research Questions**

**Study 5:**

1) Is there a difference in the overall number of rapid sequence inductions (RSIs), for all clinical presentations meeting criteria for intervention using this technique, performed by intensive care paramedics working in rural and urban areas within a state serviced by an established trauma system?

**Study 6:**

1) Is there a difference in the number of severe TBI cases that met pre-hospital RSI criteria, but where the procedure was not performed, between rural and urban areas within a state serviced by an established trauma system?

**Study 7:**

1) How do paramedic perceptions of case exposure and experience differ between rural and urban areas?
2) How do rural and urban paramedic perceptions differ regarding skills maintenance and performance?
3) Is there a difference between rural and urban paramedics’ attitudes towards intervention when faced with low-frequency, high-acuity cases?
4) Is paramedic confidence adversely impacted by low acute caseload?
2.5 Literature Review Summary

This review of the literature has established the current knowledge regarding the management of TBI, with a specific focus on pre-hospital care in rural and remote areas. Although many intervention strategies for TBI are widely accepted, the literature shows that new approaches to clinical management continue and that a degree of controversy remains regarding some strategies already in place. The paramedic use of RSI and the most appropriate utilisation of HEMS are examples of such areas within the literature.

Major trauma and severe TBI in particular, present a significant burden to individual victims and the wider community. The impact of TBI can be far reaching, in financial and societal terms, and this injury pattern is predicted to continue to grow as a major health concern in both developed and developing nations. Discrepancies between rural and urban outcomes following major trauma have been reported, and the development and maturity of trauma systems has gone some way to alleviating these differences. However, the relationship between rurality and outcomes following severe TBI remain inconclusive.

Outcomes following major trauma may be influenced by the effectiveness of trauma systems at the macro level, and the intervention provided by clinicians at the micro level. Rural communities may be disadvantaged in two regards: firstly by limited access to higher level trauma services; and secondly by the standard of care provided at a clinician level due to limited exposure to high-acuity cases. Although parts of the literature discuss both trauma system effectiveness and the relationship between case volume and standards of care, little has been written specifically regarding the impact of trauma system design and pre-hospital intervention on outcomes following severe TBI in rural locations.

The concept of rurality encompasses many factors relating to lifestyle, individual behaviours, access to services, the level of care available and outcomes following injury. Rurality has significance in the Australian and international settings, yet little is known regarding the impact of rurality on outcomes following severe traumatic brain injury.
Paramedic RSI appears to be growing in acceptance from most craft-groups working within emergency care, with findings suggesting that there may be a greater need for this intervention strategy in locations lacking direct access to higher level trauma care. Whilst the potential benefits of pre-hospital RSI are recognised in the setting of severe TBI, controversy remains regarding the use of this technique by paramedics. Research also shows that pre-hospital RSI should be utilised with caution, that in certain circumstances it may be detrimental to patient outcomes, and that the success of an RSI program relies on deliberate and structured training that incorporates skills maintenance opportunities. Regardless of the craft group performing pre-hospital RSI, case exposure, training and expertise remain inextricably linked.

The literature also suggests that there is a greater reliance of HEMS in rural and remote areas, but that appropriate utilisation of this resource involves a multitude of factors. The utilisation of HEMS in these locations also has the potential to further decrease the exposure of rural paramedics to the high-end decision making and intervention that they would be required to provide in the absence of HEMS. The literature shows that rural clinicians in general are susceptible to skill and knowledge erosion, and that long periods with decreased exposure to high-acuity cases can result in decreased clinical performance and decreased confidence.

These keys points from the literature indicate that there are still gaps in the knowledge surrounding the relationship between rurality and TBI outcomes, the use of HEMS in rural areas, and ways in which the confidence of rural clinicians may be impacted due to low case exposure. Using a range of data and statistical methods, this project aims to address these gaps and contribute to the existing understanding in each of these areas.
Chapter 3: Methodology

3.1 Introduction

This chapter outlines the research design chosen to address the research problem identified by this thesis, which is the impact of trauma system design and pre-hospital intervention on outcomes following severe TBI in rural locations. The mixed methods research design incorporates four studies relating to patient outcomes following severe TBI, and three studies relating to case-load and the effects on paramedic confidence and inclination/disposition to intervene with high risk procedures.

The chapter will begin with an outline of the research design, followed by the methods used to develop the study protocols and analysis process for the various quantitative and qualitative components of the mixed methods design.

3.2 Ethics Considerations

The collective studies received approval from the following human research ethics committees:

- Deakin University Human Research and Ethics Committee
  - 2010-141: Exemption from Ethics Review
  - 2011 – 162
- Justice Research Ethics Committee: CF/11/24591

These ethics approvals were required in order to access data from the VSTR, NCIS, VACIS, VACAR, and AV HR. Applications for data access were submitted to:

- Victorian State Trauma Outcomes Registry and Monitoring Group (VSTORM)
- National Coronial Information Service
- Ambulance Victoria Research Services Division
VSTSR data was accessed securely and remotely but was not stored in any location other than the VSTORM central server. Data and reports from the NCIS, VACIS, VACAR and AVHR were stored on the project's laptops for the duration of the project (used by principal researcher and associate researcher). Data was burned to CD to protect against hard disk failure.

No identifiable patient information was provided in the VSTR, VACIS or VACAR datasets. Individual paramedic identifiers were re-coded prior to being supplied to the principal researcher. Identifiable data was included in the NCIS cohort, but as this group included only closed cases, this information is freely available to the general public. Other details of a private or personal nature included in the NCIS reports were not disclosed. Focus group participants were referred to by an alias or participant code.

To mitigate information misuse, loss and unauthorised access, the laptops where the data reports were kept were strictly password protected, and are only used by the principal researcher and associate researcher. Backup CDs were locked in a filing cabinet. The data files were not accessible through networks, and were not available on shared university networks. No data files were emailed. Data was also secured through obscurity, by using coding in the reports.

3.3 Outline of the Study

3.3.1 Overview

This section will provide an overview of the entire project whilst also highlighting the aims, research questions and objectives for each individual study that makes up the research design.

This research project commenced as an epidemiological study of traumatic brain injury outcomes within an area serviced by a mature trauma system. The aim was to determine whether rural/urban differences in TBI outcomes were present, with the intention of identifying patient and system factors likely to influence outcomes. However, the structure and direction of the project changed
following analysis of the rural/urban TBI results. The research design was therefore iterative, and employed quantitative and qualitative methods as appropriate in a mixed methods approach.

3.3.2 Project Structure

Figure 1 shows the overall structure of this project. The overarching research problem is “The impact of trauma system design and pre-hospital intervention on outcomes following severe TBI in rural locations”. The research design can be divided into two distinct research areas:

- Research Area 1: an investigation of a systems approach to TBI management
- Research Area 2: An investigation of a clinician based approach to TBI management
Figure 1 indicates the primary research problem of interest in the project, the two key research areas, and each study within these research areas. The data source for each study is indicated in brackets. Each research area, and each study, are described and further expanded upon in the relevant methodology sections.

This project developed two distinct but complementary study areas. The first research area provides a “systems” understanding of the factors influencing TBI outcomes. The first research area focussed on the impact of rurality on TBI outcomes, from pre-hospital pre-intervention fatalities through to outcomes for TBI patients at 6 months post-injury. This research area included differences in the rural/urban profiles of TBI patients, differences in pre-hospital resourcing and staffing at severe TBI cases, and consideration of some of the system factors likely to influence TBI outcomes. Each study in this research area used a quantitative approach.

The second research area was developed following initial results that indicated greater HEMS utilisation for rural TBI cases and differences in the injury profile of severe TBI cases in rural areas. Findings from these areas suggested that road-based paramedics working in rural areas may encounter a lower acute caseload, with possible implications regarding clinical confidence and competence. The second section is clinician focussed, and utilises a mixed-methods statistical approach to measuring clinician experience and confidence.

The second research area involved the use of data from several sources, comprising both qualitative and quantitative components. The essence of the second research area was to determine the exposure of pre-hospital clinicians to TBI cases, and exposure of pre-hospital clinicians to the technique of rapid sequence induction for intubation. The second research area aimed to investigate rural and urban differences in paramedic confidence, based on caseload and exposure to trauma cases requiring critical intervention.

The two research areas are linked by the concept of rurality and the need to balance a systems approach to trauma management with strategies aimed at maintaining skills and knowledge.
amongst clinicians likely to have a low acute caseload. The rural/urban theme was continued throughout both research areas. The following sections of this chapter will outline and explain in detail, the methodology for each of the four studies within Research Area 1, and the three studies within Research Area 2. It is important to reiterate that no attempts at data linkage were made or intended between the VSTR, NCIS, VACAR or VACIS datasets.

3.4 Categorising Rural/Urban

3.4.1 ARIA+ Categories

The definition and categorisation of rural/urban was a central component of this study. In Australia, the development of geographical classifications such as the RRMA (Rural, Remote and Metropolitan Areas), ARIA (Accessibility/Remoteness Index of Australia), and the ASGC (Australian Standard Geographical Classification) systems have aimed to address the problem of defining rurality. ARIA+ is a continuous index ranging from 0 – 15 (high accessibility – high remoteness), and is based on road distances to the nearest service centres, of which there are 5 categories based on population size. The five distances to each level of service centre are divided by the mean distance for that category in Australia. The resulting score for each level of service centre are added (with a maximum limit of 3 being applied for any score), and an overall ARIA+ score is generated. The intention behind the use of ARIA+ was to focus on access to services, geographical factors, and resource allocation, as opposed to differences in lifestyle factors, community attitudes and individual behaviours in rural areas. The ARIA+ methodology was chosen as it provides a purely geographical measure of remoteness, it provides a continuum, and the methodology is clear, see image in Appendix F.

The ARIA+ system of defining rural/urban allowed categorisation of cases based on the postcode assigned to the location of injury. The ARIA+ system has 6 categories. Postcodes of injury from each case were matched with the postcode ranges within each ARIA+ category it was a matter of matching postcodes to each category and allocating a code within the dataset. Once the postcodes were matched to categories and re-coded, they were then divided into rural or urban. Table 3 outlines the postcode range, ARIA+ category and rural\urban classification:
Table 3 shows that some postcode ranges overlap. To overcome this, each individual postcode was allocated an ARIA+ category prior to re-coding. The SPSS syntax that was utilised can be viewed in Appendix P.

Cases classified as “Unknown Outside Victoria”, “NSW”, and “Tasmania” were removed from further analysis. Cases classified as “Unknown” and “Unknown in Victoria” were further investigated to determine whether rural or urban classifications could be allocated. These cases could not be allocated and were removed from analysis.
3.5 Research Area 1: Rural-Urban TBI Outcomes: The Impact of Trauma Systems

3.5.1 Study 1: In-Hospital Mortality and Functional Outcomes Following Severe TBI (VSTR)

Study 1 Aim

The aim of this study was to determine the influence of rurality and the impact of trauma system design on patient outcomes following severe TBI.

Study 1 Research Questions

1) Is there a difference in the profile of TBI patients between rural and urban areas?
2) Is there a difference in pre-hospital response to severe TBI cases?
3) Is there a difference in the type of hospital that severe TBI patients are first transported to?
4) Is there a difference in in-hospital mortality between rural and urban TBI patients?
5) Is there a difference in functional outcomes at 6 months post injury between rural and urban TBI patients?

Study 1 Hypothesis

Rural TBI patients will have higher in-hospital mortality and poorer functional outcomes at 6 months post injury when compared to urban TBI patients.
Study 1 Design

This investigation has been a retrospective case series analysis using data from the Victorian State Trauma Registry (VSTR). Traumatic head injury cases from between the period of the 1st of October 2006 and the 30th June 2009 were categorised as rural or urban by using the Accessibility and Remoteness Index of Australia (ARIA), and a comparison was made between these groups for the primary outcome measure of functional outcome at six months post-injury, and the secondary outcome measure of hospital mortality.

Study 1 Data collection

The data used for the first part of this project was accessed from the Victorian State Trauma Registry database, which has been used since 2000 to capture information from major trauma incidents in Victoria. The database was created during the implementation of a co-ordinated state trauma system, with the recognition that monitoring and reporting of trauma outcomes was integral to the effectiveness of the system and important for the review and refinement of trauma management practices in the state. The database was established, and is managed by, the Victorian State Trauma Outcomes Registry and Monitoring group (VSTORM). The VSTR collects data from pre-hospital and acute care services in order to identify all major trauma cases in Victoria.\textsuperscript{413-415}
**VSTR Inclusion and Exclusion Criteria**

All cases met the inclusion criteria for entry to the VSTR. These are outlined below:

Table 4: VSTR Inclusion and Exclusion Criteria

<table>
<thead>
<tr>
<th>VSTR Inclusion Criteria</th>
<th>VSTR Exclusion Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Any trauma patient with the principal diagnosis as “injury”, irrespective of age, who</td>
<td>The exclusion criteria for admission to the VSTR are:</td>
</tr>
<tr>
<td>also meet the following criteria:</td>
<td>- Isolated fractured neck of femur</td>
</tr>
<tr>
<td>- Died after injury</td>
<td>- Isolated upper limb joint dislocation, shoulder girdle dislocation (unless associated with vascular compromise)</td>
</tr>
<tr>
<td>- Admitted to an intensive care unit or high dependency are for more than 24 hours and</td>
<td>and toe/foot/knee joint dislocation (unless meets inclusion criteria)</td>
</tr>
<tr>
<td>mechanically ventilated after admission</td>
<td>- Isolated closed limb fractures only (unless meets inclusion criteria)</td>
</tr>
<tr>
<td>- Significant injury to two or more Injury Severity Score (ISS) body regions (corresponding</td>
<td>- Soft tissue injuries only (unless meets inclusion criteria)</td>
</tr>
<tr>
<td>to an AIS of &gt; 2 in two or more body regions) or an ISS greater than 15</td>
<td>- Burns to less than 10% body surface area (unless meets inclusion criteria)</td>
</tr>
</tbody>
</table>
| - Urgent surgery for intracranial, intra-thoracic or intra-abdominal injury, or fixation  | - Isolated injury to the eye  

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**Study 1 Inclusion criteria**

The inclusion criteria for Study 1 are listed below:

<table>
<thead>
<tr>
<th>Table 5: Study 1 Inclusion Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Definition</strong></td>
</tr>
<tr>
<td><strong>Period</strong></td>
</tr>
<tr>
<td><strong>Age</strong></td>
</tr>
<tr>
<td><strong>Location</strong></td>
</tr>
<tr>
<td><strong>Mechanism</strong></td>
</tr>
</tbody>
</table>

**Study 1 Exclusion criteria**

Paediatric patients, severe TBI resulting from penetrating trauma, and major trauma patients who did not sustain injuries to the head were excluded from this study.

**Study 1 Categorising Patient Factors**

The following section will outline the categorisation of patient and system variables, followed by the justification and validation measures associated with the use of these measures. The variables outlined are:

- Co-Morbid status
- Abbreviated Injury Score
- Injury Severity Score
- Glasgow Coma Scale
- Hospital Mortality
- Extended Glasgow Outcome Score
**Co-morbidity Status**

The patient’s co-morbidity status was measured using the 4 point grading scale of the American College of Anaesthesiologists (ASA)\textsuperscript{417,418}, outlined below:

**Table 6: Summary of ASA Co-Morbidity Status Categories**

<table>
<thead>
<tr>
<th>ASA Co-Morbidity Status</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Healthy:</td>
<td>Normal healthy patient, without known organic, physiologic or psychiatric disturbance (e.g. healthy with good exercise tolerance)</td>
</tr>
<tr>
<td>Systemic illness non-limiting:</td>
<td>A patient with controlled hypertension, controlled diabetes mellitus without systemic effects, cigarette smoking without evidence of COAD, anaemia, mild obesity, age less than one or greater than 70 years, pregnancy.</td>
</tr>
<tr>
<td>Systemic illness limiting normal activity:</td>
<td>A patient having medical conditions with significant systemic effects intermittently associated with significant functional compromise (e.g., controlled CCF, stable angina, old MI, poorly controlled hypertension, morbid obesity, bronchospastic disease with intermittent symptoms, chronic renal failure)</td>
</tr>
<tr>
<td>Systemic illness constant threat to life:</td>
<td>A patient with a medical condition that is poorly controlled, associated with significant dysfunction and is a potential threat to life (e.g., unstable angina, symptomatic COAD, symptomatic CCF, hepato-renal failure).</td>
</tr>
</tbody>
</table>

(There were a further 2 categories used in the VSTORM database requiring clarification: “Unknown” refers to patients with co-morbidities but details or classifications are unclear. “Not documented” refers to patients with co-morbidities not documented in the patient’s medical record)\textsuperscript{419}
**Abbreviated Injury Scale**

The Abbreviated Injury Scale (AIS) is “an anatomically based, consensus derived, global severity scoring system that classifies each injury in every body region according to its relative importance on a six point ordinal scale”\textsuperscript{420}. For this project therefore, only severe head injury cases only were investigated with an AIS $\geq 4$ were included.

**Injury Severity Score**

The Injury Severity Score (ISS) is considered to be the most widely used anatomical scoring system. The ISS is the sum of the squares of the highest AIS severity scores from three of six different body regions, with a maximum individual score of 25, and a maximum total score of 75. An ISS of greater than 16 is considered a severe injury requiring management at a major trauma centre\textsuperscript{421}.

The ISS body regions and computational formula are included in Appendix E. The ISS categories are shown below\textsuperscript{421}:

<table>
<thead>
<tr>
<th>ISS Score</th>
<th>Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>$&lt; 10$</td>
<td>Mild/Moderate</td>
</tr>
<tr>
<td>10 - 15</td>
<td>Serious</td>
</tr>
<tr>
<td>16 – 25</td>
<td>Severe</td>
</tr>
<tr>
<td>26 – 40</td>
<td>Severe/Critical</td>
</tr>
<tr>
<td>&gt;40</td>
<td>Critical</td>
</tr>
</tbody>
</table>

**Glasgow Coma Score**

Head injury severity was measured using the Glasgow Coma Score (GCS) recorded at initial arrival at the first treating hospital. Where GCS had not been recorded at hospital, the GCS recorded during
the pre-hospital phase of treatment was used. The GCS is used in many treatment protocols as an estimate of ‘time criticality’ and a trigger higher levels of care or intervention.

GCS was categorised to head injury severity as follows:

<table>
<thead>
<tr>
<th>GCS</th>
<th>Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;9</td>
<td>Severe</td>
</tr>
<tr>
<td>9 – 12</td>
<td>Moderate</td>
</tr>
<tr>
<td>13 - 15</td>
<td>Mild</td>
</tr>
</tbody>
</table>

**Study 1 Classification of Outcome Measures**

The outcome measures of hospital mortality and functional outcome at 6 months were categorised as outlined in the tables below.

Status at hospital discharge was classified and re-classified as follows:

<table>
<thead>
<tr>
<th>Initial Classification</th>
<th>Re-Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deceased</td>
<td>Deceased</td>
</tr>
<tr>
<td>Home</td>
<td>Not-deceased</td>
</tr>
<tr>
<td>Rehabilitation</td>
<td>Not-deceased</td>
</tr>
<tr>
<td>Nursing Home</td>
<td>Not-deceased</td>
</tr>
<tr>
<td>Special Accommodation</td>
<td>Not-deceased</td>
</tr>
<tr>
<td>Hospital for Convalescence</td>
<td>Not-deceased</td>
</tr>
<tr>
<td>Other</td>
<td>Not-deceased</td>
</tr>
</tbody>
</table>

The GOS-E, as a measure of functional outcome in trauma is widely used and accepted. For this project functional outcome at 6 months post-injury was re-classified into favourable and unfavourable outcomes. This re-classification as well as the strengths and limitations of GOS-E have been discussed in previous studies. Table 10 outlines the GOS-E classifications:
### Table 10: Functional Outcome Classifications

<table>
<thead>
<tr>
<th>Initial Classification</th>
<th>Re-Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Died</td>
<td>Unfavourable</td>
</tr>
<tr>
<td>2 Vegetative State</td>
<td>Unfavourable</td>
</tr>
<tr>
<td>3 Lower Severe Disability</td>
<td>Unfavourable</td>
</tr>
<tr>
<td>4 Upper Severe Disability</td>
<td>Unfavourable</td>
</tr>
<tr>
<td>5 Lower Moderate Disability</td>
<td>Favourable</td>
</tr>
<tr>
<td>6 Upper Moderate Disability</td>
<td>Favourable</td>
</tr>
<tr>
<td>7 Lower Good Recovery</td>
<td>Favourable</td>
</tr>
<tr>
<td>8 Upper Good Recovery</td>
<td>Favourable</td>
</tr>
</tbody>
</table>

**Study 1 Analysis**

Descriptive statistics and univariate analysis were used to identify and compare key variables within the rural and urban groups. This approach has been used in other studies investigating major trauma outcomes\(^1\,^{13,195,241}\). Multivariate analysis was used to assess the relative influence of the various patient and system factors that had been identified. The Mann-Whitney U Test was used to compare age distribution across the rural and urban groups. Pearson’s Chi Square was used to identify patient factor variables that would be included in the multivariate model, as well as identifying differences in the system factors between rural and urban groups. To determine the effect of rurality on in-hospital mortality and a favourable outcome at 6 months, a multivariate logistic regression model was used with adjusted odds ratios and 95% confidence intervals (CI) calculated. The models were adjusted for those factors significantly associated with the outcome at the univariate level and they were age, gender, cause of injury, co-morbidities, ISS and head injury severity.

A p value of < 0.05 was considered significant. Descriptive statistics and univariate analysis were undertaken using the Statistical Package for the Social Sciences SPSS (Version 17.0) and multivariate analysis was undertaken using Stata, Version 11.0 (StataCorp, College Station, TX).
3.5.2 Study 2: The Use of HEMS at Rural TBI Cases (VSTR)

Study 2 Aim

The primary aim of this study was to identify differences in the profile of severe TBI patients transported by road ambulance and HEMS. The secondary aim was to investigate the relationship between HEMS use and patient outcomes following severe TBI.

Study 2 Research Questions

1) Is there a difference in the proportion of severe TBI cases transported by HEMS between rural and urban areas of a state serviced by an established trauma system?

2) Is there a difference in the injury profile of patients transported by HEMS between rural and urban areas?

3) Does appropriate HEMS utilisation positively impact patient outcomes following severe TBI?

Study 2 Hypotheses

1. The appropriate use of HEMS in rural areas will result in TBI patients with the highest injury severity being transported directly from the scene to one of the Major Trauma Services.

2. HEMS resources manage a more severely injured cohort of TBI patients.

3. Appropriate HEMS utilisation contributes to favourable patient outcomes following severe TBI.
**Study 2 Design**

This study was a retrospective case series analysis using data from the Victorian State Trauma Registry (VSTR). This study, which investigated the use of HEMS within an established trauma system was undertaken in the same manner as the study comparing rural and urban TBI outcomes. The same dataset was used for both studies, therefore subject to the same timeframe as well as initial inclusion and exclusion. The HEMS cohort of cases was identified during univariate analysis of Study 1.

**Study 2 Inclusion Criteria**

All cases within Study 2 met the inclusion criteria outlined in Study 1. HEMS cases were identified based on the following criteria:

- Primary response via helicopter
- Primary response via fixed-wing aircraft

Less than 1% of cases received primary response via fixed-wing aircraft. As this method of primary response was likely to result in early pre-hospital intervention being provided by a MICA Flight Paramedic (MFP), these cases were included in the overall HEMS cohort.

**Study 2 Exclusion Criteria**

Exclusion criteria were the same as those outlined in Study 1.

**Study 2 Categorising Patient and System Factors**

The same patient factors used in Study 1 were used in Study 2.
**Study 2 Outcome Measures**

The same outcome measures used in Study 1 were used in Study 2.

**Study 2 Analysis**

This study adopted similar analysis techniques to Study 1. The Mann-Whitney U Test was used to compare age distribution across the rural and urban groups. Pearson’s Chi Square was used to identify patient factor variables that would be included in the multivariate model, as well as identifying differences in the system factors between rural and urban groups. To determine the effect of rurality on in-hospital mortality and a favourable outcome at 6 months, a multivariate logistic regression model was used with adjusted odds ratios and 95% confidence intervals (CI) calculated. The models were adjusted for those factors significantly associated with the outcome at the univariate level and they were age, gender, cause of injury, co-morbidities, ISS and head injury severity.

A p value of < 0.05 was considered significant. Descriptive statistics and univariate analysis were undertaken using the Statistical Package for the Social Sciences SPSS (Version 17.0) and multivariate analysis was undertaken using Stata, Version 11.0 (StataCorp, College Station, TX).

**3.5.3 Study 3: Pre-Hospital, Pre-Intervention Fatalities (NCIS)**

**Study 3 Aim**

The study of National Coronial Information System (NCIS) cases aimed to identify trends and differences in the rural/urban profile of pre-hospital pre-intervention fatalities attributed primarily to traumatic brain injury. This study was instigated following the Study 1 results indicating a trend towards higher in-hospital mortality in the urban TBI group.
**Study 3 Research Question**

1) Is there a difference in the characteristics of pre-hospital, pre-intervention deaths occurring as a result of severe TBI between rural and urban areas in a state serviced by an established trauma system?

**Study 3 Hypothesis**

Pre-hospital, pre-intervention fatalities occurring in rural areas as a result of severe TBI are more likely to involve young males and be related to road traffic incidents.

**Study 3 Design**

This study was a case review based on information from the NCIS. The NCIS is an internet data storage resource that contains information related to every death reported to an Australian coroner since mid-2000. It provides a tool for coroners to review similar cases when investigating particular deaths, while also serving as a hazard identification and death prevention tool for researchers.

Access to the NCIS was requested in order to substantiate trends in in-hospital mortality identified in Study 1. Rural and urban locations were allocated by linking postcode of injury location with ARIA+ (ASGC) categories. This was consistent with the rural/urban classification methodology used in all studies within the project.

**Study 3 Search Strategy**

The NCIS offers two avenues for identifying cases, one being referred to as a “Query Design”, and the other referred to as the “Coroners Screen”. The Query Design offers a very detailed search while the Coroners Screen offers a broad search based on key terms. This second option was used in Study 3 as due to variance in the terminology used within case reports, it was concluded that a
broad search for “trauma” fatalities was less likely to miss severe TBI cases. The timeframe for this study was based on that used in Study 1 to allow a degree of comparison between the findings.

**Study 3 Inclusion Criteria**

Inclusion criteria were consistent with the overall study design, focussing on adult patients suffering TBI as a result of blunt trauma. The following inclusion criteria were used for initial identification of cases:

Table 11: Study 3 Inclusion Criteria

<table>
<thead>
<tr>
<th>Case Type</th>
<th>Death due to external cause(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case Status</td>
<td>Closed</td>
</tr>
<tr>
<td>Search Keywords</td>
<td>“Trauma”</td>
</tr>
<tr>
<td>Period</td>
<td>1st January 2006 and the 31st December 2009</td>
</tr>
<tr>
<td>Age</td>
<td>&gt;/=16</td>
</tr>
<tr>
<td>Location</td>
<td>Victoria</td>
</tr>
<tr>
<td>General Type of Death</td>
<td>Fall/Jump</td>
</tr>
<tr>
<td></td>
<td>Traffic Incident</td>
</tr>
<tr>
<td></td>
<td>Vehicle Occupant</td>
</tr>
<tr>
<td></td>
<td>Pedestrian</td>
</tr>
<tr>
<td></td>
<td>Motorcyclist</td>
</tr>
<tr>
<td></td>
<td>Cyclist</td>
</tr>
<tr>
<td></td>
<td>Other</td>
</tr>
<tr>
<td>Intent Type</td>
<td>Unintentional</td>
</tr>
<tr>
<td>Work Relatedness</td>
<td>Not Applicable</td>
</tr>
<tr>
<td>Selected Documents</td>
<td>Findings</td>
</tr>
</tbody>
</table>
**Study 3 Exclusion Criteria**

Paediatric patients and those resulting from penetrating trauma were excluded primarily due to very small numbers of both of these types of cases. The following criteria were used to exclude cases from further analysis:

- Non-traumatic deaths
- Non-accidental deaths
- Paediatric cases
- Deaths outside Victoria

**Study 3 Case Review Process**

Once the appropriate cases were identified, both free text coroner’s findings and police reports were examined. Cases suitable for analysis were collated based on identification of the following terms within the free text:

**Reference to:** Head injury, brain injury, traumatic brain injury, TBI, trauma to the head

**Reference to death in hospital:** Yes/No

**Reference to ambulance attendance:** Yes/No

**Emergency services present at scene:**
- Police
- Fire Service
- Ambulance
- Others at scene


**Study 3 Analysis**

Analysis of the NCIS component continued with the focus on rural and urban differences, with the intention of identifying factors such as geographic constraints and case complexities, which may have influenced patient outcomes.

Rural and urban locations were allocated by linking postcode of injury location with ARIA+ (ASGC) categories. This was consistent with all aspects of methodology within the project. Rural/Urban comparisons were undertaken using the following variables:

- Age
- Gender
- Geographical location of injury (region)
- Isolated head injury or multi-system trauma
- Identification or geographic constraints: description
- Interventions or actions by others at scene
- Reference to patient access difficulties:
- Communication difficulties
- Reference to delays in emergency services attendance

Kappa scores were calculated to assess inter-rater reliability. A random sample of six cases (25% of total suitable cases) were identified and examined by a second investigator. The dichotomised variables of “Rural/Urban”, “Ambulance Attendance” and “Injury Pattern” were used to calculate the Kappa Coefficient\(^4\). The calculation of inter-rater reliability is considered a necessary process in reducing bias and error\(^5\) when conducting medical record reviews.

Due to the small number of overall cases (n=25), and the case numbers within each category, this data did not meet the assumptions for statistical testing using Pearson’s Chi Square\(^6\). Statistical analysis software used within this study included Statistical Packages for Social Sciences SPSS (versions 17-21), and Excel Statistics (Microsoft Office 2007, 2010). Descriptive analysis was comprised of cross-tabulations, frequency, range, percentage, mean and standard deviation.
3.5.4 Study 4: Pre-Hospital, Post-Intervention Fatalities (VACAR)

**Study 4 Aim**

The aim of this study was to investigate trends in the demographics and management of traumatic cardiac arrest cases, with head injury as the primary injury, which underwent paramedic resuscitation attempts. The study was based on the Study 1 results indicating a trend towards higher in-hospital mortality in the urban TBI.

**Study 4 Research Questions**

1) Is there a difference in the proportion of pre-hospital deaths occurring as a result of severe TBI, following attendance and resuscitation by pre-hospital clinicians, between rural and urban areas in a state serviced by an established trauma system?

2) Are there rural and urban differences relating to patient demographics and scene management during pre-hospital resuscitation of severe TBI cases resulting in cardiac arrest?

**Study 4 Hypotheses**

1) There is a higher pre-hospital mortality rate for patients who sustain a severe TBI in rural areas, despite pre-hospital resuscitation attempts.

2) Traumatic cardiac arrest cases occurring in rural areas, with severe head injury as the primary injury, have fewer attending paramedics and fewer procedures performed during resuscitation attempts.

**Study 4 Design**

This study, using VACAR data, was undertaken to compare rural/urban differences in pre-hospital deaths that occurred in Victoria, following attendance by ambulance resources. This study was
undertaken to further investigate the results from Part 1, which indicated a trend towards higher odds of in-hospital death for urban TBI patients.

The Victorian Cardiac Arrest Registry (VACAR) captures all cardiac arrests attended by Ambulance Victoria. The registry was established in 1999 and records information including response times, treatment and interventions performed by paramedics and outcomes following cardiac arrest. The registry acts as a resource for monitoring and improving pre-hospital cardiac arrest management, as well providing a rich source of data for various aspects of pre-hospital research. VACAR data was originally drawn from paper-based ambulance case sheets, but is now collected from the electronic Victorian Ambulance Clinical Information System (VACIS). VACIS was fully implemented in 2006. The VACAR also collects data from ambulance despatch records, hospital medical records and adult survivors at 12 months post cardiac arrest. Rural and urban locations were allocated by linking postcode of injury location with ARIA+ (ASGC) categories. This was consistent with the rural/urban classification methodology used in all studies within the project.

**VACAR Eligibility**

All cases met the VACAR inclusion and exclusion criteria as shown below:

<table>
<thead>
<tr>
<th>VACAR Inclusion Criteria</th>
<th>VACAR Exclusion Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patients of all ages who suffer cardiac arrest</td>
<td>Patients who suffer a cardiac arrest in a hospital facility, where Ambulance Victoria may be in attendance but is not the primary care giver</td>
</tr>
<tr>
<td>Occurs in the state of Victoria where Ambulance Victoria is the primary care giver</td>
<td>Brief episodes of pulselessness which do not receive cardiopulmonary resuscitation or defibrillation by EMS</td>
</tr>
<tr>
<td>Patients who are pulseless on arrival of EMS; OR</td>
<td>Bystander suspected cardiac arrest, where the patient is not in cardiac arrest on arrival of EMS, where a successful attempt at defibrillation did not occur no other evidence of verifying cardiac arrest is present</td>
</tr>
<tr>
<td>EMS witnessed arrests; OR</td>
<td></td>
</tr>
<tr>
<td>Patients who have a pulse on arrival of EMS, following successful bystander defibrillation prior to EMS arrival</td>
<td></td>
</tr>
</tbody>
</table>
**Study 4 Inclusion Criteria**

Inclusion criteria were consistent with the overall study design, focusing on adult patients suffering traumatic cardiac arrest, with severe head injury as the primary injury. The following inclusion criteria were used for initial identification of cases:

Table 13: Study 4 Inclusion Criteria

<table>
<thead>
<tr>
<th>Definition</th>
<th>All cardiac arrest cases classified as “traumatic arrest” with either isolated injuries to the head or face, or multiple injuries including injuries to the head or face.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Period</td>
<td>January 2006 – June 2011</td>
</tr>
<tr>
<td>Age</td>
<td>&gt;/=16</td>
</tr>
<tr>
<td>Location</td>
<td>Victoria</td>
</tr>
<tr>
<td>Survival to Hospital</td>
<td>Cardiac arrest cases that survived to hospital, and/or where resuscitation attempts were ceased at the scene or during transport</td>
</tr>
<tr>
<td>Other</td>
<td>Attended by Ambulance Victoria</td>
</tr>
</tbody>
</table>

**Study 4 Exclusion Criteria**

The following criteria were used to exclude cases from further analysis:

- Cardiac arrest from non-traumatic causes
- Paediatric cardiac arrest cases
- Cardiac arrest cases with other ambulance services providing primary care
Study 4 Analysis

Analysis of the VACAR component focussed on rural and urban differences, with the intention of identifying factors such as resourcing and clinical management, which may have influenced patient outcomes. Study 4 adopted a similar approach to the statistical analysis used in Studies 1 and 2.

Rural/Urban comparisons were undertaken using the following variables:

- Age and gender
- Geographical location of injury (region)
- Presence of palpable pulse on arrival: yes/no
- Presence of recordable blood pressure on arrival: yes/no
- Presence of spontaneous respirations of arrival: yes/no
- Isolated head injury or multi-system trauma
- Duration of scene management: minutes/hours
- Number of procedures performed at scene
- RSI performed: yes/no
- Paramedic skill set at scene
- Number of paramedics at scene

Statistical analysis software used within this study included Statistical Packages for Social Sciences SPSS (versions 17 – 21), and Excel Statistics (Microsoft Office 2007, 2010). Descriptive analysis was comprised of cross-tabulations, frequency, range, percent, mean and standard deviation. Where possible, comparisons were dichotomised in order to undertake analysis using Pearson’s Chi Square test. Due to small sample sizes and variance regarding distribution characteristics, a range of statistical tests were utilised. These included the Student’s t-test, the Mann-Whitney test, and the Independent Sample t-test. Where assumptions for statistical testing were not met in (e.g., low cell frequency), statistical tests were deemed inappropriate.
3.6 Research Area 2: TBI Management: Paramedic Confidence and Competence

3.6.1 Study 5: Rural-Urban Differences in Paramedic Exposure to RSI (VACIS/HR)

Study 5 Aim

The aim of this study was to investigate differences in exposure to the use of RSI between rural and urban paramedics.

Study 5 Research Question

1) Is there a difference in the overall number of rapid sequence inductions (RSIs), for all clinical presentations meeting criteria for intervention using this technique, performed by intensive care paramedics working in rural and urban areas within a state serviced by an established trauma system?

Study 5 Hypothesis

Rural MICA paramedics have lower exposure to cases requiring RSI for intubation, and therefore perform the procedure less frequently.

Study 5 Design

This study was undertaken to outline the exposure of rural and urban paramedics to the RSI procedure. Exposure to the RSI procedure was used as a surrogate measure of experience, based on several studies that highlight the relationship between procedural volume and patient outcomes. The study was also designed to illustrate associations between paramedic
experience, as measured by years at a given qualification level, and the frequency of use of the RSI procedure. This was intended to provide a discussion point relating to clinician experience and willingness to intervene with low frequency high-risk procedures.

**Study 5 Inclusion Criteria**

Data used for this section of the study was accessed via the Ambulance Victoria Research Services Division. Two data sets were used, one that provided case information relating to all RSIs that were undertaken during the 12 month period of 2011, and the other containing HR information relating to the employment status and qualifications of current, operational paramedics in Victoria.

<table>
<thead>
<tr>
<th>Source</th>
<th>Ambulance Victoria Human Resources dataset</th>
</tr>
</thead>
<tbody>
<tr>
<td>Period</td>
<td>Time of data collection (January 2012)</td>
</tr>
<tr>
<td>Cohort</td>
<td>All paramedics currently employed</td>
</tr>
<tr>
<td>Location</td>
<td>Victoria</td>
</tr>
</tbody>
</table>

**Table 14: Study 5 Inclusion Criteria**

<table>
<thead>
<tr>
<th>Source</th>
<th>Victorian Ambulance Clinical Information System</th>
</tr>
</thead>
<tbody>
<tr>
<td>Period</td>
<td>Jan 2011 – Jan 2012</td>
</tr>
<tr>
<td>Case Type</td>
<td>All cases where RSI was performed (adult and paediatric)</td>
</tr>
<tr>
<td>Search Term</td>
<td>“suxamethonium”</td>
</tr>
<tr>
<td>Location</td>
<td>Victoria</td>
</tr>
</tbody>
</table>

**Table 15: Study 5 VACIS Inclusion Criteria**
Study 5 Exclusion Criteria

The following exclusion criteria were applied to this study:

- Paramedics who ceased employment prior to January 2012
- Paramedics with a skillset of Graduate Ambulance Paramedic (GAP), BLS, or ALS
- Cases that met the criteria for intervention with RSI but where RSI was not performed
- Intubations that were achieved using IFS (Intubation Facilitated by Intubation) rather than RSI

Ambulance Victoria RSI Criteria

A dataset was provided by Ambulance Victoria Research Services Division that included all the RSIs undertaken in a 12 month period (2011). The RSIs included in this dataset were RSIs that were undertaken for any clinical presentation meeting the required criteria, not just for TBI. Under the Clinical Practice Guidelines used by Ambulance Victoria these criteria are very specific. The indications and contra-indications for RSI by AV MICA paramedics are shown in Table 16. Patients must have a GCS < 10 for RSI to be used by road-based MICA paramedics without consultation.

Table 16: Ambulance Victoria Indications and Contraindications for RSI

<table>
<thead>
<tr>
<th>Indications for RSI</th>
<th>Contra-Indications for RSI</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Traumatic brain injury</td>
<td>- The absence of functional capnography</td>
</tr>
<tr>
<td>- Non-traumatic brain injury (stroke or subarachnoid haemorrhage)</td>
<td>- Any contra-indications to the use of suxamethonium or pancuronium</td>
</tr>
<tr>
<td>- Hypoxic brain injury (post hanging, near drowning, post cardiac arrest)</td>
<td>- Coma due to uncontrolled haemorrhage</td>
</tr>
<tr>
<td>- Overdose (including tricyclic antidepressants, oxygen saturation &lt; 90% or prolonged transport)</td>
<td>- Respiratory failure</td>
</tr>
<tr>
<td>- Severe hyperthermia</td>
<td>- Diabetic keto-acidosis</td>
</tr>
<tr>
<td>- Status epilepticus</td>
<td></td>
</tr>
<tr>
<td>- Suspected airway burns (following consultation)</td>
<td></td>
</tr>
</tbody>
</table>
**Study 5 Data Collection**

This dataset outlined the skillset of the attending paramedics and the number of years qualified at the particular level. All variables used for analysis are shown in the table below:

<table>
<thead>
<tr>
<th>Variable</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Re-Coded Paramedic ID</td>
<td>Non-identifiable Indicator</td>
</tr>
<tr>
<td>Region</td>
<td>Rural or Urban as defined by ARIA+</td>
</tr>
<tr>
<td>Skill Set</td>
<td>MICA</td>
</tr>
<tr>
<td></td>
<td>CSO (Clinical Support Officer)</td>
</tr>
<tr>
<td></td>
<td>AAV (referring to MICA Flight Paramedics)</td>
</tr>
<tr>
<td>Years of Experience</td>
<td>Classified as either 1, 3 or ≥6</td>
</tr>
<tr>
<td>Number of RSIs</td>
<td>Numerical representation of the number of RSIs performed per paramedic</td>
</tr>
</tbody>
</table>

**Study 5 Variable Descriptions: Skillset**

The skill sets of MICA, CSO and AAV were included to act as pseudo indicators for overall experience as a paramedic. The MFPs and CSOs are considered to be very experienced paramedics, and although they may have undertaken these positions at varying times within their careers, the nature of these roles requires a very high level of knowledge and expertise. CSOs work both in a training and clinical role, undertaking tasks such as in-field audits, competency sign offs and responding to
time critical patients. MFPs work as the sole clinician on HEMS, undertaking both primary and secondary retrievals. MFPs are typically required to manage complex and unstable patients. It should be noted that MICA paramedics not qualified as CSOs or MFPs may be equally experienced, and the categories of skills sets are not meant to reflect a hierarchy of qualifications. These skill sets may be used as surrogates of experience when discussing the findings.

**Variable Descriptions: Experience**

The years of experience indicated for the skill set relate to the criteria used by AV’s HR department. The numbers do not refer to the paramedic’s overall years of experience, but only to the number of years they have been qualified at a particular skill set. For instance, “MICA 1 year” indicates a MICA paramedic who has been qualified for one year at that level, however “MICA 6 years” indicates a MICA paramedic who has been qualified at that level for a minimum of six years. The reference to “years” in each category does not indicate the total number of years a particular paramedic has been employed, for example a paramedic listed as “MICA 1 year” may have been working as an ALS paramedic for many years prior to gaining MICA accreditation.

**Study 5 Analysis**

Statistical analysis was undertaken using SPSS (versions 17 – 21), and Excel Statistics (Microsoft Office 2007, 2010). Analysis was based on comparison between rural/urban groups, skill sets, and a combination of skill sets and years of experience. Further analysis was undertaken to assess rural/urban differences in the number of attending MICA paramedics as cases that required RSI. Basic descriptive statistics were undertaken, providing the mean and 95% CI.
3.6.2 Study 6: Inclination to Intervene with Higher Risk Procedures (VACIS)

Study 6 Aim

The aim of this study was to identify severe TBI cases where the RSI procedure was indicated but was not performed, and to compare the occurrence of such cases between rural and urban groups. This study used VACIS data.

Study 6 Research Question

1) Is there a difference in the number of severe TBI cases that met pre-hospital RSI criteria, but where the procedure was not performed, between rural and urban areas within a state serviced by an established trauma system?

Study 6 Hypothesis

Due to decreased paramedic exposure to severe TBI cases in rural areas, there are a greater proportion of these cases that meet the criteria for intervention with RSI for intubation but where this intervention is withheld by road-based paramedics.

Study 6 Design

This study used mixed methods to identify TBI cases where the use of RSI was indicated but not performed. Quantitative methods were used to identify cases where RSI was indicated, and qualitative case reviews were then undertaken to determine whether the procedure had been withheld by road-based intensive care paramedics. The identification of such cases was intended to represent difference in clinician confidence and willingness to intervene with high-risk procedures. Several studies make reference to the relationship between clinician experience, exposure and
confidence\textsuperscript{336,331,332}. The study was designed to complement Study 5, which provided an indication of rural and urban differences in exposure to the RSI procedure for any clinical intervention.

Table 18: Study 6 Inclusion Criteria

<table>
<thead>
<tr>
<th>Study 6: Willingness to Intervene with Higher Risk Procedures</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Data Source</strong></td>
</tr>
<tr>
<td><strong>Period</strong></td>
</tr>
<tr>
<td><strong>Location</strong></td>
</tr>
<tr>
<td><strong>Injury Type</strong></td>
</tr>
<tr>
<td><strong>Glasgow Coma Score (GCS)</strong></td>
</tr>
</tbody>
</table>

**Study 6 Exclusion Criteria**

The original VACIS RSI dataset included all cases that met the inclusion criteria. A number of these cases did not meet the criteria for intervention with the RSI procedure. The following exclusion criteria applied to this study:

- Intubation was achieved using IFS
- Paediatric cases, age <=15
- Cases that met the Injury Type and GCS criteria but did not meet AV indications for RSI (as outlined in Study 5)
Study 6 Data Collection

For each case, the following variables were collected:

Table 19: Study 6 Variable Categories

<table>
<thead>
<tr>
<th>Patient Details:</th>
<th>Administrative:</th>
<th>General:</th>
<th>Clinical Assessment:</th>
<th>Clinical Management:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>Case/patient ID</td>
<td>Casenature</td>
<td>Vital Signs Survey</td>
<td>Medications (all)</td>
</tr>
<tr>
<td>Gender</td>
<td>(de-identified</td>
<td>Assessment</td>
<td>Pulse</td>
<td>Procedures (all)</td>
</tr>
<tr>
<td></td>
<td>matching variable)</td>
<td>RSI Indicator</td>
<td>Blood pressure</td>
<td></td>
</tr>
<tr>
<td>Case date</td>
<td></td>
<td>Major Trauma</td>
<td>(systolic/diastolic)</td>
<td></td>
</tr>
<tr>
<td>Postcode</td>
<td></td>
<td>Indicator</td>
<td>Respiratory rate</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Number of Teams</td>
<td>GCS</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Attending</td>
<td>Temperature</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Deceased Indicator</td>
<td>Skin</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Dispatch Code</td>
<td>(colour/temperature</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Transport Flag</td>
<td>e/moisture)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Case Description</td>
<td>VSS re-assessment</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(free text)</td>
<td>Secondary Survey</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>and Repeat</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Assessments</td>
<td></td>
</tr>
</tbody>
</table>

Study 6 Data Matching

The raw VACIS data was provided in four Microsoft Excel 2010 files. Each file shared the common variable of “Case/Patient ID” that was a unique, re-coded identifier. This variable was used to combine each file into a complete VACIS head injury dataset. Duplicate cases were identified and removed.

In order to create meaningful data for this section of the study, the VACIS RSI and HR datasets first had to be combined. This was required because the RSI dataset only provided a re-coded, non-identifiable, numeric variable for the paramedics who attended a given case, but did not include any
information regarding their qualification and years of experience at a given qualification level. The HR dataset, on the other hand, included information regarding the number of personnel at a certain qualification level and how many years of experience they had at that level. The HR dataset included a re-coded, non-identifiable, numeric variable for each paramedic listed.

The VACIS dataset contained a re-coded paramedic identifier but no reference to their skill set/qualifications. The AV HR dataset contained the same re-coded paramedic identifier. The two datasets were combined using this key variable, therefore providing an indication regarding the attendance of MICA paramedics and MICA Flight Paramedics at TBI cases within the study period. Limitations regarding this process and methodology will be discussed in later sections.

Study 6 Qualitative Search Strategy

In order to identify cases from the combined VACIS RSI and AV HR datasets, the following searches were undertaken:

<table>
<thead>
<tr>
<th>Table 20: Study 6 Qualitative Search Strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Search 1 “RSI Not Performed”</strong></td>
</tr>
<tr>
<td>- Primary injury = “Head Injury”</td>
</tr>
<tr>
<td>- RSI = No</td>
</tr>
<tr>
<td>- Deceased = No</td>
</tr>
<tr>
<td>- MICA in attendance</td>
</tr>
<tr>
<td>- AAV not in attendance</td>
</tr>
</tbody>
</table>

This search strategy was utilised to identify cases within the combined dataset where RSI was indicated for the management of TBI, but where the procedure was not performed. In order to identify these cases, further details were required from the free text case descriptions.
**Study 6 Medical Record Review**

The case descriptions from all suitable cases identified from Search 1 and Search 2 were collated and numbered in Word files. Two simple searches were then conducted on each file. The search terms used were “RSI” and “GCS”. These searches identified 7 “RSI Performed” cases, and 44 “RSI Not Performed” cases for further review.

Each free-text case description was then studied in order to identify cases where the RSI procedure had been indicated for intervention for patients with severe TBI. Case descriptions were compared against the AV Clinical Practice Guidelines, and any reference to delays in the application of the RSI procedure were noted. Cases were then classified as follows:

1. Inconclusive
2. Patient improved
3. Paediatric patient
4. Case-sheet completed by non-MICA crew
5. RSI not performed by road-based MICA crew due to close proximity to hospital
6. RSI performed by HEMS
7. Potential delay in use of RSI by road-based MICA crew
8. RSI not indicated

**Study 6 Analysis**

The application of the search protocol and classification procedure identified a very small cohort of cases for analysis (N=10). These cases were considered to have potentially met the criteria for intervention with RSI, but the procedure was either withheld or not performed. Each of the ten case descriptions were studied by two reviewers (BF and TB), which is considered an appropriate
strategy to reduce bias in the process of medical record reviews\(^{426,427,433,434}\). Due to the lack of consistency in case descriptions, no further analysis (such as calculation of the Kappa Coefficient) was undertaken. The very small number of cases identified and the lack of comparable information contained in the free-text case descriptions precluded statistical analysis. The variability in the quality and volume of information contained in the case descriptions made meaningful comparison unfeasible.

### 3.6.3 Study 7: Paramedic Confidence and Competence (Focus Groups)

**Study 7 Aim**

The aim of this study was to determine the perceptions held by both rural and urban paramedics regarding their exposure to high-acuity cases and how this influenced their clinical confidence and competence.

**Study 7 Research Questions**

1) How do paramedic perceptions of case exposure and experience differ between rural and urban areas?

2) How do rural and urban paramedic perceptions differ regarding skills maintenance and performance?

3) Is there a difference between rural and urban paramedics’ attitudes towards intervention when faced with low-frequency, high-acuity cases?

4) Is paramedic confidence adversely impacted by low acute caseload?
Study 7 Design

This qualitative study of paramedic perceptions regarding exposure, experience and clinical confidence utilised focus group discussions and thematic analysis. The initial intention was to conduct group interviews with small rural and urban groups, and to also undertake a service-wide survey. At the time of application to Ambulance Victoria, the iterative nature of the overall study design suggested that focus groups would be more appropriate than surveys in this setting. Analysis of previous studies within this project indicated a need for rich, descriptive data. Emerging research questions related to the importance of team composition, team work and the dynamics involved in acute patient management in rural and remote locations. This reinforced the importance of discussing these issues amongst groups of practitioners, thereby supporting and justifying the inclusion of focus groups within the qualitative research aspect of the overall project design.

Focus groups were utilised for this study based on methodologies used in other aspects of EMS/paramedic research. Walsh, Cone, Meyer et al. suggest that quantitative methodology is useful in pre-hospital research for providing “a theoretical underpinning for subsequent survey construction, quantitative studies, and behavioural interventions”. Additional studies with a pre-hospital focus reiterate the usefulness of focus groups for collecting information on relatively unknown topics, and for understanding cultural beliefs and perceptions. These studies highlight the usefulness of focus groups for pre-hospital research, reinforcing the use of this research method to understand perceptions and multiple views regarding complex topics. It should also be acknowledged that this research design is limited in regards to generalizability and transferability and that the application of tests of validity are considered useful.

Based on best practice research using focus groups, focus groups were designed to include 8–12 participants each. An email was sent out to all MICA paramedics employed by Ambulance Victoria during the study period, outlining the project structure, aims and purpose of the focus groups. It was highlighted that participation was voluntary and that confidentiality would be maintained regarding all aspects of the study. A Plain Language Statement was attached to the email (Appendix K).
Participants were asked to respond and express their interest either by email or phone. Two groups were recruited with participants from rural and urban locations. The focus group interviews were conducted at suitable and convenient locations for the participants. The focus group questions and prompts were semi-structured and were designed to generate discussion regarding the central themes of experience, exposure and clinician confidence. The focus group guide can be viewed in Appendix L. Each focus group was recorded using a primary and secondary audio recording device, and transcription was provided via a professional service. Transcription was considered necessary to avoid complications resulting from interviewer recall, bias, and variability in note taking. Audio recording and transcription allowed the researcher to concentrate on the focus group process, the dynamics within the each focus group, and to create the opportunity for each participant to contribute. Samples of both the rural and urban transcripts can be viewed in Appendices M and N.

**Study 7 Thematic analysis**

**First Level Coding**

Thematic analysis was undertaken utilising first and second level coding. Transcripts were coded by the researcher (BF), and checked for reliability by a second coder (SK). The final coding followed a discussion of the differences between the two coders (BF and SK). First level coding was based on central themes identified in the literature. The themes utilised in first level coding are outlined in Table 21 (p 126):
Table 21: Rural-Urban Paramedic Focus Groups: First Level Coding

<table>
<thead>
<tr>
<th>Code</th>
<th>Theme</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Confidence</td>
</tr>
<tr>
<td>2</td>
<td>Case exposure</td>
</tr>
<tr>
<td>3</td>
<td>Paramedic resources</td>
</tr>
<tr>
<td>4</td>
<td>Training</td>
</tr>
<tr>
<td>5</td>
<td>Feedback</td>
</tr>
<tr>
<td>6</td>
<td>Other medical disciplines</td>
</tr>
<tr>
<td>7</td>
<td>RSI training</td>
</tr>
<tr>
<td>8</td>
<td>Soft skills</td>
</tr>
<tr>
<td>9</td>
<td>Simulation training</td>
</tr>
<tr>
<td>10</td>
<td>Availability for training</td>
</tr>
<tr>
<td>11</td>
<td>New information/changes in practice</td>
</tr>
<tr>
<td>12</td>
<td>Single Responder Unit (SRU) model</td>
</tr>
</tbody>
</table>

**Second Level Coding**

Following identification of the principal themes, further analysis was based on emergent themes within each key topic\(^{408,433,440,441}\). A sample of second level coding and themes can be seen in the table below, the full table can be viewed in Appendix P.

Table 22: Rural-Urban Paramedic Focus Groups: Second Level Coding

<table>
<thead>
<tr>
<th>Code</th>
<th>Theme</th>
</tr>
</thead>
<tbody>
<tr>
<td>1:1</td>
<td>Confidence is related to regular exposure</td>
</tr>
<tr>
<td>1:2</td>
<td>Confidence is related to high volume of work</td>
</tr>
<tr>
<td>1:3</td>
<td>Confidence is impacted by fatigue</td>
</tr>
<tr>
<td>1:4</td>
<td>Confidence is impacted by feedback after a case</td>
</tr>
<tr>
<td>2:1</td>
<td>Exposure to TBI cases is low</td>
</tr>
<tr>
<td>2:2</td>
<td>Exposure to TBI cases is high</td>
</tr>
<tr>
<td>2:3</td>
<td>RSIs are performed frequently</td>
</tr>
<tr>
<td>2:4</td>
<td>RSIs are performed infrequently</td>
</tr>
</tbody>
</table>
The first and second level coding process was undertaken by two researchers (BF, SK). Each coder initially undertook this process individually, which was followed by discussions to identify differences regarding interpretation. The two researchers agreed on most first-level and second-level coding, and the discussion process highlighted discrepancies. These discrepancies were considered within the context of the study aims, research questions highlighted by previous findings within the project, and key emergent themes within the focus group responses. Similarities and differences in the responses between rural and urban groups were summarised and discussed. The qualitative findings were discussed in the context of the quantitative findings from the other studies in this project. This was considered an important process for reducing bias.

3.6.4 Chapter 3 Summary

This chapter has provided an outline of the methodology and processes utilised within the two main research areas and seven individual studies within each of these areas. Each of the seven studies were linked by the central theme of differences between rural and urban TBI outcomes, with studies one to four focussing on aspects of trauma system design, and studies five to seven focussing on intervention at a clinician level. A key aim of the overall project was to investigate factors likely to impact patient outcomes following severe TBI from both a systems and individual clinician perspective.

The first four studies investigated patient and system factors across a spectrum of severe TBI cases. This spectrum included pre-hospital pre-intervention fatalities, pre-hospital post-intervention fatalities, TBI cases that survived to hospital but were deceased prior to discharge, and TBI cases that survived and were discharged from hospital. The remaining three studies focussed on factors likely to impact paramedic intervention at TBI cases, particularly regarding the utilisation of RSI. Pre-hospital RSI was used to represent a high-risk skillset susceptible to erosion.

As detailed in this chapter, the methodology incorporated quantitative and qualitative research strategies. The data collection process resulted in certain aspects of the study developing sequentially, while others were undertaken concurrently. The first study, relating to in-hospital mortality and functional outcomes following severe TBI, was the catalyst for the studies that
followed. The following chapter will present the quantitative and qualitative results from each of these studies.

Chapter 4: Results:

Introduction

This chapter will provide the results from each of the seven studies conducted within the two main research areas. This chapter is structured to reiterate the individual study aims, research questions and hypotheses. Although these areas have been articulated in the Methodology chapter, it was considered important to again highlight these details due to the broad range and nature of the studies conducted. The results will be provided in tabular, graphical and descriptive formats.

Research Area 1: Rural-Urban TBI Outcomes: The Impact of Trauma Systems

4.1 Study 1: In-Hospital Mortality and Functional Outcomes Following Severe TBI (VSTR)

4.1.1 Overview

This set of results relate to the rural/urban comparison of functional outcomes and in-hospital mortality following TBI in Victoria, Australia. Data was sourced from the VSTR.
Research Questions

1) Is there a difference in the profile of TBI patients between rural and urban areas?

2) Is there a difference in pre-hospital response to severe TBI cases?

3) Is there a difference in the type of hospital that severe TBI patients are first transported to?

4) Is there a difference in in-hospital mortality between rural and urban TBI patients?

5) Is there a difference in functional outcomes at 6 months post injury between rural and urban TBI patients?

Hypothesis

Rural TBI patients will have higher in-hospital mortality and poorer functional outcomes at 6 months post injury when compared to urban TBI patients.

4.1.2 Results – Univariate Analysis

There were 2658 cases that met the inclusion criteria, and 261 cases were excluded because the location of injury was not a Victorian postcode or an ARIA+ designation could not be made (Figure 1). There was an association between age, gender, pre-injury health status, injury profile and location of injury. The rural cohort was comprised of sub-groups ranging from “inner regional” to “remote”. The breakdown within these sub-groups was: inner regional (n=417), outer regional (n=167), remote (n=12). This shows that 70% of the rural cohort was injured in inner regional locations and only 2% were injured in remote locations (Figure 2, Figure 10 Appendix F).
The rural group was younger and included a higher percentage of males (Table 23). There was a lower proportion of patients with serious co-morbidities, a higher proportion of isolated head injuries and a higher severity of head injury (measured using the GCS), in the rural group compared to the urban group (Table 23). The most common causes of head injury in both the rural and urban groups were transport crashes and falls. The rural group had a higher proportion of motor vehicle crashes and the urban group a higher proportion of falls from a height <1m (Table 23).
Table 23: Injury Profile of Severe TBI Patients in Victoria 1st October 2006 - 30th June 2009

<table>
<thead>
<tr>
<th>Variable</th>
<th>Rural</th>
<th>Urban</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age: Median (IQR) years</strong></td>
<td>48 (27-71)</td>
<td>59 (31-80)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td><strong>Gender: n (%)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>430 (72)</td>
<td>1201 (67)</td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>166 (28)</td>
<td>600 (33)</td>
<td>0.013</td>
</tr>
<tr>
<td><strong>Comorbidity Status: n (%)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No serious illness</td>
<td>372 (73)</td>
<td>852 (56)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Serious illness</td>
<td>141 (27)</td>
<td>661 (44)</td>
<td></td>
</tr>
<tr>
<td><strong>ISS Categories: n (%)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16 - 25</td>
<td>296 (50)</td>
<td>1068 (59)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>26 - 40</td>
<td>196 (33)</td>
<td>520 (29)</td>
<td></td>
</tr>
<tr>
<td>40+</td>
<td>104 (17)</td>
<td>210 (12)</td>
<td></td>
</tr>
<tr>
<td><strong>GCS Group: n (%)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13-15</td>
<td>337 (57)</td>
<td>1113 (63)</td>
<td>0.009</td>
</tr>
<tr>
<td>9-12</td>
<td>76 (13)</td>
<td>233 (13)</td>
<td></td>
</tr>
<tr>
<td>3-8</td>
<td>177 (30)</td>
<td>419 (24)</td>
<td></td>
</tr>
<tr>
<td><strong>Isolated TBI or Multiple Injuries: n (%)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Isolated TBI</td>
<td>277 (46)</td>
<td>1009 (56)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Multiple Injuries</td>
<td>319 (54)</td>
<td>792 (44)</td>
<td></td>
</tr>
<tr>
<td><strong>Cause: n (%)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Motor vehicle</td>
<td>167 (28)</td>
<td>236 (13)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Motorcycle</td>
<td>61 (10)</td>
<td>84 (4)</td>
<td></td>
</tr>
<tr>
<td>Pedal cyclist</td>
<td>19 (3)</td>
<td>47 (3)</td>
<td></td>
</tr>
<tr>
<td>Pedestrian</td>
<td>26 (4)</td>
<td>174 (10)</td>
<td></td>
</tr>
<tr>
<td>Low fall &lt;1m</td>
<td>172 (29)</td>
<td>789 (44)</td>
<td></td>
</tr>
<tr>
<td>High fall &gt;1m</td>
<td>37 (6)</td>
<td>187 (10)</td>
<td></td>
</tr>
<tr>
<td>Struck by or collision with object</td>
<td>39 (7)</td>
<td>137 (8)</td>
<td></td>
</tr>
<tr>
<td>Struck by or collision with person</td>
<td>38 (7)</td>
<td>91 (5)</td>
<td></td>
</tr>
<tr>
<td>Other cause</td>
<td>37 (6)</td>
<td>56 (3)</td>
<td></td>
</tr>
</tbody>
</table>

Missing data: ¹ Rural n= 77, Urban n=288; ² Rural n= 6, Urban n=36

These variables represent the patient factors which could impact patient outcome, but were independent of system factors relating to transport and medical intervention. The category “Other Cause” within the Injury Cause variable included a small number of horse-related, dog-related, and other animal-related incidents.
System factors were also compared, showing a higher proportion of rural TBI cases were entrapped at the scene, had MICA attendance and were transported from the scene by HEMS. A higher proportion of rural cases required at least one inter-hospital transfer prior to reaching definitive care (Table 24). This is reflected by the lower proportion of rural cases that were transported directly to a Major Trauma Service (Figure 3, p 132).

**Table 24: Comparison of Trauma System Factors Between Rural and Urban TBI Patients in Victoria 1st October 2006 - 30th June 2009**

<table>
<thead>
<tr>
<th>Pre-Hospital and System Factors</th>
<th>Rural n(%)</th>
<th>Urban n(%)</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Entrapment:</strong></td>
<td></td>
<td></td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Yes</td>
<td>70 (12)</td>
<td>90 (5)</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>525 (88)</td>
<td>1701 (95)</td>
<td></td>
</tr>
<tr>
<td><strong>MICA Attendance:</strong></td>
<td></td>
<td></td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Yes</td>
<td>274 (62)</td>
<td>701 (46)</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>166 (38)</td>
<td>835 (64)</td>
<td></td>
</tr>
<tr>
<td><strong>Transport Mode:</strong></td>
<td></td>
<td></td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>HEMS</td>
<td>194 (33)</td>
<td>114 (6)</td>
<td></td>
</tr>
<tr>
<td>Ambulance</td>
<td>333 (57)</td>
<td>1535 (86)</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>60 (10)</td>
<td>136 (8)</td>
<td></td>
</tr>
<tr>
<td><strong>Inter-Hospital Transfer:</strong></td>
<td></td>
<td></td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Yes</td>
<td>320 (54)</td>
<td>362 (20)</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>276 (46)</td>
<td>1439 (80)</td>
<td></td>
</tr>
<tr>
<td><strong>Primary Hospital:</strong></td>
<td></td>
<td></td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Major Trauma Service</td>
<td>220 (37)</td>
<td>1077 (60)</td>
<td></td>
</tr>
<tr>
<td>Regional Trauma Service</td>
<td>229 (38)</td>
<td>73 (4)</td>
<td></td>
</tr>
<tr>
<td>Other Metropolitan</td>
<td>31 (5)</td>
<td>643 (35)</td>
<td></td>
</tr>
<tr>
<td>Other Regional</td>
<td>116 (20)</td>
<td>3 (1)</td>
<td></td>
</tr>
</tbody>
</table>

Missing cases: $^1$11; $^2$412; $^3$25; $^4$5
Figure 3: Location of First Hospital Intervention for Severe TBI Cases in Victoria 2006 - 2009

N = 2391: Rural = 590  Urban = 1801: Missing cases: 16

Figure 4: Distribution of 6-Month GOS-E for Rural and Urban Cases in Victoria 2006 - 2009

N= 2175: Rural = 590  Urban = 1585: Missing cases: 2216
4.1.3 Results – Multivariate Analysis

The univariate results identified the key variables to be used for multivariate logistic regression. The intention of multivariate analysis was to compare outcomes following TBI, adjusting for factors from the time of injury through to the time of first hospital intervention. The study was designed to adjust for patient factors only, in order to identify whether system factors were likely to influence outcome. The multivariate logistic regression model was built using the variables shown in Table 25.

Table 25: Model 1 (ARIA+ Rural-Urban) Multivariable Analysis of In-Hospital Mortality and 6-Month GOS-E for Severe TBI Patients in Victoria 1st October 2006 - 30th June 2009

<table>
<thead>
<tr>
<th>Variable</th>
<th>Favourable GOSE at 6 Months (n=1769)</th>
<th>In-Hospital Mortality (n=1998)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>AOR (95% CI)</td>
<td>P value</td>
</tr>
<tr>
<td>Location of Injury</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rural (Ref)</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Urban</td>
<td>0.89 (0.68, 1.18)</td>
<td>0.44</td>
</tr>
<tr>
<td>Age</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16-24 (ref)</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>25-34</td>
<td>0.82 (0.51, 1.35)</td>
<td>0.440</td>
</tr>
<tr>
<td>35-44</td>
<td>0.61 (0.37, 1.01)</td>
<td>0.053</td>
</tr>
<tr>
<td>45-54</td>
<td>0.51 (0.29, 0.86)</td>
<td>0.012</td>
</tr>
<tr>
<td>55-64</td>
<td>0.34 (0.21, 0.57)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>65-74</td>
<td>0.21 (0.12, 0.35)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>75-84</td>
<td>0.11 (0.06, 0.17)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>85+</td>
<td>0.04 (0.02, 0.07)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>0.78 (0.60, 1.02)</td>
<td>0.07</td>
</tr>
<tr>
<td>Cause of injury</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Motor vehicle (ref)</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Motorcyclist</td>
<td>1.16 (0.65, 2.08)</td>
<td>0.614</td>
</tr>
<tr>
<td>Pedestrian</td>
<td>2.14 (0.89, 5.11)</td>
<td>0.087</td>
</tr>
<tr>
<td>Pedal cyclist</td>
<td>0.83 (0.49, 1.40)</td>
<td>0.493</td>
</tr>
<tr>
<td>Low fall &lt;= 1 metre</td>
<td>0.64 (0.40, 1.01)</td>
<td>0.052</td>
</tr>
<tr>
<td>High fall &gt; 1 metre</td>
<td>0.91 (0.67, 1.31)</td>
<td>0.723</td>
</tr>
<tr>
<td>Struck by or collision with person</td>
<td>1.29 (0.69, 2.48)</td>
<td>0.450</td>
</tr>
<tr>
<td>Struck by or collision with object</td>
<td>0.81 (0.42, 1.55)</td>
<td>0.526</td>
</tr>
<tr>
<td>Other</td>
<td>1.44 (0.76, 2.73)</td>
<td>0.260</td>
</tr>
<tr>
<td>Serious Co-morbidities</td>
<td>0.39 (0.29, 0.51)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Overall injury severity (ISS)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16-25 (ref)</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>26-40</td>
<td>0.75 (0.55, 1.02)</td>
<td>0.071</td>
</tr>
<tr>
<td>40+</td>
<td>0.28 (0.18, 0.45)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Head injury severity (pre-hospital GCS)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13-15 (ref)</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>9-12</td>
<td>0.39 (0.27, 0.57)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>3-8</td>
<td>0.13 (0.09, 0.19)</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>
After adjusting for age, gender, injury severity and other key factors, there was no evidence the odds of in-hospital mortality, and 6-month favourable outcomes, following severe TBI were different between rural and urban groups. The important predictors of favourable functional outcome were age < 45 years, the absence of co-morbidities, the overall severity of injury and severity of head injury (Table 25).

A range of other multivariate tests were undertaken, each varying slightly and each being focussed on either more detailed descriptors of rurality (Model 2), or alternative descriptors of rurality (Model 3). Following is a brief description of the results from each model, the full results can be viewed in Appendix H.

Model 2 compared in-hospital mortality and functional outcomes, after adjusting for the same patient factors as Model 1. Model 2 compared outcomes across the ARIA+ categories. The results show higher odds of favourable functional outcomes at 6 months post-injury for cases “outside Victoria”, compared to metropolitan Melbourne (AOR 2.11, 95% CI: 1.08, 4.13 p= 0.028), and a trend towards lower odds of in-hospital mortality for patients from “inner regional” areas when compared to metropolitan Melbourne (AOR 0.66 95% CI: 0.42, 1.02 p=0.064). Model 2 again confirmed that age > 45, the presence of serious co-morbidities, overall injury severity, and severity of head injury had a greater influence on in-hospital mortality than ARIA+ location of injury.

Model 3 compared functional outcomes and in-hospital mortality between rural and urban locations using an alternative categorisation of “rural and urban”. The categorisation for Model 3 was based on metropolitan and regional boundaries defined by the Department of Human Services. The intention of Model 3 was to compare definitions of rurality. The results from Model 3 indicate no difference in functional outcomes at 6 months post-injury (AOR 0.89, 95% CI: 0.68, 1.17 p = 0.406), and higher odds of in-hospital mortality for urban TBI patients (AOR 1.51, 95% CI: 1.04, 2.18 p=0.029). The results from Model 3 confirmed the influence of age, the presence of serious co-morbidities, overall injury severity and severity of head injury on both functional outcome and in-hospital mortality.
4.2 Study 2: The Use of HEMS at Rural TBI Cases (VSTR)

4.2.1 Overview

The following results relate to comparisons between TBI patients transported by HEMS and non-HEMS resources (i.e., road ambulance). This section follows the rural/urban TBI outcomes comparison that identified significant differences in the use of HEMS between rural and urban areas of Victoria. This section will outline the profile of TBI patients transported by HEMS, and will consider the use of HEMS in relation to patient outcomes.

Research Questions

1) Is there a difference in the proportion of severe TBI cases transported by HEMS between rural and urban areas of a state serviced by an established trauma system?

2) Is there a difference in the injury profile of patients transported by HEMS between rural and urban areas?

3) Does appropriate HEMS utilisation positively impact patient outcomes following severe TBI?

Hypotheses

1. The appropriate use of HEMS in rural areas will result in TBI patients with the highest injury severity being transported directly from the scene to one of the Major Trauma Services.

2. HEMS resources manage a more severely injured cohort of TBI patients.

3. Appropriate HEMS utilisation contributes to favourable patient outcomes following severe TBI.
4.2.2 Results – Univariate Analysis

The univariate results (Table 26) show that approximately 32% of rural TBI cases were transported by HEMS, compared to 6% of urban TBI cases. The results also show that rural HEMS transported a greater percentage of patients with serious co-morbidities, ISS of 40+, GCS of 3-8, and multiple injuries when compared to rural non-HEMS patients. These results indicate that HEMS resources in Victoria attend and transport high-acuity TBI patients in rural areas.

The results also show that HEMS are equally utilised in the urban setting to attend, treat and transport high-acuity patients. Urban HEMS appear to attend a slightly higher percentage of TBI cases with an ISS of 40+, and a GCS of 3-8 when compared to the rural HEMS cohort. Conversely, the rural HEMs cohort includes a slightly higher percentage of TBI case with an ISS of 26-40 and a GCS of 9-12, suggesting that in rural areas HEMS may also transport a wider cohort of TBI cases. The implications of this will be discussed in later chapters.
Table 26: Injury Profile of Rural and Urban HEMS vs Non-HEMS TBI Patients in Victoria 1st October 2006 - 30th June 2009

Missing data: 1 Rural n=77, Urban n=288; 2 Rural n= 6, Urban n=36

<table>
<thead>
<tr>
<th>Variable</th>
<th>Rural Total = 596</th>
<th>Urban Total = 1801</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variable</td>
<td>Rural HEMS</td>
<td>Rural Non-HEMS</td>
</tr>
<tr>
<td>N=189</td>
<td>N=407</td>
<td>N=114</td>
</tr>
<tr>
<td>Gender: n (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>141 (75)</td>
<td>289 (71)</td>
</tr>
<tr>
<td>Female</td>
<td>48 (25)</td>
<td>118 (29)</td>
</tr>
<tr>
<td>Comorbidity Status: n (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Serious illness</td>
<td>134 (92)</td>
<td>238 (65)</td>
</tr>
<tr>
<td>No serious illness</td>
<td>12 (8)</td>
<td>129 (35)</td>
</tr>
<tr>
<td>ISS Categories: n (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16 - 25</td>
<td>34 (18)</td>
<td>262 (64)</td>
</tr>
<tr>
<td>26 - 40</td>
<td>84 (44)</td>
<td>112 (28)</td>
</tr>
<tr>
<td>40+</td>
<td>71 (38)</td>
<td>33 (8)</td>
</tr>
<tr>
<td>GCS Group: n (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13-15</td>
<td>65 (35)</td>
<td>272 (68)</td>
</tr>
<tr>
<td>9-12</td>
<td>29 (15)</td>
<td>47 (12)</td>
</tr>
<tr>
<td>3-8</td>
<td>94 (50)</td>
<td>83 (21)</td>
</tr>
<tr>
<td>Isolated TBI or Multiple Injuries: n (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Isolated TBI</td>
<td>14 (7)</td>
<td>174 (43)</td>
</tr>
<tr>
<td>Multiple Injuries</td>
<td>175 (93)</td>
<td>233 (57)</td>
</tr>
<tr>
<td>Cause: n (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Motor vehicle</td>
<td>102 (54)</td>
<td>65 (16)</td>
</tr>
<tr>
<td>Motorcycle</td>
<td>33 (17)</td>
<td>28 (7)</td>
</tr>
<tr>
<td>Pedal cyclist</td>
<td>7 (4)</td>
<td>12 (3)</td>
</tr>
<tr>
<td>Pedestrian</td>
<td>10 (5)</td>
<td>16 (4)</td>
</tr>
<tr>
<td>Low fall &lt;1m</td>
<td>4 (2)</td>
<td>168 (41)</td>
</tr>
<tr>
<td>High fall &gt;1m</td>
<td>11 (6)</td>
<td>26 (6)</td>
</tr>
<tr>
<td>Struck by or collision with object</td>
<td>-</td>
<td>39 (10)</td>
</tr>
<tr>
<td>Struck by or collision with person</td>
<td>9 (5)</td>
<td>29 (7)</td>
</tr>
<tr>
<td>Other cause</td>
<td>13 (7)</td>
<td>24 (6)</td>
</tr>
</tbody>
</table>
4.2.3 Results – Multivariate Analysis

Univariate analysis indicated which variables to include in the multivariate analysis. Multivariate analysis provided a comparison of in-hospital mortality and functional outcomes at 6 months post-injury for rural TBI patients either transport by HEMS resources or road-ambulances. The results are outlined in Table 27.

The multivariate results show that the use of HEMS in rural areas may contribute in part to favourable functional outcomes following severe TBI (AOR 1.96 95% CI 1.13, 3.4 p=0.017). The results also suggest that the use of HEMS in rural areas was not associated with in-hospital mortality (AOR 0.64 95% CI: 0.29, 1.42 p=0.274). This result must be viewed with much caution, as many variables contribute to the despatch and use of HEMS resources. The inclusion of such variables was beyond the scope of this project. These and further limitations will be discussed in the later chapters.

The multivariate results also provide some insight into the factors most likely to influence in-hospital mortality and functional outcomes following TBI. These results suggest that age, the presence of serious co-morbidities, overall injury severity and severity of head injury have a significant influence on outcomes following TBI.
Table 27: Multivariable Analysis of In-Hospital Mortality and 6-Month GOS-E for Severe TBI Patients Transported by HEMS in Victoria 1st October 2006 - 30th June 2009

<table>
<thead>
<tr>
<th>Variable</th>
<th>Favourable GOSE at 6 Months Post Injury (n=1769)</th>
<th>In-Hospital Mortality (n=1998)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>AOR (95% CI)</td>
<td>P value</td>
</tr>
<tr>
<td><strong>Location of Injury</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rural (ref)</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>Urban</td>
<td>1.06 (0.77, 1.45)</td>
<td>0.711</td>
</tr>
<tr>
<td><strong>Transport Mode</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-HEMS (Ref)</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>HEMS</td>
<td>1.96 (1.13, 3.4)</td>
<td>0.017</td>
</tr>
<tr>
<td><strong>Interaction of HEMS and Place</strong></td>
<td>0.53 (0.25, 1.16)</td>
<td>0.114</td>
</tr>
<tr>
<td><strong>Age</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16-24 (ref)</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>25-34</td>
<td>0.77 (0.47, 1.27)</td>
<td>0.322</td>
</tr>
<tr>
<td>35-44</td>
<td>0.57 (0.34, 0.96)</td>
<td>0.033</td>
</tr>
<tr>
<td>45-54</td>
<td>0.49 (0.28, 0.84)</td>
<td>0.009</td>
</tr>
<tr>
<td>55-64</td>
<td>0.33 (0.19, 0.55)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>65-74</td>
<td>0.21 (0.12, 0.35)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>75-84</td>
<td>0.11 (0.06, 0.17)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>85+</td>
<td>0.04 (0.02, 0.07)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td><strong>Gender</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>0.77 (0.60, 1.0)</td>
<td>0.05</td>
</tr>
<tr>
<td><strong>Cause of injury</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Motor vehicle (ref)</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>Motorcyclist</td>
<td>1.19 (0.66, 2.14)</td>
<td>0.571</td>
</tr>
<tr>
<td>Pedestrian</td>
<td>2.30 (0.95, 5.60)</td>
<td>0.065</td>
</tr>
<tr>
<td>Pedal cyclist</td>
<td>0.93 (0.55, 1.58)</td>
<td>0.791</td>
</tr>
<tr>
<td>Low fall &lt;= 1 metre</td>
<td>0.77 (0.48, 1.22)</td>
<td>0.268</td>
</tr>
<tr>
<td>High fall &gt; 1 metre</td>
<td>1.02 (0.61, 1.71)</td>
<td>0.939</td>
</tr>
<tr>
<td>Struck by or collision with person</td>
<td>1.56 (0.80, 3.04)</td>
<td>0.192</td>
</tr>
<tr>
<td>Struck by or collision with object</td>
<td>0.94 (0.49, 1.81)</td>
<td>0.851</td>
</tr>
<tr>
<td>Other</td>
<td>1.62 (0.86, 3.09)</td>
<td>0.136</td>
</tr>
<tr>
<td>Serious Co-morbidities</td>
<td>0.38 (0.29, 0.51)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td><strong>Multiple Injuries</strong></td>
<td>0.83 (0.61, 1.13)</td>
<td>0.233</td>
</tr>
<tr>
<td><strong>Overall injury severity (ISS)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16-25 (ref)</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>26-40</td>
<td>0.66 (0.48, 0.89)</td>
<td>0.009</td>
</tr>
<tr>
<td>40+</td>
<td>0.24 (0.15, 0.38)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td><strong>Head injury severity (Hospital GCS)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13-15 (ref)</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>9-12</td>
<td>0.39 (0.27, 0.57)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>3-8</td>
<td>0.13 (0.09, 0.18)</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>
4.3 Study 3: Pre-Hospital, Pre-Intervention Fatalities (NCIS)

4.3.1 Overview

Analysis of the NCIS cases aimed to identify trends and differences in the rural/urban profile of pre-hospital pre-intervention fatalities attributed primarily to traumatic brain injury. This aspect of the study was investigated following the indication from the Study 1 multivariate results suggesting a trend towards higher in-hospital mortality in the urban TBI group.

Research Question

1) Is there a difference in the characteristics of pre-hospital, pre-intervention deaths occurring as a result of severe TBI between rural and urban areas in a state serviced by an established trauma system?

Hypothesis

The hypothesis for the NCIS section was that there would be a higher rate of pre-hospital pre-intervention fatalities in the rural group, as these patients would be less likely to survive to ambulance and hospital arrival due to geographical and resourcing factors. It was predicted that similar patients in the urban setting would be more likely to survive to pre-hospital intervention and treatment at hospital due to the increased availability of ambulance resources and closer proximity to hospital.
4.3.2 Results

The results indicated a total of 29 fatalities that were deceased prior to ambulance arrival with TBI or severe blunt trauma to the head as the primary cause of death. All of the cases occurred between January 2004 and December 2009.

The following figure provides an overview of the proportion of rural-urban pre-hospital pre-intervention fatalities. The following table shows the distribution and characteristics of the dataset, 4 cases could not be allocated to a rural or urban category.

![Figure 5: Study 3 Pre-Hospital Pre-Intervention Fatalities (%)]

The results show a higher proportion of males compared to females in both the rural and urban groups. Age was not available in 10 of the 29 cases (34%) and was not used for further analysis. The results indicate that the two main causes of pre-hospital pre-intervention fatalities were MVCs and low falls. Due to the small number of cases and missing data, it is difficult to comment on trends associated with single-vehicle accidents or the involvement of alcohol.
Table 28: Characteristics of Pre-Hospital Pre-Intervention Fatalities with Severe TBI as the Primary Injury January 2004 - December 2009

<table>
<thead>
<tr>
<th>Variable</th>
<th>Rural: 12</th>
<th>Urban: 13</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N (%)</td>
<td>N (%)</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>10 (83)</td>
<td>7 (54)</td>
</tr>
<tr>
<td>Female</td>
<td>2 (17)</td>
<td>5 (38)</td>
</tr>
<tr>
<td>Unknown</td>
<td>0</td>
<td>1 (8)</td>
</tr>
<tr>
<td>Mechanism of Injury²</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Motor Vehicle</td>
<td>8 (67)</td>
<td>7 (54)</td>
</tr>
<tr>
<td>Motorcycle</td>
<td>1 (8)</td>
<td>0</td>
</tr>
<tr>
<td>Pedal Cycle</td>
<td>0</td>
<td>2 (15)</td>
</tr>
<tr>
<td>Low Fall</td>
<td>2 (17)</td>
<td>4 (30)</td>
</tr>
<tr>
<td>Unknown</td>
<td>1 (8)</td>
<td>0</td>
</tr>
<tr>
<td>Isolated Head Injury or Multiple Injuries</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Isolated HI</td>
<td>9 (75)</td>
<td>10 (77)</td>
</tr>
<tr>
<td>Multiple Injuries</td>
<td>3 (25)</td>
<td>3 (23)</td>
</tr>
<tr>
<td>Single Vehicle Incident</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>9 (75)</td>
<td>6 (46)</td>
</tr>
<tr>
<td>No</td>
<td>1 (8)</td>
<td>0</td>
</tr>
<tr>
<td>Unknown</td>
<td>2 (17)</td>
<td>7 (54)</td>
</tr>
<tr>
<td>Alcohol Involvement</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>4 (33)</td>
<td>3 (23)</td>
</tr>
<tr>
<td>Unknown</td>
<td>8 (67)</td>
<td>10 (77)</td>
</tr>
</tbody>
</table>
The Kappa coefficient indicated variance regarding the inter-rater reliability of the case review process. Kappa scores were calculated for the following dichotomised variables:

- Suitable for Inclusion in Study Yes/No: Kappa = 1*
- Rural / Urban: Kappa = 0.43
- Ambulance Attendance Yes/No: Kappa = 0.27 *
- Isolated TBI / Multiple Injuries: Kappa = 0.24
- Presence of Drugs or Alcohol Y/N: Kappa = 1
- Difficult Access Y/N: Kappa = 0.24*

(* Not included in Table 28)

The low kappa scores of < 0.7 in four of the six variables chosen to test reliability indicate a degree of inconsistency in the case review process. The process and importance of calculating Kappa scores is described in the methodology section.

4.4 Study 4: Pre-Hospital, Post-Intervention Fatalities (VACAR)

4.4.1 Overview

The purpose of this section was to identify rural and urban differences associated with the management of traumatic OHCA cases where injury to the head was a primary injury. Analysis was aimed at comparing variables likely to relate to differences in the number of attending paramedics, levels of intervention and paramedic experience.

Research Questions

1) Is there a difference in the proportion of pre-hospital deaths occurring as a result of severe TBI, following attendance and resuscitation by pre-hospital clinicians, between rural and urban areas in a state serviced by an established trauma system?

2) Are there rural and urban differences relating to patient demographics and scene management during pre-hospital resuscitation of severe TBI cases resulting in cardiac arrest?
**Hypothesis**

The hypothesis being tested was that rural traumatic arrests with TBI as the primary injury would be less frequent and have fewer procedures performed during resuscitation attempts.

**4.4.2 Results**

The results indicated a total of 52 adult traumatic OHCA cases with head injury as a primary injury during the study period from 2006 – 2009. Of this total, 51 cases contained information relating to patient gender, age, location and procedures performed at the scene. There were 10 rural cases and 41 urban cases. These cases were managed in the pre-hospital setting only with the patients not surviving to hospital. The purpose of this component of the study was to compare traumatic cardiac arrests that occurred in rural and urban areas.

To begin with, Figure 6 indicates the rural-urban proportions of pre-hospital, post-intervention fatalities:

![Figure 6: Rural-Urban Proportion of Pre-Hospital TBI Fatalities Attended by Ambulance Personnel (%)](image)

The results show that overall there was a higher percentage of males compared to females, and that the rural and urban groups were similar.
Table 29: Patient Gender at Traumatic OHCA Cases Associated with Severe TBI in Victoria 2006 - 2009

<table>
<thead>
<tr>
<th></th>
<th>Full VACAR Group</th>
<th>Rural</th>
<th>Urban</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>N (%)</td>
<td>51(^1) (100)</td>
<td>10 (100)</td>
<td>41 (100)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N (%)</td>
<td>N (%)</td>
</tr>
<tr>
<td>Male</td>
<td>43 (84)</td>
<td>8 (80)</td>
</tr>
<tr>
<td>Female</td>
<td>8 (16)</td>
<td>2 (20)</td>
</tr>
</tbody>
</table>

\(^1\) Missing cases, N=1

The prevalence based on the number of severe TBI cases during this period (VSTR) and the number of traumatic OHCA cases following TBI (VACAR) are as follows: Total TBI population 51/2397 (2,128/100,000); Rural TBI population: 10/596 (1,678/100,000); Urban TBI population: 41/1801 (2,278/100,000).

The number of procedures performed during paramedic management of traumatic OHCA cases associated with TBI were used as a measure of case complexity and willingness of paramedics to intervene (Table 30). The methodology and limitations are discussed in other chapters.

Table 30 shows that CPR was performed at 40% of rural cases compared to 49% of urban cases. Endotracheal intubation and chest decompression were performed at 10% and 30% of rural cases respectively, compared to 51% and 27% of urban cases. Only 3 cases from the cohort underwent RSI, with all 3 coming from the urban group.
Table 30: Comparison of Procedures Performed at Traumatic OHCA Cases Associated with Severe TBI in Victoria 2006 - 2009

<table>
<thead>
<tr>
<th></th>
<th>Full VACAR Group</th>
<th>Rural (N/%)</th>
<th>Urban (N/%)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>N(%)</td>
<td>51 (100)</td>
<td>10 (100)</td>
<td>41 (100)</td>
<td></td>
</tr>
<tr>
<td>CPR</td>
<td>24 (47)</td>
<td>4 (40)</td>
<td>20 (49)</td>
<td>N/A</td>
</tr>
<tr>
<td>ETT Insertion</td>
<td>22 (43)</td>
<td>1 (10)</td>
<td>21 (51)</td>
<td>N/A</td>
</tr>
<tr>
<td>RSI for Intubation</td>
<td>3 (6)</td>
<td>0</td>
<td>3 (7)</td>
<td>N/A</td>
</tr>
<tr>
<td>Decompression of Tension -</td>
<td>14 (27)</td>
<td>3 (30)</td>
<td>11 (27)</td>
<td>N/A</td>
</tr>
<tr>
<td>Pneumothorax</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\(^1\text{Missing cases, N= 1}\)

Statistical tests were not used for comparison due to the small number of procedures recorded within the rural group. The very low number of procedures undertaken in rural cases precluded the use of Chi square comparison\(^{428}\). However, these results show the following:

- 97% of all procedures were instigated across 80% of the cases (urban)
- 3% of all procedures were instigated across 20% of the cases (rural)
- CPR was commenced in 40% of rural cases, compared to 49% of urban cases
- Endotracheal intubation was undertaken in 10% of rural cases, compared to 51% of urban cases
- Only 3 RSIs were performed or attempted, all in the urban group
- Chest decompression was performed in 30% of rural cases, compared to 27% of urban cases
Additional analysis was undertaken to investigate further rural and urban differences at traumatic cardiac arrest cases with TBI as the primary injury. Differences were measured between pre-hospital scene time, the relationship between scene time and the age of the patient, and the relationship between GCS on arrival and scene-time.

Table 31: Ambulance On-Scene Times for Pre-Hospital Cardiac Arrest Following Severe TBI in Victoria 2006 - 2009

<table>
<thead>
<tr>
<th></th>
<th>Full VACAR Group</th>
<th>Rural</th>
<th>Urban</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number</td>
<td>52</td>
<td>8</td>
<td>44</td>
</tr>
<tr>
<td>Mean Scene Time</td>
<td>27 minutes (SD 25)</td>
<td>21 minutes (SD 31)</td>
<td>28 minutes (SD 25)</td>
</tr>
<tr>
<td>(Standard Deviation)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Min - Max</td>
<td>1 - 95</td>
<td>1 - 94</td>
<td>1 - 95</td>
</tr>
</tbody>
</table>

Scene time (Table 31) was considered an important measure that could be related to case complexity and resourcing differences. For the overall pre-hospital TBI group that died at scene, paramedics were on scene for a mean time of 26 minutes, ranging from 1-95 minutes. The longest scene time was approximately 100 minutes, and this may account for added complications at scene such as entrapment or difficult access. The scene time was calculated based on the arrival time and clear times. The rural group had a mean on-scene time of 21 minutes (SD 31) while the urban group had a mean on-scene time of 28 minutes (SD 25). Due to the small sample size from the rural population, a non-parametric statistical approach was used to assess for differences in mean scene times. The Mann-Witney test, the non-parametric analogue to the Students’ T-test was used. No significant difference was detected (U 126, Z -1.27, p-value = 0.20).

Data was further differentiated between: Major cities of Australia (n=44), Inner regional (n=7) and outer regional Australia (n=1, removed from analysis). No significant differences were detected between these groups ( U 100, Z -1.48, p-value = 0.139).
A simple linear regression model was applied to the variables of age and scene-time. The relationship between age and scene-time in the rural (rural slope (rho) p=0.653) and urban (p = N/A) cohorts was not significant. Results for the entire traumatic OHCA group associated with TBI indicated that there was no association between the age of the patient and time spent on scene (p=0.8886). These results can be viewed in Appendix I.

Linear regression was also used to assess the relationship between GCS on arrival and overall scene time. The relationship between GCS and scene-time in the rural (rural slope (rho) p= 0.674) and urban (urban slope (rho)p=0.212) cohorts was not significant. Results for the entire traumatic OHCA group associated with TBI indicated that there was no association between initial GCS and time spent on scene (p-value = 0.240). These results can be viewed in Appendix J.

**Research Area 2: TBI Management: Paramedic Confidence and Competence**

**4.5 Study 5: Rural-Urban Differences in Paramedic Exposure to RSI (VACIS/HR)**

**4.5.1 Overview**

The following results describe various aspects relating to all RSIs that were performed in Victoria by MICA paramedics and captured within the VACIS system. The objective of this study was to compare the number of RSIs per paramedic between rural and urban areas of the state.

**Research Question**

1) Is there a difference in the overall number of rapid sequence inductions (RSIs), for all clinical presentations meeting criteria for intervention using this technique, performed by intensive care paramedics working in rural and urban areas within a state serviced by an established trauma system?
**Hypothesis**

Rural MICA paramedics have lower exposure to cases requiring RSI for intubation, and therefore perform the procedure less frequently. This is likely to have implications regarding paramedic confidence, competence and willingness to intervene with high-risk procedures.

**4.5.2 Results**

Analysis indicated there were 543 MICA paramedics employed in Victoria during 2011, and 714 RSI procedures performed during this period. Of the 714 RSIs performed, 538 (75%) were performed by urban MICA paramedics, and 176 (25%) were performed by rural MICA paramedics. Of the MICA paramedics included in this study, 314 (58%) were classified as urban paramedics and 229 (42%) were classified as rural paramedics. Overall, 459 (85%) were road-based MICA paramedics, 43 (8%) were CSOs and 41 (7%) were MFPs. In rural Victoria, 201 (88%) were road-based MICA, 21 (9%) CSOs and 7 (3%) MFPs. In urban areas 258 (82%) were road-based MICA paramedics, 22 (7%) CSOs and 34 (11%) MFPs. These results are shown in the Table 32.

<table>
<thead>
<tr>
<th></th>
<th>Rural N (%)</th>
<th>Urban N (%)</th>
<th>Total N (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Road-based MICA</td>
<td>201 (88)</td>
<td>258 (82)</td>
<td>459 (85)</td>
</tr>
<tr>
<td>CSO</td>
<td>21 (9)</td>
<td>22 (7)</td>
<td>43 (8)</td>
</tr>
<tr>
<td>MFP</td>
<td>7 (3)</td>
<td>34 (11)</td>
<td>41 (7)</td>
</tr>
<tr>
<td>Total</td>
<td>229 (100)</td>
<td>314 (100)</td>
<td>543 (100)</td>
</tr>
</tbody>
</table>
Further analysis was undertaken, investigating the years of experience of MICA paramedics across the three skill sets. The results indicated that 257 (47%) of MICA paramedics had $\geq 6$ years of experience, 161 (30%) MICA paramedics had 3–5 years of experience, and 125 (23%) had 1–2 years of experience. These results are shown in Table 33.

<table>
<thead>
<tr>
<th>Skillset of MICA Paramedics Employed in 2011</th>
<th>Years</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 - 2</td>
</tr>
<tr>
<td>MICA</td>
<td>111</td>
</tr>
<tr>
<td>CSO</td>
<td>10</td>
</tr>
<tr>
<td>MFP</td>
<td>4</td>
</tr>
<tr>
<td>Total N(%)</td>
<td>125</td>
</tr>
</tbody>
</table>

Analysis was undertaken to determine the actual and mean number of RSIs performed per “years + skill set” group, comparing these groups across rural and urban areas of the Victoria. The results indicated that rural MFPs with 3-5 years of experience had the highest average of 4.3 RSIs in 2011. The groups with the lowest average number of RSIs per year were urban road-based MICA paramedics 3-5 yrs and urban CSOs 3-5 yrs, each with 0.4 RSIs in 2011. It should be noted that these results indicated that rural and metropolitan CSOs with $\geq 6$ years, as well as rural MFPs with 1–3 years, rural MFPs with $\geq 6$ years, and urban MFPs with $\geq 6$ years did not record any RSIs during 2011. This will be discussed in later sections. These results are shown in Tables 34 and Figure 7.
Table 34: The Mean, Minimum and Maximum Number of RSIs per MICA Sub-Group in 2011

<table>
<thead>
<tr>
<th>Skill Set and Years of Experience</th>
<th>Rural Mean (Standard Deviation)</th>
<th>Rural Minimum and Maximum</th>
<th>Urban Mean (Standard Deviation)</th>
<th>Urban Minimum and Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Road-Based MICA &lt; 3 yrs</td>
<td>0.8 (SD 1.85)</td>
<td>0 - 4</td>
<td>1.6 (1.5)</td>
<td>0 - 7</td>
</tr>
<tr>
<td>Road-Based MICA 3-5 yrs</td>
<td>0.5 (SD 0.91)</td>
<td>0 - 3</td>
<td>0.4 (0.9)</td>
<td>0 - 4</td>
</tr>
<tr>
<td>Road-Based MICA ( \geq 6 ) yrs</td>
<td>0.7 (SD 1.13)</td>
<td>0 - 5</td>
<td>1.9 (2.0)</td>
<td>0 - 12</td>
</tr>
<tr>
<td>CSO &lt; 3 yrs</td>
<td>-</td>
<td>-</td>
<td>1 (1.0)</td>
<td>0 - 2</td>
</tr>
<tr>
<td>CSO 3-5 yrs</td>
<td>0.8 (SD 1.25)</td>
<td>0 - 4</td>
<td>0.4 (0.8)</td>
<td>0 - 3</td>
</tr>
<tr>
<td>CSO ( \geq 6 ) yrs</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>MFP &lt; 3 yrs</td>
<td>-</td>
<td>-</td>
<td>4 (3.0)</td>
<td>0 - 7</td>
</tr>
<tr>
<td>MFP 3-5 yrs</td>
<td>4.3 (SD 2.63)</td>
<td>1 - 7</td>
<td>4 (3.3)</td>
<td>0 - 15</td>
</tr>
<tr>
<td>MFP ( \geq 6 ) yrs</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
Figure 7: The Mean Number of RSIs per MICA Skillset in Victoria 2011

Figure 8: Percentage of Rural-Urban MICA Paramedics Who Performed a Set Number of RSIs in Victoria 2011
The results also indicated the percentage of rural and urban paramedics who undertook a set number of RSIs during the 12 month study period. These proportions are shown in Figure 8. These results show that approximately 58% of rural MICA paramedics and 36% of urban MICA paramedics did not perform any RSIs during the study period. The results also show that the majority of MICA paramedics in both groups performed 1-5 RSIs, and that only urban MICA paramedics performed more than 7 RSIs during the study period. The maximum number of RSIs performed within 12 months was 15, which were undertaken by an urban MFP (Figure 8 and Table 34).

Table 35: Comparison of Rural-Urban Paramedics Who Performed >/= 1 RSI in Victoria 2011

<table>
<thead>
<tr>
<th></th>
<th>≥1 RSI</th>
<th>Nil RSI</th>
<th>Total</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rural</td>
<td>96 (42)</td>
<td>133 (58)</td>
<td>229 (100)</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>Urban</td>
<td>201 (64)</td>
<td>113 (36)</td>
<td>314 (100)</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>297</td>
<td>246</td>
<td>543</td>
<td></td>
</tr>
</tbody>
</table>

Table 35 indicates a significant difference between the rural and urban MICA paramedic groups, comparing cohorts who performed one or more RSIs during 2011 and those who did not utilise the procedure during the study period. Table 35 shows that there was a greater proportion of rural MICA paramedics who did not perform the procedure during 2011.

4.6 Study 6: Inclination to Intervene with Higher Risk Procedures (VACIS)

4.6.1 Overview

The following results refer to analysis of TBI cases that met criteria for intervention with RSI but where the RSI was not performed. This component of the study has importance relating to the willingness of paramedics to intervene with high-risk procedures, particularly in rural areas where acute case-load may be low and clinicians may suffer from impaired confidence and performance.
Research Questions

1) Is there a difference in the number of severe TBI cases that met pre-hospital RSI criteria, but where the procedure was not performed, between rural and urban areas within a state serviced by an established trauma system?

Hypothesis

There is a greater of number of rural TBI cases that meet the criteria for intervention with RSI, but where the procedure is withheld or not performed.

4.6.2 Results

The VACIS dataset relating to TBI cases potentially meeting the criteria for intervention with RSI provided 2123 cases in total. The complete dataset was divided into two groups, which provided separate cohorts to be investigated regarding suitability for the use of RSI (Figure 9).

![Figure 9: TBI Cases Potentially Meeting the Criteria for Intervention with RSI, But Where RSI Was Not Performed]
Despite thorough reviews of the case descriptions by two investigators, the results from this section remained inconclusive. The lack of consistency regarding details included in the written case descriptions did not allow definitive identification of cases that clearly met the criteria for intervention with RSI by road-based MICA paramedics but where this procedure had been withheld.

It was deemed important to review cases where an RSI had been performed, with the aim of identifying cases where the RSI had been implemented by AAV paramedics, yet road-based MICA paramedics were present and may have had the opportunity to utilise the procedure. The subtleties associated with this interaction became apparent during analysis.

Despite the identification of potential cases, it was deemed that no further interpretation was possible due to the inconsistency and variance of information contained within the free-text case descriptions. The results for this section therefore remain inconclusive.

4.7 Study 7: Paramedic Confidence and Competence (Focus Groups)

4.7.1 Overview

The following results summarise the major themes identified in the rural and urban focus group discussions. The results indicate the themes and concepts raised by individuals within each of the groups, with the major themes shown in Table 36 (p. 167). This study was important as it provided an avenue for individual paramedics to reflect and comment on their experiences relating to the management of low-frequency high-acuity cases, including patients with severe TBI.

Research Questions

1) How do paramedic perceptions of case exposure and experience differ between rural and urban areas?
2) How do rural and urban paramedic perceptions differ regarding skills maintenance and performance?

3) Is there a difference between rural and urban paramedics’ attitudes towards intervention when faced with low-frequency, high-acuity cases?

4) Is paramedic confidence adversely impacted by low acute caseload?

4.7.2 Results

The collective focus group results provided an insight into the perceptions held by both rural and urban MICA paramedics regarding the interplay between experience, exposure, confidence and competence. Differences were evident between the group’s responses, however some similarities also emerged.

The following themes are presented with supporting comments from both rural and urban groups:

Theme: The Relationship Between Case Complexity, Experience and Confidence

Rural

Erosion of skills and confidence was identified as a clinical issue amongst both the rural and urban groups. One response in particular clearly summarised the perception of challenges faced by rural MICA officers:

RA3.4 the biggest challenge for me is that complex patient, when you’re a fair way from anywhere and you certainly can be up to an hour even from just a minor treatment centre.

Rural focus group participants were able to offer insights into the way that case frequency impacted clinical skills and decision making abilities:

RA18.2 I think when we talk about that low frequency one of the biggest, just in my own practice one of my biggest fears, speaking quite openly is when you’ve got that low frequency side.
RA15.2 Because we're doing this procedure more frequently we become better at it. And clinically I probably made the wrong decision back then, it's just through training and a bit more expertise in the area we are more confident in your own skills.

Rural focus group responses referred to the additional factors impacting confidence and skill erosion. Rural participants suggested that case complexity directly translated to the complexity of the decision making process:

RA18.2 So I also know that when you've got that RSI setting you can do a lot of harm so that can actually really dent the confidence to go in and do it, because you haven't been doing it for a while, you haven't done one in a couple of years or whatever.

Further rural responses indicated the impact of familiarity with the working environment, and the consequences of a given intervention:

RA12.2 ...we work in these very confined parameters and we are reasonably comfortable doing that.

RA18.2 I might also do significant harm so even though you do the cost benefit analysis, whilst also fighting with your own doubts separately.

One rural MICA paramedic also indicated that confidence and decision making were modified when working alone and that this was heavily influenced by expectations:

RA33.2 ...that is the expectation for the SRU guys, if you have a TBI or something that's indicated for an RSI you’ll do it and that’s the expectation, I mean you can still make a choice not to but the expectation is there that you’ll do it with or without adequate support.

Urban

The urban focus group offered an additional perspective regarding the interplay between case complexity, experience and confidence. The responses shared some similarities to the rural group. Within this group, experienced metropolitan MICA paramedics indicated that even with many years of working in high-caseload environments, there remained a degree of anxiety and anticipation if the volume of high acuity work decreased.
it certainly low frequency cases where you walk in will certainly have influence on the way you look at the job, because where as if you walk in on high frequency cases you don’t have to think as much you don’t have to task focus you just think ok I can do this in my sleep. But as soon as you walk into a low frequency job you have to be much more consciously thinking you have to be much more task focused.

UA35.1 And I don’t even think you even have to be out of the job on holidays for 3 months or have moved to RAV for a couple of years, I feel like you like, now that with the MICA truck’s taking non-sick people to hospital you can go a couple of months without seeing a sick patient even on a MICA truck and my confidence starts to sway at that point, so I don’t even have to be on holidays for my confidence to start to get shonky.

Urban focus group responses further highlighted that case complexity could impact decision making processes:

UA12.2 ...so what I find I actually do to deal with that is I stop, I do it with all high acuity jobs anyway, with jobs that I used to do normally so easily that I don’t do so easily anymore I will stop several times through that job. I don’t act instinctively at all and systematically and I think I can’t stuff it up if I do that.

This response makes reference to erosion of skills, knowledge and decision making processes in the absence of high caseload, and offers an approach to working through less-seen high acuity cases, e.g., by adopting a systematic rather than instinctive approach to practice.

Theme: Strategies for Maintaining Confidence, Psychomotor Skills and Cognitive Skills

Rural

The rural group indicated a perception that they had a lower acute caseload compared to urban MICA paramedics, and that this had implications in regards to confidence, skills maintenance and actual case management. Participants in the group highlighted that there were occasions when HEMS were unavailable, meaning that the full clinical responsibility fell on to SRU paramedics. The group indicated they had a perception that more resources were available to support SRU paramedics in urban areas, meaning that single MICA officers in urban areas would be more likely to have support from another MICA officer at high-acuity cases:
RA3.4 Sometimes that support may be staff with a certificate 2 in emergency medical response so you’ve got no other paramedic support.

RA31. Yet in the rural setting we’ve implemented the SRU’s but with no backup for them.

The following responses suggested that rural paramedics may have greater exposure to cases where doctors may also be present, that these cases brought an added challenge to the dynamic of instigating high-end care, but that the pressures of single-responding with little support is less than ideal:

RA12.3 And we’re finding that quite often it’s not the problem that doctors want to intervene we sometimes need to push them along to actually intervene or to intervene on their behalf.

RA12.3 ..quite often you have to become a strong advocate for the patient because we don’t have the medical resources there.

Rural responses indicated that specific processes and systems for mentoring were vital for the maintenance of skills and knowledge:

RA19 ..with low frequency skills you actually use a lot more simulation to practice those skills. So say in the Wimmera probably should be rocking in once a month and having a go at simulation as you’re going through that process, not just with RSI but also other less used skills.

RA29.1 But the SRU model needs to be supported by centres of excellence, training teams if you like. So I think that a model that would include MICA teams with an opportunity for members of that team to go and work on a SRU for periods of time to be discussed or maybe on an individual basis, and then back to the team to go back to get your clinical support and get back into shared discussion and getting back to being comfortable with being uncomfortable.

RA29.3 ..one of the best ways to improve your individual exposure is to gain it off a colleague by sharing experience.

Rural focus group participants indicated that actual experience, and increased frequency of exposure to cases, enhanced and reinforced learning. Participants suggested that the ability to articulate, utilise and translate collective experience in order to enhance individual performance was vital to maintaining and encouraging high clinical standards within a group or organisation. Further to this
responses indicated that individual accountability was needed to recognise deficits/weaknesses in practice or knowledge. Participants suggested that training strategies needed to incorporate elements that targeted both clinical/technical skills, and judgement/decision making skills. A participant in the rural group stated that regional centres of excellence may be required to adequately and appropriately support rural SRUs:

RA17.4 “It’s really been that as the increased familiarity and general experience across the board and that’s not just the individuals but the collective experience at branches, where people develop confidence in the procedure.

RA20 Utilisation of MICA units as trend-setters and centres of excellence for want of a better word, is the best model for passing on the confidence and the knowledge that gets passed on from the experienced operator to the novice if you like. Whilst the novice hasn’t necessarily done a procedure before because you are doing it with a more experienced person for the first time then he’ll feel confident or that confidence will be a collective one.

Rural participants expressed concerns regarding the availability of training opportunities, referring to both formal/structured opportunities as well as informal opportunities. The group suggested that the informal learning process that occurs when working with more experienced paramedics and in busier locations was limited due to decreased availability of opportunities for staff to rotate through these locations:

RA28.3 I think the other important thing complimentary of that is to be afforded the opportunity to work with people who have a high level of the experience in procedures or ambulance work in general than yourself and I think there’s been a shift away from that in the MICA profession certainly over the last couple of years.

Urban

Urban focus group participants suggested that a lack of clinical support at high-acuity cases impacted decision making, and reduced the likelihood of a higher-risk intervention being applied/utilised. Responses suggested that this decreased the likelihood of intervention occurring despite the presence of a clinical indication for the procedure/technique and the awareness that the procedure may be of benefit to the patient in those particular circumstances.
UA21 I think, I’ve done 3 or 4 patients recently that you could have intubated them, RSI for stroke or for fitting, but proximity to hospital and being by myself, no let’s just put them on their side and take them.

UA22 There are plenty of times that I’ve been by myself and I’ve thought “If I had another MICA guy with me I would embark on intubating or I would do this or I would do that” but I don’t have and its quicker to get to hospital than it is to call for another MICA guy, so I’ve put them on their side and taken them to hospital. I’ve done that lots of times.

The urban focus group participants also expressed the view that a pre-hospital model that facilitated two MICA officers at high-acuity cases could create an environment where combined experience could assist with clinical problem solving:

UA11 Over the years I think there are a couple of things that have been good from MICA is that they have always had two people in metro so there has been a bit of if you can’t remember the other one quite often does and if neither of them can remember you can work your way through it between you and come to some kind of agreement and I think that’s a good confidence booster.

UA16.2 So we do rely on guidelines and approaches and all those kinds of things but experience whether that is actual experience we gain ourselves or if experience from listening to other colleges and chatting about jobs certainly makes that progress through the guideline and the approach much quicker and simpler and with less dead ends.

The urban group responses suggested that it is a common trait for paramedics to be internally driven by a motivation to achieve optimum outcomes for patients, but that this in turn may increase the likelihood of MICA paramedics performing high-risk procedures when working alone. Participants within the urban group demonstrated an awareness and ability to recognise when their skills and confidence are low, or below a standard that they consider optimal. Responses also indicated that paramedics may take responsibility for their own skills and knowledge maintenance:

UA27.6 The last month I wasn’t really away, the last month I was getting out the books and studying and making sure that I remembered a lot of stuff, so the last week of that was my own time making sure I was up-to scratch.

UA24.1 I know that I won’t get a backup out there so I look wholly and solely at what’s the best outcome for the patient or what I think is the best outcome for the patient, and if that means RSLing by myself then so be it.
UA24.1 And it gets back to being a little bit of that fearlessness..... I couldn’t care less what the CSO’s think, it’s about what’s best for this person and if it’s got to be done then it’s got to be done

Additional Factors Impacting Paramedic Confidence

**Rural**

In addition to the perceived lack of additional MICA resources in rural areas, the rural group expressed a perception that they had an obligation to intervene, even in circumstances where they found themselves working alone and faced with low-frequency high-acuity cases. Following on from this rural MICA paramedics recognised that when required to intervene, they were often doing so with high-risk procedures, in high-acuity cases, with little additional support:

*RA4* ..you’re required to intervene at the top end of the MICA skill set, not only in clinical assessment but also in actual intervention.

*RA3.4* ..it might be a TBI or may be others, but where you’ve got the situation you’re very much on your own..

The rural group recognised that certain pressures associated with pre-hospital care/decision making could be generated by both internal and external influences. The group suggested that internal pressure could be generated by things such as an individual paramedic’s emotional response to a scene, and the presence of self-doubt. Participants also suggested that internal expectations were related to a desire to do the best for the patient, even in the presence of impaired confidence and other challenges to clinical intervention:

*RA18.2* So I also know that when you’ve got that RSI setting you can do a lot of harm so that can actually really dent the confidence to go in and do it, because you haven’t been doing it for a while, you haven’t done one in a couple of years or whatever.

**Urban**

Participants in the urban group indicated that the SRU model was likely to result in MICA paramedics having little collegial interaction during and after shifts. The group expressed a perception that this
arrangement would reduce the availability of opportunities for informal feedback and discussion, and that ultimately this could be detrimental to clinical practice:

*UA8.1 As soon as I started single responding and had to be reliant on myself for every decision it was like starting again with the confidence.*

*UA31.1 Well you’ve really got to be aware that you’ve got people sitting in branches by themselves not gaining, first of all, no skills but also none of that kind of experience that’s going to come from chatting with others and learning from inferred experience.*

Some MICA officers within the urban group stated that they were prepared to intervene in the absence of a second MICA officer. Further to this, participants within the urban group indicated that they may be reluctant to intervene with high-risk procedures if they had decreased confidence in the other non-MICA personnel at a scene:

*UA24.1 It makes me nervous because firstly I am by myself I haven’t got someone there to check off those numbers with me and all that sort of stuff, but generally I’ve got a very ageing rural paramedic and a volunteer who’s doing that RSI with me and so if things go belly up I know that everything’s squarely on my shoulders.*

The urban group suggested that there was an onus on both the individual and the service for the maintenance of clinical knowledge and standards, but also recognised that the shift towards professional recognition for paramedics may mean that there is an increasing responsibility for individuals to maintain their own clinical standards and education:

*UA25 Yourself, yeah definitely yourself. I think there’s a degree of ownership to the service as well, to give you the facilities and the ability to get to that point.*

*UA25 ...So I think its 99.9% it’s up to you to get in and get your own training and to make sure you are up to speed. But it’s the .1% that the service needs to stand up and be counted for.*

*UA30.1 When we all did RSI that was our first foray into goal driven therapies, targeted driven training all to one standard and we’ve applied it to that, we then applied it to post resuscitation in cardiac arrest so it is a known thing and we need to apply it to ourselves but drive the actual service to provide that to us.*
Participants in the urban focus group made specific reference to the development of a systematic approach to patient care, highlighting the benefits to individual practice, and identifying that responsibility for the adoption of this approach fell on individual clinicians as well as the service as a whole:

UA17.1 ..have a systematic approach and follow the guidelines but you have some very good practitioners in this job and they all have very good understanding behind all of the guideline that we operate under.

UA13 You still work to a system because the system is built in and it’s been hard wired and you know to do it but when you are doing those jobs that you haven’t done all that often, I verbalise it some of the time to make sure that I haven’t missed something.

UA13.2 And I think the only thing that I’ve learnt over the years is to concentrate on getting people to practice systematically in step then that will relieve a lot of people’s stress, we do our training in the same way.

UA12.2 I don’t act instinctively at all and systematically and I think I can’t stuff it up if I do that so, I mean everybody does it differently but I recon if you’re not sure just go straight to that slow approach of the job and then stop several times, so stop once before you decide that you are actually going to treat and think “well am I doing the right thing”. Then after the first 5 minutes of treatment you stop then you load them in the car and it might be that when you have got a little bit of time on the way to the hospital have another think about it and go from head to foot and look at everything and think well did I actually miss anything.

Urban focus group responses also confirmed that paramedics wanted clarification of expectations regarding clinical practice under certain circumstances, such as when working alone. The group also felt that ambulance services should provide facilities, facilitators and time to engage in training and/or skills/knowledge maintenance. Further to this, they felt the need for adoption of non-confrontational methods of education delivery and clinical review:

UA27.1 Ok 25 years ago on MICA every time you went on leave you came back for a week at school so you did lots of prac, lots of case reviews, lots of discussion between things that, cases that were interesting “I would have never thought of that” you know “this person’s done such and such I would never have thought of that”.

UA26.1 ..by accessing the right people and it’s better to have that contact too, it’s having that network of people that you know, you’ll have one bloke that you’ll ask about this type of thing and another you’ll ask about this.
UA31.8 I mean everybody in this room is very clinically minded, motivated, and most of MICA are very clinically minded and motivated but there are a lot of people that just sit back and go “oh well I’ve got my qualification now, I don’t need to do anymore” and they are not interested in doing anymore, and so if they’ve got that downtime and sit around and do nothing and that’s what you were saying about the AP’s they get to that level and they just don’t want to learn more.

One urban response indicated an attitude that regardless of the possibility of negative feedback following a case, there was a high probability that they would intervene and provide what they considered to be the highest standard of care based on the patient’s needs, even when this required deviation from the established guidelines:

UA19.2 I’ve done some stuff way out of guidelines, I don’t do it routinely cause I’m a conservative person but I have done a few things where I think “Ah I know there’s going to be a lot of talk about this.” But I know it’s a required thing to do, so I just think that I’ll wear all the out flow of grief that might, you know, come my way.
Summary

The combined results of the rural and urban focus group responses were summarised into six major influences on clinician confidence. These will be expanded upon in the discussion chapter.

Table 36: Thematic Analysis Summary: Influences on Clinician Confidence

<table>
<thead>
<tr>
<th>Influences on Clinician Confidence</th>
<th>Rural and Urban Differences</th>
<th>Case Exposure</th>
<th>Training</th>
<th>Strategies for Minimising Risk and Error</th>
<th>Continued Learning</th>
<th>Cultural Considerations</th>
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<tbody>
<tr>
<td></td>
<td>A need for recognition of the unique characteristics of rural paramedic practice</td>
<td>The need for actual case exposure to consolidate theory and training - Systems that support exposure to increased high volume environments - The influence of both internal and external expectations at cases - The differentiation, and relationship between clinical judgement and intervention</td>
<td>The need for targeted training for paramedics in rural areas - The importance of the integration of soft skills and hard skills - A willingness from individuals to engage in skills and knowledge maintenance - A service approach to skills and knowledge maintenance - Broader application of training programs to incorporate multi-disciplinary management of high acuity cases in rural areas</td>
<td>The importance of an individual approach to systematic practice - Recognition of the differences between systematic and instinctive practice - The need for accepted standards to reduce ambiguity</td>
<td>The need for “refresher” training - The need for formal and informal processes of feedback and mentoring - The importance of self-reflection (reflective practice)</td>
<td>The influence of peer interactions - The need for recognition of cultural influence - The support for implementation of a culture of excellence, innovation and accountability - A shift towards standardised care of major trauma in rural and remote areas between clinical disciplines</td>
</tr>
</tbody>
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Chapter 5: Discussion

Introduction

This chapter will link and discuss the key findings from each of the research areas included in the project. The discussion will highlight the broad links between rurality and emergency care, whilst emphasising the relationships discovered between patient outcomes following TBI, the establishment and operation of effective trauma systems, case exposure and clinician confidence. Each sub-section in this chapter will highlight the findings, how these relate to the existing literature, and any implications relating to practice, policy and procedure. The summary will synthesise the findings from each separate study and aim to provide a cohesive understanding of the key arguments and implications following on from the study as a whole.

This research project had two main objectives. Firstly, the project aimed to investigate the relationship between trauma system design and rurality by comparing rural and urban traumatic brain injury outcomes (Research Area 1). Secondly, the project aimed to determine how decreased paramedic exposure to severely injured patients may impact confidence, performance and the willingness to intervene with high-risk procedures (Research Area 2).

The key findings that make an original contribution to knowledge are:

- In-hospital mortality and functional outcomes following severe TBI are no different between rural and urban areas serviced by a mature trauma system in Victoria

- Rural intensive care paramedics may be more willing to intervene with higher-risk procedures despite decreased exposure to low-frequency high-acuity cases
5.1 Rural-Urban TBI Outcomes - The Impact of Trauma Systems

5.1.1 Study 1: In-Hospital Mortality and Functional Outcomes Following Severe TBI

The findings for this sub-section did not support the hypothesis that severe TBI patients from rural areas would have higher in-hospital mortality and poorer functional outcomes at 6 months post injury. The findings indicated no association between rurality and functional outcomes at 6 months post injury, and no difference for in-hospital mortality between the rural and urban groups. These findings contribute to the existing knowledge by suggesting that trauma system design and maturity can mitigate potential disadvantages that may be encountered by rural TBI patients.

The methodological approach of this aspect of the study contrasts with the approaches of some previous studies that have compared major trauma and TBI outcomes based on the location of hospital intervention. This sub-section assessed the relationship between rurality and outcome using the location of injury as the reference variable, rather than the location of first hospital intervention. Although there is variance in the literature regarding the rural/urban differences in outcome following severe TBI, several studies suggest that patients suffering traumatic injuries have worse outcomes when injuries are sustained in rural or remote locations.

The profile of TBI patients shown in the univariate results reflect the profile outlined in previous studies. The results of Study 1 indicated that the TBI population in Victoria was over-represented by males, with the main injury patterns being road traffic incidents (rural) and low falls (urban). The proportion of rural TBI patients with an ISS of 40+ was higher when compared to the urban cohort, yet the urban cohort had a higher proportion of patients with serious co-morbidities. Cameron, Purdie, Kliwer et al also found an over-representation of males and a high representation from rural areas when studying 10 year outcomes following severe TBI. Chapital et al found a similar distribution relating to age and injury severity. Harradine et al found a similar proportion of TBI cases resulting from transport incidents and falls in their rural cohort, yet a higher proportion of transport incidents in their urban cohort when compared to this study. The study by Harradine et al did not use the AIS or ISS as inclusion criteria, and therefore did not specifically investigate a
severe TBI population. Chiu et al\textsuperscript{29} also found that the majority of TBI cases in both rural and urban settings occurred as a result of traffic incidents, with very high representation within the sub-group of motorcycle accidents. In a later study, Chiu et al\textsuperscript{27} found a higher severity of injury in a rural TBI population and similar trends in age and cause of injury as those found in Study 1. Motorcycle accidents remained over-represented in Chiu et al’s second study\textsuperscript{27}. It is likely that the studies by Chiu et al\textsuperscript{27,29} differs from the Study 1 findings due to the cohort being selected from rural and urban locations in Taiwan. In regards to this project, it becomes obvious that definitions of rurality may differ greatly between Australia and Taiwan, yet despite this there may be some benefit when considering programs aimed at reducing the incidence of severe TBI in developing nations.

The findings from this study indicated no difference in patient outcomes or in-hospital mortality, however the multivariable results suggested there may be a trend towards higher in-hospital mortality for urban TBI patients. This trend may relate to the proximity of urban TBI patients to urban hospitals. A possible explanation for this is that rural patients with similar severity of injury may not survive to hospital due to greater ambulance response times and transport times. This cohort of patients may survive to hospital in urban areas simply because they arrive at hospital in a shorter time frame, but ultimately do not survive due to the severity of their injuries. These findings lead to the Study 3 investigation into rural and urban pre-hospital pre-intervention TBI fatalities via the NCIS database. The Study 3 findings indicate some differences in the profile of rural and urban TBI fatalities but further research would be required to understand the relationship between pre-hospital resourcing, responses times and survivability to hospital following severe TBI. The findings also support parts of the literature by reinforcing that trauma systems can positively impact patient outcomes following traumatic injury\textsuperscript{7,42,184}.

The findings from Study 1 suggest that trauma system design may impact patient outcomes following severe TBI. It seems reasonable to suggest that the many factors that may adversely influence patient outcomes in rural areas may be counteracted by trauma systems that are capable of identifying, accessing and transporting severe TBI cases to the highest level trauma centres. Several studies support the positive impact of trauma system design and outcomes following major trauma. Gabbe et al\textsuperscript{13} confirmed the high proportion of severe TBI cases within the major trauma patient cohort in Victoria and concluded that functional outcomes following major trauma were better following management at MTS. An additional study by Gabbe et al\textsuperscript{195} found that the absence
of an organized trauma system was associated with increased risk-adjusted mortality in major trauma cases involving serious head injury. A Scottish study\textsuperscript{241} found the same trends relating to the cause of injury as those found in Study 1, but also found a higher proportion of males in the urban group and no difference in ISS. The study by McGuffie et al\textsuperscript{241} focussed on major trauma patients in general and concluded that longer pre-hospital times in rural areas were not associated with differences in patient outcomes.

**Strengths**

The strengths of this study are that the data was sourced from the VSTR, which is an established and robust population registry\textsuperscript{12,195,413}. The VSTR uses extensive inclusion criteria to ensure that it captures all major trauma cases within Victoria\textsuperscript{413,414}, and has good follow up rates\textsuperscript{415}. Only 10\% of the cases that met the inclusion criteria were lost to follow up. Additionally, the results provided a profile of TBI patients consistent with previous epidemiological studies\textsuperscript{36,157,167}. It seems reasonable to suggest that data used for this study provided an accurate representation of a severe TBI population managed within a setting serviced by an established trauma system.

A further strength of this study is the methodological approach that followed TBI cases from the point and location in which the injury occurred through to outcomes at 6 months post-injury. Much of the existing literature related to rural-urban patient outcomes classify rurality based on the location where as patient first attended hospital\textsuperscript{27,29,34,35,174-178,180-183}. Although there may be a close correlation between the location of injury and the location of first hospital intervention (e.g., an injured patient in a rural area may first attend a rural hospital), the literature regarding regionalisation of trauma systems and the use of retrieval services\textsuperscript{12,14,194,197,199-201,207,221,222,229} also shows that severely injured patients from rural areas within a region serviced by an established trauma system may well be treated initially at a major trauma service rather than a smaller regional hospital. In this regard, a classification of rurality based on location of first hospital intervention may not clearly represent those patients who sustained their injury in a rural area. This study classified patients based on the location of injury, and from a patient centred perspective this is likely to be very important. It seems logical that people living in rural areas will primarily be interested to know whether they will be disadvantaged if they sustain a serious injury where they live.
Limitations

The findings cannot attribute causality because of their observational nature. This study was also limited by the inability to allocate ARIA+ categories to some cases, and that all key variables defining differences in patient profile may not have been identified. Further to this, the current range of rurality indices is relatively small\textsuperscript{256}, which reflects the difficulty of providing an objective and measurable tool that encompasses the many differences between rural and urban communities.

It is important to mention the use of the ASA co-morbidity grading scale in this study. Whilst there were a relatively small number of cases missing co-morbidity data in Study 1, the ASA index has been recognised as having high subjectivity\textsuperscript{446} and varying reliability\textsuperscript{446,447}. The advantages and disadvantages of instruments used to effectively measure outcomes following major trauma are recognised in the literature\textsuperscript{422}, and whilst the rate of GOS-E capture was very high for the TBI cohort in Study 1, consideration of other measures may have been useful. The use of the ASA co-morbidity scale and GOS-E in this study was primarily dictated by the capture rate of these measures within the VSTR during the applicable study period.

Study 1 Summary

Key findings;

- No difference in functional outcomes between rural and urban TBI cases
- No difference in in-hospital mortality between rural and urban TBI cases

These findings suggest that although rural populations may have adverse outcomes in other critical areas such as cardiac arrest\textsuperscript{154}, and are considered to be disadvantaged in regards to health care access, quality of care and other health determinants\textsuperscript{42,257,260,262,263,270}, that elements within a mature trauma system may counteract aspects of rurality normally associated with adverse trauma outcomes.
5.1.2 Study 2: The Use of HEMS at Rural TBI Cases (VSTR)

The findings of this study supported the hypothesis that appropriate HEMS utilisation within established trauma systems can maximise the capture of severely injured patients in rural areas, providing a link with major trauma services in metropolitan areas. The findings also suggest that greater HEMS utilisation in rural areas may contribute to decreased exposure of road-based paramedics to high-acuity cases. These findings contribute to the existing knowledge by confirming that effective trauma systems rely on the combination of many system-factors to achieve optimal patient outcomes, and also that there may be a need to establish programs aimed at enhancing the capability of road-based intensive care paramedics in rural areas who may be tasked with managing low-frequency high-acuity cases.

These findings support the literature that shows effective HEMS utilisation can capture more severely injured patients when compared to road ambulances. These findings also suggest that the appropriate tasking and utilisation of HEMS may have cost benefits, although the literature reiterates that such analyses are often subjective and dependent on many factors. Although these findings suggest an association between HEMS utilisation and favourable functional outcomes, other studies highlight the difficulties in making such associations between HEMS utilisation and patient outcomes.

HEMS may have a greater benefit for rural trauma patients compared to urban patients, within certain parameters. However we do not know whether it is the care provided by paramedics, the intervention that is provided by HEMS crews, the decrease in overall transfer times, the initial stabilisation at a major trauma centre, surgical intervention or rehabilitation services that contributes the most to favourable outcomes following severe TBI. It is likely that each of these components makes an important contribution, therefore strengthening the overall system.

A study by Melton et al suggests that the benefit of HEMS lies in the ability to provide a rapid transport platform from remote locations, rather than any interventions that may be performed. Parts of the literature suggest high-risk pre-hospital interventions should only be performed by physicians, although current thinking tends to indicate that appropriate training rather than
clinical discipline dictates the level of safety regarding such procedures\textsuperscript{17,18,21,219}. It remains important therefore to keep in mind the “bigger picture” and to question whether the true benefit of HEMS utilisation is the transport platform or the intervention provided\textsuperscript{231}. It is likely that the benefits arise from a combination of these factors. It follows then that severe trauma patients in rural areas are likely to benefit from higher-level intervention whether that is provided by a HEMS team, road-based intensive care paramedics, or clinicians from another discipline.

Whilst the findings from Study 1 indicate that elements within the trauma system minimise disadvantages experienced by rural trauma patients, it must be recognised that the methodology did not isolate individual elements. It is therefore very difficult to quantify the contribution of system factors such as pre-hospital intervention, HEMS utilisation, ED management or early surgery in the context of favourable outcomes following major trauma. With this caution in mind, it still seems logical to suggest that improvements within small components of the trauma system may still contribute to the overall effectiveness of the system. The Study 1 findings that indicate greater HEMS utilisation in rural areas, and the Study 2 findings that indicate differences in the profile of TBI patients transported by HEMS, both suggest that the pre-hospital elements within a trauma system are important. The findings also highlight the need to have strategies in place when elements within the trauma system may not be available. In the absence of HEMS resources, it therefore becomes important for rural clinicians to be capable of accessing, treating and stabilising major trauma cases despite delays in patient retrieval and transport to the Major Trauma Services. Rural paramedics and clinicians from other disciplines may need deliberate support in order to maintain their skills and confidence.

This study does not intend to contribute to the discussions regarding who should staff HEMS resources. The underlying concept to be reinforced is that regardless of the craft group undertaking HEMS retrievals, high-risk interventions must be performed safely and deemed beneficial to patient outcomes\textsuperscript{230}. The use of RSI by MFPs in the Victorian system is one such example, and this example holds some relevance this our study. If RSI performed by HEMS paramedics is considered beneficial to rural head-injured patients, the question should be asked how best to maintain this standard of care in the absence of HEMS resources.
In the setting of severe TBI in rural areas, road-based pre-hospital RSI may have great importance when HEMS resources are unavailable. The key principles of pre-hospital care are to provide a high level of appropriate stabilisation and intervention, whilst minimising overall transport and transfers times, and striving to ensure that specific patients are transported to the most appropriate medical facilities\textsuperscript{232,233}. Pre-hospital care of major trauma patients may include interventions across the spectrum of patient access, extrication, immobilisation, physiological stabilisation, pain management, packaging and transport. Each of these elements within the spectrum may have greater emphasis from case to case, and it could be argued that each element requires a high degree of knowledge and experience.

**Strengths**

A strength of the Study 2 findings is that they are based on data from the VSTR. As mentioned previously, the VSTR uses extensive inclusion criteria to ensure that it captures all major trauma cases within Victoria\textsuperscript{414}, and has good follow up rates\textsuperscript{415,422}. As per Study 1, a further strength of Study 2 is that the methodology was designed to follow severe TBI cases from the location of injury through to 6-months post-injury.

**Limitations**

A limitation of this study is the observational nature of the study design and the inability to randomise patients into HEMS and non-HEMS groups. To accurately determine the association between HEMS utilisation and patient outcomes, variables that relate to tasking decisions and resource availability must be included. Such information was not available for this study, therefore any association between HEMS utilisation and patient outcomes must be taken with great caution. The limitations in Study 1 also apply to Study 2.
Study 2 Summary

Key findings:

- Appropriate integration and utilisation of HEMS within established trauma systems can maximise the capture and treatment of severe TBI case in rural locations
- HEMS utilisation in rural areas may decrease the exposure of road-based paramedics to the management of severe TBI cases

These findings suggest that appropriate HEMS utilisation within an established trauma system may have a positive influence on patient outcomes following severe TBI, but also that such utilisation may decrease the exposure of rural road-based paramedics to high acuity cases. Caution must be exercised regarding the influence of HEMS utilisation on patient outcomes, as highlighted in the limitations, and further research into this area may be needed and warranted.

These findings are important as they reinforce the need to address specific factors likely to impact the trauma outcomes in rural areas. These findings suggest appropriate trauma system design may mitigate inherent difficulties in accessing severe TBI cases in rural areas and ensuring that they receive appropriate and timely management at designated Major Trauma Services. The findings also suggest that further studies may be useful regarding the relationship between case volume, clinician experience, clinician confidence and the management of severe TBI cases in rural areas.

5.1.3 Study 3: Pre-Hospital, Pre-Intervention Fatalities (NCIS)

The findings from this study are important as they reiterate that there are rural-urban differences in the profile of fatalities occurring as a result of severe TBI. This cohort of cases reflects those incidents where a fatality occurred prior to arrival of ambulance services, and where no clinical intervention was required or performed. The findings show that there are a very small number of pre-hospital pre-intervention fatalities with severe TBI as the primary injury in both rural and urban areas of Victoria. The findings provide some insight into characteristics of these cases.
These findings support the literature by confirming that males are over-represented in certain subsets of pre-hospital fatalities. Studies by Treacy, Jones and Mansfield\textsuperscript{137}, Soriede\textsuperscript{135}, the BIRTE\textsuperscript{131}, Wisborg\textsuperscript{127}, and Simons et al\textsuperscript{43} confirmed this gender difference whilst also reiterating a high incidence of road traffic related fatalities. The small number of pre-hospital pre-intervention fatalities identified may reflect the efficiency of the pre-hospital component of the trauma system in the Victorian setting. The findings may suggest that a large number of pre-hospital trauma fatalities are at least attended by ambulance paramedics, even in circumstances where no intervention is provided. Although the strength of the findings are limited, this premise would support the conclusions by Simons et al\textsuperscript{43} who suggest that improving trauma outcomes in rural and remote areas requires an approach that addresses delays in EMS access and initiation of care within a given trauma system\textsuperscript{43}.

As the findings from this sub-section were limited, they are unable to support the literature that indicates higher mortality from rural vehicle trauma\textsuperscript{177}, although the findings do show that motor vehicle crashes represent a large proportion of both rural and urban fatalities. Further to this, these findings seem to contrast the number of cases identified in previous studies. A study by Rosenfeld et al\textsuperscript{136} found 355 pre-hospital road traffic fatalities over a 5 year period that had sustained head injury, also indicating that 237 of these cases were considered non-preventable. No reference was made to the percentage of these non-preventable deaths that were attended by ambulance. In addition to this, a Norwegian study\textsuperscript{127} concluded that over 65% of trauma fatalities are deceased at the scene, which may suggest that a higher number of pre-hospital pre-intervention fatalities would be expected in Victoria. However, differences in the geography, population demographics, pre-hospital services and trauma systems may limit comparison with the Norwegian findings.

**Strengths**

A strength of this study is the use of the NCIS database. This source provides extensive information regarding all aspects of case information from police reports through to coronial reports. The methodological approach was sound and yielded an accurate number of cases. The cases included are the actual population of pre-hospital pre-intervention, thus sample size calculation was not required.
Limitations

This study is limited by the small number of cases and limited statistical power. This study is further limited as the NCIS database does not collect information from sources with strict or mandatory parameters. Much of the information included in the NCIS is extracted from reports that are not written specifically for research. It follows that key parameters deemed important to this study (such as the presence of absence of alcohol) may not have been included in all reports due to a lack of relevance at the time of the fatality. Low inter-rater reliability indicated the difficulties associated with analysing cases from this data source.

Study 3 Summary

These findings indicate that there are a small annual number of pre-hospital pre-intervention fatalities due to severe TBI, in both rural and urban locations in Victoria. The small number of cases and lack of statistical power has limited analysis for this section, however the findings support the rural and urban profiles of these case types as identified in the literature.

5.1.4 Study 4: Pre-Hospital, Post-intervention Fatalities (VACAR)

The findings of this study confirm the initial hypothesis that amongst the TBI population there is a higher proportion of traumatic cardiac arrest cases, with TBI as the primary injury, in rural areas. The findings also suggest that fewer procedures are performed during the resuscitation attempts at these cases in rural areas. These findings are important as they show that the frequency of traumatic cardiac arrest cases with severe TBI as the primary injury is low in both rural and urban settings, which has implications for paramedic skills maintenance, exposure and confidence.

The findings add to the literature primarily via the methodological approach designed to compare paramedic intervention at traumatic cardiac arrest cases rather than patient outcomes. Previous studies investigating rural/urban difference in critical care outcomes found worse outcomes following cardiac arrest in rural areas\textsuperscript{154}, and numerous studies highlight the likelihood of poor outcomes following traumatic cardiac arrest\textsuperscript{138-142,144-148}. 
In addition to this, the findings may also support the literature by highlighting the potential influence of pre-hospital intervention. Much debate remains regarding the most appropriate type and level of intervention administered by paramedics, however parts of the literature reinforces the importance of pre-hospital services in “chain of survival”.

Although an association cannot be drawn between the low frequency of this case type in rural areas and patient outcomes, the findings add to the literature by highlighting problems associated with skills maintenance of critical care procedures. The literature suggests that skill erosion can occur even amongst experienced clinicians. The findings from Study 4 may suggest that fewer procedures are performed during rural traumatic cardiac arrest cases, which may be attributed to fewer attending paramedics. As the literature shows that cardiac arrest outcomes are worse in rural areas, some links may be made between the number and experience of attending paramedics and patient outcomes in certain case types. The low number of procedures performed may also be related to the severity of injuries and the viability of the patient on arrival of ambulance crews, or the confidence and competence of the attending paramedics. The Study 4 findings are not conclusive regarding these considerations, and further research into these areas is required.

**Strengths**

Cases for this study were selected from a 3 year time period designed to correlate with the other areas of quantitative analysis. A strength of this study is that data were sourced from the VACAR. VACAR data have been utilised in other studies comparing cardiac arrest outcomes within the Victorian system. Thorough statistical analysis was conducted in this section, aiming to provide a broad overview of time-frames, personnel and interventions associated with traumatic OHCA cases with severe TBI as the primary injury. The methodological approach for this section was simple, and designed to detect small differences between rural and urban cases.
Limitations

A limitation of these findings is that they were based on only a small number of cases (8 rural: 44 urban). The small number of cases and very low number of procedures performed in rural cases precluded the use of Chi square analysis to test the significance of the result. A further limitation is that the VACAR data do not include extensive case details, which may otherwise have provided insight into factors likely to increase case complexity. In addition, this patient cohort prevents making an association between the number of attending paramedics, number of procedures and outcomes following cardiac arrest.

Study 4 Summary

These findings are important as they indicate that traumatic cardiac arrests in rural areas, with TBI as the primary injury may have fewer procedures performed during the resuscitation attempt. This may have implications regarding resourcing and clinician confidence, each of which will be discussed in detail later in this chapter.

5.2 Rural-Urban TBI Outcomes: Paramedic Confidence and Competence

5.2.1 Study 5: Rural – Urban Differences in Paramedic Exposure to RSI (VACIS/HR)

The findings from this study supported the hypothesis that paramedics working in rural areas performed a lower average number of RSIs. The findings are important as they also indicate that exposure to the RSI procedure is low regardless of whether the paramedic is working in a rural or urban location.

An extensive literature review revealed no studies comparing the difference in the number of RSI procedures performed between rural and urban paramedics. There are however studies within the literature that discuss the relationship between caseload, procedural volume and either quality of care or the potential impact on patient outcomes. The findings from this study in isolation are
unable to indicate the impact of procedural volume on patient outcomes, but it seems reasonable to suggest that the premise articulated by Killeen et al, that “practice makes perfect”, might apply to the use of RSI by paramedics working in rural areas. Several studies reiterate the importance of regular and specific training in preparation for the management of airway emergencies\textsuperscript{325,326,338}, and the findings of low procedural volume for rural paramedics using RSI may further highlight the need for such training in low-volume locations. The findings compliment studies that have indicated case volume and clinician confidence are closely linked\textsuperscript{294,299-301,312,315,389}.

The findings for this section are clinician-centred and therefore contrast those aspects of the literature that make specific reference to the importance of “institutional volume” and patient outcomes. This area of the literature discusses the benefits on patient outcome when cases are managed at hospitals that have a high annual volume in specific procedures\textsuperscript{316,318-320}. The findings from this study relate directly to individual clinician exposure, and the rural/urban comparison was important as it highlighted potential deficits within a service that may have a high overall volume of RSIs per year. Even within such services it is important to identify groups of clinicians who may be susceptible to skill erosion. The study is limited however, as many factors influence the experience, exposure, confidence and competence of individual clinicians. The VACIS analysis was based only on data relating specifically to years of experience and the application of RSI, and additional influences were not accounted for.

\textbf{Strengths}

A strength of this study is that the combined datasets both originated from the one source, Ambulance Victoria. The combined VACIS and HR datasets were collated during the same time period (2011), therefore providing an accurate representation of the number of paramedics employed by AV during that time, and the number of RSIs that were performed. The use of VACIS data also strengthened the overall study design as the VACIS database is also used by VACAR\textsuperscript{429,448}. 
Limitations

The study was limited by the methodological approach used to combine data sources. The methodology required the combination of VACIS/RSI and HR datasets, in order to provide a complete data table including all RSIs performed in 2011, who had performed them, and where they were undertaken (postcode). Cases may have been lost due to the inability to link cases with treating paramedics, considering that some paramedics may have changed roles or may have no longer been employed. The categorisation of paramedic skillsets and years of experience may not accurately represent these variables, as some paramedics may be listed under one generic category (e.g., rural MICA), but may in fact be a MICA flight paramedic. The case details may indicate that an RSI was performed, and therefore that a MICA paramedic had treated the patient, but it does not tell us how experienced that MICA paramedic was, or whether there was single or multiple MICA paramedics at the scene. Further to this, the experience/skillset data did not differentiate between those MICA paramedics who were operational, and those who may still hold the qualification but were working in an administrative role. There may have been MICA paramedics employed by AV during the study period who were on prolonged leave (e.g., sick leave or long-service leave), or did not work on-road, and therefore would not have performed any RSIs during that period.

Study 5 Summary

These findings are important as they indicate that rural intensive care paramedics perform a lower average number of RSI procedures compared to their urban counterparts. In addition to this, the average annual number of RSIs performed by the combined rural and urban cohort remains low. Each of these points may have implications regarding skills maintenance, clinician confidence and a willingness to intervene with high-risk procedures.
5.2.2 Study 6: Inclination to Intervene with Higher Risk Procedures (VACIS)

Extensive case reviews were unable to clearly identify suitable cases, therefore the findings from this study were inconclusive.

The hypothesis for Study 6 was partly based on the results of Study 1, which indicated that rural TBI cases occurred mostly as a result of traffic related incidents, with rural TBI patients having a greater severity of head injury and associated injuries. Study 1 also indicated that a much higher proportion of rural TBI cases were transported by HEMS. This was interpreted as indicating that road-based MICA paramedics in rural areas may perform fewer RSIs for this patient group, due to MICA Flight Paramedics (MFPs) attending the scene and performing this procedure. The combination of higher severity of injury for rural TBI patients and potential for lower exposure of rural road-based MICA paramedics to the RSI procedure suggested there may be a greater likelihood of this procedure not being performed when it was required and indicated.

A mixed quantitative and qualitative approach was used to identify potential cases. A total of 10 potential cases were identified, but the lack of sufficient detail within the case descriptions prevented conclusive identification of cases where RSI was indicated but withheld by road-based intensive care paramedics. It is important to highlight the possibility that such cases may not have been identified because there have been no occasions where RSI was indicated and necessary but was withheld by road-based intensive care paramedics. In the context of the overall study it was hypothesised that due to decreased exposure to severe TBI cases in rural areas, in combination with the higher severity of TBI cases (Study 1), the lower RSI utilisation rate per paramedic (Study 5) and limited availability of MICA resources, that there was a greater likelihood of rural road-based MICA paramedics electing not to utilise RSI in preference to waiting for HEMS resources to arrive a given scene. It should be highlighted, that although the findings from Study 6 were inconclusive, the findings based on focus group responses in Study 7 suggested that rural road-based MICA paramedics were more inclined to intervene with RSI in such cases, even whilst recognising the limitations regarding experience, exposure and resourcing. These findings will be discussed in the following section.
**Strengths**

A strength of this study was the number of VACIS cases available for review (n= 2123), and the application of mixed qualitative/quantitative approach to identifying potential cases. The review of cases was conducted by two reviewers, therefore decreasing the chance of bias and increasing validity.

**Limitations**

A limitation of this study was that the combination of VACIS and HR datasets may not have correctly identified all attending paramedics at a given TBI cases, or accurately represented who had performed the RSI if this procedure was performed. The datasets were combined by matching the variable “case patient ID” in both datasets. The time periods for both datasets did not correlate exactly, and not all paramedic reference numbers were present in both datasets. The datasets had the following timeframes: RSI data included case from 2008 – 2011; HR data only included paramedics who were operational in 2011.

A further limitation of this study was the variance of information included in the VACIS case details. As these cases details were written by individual paramedics, the degree of detail and the quality of information varied greatly between cases. In addition to this a quantitative approach was also unable to clearly identify cases. The case review process may have been strengthened through the application of a more stringent review process. Such a process could have been enhanced by ensuring that reviewers were blinded to the hypothesis and by applying a more detailed case interpretation strategy.

An additional limitation of this study is that it was not designed to identify cases where RSI was required but delayed or withheld at cases presenting at small hospitals or other rural medical facilities. It is possible that Air Ambulance resources attended these cases (either HEMS or fixed-wing resources), but the cases were not attended by road-based paramedics. In such cases it is possible that the use of RSI was indicated but the procedure was not undertaken by medical staff in attendance. Within the data used for this study, these cases may have been listed as “RSI
performed” by the attending HEMS paramedic, with no reference to delays in the procedure prior to their arrival.

**Study 6 Summary**

An attempt to identify cases that met the criteria for RSI but where the procedure was not performed was unsuccessful. Limited and varied information contained in the case descriptions limit the conclusions that can be drawn from this finding.

**5.2.3 Study 7: Paramedic Confidence and Competence (Focus Groups)**

This study focussed on the performance of rapid sequence induction (RSI) for intubation performed by paramedics, with this intervention representing a low-frequency, high-risk procedure. The findings from this section did not support the hypothesis that rural intensive care paramedics are less willing to intervene with higher risk procedures due to decreased exposure to these case types.

This finding supports the literature by confirming that frequency and exposure are factors that directly influence an individual clinician’s decision making and willingness to intervene with high-risk procedures. The finding also indicated that case complexity directly translated to complexity associated with decision making, which was referred to in the literature. Further to this, the finding indicates that both rural and urban paramedics experience a degree of pressure, expectation, and concern regarding the management of low-frequency high-acuity cases, regardless of the geographical location they work in. This perception did not appear to be isolated to the rural group only, as the literature makes clear reference to the need for practical application (ie actual cases) as well as training, particularly in areas with low-volume caseload. An important study by Gerhardt suggested that there is a finite availability of severely injured patients, which translates to limited exposure for a set number of paramedics within a certain demographic. Focus group responses build on this concept by confirming that the application of skills in the live setting, after having undergone specific skills training, was vital for the development and maintenance of confidence. The findings further supported aspects of the literature by reinforcing the need for
strategies to develop team work in simulation for health providers working in the acute care setting$^{292-294}$.

Confidence emerged as an underlying theme throughout the discussion. Several participants indicated that confidence in performing RSI had increased since the introduction of the RSI training package, and that this impacted the way that they approached undertaking the procedure. The aspects of the package that seemed to contribute to this included the structure of the program itself, the clarity and lack of ambiguity in the procedural pathway, and the consistency of the way that the program was actually taught.

Focus group findings suggest that frequency and exposure are factors that directly influence an individual clinician’s decision making and willingness to intervene with high-risk procedures. Responses also point towards the influence of culture and collective learning, suggesting that individual experience may not be the only factor that impacts clinician confidence. These findings suggest that support structures and the active inclusion of mentoring systems may assist individuals with developing and maintaining their own decision making processes, and that these processes are directly linked to skills and knowledge maintenance.

The focus group findings indicate inherent differences between rural and urban practice. The differences that were described related primarily to culture, attitudes and differing characteristics of case types between rural and urban areas. Although there may be some negative aspects related to the cultural difference, there are also some positive traits that seem inherent in rural practice. Findings indicated an inclination amongst rural paramedics to intervene with high-risk procedures even in circumstances that were less-than ideal (e.g., no MICA backup, long transport times, no HEMS). There was also a similar inclination amongst urban paramedics to intervene on the patient’s behalf, despite the potential consequences including increased scrutiny and criticism. Both examples highlight a strong characteristic within paramedics to provide high level clinical intervention, to challenge contemporary thinking, and to expand the paramedic scope of practice$^{92}$.

Although several studies recognise the need for refresher training to minimise skill and knowledge erosion$^{304,306,310-312}$, little has been written regarding the process of clinicians developing their own
frameworks and decision making tools. Focus group responses indicated that urban paramedics may have higher levels of motivation to develop such processes, and this may be a reflection of higher case exposure and higher individual confidence amongst urban paramedics. The qualitative findings indicated that both rural and urban paramedics were proactive in developing their own personal strategies and decision making systems in order to effectively manage low-frequency cases. This supports the findings of Thomas, Abo, and Wang\textsuperscript{132} indicating that paramedics take pride and gain confidence from their intubation skills. The authors suggest that ETI performance by paramedics is dependent on many factors including education, oversight, professionalism and skill retention strategies.

The combined findings from Study 2, Study 5 and Study 7 suggest that the use of HEMS in rural areas may further compound issues regarding skill and knowledge erosion amongst road-based intensive care paramedics. Study 2 highlighted the greater use of HEMS for rural TBI cases while Study 7 indicated that both rural and urban paramedics are aware of the relationship between case-volume and clinical performance. Further to this, Study 5 confirmed that rural MICA paramedics have lower exposure to the RSI procedure, yet the qualitative findings from Study 7 indicated that rural road-based MICA paramedics were more inclined to perform RSI despite inherent barriers and resourcing issues in rural areas. Low exposure to severe TBI cases and decreased levels of confidence may negatively impact the performance of RSI by road-based paramedics, and strategies may be required to address this in rural areas.

**Strengths**

A strength of this study is that the small size of the rural and urban focus groups allowed for in-depth discussion and elaboration of responses. A further strength is that the composition of both groups included paramedics with a range of experience, seniority and practical experience. This allowed for rich contributions based on a depth of knowledge and expertise.
Limitations

A limitation of this study is that only two focus groups were conducted, and this may have limited the scope of responses. A selection bias was also likely present as participation was voluntary, resulting in inclusion of paramedics who were more willing to offer positive contributions and solutions. Paramedics who did not volunteer may well have had valuable contributions and alternative perspectives.

Study 7 Summary

The qualitative findings are important as they highlight differences in the attitudes between rural and urban paramedics, particularly regarding a willingness to intervene with high-risk procedures and the need for self-generated strategies for managing low-frequency high-acuity cases. These findings relate closely to the quantitative findings regarding paramedic experience and exposure, and will be discussed in the broader context in the following section.

5.3 Considerations Regarding Rural/Urban Classifications

Differentiating between rural and urban locations formed a fundamental component of this project. Defining and understanding rurality is important, particularly when comparisons are made regarding clinical intervention and patient outcomes. The purpose of this section is to reflect upon the available methods for classifying rural and urban cases in the setting of emergency care, why this may differ in regards to other aspects of health service delivery, and to assess the gaps in current definitions that are available.

The concept of rurality encompasses many factors and a useful definition should aim to incorporate these. Wakeman states that the concept of rurality is “complex, variable and evolving; there is no satisfactory, universally applicable index of remoteness, nor definition of remote health or remote health practice”⁵. This statement provides an insight into the complexity of not only defining rurality, but more importantly of developing a meaningful, applicable and usable definition of
rurality. An understanding of the complexity surrounding the definition of rurality provides some insight into the challenges regarding the development and application of useful rural indices.

Appropriate use of any definition must be closely aligned with the context in which it is used. In the context of health research definitions of rurality are predominantly used as the foundation for investigations regarding health outcomes in rural areas. With rurality definitions playing such a fundamental role in health research, their classification structure, accuracy, currency and validity become very important. In this regard definitions and resulting classifications have the potential to influence findings, policy and the development of future practices. The methodology of this research project contributes to the existing knowledge by highlighting the need for specific measures of rurality designed for application in the context of emergency practice. This project specifically highlights that the study of rural pre-hospital care could benefit from a remoteness classification encompassing elements that impact patient access to pre-hospital services, acute care services, and trauma services.

The importance of accuracy and sensitivity in rural definitions and classifications has been discussed in parts of the literature. The methodology for Studies 1 and 2 included comparisons between rural/urban classifications. These studies utilised ARIA+ (Model 1), and a generic rural/urban classification used by the Victorian Department of Human Services based on local government areas, which also corresponded with Ambulance Victoria regions (Model 3). Model 1 indicated no difference but suggested a trend towards higher in-hospital mortality, while Model 3 indicated significantly higher odds of in-hospital mortality in the urban group. In the context of rural/urban classifications, the importance of the difference in results from Model 1 and Model 3 is the suggestion that rurality indices can influence research findings, and may therefore influence the conclusions and implications based on such findings. This contrasts the findings by Dempsey et al who found no difference in patterns of health service utilisation when location of residence was classified by three different methods.

Access to health care in rural areas is well-studied in the literature. It follows that the deficits regarding health care access between rural and urban locations may influence patient outcomes across a broad spectrum of illness and injury. This highlights the importance of the
findings from Study 1, which suggest that trauma system design can overcome some of the limitations regarding rural access to Major Trauma Services.

This project utilised the ARIA+ methodology for classifying rural and urban cases. ARIA+ uses a geographical approach to defining rurality, based on road distances from populated localities to the nearest service centre. These service centres are based on population size and include five categories. A ratio and subsequent score is calculated based on interpolation of the distances to each category of service centre. It has been suggested the strengths of ARIA+ over other systems include its purely geographic nature, which does not take into consideration other factors and differences inherent between rural and urban locations. Mc Grail and Humphreys however, suggest that an appropriate rural index should incorporate both spatial and aspatial (non-geographic) factors. Other studies reiterate that defining access to health services should include aspatial factors such as availability, affordability and acceptability. Murray et al. highlight the need for inclusion of person-environment interactions when determining differences in access to services, particularly in rural areas.

The suggestion that these aspects, or characteristics, have value in defining rurality further indicate that the quality of health is not just determined by the level of care that is available or the way that health services can be accessed. What becomes evident is that health is partly determined by the individual and the community. At the most basic level this may be demonstrated by the activities an individual or community engages in, and how these relate to injury patterns and fatalities.

Within this project, Studies 1, 2 and 3 found differences in the demographics of TBI cases, and the way that these injuries are sustained. These studies indicate a higher proportion of injuries in rural areas amongst younger males involved in motor vehicle incidents. This may be interpreted to show behavioural and demographic differences between rural and urban communities. Although it is beyond the scope of this study, these findings may also be related to decline and social disadvantage in rural Australia, and the possibility of people living in rural areas being exposed to greater physical risks.
Lopez-Abuin, Garcia-Criado and Chacon-Manzano\textsuperscript{250} state that rural communities expect access to “rapid and high-quality health assistance in an emergency”, indicating that the delivery of such care is more difficult in these locations. These challenges, as they relate to emergency care, are supported by other studies\textsuperscript{253,277}. Conversely O’Meara, Burley and Kelly\textsuperscript{280} indicate that the success of rural urgent care systems is based on geographical, social and economic influences, which further reinforces the need for indices of rural access to consider factors beyond geographical distance. Humphreys\textsuperscript{269} highlights that health care in rural areas requires integration, co-ordination, public participation and service suitability. Each of these factors provides an indication of influences regarding access to health services. Pong, DesMeules and Legace\textsuperscript{251} reinforce that the issues are not isolated to the Australian context.

This summary has highlighted the project findings as they relate to the challenges surrounding access to emergency and acute care services in rural areas. This section has aimed to show the complexities surrounding definitions of rurality, and the challenges in measuring access to services. The findings are supported by elements within the literature, and highlight that an index of rurality designed to measure access to emergency care may be useful for future research and planning.

Chapter 6: Implications for Policy, Practice and Future Research: Project Conclusions

6.1 Introduction

This chapter aims to integrate the research findings from this study, presenting them as building blocks for policy development, changes in clinical practice and future research. The first section, 6.1, will outline the implications for policy and practice relating to trauma system design, HEMS utilisation within existing trauma systems, and paramedic practice relating to the application of RSI and the management of severe TBI cases. Section 6.2 will outline key areas for future research specifically related to the use of decision support tools in the pre-hospital setting, whether reduced scope of practice for paramedics in areas of low caseload may be viable, and strategies for enhancing the performance of multi-disciplinary teams in rural and remote locations.
The final two sections of this chapter will reiterate the limitations of the study and offer final conclusions based on the findings. The conclusions will be offered in the context of the current literature and the limitations of the seven individual studies, as well as the overall study design and methodology.

### 6.2 Implications for Policy and Practice

#### 6.2.1 Trauma System Design

By looking for an association between location of injury and functional outcome following TBI Study 1 aimed to determine whether the previously reported negative aspects of rurality, in the setting of emergency health care, could be influenced by trauma system design. Having found no difference in outcome these findings are suggestive of the benefits of trauma system design and maturity. This may be useful in locations either lacking the services of any trauma system at all, or having a trauma system that lacks integration and functionality.

Mature trauma systems provide an example of the structure required to minimise disadvantages across geographical regions, which has particular importance for rural and remote communities. Access to emergency health care and high level trauma intervention is likely to remain a problem in both developed and developing countries, yet the Victorian State Trauma System may provide a sound example of the way that system design can influence patient outcomes. The finding that trauma system design can positively impact outcomes following severe TBI is important, and supports the level of maturity and integration within the Victorian State Trauma System. If the most seriously injured patient cohort can benefit from trauma system maturity, then other trauma patient profiles are also likely to benefit. The VSTR may therefore represent a model of trauma system design able to meet the demands of catchments encompassing locations across a broad geographical spectrum.
6.2.2 HEMS Utilisation Within Established Trauma Systems

Studies 1 and 2 highlighted the greater use of HEMS resources in rural areas. The possible benefits of HEMS utilisation in rural areas have been discussed. These benefits are likely to stem from a combination of efficient patient access, clinician expertise, minimisation of inter-facility transfers and early management at Major Trauma Services.

The higher utilisation rate of HEMS in rural areas may also have implications for rural road-based paramedics. With a lower volume of severe TBI cases in rural areas, greater HEMS utilisation may further dilute the exposure of road-based paramedics to this patient cohort. Infrequent exposure to high-acuity cases (e.g., severe TBI cases) and the subsequent decreased use of higher level intervention (e.g., RSI) has implications for skills maintenance, clinician confidence and patient safety. The combined results of Studies 2, 5 and 7 suggest that comparatively higher utilisation rate of HEMS in rural areas may contribute to skill erosion of road-based MICA paramedics. The high rate of HEMS utilisation for rural TBI cases seems appropriate, and reflects a high degree of effectiveness within the trauma system. The use of HEMS for these cases makes practical sense in regards to accessing and transporting severely injured patients who may be in locations some distance from higher level trauma care. The use of HEMS for these cases may ensure that highly skilled and experienced clinicians are attending the most severely injured patients, however this may have implications for road-based intensive care paramedics working in rural areas. Considering that the acute caseload in rural areas is low compared to urban areas, it follows that paramedics in rural areas are likely to have limited exposure to these case types. Despite road-based paramedics being present at these cases, it is likely that more invasive interventions will be performed by HEMS paramedics, further limiting opportunities for road-based intensive care paramedics to develop and maintain these skills. This combination of findings has implications regarding skills maintenance strategies for rural intensive care paramedics. Further studies regarding the way that system factors impact clinician experience in low volume areas would be useful in exploring this issue.
6.2.3 Pre-Hospital Pre-Intervention Fatalities

The Study 3 findings, which indicated a difference in the proportion of pre-hospital pre-intervention fatalities (i.e., trauma victims who were deceased on ambulance arrival), may be a useful indicator of pre-hospital resourcing. Any implications based on these findings are limited however they may partially support the Study 1 findings that indicated a trend towards higher in-hospital mortality in the urban TBI group. The combined findings may be representative of differences in ambulance access in rural and urban areas, showing that major trauma cases in urban areas are more likely to be transported to hospital in a shorter timeframe. The severity of injury for this cohort may still result in a death in hospital despite clinical intervention, yet in rural areas patients with the same severity of injury may not be attended by ambulance as quickly therefore resulting in the patient being deceased at the scene. Any further or definitive conclusions regarding these findings would require more extensive research, and as such these studies could act as a foundation for future projects.

6.2.4 Pre-Hospital Post-intervention Fatalities

The Study 4 findings related to pre-hospital post-intervention fatalities (i.e., patients who were in traumatic cardiac arrest just prior to ambulance arrival or those who deteriorated into cardiac arrest during paramedic intervention) may partially reinforce the differences in pre-hospital resourcing between rural and urban areas. Links between the number of attending paramedics, the number of interventions performed during traumatic cardiac arrest cases and survival rates to hospital indicate rural/urban differences in pre-hospital resourcing. The findings suggest that rural traumatic cardiac arrest cases with TBI as the primary injury have fewer procedures performed, which may correlate with fewer attending paramedics. This may indicate a trend towards lower ambulance resourcing in rural areas, complementing the limited findings from Study 3. In combination with Study 2 and Study 7 these findings have further implications regarding paramedic exposure and experience. Whilst the Study 4 suggest there may be a lower inclination to intervene amongst rural paramedics, the qualitative findings from Study 7 suggest rural intensive care paramedics have a greater inclination to intervene with higher risk procedures despite their recognition of low case-load and exposure. If this greater inclination to intervene amongst rural paramedics is correct, it is possible that there are barriers that inhibit practice in rural areas, resulting in lower actual rates of intervention. This study did not identify such barriers, and further research in this area could be of
great benefit. As traumatic cardiac arrests with severe TBI as the primary injury represent only a very small sub-set of all cardiac arrests, this study provides the rationale for further investigations relating to the relationship between volume and confidence, as well as the relationship between the number of attending paramedics and outcomes following cardiac arrest.

6.2.5 Paramedic Exposure to RSI

The findings from Study 5 indicate that rural intensive care paramedics have lower exposure to the use of RSI for intubation. The findings also indicate that both rural and urban paramedics have low average exposure to this technique. This suggests that rural paramedics may be at greater risk of skill and knowledge erosion for low-frequency high-risk procedures. The qualitative findings from Study 7 support those aspects of the quantitative findings from Studies 2, 3, 4 and 5 that suggest rural paramedics may have lower exposure to high acuity cases and the application of higher-risk procedures. These studies did not attempt to measure the relationship between clinician exposure and outcomes following severe TBI. However, the combination of findings may be useful as a basis for further studies aimed at determining the individual experience of paramedics, and for comparisons between rural and urban craft groups.

6.2.6 Paramedic Confidence and Competence

The qualitative findings from Study 7 suggest that particular strategies may be required for the maintenance of cognitive (e.g., decision making), and psychomotor skills for intensive care paramedics working in areas of low acute caseload. The findings may be useful for generating a pedagogical approach that incorporates and encourages the development of individual problem solving approaches amongst paramedics. Importantly the findings indicate a greater inclination amongst rural intensive care paramedics to intervene using high-risk procedures despite having the insight that they attend fewer acute cases.

Urban focus group responses supported the need for targeted training strategies, indicating that despite higher levels of case exposure and work volume, experienced metropolitan MICA paramedics were susceptible to decreased levels of confidence in the absence of recent exposure.
Urban focus group responses suggested that there was a pressing need for facilities and time to engage in continuing education. This seems to be exacerbated by rapid changes in paramedic practice and perceived reductions in the availability and quality of continuing education and professional development opportunities. This indicates that the need for targeted training is not isolated to rural areas.

The findings also indicate that rural intensive care paramedics perceive themselves to be more likely to attend complex cases already being managed at small health facilities. Whilst acknowledging that Major Trauma Systems work well to facilitate the stabilisation, transfer and treatment of major trauma patients, focus group responses suggested that there are still occasions when HEMS may be delayed or unavailable. These cases may involve patients who have attended or been transported to rural/regional health facilities. These case types may be perceived as being outside the traditional pre-hospital environment, yet when these cases occur, it is likely that rural road-based intensive care paramedics may be required to assist with the initial management, stabilisation and possible resuscitation of critical patients in the hospital setting. Focus group responses suggested that the uniqueness of these cases requires a targeted strategy aimed at improving the overall capability to optimise the performance of ad-hoc teams in these circumstances. When considering these points, future training and skills maintenance programs may need to incorporate elements that include “cross-training” with other disciplines.

6.3 Key Areas for Future Research

This study considered the management of severe TBI cases from both a systems perspective and a clinician perspective. The findings are supportive of the effectiveness of trauma system design and maturity. Further to this, a major component of the project focussed on potential differences in the management of severe TBI cases by paramedics working in rural and urban locations. This section will outline factors that should be considered regarding the volume-confidence-performance relationship as it relates to pre-hospital RSI in rural areas.

The findings suggest that confidence, experience and training each have an influence on the way that high-acuity cases may be managed. Essentially, as rural paramedics are more likely to find
themselves in the position of being the only clinician at a case who is authorized to perform an RSI, they may feel an increased amount of pressure when faced with a severely injured patient who may benefit from the procedure. The risks associated with performing the procedure may be magnified due to their relative clinical isolation. This highlights the importance of clinician confidence and its relationship to decision making and the practical application of clinical skills and knowledge. These factors should therefore be incorporated into strategies aimed at improving the management of these case types in low-volume areas.

6.3.1 The Use of Decision Support Tools in Pre-Hospital Care

Checklists

The findings from this study suggest that research into the development, introduction, acceptance and effectiveness of checklists in the pre-hospital environment may be useful and beneficial. This may have particular importance in low-volume settings where the use of high-risk procedures may be required. The clinical isolation described by focus group participants and the low exposure of rural paramedics to severe TBI cases and RSI as indicated in the quantitative findings suggests that strategies may be required to enhance decision making related to high-level intervention. An important text by Gawande\textsuperscript{355} highlights the application and benefits associated with the use of checklists in surgical practice. Studies also highlight the application of checklists in clinical practice\textsuperscript{356,357}. A pocket-card sized checklist or smart phone application designed to assist paramedics working in isolation may be useful. Such a checklist would need to meet criteria outlined by Hales et al\textsuperscript{358}, ensuring that it was contextual, contained appropriate content, was structured and was usable. Based on the focus group findings, such a tool may be useful in alleviating additional pressure generated by working in isolation, whilst also providing a succinct guide to aid clinical decision making at critical cases. The acceptance and use of such a checklist would likely be influenced by cultural norms within a given craft group.
Technological Support

The findings from this study suggest that further research regarding the efficacy and usefulness of telemedicine in the pre-hospital setting may be warranted. Telemedicine has been demonstrated as a useful tool in the management of rural trauma cases\textsuperscript{359,360}. As a concept, it seems logical that such technology may also be useful in the pre-hospital environment. The concept is not new, and has been utilised in the pre-hospital setting with varying results\textsuperscript{361-364}. The nature of pre-hospital practice in rural and remote locations is likely to add further complications regarding the application of current technologies, but despite these limitations such a resource may still be of use. It may be feasible to transmit details of a patient’s physiological status combined with a video image from the rear of a mobile ambulance. This strategy is unlikely to be of use in the first stages of patient assessment and intervention, but once the patient has been transferred to an ambulance, consultation or advice from trauma experts could act as a valuable decision support tool for paramedics working in isolation.

6.3.2 Reduced Scope of Practice

The findings from this study support future research aimed at determining the appropriateness of modified clinical practice guidelines based on the volume-competency relationship. As an example it may be feasible to remove high-level procedures such as RSI from the scope of practice of intensive care paramedics working in low-volume locations. If it is acknowledged that this group of clinicians experience decreased levels of confidence and performance due to minimal and infrequent exposure to high-acuity cases, then it may be a safe and conservative option to delay intubation for head-injured patients. Rural TBI patients would then rely on this procedure being performed by either MFPs or medical personnel at small rural hospitals when HEMS was unavailable.

This model may mean that there would be some delays in the administration of high-level intervention as road-based paramedics would not be able to utilise RSI for intubation in the setting of severe TBI. They would however, be able to prepare and stabilise the patient so that when HEMS arrived, much of the groundwork would already have been undertaken and the higher level procedures could be provided by the MFPs. This type of logic could also be applied to small rural
medical facilities where clinicians may also be faced with performing higher-level procedures with little actual case exposure.

The removal of RSI from road-based MICA paramedics working in low-volume areas could potentially have significant cost-savings, as well as reducing pressure on individual clinicians. However it may not be an entirely appropriate strategy. If clinical errors were resulting in clear instances of patient harm and these could be linked to decreased confidence and competence following periods of low case exposure then it would be reasonable to modify practice in order to minimise patient harm. If however, no clinical harm was occurring but case reviews indicated sub-optimal performance of complex procedures then it could be reasonable to consider targeted strategies aimed at improving practice, as discussed in the following section.

Further research is required regarding rural-urban differences in the error rate and occurrence of patient harm following complex procedures performed in the pre-hospital setting. Such research should also consider the volume-performance relationship in the setting of pre-hospital care.

6.3.3 Targeted Training Strategies

Future research regarding the most appropriate methods of enhancing confidence and competence amongst clinicians in low-volume locations has potential benefits for both practitioners and patients. The problems associated with low case volume, clinician confidence and intervention with high risk procedures may benefit from the application of specific training strategies. Simulation training offers an established, practical and modifiable solution.

Previous studies have highlighted the benefits of simulation training in the context of increased confidence and the positive impact regarding the use of low-frequency skills. Studies have also documented the benefits of the debriefing process following simulation training. Further to this, the application of flexible simulation and training models has been discussed. Several studies have highlighted the benefits of simulation specifically in the context of emergency medicine, others reiterate the benefits of simulation for paramedic practice, whilst
others highlight the applicability to the maintenance of advanced airway skills\textsuperscript{312,339,396,397}. Targeted training could highlight the use of heuristics in clinical decision making\textsuperscript{345,346,352}, reinforcing the strengths and weaknesses of this cognitive approach.

The development of a strategic pre-hospital simulation package, designed to meet the needs of intensive care paramedics working in low-volume locations, is beyond the scope of this project. However, such a program may be of great benefit. This approach to training would be based on the premise that skill mastery is possible over time, even in the absence of regular case exposure. This type of program would encourage self-learning and development.

The findings from this study and the literature suggest that such a program would need to encompass the following principles:

- Both low and high-technology options
- Skilled facilitators
- Scenarios designed to address specific learning points related to the following areas:
  - The application of clinical/practical/technical skills
  - The application of clinical judgment and decision making
  - The application of leadership and communication skills
  - Team dynamics and enhancing team performance
  - Managing unanticipated clinical crises

Such a strategy would aim to address internal and external factors impacting clinician decision making, ensuring that psychomotor and cognitive aspects of clinical intervention are addressed. The impact of “less-tangible” influences on clinician decision making, particularly in respect to low-frequency high-risk procedures, is an important area for future research. Research regarding the impact of such influences on the performance of RSI in the setting of TBI patients is sparse, but has the potential improve clinical performance in rural areas.
6.3.4 Integration with Multi-Disciplinary Teams

Future studies aimed at determining the most appropriate strategies for generating team cohesion and performance in low-volume settings, particularly in rural locations, are needed and may be of great benefit. Findings from this study suggest that many factors influence paramedic decision making, particularly in regards to the application of high-risk procedures in low-volume work environments. Proximity to hospital may be a factor that influences paramedic use of RSI. In the rural setting and in the absence of HEMS, paramedics may elect to transport a patient to the closest hospital. If delays are incurred, the situation may arise where an RSI needs to be performed at the hospital. In this situation, the procedure is likely to be performed by an ad-hoc multi-disciplinary team. Such a situation is likely to present particular challenges.

The importance of teamwork in the acute care setting has been highlighted in the literature, along with the subtleties of human factors and team dynamics, and the concept of crisis management in emergency care. Differences in community expectations of acute care services and the role of paramedics in rural communities have also been discussed.

Based on these points from the literature and the research findings from this project, consideration of strategies aimed at enhancing the management of major trauma patients at small rural hospitals may be warranted. This study has highlighted the perception amongst paramedics that there is an increasing frequency of trauma cases at rural hospitals requiring collaborative management between ambulance personnel and hospital staff. The findings from this study that indicate decreased exposure of rural paramedics to severe TBI cases and the use of the RSI procedure are likely to be transferrable to other craft groups. These factors combined support the notion of programs aimed at enhancing the performance of ad-hoc teams in rural and remote areas who may be likely to encounter severely injured patients. This patient cohort is likely to require varying degrees of resuscitation and stabilisation prior to transfer to Major Trauma Services, and the timeframe for transfer is likely to vary depending on location and resource availability.

Strategies designed to enhance this capability may encourage the integration of rural intensive care paramedics within small hospitals teams. This may involve a process of familiarisation, training and
performance maintenance. Studies designed to identify cases where high-risk interventions were withheld or delayed at rural hospitals or other medical facilities are needed. Such studies may further support the need to integrated training strategies.

6.4 Limitations of the Study

The findings and conclusions from this study must be considered in the context of its limitations. The retrospective and mixed methods design does not allow determination of causality, and any assumptions and conclusions have been based on trends indicated within the quantitative and qualitative findings from analysis of the data that was available, and how these findings relate to the existing literature.

Whilst the iterative design allowed a degree of cross-referencing between the individual studies, no attempt at data linkage was made or intended. Further to this the differences in timeframes for each study were partly dictated by data availability. The differences listed below have been a limitation to comparisons and relationships between the datasets:

- Study 5 related to RSI procedures performed in the 2011 period, Study 6 related to RSIs from 2006 – 2009
- Study 5 related to RSIs performed for any procedure, Study 6 related to RSIs performed specifically for severe TB
- In Study 5, the paramedic qualifications were taken from a single point in time, while the RSIs related to cases over a 12 month period
- In Study 6, the RSI cases were identified during 2008 – 2011, while the paramedic qualifications that were matched to the paramedic identifier were taken from a single point in time (i.e., January 2012). As the AV HR data gives an indication of the years of experience at a given qualification level, it is reasonable to assume that paramedics from the AV HR dataset were working with AV during the Study 6 time period.
In addition to this, the combined study findings were limited by the number and size of focus groups, and the possibility of selection bias within the groups. Some aspects of the quantitative studies were limited by the small number of cases and the lack of statistical testing due to assumptions for testing not being met. In addition to this, medical record reviews and the analysis of case details were impaired by the lack of standardisation of reporting, and the lack of detail within certain cases.

Finally, the overall study was limited due to the specific focus on pre-hospital intervention as this may have excluded cases managed at small rural facilities where high-risk procedures were performed by Air Ambulance paramedics or other retrieval staff. This highlights that the definition of “pre-hospital” may need clarification, whether referring to cases where any intervention was provided by paramedics, or whether care was provided prior to attendance at any type of medical facility. The qualitative findings from Study 7 suggest that there is a cohort of cases in rural areas where care is provided by paramedics, despite the patient being located in a rural medical facility. The findings suggest that there may be a growing number of these cases managed by road-based paramedics. The pre-hospital focus of this project was not designed or intended to suggest that this element of trauma care has greater importance than other aspects of a given trauma system.

### 6.5 Conclusions

The findings from this study support the need for a balanced approach regarding the management of major trauma cases in rural locations. The findings support the need for trauma system design that encompasses integration across the spectrum of care from the pre-hospital setting to recovery and rehabilitation services. Optimal trauma systems also require the structure and resources to meet patient needs across diverse geographical regions. The findings suggest that trauma system design and maturity can mitigate some of the difficulties and disadvantages associated with managing severely injured trauma patients in rural areas. The findings also suggest that there may be occasions when elements within a given trauma system may be lacking, and on many of these occasions the importance of clinician experience is highlighted. The dilemma faced by all rural clinicians who may be required to manage infrequent high-acuity cases is centred on the relationship between case-volume and clinical performance.
The combination of findings suggests that rural clinical practice differs from urban practice, and that pre-hospital practice represents a unique sub-specialty within rural practice. There are unique characteristics associated with rural paramedic practice and the implications are two-fold. Firstly, rural paramedic practice brings with it certain challenges that cannot be met simply by adopting practices and solutions from medicine or nursing. Secondly, the field of pre-hospital care is likely to continue to progress rapidly, with evidence-based practice supporting the inclusion of more invasive high-risk procedures. It must be acknowledged that controversies and debate will remain regarding the value and need for high-level pre-hospital intervention, yet it is likely that the need for strategies aimed specifically at enhancing paramedic practice in rural and remote areas will increase. The benefits of targeted strategies may be transferrable to other craft groups faced with similar challenges related to high-acuity case volume, exposure, confidence and clinical performance.

This study has examined two key aspects relating to the management of severe traumatic brain injury in rural locations. The first aspect related to the impact of trauma system design on outcomes following severe TBI, and the second aspect related to the relationship between case exposure, clinician confidence and the pre-hospital management of severe TBI. The findings, in the context of the existing literature and limitations of the study design, reinforce the importance of the inter-relationship between trauma system design and individual clinical intervention in the rural context.

The findings from this study are important and contribute to the existing knowledge relating to trauma system design, and clinician experience and confidence. The key findings from this study reinforce that trauma system design and maturity can mitigate the disadvantages faced by rural patients suffering severe injury. The findings also highlight that rural pre-hospital practice differs to urban practice and that unique challenges exist when managing high-acuity low-frequency cases in this setting. This study has addressed only a small aspect of the overall spectrum of care required to achieve optimal outcomes following severe injury, but it is hoped that the methodology, findings and conclusions may provide the foundation for future research in this challenging area.
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Appendices
Appendix A: DUHREC Ethics Exemption: 2010-141

Office of Research Integrity
Research Services Division
70 Elgar Road Burwood Victoria Postal: 221 Burwood Highway Burwood Victoria 3125 Australia
Telephone 03 9251 7123 Facsimile 03 9244 6581 research-ethics@deakin.edu.au

Memorandum

To: Prof Sue Kilpatrick, Office of Pro Vice-Chancellor (Rural and Regional)

From: Deakin University Human Research Ethics Committee (DU-HREC)

Date: 02 July, 2010

cc: Mr Benjamin Fisk

Subject: 2010-141 Head Injury Outcomes in Rural and Urban Areas of Victoria

Please quote this project number in all future communications

Exemption from Ethics Review was granted for this project on 2/07/2010.

Authorisation has been given for Mr Benjamin Fisk under the supervision of Prof Sue Kilpatrick, Office of ProVice-Chancellor (Rural and Regional), to undertake this project for the life of the project from 2/07/2010.

This Exemption from Ethics Review is given only for the project as stated in this memo. It is your responsibility to contact the Human Research Ethics Unit, immediately regarding any of the following:

- Any adverse events or events which might affect the continuing ethical acceptability of the project
All modifications to the research relating to the data or records must be submitted to the Human Research Ethics Unit for review prior to being implemented. In addition, you will be required to report on the progress of your project at least once every year and at the conclusion of the project. You are furthermore required to retain auditable records of the project demonstrating compliance with the *National Statement on Ethical Conduct in Human Research* (2007) (paragraph 5.2.9) and to produce these if required.

Human Research Ethics Unit
research-ethics@deakin.edu.au
Telephone: 03 9251 7123
Appendix B: DUHREC Ethic Amendment: 2011-162

Memorandum

Office of Research Integrity
Research Services Division
70 Elgar Road Burwood Victoria Postal: 221 Burwood Highway Burwood Victoria 3125 Australia
Telephone 03 9251 7123 Facsimile 03 9244 6581 research-ethics@deakin.edu.au

To: Prof Sue Kilpatrick, Office of Pro Vice-Chancellor (Rural and Regional) W
cc: Mr Benjamin Fisk

From: Deakin University Human Research Ethics Committee (DUHREC)

Date: 21 September, 2011

Subject: 2011-162

Differences in traumatic head injury outcomes between rural and urban areas of Victoria: The impact of experience and confidence on Paramedic intervention

Please quote this project number in all future communications

The application for this project was considered at the DUHREC meeting held on 29/08/2011.

Approval has been given for Mr Benjamin Fisk, under the supervision of Prof Sue Kilpatrick, Office of Pro Vice-Chancellor (Rural and Regional), to undertake this project from 21/09/2011 to 21/09/2015.

The approval given by the Deakin University Human Research Ethics Committee is given only for the project and for the period as stated in the approval. It is your responsibility to contact the Human Research Ethics Unit immediately should any of the following occur:
• Serious or unexpected adverse effects on the participants
• Any proposed changes in the protocol, including extensions of time.
• Any events which might affect the continuing ethical acceptability of the project.
• The project is discontinued before the expected date of completion.
• Modifications are requested by other HRECs.

In addition you will be required to report on the progress of your project at least once every year and at the conclusion of the project. Failure to report as required will result in suspension of your approval to proceed with the project.

DUHREC may need to audit this project as part of the requirements for monitoring set out in the National Statement on Ethical Conduct in Human Research (2007).

Human Research Ethics Unit
research-ethics@deakin.edu.au
Telephone: 03 9251 7123
Appendix C: JHREC Approval: CF/11/24591

9 December 2011

Reference: CF/11/24591

Prof Sue Kilpatrick

Centre for Rural Emergency Medicine & Deakin University

Re: Difference in Rural and Urban Head Injury Outcomes in Victoria

Dear Prof Sue Kilpatrick,

I am happy to inform you that the Department of Justice Human Research Ethics Committee (JHREC) considered your response to the project Difference in Rural and Urban Head Injury Outcomes in Victoria and granted full approval for the duration of the investigation. The Department of Justice reference number for this project is CF/11/24591. Please note the following requirements:

- To confirm JHREC approval sign the Undertaking form attached and provide both an electronic and hardcopy version within ten business days.
- The JHREC is to be notified immediately of any matter that arises that may affect the conduct or continuation of the approved project.
- You are required to provide an Annual Report every 12 months (if applicable) and to provide a completion report at the end of the project (see the Department of Justice Website for the forms).
- Note that for long term/ongoing projects approval is only granted for three years, after which time a completion report is to be submitted and the project renewed with a new application.
- The Department of Justice would also appreciate receiving copies of any relevant publications, papers, theses, conferences presentations or audiovisual materials that result from this research.
- All future correspondence regarding this project must be sent electronically to ethics@justice.vic.gov.au and include the reference number and the project title. Hard copies of signed documents or original correspondence are to be sent to The Secretary, JHREC, Level 21, 121 Exhibition St, Melbourne, VIC 3000.
If you have any queries regarding this application you are welcome to contact me on (03) 8684 1514 or email: ethics@justice.vic.gov.au.

Yours sincerely,

[Signature Redacted by Library]

Dr Yasmine Fauzee

Secretary, Department of Justice Human Research Ethics Committee
Appendix D: Ambulance Victoria Data Request Approval: R11-005

DATA REQUEST FORM: RESEARCH AND EVALUATION TEAM

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<tr>
<td>PERSON MAKING REQUEST</td>
<td>Ben Fisk</td>
</tr>
<tr>
<td>DATA ANALYST RESOURCE</td>
<td>Amee Morgans</td>
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DATA PROVIDED

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NOTES:

- This data has been approved for HREC approved research purposes only. It is not for release as per confidentiality deed.

ANALYST NAME       AMEE MORGANS

DATE COMPLETED     16 MAR 2012

Notes

Inclusion criteria:

- GCS (initial or final) <10
- Assessment = head injury (all types)
- Assessment = face injury (all types)
- Case date 1/1/2008 to 31/12/2011
- Region = all

Variables

Sheet 1:

- Case patient ID – matching variable
- Case Date
• Age
• Gender
• Postcode
• Case nature
• Assessment
• RSI indicator
• Major Trauma Indicator
• Number teams attending
• Deceased indicator
• Dispatch Code
• Transport Flag
• Case description (free text)
• VSS - all

**Sheet 2**

• Case patient ID – matching variable
• Case Date – matching variable
• Secondary surveys

**Sheet 3**

• Case patient ID – matching variable
• Case Date – matching variable
• Medications (all)
• Procedures (all)

**Sheet 4**

• Case patient ID – matching variable
• Case Date – matching variable
• Teams attending (Team name)
• Employee ID
• Vehicle type (HEMS/Fixed wing/MICA/AP)
### Appendix E: AIS and ISS Summaries

Table 37: Computational Strategy for AIS and ISS

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<th>Abbreviated Injury Score (AIS)</th>
<th>Injury Severity Score (ISS)</th>
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<td>The ISS body regions are:</td>
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<tr>
<td>A B CC DD E</td>
<td>1 = head</td>
</tr>
<tr>
<td>A = body region</td>
<td>2 = face</td>
</tr>
<tr>
<td>B = type of anatomic structure involved</td>
<td>3 = chest</td>
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<tr>
<td>CC = specific anatomic structure</td>
<td>4 = abdominal and pelvic contents</td>
</tr>
<tr>
<td>DD = level</td>
<td>5 = extremities and pelvis</td>
</tr>
<tr>
<td>E = severity:</td>
<td>6 = general/skin</td>
</tr>
<tr>
<td>1 = minor</td>
<td>The computational formula for ISS is as follows:</td>
</tr>
<tr>
<td>2 = moderate</td>
<td>ISS score = SUM of:</td>
</tr>
<tr>
<td>3 = serious</td>
<td>(AIS score of most severe injury in any ISS region) squared +</td>
</tr>
<tr>
<td>4 = severe</td>
<td>(AIS score of the next most severe injury in another ISS region) squared +</td>
</tr>
<tr>
<td>5 = critical</td>
<td>(AIS score of the most severe injury in any remaining ISS region) squared = ISS Score</td>
</tr>
<tr>
<td>6 = maximum</td>
<td></td>
</tr>
</tbody>
</table>

251
Appendix F: Study 1 ARIA+ Sub-Categories

Rural TBI Cohort: 596

- Inner Regional: 417
- Outer Regional: 176
- Remote: 12

Figure 10: Summary of ARIA+ Categories in Rural Severe TBI Cohort in Victoria 2006 - 2009
Appendix G: Profile of Severe TBI Cases Lost to Follow-Up

Tracking of Cases lost from Original Data Set:

**Original Data Set:**

N: 5643
From: Jul-Sept 2001
To: Apr – Jun 2009
Rural: 1363 (24.2%)
Urban: 3761 (66.6%)
Other: 519 (9.2%)

**Refined by GOSE capture:**

N: 2658
Lost: 2985
From: Oct-Dec 2006
To: Apr–Jun 2009
Rural: 596 (22.4%)
Urban: 1801 (67.8%)
Other: 261 (9.8%)

**Refined by Postcode – ASGC Region – Other:**

N: 2397
Lost: 261: (51 NSW, 5 Tas, 3 Unknown, 194 Unknown in Vic, 8 Unknown Outside Vic)
Note: Re-checked “unknown in Vic”: not all UCS are rural; not all PCS are rural, not all MTS are urban, not all RTS are rural.
From: Oct-Dec 2006
To: Apr-Jun 2009
Rural: 596 (24.9%)
Urban: 1801 (75.1%)
**Multivariate Analysis:**

Outcome: In-Hospital Mortality
N: 2397

Outcome: GOSE6
N: 2117

Lost: 280: (276 Not recorded [60 Rural, 216 Urban], 4 Unable to be determined [0 Rural, 4 Urban])
Rural: 536 (25.3%)
Urban: 1581 (74.7%)

**Total lost: 3526**

### Profile of Patients lost to Follow Up at 6 Months:

**Missing GOSE6 Profile: Mean Age**

| Rural (N 60) | 39 (16-86) |
| Urban (N 220) | 50 (16-96) |

**Missing GOSE6 Profile: Gender**

<table>
<thead>
<tr>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rural (N 60)</td>
<td>44 (73%)</td>
</tr>
<tr>
<td>Urban (N 220)</td>
<td>162 (74%)</td>
</tr>
</tbody>
</table>

**Missing GOSE6 Profile: Co-morbidity Status**

<table>
<thead>
<tr>
<th>Significant</th>
<th>Non-Significant</th>
<th>Missing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rural (N 60)</td>
<td>13 (22%)</td>
<td>38 (63%)</td>
</tr>
<tr>
<td>Urban (N 220)</td>
<td>63 (28%)</td>
<td>118 (54%)</td>
</tr>
</tbody>
</table>

**Missing GOSE6 Profile: Mechanism of Injury**

<table>
<thead>
<tr>
<th>Low Fall</th>
<th>High Fall</th>
<th>MV Driver</th>
<th>MV Passenger</th>
<th>MCycle Driver</th>
<th>Pedal cycle</th>
<th>Pedestrian Struck by Object</th>
<th>Struck by Person</th>
<th>Unspecified</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rural (N 60)</td>
<td>13</td>
<td>4</td>
<td>10</td>
<td>8</td>
<td>5</td>
<td>1</td>
<td>4</td>
<td>9</td>
</tr>
<tr>
<td>Urban (N 220)</td>
<td>93</td>
<td>18</td>
<td>11</td>
<td>9</td>
<td>10</td>
<td>6</td>
<td>15</td>
<td>17</td>
</tr>
</tbody>
</table>

**Missing GOSE6 Profile: ISS injury Severity**

<table>
<thead>
<tr>
<th>Severe</th>
<th>Severe/Critical</th>
<th>Critical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rural (N 60)</td>
<td>33</td>
<td>20</td>
</tr>
<tr>
<td>Urban (N 220)</td>
<td>162</td>
<td>47</td>
</tr>
</tbody>
</table>
### Missing GOSE6 Profile: Isolated/Multiple Injuries

<table>
<thead>
<tr>
<th></th>
<th>Isolated HI</th>
<th>Multiple Injuries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rural (N 60)</td>
<td>20</td>
<td>40</td>
</tr>
<tr>
<td>Urban (N 220)</td>
<td>91</td>
<td>129</td>
</tr>
</tbody>
</table>

### Missing GOSE6 Profile: Pre-Hospital Head Injury Severity

<table>
<thead>
<tr>
<th></th>
<th>Mild</th>
<th>Moderate</th>
<th>Severe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rural (N 60)</td>
<td>31</td>
<td>4</td>
<td>25</td>
</tr>
<tr>
<td>Urban (N 220)</td>
<td>132</td>
<td>35</td>
<td>53</td>
</tr>
</tbody>
</table>

### Missing GOSE6 Hospital Discharge Status

<table>
<thead>
<tr>
<th></th>
<th>Other</th>
<th>Hospital for Convalescence</th>
<th>Special Accom</th>
<th>Nursing Home</th>
<th>Rehab</th>
<th>Home</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rural (N 60)</td>
<td>3</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>28</td>
<td>27</td>
</tr>
<tr>
<td>Urban (N 220)</td>
<td>9</td>
<td>6</td>
<td>4</td>
<td>6</td>
<td>83</td>
<td>112</td>
</tr>
</tbody>
</table>

### Mechanism of Injury/Hospital Mortality/6 Month Outcome Profile:

<table>
<thead>
<tr>
<th></th>
<th>Urban (%)</th>
<th>Rural (%)</th>
<th>Total Deceased (%)</th>
<th>Total Unfavourable (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Motor Vehicle</strong></td>
<td>13</td>
<td>28</td>
<td>13</td>
<td>41</td>
</tr>
<tr>
<td><strong>Motorcycle</strong></td>
<td>5</td>
<td>10</td>
<td>11</td>
<td>31</td>
</tr>
<tr>
<td><strong>Pedestrian</strong></td>
<td>10</td>
<td>4</td>
<td>26</td>
<td>55</td>
</tr>
<tr>
<td><strong>Low Fall</strong></td>
<td>44</td>
<td>29</td>
<td>22</td>
<td>67</td>
</tr>
<tr>
<td><strong>High Fall</strong></td>
<td>10</td>
<td>6</td>
<td>23</td>
<td>43</td>
</tr>
<tr>
<td>Struck by or Collision with Person</td>
<td>8</td>
<td>7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Struck by or Collision with Object</td>
<td>5</td>
<td>7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pedal Cyclist</td>
<td>2</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>3</td>
<td>6</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

100 100
Table 38: Model 2 (ARIA+ Categories): multivariable Analysis of In-Hospital Mortality and 6-Month GOS-E for Severe TBI Patients in Victoria 2006 - 2009

<table>
<thead>
<tr>
<th>Variable</th>
<th>Favourable GOSE at 6 Months Post Injury</th>
<th>In-Hospital Mortality</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number of observations: 1823</td>
<td>Number of observations: 2059</td>
</tr>
<tr>
<td>Location of Injury</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Metropolitan</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Inner Regional</td>
<td>1.09 (0.79, 1.49)</td>
<td>0.65 (0.42, 1.02)</td>
</tr>
<tr>
<td>Outer Regional</td>
<td>1.11 (0.71, 1.74)</td>
<td>0.72 (0.39, 1.32)</td>
</tr>
<tr>
<td>Remote</td>
<td>5.12 (0.56, 46.94)</td>
<td>1.39 (0.11, 16.89)</td>
</tr>
<tr>
<td>Outside Victoria</td>
<td>2.12 (1.08, 4.13)</td>
<td>0.52 (0.21, 1.28)</td>
</tr>
<tr>
<td>Age</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16-24 (ref)</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>25-34</td>
<td>0.84 (0.52, 1.37)</td>
<td>1.04 (0.53, 2.01)</td>
</tr>
<tr>
<td>35-44</td>
<td>0.62 (0.38, 1.02)</td>
<td>0.99 (0.48, 2.04)</td>
</tr>
<tr>
<td>45-54</td>
<td>0.49 (0.29, 0.83)</td>
<td>1.09 (0.51, 2.39)</td>
</tr>
<tr>
<td>55-64</td>
<td>0.34 (0.21, 0.56)</td>
<td>2.07 (1.01, 4.29)</td>
</tr>
<tr>
<td>65-74</td>
<td>0.21 (0.12, 0.34)</td>
<td>2.86 (1.39, 5.87)</td>
</tr>
<tr>
<td>75-84</td>
<td>0.11 (0.06, 0.17)</td>
<td>7.69 (3.96, 14.91)</td>
</tr>
<tr>
<td>85+</td>
<td>0.35 (0.19, 0.66)</td>
<td>15.72 (7.59, 32.55)</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>0.81 (0.62, 1.04)</td>
<td>0.86 (0.62, 1.18)</td>
</tr>
<tr>
<td>Cause of injury</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Motor vehicle (ref)</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Motorcyclist</td>
<td>1.21 (0.68, 2.14)</td>
<td>0.73 (0.31, 1.71)</td>
</tr>
<tr>
<td>Pedestrian</td>
<td>2.21 (0.93, 5.25)</td>
<td>1.41 (0.48, 4.07)</td>
</tr>
<tr>
<td>Pedal cyclist</td>
<td>0.84 (0.51, 1.38)</td>
<td>1.25 (0.63, 2.46)</td>
</tr>
<tr>
<td>Low fall &lt;= 1 metre</td>
<td>0.78 (0.49, 1.22)</td>
<td>1.79 (0.94, 3.43)</td>
</tr>
<tr>
<td>High fall &gt; 1 metre</td>
<td>1.03 (0.62, 1.69)</td>
<td>1.92 (1.01, 3.68)</td>
</tr>
<tr>
<td>Struck by or collision with person</td>
<td>1.38 (0.73, 2.61)</td>
<td>1.46 (0.61, 3.56)</td>
</tr>
<tr>
<td>Struck by or collision with object</td>
<td>1.01 (0.53, 1.89)</td>
<td>1.35 (0.53, 3.45)</td>
</tr>
<tr>
<td>Other</td>
<td>1.62 (0.86, 3.01)</td>
<td>0.51 (0.17, 1.51)</td>
</tr>
<tr>
<td>Serious Co-morbidities</td>
<td>0.38 (0.29, 0.51)</td>
<td>1.54 (1.06, 2.23)</td>
</tr>
<tr>
<td>Multiple Injuries</td>
<td>0.81 (0.59, 1.09)</td>
<td>1.76 (1.18, 2.63)</td>
</tr>
<tr>
<td>Overall injury severity (ISS)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16-25 (ref)</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>26-40</td>
<td>0.71 (0.28, 0.59)</td>
<td>2.53 (1.68, 3.79)</td>
</tr>
<tr>
<td>40+</td>
<td>0.26 (0.17, 0.41)</td>
<td>5.81, (3.27, 10.33)</td>
</tr>
<tr>
<td>Head injury severity (pre-hospital GCS)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13-15 (ref)</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>9-12</td>
<td>0.41 (0.28, 0.59)</td>
<td>3.56 (2.33, 5.45)</td>
</tr>
<tr>
<td>3-8</td>
<td>0.14 (0.11, 0.19)</td>
<td>21.72 (14.53, 32.47)</td>
</tr>
<tr>
<td>Variable</td>
<td>Favourable GOSE at 6 Months Post Injury</td>
<td>In-Hospital Mortality</td>
</tr>
<tr>
<td>-------------------</td>
<td>----------------------------------------</td>
<td>-----------------------</td>
</tr>
<tr>
<td></td>
<td>Number of observations: 1766</td>
<td>Number of observations: 1994</td>
</tr>
<tr>
<td>Location of Injury</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DHS Rural</td>
<td>1</td>
<td>1.51 (1.04, 2.18)</td>
</tr>
<tr>
<td>DHS Urban</td>
<td>0.89 (0.68, 1.17)</td>
<td>0.406</td>
</tr>
<tr>
<td>Age</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16-24 (ref)</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>25-34</td>
<td>0.83 (0.51, 1.35)</td>
<td>0.450</td>
</tr>
<tr>
<td>35-44</td>
<td>0.61 (0.36, 1.01)</td>
<td>0.051</td>
</tr>
<tr>
<td>45-54</td>
<td>0.51 (0.29, 0.86)</td>
<td>0.012</td>
</tr>
<tr>
<td>55-64</td>
<td>0.35 (0.21, 0.58)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>65-74</td>
<td>0.21 (0.12, 0.35)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>75-84</td>
<td>0.11 (0.61, 0.17)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>85+</td>
<td>0.04 (0.19, 0.07)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>0.18 (0.59, 1.02)</td>
<td>0.068</td>
</tr>
<tr>
<td>Cause of Injury</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Motor vehicle (ref)</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Motorcyclist</td>
<td>1.14 (0.64, 2.05)</td>
<td>0.652</td>
</tr>
<tr>
<td>Pedestrian</td>
<td>2.11 (0.87, 5.02)</td>
<td>0.095</td>
</tr>
<tr>
<td>Pedal cyclist</td>
<td>0.84 (0.51, 1.41)</td>
<td>0.504</td>
</tr>
<tr>
<td>Low fall &lt;= 1 metre</td>
<td>0.71 (0.45, 1.13)</td>
<td>0.147</td>
</tr>
<tr>
<td>High fall &gt; 1 metre</td>
<td>0.94 (0.57, 1.56)</td>
<td>0.812</td>
</tr>
<tr>
<td>Struck by or collision with person</td>
<td>1.5 (0.71, 2.59)</td>
<td>0.365</td>
</tr>
<tr>
<td>Struck by or collision with object</td>
<td>0.85 (0.45, 1.63)</td>
<td>0.632</td>
</tr>
<tr>
<td>Other</td>
<td>1.51 (0.79, 2.86)</td>
<td>0.203</td>
</tr>
<tr>
<td>Serious Co-morbidities</td>
<td>0.39 (0.29, 0.52)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Multiple Injuries</td>
<td>0.81 (0.59, 1.11)</td>
<td>0.185</td>
</tr>
<tr>
<td>Overall injury severity (ISS)</td>
<td>0.81 (0.59, 1.11)</td>
<td>0.185</td>
</tr>
<tr>
<td>16-25 (ref)</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>26-40</td>
<td>0.67 (0.49, 0.92)</td>
<td>0.014</td>
</tr>
<tr>
<td>40+</td>
<td>0.25 (0.16, 0.39)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Head injury severity (pre-hospital GCS)</td>
<td>0.39 (0.27, 0.58)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>13-15 (ref)</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>9-12</td>
<td>0.39 (0.27, 0.58)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>3-8</td>
<td>0.14 (0.98, 0.19)</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>
### Appendix I: Comparison of Rural-Urban TBI Deaths in Study 1, Study 3 and Study 4

Table 40: Comparative Table of Deaths Within NCIS, VACAR and VACIS Cohorts

| Proportion of Rural-Urban TBI Deaths | Rural (N | %) | Urban (N|%) | Total |
|--------------------------------------|---------|----------|--------|
| Deceased                             |         |          |        |
| NCIS                                 | 12 | 48 % | 13 | 52 % | 25 | 100 |
| VACAR                                | 8 | 15% | 44 | 85% | 52 | 100 |
| VSTR                                 | 85 | 19 % | 357 | 81 % | 442 | 100 |
Appendix J: Study 4 Results: Linear Regression Models

Figure 11: Relationship Between Age and Scene Time at Traumatic OHCA Cases with Severe TBI as the Primary Injury: Slope (rho) \( p = 0.886 \)

Figure 12: Relationship Between Age and Scene Time at Traumatic OHCA Cases with Severe TBI as the Primary Injury, Shown in Rural and Urban Cohorts: Rural slope (rho) \( p=0.653 \), Urban slope (rho) \( p=N/A \)
Figure 13: Relationship Between GCS on Arrival and Scene Time at Traumatic OHCA Cases with Severe TBI as the Primary Injury: Slope (rho) p=0.240

Figure 14: Relationship Between GCS on Arrival and Scene Time at Traumatic OHCA Cases with Severe TBI as the Primary Injury, Shown in Rural and Urban Cohorts: Rural slope (rho) p=0.674, Urban slope (rho) p=0.212
Appendix K: Focus Group Plain Language Statement, Consent Form and Revocation of Consent Form

PLAIN LANGUAGE STATEMENT AND CONSENT FORM

TO: Focus Group Participants

Plain Language Statement

Date: 1/3/2012

Full Project Title: Differences in Traumatic Brain Injury Outcomes Between Rural and Urban Areas of Victoria - The Impact of Experience and Confidence on Paramedic Intervention

Principal Researcher: Professor Sue Kilpatrick

Student Researcher: Mr Benjamin Fisk

Associate Researcher(s): Associate Professor Tim Baker, Associate Professor Tony Walker

The Plain Language Statement, Consent Form and Revocation of Consent Form are 7 pages long. Please make sure you have all the pages.

1. Your Consent:

You are invited to take part in this research project.

This Plain Language Statement contains detailed information about the research project. Its purpose is to explain to you as openly and clearly as possible the requirements of this project so that you can make a fully informed decision whether you are going to participate.
2. Purpose and Background:

**Purpose:**

The purpose of this focus group is to find out how exposure impacts paramedic confidence and performance when managing patients with severe traumatic brain injury.

The focus group is part of a larger PhD project being conducted through the Centre for Rural Emergency Medicine, part of the School of Medicine at Deakin University. Overall, the project is looking at rural and urban differences in traumatic brain injury outcomes, and whether paramedic experience and confidence differs between rural and urban areas.

A total of 8-10 paramedics will participate in the focus group.

**Background:**

Serious trauma, and traumatic brain injury in particular, present a significant cost to individuals and society, measured in terms of quality of life and financial burden.

Rural and remote areas in Australia have higher mortality rates associated with traumatic brain injury, and paramedics working in these locations tend to experience lower exposure to these types of cases. A high standard of care is required for head injured patients, regardless of where the injury occurs, and the expectation is increasing for paramedics to contribute to the stabilization and initiation of critical care treatments for this patient group.
Paramedics in areas of low case load are susceptible to skill and knowledge erosion and this may impact their confidence and ability to manage severe traumatic brain injury cases.

Alternative methods of maintaining skills and confidence may be required in areas of low acute case load.

You are invited to participate in this focus group to provide your thoughts, ideas, and opinions regarding this problem of low case load and high clinical expectations.

3. **Funding:**

This project is funded by the Windermere Foundation. The Centre for Rural Emergency Medicine is a joint initiative between the Department of Human services, Portland District Health, South West Healthcare (Warrnambool), Alcoa of Australia and the Deakin Medical School.

4. **Procedures:**

During a one to two hour group discussion, focus group participants will be asked to comment on a series of questions and scenarios focused on the issue of low acute case load and high clinical expectations in the setting of traumatic brain injury.

The discussion will be audio recorded, so that a transcript can be produced.

Participants will not be identified in the transcript, on which the research will be based, and will therefore remain anonymous in all papers, reports, documents and presentations.

5. **Possible Benefits:**

The results of this study may help ambulance services to provide alternative methods of training and on-going clinical support for paramedics working in areas of low case load who may be required to provide infrequent but high level interventions. Such models may also have wider implications for other health care groups with acute care or critical care responsibilities. This may impact the outcome of patients who suffer severe traumatic brain injury.

6. **Possible Risks:**
There are few risks to the focus group participants. Individuals may raise examples where clinical performance was below what was required or expected, however the fact that participants will remain anonymous means there will be no adverse consequences with Ambulance Victoria.

7. **Alternative to Focus Group Participation:**

Participation in the Focus Group is voluntary.

8. **Results of Project:**

Focus group participants will be informed about the results of the study by means of a letter with a short summary. The results might also be published in a peer-reviewed journal which will be freely accessible, and presented at national and international conferences.

9. **Participation is Voluntary:**

Participation in any research project is voluntary. If you do not wish to take part in the focus group you are not obliged to. If you decide to take part in the focus group and later change your mind, you are free to withdraw at any stage, however as answers or comments will be anonymous these will still be used within the project.

Your decision to take part or not take part, or to take part and then withdraw, will not affect your relationship with Ambulance Victoria, the Centre for Rural Emergency Medicine, or Deakin University.

Before you make your decision, a member of the research team will be available to answer any of your questions. You can ask questions about any details of the project. Only sign the consent form after you have had a chance to ask your questions and have received satisfactory answers.

If you decide to withdraw from the project, please notify a member of the research team or complete and return the Revocation of Consent Form attached.

10. **Ethical Guidelines:**

This project will be carried out according to the *National Statement on Ethical Conduct in Human Research* (2007) produced by the National Health and Medical
Research Council of Australia. This statement has been developed to protect the interests of people who agree to participate in human research studies. The ethics aspects of this research project have been approved by the Human Research Ethics Committee of Deakin University.

Approval for your participation has been obtained from the Research Services Division of Ambulance Victoria.

11. Complaints:

If you have any complaints about any aspect of the project, the way it is being conducted or any questions about your rights as a research participant, then you may contact:

The Manager, Office of Research Integrity, Deakin University, 221 Burwood Highway, Burwood Victoria 3125, Telephone: 9251 7129, Facsimile: 9244 6581; research-ethics@deakin.edu.au

Please quote project number [2011-162].

12. Reimbursement of Costs:

You will not be paid for your participation in this project. However, refreshments will be provided during the focus group discussion.

13. Further Information, Queries or Problems:

If you require further information, wish to withdraw your participation, or if you have any problems or concerns, please contact the principal researcher.

The principal researcher for this project is:

Ben Fisk
PhD Candidate
Centre for Rural Emergency Medicine
Deakin University
Ph: 03 55633119
Mob: 0412264550
Email: bfis@deakin.edu.au
PLAIN LANGUAGE STATEMENT AND CONSENT FORM

TO: Focus Group Participants

Date: 1/3/2012

Full Project Title: Differences in Traumatic Brain Injury Outcomes Between Rural and Urban Areas of Victoria - The Impact of Experience and Confidence on Paramedic Intervention

Reference Number: DU 2011-162

I have read, or have had read to me in my first language and I understand the attached Plain Language Statement.

I freely agree to participate in this project according to the conditions in the Plain Language Statement.

I have been given a copy of the Plain Language Statement and Consent Form to keep.

The researcher has agreed not to reveal my identity and personal details, including where information about this project is published, or presented in any public form.

Participant’s Name (printed) ……………………………………………………………………

Signature ……………………………………………………… Date ……………………………

Please return by mail to:

Ben Fisk
Centre for Rural Emergency Medicine

South West Healthcare
Ryot Street Warrnambool VIC 3280

Ph: 03 55633119
Mob: 0412264550
Email: bfis@deakin.edu.au
PLAIN LANGUAGE STATEMENT AND CONSENT FORM

TO: Focus Group Participants

Revocation of Consent Form

Date: 1/3/2012

Full Project Title: Differences in Traumatic Brain Injury Outcomes Between Rural and Urban Areas of Victoria - The Impact of Experience and Confidence on Paramedic Intervention.

Reference Number: DU 2011-162

I hereby wish to WITHDRAW my consent to participate in the above research project and understand that such withdrawal WILL NOT jeopardize my relationship with Deakin University, the Centre for Rural Emergency Medicine or Ambulance Victoria.

Participant’s Name (printed) .................................................................

Signature .......................................................... Date ......................

Please return by mail to:

Ben Fisk
Centre for Rural Emergency Medicine
South West Healthcare
Ryot Street Warrnambool VIC 3280

Ph: 03 55633119
Mob: 0412264550
Email: bfis@deakin.edu.au
Appendix L: Focus Group Guide

1. What types of cases present the greatest challenges to you as a paramedic?

2. Can you give an example of a case you managed which was at the limit of your abilities?
   a. What was the case?
   b. What made the case difficult?
   c. What did you do?
   d. What was the outcome?
   e. What could have made the case easier at the time?
   f. What steps could you take to improve your ability to manage these types of cases?
   g. What type of training would make you feel more prepared to handle this type of case in the future?

3. Can you give an example of a case you managed that didn’t go well?
   a. What was the case
   b. What elements did not go well
   c. What did you do
   d. What was the outcome

4. What do you consider to be the elements that contribute to a complex case?
   a. Are these elements that can be controlled or are they uncontrolled?

5. Can you give an example of a complex case that you managed well?
   a. What was the case
   b. What made the case complex
   c. What did you do
   d. What was the outcome

6. There have been significant changes in clinical practice in Ambulance Victoria over the last few years, the introduction of RSI is a significant development in our ability to manage head injuries in the pre-hospital setting.
a. How would you rate your confidence in performing all the components necessary for a successful RSI in the trauma setting (ie, patient access, time critical recognition, stabilisation, extrication, delegation, patient preparation, equipment/drug preparation, induction, intubation, post-intubation management including ventilator)

7. You have just returned from 4 weeks annual leave. You are relieving/working in an isolated rural branch, you have not done a case in the last 3 shifts, when you are despatched (as either a single responder or single officer with an ACO), to a remote farm residence for a high speed motorcycle accident involving one adult and one paediatric patient. The time is 1700 hrs, there is 1 hr to last light, the weather is overcast with strong winds and intermittent rain. The farm you are attending is in a known communication blackspot and you anticipate marginal radio or phone communication when you arrive. Backup has also been despatched, but will take approx 50 minutes to arrive at scene. Your ETA means you may be at scene for approximately 30 minutes prior to the arrival of the second crew. The communication centre has contacted HEMS, but the closest helicopter is off-line. A helicopter can be despatched from Melbourne but will take at least 80 minutes to arrive at scene.

a. What aspects of this case are you concerned about prior to arrival?

b. What logistical planning would you undertake?

c. What contingency planning would you undertake?

d. How would you rate our confidence in your current skills and knowledge in anticipation of this case?

You arrive at scene and attempt to log your status and call in by radio but radio reception has dropped out. You are met by a distraught female who tells you that her two sons, aged 19 and 11, were riding a motorbike at high speed, without helmets, and failed to see the closed gate. The eldest was riding and has sustained obvious bilateral fractured radius/ulnar, suspected fractured sternum, has a rigid abdomen and suspected fractured pelvis. He also has facial injuries, a significant temporal contusion and a GCS of 9. The younger patient was a pillion passenger and has what looks like a flail chest, a suspected fractured femur and exhaust burns to both thighs.
It has started raining, is getting dark and the incident site is approximately 200 metres from the residence. The local police officer has arrived, and the only other person present is the mother who is very distressed.

e. What are your immediate actions?
f. What are your clinical priorities?
g. What are the logistical considerations?
h. What aspects of this case would test you the most?
i. How would you rate your confidence in managing this case?
<table>
<thead>
<tr>
<th>RQ1</th>
<th>I</th>
<th>Great, so we’ve got a lot of experience in the room. OK the first question I’ll put out there. Oh I’ve just got to say some very quick ground rules, we’ll just try to have one person talking at a time, particularly cause we’ve got the guys on the phone as well, and I’ll just reiterate the confidentiality what’s said in the room stays in the room, that relies on us to maintain that professionalism in the group as well. So the first question I’ll put out there is what types of cases present the greatest challenges for you individually as a paramedic? So what types of cases present the greatest challenges?</th>
</tr>
</thead>
<tbody>
<tr>
<td>P</td>
<td>?- Can you just come closer to the phone and say the question again?</td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>Yeah no worries. So the first question is what types of cases present the greatest challenges to you as a paramedic?</td>
<td></td>
</tr>
<tr>
<td>RA1</td>
<td>P</td>
<td>Jock- I’ll start it off, probably multi patient jobs I would say, triaging, you know it’s easy to get tunnel vision onto one patient and miss something else going on so for me probably the multi patient jobs.</td>
</tr>
<tr>
<td>RQ2</td>
<td>I</td>
<td>Yep, and if you looked at multi patient jobs or multi casualty jobs as presenting the greatest challenges, could you even break that down even further to what it is about those types of jobs that’s..</td>
</tr>
<tr>
<td>RA2</td>
<td>P</td>
<td>J- As I said it’s probably if you get sucked into managing one patient and just ignoring the rest that obviously becomes a problem. You tend to, your hands are tied and your missing out on others stuff that people might well need your intervention. I think the triage thing we’re not used to doing it we’re used to going to single patients and sometimes unless you step back and have a look you can overlook the problem.</td>
</tr>
<tr>
<td>RQ3</td>
<td>I</td>
<td>And that thing about getting sucked into one patient what are the circumstances that lead you getting into that? Because you go to a job and there’s multi patients and you see them when you rock up.</td>
</tr>
<tr>
<td>RA3.1</td>
<td>P</td>
<td>J- Yeah it’s usually a stuff up on your behalf not taking a deep breath and thinking “what do I have to do here?” And sometimes it’s occasionally if you’re second on scene and someone calls you in and you get sucked in that way, but you really have to assess the scene. And they happen reasonably rarely so you just don’t see that many of them.</td>
</tr>
<tr>
<td>RA3.2</td>
<td>P</td>
<td>S- I’ll just take that a step further and I’ll just say the most stressful thing and I’ll back Jock up here, that the lack of triage skills at multi trauma incident. As if we make the wrong decision early in that setting we’re stuck with probably not a time critical patient and the actual time critical patient’s gone to another crew and consequently we’re stuck with this patient that may be urgent but not critical and we sort of can’t back pedal out of that. And consequently we make the wrong resourcing decision as well, we may put that emergent non critical patient on the chopper where we bring the actual time critical, maybe with the TBI to our regional hospital and therefore we have to secondary transport 2, 3, 4 or 6 hours later to get them to the major trauma centres.</td>
</tr>
<tr>
<td>RA3.3</td>
<td>P</td>
<td>J- I remember one of the most satisfying jobs I did where triage worked really well and things happened in good order and we about got 5 or 6 patients out in reasonable time and had the right people with the right patients, and that was very satisfying, but I think that was probably after 1 or 2 that hadn’t gone so well.</td>
</tr>
<tr>
<td></td>
<td>I</td>
<td>Anyone else got some thoughts on that?</td>
</tr>
<tr>
<td>RA3.4</td>
<td>P</td>
<td>S- I was just going to say that we don’t have that many multi-trauma situations up in the Wimmera, certainly a few. But the biggest challenge for me is that complex patient, when you’re a fair way from anywhere and you certainly can be up to an hour even from just a minor treatment centre. I shouldn’t call them minor treatment centre’s but very limited resources and have the situation where air support’s not available and so you have not only the situation where you’ve got the complex patient, it might be a TBI or may be others, but where you’ve got the situation you’re very much on your own, some support. Sometimes that support may be staff with a certificate 2 in emergency medical response so you’ve got no other paramedic support, and even the strong self-doubts you have yourself because you haven’t been involved with a complex patient for quite some time. So you’ve got the clinical aspect, your emotional aspect and the resource aspect which can be quite daunting with the complex patient.</td>
</tr>
<tr>
<td>RQ4</td>
<td>I</td>
<td>So I want to come back to the multi casualty job as well, but just on the</td>
</tr>
</tbody>
</table>
term of complex patient, either Sandy or someone else can you start to refine down what it is that makes it a complex patient?

RA4 P S- Probably in a few ways of saying it. As far as break it up into subgroups, but certainly in the trauma situation and the cardiac situation and to some extent the respiratory area, but the more you’re required to intervene at the top end of the MICA skill set, not only in clinical assessment but also in actual intervention, and then the realisation that that patient needs to be moved to an appropriate facility very quickly and not having that capacity to do that, so you’re very aware of what that patient needs and not being able to provide the full spectrum of what the patient needs. So there’s a bit where you might get the job done OK but then you’ve got nowhere to go.

RQ5 I So how much does that being able to deliver what the patient needs comes down to you as an individual paramedic or to things that are outside of what you can actually do then and there?

RA5 P S- I’d say two components, there is a high extent of what you can provide yourself but also a high component of what our integration system can provide when you’re in the middle of. Even though Victoria is a small state it can be fairly remote, certainly with the Wimmera.

J- If someone’s answering a question can they please move a little closer to the microphone?

I We’re going to really struggle with that,

P J- I know you don’t want to get close to each other but

I We can try that, but I will just encourage the blokes to speak up a bit, so we will do as well as we can John.

P J- Yea it was only Sandy so...

RQ6 I So you did hear everything? OK, that leads nicely, but can someone give an example then of a case that you would consider was the top end of your capabilities or abilities but that went well and had a good outcome?

RA6.1 P ?- Just about any cardiac arrest you do really.

I Hang on, is that you Worm?

P W- Yea mate, sorry was someone already answering that question?

I No you can go ahead mate.
RA6.2 P W- Just in regards to, it was a two casualty trauma job that required RSIing, the outcome was quite positive in rather still got some neurological damage that [the patient has a] normal life at the moment.

RQ7 I And where-a-bouts did that happen? Not as in a specific location but was that a country area or metro area? 13, 19

RA7 P W- No it was in a rural area mate. 20 odd kms.

RQ8 I Yep great. Can you expand a bit more on what resources you had there? 13, 3, 2, 17

RA8 P W- it was actually a multi casualty, two cars arrived at similar times a ??? and myself and the wagon. You know Jock talked about being caught up with one patient well that was unfortunately what happened to myself, being the so-called senior person at the scene getting tied up with looking after a very sick 8 year old and then having other resources come along and delegating the role of helping and so forth to second and third vehicles.

RQ9 I So do you recon the resourcing was a key thing that helped that job go well or were there other factors as well? 13, 3, (19)

RA9 P W- The resources were fantastic, when we had to hand over (to HEMS) and by the time they had to landed because very well they stayed as best they could, but when the higher level of things stabilising the young children and getting off to Melbourne, I think it was the key elements.

RQ10 I I guess playing the devil’s advocate, if we take that resourcing out of that job, nobody can say how that job would have gone but what position does that put you in I guess? 13, 15, 3

RA10 P W- Very stressful position depending on what happened to them in road transport, the young child or two young children actually to the Royal Children’s Hospital would have put a whole new condition on resources and stress on their resources, but I doubt whether we’d be able to maintain the ??? (level of care) of this particular child the entire way.

RQ11 I Thank you. So the next logical question is can you give me an example of a case that you would consider was at the top end of your capability or ability that didn’t go well and then what are the factors that
contributed to that?

P  ?- That hadn’t gone well?

I  That hadn’t gone well yea.

P  ?- As far as outcome or as just the job stuffed up?  

RA11  ?- I recall a case where I had a student with me and a (MICA ?) candidate, an asthmatic child arrested at a private school event and the consequence we were called out earlier to the same location to a so-called asthmatic child, which ended up being a hyperventilating young child. And the second time we were called out thinking it was the same thing when actually it was an asthmatic arrest. And in a tent that was probably 8ft by 8 ft there was probably every known private consultant in the world in there, but none of them were emergency consultants, I had cardiovascular, I had respiratory, I had brain surgeons, I had everybody in there and they were all wanting everything done at the one time and it was very stressful to try and get all those people to listen to actual logic at that point in time, one because there was emotional ties with those people with their children and secondly they were out of their comfort zone and in an area they were not used to. And as consequence of that getting control of those people who were logical, very smart bunch of people but to get them to see reasoning in regards of ventilation of an asthmatic child, the importance of drug dosages. I had an anaesthetist that turned up and blind tubed the child, and pushed me aside and blind tubed the child and then had no insight into the fact that this was an [oesophageal] tube which seemed like there was coming out of it, even though she was told at the time, however the consequences of that, I could see that that was getting away I think, as soon as it was given back to do an intubation was one to bag the child all the way to the hospital, I was dragged off to the bosses with me, two of the consultants with me and I said they were just refusing to listen to any logic coming from me, I was actually told I was an ambulance driver at one stage and what would I know. So it was pretty hard to look after the child in a tent with six or eight other people.
| UQ1 | Just for the guys that came in late, just basic stuff we will try to have one person talking at a time. So the first question I will put out there and I will ask you or encourage you to answer this as an individual rather than as what paramedics do as a group but can somebody tell me what types of cases they feel present the greatest challenge to them personally as a paramedic? So what types of cases present the greatest challenges to you as a paramedic? |
| UQ2 | So can you give me 5 things in paediatric cases that make them the most challenging what could you tell me? |
| UQ3 | So out of the stuff that makes those type of jobs difficult how much of that is sort of related to external, so how much is that the way you are perceiving the job and how much the other things that are |
| UQ4 | So why is there a difference in this emotions thing between paeds and adult patients? |
| UA1 | P-I think paediatrics because we just don’t touch them enough |
| UA2 | P-I guess the recollection of their physiology as opposed to adults and not I think it’s mainly a confidence thing when you touch them you get nervous because of the outcome, for me I think I want things to go well and if it’s an adult and things don’t go well you just think that how it is where as with kids you feel that emotional attachment a bit more I think and particularly when the parents are there they are obviously looking at you and wanting you to do something about what’s going on. |
| UA3 | P-I think a fair bit is related to how you feel yourself on the job compared to what is going on around you because you stick with your guide line and your protocol and do what you can do and if it doesn’t work out it doesn’t work out but still there’s that driving emotion inside you that says I want this to work and I want to be able to fix this and I want to be able to move on and get a ??? and make this kid better. If it doesn’t work you might feel a little bit challenged or think that maybe you should have done a bit more training in respect to the kids because you don’t touch them anymore. |
| UA4 | P-I think with adults we see a lot more death in them so it becomes firstly they’ve had an innings and you see a lot more death in the adults so you |
become a little more accustomed to that where as you don’t see it as much in the kids. We are not really a tuned to it. Then you have the emotion of I’m a father and I have got two kids just can imagine if that was my son there.

UQ5 So where does the greatest amount of pressure come from the stuff is it the way you perceive the job?

UA5 P-Yes

UQ6 You just mentioned confidence in there, so what are the sorts of things that influence your confidence in being able to get that outcome from those types of jobs?

UA6 P-Well obviously the type of exposure you have and how many times you have done that particular job and how much training you have done in that particular thing and your skill set that you need to bring to the table.

UQ7 Has anyone else got any ideas on how, well Pete mentioned a couple of things about not seeing a lot of those types of cases and then he mentioned confidence as well so has anyone else got some thoughts on that whether paed cases or adult cases?

UA7 K- it certainly low frequency cases where you walk in will certainly have influence on the way you look at the job, because where as if you walk in on high frequency cases you don’t have to think as much you don’t have to task focus you just think ok I can do this in my sleep. But as soon as you walk into a low frequency job you have to be much more consciously thinking you have to be much task focused and then you well I certainly notice that I’m not concentrating on the fuller picture as I would normally like to and so I have to give much more consciously thought to what I’m doing and about what I’m missing and how it’s all going and consciously keeping track of that and that’s an external things but the internal thing with me is not whether paed or not it the time of day or whether I’m tired walking into the case or not. As soon as it’s that Sam on the second nights shift that for me is going to be a key indicator of my confidence when I’m walking in thinking I don’t want to be here I’m tired, I might make a mistake and then that’s much more a conscious thought as opposed to the subconscious jobs going well, trained well we are thinking a ok here.

UQ8 How much do you think your actual time in the job not necessarily time and at qualification, just the overall time on the job, how does that impact your
confidence and perception of the particular types of cases? So you mention a chest pain, but is that different at the start of your career as opposed to later?

<table>
<thead>
<tr>
<th>UA8.1</th>
<th>K- I think it has a lot to do with rank because I was 10 years as an AP and it was still a complete step up when I got on mica and then again when I started single responding. As soon as I started single responding and had to be reliant on myself for every decision it was like starting again with the confidence. So I don’t think it is over all it may be overall part of the job but I think time at each rank and I think time at each response at every level is the one that certainly stepping on the ??? or mica or single responding where you go shit I’m in charge of everything. Where if you were an AP student or if you are an AP it doesn’t matter because mica turns up you’re not responsible any more you kind of not taking as much in whereas if you’re in charge of everything there is a shift.</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>UA8.2</th>
<th>C – I would like to say for me there are some things that get easier with time on mica and they are exactly those little things the bread and butter things like cardiac arrest I could do in my sleep now with mica but the ones that we do less frequently are probably more stressful now than when I did as a mica student or shortly after because I was more ok with my protocols and guidelines that I knew that if I turned up to this scenario these are the steps that I would have to follow but as time has gone by and they have changed the CPG’s then you get there and think oh I can’t remember if it this now or have they changed it to that. So you end up second guessing yourself because you have got all this extra information that you trying to sort out so I think that some of the jobs become much easier with time but some become far more complex as well.</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>UQ9</th>
<th>So are there any strategies that you are aware of and that you know there is this stuff that influences our guidelines at the given time? So what are the strategies that would make you feel better about that?</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>UA9.1</th>
<th>C- Well the strategy would be to read the guidelines more frequently to make sure you are set, but I even find that when I read them I’m looking through them going lucky I know that and I know that ,then when I have a problem I think bloody hell what was it again. So clearly more study would reinforce that confidence.</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>UA9.2</th>
<th>K- I find that the more I get on the mica and the more I forget I actually I bring</th>
</tr>
</thead>
</table>
my guide lines in and I stop fully relying on my memory because it’s getting old and it’s fading and I’m actually much more reliant on the written word on the job.
Appendix O: Second Level Coding for Focus Group Thematic Analysis

Table 41: Second Level Coding of Rural-Urban Transcripts

<table>
<thead>
<tr>
<th>Code</th>
<th>Theme</th>
</tr>
</thead>
<tbody>
<tr>
<td>Confidence 1:1</td>
<td>Confidence is related to regular exposure</td>
</tr>
<tr>
<td>1:2</td>
<td>Confidence is related to high volume of work</td>
</tr>
<tr>
<td>1:3</td>
<td>Confidence is impacted by fatigue</td>
</tr>
<tr>
<td>1:4</td>
<td>Confidence is impacted by feedback after a case</td>
</tr>
<tr>
<td>1:5</td>
<td>Confidence is impacted by case complexity</td>
</tr>
<tr>
<td>1:6</td>
<td>Confidence is impacted by patient outcomes</td>
</tr>
<tr>
<td>1:7</td>
<td>Confidence is impacted by familiarity with work environment</td>
</tr>
<tr>
<td>1:8</td>
<td>Confidence is impacted by training</td>
</tr>
<tr>
<td>1:9</td>
<td>Confidence is impacted by other personnel at a case</td>
</tr>
<tr>
<td>1:10</td>
<td>Confidence is impacted by individual experience</td>
</tr>
<tr>
<td>1:11</td>
<td>Confidence is impacted by collective experience</td>
</tr>
<tr>
<td>1:12</td>
<td>Confidence is impacted by the consequences of a particular intervention</td>
</tr>
<tr>
<td>1:13</td>
<td>Confidence is impacted by internal expectations</td>
</tr>
<tr>
<td>1:14</td>
<td>Confidence is impacted by external expectations</td>
</tr>
<tr>
<td>1:15</td>
<td>Confidence can impact clinical judgment</td>
</tr>
<tr>
<td>1:16</td>
<td>Confidence can be impacted by mentoring</td>
</tr>
<tr>
<td>Case exposure 2:1</td>
<td>Exposure to TBI cases is low</td>
</tr>
<tr>
<td>2:2</td>
<td>Exposure to TBI cases is high</td>
</tr>
<tr>
<td>2:3</td>
<td>RSIs are performed frequently</td>
</tr>
<tr>
<td>2:4</td>
<td>RSIs are performed infrequently</td>
</tr>
<tr>
<td>Paramedic resources 3:1</td>
<td>It is difficult to gain experience</td>
</tr>
<tr>
<td>3:2</td>
<td>The number of paramedics at a case</td>
</tr>
<tr>
<td>3:3</td>
<td>Lack of resources at high acuity cases</td>
</tr>
<tr>
<td>3:4</td>
<td>Competence of the other paramedics</td>
</tr>
<tr>
<td>3:5</td>
<td>Difficulty to assessing the competence of other paramedics</td>
</tr>
<tr>
<td>3:6</td>
<td>Cases are easier to manage when you know the other paramedics</td>
</tr>
<tr>
<td>Training 4:1</td>
<td>Skills training improves confidence</td>
</tr>
<tr>
<td>4:2</td>
<td>Case reviews improve confidence</td>
</tr>
<tr>
<td>4:3</td>
<td>Scenarios improve confidence</td>
</tr>
<tr>
<td>4:4</td>
<td>Practicing decision making</td>
</tr>
<tr>
<td>4:5</td>
<td>Adequate time available for training in low frequency skills</td>
</tr>
<tr>
<td>4:6</td>
<td>Inadequate time available for training in low frequency skills</td>
</tr>
<tr>
<td>4:7</td>
<td>There is adequate equipment and facilities available for training</td>
</tr>
<tr>
<td>4:8</td>
<td>There is adequate time available for training</td>
</tr>
<tr>
<td>Feedback 5:1</td>
<td>Clinical staff are available to debrief and give feedback on cases</td>
</tr>
<tr>
<td>-------------</td>
<td>---------------------------------------------------------------</td>
</tr>
<tr>
<td>5:2</td>
<td>Feedback on cases improves performance of similar cases</td>
</tr>
<tr>
<td>5:3</td>
<td>Positive feedback on cases improves confidence</td>
</tr>
<tr>
<td>5:4</td>
<td>Negative feedback on cases decreases confidence</td>
</tr>
<tr>
<td>5:5</td>
<td>Informal clinical discussions with peers improves confidence</td>
</tr>
<tr>
<td>5:6</td>
<td>Fear of doing the “wrong thing”</td>
</tr>
<tr>
<td>Other medical disciplines 6:1</td>
<td>Influence of other health professionals</td>
</tr>
<tr>
<td>6:2</td>
<td>Difficulties when working with non-paramedic health professionals</td>
</tr>
<tr>
<td>RSI training 7:1</td>
<td>The RSI training package was well developed and implemented</td>
</tr>
<tr>
<td>7:2</td>
<td>The RSI training package increased confidence in performing the procedure</td>
</tr>
<tr>
<td>7:3</td>
<td>RSI training needs to be provided for other non-MICA paramedics who may be required to assist with these cases</td>
</tr>
<tr>
<td>7:4</td>
<td>Regular RSI training is required to maintain confidence and competence in the skill</td>
</tr>
<tr>
<td>Soft skills 8:1</td>
<td>Difficult aspects of performing an RSI</td>
</tr>
<tr>
<td>8:2</td>
<td>The role of communication in the management of acute patients</td>
</tr>
<tr>
<td>8:3</td>
<td>Opportunities to improve communication skills</td>
</tr>
<tr>
<td>8:4</td>
<td>Leadership is a key component of the successful management of acute patients</td>
</tr>
<tr>
<td>8:5</td>
<td>Opportunities for paramedics to develop leadership skills</td>
</tr>
<tr>
<td>8:6</td>
<td>Ongoing training should focus on clinical skills</td>
</tr>
<tr>
<td>8:7</td>
<td>Ongoing training should focus on decision making</td>
</tr>
<tr>
<td>8:8</td>
<td>Ongoing training should focus on communication skills</td>
</tr>
<tr>
<td>8:9</td>
<td>Ongoing training should focus on leadership skills</td>
</tr>
<tr>
<td>8:10</td>
<td>Ongoing training should focus on team performance</td>
</tr>
<tr>
<td>Simulation training 9:1</td>
<td>Simulation training is available as a tool for paramedics to maintain performance</td>
</tr>
<tr>
<td>9:2</td>
<td>Simulation training is a valuable tool</td>
</tr>
<tr>
<td>9:3</td>
<td>Simulation training is of no benefit</td>
</tr>
<tr>
<td>9:4</td>
<td>Simulation training requires advanced technology to be of benefit</td>
</tr>
<tr>
<td>9:5</td>
<td>Simulation training can be effective even with low technology</td>
</tr>
<tr>
<td>9:6</td>
<td>Simulation facilities are available to all paramedics</td>
</tr>
</tbody>
</table>

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<table>
<thead>
<tr>
<th>Availability 10:1</th>
<th>Time is available for paramedics to improve their knowledge and skills</th>
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</thead>
<tbody>
<tr>
<td>10:2</td>
<td>No time is available for paramedics to improve their knowledge and skills</td>
</tr>
<tr>
<td>New information/changes 11:1</td>
<td>New information and guidelines are introduced appropriately</td>
</tr>
<tr>
<td>11:2</td>
<td>Too much new information has been introduced over a short period of time</td>
</tr>
<tr>
<td>11:3</td>
<td>Increasing expectations on MICA paramedics</td>
</tr>
<tr>
<td>11:4</td>
<td>MICA paramedics feel supported in their work</td>
</tr>
<tr>
<td>11:5</td>
<td>Online training packages are effective</td>
</tr>
<tr>
<td>11:6</td>
<td>Self-directed learning</td>
</tr>
<tr>
<td>SRU model 12:1</td>
<td>The MICA single responder model positively affects work performance</td>
</tr>
<tr>
<td>12:2</td>
<td>The MICA single responder model negatively affects work performance</td>
</tr>
</tbody>
</table>
Appendix P: SPSS Syntax for Re-Coding of Patient Residence Postcode and Injury Location Postcode to Allocate ARIA+ Categories

Table 42: SPSS Coding for ARIA+ Categories

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RECODE InjuryPostcode, PatientPostcode
(3284=3) (3396=3) (3418=3) (3420=3) (3509=3) (3512=3) (3960=3) (3233=2) (3238=2) (3239=2) (3266=2) (3268=2) (3274=2) (3283=2) (3285=2) (3289=2) (3351=2) (3361=2) (3377=2) (3379=2) (3381=2) (3384=2) (3387=2) (3388=2) (3395=2) (3400=2) (3401=2) (3407=2) (3409=2) (3423=2) (3475=2) (3478=2) (3480=2) (3485=2) (3487=2) (3494=2) (3496=2) (3498=2) (3500=2) (3501=2) (3505=2) (3507=2) (3517=2) (3518=2) (3520=2) (3525=2) (3527=2) (3529=2) (3530=2) (3531=2) (3533=2) (3537=2) (3540=2) (3542=2) (3544=2) (3546=2) (3549=2) (3562=2) (3566=2) (3573=2) (3575=2) (3579=2) (3597=2) (3599=2) (3637=2) (3639=2) (3641=2) (3673=2) (3675=2) (3678=2) (3691=2) (3697=2) (3701=2) (3705=2) (3707=2) (3709=2) (3713=2) (3720=2) (3722=2) (3723=2) (3732=2) (3733=2) (3737=2) (3744=2) (3825=2) (3851=2) (3858=2) (3860=2) (3862=2) (3865=2) (3874=2) (3875=2) (3878=2) (3880=2) (3882=2) (3885=2) (3898=2) (3900=2) (3902=2) (3904=2) (3909=2) (3921=2) (3956=2) (3959=2) (3962=2) (3965=2) (3966=2) (3971=2) (3000=0) (3008=0) (3099=0) (3111=0) (3212=0) (3224=0) (3335=0) (3752=0) (3754=0) (3759=0) (3800=0) (3915=0) (3970=0) (9998=6) (9000=7) (9999=8) (8888=9) (3888 thru 3892=3) (3269 thru 3272=2) (3286 thru 3287=2) (3292 thru 3294=2) (3300 thru 3305=2) (3310 thru 3312=2) (3314 thru 3315=2) (3317 thru 3319=2) (3324 thru 3325=2) (3390 thru 3393=2) (3412 thru 3414=2) (3418 thru 3420=2) (3482 thru 3483=2) (3490 thru 3491=2) (3567 thru 3568=2) (3580 thru 3581=2) (3584 thru 3586=2) (3588 thru 3591=2) (3594 thru 3595=2) (3698 thru 3699=2) (3739 thru 3741=2) (3886 thru 3888=2) (3895 thru 3896=2) (3002 thru 3006=0) (3010 thru 3013=0) (3015 thru 3016=0) (3018 thru 3034=0) (3036 thru 3062=0) (3064 thru 3068=0) (3070 thru 3076=0) (3078 thru 3079=0) (3081 thru 3091=0) (3093 thru 3097=0) (3101 thru 3109=0) (3113 thru 3116=0) (3121 thru 3156=0) (3158 thru 3163=0) (3165 thru 3175=0) (3177 thru 3202=0) (3204 thru 3207=0) (3214 thru 3221=0) (3337 thru 3338=0) (3427 thru 3429=0) (3765 thru 3767=0) (3781 thru 3782=0) (3786 thru 3789=0) (3791 thru 3793=0) (3795 thru 3796=0) (3802 thru 3810=0) (3910 thru 3913=0) (3918 thru 3920=0) (3926 thru 3928=0) (3930 thru 3931=0) (3933 thru 3934=0) (3936 thru 3944=0) (3975 thru 3978=0) (2000 thru 2999=10) (7000 thru 7999=11)(ELSE=1) INTO InjuryASGC, PatientASGC.
EXECUTE.
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