Investigation of the potential to enhance emergency response to motorcyclists involved in crashes

The George Institute for Global Health
and
Monash University

Soufiane Boufous, Belinda Gabbe, Jane Elkington, Megan Bohensky, Peter Cameron, Liz de Rome

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EXECUTIVE SUMMARY

Circumstances of motorcycle crashes

Between 2001 and 2010, 19,418 crashes involving motorcyclists were reported to the Victorian police. These crashes resulted in 20,368 motorcyclist casualties involving 19,427 motorcycle riders and 941 pillion passengers. This represents an average of just over 2000 motorcyclist casualties reported to the police per year.

Overall, nearly half (49.6%) of motorcycle crashes reported to the police in Victoria between 2001 and 2011 were single vehicle crashes involving only the motorcycle. The most common crash types resulted from riders losing control of the motorcycle on the road followed by “right through” crashes (where a vehicle approaching from the opposite direction turns right in front of another vehicle), and rear end crashes.

Overall, 3.1% of motorcyclist casualties were reported not to have worn a helmet at the time of the crash. Generally this proportion decreased with age with those aged less than 18 years having the highest proportion of non helmet use (23%) and those aged 60 years and older the lowest (1.6 %).

The vast majority of motorcycle casualties were males (88%) with those aged 26-39 years representing 40% of motorcyclists involved in police reported crashes in Victoria. Similar age and gender distributions were found in cases recorded in other population-based datasets, including the Ambulance Clinical Data Warehouse, Emergency Minimum Dataset, Admitted Episode Dataset, State Trauma Registry and National Coroner’s Information System, where rates per 100,000 were highest among males aged 15-34 years.

An examination of these datasets also showed that over the 5-year period from July 2005 to June 2010, there were 20,357 motorcycle-related Emergency Department (ED) presentations, 9,012 hospital admissions with a length of stay >24 hours, 1166 hospitalised major trauma cases, and 239 motorcycle-related deaths in the state. There was no evidence of a significant increase in motorcycle-related injury in Victoria in the 5-year timeframe with approximately 250 major trauma cases and 50 deaths per year.

Similar to police reported crashes, the majority of injured motorcyclists identified in other population-based datasets were motorcycle drivers, with pillion passengers accounting for 3 per cent of major trauma cases (i.e. critically injured) and 1 per cent of hospital admissions. Pillion passengers were over-represented in coroner's records, accounting for 20 per cent of motorcycle-related deaths.

A consistent finding across all population-based datasets, including police records, was the high proportion of cases occurring on weekends and between the hours of midday and 6pm, most likely reflecting the prevalence of recreational motorcycle riders.

Despite the limitations of mapping crashes due to missing geographical location data, there were clear patterns for motorcycle crashes resulting in major trauma. Half of the crashes resulting in major trauma and death occurred in regional Victoria and the most common locations for sustaining motorcycle-related major trauma were Gippsland (particularly Phillip Island), and the Southern Metropolitan Melbourne (predominantly Casey, Frankston and Greater Dandenong) areas, the Yarra Ranges and the Mornington Peninsula. This was generally consistent with police crash records.

Injury sustained by motorcyclists

The most prevalent injury types for motorcycle-related ED presentations were upper extremity injuries, predominantly involving the shoulder. For cases admitted to hospital, lower extremity injuries were most common, followed by upper extremity injuries, with head injuries accounting for only 11 per cent of hospital admissions.

For major trauma cases, almost half of the cases had sustained serious chest injuries, while almost one third had sustained serious lower extremity injuries, including pelvic fractures, fractures of the tibia or ankle, fractures of the femur and fibula fractures. More than a quarter of cases sustained a serious head injury (intracranial injury and/or skull fracture).

Multiple injuries were the most common causes of death reported by the coroner accounting for more that half of motorcycle-related deaths. Other common injuries include blunt head trauma and chest and abdominal injuries.

Early management of injured motorcyclists

According to the Ambulance Clinical Information System and the State Trauma Registry, between July 1 2005 and June 30 2010, most major trauma cases were transported to hospital by ambulance and the median time from receipt of the '000 or 112' call to ambulance arrival at the crash scene was 16 minutes.

The major factors contributing to response time were the place of injury and the time of call. Compared to "on-road" incidents, crashes occurring on farms resulted in significantly longer response times, while those occurring at homes, and athletic/sports arenas were associated with shorter response times. Response times were also significantly shorter for crashes occurring in metropolitan Melbourne. Response times were highest for calls to '000' made during daylight hours, which most likely reflect the high levels of congestion on the roads during the daytime.

The median time spent at scene by the ambulance paramedics was 27 minutes. The factors most predictive of time at scene were the type of transport used, the location of the crash, and the physiological state of the patient. The time spent at scene was highest for helicopter transport cases, cases with a severe head injury, and hypotensive patients. Adjusting for these factors, the time spent at scene for ambulances attending motorcycle-related major trauma cases in metropolitan Melbourne was shorter than for cases occurring in regional Victoria.

The median time from departure of the scene to arrival at hospital was 34 minutes. The location of the crash was an important predictor of transport time from the scene to hospital with regional cases requiring longer transport times than metropolitan cases, cases occurring on farms requiring longer transport times than "on road" crashes, and all other times of the day resulting in shorter transport times than cases where the ambulance left the scene of injury in the afternoon.

Overall, the median time from injury to arrival at the hospital providing complete care of the motorcyclists' injuries was 2.0 hours for motorcycle-related major trauma cases. The multivariate analysis indicates that the strongest predictor of time to definitive care was inter-hospital transfer. Cases requiring inter-hospital transfer resulted in an almost eight-fold increase in the mean time to definitive care. Consistent with other pre-hospital and transport outcomes, transport by air ambulance, a farm location (relative to "on road"), and crashes occurring in regional areas, including off road crashes, were associated with a longer time to definitive care.

Long term outcomes

Overall, the vast majority of hospitalised, injured motorcyclists survived their injuries. Motorcycle-related trauma victims tend to be young, healthy and working prior to injury. The types of injuries sustained, including head and limb fractures, have the potential for lifelong disability and the burden of non-fatal injury must be considered.

Ongoing functional limitations were prevalent even at 12-months post-injury. One in five major trauma survivors, and 26 per cent of orthopaedic trauma patients, had fully recovered by 12-months post-injury. The return to work rate at 12-months post-injury was 67 per cent for motorcycle-related major trauma cases, and 76 per cent for motorcycle-related orthopaedic trauma.

Both motorcycle-related major trauma and orthopaedic trauma patients continued to have physical and mental health scores significantly below population norms. These findings highlight the burden of non-fatal motorcycle-related injury.

Literature Review

First-aid programs for motorcyclists as first-responders have attracted growing support within the US, UK and Australia. Despite the lack of rigorous evaluations, these courses tend to be well-received among riders, with indications that the training has been used in a crash situation.

While there may be some merit in providing first-aid training to other road users as well as other members of the community, there is currently a lack of evidence about the effectiveness of these programs in improving emergency response and injury outcomes of motorcyclists involved in crashes.

A fairly consistent finding from several process evaluations and qualitative reviews of first-responder training is the perceived need of the first responder to be adequately trained in managing their emotional response, as much as having the knowledge and skills to respond to the physical emergency.

Communication technology is another promising area for improving emergency response times in road trauma, although its use has not directly been tested in the event of serious motorcycle crashes. Many of these technologies, such as eCall, vehicle to vehicle communication systems and hybrid wireless mesh networks, are yet to be adapted to motorcycles.

The use of GPS devices in ambulance service vehicles appears to reduce the time to reach the injured person most notably in rural areas. However, the impact on survival rates in motorcycle related trauma is yet to be evaluated.

Survey of motorcycle riders

More than half of the 401 motorcycle riders who participated in the survey (58%) reported obtaining medical or first aid training. Among those, 90% reported receiving standard first aid and only 9% received motorcycle specific first aid training.

More than a third of respondents (36%) reported having been present at the scene of a serious motorcycle crash where someone was injured. Just over a third of those (34%) reported providing first aid to the injured person.

Just under half of respondents (46%) said that they would know what to do at the scene of a serious motorcycle crash before emergency service arrived. This proportion was higher (62

%) among those who reported receiving medical/first aid training compared to those who did not receive such training (23%).

When asked about the steps to take when presented with a theoretical crash scenario, those who reported receiving first aid training were more likely to provide the “correct” answers compared to those who did not receive such training except for the decision related to helmet removal which did not seem to be affected by the history of first aid training.

Two thirds of respondents (66%) said they would attend a motorcycle specific first aid training program on what to do before professional help arrives at a motorcycle crash if such programs were readily available. About, the same proportion (69%) said that such training programs should be included in the licensing process for riders.

Nine out of 10 respondents said that they would be prepared to assist a crashed motorcyclist if they could get first aid advice over the phone.
Over half of interviewed riders (58%) said that they would install an automatic crash notification and GPS location system to relay information to emergency services if such technology was available for their bikes.

Consultations with stakeholders

Eighteen individuals from various emergency organisations and motorcycle riders groups were interviewed to discuss factors that influence crash outcomes in motorcyclists and strategies that have the potential to improve emergency response to motorcycle crashes in Victoria.

While interviewees described a well-integrated system of emergency care for trauma victims in Victoria, they also identified a number of gaps related to delays in locating and reporting crashes as well as in reaching crash sites, particularly in rural and remote areas. Provision of appropriate first aid to motorcyclists involved in traffic crashes prior to the arrival of emergency teams is another area that needs further consideration according to interviewed stakeholders.

Suggestions to improve locating and reporting crashes include the installation of additional mobile phone towers, emergency satellite telephones, emergency markers, distance markers and other location signage, particularly in rural areas where motorcycle crashes are likely to occur.

Communication technology such as personal tracker devices for motorcyclists and GPS navigation devices for emergency vehicles were also suggested as effective methods to better locate and reach injured motorcyclists. Ambulance Victoria is currently piloting GPS technology in some vehicles.

Some stakeholders highlighted the need to extend the Emergency Medical Response program of the Metropolitan Fire Brigade to the Country Fire Services as these services are widely distributed in regional and remote areas and staff may therefore reach crash sites sooner than ambulance services.

Interviewees also suggested raising awareness among riders about the benefits of riding in a group and the strategies that need to be followed when riding alone, particularly in rural and remote areas. The provision of motorcycle specific emergency first aid training (e.g. the Bystander Assistance programme) has also been highlighted as an initiative that has the potential to improve crash outcomes in motorcyclists.

1. BACKGROUND

Motorcyclists represent an increasing proportion of road crash casualties in Victoria, across Australia and around the world (Newgard 2007; VicRoads 2009; WHO 2009; Mikocka-Walus et al. 2010; AIHW 2011). This is due to the increasing numbers of riders, as motorcycles and scooters have become the fastest growing sector of motor vehicles globally (Rogers 2008). In Australia, as in many other high income countries, the increasing numbers of motorcycles are primarily associated with recreational rather than transport usage (Paulozzi 2005; Haworth 2010). In Victoria more people are riding on weekends particularly along popular tourist routes such as the Great Ocean Road and in the Yarra Ranges. In addition, there has been a substantial increase in off-road riding in State Forests and private land as almost half the motorcycles sold are for off-road use (VicRoads 2009).

The outcome of road trauma has been noted to be dependent upon four factors – two associated with the situation as presented at the scene: injury severity and individual factors, and two related to the management of the situation: quality of first responder care and the time to receive definitive treatment (Marson 2001). This report provides an epidemiological profile of motorcycle crashes in Victoria and focuses on the latter two factors (first responder care and the time to receive definitive treatment) and investigates factors that impact on, and the most effective strategies to, improve emergency response to motorcycle crashes in Victoria.

This first part of the report provides findings of detailed analyses of available population-based datasets in Victoria. It describes the epidemiology of motorcycle crashes and injured motorcyclists, their management in the Victorian State Trauma System, and the in-hospital and long term outcomes of injured motorcyclists. The data presented provide information about the incidence of motorcycle-related serious injury and death, the geographic location of crashes resulting in serious injury, the response times for pre-hospital services where these services were engaged, the injuries sustained, and factors predictive of response times and outcomes of injury in motorcyclists involved in crashes. Where relevant, changes over time are provided.

The report also contains the findings of a literature review that was undertake to identify methods to improve the capability of first responders at motorcycle crash scenes and strategies to improve the speed of professional response, especially in rural and remote areas. The final part of the report presents the findings of a survey of motorcycle riders and consultations with relevant emergency and motorcycling groups that assessed levels of first aid knowledge among riders and solicited views about best strategies to improve emergency response to motorcyclists involved in crashes in Victoria.

2. DATA AND METHODS

2.1 Interrogation of relevant databases

2.1.1 Sources of data

Sources of data regarding motorcycle crash response times, and medical outcomes were explored. The proposal to the funding body highlighted seven sources for use in this study, while 18 potential sources were identified through an initial consultation process with major stakeholders (Appendix 1). Of the additional databases identified through the consultation process, many were not relevant, were included in the statewide datasets already identified in the project proposal or were not yet in operation. The registries at the Royal Melbourne Hospital and The Alfred Hospital contribute data directly to the Victorian Orthopaedic Trauma Outcomes Registry (VOTOR) and the Victorian State Trauma Registry (VSTR). The registry maintained at the Royal Children's Hospital contributes data directly to the VSTR. The Alfred Hospital's Intensive Care Traumatic Brain Injury Database is not yet fully operational, but motorcycle related head injury cases are already captured by the VSTR at this site. Data from the Computer Aided Despatch database contributes directly to the Victorian Ambulance Clinical Data Warehouse, already identified in the original proposal.

The Medicare dataset contains information about health service utilisation, for items charged to Medicare, but will not allow identification of motorcycle crashes specifically and provides no information about emergency response or patient outcomes. The National Trauma Registry is not yet operational, and was not able to provide additional data within the timeframes of this study. The Victorian Adult Burns Service Registry is based at The Alfred. Motorcycle crash related burn injury is rare and was included in the VSTR for this site.

The Transport Accident Commission (TAC) Claims Data contributes directly to the Institute for Safety, Compensation and Recovery Research (ISCRR) Compensation Research Database and ethics approval for linkage with the VSTR and VOTOR was obtained. However, the data linkage is currently in process but data were not available within the project timelines. The Epworth Head Injury Database (HID) collects outcome data for all cases admitted to rehabilitation at this site. These cases are contained on the VSTR and routinely followed-up.

Therefore, to explore the response time trends, response times, and medical outcomes for different types of injuries and severities, seven data sources were interrogated. These included:

i. Victorian Emergency Minimum Dataset (VEMD)
ii. Victorian Admitted Episode Dataset (VAED)
iii. Victorian Ambulance Clinical Data Warehouse
iv. Victorian State Trauma Registry (VSTR)
v. Victorian Orthopaedic Trauma Outcomes Registry (VOTOR).
vi. National Coroner's Information System (NCIS)
vii. VicRoads Crash data (Police crash data)

VicRoads crash data

Police reported crashes were obtained from VicRoads for a 10-year period between 2001 and 2010. The dataset contains crashes that occurred on public roads where at least one person was killed or injured and the crash was attributable to vehicle movement. The data does not include crashes that occurred on private property, car parks, etc., but includes those that occurred on footpaths if they are part of the public road.

Victorian Emergency Minimum Dataset

The Victorian Emergency Minimum Dataset (VEMD) commenced in October 1995 and is maintained by the Victorian Department of Health. The VEMD contains de-identified demographic, administrative and clinical data on emergency department presentations occurring at Victorian public hospitals with 24 hour emergency departments (ED), representing approximately 80 per cent of Victoria's registered public hospitals. These data are used by the Department of Health for monitoring access to health services and emergency department planning and state-wide services but are also used for clinical research purposes. Data are collected upon the patient's presentation and injury data are coded by the Victorian Injury Surveillance and Applied Research System (VISAR), located within Monash University Accident Research Centre (MUARC) on a monthly basis according to the International Statistical Classification of Diseases and Related Health Problems, 10th Revision, Australian Modification (ICD-10-AM). To maintain the anonymity of patients in the VEMD, the data are provided in modified format. For example, the hospital of presentation is not named, date of birth is not provided and the age of the patient is provided in 5-year age groups (i.e. 0-4 years, 5-9 years, etc.).

Victorian Admitted Episode Dataset

The Victorian Admitted Episodes Dataset (VAED) is also maintained by the Victorian State Department of Health and holds data dating back to the 1987-88 financial year. It includes all hospital admitted patient episode data collected from public and private hospitals. The VAED is used to inform case-mix funding, however, data are also used to study disease prevalence estimation, healthcare utilisation patterns and inform policy planning. Clinical data are also recorded using the ICD-10-AM. Private hospitals are also required to submit a sub-set of data. The quality of the data is assessed through routine auditing of public hospital data to determine the accuracy of ICD-10-AM coding, especially in relation to the Australian Refined Diagnosis Related Groupings. The VAED does not contain detailed data about injury management and outcomes and only general patient demographic data. It was used to provide an overview of admissions across the state as a useful adjunct to the Victorian State Trauma Registry and Victorian Orthopaedic Trauma Outcomes Registry datasets. To maintain the anonymity of patients in the VAED, the data are provided in modified format. For example, the hospital of admission is not named, date of birth is not provided and the age of the patient is provided in 5-year age groups (i.e. 0-4 years, 5-9 years, etc.).

National Coroner's Information System

The National Coroner's Information System (NCIS) is a national centralised data storage and retrieval system for coronial information managed by the Victorian Institute of Forensic Medicine. The NCIS is the world's first electronic national collection of coronial information. Information on all deaths referred to Australian coroners since July 2000 are captured in both coded and narrative text format. The data collected for coronial cases is extensive and includes information from the police report, detailed clinical and injury data by autopsy or CT scan and toxicology.

Ambulance Victoria Data Warehouse (AV DW)

The Victorian Ambulance Clinical Information System (VACIS) is an in-field electronic data capture system and linked clinical database, based on Oracle database software. It allows paramedics to record patient information electronically at the point of care on a tablet PC. The primary output of VACIS is an electronic Patient Care Record (ePCR), which replaces the handwritten PCR which had been in use for many years. VACIS was developed in-house by Ambulance Victoria (AV). Implementation of VACIS commenced in metropolitan regions in November 2005 with full implementation across the service completed in 2008.

Ambulance paramedics record clinical and operational data for all emergency incidents via the VACIS. Each individual record is called an 'electronic patient care record' (ePCR). Key areas of data collection include event details, patient details, attending teams, patient pre-existing conditions, cause of the event, vital signs and symptoms, management, diagnosis and outcome. A specific road trauma accident screen is available when the cause is traumatic. All pertinent variables in VACIS are time stamped. Data from completed ePCRs is uploaded to a database, before being integrated into a Data Warehouse for analysis and reporting.

Organisation data from AV is stored in the Ambulance Victoria Data Warehouse (DW), which is built on Solaris Unix and Oracle database platforms. The AV DW has five Business Areas (similar to Data-marts), which logically combine information types (eg finance, response, workforce and clinical data). Two Business Areas, AV Clinical and AV Clinical Private contain clinical information sourced from the VACIS system.

Ambulance Victoria provides key pre-hospital data to the Victorian State Trauma Registry for all major trauma cases transported by AV. Cases meeting the Registry's definition of major trauma (see next section) are identified and AV DW data obtained. Additional data were sought for this project. The geographical location of the crash site was mapped by AV using geographic mapping software. Additionally, qualitative (text) information recorded by the paramedics was made available for major trauma cases captured by the Victorian State Trauma Registry. These additional data items were made available for cases from January 2007.

Victorian State Trauma Registry

The Victorian State Trauma Registry (VSTR) is a population-based trauma registry capturing data on all major trauma patients in Victoria. Data are collected from all 138 health services receiving trauma in the state. The VSTR collects pre-hospital data (including AV response, treatment and transport times), patient demographic, injury event (including the location of the injury event or crash), injury diagnosis and severity data, in-hospital outcomes (e.g. mortality, length of hospital stay) and functional and health-related quality of life outcomes at 6, 12 and 24-months post-injury. The VSTR has been operating since July 2001 and shares an existing data linkage arrangement with Ambulance Victoria.

The VSTR uses an opt-off consent process where all eligible patients (or their next of kin in the case of deaths) are sent a letter and a brochure to explain the purpose of the registry, why they have been included, the registry processes and how to opt-off if they choose to do so. The VSTR has ethics approval from all participating hospitals and Monash University, and the opt-off rate for VSTR patients is <1 per cent, assuring almost complete capture of eligible patients for analysis. The definition of major trauma aims to identify the most seriously injured patients who will benefit most from rapid transport to trauma centres for treatment. A major trauma is defined by the state trauma system as meeting any of the following criteria:

1. Death following injury
2. An Injury Severity Score (ISS) >15
3. Admission to an intensive care unit (ICU) for >24 hours and requiring mechanical ventilation
4. Urgent surgery.

Data pertaining to the pre-hospital care, acute hospital care and post-discharge outcomes of major trauma patients are collected by the VSTR. A standardised telephone interview is completed at 6, 12, and 24-months after injury by trained registry staff. This process is fully integrated with VOTOR to prevent multiple calls to the same patient. The data collected by telephone interview includes:

(i) Pre-morbid status (disability, work status, occupation, level of education);

(ii) Pain (measured using a numerical rating scale ranging from *0* (no pain) to *10* (worst possible pain)

(iii) Functional level using the Glasgow Outcome Scale – Extended (GOS-E) which rates the patient's level of function on a scale from *1* (Death) to *8* (Upper good recovery). A score of 8 represents a return to pre-injury levels of function and the absence of any ongoing issues related to injury;

(iv) Work disability measured as return to work, return to the pre-injury place of employment, and return to the same role within the pre-injury place of employment;

(v) Health-related quality of life using the 12-item Short Form Health Survey (SF-12). The SF-12 is a generic measure of health status or health-related quality of life. Responses to the 12 questions of the SF-12 are combined into mental and physical health summary scores – the Mental Component Summary score (MCS-12) and the Physical Component Summary score (PCS-12). There are Australian population norms for the PCS-12 and MCS-12 for comparison.

For the purposes of this study, motorcycle-related major trauma cases with a date of admission from July 1 2005 to June 30 2010 were extracted for analysis. For these cases, additional data were received from AV regarding the geographic location of the crash, mapped to statistical local areas and local government areas.

Victorian Orthopaedic Trauma Outcomes Registry

The Victorian Orthopaedic Trauma Outcomes Registry (VOTOR) is a sentinel site registry capturing data about all orthopaedic trauma admissions to four hospitals in Victoria. The four hospitals include the two adult major trauma service (MTS) hospitals, one regional trauma service (RTS) and one metropolitan trauma service (MeTS). This registry has been operating since 2003 and collects demographic, injury event, diagnosis, clinical management data, in-hospital outcomes and long term (6 and 12-months) functional and health-related quality of life data for all eligible cases. VOTOR does not capture pre-hospital response times but contains detailed injury and outcomes data for registered cases, providing valuable additional information about the burden of non-fatal motorcycle crash related injuries.

All patients admitted to hospital with an emergency admission (>24 hours) for an orthopaedic injury (fracture and/ or soft tissue injury (if treated surgically)) are eligible for inclusion on the registry. Patients with a pathological fracture related to metastatic disease are excluded. The registry has been collecting data from The Alfred and Royal Melbourne Hospital (RMH) since 2003 and was extended to the Geelong Hospital and Northern Hospital in 2007. Patients are identified by the discharge diagnosis through ICD-10 reports from the hospitals.

The registry uses an opt-off consent process where all eligible patients (or their next of kin in the case of deaths) are sent a letter and a brochure to explain the purpose of the registry, why they have been included, the registry processes and how to opt-off if they choose to do so. VOTOR has ethics approval from all participating hospitals and Monash University, and the opt-off rate for VOTOR patients is approximately 1.9%, assuring almost complete capture of eligible patients for analysis.

The VOTOR dataset is fully linked with the VSTR to eliminate duplication of effort and to streamline follow-up procedures. Data relating to the hospital admissions are obtained electronically from the participating hospitals and include: (i) Patient details; (ii) Injury event details; (iii) Injury diagnoses; (iv) Injury management; (v) Key in-hospital indicators; (vi) Complications and pre-morbid conditions; and (vii) Implant information. Additionally, a standardised telephone interview is completed at 6 and 12-months after injury by trained registry staff. This process is fully integrated with the VSTR to prevent multiple calls to the same patient and the data for VOTOR are the same as collected for VSTR cases.

As for all databases examined in this study, with the exception of police crash data, motorcycle-related cases with a date of admission from July 1 2005 to June 30 2010 were extracted for analysis.

2.1.2 Data Analysis

Describing the profile of crashes and cases

Summary statistics were used to describe the profile of motorcycle crashes, crash victims and outcomes across the included datasets. For categorical variables, frequencies and percentages were used. The mean and standard deviation (SD) were used to describe variables with a normal distribution. The median and interquartile range (IQR), were used to summarise continuous data items where the data were skewed. Pie, bar, boxplots and line graphs were used to provide a visual representation of the data. Age and sex adjusted incidence rates were calculated where possible.

Identifying predictors of response times and time to hospital care

The VSTR (with inputted AV DW data) provide the most comprehensive data regarding the response times for motorcycle crash victims and the time to definitive hospital care. The key time outcomes of interest were:

i. Time from receipt of the '000' and "112" call to arrival of an AV unit at the scene.
ii. Time at scene for paramedic care
iii. Time for transport from scene to hospital care
iv. Time from injury to definitive care.

Univariate and multivariate linear regression modelling were used to identify important predictors of response times and time to hospital care. Variables demonstrating an association with a p-value <0.20 on univariate testing were included in the multivariate model. Where the outcome was heavily skewed, log transformation was undertaken. Model coefficients and 95% confidence intervals (CI) were reported. The coefficients broadly represent the mean difference in times between the reference group and the comparison group. Negative co-efficients represent shorter times compared to the reference group, while positive co-efficients represent longer times relative to the reference group.

Where the time was heavily skewed and a log transformation was needed, the typical mean is no longer applicable and the *geometric mean* (a variation on the typical mean) is calculated. The coefficients for a model which has been log transformed do not provide the mean difference but provide a ratio of the geometric mean, allowing the difference to be summarised as a percentage.

Identifying predictors of in-hospital mortality

The VEMD, VAED, VSTR and VOTOR routinely record in-hospital mortality. Univariate and multivariate binary logistic regression modelling were used to identify important predictors of in-hospital mortality. Variables demonstrating an association with a p-value <0.20 at the univariate level were included in the multivariate model. Age was modelled as a categorical variable as it was not linearly associated with the log-odds of mortality (and therefore did not meet the assumptions of the statistical model). Adjusted odds ratios (AOR) and 95% CI were reported.

The odds ratio (OR) provides the odds of dying in the group of interest with the odds of dying in the reference group. The adjusted odds ratio (AOR) provides the odds ratio of the association between the group of interest and the reference group, keeping all other factors in the model steady.

Identifying predictors of long term outcomes

The key outcomes of interest were a full functional recovery (GOS-E score of *8* - upper good recovery), return to work (for motorcycle crash victims working prior to injury), physical health (as measured by the PCS-12 summary score of the SF-12), and mental health (as measured by the MCS-12 summary score of the SF-12). There were a small number of important covariates with missing data. It was reasonable to assume that data were not missing in a way that depended on unobserved values and multiple imputation of these variables was performed. The data were imputed using multiple imputation by chained equations. Ten datasets were imputed. The models using imputed data were compared with models using complete case analysis (i.e. cases with missing data excluded) and the findings were consistent. Therefore, the imputed models were included in the final report as they used all available cases and data, are less biased, and provide more precise estimates.

Generalised Estimating Equations (GEE) analysis was used to model long term outcomes, providing a "population-average" (or marginal) approach to modelling data with repeated measures. An exchangeable working correlation was used. Variables showing an association with a p-value <0.20 on univariate testing were included in the multivariate model.

Adjusted odds ratios (AOR), and 95% CI, were reported for logistic regression models involving a binary outcome (e.g. recovered vs. not recovered). As noted for mortality outcomes, the odds ratio (OR) provides the odds of the outcome in the group of interest with the odds of the outcome in the reference group. The AOR provides the odds ratio of the association between the group of interest and the reference group, keeping all other factors in the model steady.

For continuous variables such as the PCS-12 and MCS-12 scores, coefficients and 95% CI were reported. As noted for the time models, the coefficients provide an estimate of the mean difference between the group of interest and the reference group, keeping all other factors in the model steady. For all analyses, a p-value <0.05 was considered significant. All analyses were performed using Stata Version 11.2 (StataCorp, College Station, TX).

2.2 Literature review

A review of the international literature, both peer reviewed and "grey literature", was undertaken to search for the available evidence on approaches to enhance the capacity of first responders and professional response teams to effectively respond to the situation of an injured motorcyclist and/or passenger. To be relevant to the Victorian context, the review focused on literature available from industrialised countries, where trauma systems are relatively well developed, as well as specifically searching for systems or approaches in rural areas, where distances to medical attention and definitive care have been examined. Published articles and reports were searched using the following databases: APAIS-Health, Australian Transport Index, CINAHL, Cochrane Library, Medline and PsychInfo. Only English publications between 1990 and 2011 were retrieved. Search terms included were:

- Motorcycles OR motor vehicles: AND
- First aid, first responders, emergencies, emergency medical services, accident, traffic/road trauma, crash, road injury, AND/OR
- Emergency medical service communication system, pre-hospital, transportation of patients, emergency transport systems, emergency medicine, ambulances.

Second order search terms included:

- Sports injuries AND helmet removal.
- Rural/remote
- Barriers to first responder/speed of response
- Community-based.

While the focus of the review was on motorcycle crashes, literature on other forms of trauma, notably road trauma, were included where it was considered they addressed a model of practice relevant to the injured motorcycle rider or passenger and/or to the issues related to managing medical emergencies in rural or remote areas. Publications discussing issues related to the removal of helmets in the sports injury area were also examined because of their relevance to motorcyclist crash injuries.

Grey literature was searched via the publications listed on relevant organisations websites, including Australian Transport Index, Transport Research Laboratory (TRL), International Transport Research Documentation (IRTD), National Highway Transport Safety Administration (NHTSA), Transportation Research Board (TRB), Transportation Research Information Database (TRID), and Transportation Research Information Services (TRIS). Article titles and abstracts were reviewed to select those relevant to the current report. Hand searching of reference lists was undertaken of articles that were retrieved.

It is important to note that the review was designed to cover a broad number of possible approaches to improving, via first responders and professional services responses, injury outcomes among motorcyclists who have crashed. As a result, the review has not attempted to be comprehensive or systematic. It serves, more to provide an overview of the types of approaches that have been investigated and an understanding of the current best practice in each area, albeit often limited to process evaluation and the lessons learned from some other areas of medical emergencies to motorcycle crashes, when no directly relevant studies could be identified.

2.3 Survey of motorcycle riders

An on-line survey of riders was conducted to determine their level of first aid knowledge as well as their views on the feasibility of various strategies to improve emergency response to motrocycle response as identified in the literature. The on-line survey content was developed by the research team while the programming and delivery of the survey was undertaken by an on-line research panel provider. Of the 569 eligible riders identified by the on-line research panel, 401 (70.1%) completed the survey. Similar approach was recently undertaken by the Victorian Department of Environment and Sustainability for research with trail bike riders (Trail Bike Market Research, 2009).

It is important to note that, given the heterogeneity of motorcycle riders and the resource restraints (time and funding), it was not possible to conduct a single statewide survey that is representative of all riders in Victoria. However, in conjunction with the information provided by representatives of motorcycle groups and other stakeholders, the proposed methodology provides a balanced snapshot of the current knowledge and potential use of first aid as well as views on strategies to improve emergency response among Victorian motorcyclists.

2.4 Consultations with relevant stakeholders

At the onset of the project, initial consultations were undertaken with relevant organisations, including Ambulance Victoria, Emergency Services Telecommunications Authority and the Victorian State Trauma Service, mainly to identify current processes for providing emergency response and relevant data sources available regarding road trauma injuries and/or response times for providing professional medical/para-medical services to motorcyclists injured in crashes in Victoria.

A second and wider round of consultations was undertaken at a later stage of the project, after the literature review, the analysis of population-based databases and the interview of motorcycle riders. Using semi-structured interviews, a number of representatives from emergency organisations and motorcycle riders groups were approached to discuss factors that influence crash outcomes in motorcyclists, suggestions on how to improve emergency response and to gain insights into the feasibility of these strategies in Victoria. Organisations interviewed during this phase include:

- Emergency services: Ambulance Victoria, Alfred Hospital Trauma Centre, Emergency Services Telecommunications Authority, the Metropolitan Fire Brigade, Melbourne and the Accident Scene Management Australia Ltd

- Motorcycle community: Australian Government Motorcycle Safety Consultative Committee, Australian Motorcycle Council, Motorcycle Riders Association (Victoria), Victorian Motorcycle Council (VMC), Honda Australia Motorcycles & Power Equipment, VicRoads Motorcycle Advisory Group (MAG) and the Independent Riders' Group

- Other groups including the Yarra Ranges Shire Council.

3. RESULTS

3.1 Population-based databases

I. Police reported motorcycle crashes

Between 2001 and 2010, 19,418 on-road crashes involving motorcyclists were reported to the Victorian police. These crashes resulted in 21,427 casualties, including 19,427 motorcycle riders, 941 pillion passengers and 1059 other road users. This analysis describes the characteristics of motorcycle crashes as well as some individual characteristics of casualties involved in these crashes, particularly motorcycle riders and pillion passengers.

<u>Characteristics of on-road motorcycle crashes</u>

Temporal characteristics of motorcycle crashes

More than half of motorcycle crashes (55.3%) occurred during the warmer months (October to March), with February the month with the lowest proportion of crashes during this period. Overall, March was the month with the highest proportion of crashes (10.1%) and July the month with the lowest (6.5%).

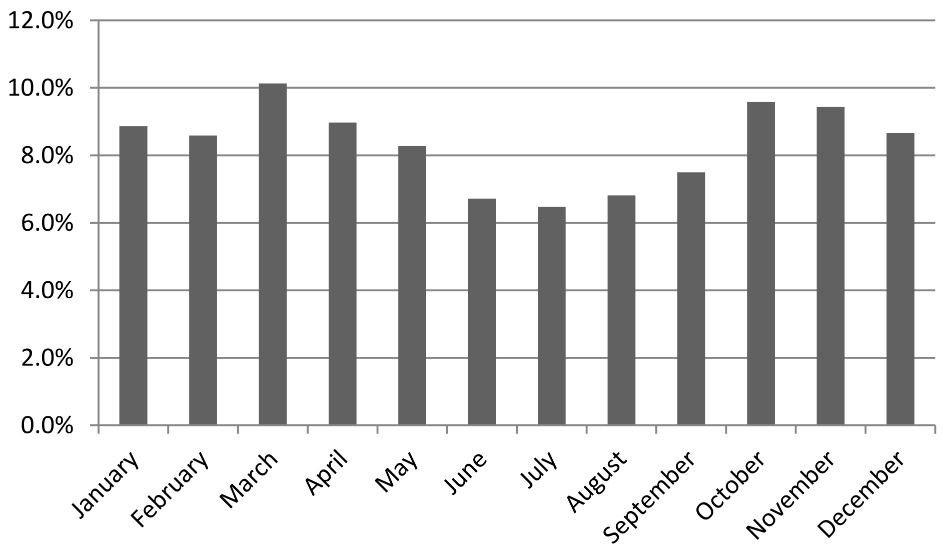


Figure 1: Motorcycle crashes by month, Victoria 2001-2010

Nearly 40% of motorcycle crashes occurred on weekends. The highest proportion of crashes occurred on Sundays (20%) followed by Saturdays (19.2%). The lowest proportion of crashes occurred on Mondays (11.3%).

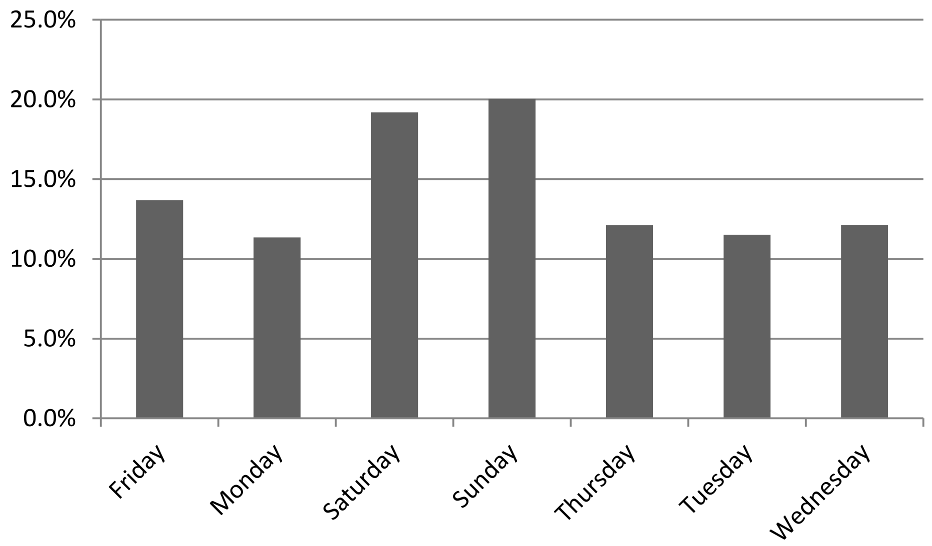


Figure 2: Motorcycle crashes by day of the week, Victoria 2001-2010

The occurrence of motorcycle crashes increased throughout the day to reach its peak at 4 pm before decreasing during evening and night time. Overall, motorcycle crashes were more likely to occur during afternoon peak hours between 3 pm and 6 pm (35%).

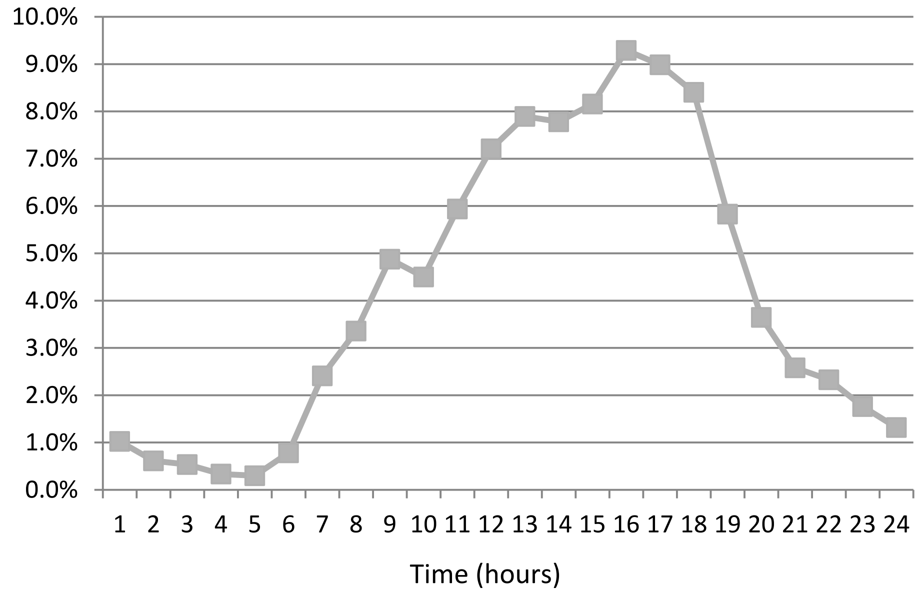


Figure 3: Motorcycle crashes by time (hours), Victoria 2001-2010

While the proportion of motorcycle crashes occurring between 2 pm and 6 pm was similar during the week and on weekends, those that occurred between 10 am to 2 pm were more frequent on weekends. Crashes that occurred between 6am and10 am, and 6 pm and 10 pm were more frequent during weekdays.

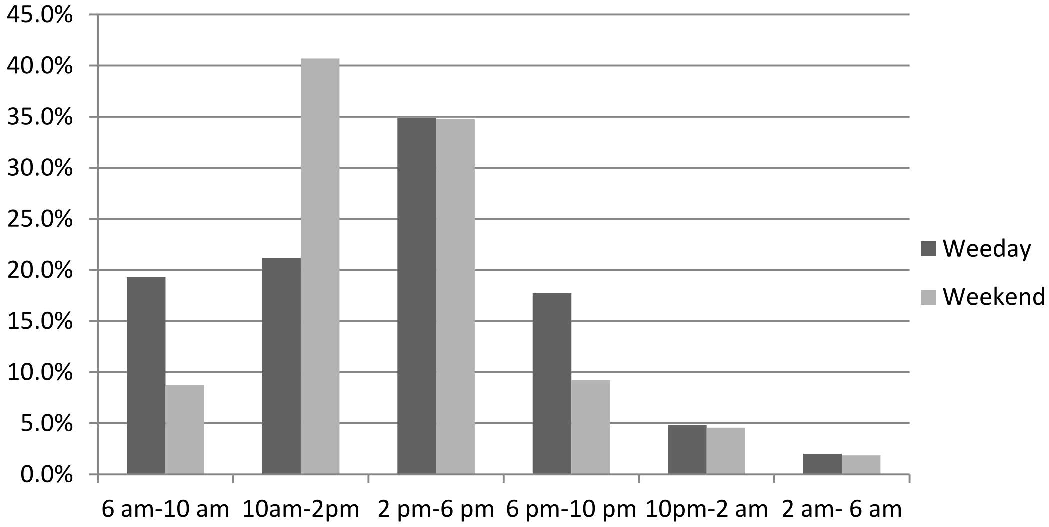


Figure 4: Motorcycle crashes time by weekday, Victoria 2001-2010

Motorcycle crashes - location and road characteristics

More than 60% of motorcycle crashes occurred in urban areas with the rest occurring in rural areas. About a third of motorcycle crashes (33.7%) occurred on roads with speed limits of 60 km/h with nearly another third (31.8%) occurring on roads with speed limits of 100 km/h and over. Another 17.6% of crashes occurred on roads with speed limits between 40 and 50 km/h and 16.9% on roads with speed limits between 70 and 90 km/h.

Just under 40% of motorcycle crashes occurred at intersections. T-intersection and cross intersection were the most common intersection types where these crashes occurred. The majority of crashes (81%) occurred on sealed road.

Table 1: Motorcycle crashes - location and road characteristics

	Frequency (%)
Road location	
Country	7290 (37.5)
Urban - inner suburbs	6442 (33.2)
Urban - outer suburbs	5684 (29.3)
Unknown	2 (0.0)
Road type	
Sealed	15724 (81.0)
Unsealed	3398 (17.5)
unknown	296 (1.5)
Speed zone	
40-50	3415 (17.6)
60	6548 (33.7)
70-90	3287 (16.9)
100+	6166 (31.8)
Unknown	2 (0.0)
Intersection	
Cross intersection	3118 (16.1)
T-intersection	4178 (21.5)
Y-intersection	65 (0.3)
Multiple intersections	324 (1.7)
Not at intersection	11690 (60.2)
Unknown	43 (0.2)
Total	19418 (100)

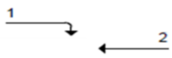
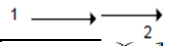
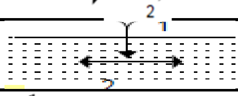
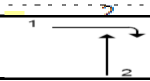
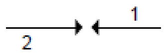
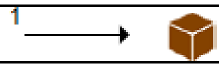
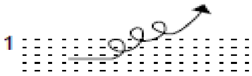
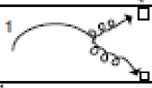
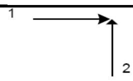
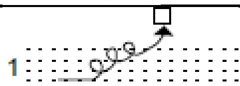
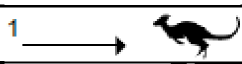
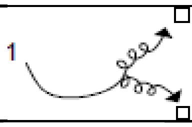
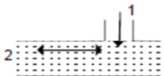
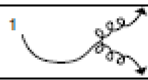
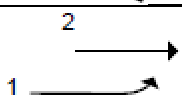
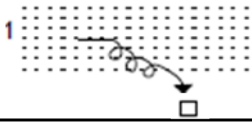
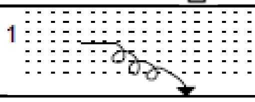
Melbourne city was the LGA where the highest number of motorcycle crashes occurred between 2001 and 2010 followed by the Yarra Ranges Shire, located in the outer eastern and North-eastern suburbs of Melbourne, Baw Baw, about 100 km east of Melbourne and Murrindindi located along the valley of the Murrundindi River north east of Melbourne.

Table 2: Top 20 LGAs where motorcycle crashes occurred in Victoria, 2001-2010

LGA	Frequency (%)
MELBOURNE	1282 (6.6)
YARRA RANGES	1022 (5.3)
BAW BAW	572 (3.0)
MURRINDINDI	550 (2.8)
BOROONDARA	527 (2.7)
CASEY	527 (2.7)
MORELAND	510 (2.6)
YARRA	496 (2.6)
STONNINGTON	449 (2.3)
DANDENONG	444 (2.3)
PORT PHILLIP	442 (2.3)
GEELONG	439 (2.3)
BRIMBANK	426 (2.3)
HUME	424 (2.3)
MONASH	403 (2.1)
KNOX	398 (2.1)
DAREBIN	386 (2.0)
CARDINIA	385 (2.0)
MORNINGTON PENINSULA	382 (2.0)
EAST GIPPSLAND	343 (1.8)
Other locations	9011 (46.4)
Total	19418 (100.0)

An examination of motorcycle crash types according to definitions for classifying crashes (DCAs) (Table 3) shows that the most common crash types were when riders lose control of the motorcycle on the road (just over one in five crashes) followed by "right through" crashes (7.6%), where a vehicle approaching from the opposite direction turns right in front of another vehicle, and rear end crashes (5.1%). Emerging from footpaths was another common crash type (5.0%) followed by head on collisions. Overall, nearly half (49.6%) of motorcycle crashes that occurred in Victoria between 2001 and 2011 were single vehicle crashes involving only the motorcycle.

Table 3: Common types of motorcycle crashes according to road user movements Victoria 2001-2010.

Road user movements		Frequency (%)
Out of control on road		4013 (20.7)
Right through		1482 (7.6)
Rear end		992 (5.1)
Emerging from footway		978 (5.0)
Right near		744 (3.8)
Head on		688 (3.5)
Struck object on the road		663 (3.4)
Off carriageway to the left		648 (3.3)
Off carriageway right bend		644 (3.3)
U turn		642 (3.3)
Off right bend into object/parked vehicle		632 (3.3)
Cross traffic (intersection)		626 (3.2)
Left off carriageway into object/parked vehicle		515 (2.7)
Animal (not ridden)		477 (2.5)
Off left bend into object/parked vehicle		466 (2.4)
Emerging from driveway		420 (2.2)
Off carriageway left bend		392 (2.0)
Lane change left		345 (1.8)
Right off carriageway into object/parked vehicle		337 (1.7)
Off carriageway to right		283 (1.5)
Other		3431 (17.7)
Total		19418 (100)

Characteristics of motorcycle crash casualties reported to police in Victoria

The 19418 motorcycle crashes that occurred in Victoria between 2001 and 2010 resulted in 21427 casualties including 479 deaths (2.2%), 9556 serious injury (44.6%) and 11392 (53.2%) other injuries (Table 1). Just over 90% of casualties of motorcycle crashes were motorcycle riders (19427 cases) and another 4% were pillion passengers (941 cases). Motorcyclist riders and pillion passengers were more likely to be seriously injured or die as a result of a crash than other involved road users. For the purpose of this report, the remaining results will only focus on the 20368 motorcyclist riders and pillion passenger casualties.

Table 4: The number of motorcycle crash casualties, by severity of injury and road user type Victoria 2001-2010.

	Deaths n (%)	Serious injury n (%)	Other injury n (%)	Total
Pedestrian	6 (2.2)	111(41.4)	151 (56.3)	268
Driver	3 (0.6)	114 (22.2)	397 (77.2)	514
Passenger	2(1.0)	38 (18.4)	167 (80.7)	207
Motorcyclist	452(2.3)	8834 (45.5)	10141 (52.2)	19427
Pillion Passenger	14 (1.5)	429 (45.6)	498 (52.9)	941
Bicyclist (incl. passengers)	2 (3.0)	29 (43.3)	36 (53.7)	67
Not known	0 (0.0)	1 (33.3)	2 (66.7)	3
Total	479(2.2)	9556 (44.6)	11392 (53.2)	21427

The vast majority of motorcycle casualties were males (88%), 11% were females with the gender not reported in 1% of cases.

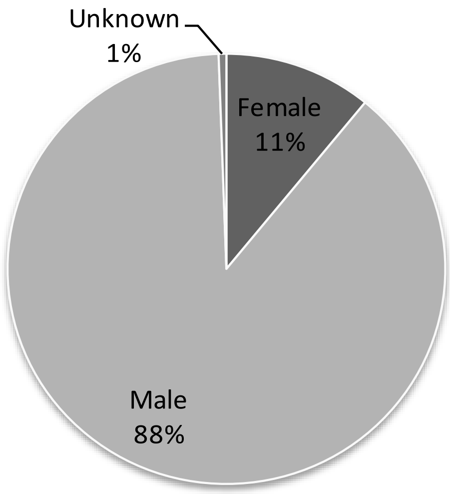


Figure 5: Gender of motorcycle crash casualties, Victoria 2001-2010

Those aged 26-39 years represented 40% of motorcyclists involved in police reported crashes in Victoria, with nearly a third aged 40-59 years and a just over a quarter aged 18-25 years.

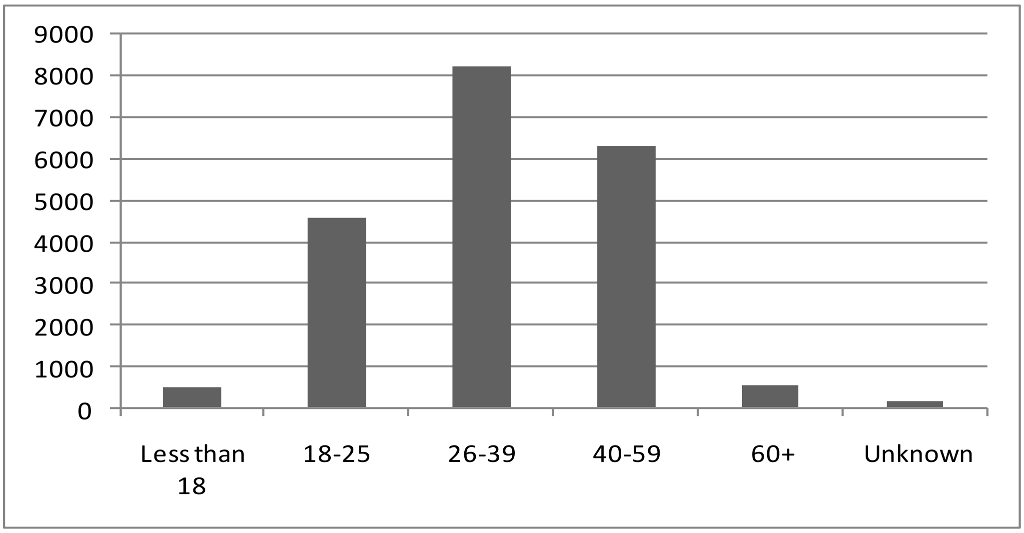


Figure 6: Age distribution of motorcycle crash casualties, Victoria 2001-2010

Overall, 3.1% of motorcyclist casualties were reported not to have worn a helmet at the time of the crash. Generally this proportion decreased with age with those aged less than 18 years having the highest proportion of non helmet use (23%) and those aged 60 years and older the lowest (1.6 %). Helmet use status was unknown in 27% of cases.

Table 5: Helmet wearing status among motorcycle crash casualties by age, Victoria 2001-2010.

Age in years	Helmet worn	Helmet not worn	Unknown	Total
	n (%)	**n (%)**	**n (%)**	
Less than 18	248 (49.1)	116 (23)	141 (27.9)	505
18-25	3131 (68.2)	220 (4.8)	1241 (27)	4592
26-39	5787 (70.5)	185 (2.3)	2240 (27.3)	8212
40-59	4522 (71.5)	101 (1.6)	1703 (26.9)	6326
60+	417 (73.4)	9 (1.6)	142 (25)	568
Unknown	109 (66.1)	7 (4.2)	49 (29.7)	165
Total	14214 (69.8)	638 (3.1)	5516 (27.1)	20368

Helmet wearing status also varied according to road user type with 2.9% of motorcycle riders reported not to have worn a helmet at the time of the crash compared to 8.1% of pillion passengers.

Table 6: Helmet wearing status among motorcycle crash casualties by road user type, Victoria 2001-2010.

Road user	Helmet worn	Helmet not worn	Unknown	Total
	n (%)	n (%)	n (%)	
Motorcycle rider	13611(70.1)	562 (2.9)	5254 (27.0)	19427
Pillion Passenger	603 (64.1)	76 (8.1)	262 (27.8)	941
Total	14214 (69.8)	638 (3.1)	5516 (27.1)	20368

While nearly 90% of motorcyclist casualties had an appropriate licence at the time of the crash, about 2.6% were unlicensed or had an inappropriate licence. Status was unknown for 7.6% of riders.

Table 7: Licence status of motorcycle riders involved in crashes in Victoria, 2001-2010.

License status	n (%)
Learner	2717 (14.0)
Probationary	828 (4.3)
Prob & cond	64 (0.3)
Standard	13590 (70.0)
Stand & cond	213 (1.1)
Inappropriate	54 (0.3)
Unlicensed	449 (2.3)
Not applicable	34 (0.2)
Unknown	1478 (7.6)
Total	19427 (100)

II. Victorian Emergency Minimum Dataset (VEMD)

Demographic profile of cases

From July 2005 to June 2010, there were 20,357 motorcycle-related emergency department (ED) presentations that were not subsequently admitted to a Victorian hospital. The number of cases presenting to ED increased from 3719 in the 2005-06 financial year peaking at 4414 in the 2006-07 financial year and then decreasing again to 3753 in the 2009-10 financial year. Figure 7 shows the frequency of motorcycle-related emergency presentations occurring in Victoria for each of the 5 financial years.

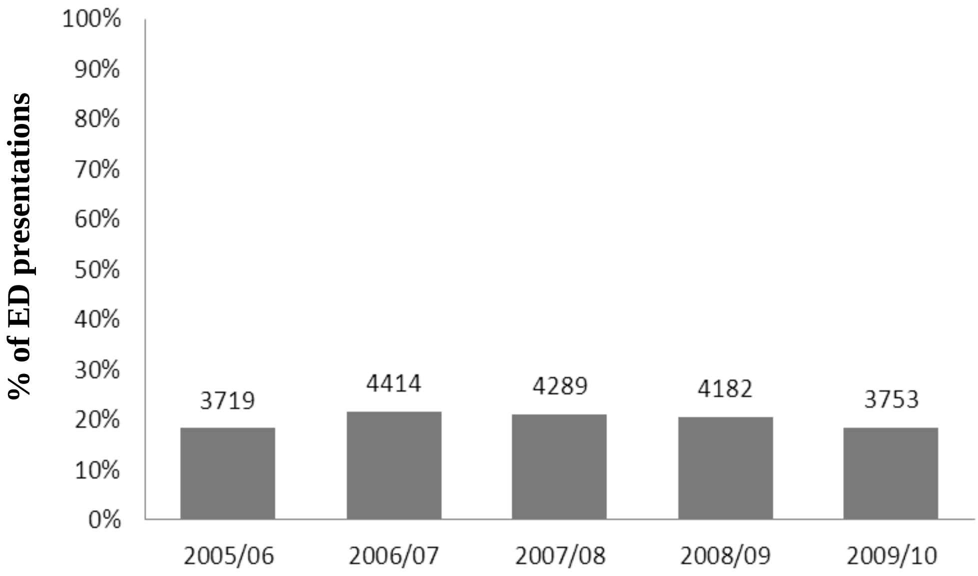


Figure 7: Overall incidence of motorcycle-involved Emergency Department presentations (non-admitted) by financial year (n=20,357 cases)

The estimated age and sex standardised rates of motorcycle-involved non-admitted emergency presentations per 100,000 population in Victoria were calculated (Table 8). Males were represented nearly four times more than females in all age categories. People aged 15-24 years tended to be the most represented age group for both genders. Males aged 25-34 were also highly represented. Admissions tended to peak in 2006-07 and 2007-08 returning to initial or lower rates by 2009-10.

Table 8: Age and sex standardised rates of non-admitted motorcycle-involved ED presentations (per 100,000 population)

Gender	Age group	Financial Year				
Males		2005-06	2006-07	2007-08	2008-09	2009-10
	0-14 years	84.8	109.6	92.4	90.9	80.4
	15-24 years	305.6	352.4	332.6	321.9	278.3
	25-34 years	223.5	237.2	231.2	202.9	170.0
	35-54 years	103.5	122.8	122.9	118.1	113.8
	55 plus years	17.1	19.7	20.1	18.8	19.0
Females						
	0-14 years	23.6	28.2	22.7	18.1	20.4
	15-24 years	42.1	53.1	54.0	49.2	41.7
	25-34 years	26.2	34.6	28.8	29.6	22.8
	35-54 years	16.0	16.6	17.8	20.3	17.2
	55 plus years	5.3	7.3	6.3	6.7	4.0

Table 9 shows the demographic profile of the non-admitted cases presenting to ED. Motorcycle riders presenting to ED in Victoria tended to be predominantly young (34.7% in the 15-24 year old age group) and male (86.0%) who reside in Metropolitan Melbourne areas (45.4%). Of those residing in regional areas, the majority were from the Gippsland (8.9%) and Goulburn (6.7%) statistical divisions.

Table 9: Demographic characteristics of motorcycle-involved ED presentations (n=20,357)

Descriptor		n (%)
Age Group	0-14 years	2,886 (14.2)
	15-24 years	7,060 (34.7)
	25-34 years	4,624 (22.7)
	35-54 years	5,003 (24.6)
	55 plus years	784 (3.9)
Sex	n (%) Male	17,512 (86.0)
Region of residence	Metropolitan Melbourne	9247 (45.4)
	Regional Victoria	
	Gippsland	1,802 (8.9)
	Goulburn	1,360 (6.7)
	Mallee	1,154 (5.7)
	Central Highlands	959 (4.7)
	Ovens_Murray	894 (4.4)
	East Gippsland	888 (4.4)
	Western District	699 (3.4)
	Barwon	637 (3.1)
	Loddon	495 (2.4)
	Wimmera	347 (1.7)
	Interstate or overseas	683 (3.4)
	Unknown	1192 (5.9)

Medicare was the fund source for 14,299 (70.2%) cases, while the Transport Accident Commission (TAC) covered 5754 (28.3%) cases. The remaining cases were covered by WorkCover (n=190, 0.2%), another compensable body (n=53, 0.3%), the Department of Veterans Affairs (n=6, 0.03%) or were ineligible for compensation (n=41, 0.2%). For 14 (0.1%) cases, the fund source for the admission was not known.

Injury Event

Ninety per cent of ED presentations involved a motorcycle driver (n=18,249) and 2,108 (10.4%) were passengers. There were only 10 events (0.05%) that were classified as involving intentional self-harm with 97 per cent (n=19,691) classified as unintentional, and 3.2 per cent (n=656) classified as other type of intent. As the time of the crash was not available within this dataset, the reported time of the emergency presentation are provided (Figure 8). Almost half of the presentations (n=9,529, 46.8%) occurred on a weekend, and the majority of cases presented in the afternoon.

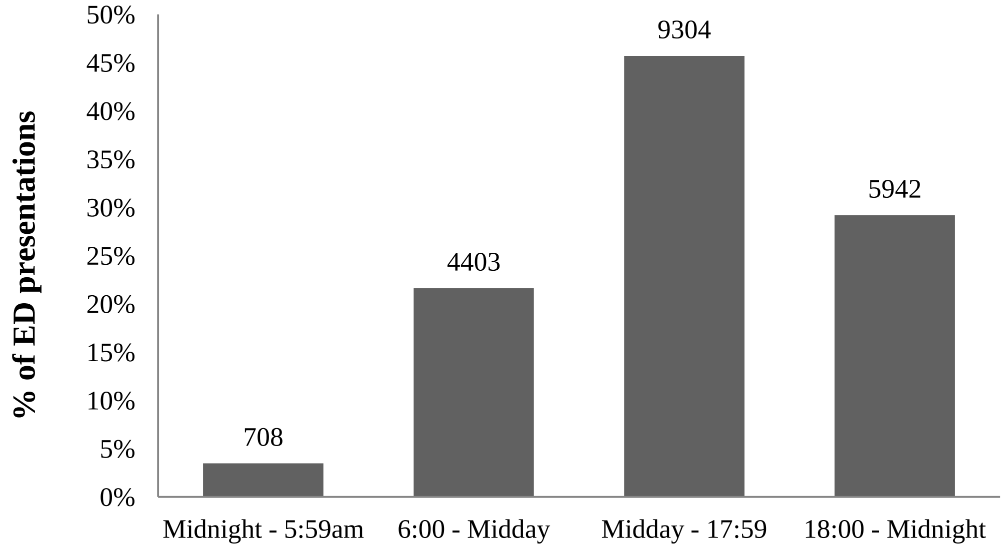


Figure 8: Time of motorcycle-involved emergency presentations (non-admitted) (n=20,357)

Pre-hospital transport and transfers

The type of place where the injury occurred was known for 16,663 (81.8%) cases and the distribution of these is shown in Figure 9. There were 41 per cent of cases that occurred on a confirmed road, street or highway. Forty-one per cent of cases occurred in a place other than a road, including a place for recreation (15.1%), at the person's home (11.3%), on a farm (10.1%) or in an athletic or sports area (4.2%). Codes for place of injury are entered by clinical coders at each hospital based on ICD-10AM coding classifications, so it was not possible to obtain additional details about cases coded as "other."

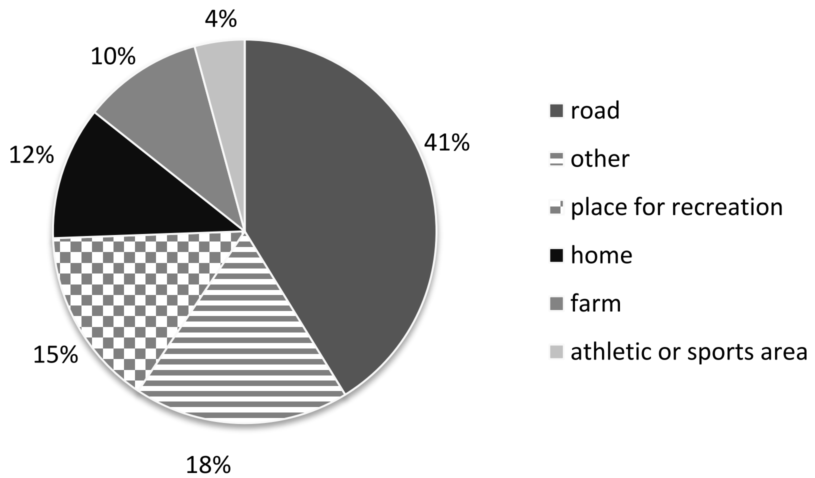


Figure 9: Place of injury for motorcycle-involved ED presentations (non-admitted) (n=20,357)

Emergency department arrival

Approximately 81 per cent of cases (n=16,405) were transported to hospital by a private car or other form of transport, while the remaining cases arrived at hospital by road ambulance (n=3,930, 19.3%) or air ambulance (n=22, 0.1%). Figure 10 displays the level of trauma service to which cases were transported. The majority of these (n=7,090, 35%) arrived at a regional trauma service (RTS, e.g. Geelong Hospital) or other trauma service, such as a community or district health service (n=6571, 32%), with 5,244, (26%) arriving at a metropolitan trauma service (MeTS, e.g. St Vincent's Hospital), and 1,452 (7%) at a major trauma service (MTS, e.g. the Alfred Hospital) across the five years. The majority of patients were triaged to category 4 (n=10,258, 50.4%) indicating a semi-urgent emergency where the patient should be seen within an hour, or category 3 (n=5,987, 29.4%) indicating an urgent situation where the patient should be seen within 30 minutes. There were 84 patients (0.4%) triaged to category 1, signalling a need for resuscitation.

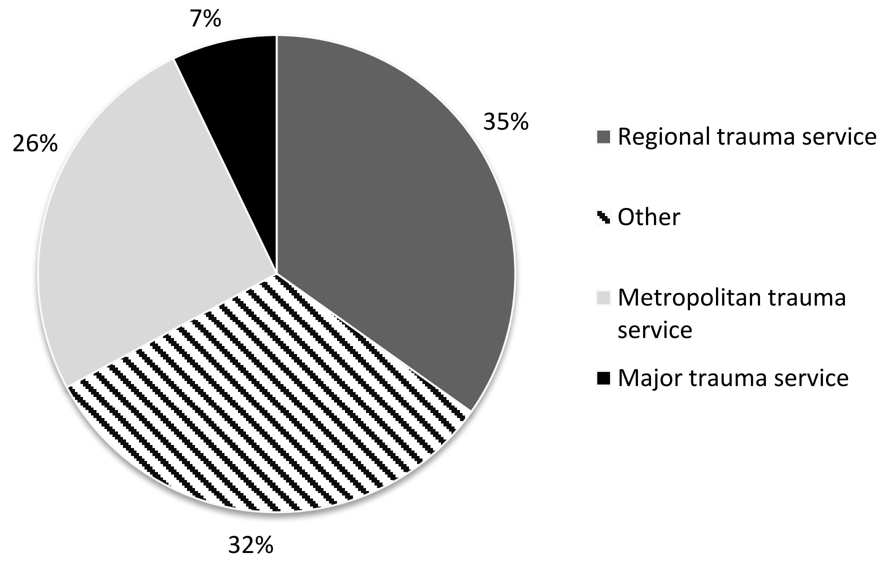


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Figure 10: Level of trauma service for ED presentations (n=20,357)

Injuries sustained

Figure 11 presents the broad nature of injuries for cases presented to emergency departments. As this cohort of patients represents non-admitted patients, they experienced less severe injuries with the majority presenting with sprains, strains and muscular injuries (n=6679, 33%), fractures (n=5,280, 26%) and superficial wounds and burns (n=4783, 23%). A smaller proportion suffered from multiple injuries (n=993, 5%), and intracranial and internal organ injuries (n=343, 2%), with the rest classified as having other types of injuries (n=2279, 11%). The body region to which injuries were sustained is presented in Figure 11. These are classified broadly by the Abbreviated Injury Scale (AIS) regions.

Table 10: Prevalence of injuries to AIS body regions for motorcycle-related ED presentations

AIS body region	n (%)
Upper extremity	7,796 (38.3)
Lower extremity	6,283 (30.9)
Multiple regions	2,335 (11.5)
Thorax	1,013 (5.0)
Abdominal or pelvic contents	703 (3.5)
Neck	648 (3.2)
Other	610 (3.0)
Head	526 (2.6)
Face	443 (2.2)
Total	20,357 (100)

The AIS body regions by the three most common types of injuries (82% of all injuries) are presented in Figure 11. The most common type of injury sustained was an upper extremity fracture. These most commonly involved shoulder fractures (n=1,296), shoulder sprains, strains and muscular injuries (n=1,124), and wrist fractures (n=971). The most common lower extremity injuries were knee sprains, strains and muscular injuries (n=1,064), ankle sprains, strains and muscular injuries (n=833), and superficial wounds and burns to the knee (n=702) and lower leg (n=626). The majority of injuries to the head involved superficial wounds and burns (n=243) with only 80 patients cases sustaining intracranial injuries.

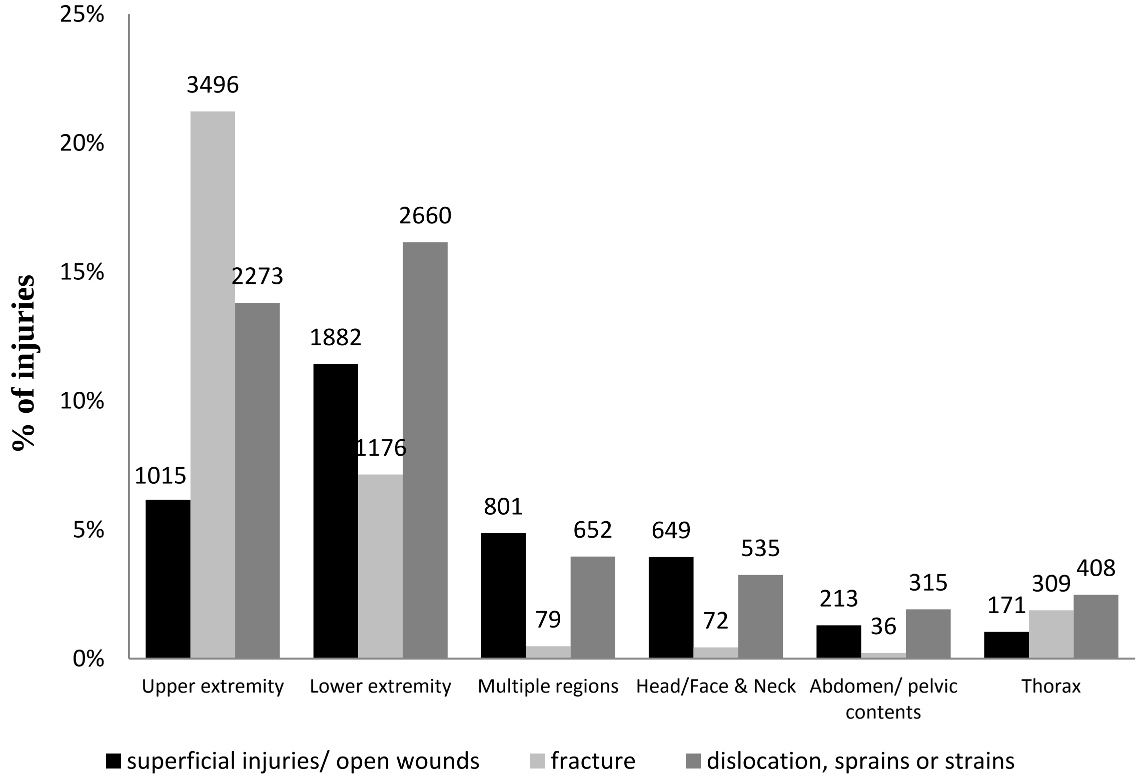

Figure 11: Injuries by AIS body region and nature of injury (n=16,742)

Patient outcomes

Nine patients (0.04%) died within the emergency department. Approximately 99% of cases (n=20,129) were discharged directly home from the ED with 211 (1.0%) leaving at their own risk after treatment was started. Five cases (0.02%) were discharged to a correctional or custodial facility and three (0.01%) were discharged to a residential care facility. The median (IQR) length of stay in the emergency department was 153 (98-226) minutes. Patients presenting to the ED and subsequently admitted to hospital are included in the VAED section of this report.

III. Victorian Admitted Episode Dataset (VAED)

Demographic profile of cases

From July 2005 to June 2010, there were 9,012 motorcycle-related emergency hospital admissions to a Victorian hospital where the patient's stay was overnight or longer, or a death occurred. Cases were excluded if they were same-day admissions (n=3493, 26.5%). To avoid double-counting the same incident, cases were also excluded if they were transferred in from another hospital (n=673, 6.9%). The number of cases in each financial year was relatively consistent, reaching a small peak of 1,981 in the 2007-08 financial year and then decreasing again to 1,715 cases in the 2009-10 financial year. Figure 12 shows the frequency of motorcycle-related hospital admissions occurring in Victoria for each of the five financial years.

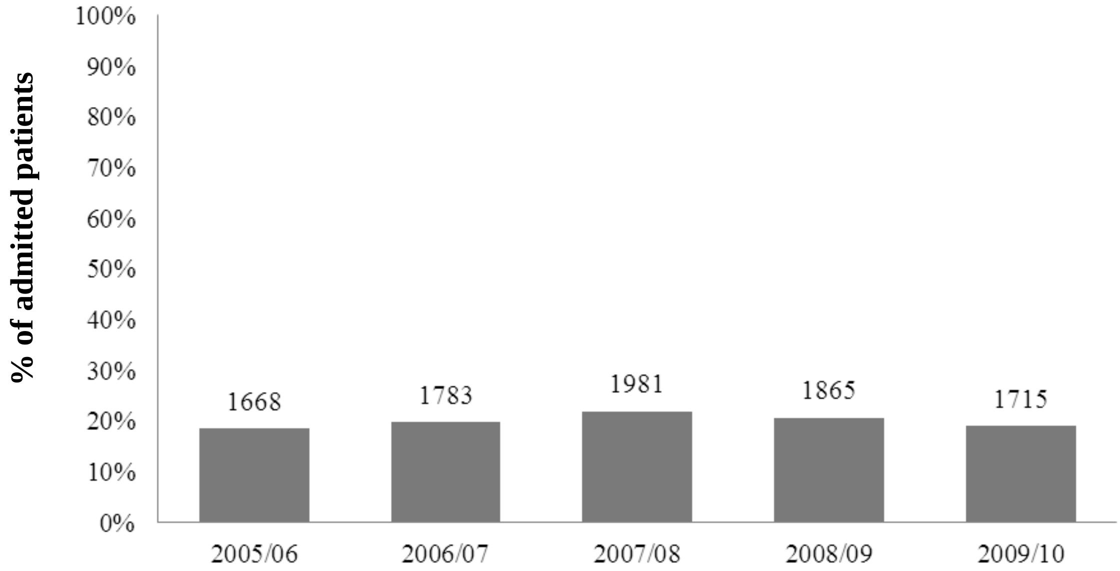

Figure 12: Motorcycle-involved hospital admissions by financial year (n=9,012 cases)

The majority of cases were aged 15-34 years and tended to be relatively healthy (97% had no comorbidities documented). Approximately 70 per cent were Australian born and 0.3 per cent were identified as Indigenous/Torres Strait Islander. These figures are reasonably consistent with the population of Victoria. According to Australian Bureau of Statistics 2006 census data, 74 per cent of Victoria's total population and 69 per cent of Melbourne's population was Australian-born and 0.6 per cent of Victoria's population is estimated to be of Indigenous origin. Hospital administrative data is known to under-capture indigenous status (Draper et al 2009), which may explain the under-representation of indigenous Australians in our motorcycle-involved cohort of hospital admissions.

Table 11: Demographic characteristics of motorcycle-involved hospital admissions (n=9,012)

Descriptor		n (%)
Age Group	0-14 years	980 (10.9)
	15-24 years	2579 (28.6)
	25-34 years	1953 (21.7)
	35-54 years	2871 (31.9)
	55 plus years	629 (7.0)
Sex	Male	8197 (91.0)
Marital Status	Married	2033 (22.6)
Comorbid status*	No documented comorbidity	8775 (97.4)
	CCI=1	217 (2.4)
	CCI>1	20 (0.2)
Ethnicity	Born in an English-speaking country	6550 (72.7)
	Australian born	6267 (69.5)
	Indigenous/Torres Strait Islander	27 (0.3)

* The Charlson comorbidity index was used to identify comorbidities. It relies on the presence or absence of seventeen co-morbid conditions and has been applied broadly to predict mortality outcomes in hospitalised patient populations. These co-morbidities have been extrapolated from ICD-10-AM codes.

The estimated age and sex standardised rates of motorcycle-involved hospital admissions per 100,000 population in Victoria are reported in Table 12. Males are represented more than females in all age categories. People aged 15-24 years tended to be the most represented age group for both genders. Males aged 25-34 years were also highly represented. Admissions tended to peak in 2007-08 for most age and sex categories, consistent with Figure 12. As data collection methods for the VAED and admission practices were unlikely to change in this timeframe, the small rise in incidence is likely to be due to other causes.

Table 12: Age and sex standardised rates motorcycle-involved hospital admissions (per 100,000 population)

Gender	Age Group	Financial Year				
Males		2005-06	2006-07	2007-08	2008-09	2009-10
	0-14 years	34.8	41.1	39.2	32.7	25.5
	15-24 years	128.3	141.5	154.5	143.8	126.9
	25-34 years	105.7	98.3	109.7	106.3	79.7
	35-54 years	68.2	70.9	80.0	74.8	78.1
	55 plus years	17.4	20.7	21.5	22.0	21.0
Females						
	0-14 years	4.9	3.4	6.2	5.5	6.1
	15-24 years	10.0	11.3	14.1	12.1	10.1
	25-34 years	7.9	6.5	9.8	7.3	7.6
	35-54 years	5.7	8.1	8.3	7.8	8.4
	55 plus years	2.6	3.2	2.6	2.7	2.5

Injury Event

Details of the injury event are recorded in Table 13. The most common place of injury for admitted injured motorcyclists was on a road, street or highway (42.9% of cases), closely followed by other specified place (42.2% of cases). Codes for place of injury are entered by clinical coders at each hospital based on ICD-10AM coding classifications. While the medical record may specify the place of injury, the clinical coder will code to "other specified place" where the documented place of injury is inconsistent with the more specific ICD-10 Chapter XX (20) codes, precluding the extraction of further detail from the VAED.

Table 13: Injury event details of VAED motorcycle-related trauma (n=9,012)

Descriptor		n (%)
Place of occurrence	Road, street or highway	3868 (42.9)
	Athletic or sports area	717 (8.0)
	Farm	436 (4.8)
	Place for recreation	191 (2.1)
	Other specified place	3800 (42.2)
Cause of injury	Motorcycle rider	9,060 (98.1)
	Pillion passenger	95 (1.0)
	Unspecified	78 (0.8)

Injuries sustained

As the VAED can record up to 40 diagnostic codes for each patient, there were a total of 28,291 ICD-10-AM coded injuries recorded for motorcycle-related patients in the data. The median (IQR) number of injuries per patient was 2 (1-5) injuries. Table 14 presents the distribution of injury by AIS body region for both the primary injury, defined as the first-coded injury, and all recorded injuries to motorcycle riders in the dataset. Lower extremity injuries were predominant in the admitted patient group, in contrast to patients presenting to an ED but not admitted where upper extremity injuries were predominant. The majority (61.3%) of primary injuries were fractures, while a greater number of superficial and open wounds were recorded across all injuries (27.6% vs 12.4% for primary injuries).

Table 14: Prevalence of injury to AIS body region for motorcycle related hospital admissions

AIS body region	Primary injury	All injuries*
	n (%)	n (%)
Lower extremity	3,254 (36.1)	8,603 (30.4)
Upper extremity	2,591 (28.8)	7,536 (26.6)
Head	1,070 (11.9)	4,405 (15.6)
Thorax	915 (10.2)	3,697 (13.1)
Abdominal or pelvic contents	845 (9.4)	3,152 (11.1)
Neck	249 (2.8)	785 (2.7)
Other	88 (1.0)	113 (0.4)
Total	9,012 (100)	28,291 (100)

*** N.B. Number of injuries exceeds the number of admissions as multiple injuries can be sustained by a single patient**

Figure 13 presents the injuries separated into the most common AIS body regions and injury types, accounting for 77% of all injuries. The majority of injuries involved fractures to upper and lower extremities. The most common of these were fractures (n=2168, 7.7%) and superficial injuries or open wounds to the knee (n=2031, 7.2%) , fractures (n=863, 3.1%) to the foot and ankle, and superficial injuries to the thigh (n=660, 2.3%). Shoulder fractures accounted for 8 per cent (n=1575) of all injuries, elbow fractures accounted for 6 per cent (n=1566) and superficial injuries and open wounds to the shoulder accounted for 2 per cent (n=569) of all injuries. Crushing injuries were most common to the thorax (n=1131, 4% of all injuries) and the abdomen and pelvic contents (n=230, 1% of all injuries). Approximately seven per cent of all injuries (n=1,981) were intracranial injuries, or injuries involving the eye.

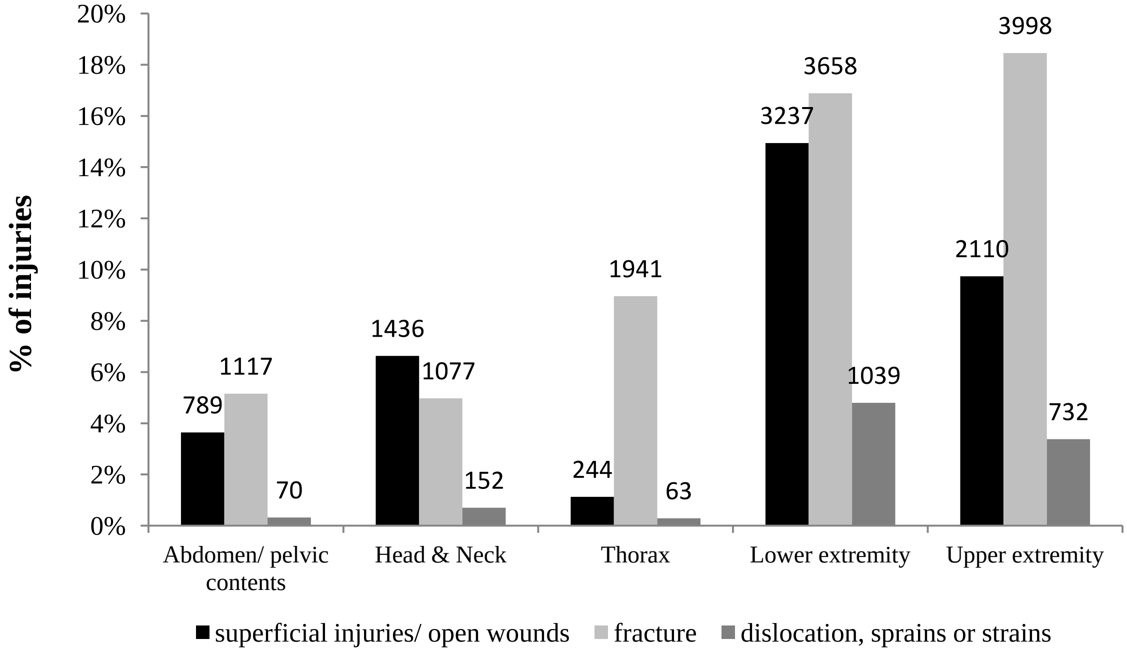

Figure 13: Injuries by most common AIS body region and nature of injury (n=21,663, 77% of all injuries for admitted patients)

Admission Characteristics

The hospital's ED was the most common source of admission for patients (92.8%), while 7.2 per cent of patients were classified as "other" emergency admissions. The time of admission is shown in Figure 14. The majority of admissions occurred in the afternoon (34.3%) or the evening (34.0%), and only 4.0% (n=329) of cases were admitted between midnight and 6am. Medicare was the fund source for 4,378 (48.6%) cases, while the TAC covered 4,047 (44.9%) cases. The remaining admissions were funded by WorkCover (n=115, 1.3%), another compensable body (n=443, 4.9%), the Department of Veterans Affairs (n=17, 0.2%) or were ineligible for compensation (n=12, 0.1%).

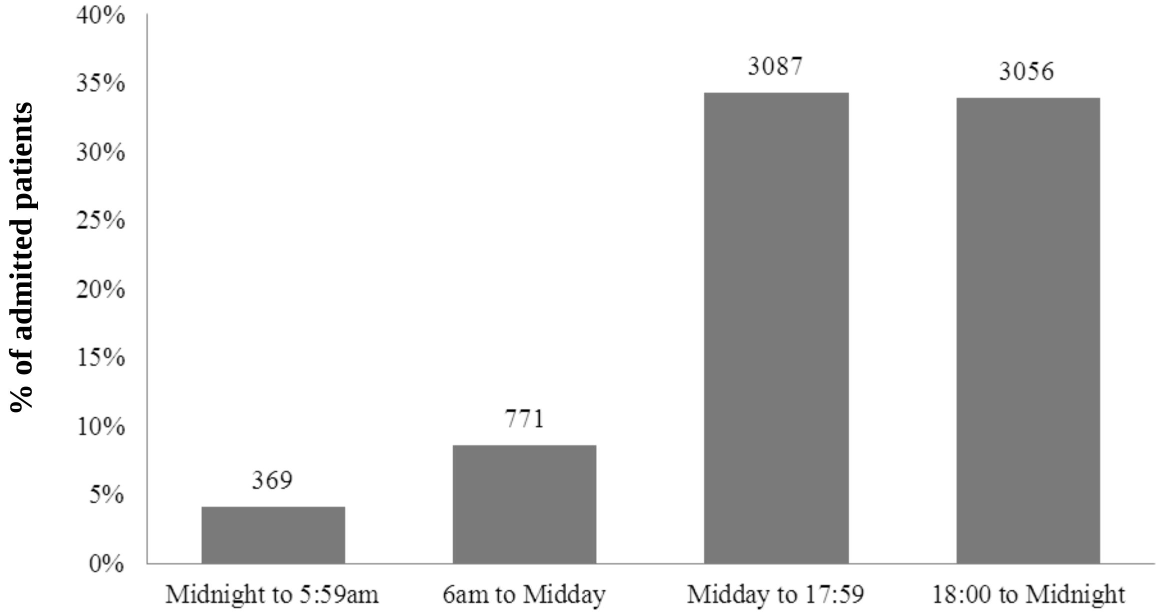

Figure 14: Time of motorcycle-involved hospital admissions (n=7,283 patients with known admission times)

The majority of motorcycle-involved patients were admitted to teaching (34.9%) and rural hospitals (33.7%) with 30 per cent admitted to metropolitan hospitals and 2 per cent admitted to private hospitals (Table 15). Seven per cent of patients had an intensive care admission, and 4 per cent received mechanical ventilation. The median hospital stay was 2 days (Table 15).

Table 15: Admission and discharge characteristics of motorcycle-related hospital admissions (n=9,012)

Descriptor		n (%)
Hospital Type	Teaching	3149 (34.9)
	Rural	3035 (33.7)
	Metro	2678 (29.7)
	Private	150 (2.1)
ICU admission	Yes	606 (6.7)
Mechanical Ventilation	Yes	331 (3.7)
Hospital length of stay	Median (IQR) days	2 days (1-5 days)
Discharge destination	Home	7512 (83.4)
	Residential Facility	8 (0.1)
	Transfer to another acute care hospital	1338 (14.8)
	In-hospital death	26 (0.3)
	Other	128 (1.4)

Outcomes of admitted patients

There were 26 (0.3%) in-hospital deaths. The majority of patients (83.4%) were discharged directly home (Table 9). Approximately 15 per cent of patients were transferred to another acute care centre (14.8%) or a residentail facility (0.1%).

IV. National Coroners Information System (NCIS)

Demographic Profile

From July 2005 to June 2010, there were 239 motorcycle-related deaths investigated by a Victorian Coroner. The number of investigated deaths was relatively consistent over the 5-year period with a slight decline in 2008-09. Of these cases, 205 (85.8%) were currently "closed" and the remaining 34 cases were "open", limiting the information available for analysis. Age and gender were available for all cases. The median (IQR) age was 36 (26-44) years and the majority of cases were male (95.4%).

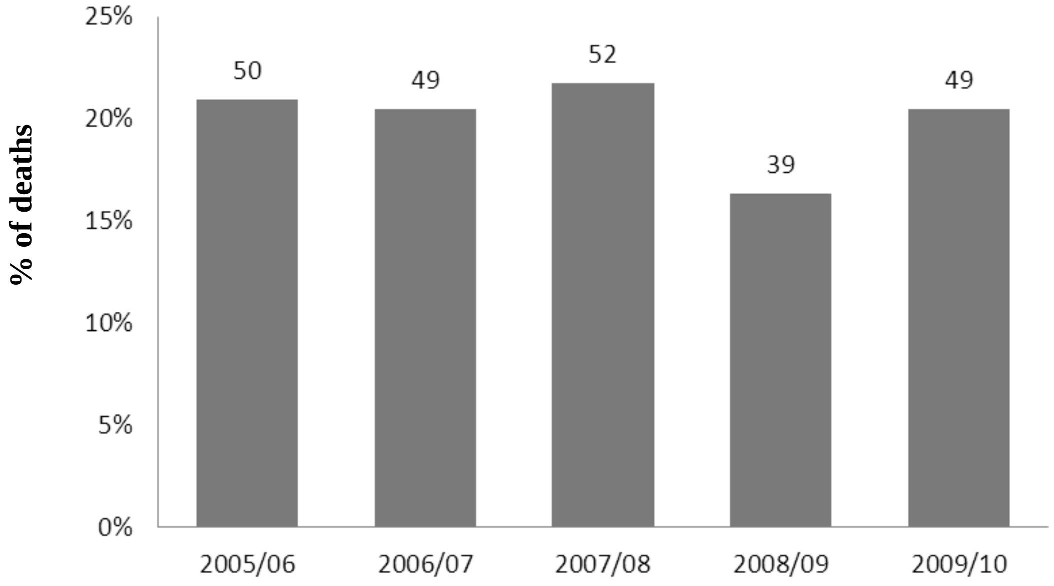

Figure 15: Motorcycle-related deaths in Victoria (July 2005-June 2010) (n=239 deaths investigated by a Coroner)

The demographic profile of motorcycle-related cases that were reported to a Coroner during the study period is shown in Table 16. Fatally injured motorcyclists in Victoria tended to be young (mean age of 36.3 years), male (95.4%), and from the Melbourne metropolitan area, with the majority residing in the Eastern Metropolitan area (18%). There were 12 (5%) cases involving interstate residents. There are likely to be discrepancies between the various data sources with respect to the number of deaths recorded. Each data source will collect a specific sub-set of deaths (e.g. admissions, deaths in the ED, on-road deaths, etc.). The NCIS should contain all motorcycle-related deaths over the study timeframe but some cases are still under investigation by a Coroner (and therefore the detail of the case is not yet available), not all cases may be investigated by a Coroner, the event cause may not be confirmed to ensure every motorcycle-related death is identified, and the NCIS includes both on-road and off-road crashes.

Table 16: Demographic characteristics of motorcycle-related deaths investigated by a Coroner (n=239)

Descriptor			n (%)
Age	Mean (SD) years		36.3 (12.7)
	Range (years)		3-74
Sex	Male		228 (95.4)
Region of residence	Metropolitan Melbourne		
		Eastern	43 (18.0)
		Northern	28 (11.7)
		Western	32 (13.4)
		Southern	12 (5.0)
	Regional Victoria	Eastern	43 (18.0)
		Northern	33 (13.8)
		Western	32 (13.4)
	Interstate		12 (5.0)

The majority of riders were motorcycle drivers (79.1%) with approximately 21 per cent riding as pillion passengers (Table 17). The majority of cases were also found to be unintentional deaths (Table 17). The remaining 1.6% of cases involved assault, self-harm or “legal intervention “ (e.g. pursuit by the police).

Table 17: Characteristics of motorcycle crashes investigated by a Coroner

Descriptor		n (%)
Mechanism	Motorcycle driver	189 (79.1)
	Motorcycle pillion rider	49 (20.5)
	Mini-bike rider	1 (0.4)
Intent	Unintentional	201 (84.1)
	Still under investigation	34 (14.2)
	Other	4 (1.7)

Location of injury

The region of the location of the death is listed in Table 18 for all cases where the location was known (n=213). The most common location of death was Metropolitan Melbourne (Eastern -19.7%, Northern -10.8% and Western 10.8%), followed by the regional areas of Goulburn (15.6%) and Barwon (8.0%).

Table 18: Location of deaths for motorcycle-involved deaths investigated by a Coroner (n=213)

Location	n (%)
Eastern Metropolitan	42 (19.7)
Goulburn	33 (15.6)
Northern Metropolitan	23 (10.8)
Western Metropolitan	23 (10.8)
Barwon	17 (8.0)
Gippsland	15 (7.0)
Southern Metropolitan	14 (6.6)
East Gippsland	12 (5.6)
Wimmera	11 (5.2)
Loddon Mallee	10 (4.7)
Ovens Murray	7 (3.3)
Western district	4 (1.9)
Central highlands	2 (0.9)
Total	213 (100)

Place of death

The majority of motorcyclists (70%) died at the crash location (Figure 16). Of the 49 people who died in-hospital or en route, 41 (83.6%) were brought to a major trauma service, 5 (10.2%) were brought to a regional trauma service, 2 (4.1%) died en route to a hospital (in an ambulance or air ambulance) and 1 (2.0%) was brought to a metropolitan trauma service. The total of 47 in-hospital deaths is consistent with the number reported by the VSTR but exceeds the number reported by the VAED (n=26) and VEMD (n=9). This may be due to different definitions between the data sources of what constitutes "in-hospital" (e.g. death within a certain timeframe) or misclassification by one or both data sources. Codes for place of death are entered by coders at the Coroner's offices based on ICD-10AM coding classifications, so it was not possible to obtain additional details about cases coded as "other." As the VAED and VEMD data are de-identified for provision and analysis, cross-checking of individual cases is not possible to identify the source of discrepancies.

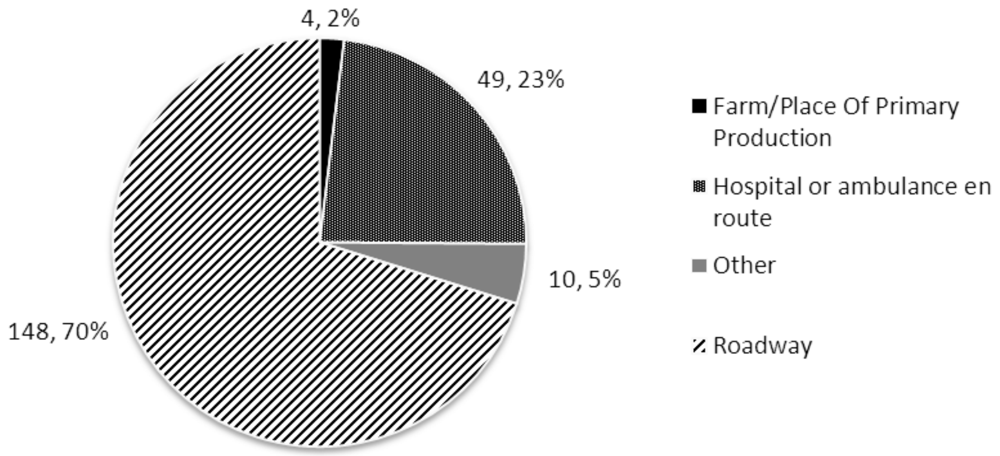

Figure 16: Location of death of motorcycle-involved cases investigated by a Coroner (n=211 cases)

Cause of death

The medical cause of death is assigned by the forensic pathologist conducting the autopsy, if one has been performed, or the physical examination. As pathologists do not assign codes to the causes of death, the primary cause of death is grouped into similar causes as reported in Table 19. Multiple injuries were the most common cause of motorcycle-related deaths, followed by blunt head trauma. Together, these causes of death accounted for more than 80 per cent of all deaths.

Table 19: Cause of death for motorcycle-involved cases investigated by a Coroner (n=235)

Primary Medical Cause of Death (1a)	n (%)
Multiple injuries	136 (57.9)
Blunt head trauma	55 (23.4)
Chest and abdominal injuries	21 (8.9)
Head and neck injuries	10 (4.3)
Exsanguination & asphyxiation due to laceration	7 (3.0)
Injuries to the aorta	2 (0.9)
Sepsis (ruptured bowel)	2 (0.9)
Traumatic compression asphyxia	2 (0.9)
Total	235 (100)

V. Victorian State Trauma Registry (VSTR)

Demographic profile of cases

From July 2005 to June 2010, there were 1,221 motorcycle-related major trauma cases admitted to Victorian hospitals. Of these, 55 occurred interstate or overseas and were excluded, leaving 1,166 cases for analysis for this study.

Table 20: Incidence of motorcycle-related major trauma cases occurring in Victoria (n=1,166)

Financial year	n	Incidence per 100,000 population (95% CI)
2005-06	215	4.2 (3.7, 4.8)
2006-07	216	4.2 (3.6, 4.7)
2007-08	226	4.3 (3.7, 4.8)
2008-09	252	4.6 (4.1, 5.2)
2009-10	257	4.7 (4.1, 5.3)

The incidence of major trauma cases admitted to hospital across the years is shown on stable (Table 20). Adjusted for the Victorian population, the increase in incidence was not significant (IRR 1.44, 95% CI: 0.93, 2.24). Table 21 shows the profile of motorcycle-related major trauma cases occurring in Victoria. Seriously injured motorcyclists in Victoria tend to be young, male and previously healthy, and from the Melbourne metropolitan area with one in five residing in the Southern Metropolitan area. There were 12 cases involving Victorian residents but their residential address was unknown.

Table 21: Demographic and pre-injury status of motorcycle-related major trauma (n=1,166)

Descriptor			n (%)
Age	Mean (SD) years		35.4 (14.5)
	Range (years)		3-88
Sex	n (%) Male		1,091 (93.6)
Comorbid status	n (%)		
	No documented comorbidity		859 (73.7)
	CCI=1		254 (21.8)
	CCI>1		53 (4.5)
Region of residence	Metropolitan Melbourne	Southern	255 (22.1)
		Eastern	167 (14.5)
		Northern	148 (12.8)
		Western	148 (12.8)
	Regional Victoria	Gippsland	93 (8.1)
		Barwon South West	82 (7.1)
		Hume	75 (6.5)
		Loddon-Mallee	72 (6.2)
		Grampians	61 (5.3)
	Interstate or overseas		53 (4.6)

The Transport Accident Commission was the fund source for care for 847 (72.6%) of cases while 269 (n=23.1) were covered by Medicare. The remaining 50 cases were covered by WorkCover (n=17), private health insurance (n=15), Department of Veterans Affairs (n=2) or another compensable body (n=1). For 15 cases, the fund source for the admission was not known.

Injury event

Ninety seven per cent (n=1,126) of cases involved the motorcycle driver while 40 (3.4%) involved a pillion passenger. Consistent with ED presentations and admissions, almost half of all motorcycle-related major trauma cases occurred on the weekend (Figure 17), and most (n=545, 51.2%) occurred between midday and 6pm. One in five cases (n=217, 20.4%) were sustained between 6am and midday, while 22 per cent (n=237) occurred between 6pm and midnight. Only 66 cases (6.2%) occurred between midnight and 6am.

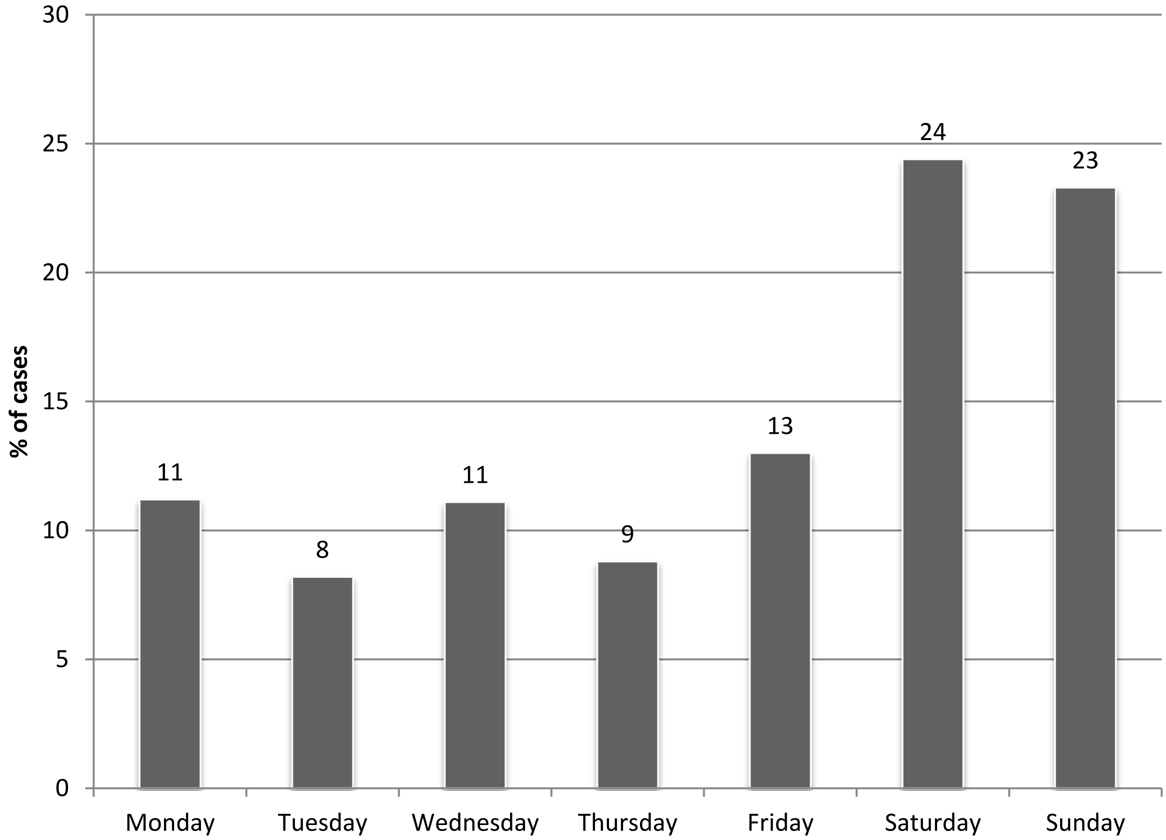

Figure 17: Day of the week of crash – motorcycle-related major trauma

The type of place of injury where the injury occurred, as mapped from the ICD-10 Chapter 20 codes, was known for 1,121 (96.1%) of cases and the distribution is shown in Figure 18. Three quarters of cases occurred on a road, street or highway. A further 14 per cent of cases were sustained while riding motorcycles on farms, athletic or sports areas, and places for recreation.

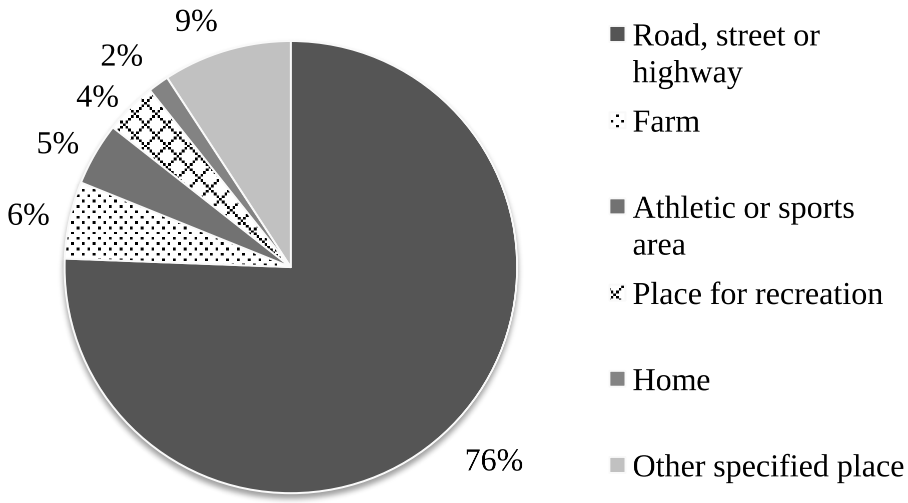

Figure 18: Place of injury for motorcycle related major trauma cases (% of cases)

The postcode of the injury event was recorded for 1,064 (91.2%) cases in the VSTR. Using the postcode of the injury event, just over half of the cases (n=549, 51.6%) occurred in regional Victoria. Table 22 shows the breakdown of the location of injury event based on the injury event postcode. The most common locations for sustaining motorcycle-related major trauma were Gippsland (17%) and the Southern Metropolitan Melbourne areas (16%).

Table 22: Location of motorcycle-related major trauma crashes

Region of Victoria		n (%)
Metropolitan Melbourne	Southern	172 (16.2)
	Western	122 (11.5)
	Eastern	115 (10.8)
	Northern	106 (10.0)
Regional Victoria	Gippsland	180 (16.9)
	Hume	156 (14.7)
	Barwon South West	88 (8.3)
	Loddon-Mallee	64 (6.0)
	Grampians	61 (5.7)

Ambulance Victoria (AV) has provided GIS mapping for the address of the injury event to the Local Government Area (LGA) and Statistical Local Area (SLA) level for cases transported by AV from January 2007 to June 2010. There were 851 motorcycle-related major trauma cases captured by the VSTR in this timeframe, of which 768 were transported from the scene of injury to hospital by AV. Mapping of the crash location was possible for 548 (71.4%) of cases.

Table 23: Most common statistical locations of motorcycle related major trauma

Statistical Local Area of crash	n (%)
Yarra Ranges (North)	18 (3.3)
Yarra Ranges (South West)	18 (3.3)
Melbourne – remainder	16 (2.9)
Wyndham North	14 (2.6)
Mornington Peninsula (South)	13 (2.4)
Bass Coast (Phillip Island)	11 (2.0)
Casey – Cranbourne	11 (2.0)
Frankston West	11 (2.0)
Hume – Broadmeadows	11 (2.0)
Melton	10 (1.8)
Brimbank – Keilor	9 (1.6)
Brimbank – Sunshine	9 (1.6)
Delatite (South)	9 (1.6)
Monash – Waverley West	9 (1.6)
Murrindindi (East)	9 (1.6)

The mapped cases occurred in 120 SLA regions. The 15 most commonly represented SLA regions are shown in Table 23. Fifty six cases (10.2%) occurred in Gippsland, of which 11 occurred on Phillip Island. Fifty one (9.3%) cases occurred in the Yarra Ranges, while 17 (3.1%) occurred on the Mornington Peninsula. Only six (1.1%) cases occurred in the Otway Ranges area, and four cases (0.7%) occurred in the Alpine Region of Victoria. There were 78 (14.2%) cases occurring in Southern Melbourne. Another 23 cases occurred in Casey, 15 in Frankston and 14 in Greater Dandenong. Detailed maps of Victoria's statistical divisions can be found:
http://www.abs.gov.au/AUSSTATS/abs@.nsf/0/d4f3b7af766a4c4dca256f1900134a73/$FILE/Victoria.pdf

Of the 548 cases mapped by AV, 393 were recorded as occurring on a road, with 335 (85.2%) occurring on sealed roads. No information was provided for this variable for the remaining cases, with other places of injury (e.g. farm, bush track) presumed.

Injuries sustained

The median (IQR) Injury Severity Score (ISS) of motorcycle-related major trauma cases was 17 (14-25). Using the Abbreviated Injury Scale (AIS) criterion of a severity score >2, 27 per cent (n=313) of cases had sustained a serious head injury, while the head injury was considered severe (Glasgow Coma Scale (GCS) score 3-8) for 10 per cent (n=113) of all cases. Figure 19 shows the broad injury grouping of motorcycle-related major trauma cases. More than half of the cases had sustained orthopaedic injuries only, while 22 per cent had sustained a serious head injury combined with other associated injuries. Forty-five cases (4%) sustained a spinal cord injury in the crash.

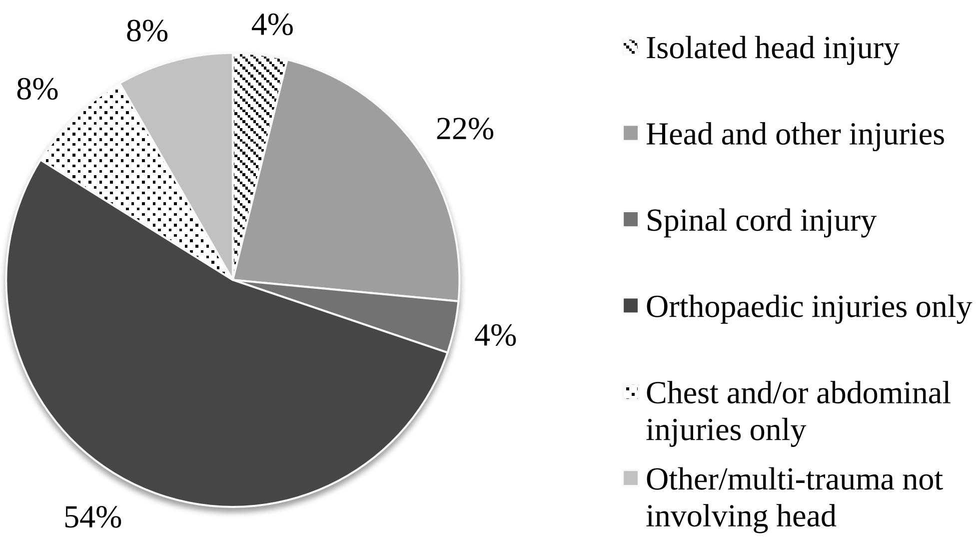

Figure 19: Broad injury grouping of motorcycle-related major trauma cases in Victoria

The proportion of cases who had sustained a serious injury (AIS severity score >2) to each body region is shown in Table 24. Almost half of the cases had sustained serious chest injuries, while almost one third had sustained serious lower extremity injuries. Table 24 shows the proportion of cases with at least one serious injury to each AIS body region but multiple injuries to each body region can be sustained. The chest injuries most commonly sustained were a haemopneumothorax (n=459), lung contusions or laceration s(n=347) and multiple rib fractures (not involving lung injury) (n=163). The most prevalent lower extremity injuries sustained were pelvic fractures (n=213), fractures of the tibia or ankle (n=148), fractures of the femur (n=142) and fibula fractures (n=115). Three hundred and six cases sustained an intracranial injury while 163 cases sustained a skull fracture. Three hundred and ten cases sustained a thoracic spine fracture. A clavicle fracture was the most commonly sustained upper extremity injury (n=216) followed by forearm (n=179), and scapula (n=176) fractures.

Table 24: Prevalence of injury to each AIS body region for motorcycle related major trauma

AIS body region	n (%) of cases
Chest/thorax	541 (49.1)
Lower extremity	342 (31.0)
Head	313 (28.4)
Abdominal or pelvic contents	190 (17.2)
Spine	173 (15.7)
Face	14 (1.3)
Neck	13 (1.2)
Upper extremity	13 (1.2)
External	2 (0.2)

Pre-hospital transport and transfers

The mode of arrival to first hospital for the motorcycle-related major trauma cases was known for 1,138 (98.0%) cases and is shown in Figure 20. Ninety-two per cent of cases (n=1,045) were transported from the scene of injury to hospital by Ambulance Victoria, while the remaining cases arrived at hospital by private car. Of the 351 air ambulance transports, 346 (98.6%) were helicopter transports with the remainder transported by fixed wing aircraft.

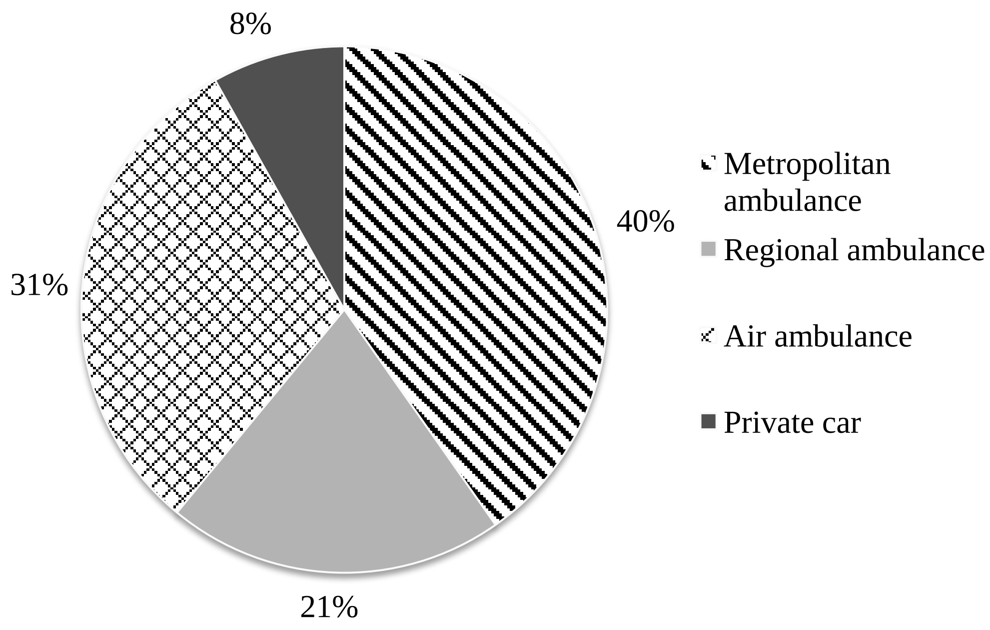

Figure 20: Mode of arrival to hospital for motorcycle-related major trauma cases

Time from '000' call to arrival of ambulance at the scene

Of the 1,045 cases transported to hospital by ambulance, the time from '000' and "112"call to arrival of the ambulance at the scene was known for 901 (86.2%) cases. The distribution of response times is shown in Figure 21. The median (IQR) time from '000' call to arrival of the ambulance at the scene was 16 (9-28) minutes.

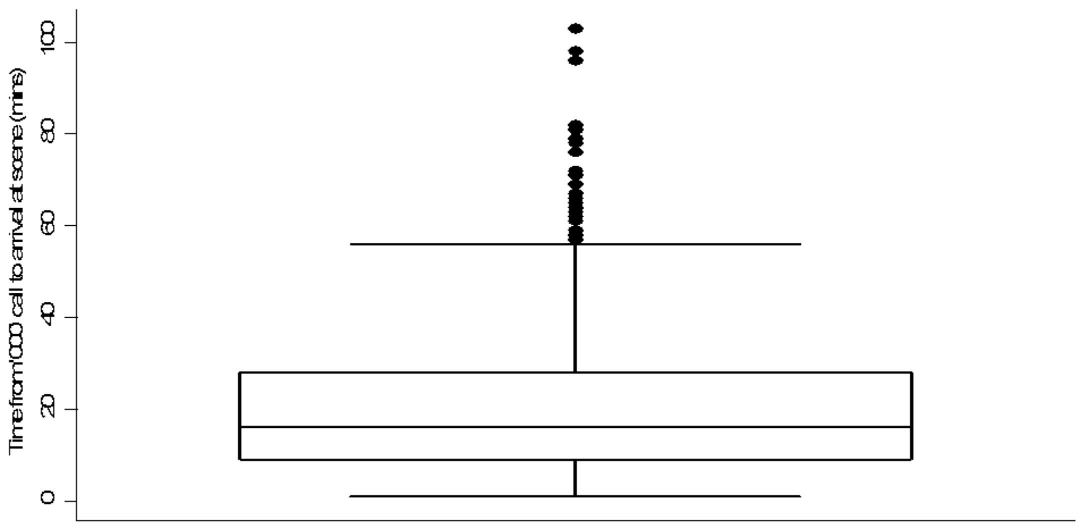

Figure 21: Distribution of time from '000' call to arrival of an ambulance at the scene of crash

Factors recorded by the VSTR and considered as potential predictors of the time from receipt of the ‘000’ call to arrival of the ambulance at the scene included the age and sex of the motorcyclist, the day of the week and time of day at which the ‘000’ call was placed, the region of Victoria in which the motorcyclist was injured, and whether the motorcyclist was unconscious at the scene (using an ambulance GCS score on arrival of 3-8 to approximate unconsciousness). The indicator of unconsciousness was not associated with time to arrival of the ambulance ($p=0.519$) on univariate testing and was excluded from the multivariate model. All other potential predictors demonstrated a p-value <0.2 on univariate testing and were included in the multivariate model, with the results presented in Table 25. Negative co-efficients represent shorter times compared to the reference group, while positive co-efficients represent longer times between the ‘000’ call and ambulance arrival relative to the reference group.

Adjusting for all potential predictors, only the place of injury, the time the call was placed, and the region of Victoria in which the crash occurred were associated with the time from ‘000’ call to arrival of the ambulance at the scene (Table 25). Response times in Barwon South West, Loddon-Mallee and all Melbourne metropolitan areas were lower when compared to crashes occurring in Gippsland. Compared to crashes occurring on a road, street or highway, the response times were 7.8 minutes shorter for ‘000’ calls to athletic and sports area crashes. In contrast, compared to crashes occurring on a road, street or highway, the response times were 15.0 minutes longer for calls made for farm-related crashes. The shorter response times to athletic and sports areas could relate to the presence of emergency services at the site (e.g. for race events). Compared to calls made from 1600-1859 hours, calls made between 2200-0059 hours were associated with a shorter (4.4 minutes) response time.

Table 25: Predictors of time from '000' call to arrival of ambulance at the scene (multivariate linear regression)

Predictor		n	Mean (SD) minutes	Co-efficient (95% CI)	p-value
Place of injury	Road, street or highway (ref)	698	19.4 (15.4)	-	<0.000
	Athletic or sports area	38	17.6 (9.4)	-7.8 (-12.8, -2.8)	
	Place for recreation	31	24.6 (13.3)	1.9 (-3.8, 7.7)	
	Farm	32	39.2 (20.4)	15.0 (9.6, 20.4)	
	Home	11	20.3 (10.7)	-1.9 (-10.9, 7.1)	
	Other specified place	75	29.0 (20.2)	4.1 (0.3, 7.8)	
Region of Victoria	Gippsland (ref)	126	29.9 (19.1)	-	<0.000
	Barwon South West	70	25.0 (16.0)	-5.5 (-9.8, -1.2)	
	Grampians	44	25.2 (15.1)	-3.9 (-8.9, 1.2)	
	Hume	120	32.7 (19.5)	3.1 (-0.7, 6.8)	
	Loddon-Mallee	47	19.7 (12.9)	-9.7 (-14.7, -4.8)	
	Eastern metro	103	17.2 (13.0)	-10.4 (-14.4, -6.4)	
	Northern metro	101	13.4 (9.8)	-13.4 (-17.5, -9.4)	
	Southern metro	156	16.6 (13.4)	-10.8 (-14.4, -7.2)	
	Western metro	111	12.7 (9.5)	-14.5 (-18.4, -10.5)	
Time of call	1600-1859 hrs (ref)	218	21.1 (16.1)	-	0.006
	0100-0359 hrs	40	14.9 (9.7)	-3.4 (-8.4, 1.7)	
	0400-0659 hrs	28	14.3 (8.5)	-2.6 (-8.4, 3.2)	
	0700-0959 hrs	64	16.9 (15.0)	-3.9 (-8.0, 0.3)	
	1000-1259 hrs	178	26.6 (18.8)	2.9 (-0.2, 5.9)	
	1300-1559 hrs	205	23.3 (16.9)	1.3 (-1.6, 4.2)	
	1900-2159 hrs	108	17.9 (14.6)	-2.1 (-5.5, 1.3)	
	2200-0059 hrs	60	14.5 (10.4)	-4.4 (-8.6, -0.1)	
Age group	15-24 years (ref)	213	20.3 (15.2)	-	0.613
	<15 years	21	25.3 (16.5)	1.4 (-6.0, 8.7)	
	25-34 years	198	19.7 (15.8)	-0.8 (-3.7, 2.1)	
	35-44 years	197	20.9 (15.4)	-0.4 (-3.3, 2.5)	
	45-54 years	167	21.0 (16.7)	-1.7 (-4.8, 1.3)	
	55-64 years	81	25.9 (21.2)	2.1 (-1.8, 6.0)	
	65+ years	24	20.4 (15.4)	-2.4 (-9.2, 4.3)	
Sex	Male (ref)	842	20.9 (16.2)	-	0.261
	Female	59	23.8 (18.6)	2.3 (-1.7, 6.2)	
Day of call	Sunday (ref)	195	23.8 (15.3)	-	0.274
	Monday	108	17.8 (13.8)	-3.3 (-6.9, 0.3)	
	Tuesday	76	21.6 (17.3)	1.1 (-2.9, 5.2)	
	Wednesday	109	17.1 (12.5)	-1.2 (-4.8, 2.4)	
	Thursday	75	23.6 (20.1)	2.0 (-2.0, 6.1)	
	Friday	130	19.2 (17.2)	-1.1 (-4.5, 2.3)	
	Saturday	208	22.4 (17.2)	-0.6 (-3.6, 2.3)	

Bystander first aid

The VSTR does not collect data regarding bystander first aid. The case notes for 675 AV transported motorcycle-related major trauma patients were provided. Of these, 226 had no information recorded in the case description. Of the 449 cases where a case description was recorded, 134 mentioned “bystander” and/or “first aid”. The majority of the cases mentioning the presence of a bystander related to bystander calling of ‘000’ or bystander reports of the crash. Only 34 cases (7.5%) reported intervention of a bystander in the care of the motorcycle crash victim. It is important to note that case description is the free text function in VACIS, which allows paramedics to record additional notes. Specific data on the action of bystanders is captured in a section of VACIS called “others at scene”. This data was not provided to the VSTR due to time constraints.

There was no consistency in the documentation of first aid provided. For seven cases, the paramedic reported that the bystander rendered “assistance” or “attended” to the patient. For four cases, the bystander kept the patient still and provided reassurance and comfort. In 14 cases, the helmet was removed by the bystander, with one report of doing so to administer CPR. For three cases, the helmet was removed by an off-duty nurse, registrar or paramedic. In nine cases, the patient was placed in the “recovery” position by the bystander, with the head supported for six cases, and a fractured limb “supported” for one case. In five cases, the patient was moved by the bystander, generally to prevent oncoming dangers. “C-spine care” was provided to one case by a bystander and bleeding control attempted by the bystander for three cases, including one involving introduction of a tourniquet.

Time at scene for the ambulance

The time at scene for the ambulance service was known for 950 (90.9%) of the cases transported to hospital by ambulance, with the distribution of scene times shown in Figure 22. The median (IQR) time at scene for the ambulance was 27 (20-38) minutes.

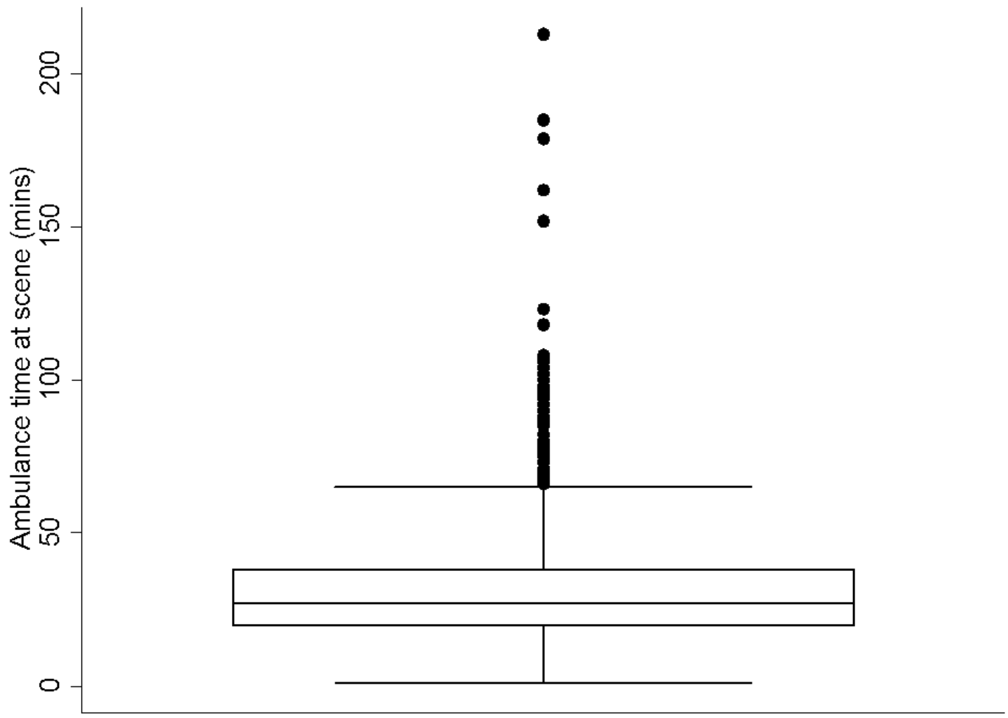

Figure 22: Distribution of the time spent at scene by the ambulance (minutes)

Ambulance paramedics are able to perform numerous interventions at the scene. The VSTR captures indicators for the following: cardiopulmonary resuscitation (CPR); chest decompression; endotracheal intubation (ETT); laryngeal mask airway management; insertion of a nasogastric tube; administration of intravenous (IV) fluid; administration of sedative, analgesic, antiemetic, paralysing agents; administration of adrenaline; and defibrillation.

The percentage of cases receiving each intervention is shown in Figure 23. Most cases received analgesic medication while two thirds of cases received IV fluid. Anti-emetic medication was administered to more than 40 per cent of cases, but in only 19 cases was this prescribed without accompanying analgesia. Intubation at the scene was required for 14 per cent of cases, and all cases given a paralysing agent were intubated. Only 20 of the 120 cases administered a sedative received the sedative without accompanying intubation. Ten of the thirteen cases requiring CPR at the scene died in-hospital. Sedative and paralysing medications were administered almost exclusively with intubation, while administration of anti-emetic medication without analgesic medication was uncommon.

The prevalence of interventions performed at the scene was consistent with motor vehicle crash major trauma cases for the same period for most intervention types. Motorcycle major trauma cases received a higher prevalence of analgesia (83% vs. 74%) and anti-emetic medication (42% vs. 34%) compared to motor vehicle crash victims. The percentage of cases intubated at the scene was lower for motorcycle-related major trauma cases when compared with motor vehicle major trauma cases (14% vs. 19%). There may be some missing data in the VSTR with respect to paramedic interventions. Prior to recently establishing a data linkage exercise with AV, the VSTR relied on a copy of the AV patient care record (PCR) found in hospital records. This record would belong to the transporting ambulance team and any interventions performed by other AV teams would be missing (ie teams fill out individual PCRS).

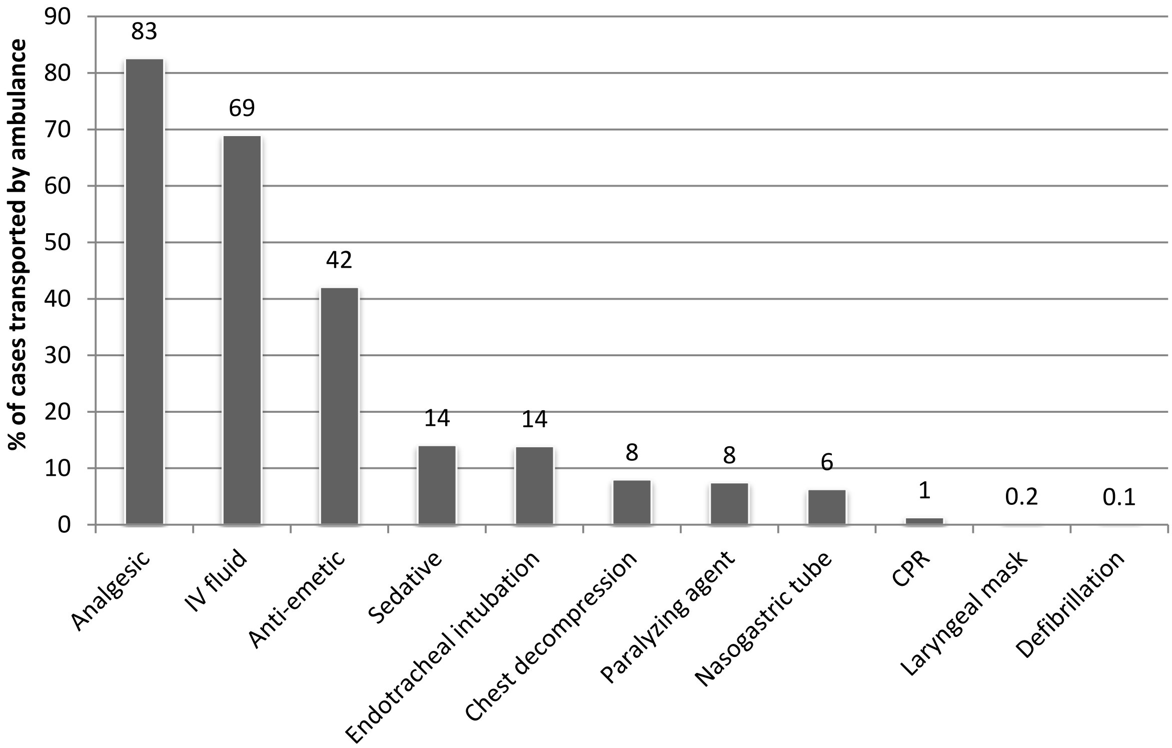

Figure 23: Interventions provided at the scene by ambulance paramedics

Factors considered as potentially important predictors of the time at scene were: the age and sex of the injured motorcyclist; the location of the injury (place and Victorian region); observations on arrival at the scene; and whether the patient was transported by helicopter.

As the condition of the patient determines the interventions undertaken at the scene, the interventions themselves were not considered as predictors of scene time.

Sex (p=0.366), and whether the patient was tachycardic (pulse rate >120 bpm) on arrival at the scene (p=0.324), were not associated with the time spent at scene and were therefore excluded from the multivariate model. After adjusting for all considered predictors, the respiratory rate of the patient on arrival at the scene, the geographic location of injury and the age of the motorcycle crash victim were not important predictors of the time spent at the scene by paramedics.

Keeping all other factors constant, transport by helicopter was associated with a scene time 12 minutes longer than patients transported to hospital by road ambulance. Adjusting for other factors, the scene time for cases attended to in metropolitan regions was 6.9-10.0 minutes shorter than motorcycle crash victims attended to in Gippsland, while cases transported from other regional Victoria areas were shorter but significantly different to scene times for Gippsland cases. Injured motorcyclists who were hypotensive (SBP<90 mmHg) had a scene times 6.5 minutes longer than non-hypotensive patients, while a Glasgow Coma Scale (GCS) score of 9-12 (representing moderate head injury) was associated with a scene time 9.3 minutes longer than cases with a GCS score of 13-15 (representing none to mild head injury). Cases with a GCS score of 3-8, typically representing a severe head injury, experienced scene times comparable to cases with a GCS score of 13-15 (Table 26).

Analysis of predictors of scene time is complex and not all variables will have been considered / available for this analysis.

Table 26: Predictors of time at the scene (multivariate linear regression)

Predictor		n	Mean (SD)	Co-efficient (95% CI)	p-value
Helicopter transport	No (ref)	651	27.5 (15.2)	-	<0.001
	Yes	299	42.6 (27.7)	12.0 (8.7, 15.3)	
Glasgow Coma Scale (GCS) score on arrival	13-15 (ref)	115	31.4 (21.5)	-	0.022
	9-12	43	41.3 (23.4)	9.3 (2.7, 15.8)	
	3-8	786	34.4 (16.8)	0.7 (-3.7, 5.2)	
Region of Victoria	Gippsland (ref)	146	41.9 (28.6)	-	0.007
	Barwon South West	71	36.2 (23.5)	-1.6 (-7.6, 4.4)	
	Grampians	49	33.1 (17.4)	-4.9 (-11.7, 2.0)	
	Hume	128	38.1 (27.2)	-2.0 (-6.9, 2.9)	
	Loddon-Mallee	50	31.4 (19.7)	-3.4 (-10.4, 3.5)	
	Eastern metro	103	26.7 (13.8)	-10.1 (-15.6, -4.6)	
	Northern metro	102	26.6 (11.1)	-8.2 (-13.8, -2.5)	
	Southern metro	160	28.6 (14.2)	-8.1 (-13.1, -3.1)	
	Western metro	113	27.2 (18.3)	-6.9 (-12.5, -1.3)	
Systolic Blood Pressure on arrival	≥ 90 mmHg (ref)	833	31.8 (20.2)	-	0.005
	<90 mmHg	98	37.1 (28.4)	6.5 (1.9, 11.0)	
Age group	15-24 years (ref)	220	28.8 (15.1)	-	0.203
	<15 years	30	34.9 (17.2)	2.2 (-6.5, 10.9)	
	25-34 years	210	31.6 (19.4)	1.1 (-2.9, 5.1)	
	35-44 years	205	34.3 (22.9)	3.7 (-0.3, 7.8)	
	45-54 years	173	34.3 (22.9)	3.4 (-0.8, 7.6)	
	55-64 years	88	31.9 (22.6)	1.4 (-3.9, 6.8)	
	65+ years	24	35.6 (42.8)	11.1 (1.8, 20.4)	
Place of injury	Road/street/highway (ref)	725	31.3 (20.8)	-	0.463
	Athletic or sports area	44	31.4 (20.2)	-0.47 (-7.0, 6.1)	
	Place for recreation	33	38.9 (19.0)	5.0 (-2.5, 12.6)	
	Farm	38	34.6 (18.5)	-3.7 (-10.7, 3.3)	
	Home	10	33.3 (12.8)	2.1 (-10.7, 14.9)	
	Other specified place	81	38.2 (26.5)	3.1 (-1.9, 8.0)	
Respiratory rate on arrival	≤ 25 breaths per min (ref)	782	31.7 (21.3)	-	0.795
	>25 breaths per min	145	34.3 (20.5)	0.5 (-3.2, 4.2)	

Time from departing the scene to arrival at hospital

The time from departing the scene to arrival of the ambulance at the hospital (first or definitive) was known for 974 (93.2%) cases. The median (IQR) time from departing the scene to arrival at hospital was 34 (23-49) minutes. Forty-five per cent (n=434) of cases with a transport time from the scene to hospital >30 minutes were a direct transport to a major trauma service (MTS) hospital, the highest level of care in the Victorian State Trauma System.

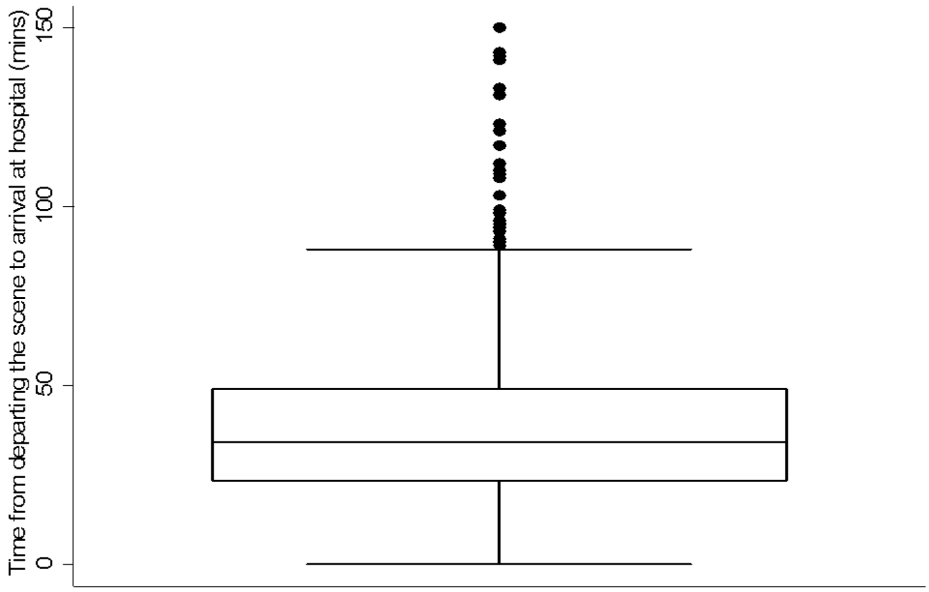

Figure 24: Distribution of the time from departing the scene to arrival at hospital (minutes)

Factors considered as potential predictors of the transport time from the scene to hospital were the age and sex of the patient, the scene location (region and place), mode of transportation (air vs. road), the time the ambulance departed the scene, the day of the week departing the scene, and whether the patient was intubated. Sex was not associated (p=0.590) with the transport time on univariate testing and was excluded from the multivariate model. Table 27 shows the results of the multivariate analysis. Negative co-efficients represent shorter times compared to the reference group, while positive co-efficients represent longer times between departing the scene and arriving at hospital relative to the reference group.

Keeping all other factors fixed, transport by fixed or rotor wing aircraft was associated with a transport time 6.5 minutes longer than patients transported by road (Table 27). All motorcycle-related major trauma cases transported from a metropolitan Melbourne scene of injury experienced transport times ranging from 9.4 to 16.4 minutes shorter than cases transported in Gippsland. Retrieval from a farm or "other" place of injury was associated with transport times 13.0 and 7.5 minutes longer than transports from a road, street or highway, respectively. The transport times were shorter for patients transported from the scene between midnight and midday, compared to patients transferred in the afternoon (Table 27).

Table 27: Predictors of transport time from the scene to hospital (multivariate linear regression)

Predictor		n	Mean (SD)	Co-efficient (95% CI)	p-value
Air transport	No (ref)	649	34.1 (19.8)	-	<0.001
	Yes	325	48.5 (23.6)	6.5 (3.2, 9.7)	
Region of Victoria	Gippsland (ref)	153	49.8 (25.9)	-	<0.0001
	Barwon South West	75	43.1 (25.4)	-4.4 (-10.1, 1.3)	
	Grampians	51	42.9 (24.8)	-6.1 (-12.6, 0.5)	
	Hume	130	48.8 (27.1)	-1.3 (-6.1, 3.6)	
	Loddon-Mallee	54	40.0 (23.3)	-7.9 (-14.4, -1.4)	
	Eastern metro	105	33.8 (11.2)	-11.0 (-16.3, -5.6)	
	Northern metro	103	27.8 (13.1)	-15.0 (-20.6, -9.5)	
	Southern metro	164	35.5 (17.1)	-9.4 (-14.2, -4.6)	
	Western metro	112	26.2 (11.7)	-16.4 (-21.9, -11.0)	
Place of injury	Road/ street/highway (ref)	747	36.5 (20.9)	-	0.0001
	Athletic or sports area	43	36.7 (18.6)	-4.7 (-11.1, 1.8)	
	Place for recreation	35	41.1 (25.1)	-1.0 (-8.4, 6.3)	
	Farm	39	55.3 (20.1)	13.0 (6.2, 19.7)	
	Home	10	34.3 (18.0)	-1.0 (-13.9, 11.9)	
	Other specified place	81	50.5 (26.8)	7.5 (2.5, 12.4)	
Time departed scene	1200-1759 (ref)	482	42.5 (22.5)	-	0.005
	0000-0559	69	28.9 (17.5)	-6.7 (-12.0, -1.5)	
	0600-1159	138	33.4 (18.4)	-5.9 (-9.8, -1.9)	
	1800-2359	285	37.9 (23.2)	-1.1 (-4.3, 2.1)	
Age group	15-24 years (ref)	227	37.6 (21.3)	-	0.206
	<15 years	31	40.3 (20.0)	-4.1 (-12.6, 4.5)	
	25-34 years	212	35.1 (18.7)	-2.1 (-5.9, 1.8)	
	35-44 years	210	41.9 (25.3)	1.7 (-2.2, 5.6)	
	45-54 years	181	40.0 (21.7)	0.5 (-3.6, 4.6)	
	55-64 years	89	42.7 (25.0)	1.6 (-3.6, 6.8)	
	65+ years	24	36.2 (22.6)	-8.0 (-17.3, 1.3)	
Intubated at scene	No (ref)	841	38.5 (22.1)	-	0.714
	Yes	132	41.5 (23.0)	-0.8 (-4.8, 3.3)	
Weekday departed scene	Sunday (ref)	212	42.0 (23.2)	-	0.368
	Monday	114	35.2 (17.7)	-3.5 (-8.3, 1.3)	
	Tuesday	81	36.0 (18.2)	-2.3 (-7.7, 3.1)	
	Wednesday	119	34.9 (17.4)	-0.1 (-4.9, 4.7)	
	Thursday	82	39.5 (24.0)	1.3 (-4.0, 6.7)	
	Friday	133	35.3 (22.2)	-1.5 (-6.1, 3.1)	
	Saturday	233	42.8 (25.1)	1.7 (-2.2, 5.6)	

Inter-hospital transport and definitive care

The majority of motorcycle-related major trauma cases (84%) were managed within the Major Trauma Service (MTS) hospitals, with a further five per cent managed at the MTS hospital for spinal injury (The Austin) (Figure 25). Almost 30 per cent (n=347) of cases experienced an inter-hospital transfer, with 20 cases experiencing two inter-hospital transfers.

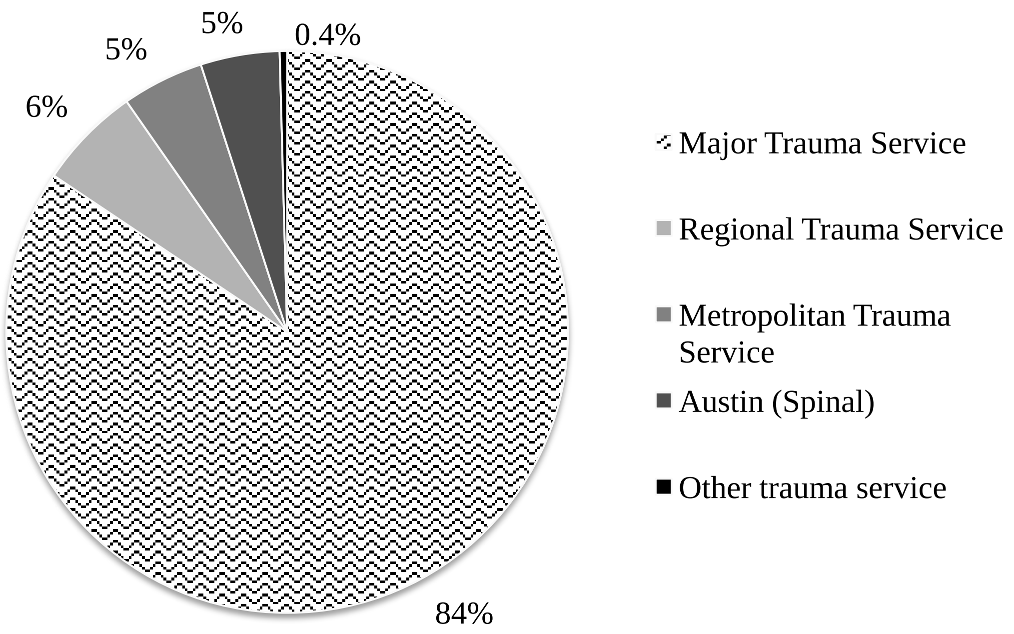

Figure 25: Victorian State Trauma System level of definitive care

The time from injury to arrival at the hospital of definitive care was known for 1,063 (91.2%) of cases. The median (IQR) time from injury to arrival at the definitive hospital of care was 2.0 (1.3-5.9) hours, reflecting the high proportion of cases transported from regional Victoria. Forty-six cases (4.3%) arrived at the definitive hospital of care more than 24 hours after injury. The time from arrival at the first hospital to arrival at the definitive hospital of care was known for 332 (96.0%) transferred cases. The median (IQR) transfer time was 7.2 (5.0-11.3) hours.

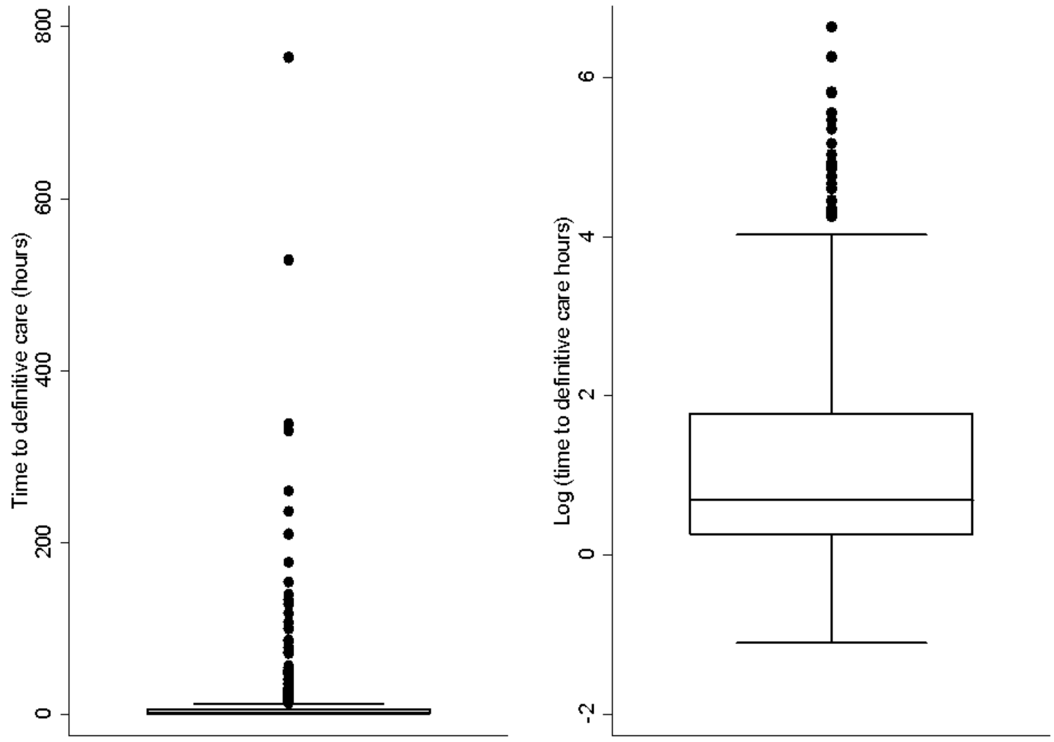

Figure 26: Distribution of times from injury to arrival at definitive care (hours)

The time to definitive care was heavily skewed (a wide range of times but most values at one end of the scale) as shown in the left hand graph of Figure 26. To analyse this outcome, log transformation was needed. A natural log of each time to arrival at definitive care was calculated and the change resulted in a normal distribution of the times (Figure 26, right hand graph). Factors considered as potential predictors of the time to definitive care were the age and sex of the injured motorcyclist, the place and region of Victoria of the crash, the mode of transportation to hospital and whether the injured motorcyclist experienced an inter-hospital transfer. The results of the multivariate analysis are shown in Table 28. As noted in the data analysis section of the methods for this report, the change of the scale of measurement to a log scale changes the estimate of the models to ratios of the geometric mean which are interpreted as percentage changes/differences.

Inter-hospital transfer, the mode of transportation to hospital, the region of Victoria in which the crash occurred, and the type of place the crash occurred were important predictors of time from injury to definitive care. Keeping all other factors fixed, inter-hospital transfer increased the geometric mean time to definitive care by nearly eight-fold (Table 28). Transport by air ambulance was associated with a 27 per cent increase in mean time to definitive care compared to transport by metropolitan road ambulance, and crashes occurring in any metropolitan area were associated with a 25-39 per cent decrease in the mean time to definitive care compared to patients transported from Gippsland (Table 28). A farm crash location increased the mean time to definitive care by 29 per cent compared to crashes occurring on a road, street or highway, when all other factors were held steady.

Table 28: Predictors of the time from injury to arrival at definitive care (log(hours)) (multivariate linear regression)

Predictor		n	Mean (SD)	Ratio of geometric means (95% CI)	p-value
Inter-hospital transfer	No (ref)	758	0.50 (0.63)	-	<0.001
	Yes	302	2.43 (0.92)	7.99 (6.99, 9.14)	
Mode of transport to hospital	Metropolitan ambulance (ref)	434	0.49 (1.01)	-	<0.001
	Regional road ambulance	214	1.96 (1.08)	0.77 (0.64, 0.93)	
	Air ambulance	330	0.92 (0.64)	1.27 (1.11, 1.46)	
	Private car	67	2.19 (1.21)	0.75 (0.57, 0.99)	
Region of Victoria	Gippsland (ref)	169	1.67 (1.08)	-	<0.001
	Barwon South West	75	1.45 (0.91)	0.93 (0.78, 1.12)	
	Grampians	53	1.46 (1.02)	0.83 (0.67, 1.02)	
	Hume	150	1.39 (0.98)	0.96 (0.83, 1.11)	
	Loddon-Mallee	60	1.64 (1.28)	1.03 (0.84, 1.26)	
	Eastern metro	105	0.51 (0.76)	0.68 (0.56, 0.82)	
	Northern metro	105	0.18 (0.47)	0.60 (0.49, 0.74)	
	Southern metro	164	0.75 (1.19)	0.75 (0.63, 0.89)	
	Western metro	117	0.33 (1.04)	0.61 (0.50, 0.75)	
Place of injury	Road, street or highway (ref)	778	0.87 (1.11)	-	0.027
	Athletic or sports area	48	1.31 (0.91)	0.90 (0.73, 1.09)	
	Place for recreation	39	1.31 (1.06)	1.19 (0.95, 1.50)	
	Farm	55	1.79 (1.03)	1.29 (1.06, 1.57)	
	Home	13	1.74 (1.09)	1.34 (0.92, 1.96)	
	Other specified place	94	1.47 (0.98)	1.09 (0.93, 1.27)	
Age group	15-24 years (ref)	255	0.99 (1.03)	-	0.264
	<15 years	48	1.79 (1.15)	1.25 (0.97, 1.61)	
	25-34 years	231	0.95 (1.22)	1.14 (1.01, 1.29)	
	35-44 years	226	1.07 (1.15)	1.11 (0.98, 1.26)	
	45-54 years	189	0.96 (1.09)	1.08 (0.95, 1.23)	
	55-64 years	87	1.13 (1.09)	1.16 (0.98, 1.36)	
	65+ years	24	1.29 (1.15)	1.06 (0.79, 1.43)	

In-hospital outcomes

Table 29 shows the in-hospital outcomes for motorcycle-related major trauma cases. The vast majority of cases were definitively managed at Major Trauma Service (MTS) or the MTS for spinal injury in Victoria (Austin Hospital), which is consistent with the trauma triage guidelines for the state. While 46 per cent of cases were admitted to an Intensive Care Unit (ICU), the overall in-hospital mortality rate was low at 4 per cent, relative to the wider major trauma population where in-hospital mortality is approximately 12 per cent, potentially reflecting the younger, healthier cohort of motorcycle riders compared to the wider major trauma population where the prevalence of falls in the elderly is high. Forty-seven deaths were recorded which is consistent with the number of in-hospital deaths recorded by the NCIS over the same timeframe. Forty three per cent of survivors were discharged to inpatient rehabilitation facilities (Table 29).

Table 29: In-hospital management and outcomes of motorcycle-related major trauma cases

Descriptor		
Level of definitive care	n (%)	
	Major Trauma Service	984 (84.4)
	Regional Trauma Service	69 (5.9)
	Metropolitan Trauma Service	55 (4.7)
	Austin (spinal)	53 (4.6)
	Other	5 (0.4)
ICU admission	n (%) Yes	533 (45.8)
Hospital length of stay	Median (IQR) days	8.7 (4.8-14.8)
Discharge destination	n (%)	
	Home	592 (50.8)
	Inpatient rehabilitation	501 (43.0)
	In-hospital death	47 (4.0)
	Hospital for convalescence	11 (1.0)
	Other	15 (1.3)

Predictors of in-hospital mortality

There were 47 in-hospital deaths in the injured cohort. There was no association between sex, region of Victoria, place of injury, and the mode of arrival at hospital, and in-hospital mortality (Table 30). Factors included in the multivariate model included age, comorbid status, GCS on arrival, ISS, transfer status and scene time. Injury group was not included due to its strong relationship with ISS, and transfer status was included rather than time to definitive care for the same reason. Because of the low number of deaths, and homogeneity in the death rate for some sub-groups, a number of variables were collapsed for the multivariate analysis.

Table 30: Association between patient factors, injury event, injuries sustained and in-hospital mortality

Descriptor		Survivors (n=1119)	In-hospital deaths (n=47)	p-value
Age group	n (%)			0.118
	<15 years	52 (4.7)	1 (2.1)	
	15-24 years	262 (23.4)	16 (34.0)	
	25-34 years	240 (21.5)	11 (23.4)	
	35-44 years	241 (21.5)	11 (23.4)	
	45-54 years	204 (18.2)	3 (6.4)	
	55-64 years	93 (8.3)	2 (4.3)	
	>64 years	27 (2.4)	3 (6.4)	
Sex	n (%)			0.989
	Male	1047 (93.6)	44 (93.6)	
	Female	72 (6.4)	3 (6.4)	
Comorbid status	n (%)			0.012
	No documented comorbidity	817 (73.0)	42 (89.4)	
	CCI=1	252 (22.5)	2 (4.3)	
	CCI>1	50 (4.5)	3 (6.4)	
Place of injury	n (%)			0.554
	Road, street or highway	807 (75.1)	40 (85.1)	
	Athletic or sports area	49 (4.6)	2 (4.3)	
	Place for recreation	42 (3.9)	0 (0.0)	
	Farm	60 (5.6)	1 (2.1)	
	Home	16 (1.5)	1 (2.1)	
	Other specified place	100 (9.3)	3 (6.4)	
Location in Victoria	n (%)			0.499
	Metropolitan	491 (48.2)	24 (53.3)	
	Regional	528 (51.8)	21 (46.7)	
Injury group	n (%)			<0.001
	Isolated head injury	40 (3.6)	5 (10.6)	
	Head and other injuries	243 (21.7)	21 (44.7)	
	Spinal cord injury	42 (3.8)	1 (2.1)	
	Orthopaedic injuries only	317 (55.1)	9 (19.2)	
	Chest and/or abdominal injuries only	86 (7.7)	5 (10.6)	
	Other multi-trauma	91 (8.1)	6 (12.8)	
Glasgow Coma Scale score on arrival	n (%)			<0.001
	3-8 (severe head injury)	83 (7.6)	30 (76.9)	
	9-12 (moderate head injury)	51 (4.7)	1 (2.6)	
	13-15 (none/mild head injury)	960 (87.8)	8 (20.5)	
Injury Severity Score	Median (IQR)	17 (14-24)	30 (23-42)	<0.001
Mode of arrival	n (%)			0.424
	Metropolitan road ambulance	436 (40.0)	22 (46.8)	
	Regional road ambulance	227 (20.8)	9 (19.2)	
	Air ambulance	336 (30.8)	15 (31.9)	
	Private car	92 (8.4)	1 (2.1)	
Scene time	Median (IQR) minutes	27 (20-38)	33 (23-42)	0.061
Time to definitive care	Median (IQR) hours	2.0 (1.3-6.1)	1.5 (1.1-2.2)	0.002
Inter-hospital transfer	n (%)			0.023
	No	779 (69.6)	40 (85.1)	
	Yes	340 (30.4)	7 (15.0)	

The primary predictors of in-hospital mortality were the GCS on arrival and the severity of injuries sustained (ISS) (Table 31). Injured motorcyclists with a GCS of 3 to 8 on arrival, indicating severe head injury, demonstrated a 22-fold increase in the odds of mortality, while the adjusted odds of in-hospital mortality increased by 7 per cent with each unit increase in the ISS.

Table 31: Predictors of in-hospital mortality (multivariate analysis)

Predictor		AOR (95% CI)	p-value
Injury Severity Score		1.07 (1.03, 1.11)	<0.001
Glasgow Coma Scale score on arrival	9-15 (reference)	-	<0.001
	3-8	22.20 (8.52, 57.90)	
Comorbid status	None (reference)	-	0.005
	CCI 1-6	0.15 (0.04, 0.55)	
Scene time		1.00 (0.98, 1.02)	0.773
Age group	<25 years (reference)	-	0.637
	25-34 years	1.69 (0.53, 5.37)	
	35-44 years	1.39 (0.43, 4.52)	
	45-54 years	0.89 (0.19, 4.08)	
	55-64 years	1.69 (0.16, 15.72)	
	65+ years	7.84 (0.70, 87.9)	
Inter-hospital transfer	No (reference)	-	0.750
	Yes	0.82 (0.23, 2.84)	

Long term outcomes

The VSTR follow-up was extended from 6-months to include 12 and 24-months post-injury, and a measure of health-related quality of life, from 2006-07. Not all cases in the 2009-10 financial year were eligible for 24-month follow-up. Therefore, the outcomes presented are limited to 6 and 12-months post-injury. Additionally, as follow-up of paediatric (<15 years) cases was not commenced until September 2010, all analyses related to follow-up are limited to adults.

For each outcome, factors considered as potential predictors of outcome were age, sex, comorbid status, pre-injury disability, pre-injury employment status, highest level of education, injury group, GCS score, compensable status (TAC or WorkCover vs. other), level of VSTS management (MTS vs. other), region patient lives in, region of injury event, and whether the crash occurred on the road or not. Multivariate GEE models, accounting for the repeated outcome measures at 6 and 12-months, were used to identify important predictors of long term outcome. An a priori interaction between place of injury (road vs. off-road) and compensable status was explored.

Function

There were 868 adult survivors to hospital discharge in the timeframe specified. Using the GOS-E as the primary outcome measure, the follow-up rate at 6-months was 85 per cent (n=737) and 81 per cent at 12-months post-injury (n=706). The functional outcomes at each time point are shown in Table 32. Only two injured motorcyclists surviving to hospital discharge, subsequently died in the first 12-months post-injury (one in discharge – 6-months timeframe, and one between 6 and 12-months post-injury). The prevalence of severe disability was low (11.7% at 6-months and 10.9% at 12-months). Sixteen per cent of cases had fully recovered (upper good recovery) by 6-months and 21 per cent had recovered at 12-months (Table 32).

Table 32: Functional outcome (GOS-E) at 6 and 12-months post-injury

GOS-E rating	6-months (n=737)	12-months (n=706)
Death/vegetative state	1 (0.1)	2 (0.3)
Lower severe disability	42 (5.7)	31 (4.4)
Upper severe disability	44 (6.0)	46 (6.5)
Lower moderate disability	227 (30.8)	166 (23.5)
Upper moderate disability	221 (30.0)	230 (32.6)
Lower good recovery	85 (11.5)	86 (12.2)
Upper good recovery	117 (15.9)	145 (20.5)

Age, GCS on arrival at hospital, the injuries sustained, place of injury, compensable status and the highest level of education were important predictors of long term functional recovery. The adjusted odds of functional recovery decreased by 2 per cent for each increasing year of age (Table 33). Functional recovery was more likely for cases with isolated head injury or chest/abdominal injuries only, compared to motorcyclists who had sustained orthopaedic injuries only. Not surprisingly, the adjusted odds of functional recovery were extremely low for spinal cord injury cases. There was no interaction between the place (road vs. off-road) of injury and compensable status. Both factors were important predictors of outcome with crashes occurring on the road, and those covered by TAC or WorkCover, demonstrating lower odds of functional recovery, despite adjustment for the types of injuries sustained. Consistent with other studies of outcomes following serious injury, cases with lower levels of education were less likely to have recovered, potentially reflecting the types of occupations of these education groups (Table 33).

Table 33: Predictors of functional recovery (GOS-E upper good recovery) (multivariate analysis)

Predictor		AOR (95% CI)	p-value
Age	Years	0.98 (0.96, 0.99)	0.002
Glasgow Coma Scale score on arrival	13-15 (reference)	1	
	9-12	1.37 (0.62, 3.03)	0.430
	3-8	0.14 (0.04, 0.47)	0.001
Injury group	Orthopaedic injuries only (reference)	1	
	Isolated head injury	2.67 (1.18, 6.04)	0.019
	Head and other injuries	1.55 (0.99, 2.42)	0.053
	Spinal cord injury	0.10 (0.01, 0.81)	0.031
	Chest and/or abdominal injuries only	3.29 (1.81, 5.96)	<0.001
	Other	0.91 (0.46, 1.78)	0.777
Place of injury	Off-road (reference)	1	
	Road	0.49 (0.31, 0.77)	0.002
Compensable status	Not compensable (reference)	1	
	Compensable	0.61 (0.39, 0.96)	0.034
Level of education	University degree (reference)	1	
	Advanced diploma, diploma, certificate	0.52 (0.30, 0.90)	0.020
	Completed high school	0.66 (0.35, 1.24)	0.195
	Did not complete high school	0.52 (0.31, 0.89)	0.017
Comorbid status	None (reference)	1	
	CCI=1	0.66 (0.43, 1.03)	0.067
	CCI>1	0.28 (0.07, 1.13)	0.074
Employment status	Not working (reference)	1	
	Working	1.14 (0.59, 2.19)	0.702
Sex	Male (reference)	1	
	Female	1.12 (0.58, 2.16)	0.730
Region of injury	Metropolitan Melbourne (reference)	1	
	Regional Victoria	1.32 (0.83, 2.08)	0.239
Residential region	Metropolitan Melbourne (reference)	1	
	Regional Victoria	0.78 (0.50, 1.22)	0.280
	Interstate/overseas	0.60 (0.25, 1.40)	0.237
Trauma system level of care	Non-MTS hospital (reference)	1	
	MTS hospital	0.90 (0.51, 1.62)	0.735
Pre-injury disability	None (reference)	1	
	Mild/moderate/marked/severe	0.88 (0.45, 1.73)	0.719

Return to work

The pre-injury work status was known for 789 (90.9%) adult survivors to hospital discharge, with 89 per cent (n=699) working prior to injury. Just over half (56.4%) of the patients working prior to injury had returned to work by 6-months post-injury, while the return to work rate increased to 67 per cent at 12-months.

Table 34: Predictors of longer term return to work (multivariate analysis)

Predictor		AOR (95% CI)	p-value
Glasgow Coma Scale score on arrival	13-15 (reference)	1	
	9-12	1.33 (0.57, 3.08)	0.504
	3-8	0.28 (0.14, 0.55)	0.003
Injury group	Orthopaedic injuries only (reference)	1	
	Isolated head injury	3.11 (1.82, 1.63)	0.030
	Head and other injuries	1.33 (0.88, 2.00)	0.178
	Spinal cord injury	0.06 (0.02, 0.20)	<0.001
	Chest and/or abdominal injuries only	6.34 (2.10, 19.17)	0.001
	Other	1.42 (0.78, 2.58)	0.251
Place of injury	Off-road (reference)	1	
	Road	0.32 (0.19, 0.54)	<0.001
Compensable status	Not compensable (reference)	1	
	Compensable	0.47 (0.28, 0.79)	0.005
Trauma system level of care	Non-MTS hospital (reference)	1	
	MTS hospital	0.36 (0.18, 0.71)	0.003
Level of education	University degree (reference)	1	
	Advanced diploma, diploma, certificate	0.46 (0.29, 0.78)	0.004
	Completed high school	0.57 (0.30, 1.09)	0.090
	Did not complete high school	0.36 (0.21, 0.62)	<0.001
Age	Years	0.99 (0.97, 1.00)	0.201
Comorbid status	None (reference)	1	
	CCI=1	0.87 (0.60, 1.26)	0.457
	CCI>1	0.56 (0.27, 1.13)	0.105
Sex	Male (reference)	1	
	Female	0.86 (0.46, 1.60)	0.641
Region of injury	Metropolitan Melbourne (reference)	1	
	Regional Victoria	1.25 (0.83, 1.88)	0.293
Residential region	Metropolitan Melbourne (reference)	1	
	Regional Victoria	0.77 (0.50, 1.17)	0.221
	Interstate/overseas	0.63 (0.30, 1.28)	0.201
Pre-injury disability	None (reference)	1	
	Mild/moderate/marked/severe	1.47 (0.73, 2.94)	0.276

Consistent with the prediction of functional recovery, GCS on arrival at the hospital, injury group, place of injury, level of education, level of care, and compensable status were important predictors of return to work for motorcycle major trauma victims working prior to injury (Table 34). A severe head injury (GCS 3-8), spinal cord injury, compensation by TAC or WorkCover, and sustaining the injury in a road-related crash were also associated with lower adjusted odds of return to work. Cases managed at MTS hospitals, and those with lower levels of education, were also less likely to return to work.

Health-related quality of life

The SF-12 is a measure of health-related quality of life, relying on patient perceptions, experiences and expectations. As such, this instrument cannot be administered by proxy and SF-12 scores are not collected for all patients (e.g. head injured patients with cognitive difficulties). SF-12 scores were available for 81 per cent (n=579) of patients followed-up at 6-months and 79 per cent of patients followed-up at 12-months (n=573). The mental and physical health scores of cases, and the Australian population norms, are shown in Table 35. The mean physical health (PCS-12) score for motorcycle-related orthopaedic trauma patients was significantly below the mean score for the Australian population at 6-months (t=-18.4, p<0.0001) and 12-months (t=-16.1, p<0.0001) post-injury. Mental health scores (MCS-12) were also well below population norms at 6-months (t=-9.6, p<0.0001) and 12-months (t=-10.4, p<0.0001).

Table 35: Mean physical (PCS-12) and mental (MCS-12) scores of motorcycle-related orthopaedic trauma cases

SF-12 summary score		6-months	12-months	Australian population
PCS-12 score	**Mean (95%CI)**	38.8 (37.7,39.9)	40.2 (39.1,41.3)	49.7 (49.1,50.3)
MCS-12 score	**Mean (95%CI)**	48.1 (46.9,49.2)	47.7 (46.6,48.8)	53.4 (52.9,53.9)

Figure 27 shows the standardised mean difference (SMD) of the PCS-12 and MCS-12 scores at 6 and 12-months post-injury. The SMD provides a method of showing the degree of deviation from the population norm by standardising individual scores by age and gender. The SMD is effectively an effect size where an SMD of zero suggests no difference to population norms and a score above zero suggests health-related quality of life of major trauma motorcyclists above population norms. The size of the SMD represents the magnitude of difference between the SF-12 scores of the Australian population and motorcycle-related major trauma patients, with values >0.8 considered to be large. The SMD for the physical and mental health scores of all motorcycle-related orthopaedic trauma cases were below the population norms at 6 and 12-months, with large effects noted for physical health and moderate effects for mental health. While physical health scores improved from 6 to 12-months, the difference between the mental health scores of the patient and general population period increased in this timeframe (Figure 27).

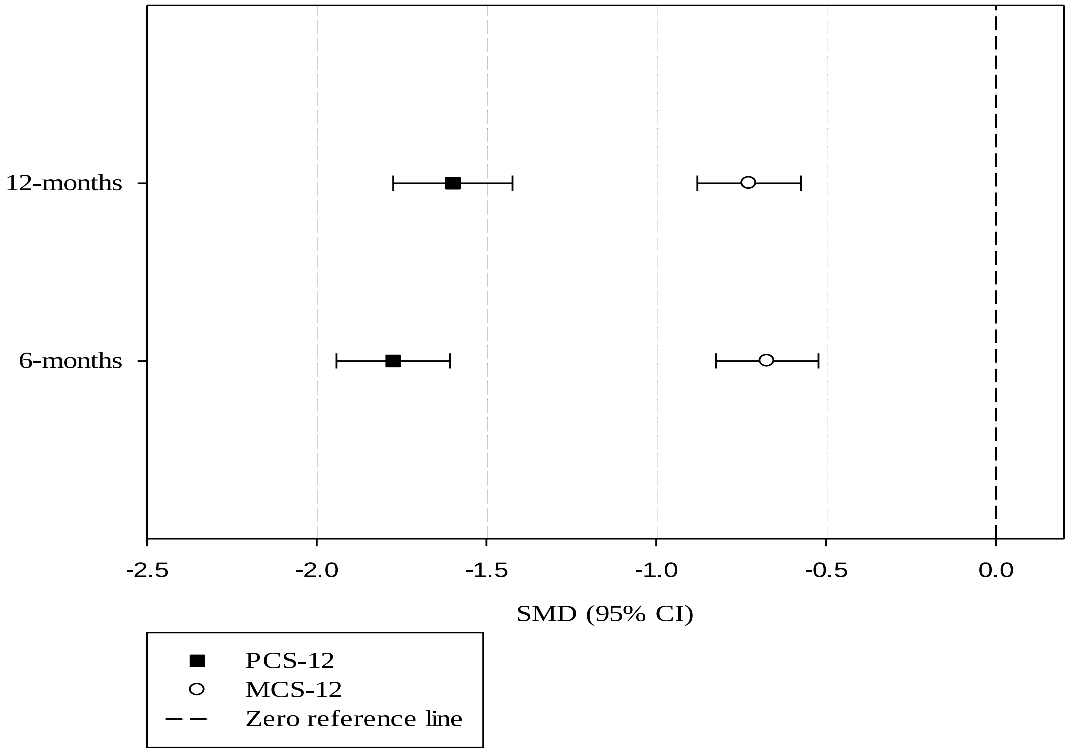

Figure 27: Comparison of SF-12 physical and mental health scores of motorcycle-related major trauma cases relative to the Australian population

Adjusted for age, sex and other potential confounders, the injuries sustained, level of education, and the GCS on arrival at hospital were important predictors of longer term physical health (PCS-12 scores) (Table 36). Keeping all other factors stable, the PCS-12 scores of motorcycle major trauma crash victims with chest and/or abdominal injuries only were more than 10 points higher than cases who sustained orthopaedic injuries. The PCS-12 scores were almost 7 points lower for spinal cord injury patients compared to those with orthopaedic injuries. Cases with an advanced diploma, diploma or certificate, and those not completing high school, demonstrated lower physical health scores than patients with a university level education (Table 36). Adjusting for the severity of head injury and other factors, head injured patients reported better physical health outcomes than orthopaedic cases, although the administration of the PCS-12 is limited to head injured patients with none to minimal cognitive deficit, representing the less severe end of the head injury spectrum.

Table 36: Predictors of longer term physical health (PCS-12 scores) (multivariate analysis)

Predictor		Coefficient (95% CI)	p-value
Injury group	Orthopaedic injuries only (reference)	-	
	Isolated head injury	6.81 (2.06, 11.56)	0.005
	Head and other injuries	3.95 (1.59, 6.32)	0.001
	Spinal cord injury	-6.60 (-11.95, -1.25)	0.016
	Chest and/or abdominal injuries only	10.19 (6.36, 14.02)	<0.001
	Other	3.22 (-0.08, 6.52)	0.056
Level of education	University degree (reference)	-	
	Advanced diploma, diploma, certificate	-5.03 (-7.84, -2.21)	<0.001
	Completed high school	-1.07 (-4.54, 2.40)	0.546
	Did not complete high school	-3.24 (-6.06, -0.43)	0.024
Glasgow Coma Scale score on arrival	13-15 (reference)	-	
	9-12	1.17 (-3.28, 5.61)	0.607
	3-8	-4.35 (-8.33, -0.37)	0.032
Age	Years	-0.07 (-0.14, 0.01)	0.060
Trauma system level of care	Non-MTS hospital (reference)	-	
	MTS hospital	1.75 (-1.37, 4.87)	0.271
Comorbid status	None (reference)	-	
	CCI=1	-0.82 (-2.96, 1.32)	0.451
	CCI>1	-3.41 (-7.59, 0.78)	0.111
Sex	Male (reference)	-	
	Female	0.11 (-3.36, 3.59)	0.949
Region of injury	Metropolitan Melbourne (reference)	-	
	Regional Victoria	1.38 (-0.83, 3.60)	0.220
Residential region	Metropolitan Melbourne (reference)	-	
	Regional Victoria	0.15 (-2.12, 2.43)	0.897
	Interstate/overseas	-1.59 (-5.76, 2.59)	0.456
Pre-injury disability	None (reference)	-	
	Mild/moderate/marked/severe	-1.23 (-4.48, 2.01)	0.455
Compensable status	Not compensable (reference)	-	
	Compensable	-2.26 (-6.04, 1.52)	0.240
Place of injury	Off-road (reference)	-	
	Road	-0.95 (-5.11, 3.21)	0.653

Adjusting for age, gender and other key confounders, motorcyclists injured in road crashes reported lower MCS-12 scores than motorcyclists injured in off-road crashes (Table 37). Injured motorcyclists with pre-existing disability, and comorbidities, also demonstrated lower adjusted MCS-12 scores when compared to those without pre-injury disability or comorbidities (Table 37). There was no association between longer term mental health and the type of injuries sustained, level of education and other key factors.

Table 37: Predictors of longer term mental health (MCS-12 scores) (multivariate analysis)

Predictor		Coefficient (95% CI)	p-value
Place of injury	Off-road (reference)	-	
	Road	-2.96 (-5.66, -0.27)	0.031
Pre-injury disability	None (reference)	-	
	Mild/moderate/marked/severe	-3.62 (-7.09, -0.15)	0.041
Comorbid status	None (reference)	-	
	CCI=1	-3.53 (-5.82, -1.24)	0.003
	CCI>1	0.41 (-4.06, 4.87)	0.858
Injury group	Orthopaedic injuries only (reference)	-	
	Isolated head injury	-1.27 (-6.35, 3.81)	0.624
	Head and other injuries	-1.07 (-3.60, 1.46)	0.409
	Spinal cord injury	3.84 (-1.93, 9.62)	0.192
	Chest and/or abdominal injuries only	0.81 (-3.30, 4.92)	0.698
	Other	-0.36 (-3.89, 3.17)	0.841
Level of education	University degree (reference)	-	
	Advanced diploma, diploma, certificate	-1.03 (-4.03, 1.97)	0.501
	Completed high school	1.29 (-2.41, 4.99)	0.493
	Did not complete high school	-1.64 (-4.63, 1.36)	0.284
Glasgow Coma Scale score on arrival	13-15 (reference)	-	
	9-12	-0.04 (-4.86, 4.78)	0.986
	3-8	-2.87 (-7.02, 1.27)	0.174
Age	Years	-0.02 (-0.09, 0.06)	0.686
Trauma system level of care	Non-MTS hospital (reference)	-	
	MTS hospital	1.98 (-1.36, 5.32)	0.245
Sex	Male (reference)	-	
	Female	-1.19 (-4.90, 2.52)	0.528
Region of injury	Metropolitan Melbourne (reference)	-	
	Regional Victoria	1.92 (-0.44, 4.29)	0.111
Residential region	Metropolitan Melbourne (reference)	-	
	Regional Victoria	1.27 (-1.15, 3.69)	0.303
	Interstate/overseas	0.10 (-4.36, 4.57)	0.964
Compensable status	Not compensable (reference)	-	
	Compensable	-2.13 (-4.95, 0.68)	0.137

VI. Victorian Orthopaedic Trauma Outcomes Registry (VOTOR)

Demographic profile of cases

There were 2,221 motorcycle-related orthopaedic trauma cases registered by VOTOR in the 5-year period spanning July 2005 to June 2010, although registration of patients was limited in 2006-07 due to funding constraints. Only 88 motorcycle-related cases were enrolled in 2006-07. The profile of all cases is shown in Table 37. Consistent with ED presentations, hospital admissions, major trauma data, and coroner's data, the majority of motorcycle-related orthopaedic trauma cases were young, male, previously healthy and working prior to injury (Table 38).

Table 38: Demographic and pre-injury status of VOTOR registered motorcycle-related trauma (n=2,221)

Descriptor		
Age	Mean (SD) years	35.9 (12.9)
	Range (years)	15-87
Sex	n (%) Male	2,041 (91.9)
Comorbid status*	n (%)	
	No documented comorbidity	1666 (84.4)
	CCI=1	261 (13.2)
	CCI>1	47 (2.4)
Working prior to injury*	n (%) Yes	1,745 (89.5)
Highest level of education*	n (%)	
	University education	282 (14.8)
	Advanced diploma/diploma/certificate	646 (33.9)
	Completed high school	276 (14.5)
	Did not complete high school	703 (36.9)
Pre-injury disability*	n (%)	
	None	1826 (91.5)
	Mild	102 (5.1)
	Moderate to severe	67 (3.4)

*Pre-injury work status missing for 271 cases; highest level of education missing for 314 cases; pre-injury disability missing for 226 cases; comorbid status missing for 247 cases

Injury event

Most cases were sustained on a road, street or highway, and involved the motorcycle rider rather than a pillion passenger (Table 39).

Table 39: Injury event details of VOTOR registered motorcycle-related trauma (n=2,221)

Descriptor		
Place of occurrence*	n (%)	
	Road, street or highway	1,350 (75.5)
	Athletic or sports area	143 (8.0)
	Farm	58 (3.2)
	Place for recreation	26 (1.5)
	Other specified place	210 (11.8)
Person injured	n (%)	
	Motorcycle rider	2,154 (97.0)
	Pillion passenger	67 (3.0)

*Place of injury unspecified for 434 cases

In-hospital outcomes

Thirty per cent (n=676) of cases sustained non-orthopaedic injuries. The 2,221 cases sustained 3,995 orthopaedic injuries; an average of 1.8 injuries per case.

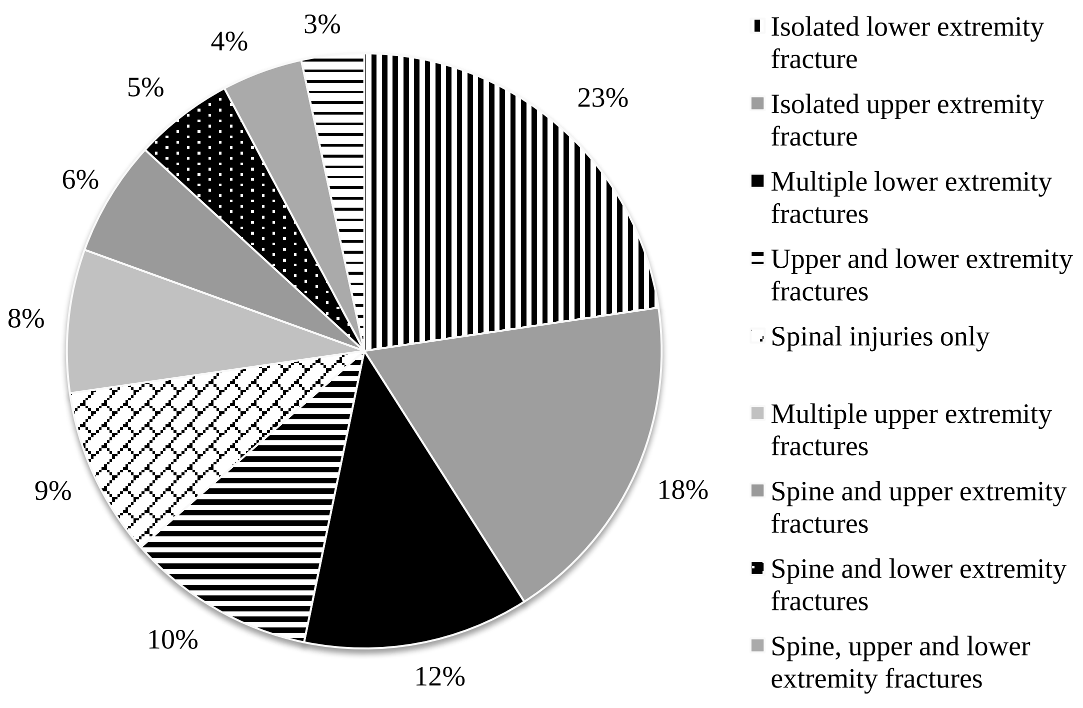

Figure 28: Orthopaedic injury group of motorcycle-related trauma

Figure 28 shows the broad orthopaedic injury group of cases, while Table 40 shows the prevalence of specific orthopaedic injuries in the cohort. Isolated extremity fractures accounted for 41 per cent of cases (Figure 28). Tibial and ankle fractures were most prevalent, sustained by a quarter of cases. Forearm, thoracic spine, clavicle and pelvic fractures were also prevalent in this cohort of injured motorcyclists (Table 40).

Table 40: Orthopaedic injuries sustained by motorcycle-related orthopaedic trauma cases

Descriptor	n (%) of cases
Tibia or ankle fracture	551 (24.8)
Forearm fracture	490 (22.1)
Thoracic spine fracture	350 (15.8)
Clavicle fracture	310 (13.9)
Pelvic fracture	280 (12.6)
Femur fracture – shaft or distal femur	257 (11.6)
Foot fracture	227 (10.2)
Scapula fracture	220 (9.9)
Lumbar spine fracture	208 (9.4)
Cervical spine fracture	204 (9.2)
Fibula fracture	177 (8.0)
Humerus fracture	139 (6.3)
Wrist or hand fracture	100 (4.5)
Fractured neck of femur	95 (4.3)
Patella fracture	73 (3.3)
Ankle dislocation	66 (3.0)
Shoulder dislocation	57 (2.6)
Hip dislocation	51 (2.3)
Knee dislocation	39 (1.8)
Elbow dislocation	28 (1.3)
Bracial plexus injury	26 (1.2)
Other injury	47 (2.1)

In-hospital outcomes

The injuries sustained by motorcycle trauma cases were serious enough to require admission to ICU in 16 per cent of cases, though less than one per cent of cases (n=10) died during their hospital stay. The majority of cases stayed at least five days in hospital and more than one in four cases were discharged to an inpatient rehabilitation centre (Table 41).

Table 41: In-hospital outcomes of VOTOR registered motorcycle-related trauma (n=2,221)

Descriptor		
Hospital	n (%)	
	The Alfred	1,041 (46.9)
	RMH	787 (35.4)
	Geelong	198 (8.9)
	Northern	195 (8.8)
ICU admission	n (%) Yes	358 (16.2)
Hospital length of stay	Median (IQR) days	5.0 (2.8-10.7)
Discharge destination	n (%)	
	Home	1,490 (68.3)
	Inpatient rehabilitation	602 (27.6)
	Hospital for convalescence	46 (2.1)
	In-hospital death	10 (0.5)
	Other	34 (1.6)

Long term outcomes

Methods for follow-up of VOTOR cases changed in 2006-07 to include a measure of function; the Glasgow Outcome Scale – Extended (GOS-E). The SF-12 and return to work data have been collected since the commencement of VOTOR. However, for consistency, cases with a date of injury from the 1 July 2006 were included in the analysis of long term outcomes.

Function

There were 1,570 motorcycle-related orthopaedic trauma cases discharged alive from participating VOTOR hospitals from 1 July 2006 to 30 June 2010. Using the GOS-E as the primary outcome measure, the follow-up rate at 6-months was 86 per cent (n=1,342) and 87 per cent at 12-months post-injury (n=1,369).

The post-discharge death rate for motorcycle-related trauma is low, and functional improvement from 6 to 12 months was evident (Table 42). Overall, the proportion of cases still experiencing severe disability at 12-months was low. Nevertheless, three out of four cases reported ongoing disability (less than an upper good recovery) 12-months after injury.

Table 42: Functional outcomes of motorcycle-related orthopaedic trauma cases

GOS-E rating	6-months (n=1,342)	12-months (n=1,369)
Death/vegetative state	1 (0.1)	2 (0.2)
Lower severe disability	29 (2.2)	25 (1.8)
Upper severe disability	47 (3.5)	34 (2.5)
Lower moderate disability	351 (26.2)	274 (20.0)
Upper moderate disability	454 (33.8)	456 (33.3)
Lower good recovery	207 (15.4)	217 (15.9)
Upper good recovery	253 (18.8)	361 (26.4)

The adjusted odds of a full recovery within 12-months reduced by 2 per cent for each increasing year of age, with motorcyclists compensated by TAC or WorkCover demonstrating less than half the odds of a functional recovery compared to non-compensable cases (Table 43). Odds of a functional recovery were higher for isolated upper extremity fracture cases and lower for cases with multiple lower extremity and combined upper and lower extremity fracture cases, compared to cases sustaining an isolated lower extremity fracture (Table 43). Consistent with major trauma motorcycle crash victims, cases with lower levels of education demonstrated lower adjusted odds of recovery compared to motorcyclists with a university level of education.

Table 43: Predictors of functional recovery (GOS-E upper good recovery) (multivariate **analysis)**

Predictor		AOR (95% CI)	p-value
Age	Years	0.98 (0.97, 0.99)	<0.001
Injury group	Isolated lower extremity (reference)	1	
	Soft tissue injury	1.21 (0.62, 2.34)	0.580
	Isolated upper extremity	2.20 (1.66, 2.92)	<0.001
	Multiple upper extremity	1.23 (0.78, 1.94)	0.379
	Multiple lower extremity	0.60 (0.39, 0.93)	0.021
	Upper and lower extremity	0.63 (0.40, 0.97)	0.035
	Isolated spinal injuries	1.32 (0.92, 1.91)	0.134
	Spine and upper extremity	1.32 (0.82, 2.12)	0.247
	Spine and lower extremity	0.81 (0.47, 1.40)	0.447
	Spine, upper and lower extremity	0.49 (0.23, 1.06)	0.071
Compensable status	Not compensable (reference)	1	
	Compensable	0.48 (0.37, 0.61)	<0.001
Level of education	University degree (reference)	-	
	Advanced diploma, diploma, certificate	0.66 (0.48, 0.90)	0.010
	Completed high school	0.79 (0.55, 1.14)	0.210
	Did not complete high school	0.73 (0.53, 1.00)	0.050
Pre-injury disability	None (reference)	-	
	Mild/moderate/marked/severe	0.56 (0.36, 0.87)	0.010
Comorbid status	None (reference)	-	
	CCI=1	0.65 (0.45, 0.92)	0.017
	CCI>1	0.41 (0.14, 1.19)	0.100
Employment status	Not working (reference)	-	
	Working	1.09 (0.74, 1.62)	0.664
Sex	Male (reference)	-	
	Female	1.05 (0.73, 1.53)	0.784
Associated injuries	No (reference)	-	
	Yes	0.83 (0.65, 1.07)	0.153
Place of injury	Off-road (reference)	-	
	Road	1.05 (0.82, 1.36)	0.681

Return to work

Of the 1,311 cases discharged alive and working prior to injury, return to work status was known for 1,176 (89.7%) at 6-months and 1,229 (93.7%) at 12-months. Ninety per cent of cases were working prior to injury, but the return to work rate was 68 per cent (n=799) at 6-months and 76 per cent (n=934) at 12-months.

Compensation status, nature of injuries sustained, highest level of education, comorbid status and the presence of non-orthopaedic injuries were important predictors of longer term return to work (Table 44). Consistent with major trauma motorcycle crash victims, and other cohorts of trauma patients, cases compensated by TAC and WorkCover demonstrated much lower adjusted odds or returning to work. Return to work was more likely for soft tissue injury and isolated upper extremity cases, relative to isolated lower extremity fractures. In contrast, the odds of return to work were lower where the upper and lower extremities, spine and lower extremity, and spine, upper and lower extremities were involved (Table 44). The presence of associated non-orthopaedic injuries also lessened the odds of return to work, as did the presence of serious comorbidities (CCI>1).

Table 44: Predictors of longer term return to work for orthopaedic trauma cases.

Predictor		AOR (95% CI)	p-value
Compensable status	Not compensable (reference)	1	
	Compensable	0.54 (0.40, 0.73)	<0.001
Injury group	Isolated lower extremity (reference)	1	
	Soft tissue injury	3.12 (1.11, 8.80)	0.032
	Isolated upper extremity	2.03 (1.42, 2.91)	<0.001
	Multiple upper extremity	1.43 (0.84, 2.41)	0.180
	Multiple lower extremity	0.71 (0.49, 1.02)	0.064
	Upper and lower extremity	0.45 (0.32, 0.65)	<0.001
	Isolated spinal injuries	1.13 (0.76, 1.68)	0.544
	Spine and upper extremity	0.93 (0.58, 1.50)	0.776
	Spine and lower extremity	0.42 (0.27, 0.68)	<0.001
	Spine, upper and lower extremity	0.32 (0.19, 0.56)	<0.001
Level of education	University degree (reference)	1	
	Advanced diploma, diploma, or certificate	0.43 (0.30, 0.62)	<0.001
	Completed high school	0.60 (0.38, 0.93)	0.021
	Did not complete high school	0.33 (0.22, 0.47)	<0.001
Associated injuries	No (reference)	1	
	Yes	0.68 (0.53, 0.87)	0.003
Comorbid status	None (reference)	1	
	CCI=1	0.79 (0.58, 1.09)	0.154
	CCI>1	0.36 (0.18, 0.74)	0.005
Age	Years	1.00 (0.99, 1.01)	0.401
Pre-injury disability	None (reference)	1	
	Mild/moderate/marked/severe	0.78 (0.51, 1.20)	0.262
Sex	Male (reference)	1	
	Female	0.89 (0.60, 1.32)	0.561
Place of injury	Off-road (reference)	1	
	Road	0.93 (0.72, 1.20)	0.590

Health-related quality of life

As noted previously in this report, the SF-12 cannot be administered by proxy. Therefore, SF-12 scores were only available for 81 per cent (n=1,087) of patients followed-up at 6-months and 80 per cent of patients followed-up at 12-months (n=1,098). The mental and physical health scores of cases, and the Australian population norms, are shown in Table 45. The mean physical health (PCS-12) score for motorcycle-related orthopaedic trauma patients was significantly below the mean score for the Australian population at 6-months (t=-19.01, p<0.0001) and 12-months (t=-14.04, p<0.0001) post-injury. Mental health scores (MCS-12) were also well below population norms at 6-months (t=-4.04, p=0.0001) and 12-months (t=-5.54, p<0.0001).

Table 45: Mean physical (PCS-12) and mental (MCS-12) scores of motorcycle-related orthopaedic trauma cases

SF-12 summary score		6-months	12-months	Australian population
PCS-12 score	**Mean (95%CI)**	40.6 (39.9,41.3)	43.1 (42.4,43.8)	49.7 (49.1,50.3)
MCS-12 score	**Mean (95%CI)**	51.7 (51.0,52.3)	51.0 (50.4,51.7)	53.4 (52.9,53.9)

Figure 29 shows the standardised mean difference (SMD) of the PCS-12 and MCS-12 scores at 6 and 12-months post-injury. The SMD provides a method of showing the degree of deviation from the population norm by standardising individual scores by age and gender. An SMD of zero suggests no difference to population norms and a score above zero suggests SF-12 summary scores above population norms. The SMD for the physical and mental health scores of all motorcycle-related orthopaedic trauma cases were below the population norms at 6 and 12-months. While physical health scores improved over time, there was a small decline in mental health scores over the same period (Figure 29).

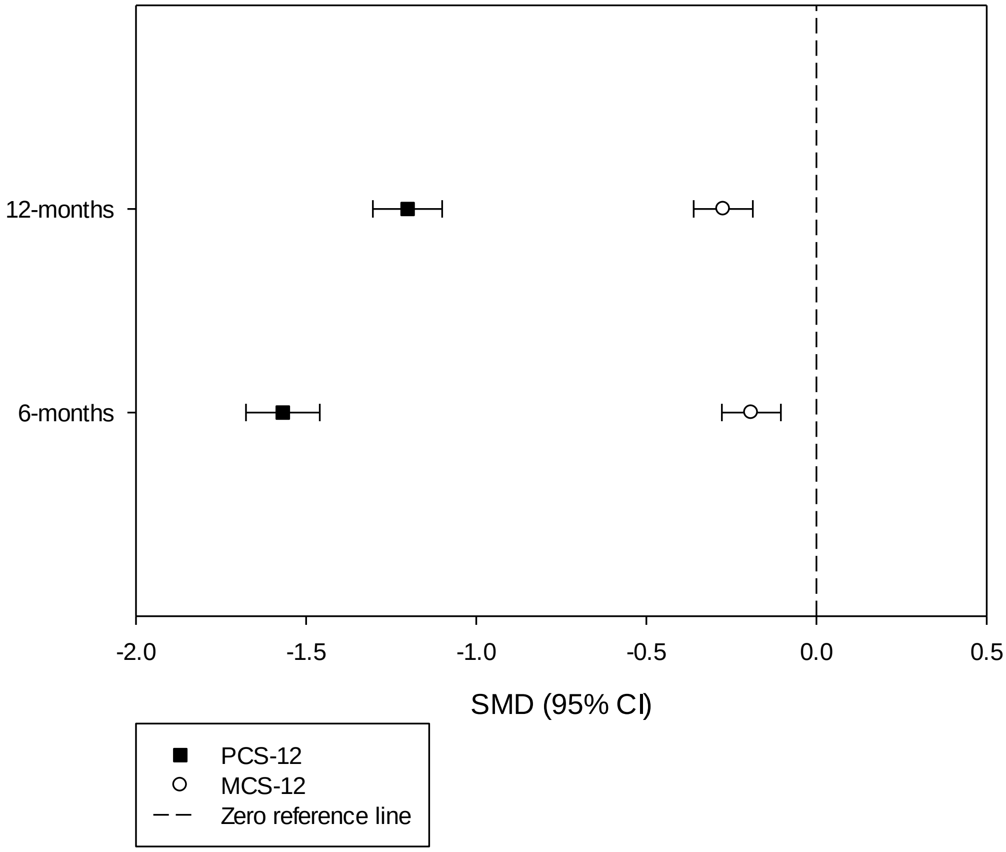

Figure 29: Comparison of SF-12 physical and mental health scores of motorcycle-related orthopaedic trauma cases relative to the Australian population

Important predictors of longer term physical health following motorcycle crashes resulting in orthopaedic trauma were age, the nature of the orthopaedic injuries sustained, compensable status, level of education, pre-existing comorbidities and disability, and whether the patient was working prior to injury (Table 46). Factors associated with better physical health outcomes were working prior to injury, and sustaining only soft tissue or isolated upper extremity injuries relative to isolated lower extremity injuries. Compensation by TAC or WorkCover, lower levels of education, the presence of pre-existing disability or comorbidities, and injuries involving multiple orthopaedic injuries or multiple lower extremity injuries, were all associated with poorer longer term physical health as measured by the PCS-12 score (Table 46).

Table 46: Predictors of longer term physical health (PCS-12 scores)

Predictor		Coefficient (95% CI)	p-value
Age	Years	-0.10 (-0.14, -0.06)	<0.001
Injury group	Isolated lower extremity (reference)	-	
	Soft tissue injury	4.12 (0.45, 7.79)	0.028
	Isolated upper extremity	4.83 (3.24, 6.43)	<0.001
	Multiple upper extremity	1.92 (-0.48, 4.32)	0.116
	Multiple lower extremity	-3.60 (-5.51, -1.69)	<0.001
	Upper and lower extremity	-2.23 (-4.22, -0.25)	0.028
	Isolated spinal injuries	1.21 (-0.75, 3.17)	0.225
	Spine and upper extremity	0.96 (-1.50, 3.43)	0.444
	Spine and lower extremity	-2.98 (-5.57, -0.39)	0.024
	Spine, upper and lower extremity	-6.30 (-9.20, -3.40)	<0.001
Compensable status	Not compensable (reference)	-	
	Compensable	-4.19 (-5.56, -2.81)	<0.001
Level of education	University degree (reference)	-	
	Advanced diploma, diploma, or certificate	-3.08 (-4.70, -1.46)	<0.001
	Completed high school	-0.59 (-2.55, 1.38)	0.560
	Did not complete high school	-1.77 (-3.44, -0.10)	0.037
Pre-injury disability	None (reference)	-	
	Mild/moderate/marked/severe	-3.27 (-5.23, -1.32)	0.001
Comorbid status	None (reference)	-	
	CCI=1	-0.31 (-1.96, 1.33)	0.709
	CCI>1	-3.21 (-6.83, 0.42)	0.083
Employment status	Not working (reference)	-	
	Working	2.13 (0.16, 4.09)	0.001
Sex	Male (reference)	-	
	Female	-0.10 (-2.65, 1.18)	0.452
Associated injuries	No (reference)	-	
	Yes	-0.65 (-1.82, 0.62)	0.318
Place of injury	Off-road (reference)	-	
	Road	-0.57 (-1.83, 0.68)	0.369

The most important predictors of longer term mental health outcomes were compensable status, pre-injury employment status, pre-existing comorbidity and disability and whether non-orthopaedic injuries were sustained (Table 47). Keeping all other factors stable, compensable (TAC and WorkCover) cases demonstrated MCS-12 scores 3 points lower than their non-compensable counterparts. Working prior to injury was associated with a 2.7 point higher MCS-12 score than not working prior to injury. Motorcycle-related orthopaedic trauma patients with pre-existing disability and comorbidities demonstrated poorer mental health outcomes than patients with no pre-injury comorbidities or disability. The presence of associated injuries was associated with a small (1.3 point) decreased in longer term mental health outcomes than orthopaedic trauma cases without associated non-orthopaedic injuries (Table 47).

Table 47: Predictors of longer term mental health (MCS-12 scores) (multivariate analysis)

Predictor		Coefficient (95% CI)	p-value
Compensable status	Not compensable (reference)	-	
	Compensable	-2.99 (-4.31, -1.66)	<0.001
Employment status	Not working (reference)	-	
	Working	2.66 (0.76, 4.56)	0.006
Pre-injury disability	None (reference)	-	
	Mild/moderate/marked/severe	-3.69 (-5.59, -1.79)	<0.001
Comorbid status	None (reference)	-	
	CCI=1	-2.64 (-4.23, -1.05)	0.001
	CCI>1	-3.29 (-6.79, 0.22)	0.066
Associated injuries	No (reference)	-	
	Yes	-1.30 (-2.53, -0.07)	0.039
Place of injury	Off-road (reference)	-	
	Road	-1.21 (-2.43,0.01)	0.051
Injury group	Isolated lower extremity (reference)	-	
	Soft tissue injury	-1.26 (-4.80, 2.29)	0.487
	Isolated upper extremity	0.53 (-1.01, 2.08)	0.498
	Multiple upper extremity	0.26 (-2.06, 2.58)	0.827
	Multiple lower extremity	-0.62 (-2.47, 1.22)	0.508
	Upper and lower extremity	-1.23 (-3.14, 0.69)	0.210
	Isolated spinal injuries	-1.31 (-3..20, 0.58)	0.175
	Spine and upper extremity	-0.51 (-2.89, 1.87)	0.674
	Spine and lower extremity	-2.98 (-5.49, -0.48)	0.020
	Spine, upper and lower extremity	-1.59 (-4.40, 1.21)	0.265
Age	Years	-0.02 (-0.06,0.03)	0.323
Level of education	University degree (reference)	-	
	Advanced diploma, diploma, certificate	-0.17 (-1.73, 1.38)	0.827
	Completed high school	1.23 (-0.68, 3.14)	0.206
	Did not complete high school	-0.76 (-2.36, 0.84)	0.353
Sex	Male (reference)	-	
	Female	-1.20 (-3.05,0.65)	0.203

3.2 Literature review on strategies to improve emergency response to motorcycle crashes

The aim of the literature review was to identify methods to improve the capability of first responders at motorcycle crash scenes and methods to improve the speed of professional response especially in rural and remote areas. After consideration of all potentially relevant abstracts, 79 articles and reports were retrieved and reviewed. Of these, 42 studies and reports on interventions were included in the current review. As there was a very limited number of articles specific to the first response and professional response team management of people injured as a result of motorcycle crashes, evidence was included from the broader area of all motor vehicle crashes and, in some cases, other medical emergencies – where a model of response was relevant to the Victorian context. Below is a summary of the key findings emerging from the literature review relating to describing the problem and models for capacity development of first responders and professional response teams. Where available, evidence of the effectiveness of these models is summarised. On the whole, however, evaluation studies of the effectiveness of these models were not found. Information available on the models of practice and the ideas they might provide to the Victorian context are described.

First responders

The term *"chain of survival"* was developed in the field of emergency care of the cardiac arrest victim and has been used to refer to the steps (or links) between the critical event and definitive medical care (Cummins 1993). Cummins noted that survival of an out-of-hospital cardiac arrest is dependent upon the time associated with key links in the chain: recognition of early warning signs, activation of the emergency medical system, basic cardiopulmonary resuscitation (CPR), defibrillation, intubation, and intravenous medication. He concluded that "the public health challenge is to develop programs that will allow recognition, access, bystander-CPR, defibrillation, and advanced care to be delivered as quickly as possible, ideally within moments of the collapse of a sudden death victim".

A St John Ambulance statement on Basic Life Support cited the "chain of survival" model in the context of a range of emergency medical situations including road trauma and there is some argument that the weakest link in the chain of survival is the first responders – those who are first at the scene and have to manage the situation and the injured person until professional help arrives (St John Ambulance et al. 2006). Pearn (2000) argued that the domain of basic life support inescapably belongs to the incidental bystanders or opportunistic first responders. The trained first responder at the site of a crash can significantly assist in the timely treatment of potentially life threatening or disabling injury (St John Ambulance et al. 2006).

In a review of the literature, Mabbott (Mabbott 2001) reported from the research papers reviewed at the time, that there was a clear case for the reduction in roadside fatalities through the early intervention of laypersons. He suggests that around 7% of lives lost through motor vehicle trauma could be saved by early intervention. Based on an estimate of $672,000 per life lost over a four year period in Queensland, it was estimated that 93 lives could be saved which would amount to $62.5 million in savings if immediate first-aid had been available. Of course it needs to be considered that even if 100% of the population were adequately trained in first-aid, its application may have been far from 100% of events. Having a confident and willing bystander at the scene within the first few minutes to undertake first-aid will not be possible in many situations.

Qualitative analyses indicates that emotional preparedness by the first-responder to the chaotic crash and trauma environment, and possible feelings of helplessness, are important training considerations with both lay and paramedical first-aid providers. A qualitative study comprising interviews with 18 informants (four patients, one next of kin, eight policemen, two firemen and three ambulance staff) was conducted to review the emotional response to the first-responder experience from both the patients' and the first-responders' experiences (Elmqvist et al, 2010). Findings suggested that managing the chaotic environment, coping with feelings of helplessness, being close physically, the importance of touch and calm speech, addressing fear and anxiety, and waiting for further help to arrive, were all highlighted as important elements during that first-responder's encounter. The authors conclude that these aspects should be covered as part of training with lay or paramedical first-aid providers. However given the small sample size, results should be treated with caution.

It is argued that the type of injuries sustained by motorcyclists as well as the use of full faced helmets (Branfoot 1994; Waninger 1998; Waninger 2004), chin straps, and some types of protective clothing meant that there are several unique aspects of airway, circulatory and spine management for motorcycle crash casualties (Hinds, Allen et al. 2007). Knowledge of what to do with protective clothing in the event of injuries to the extremities, and even locating an injured motorcyclist who has crashed in a remote location, present unique considerations in developing strategies to improve the outcome for the injured motorcyclist.

Motorcyclists as first responders

There are a few reports of first-aid training programs for motorcycle riders as first responders, including Biker Angels and First Biker on the Scene which originated in the USA (Roberts-Sanfelipo 2005, ASMI, 2011) and have been implemented in Australia. These training programs were based on the premise that the most likely person to be at the crash scene is another motorcyclist. Over 5000 motorcyclists were trained in 14 US states. While surveys of participants regarding whether they had used their training have been conducted as part of the US programs, no evaluations of their effectiveness have been found. Surveys were sent in 2005 to a sample of students who had completed Bystander Assistance Program (BAP) training in the years 2002 through 2004 (Roberts-Sanfelipo 2005). Survey responses were received from 846 participants (42.3% response rate) of the Bystander Assistance Training program indicating:

- 98% of the students would recommend that a friend take the course
- 96% felt the class was useful to them personally
- 29% reported using the training in a crash or any other situation – with the majority reporting using the information to a considerable degree.
- 5% had been involved in a crash themselves and nearly 50% of these reported using the information (a great deal, i.e. 10 on a scale of 1 to 10) in their own crash.

The author concluded that increased confidence, a focus on securing the scene and focusing on life threatening injuries among bystanders have the potential to improve outcomes in motorcyclists involved in traffic crashes (Roberts-Sanfelipo 2005). Course content included CPR and first-aid skills training as well specific issues related to motorcycle trauma response such as helmet removal, Jaw Thrust Rescue Breathing (a technique used to protect the neck in the event breathing must be supported), how to handle the crash scene, how to remove the bike from someone if they were still under it, and how best to move someone to safety if deemed necessary. Results from feedback surveys on an earlier and similar program, the ASMI Bystander Assistance Program conducted in conjunction with the Wisconsin

Department of Transport, were closely aligned with the 2005 process evaluation findings (Roberts 1999).

“Biker Angels” based on the USA model (above) is a Bystander Assistance Program designed to empower motorcyclists to manage a crash scene until emergency services arrive and train riders in the area of the specifics of motorcycle trauma that are not taught in standard first aid classes. (ASMI 2011). A number of courses, including “crash course for the motorcyclist" through to "professional classes for emergency responders”, have been available since early 2011 in most states and territories, including Victoria. To date, no evaluation of this program has been reported; however Accident Scene Management Australia is currently conducting evaluations of its courses including class assessments and a survey 1-month, 6-months and 12-months post training.

A number of similar courses exist in other industrialised countries, including “First Bike on Scene”: North West Ambulance Service (UK) and “First-aid for motorbikers” (NorthWest Ambulance Service 2012; React First UK 2012). The courses cover difficult decisions not covered by a standard basic first aid course, including when and how to remove a casualty’s helmet and managing scene safety. Other elements include: vital signs and incident management; safe best practice – protecting the scene, casualty moving and handling techniques; airway management/breathing problems; circulation problems/cardiopulmonary resuscitation (CPR); spinal management; helmet removal, simulated incidents – using participants’ own bike gear. No formal evaluations of the effectiveness of these programs were found.

Commercial drivers

Training of commercial drivers, notably taxi drivers and truck drivers, has been undertaken in other, but primarily low income, countries. These have tended to focus on all motor vehicle crashes, not specifically motorcycle crashes (Alonso-Serra 1997; Tiska 2004; Arellano, Mello et al. 2010; Geduld 2011). Tiska, for example, described the skills covered as including: scene management/universal precautions; moving casualties and care with regard to spinal injuries; first-aid/CPR, the first-aid kit. Training was conducted by emergency medical professionals. The challenge was described as ensuring the information was understandable by lay persons of low educational backgrounds. While the model is possibly worth considering (and perhaps extended to heavy vehicle drivers who are more likely to be on rural roads) the findings from the evaluations of these programs, conducted in Ghana (Tiska 2004), the Dominican Republic (Arellano, Mello et al. 2010) and Madagascar (Geduld 2011), regarding the success of these strategies cannot be generalised to the Victorian context – given the differences in population density of rural Victoria and most low income countries, and differences relating to availability of professional emergency and medical services.

All licensed drivers

Over the past decade, countries in the United Kingdom and Europe have introduced recommendations from the World Health Organisation and the Red Cross that all learner drivers be knowledgeable on how to respond in the event of being the first on the scene of a crash or to obtain a first-aid certificate from a registered organisation, e.g. Red Cross (Fiander 2001; Global Road Safety Partnership 2003). The skills covered include how to: respond to bleeding and breathing problems; protect the scene to prevent further crashes; assess the physical state; summon help (and what information to provide); respond to life threatening conditions; and how to offer psychological help. The approach typically taken in these countries (United Kingdom and other European countries) is to work with communities to complement existing services (Fiander 2001). The Red Cross advocated for all registered motor vehicles also to have a first aid kit in the glove box (Fiander 2001). In Belgium, it has been a legal requirement since 1975 that all motor vehicles carry a first aid kit, a first aid guidance fact sheet as well as warning devices.

Despite almost half of the EU countries having implemented the learner driver first-aid training initiative, there is only one reported evaluation study (Adelborg, Thim et al. 2011). This study, conducted with 115 Danish participants by way of pre-post multiple choice knowledge tests, found that almost all knowledge areas improved significantly after the training, and confidence levels in applying first-aid and responding appropriately in a medical emergency improved. The study does not indicate how long after the training the post-test was undertaken. It is not known, therefore, if the training has any long-term impact on the knowledge of first-aid and basic life support. No studies were identified that evaluate the impact of the learner driver first-aid and basic life support training in terms of the proportion who have used the training in a crash or other emergency situation or on outcomes such as serious injury and mortality following a crash.

Overall, the literature suggests that there is potential value of first-aid training as a requirement for newly licensed drivers (or motorcycle riders), as a strategy to reduce mortality and to improve the outcomes for those injured in road crashes, but there are no reported outcome evaluations of the effectiveness of this approach.

Community or volunteer training

Some studies were identified which evaluated community volunteer bystander training focusing on any medical emergency and cardiac arrests but evaluation has been limited to knowledge and confidence levels (Peterson 1999; Larsson 2002 ; Jayaraman 2009) or the number of events was too low to make conclusions about their effectiveness (Rørtveit 2010). While it appears that first-aid knowledge was retained for at least 6 months, the need for refresher training was recommended within 2-5 years. These studies provided no evidence of change in "chain of survival" i.e. injury outcome/fatality.

An earlier evaluation of the retention of mouth-to-mouth resuscitation skills six months following training in a group of medical students in Florida, USA, found poor correlation between the ability to apply the skills immediately after training and six months later (Wenzel, Lehmkuhl et al. 1997). Swor et al reported from a prospective study of 684 interviews with bystanders who called the emergency number 911 when present during a cardiac arrest, that only 35% of bystanders with CPR training actually performed CPR in the cardiac arrest situation. However, it is worth noting that only 15 of the 314 (4.8%) bystanders who were not CPR trained, attempted CPR. The most commonly provided response (37%) of those who did not conduct CPR in those trained to conduct CPR was "panicking" (Swor, Kahn et al. 2006).

The effectiveness of bystander administration of first-aid to primarily motor vehicle trauma patients in Victoria was examined through data linkage of patient records of ambulance, hospital and Victorian Institute of Forensic Pathology (VIFP) records (Ashour 2007). No data were presented about the type of bystander and the first-aid training they had received. A case review of fatalities as a result of motor vehicle crashes found close to 5% might have been saved if there was a trained bystander on the scene; although the impact on motorcyclists was not estimated. Data extracted included: initial bystander interventions, ambulance response times, treatment by paramedics, transport time, Abbreviated Injury Score, Injury Severity Score (ISS) and time of death. All cases with initial signs of life (any ECG activity present) were reviewed for potentially preventable contributing factors to death. The analysis of individual records suggests that 5 patients might have been saved by bystander first-aid if available, as the person had airway obstruction or significant bleeding and there was a delay in calling for an ambulance. These findings were consistent with an earlier Victorian study (around 2% preventable deaths due to airway obstruction) (Ryan et al. 2004, as cited in Ashour 2007). The authors concluded that while further education of the public on the importance of CPR administration may achieve higher participation of bystanders, relatively few trauma victims received bystander first-aid and the effect on survival is uncertain. A limitation of the study is that only fatalities were examined to see what could have been prevented rather than instances where bystander intervention appears to have saved the patient's life. Further limitations were that data were examined retrospectively and limited information was available on bystander involvement.

Hatzolah, a volunteer Jewish community first responder group, was established in a localised area of metropolitan Melbourne, Victoria in 1995 and three rural groups were established in 1996. Hatzolah responders undergo an 18-month training course comprising first aid, cardiopulmonary resuscitation, the use of semi-automated defibrillators, and oxygen therapy. A review of its impact over its first 11 years of operation indicated that the mean response time to all emergencies in the areas served by the groups was 3 minutes, compared to the Melbourne Ambulance Service response time of 8 minutes. The rural groups had response times of about 4.5 minutes compared with the mean time before ambulance arrival of 14–18 minutes (Chan, Braitberg et al. 2007). Survival rates for cardiac arrest cases (14%) were noted to be higher among those attended by the Hatzolah group than the 3 to 7.2% reported in other studies. The difference was attributed to the quicker response times in the Hatzolah group.

Professional non-medical and medical/paramedical services

Non-medical Emergency Services

A number of jurisdictions have implemented programs in which non-medical emergency service personnel are trained as first responders to provide first-aid until medical or paramedical staff can be present. While there are few documented evaluations of these programs, those identified have spanned focus group feedback to analysis of survival rates attributed to the initiative. Findings from qualitative data (interviews with Swedish police and fire fighters) on experiences of being the first responder on the scene of a crash identified a need for equipping first responders with required knowledge as well as psychological preparedness. In particular, the skills to be able to manage the situation medically and keep victims calm were considered highly important (Elmqvist 2010). The first responders interviewed described the need to be prepared for the stress of not having the required equipment to treat the injured person. Furthermore, participants need to be prepared for the personal relationship (physically and emotionally) that defines those critical and frightening moments for the injured person, and the importance of being calm and focused for the injured person.

This finding was compatible with that of a qualitative study conducted with Victorian fire-fighters who were asked to provide their views of being trained as first responders to medical emergencies (Smith, Rich et al, 2001). While the new skills were generally viewed positively by the fire-fighters who took part in the focus group discussions, there were concerns about the lack of training in coping with the stress of the situation.

In a survey of law enforcement agencies in the US about their role and response to providing pre-hospital emergency care, 80% reported that they had responded to such a situation and 50% had provided patient care. There was a general tendency of the police officers to report that they felt this role interferes with regular duties but is an important skill to have (Alonso-Serra 1997). A more recent study found that nearly three quarters of law enforcement agents interviewed felt that their role as providers of out-of-hospital emergency care to be appropriate (Hawkins et al, 2007).

Smith et al (2001) undertook a 12 month trial to assess the impact of adding fire officers as first responders to the existing ambulance response to out-of-hospital cardiac arrests. The study found that response time to arrival at scene was reduced by an average of 1.6 minutes and that the time from event to defibrillation was reduced by an average of 1.43 minutes compared to a comparison community which suggests that fire officers can be successfully trained in the use of external defibrillators and can integrate well into a medical response role. Based on the results of this study, the Victorian Government expanded the program across all of metropolitan Melbourne serviced by the Fire Brigade in February 2000. During the first year of the expanded program, fire fighters provided the initial defibrillation to 41 (26.5%) patients presenting in ventricular fibrillation (Smith and McNeil 2002).

This fire fighter first responder system continues to operate in Victoria, and is seen as an adjunct to the emergency services provided by the existing ambulance services. While the ambulance service continues to provide holistic pre-hospital patient care, the fire fighter first responder training and equipment serves to improve the speed of first-aid care with a focus on the initial management of the patient in cardiac arrest, including defibrillation using a shock-advisory defibrillator and the use of oxygen and assisted ventilation in resuscitation. Training includes management of the scene and provision of initial first aid until an ambulance arrives. However given fire first responders are dispatched in the same way as ambulance paramedics, fire fighter first responder system would not solve the issue of crashes occurring in remote areas and those involving lone riders.

Medical and paramedical services

The Ontario Pre-hospital Advanced Life Support (OPALS) study examined the extent to which advanced life support (airway management and intravenous fluids administration) operating at a system wide level saves lives (Stiell, Nesbitt et al. 2008). The study found there was no benefit of fluid therapy or other advanced life support. Furthermore, there was evidence that patients with head injury with a Glasgow Scale score of less than 9 were likely to have a higher mortality rate than those administered basic life support. As the study was conducted in 17 cities within the province of Ontario, Canada, the authors noted that the findings could not be extrapolated to rural areas (Stiell, Nesbitt et al. 2008).

Technology and Communication systems

In-vehicle technology

Telematics Service Provider (TSP) is technology built into a motor vehicle (BMWs initially) to notify emergency responders when the vehicle is involved in a moderate to severe crash, to shorten the time to emergency medical services. The three key features of the system are: the provision of GPS coordinates of the crash, voice communication with those in the vehicle, and useful data about the vehicle which can be relayed without voice communication. The system, termed "BMW assist", was offered for 4 years after purchase, and has been described as being operational but no evaluation of its effectiveness has been published (Jolly 1997; Augenstein 2007).

In-vehicle technology, known as eCall, has recently been implemented in many makes of vehicles in Europe and is based on sensors in an automobile (such as airbag system components and deceleration information) used to trigger an emergency transmission. An extensive review of the literature conducted by the European Association of Motorcycle Manufacturers (ACEM 2010) on the potential benefits of eCall for motorcycle users indicated an estimated reduction of between 1% and 20% of all motorcycle related fatalities if the eCall system were universally implemented. It was noted that the majority of the 11 studies included in the review were not based on evidence but relied on unfounded assumptions such as while the device was not tested with motorcycles, conclusions were drawn that as motorcycle crashes tend to have longer periods between crash and arrival of emergency medical services, then its benefits would most likely be greater for motorcycle crashes. The strongest study to date (McClure & Graham 2006) as cited in ACEM (2010), which examined the impact of the eCall system with motor vehicles crashes (to which it has been limited to date), reported that the highest level of benefit for the in-vehicle technology was associated with single vehicle accidents in non-built-up roads. It would seem that such technology can potentially have the greatest impact on events in isolated areas which experience the greatest delays in injured people receiving emergency medical services. While this suggests that motorcycle crashes in rural areas would potentially be maximally impacted by the eCall system, the paper presented by the ACEM offers two counterpoints to this projection: 1) the technology that has been applied to cars is not suitable (currently) for powered two-wheelers, and 2) that some of the studies' data are based on multiple people being injured per crash event and thus the impact of the technology would be less in single rider crashes. The conclusions from the consultation process covered in this report were that the application of the eCall technology on powered two-wheelers is not sufficiently advanced to identify the best viable solution.

Integrated Active Transport System

Integrated Active Transport System is a vehicle to vehicle (V2V) communication system that enables real-time transmission of data such as GPS coordinates, speed, and throttle position to emergency services. In a brief report covering standard current practice, and new directions in technology in emergency communication systems, Flannigan suggests that the V2V communication system could be most beneficial in rural areas where the first on the scene are often volunteers with minimal training (Flanigan 2010). The six responses and rescue functions of the system are described as:

- Emergency management
- Problem detection and characterisation
- Notification and dispatch
- Emergency responder travel to scene
- Scene management and operations, and
- Patient transport

The purpose of the article was to propose the investment directions for research in this field. However, no evidence on effectiveness of this strategy is provided.

Hybrid Wireless Mesh Network

Dilmaghani describes elements of a robust communication infrastructure for emergency response situations. The focus of the technical article is on large scale disasters and distribution of warning and alert messages to a large number of users in a heterogeneous environment. While there are projections that this approach could be cost efficient (if employed for large scale disasters), it would seem to have limited applicability to the isolated motorcycle crash event (Dilmaghani 2008).

Information on injured motorcyclists

A program was developed in the UK to provide free identification data cards to help first responders provide rapid and accurate medical assistance to riders involved in motorcycle crashes. The Rider Alert cards (www.RiderAlert.org), placed inside riders' helmets are accompanied by a one-inch, round sticker placed on the outside of the helmet to indicate that the rider has the Rider Alert card inside the helmet. The sticker warns bystanders not to remove the helmet as it could cause further injury. The program has subsequently been adopted in the US from the UK. No evaluation of its effectiveness has been reported. No information was available on how first responders could access the information on the card inside the helmet if they are warned not to take the helmet off in the event of a possible spinal injury.

Transport to definitive care

Helicopter retrieval

One Australian case review study indicated that while air transport was shown to be significantly faster for distances greater than 100 kilometres, there was no significant difference between the air and road groups in terms of outcome or fatality rate (Shepherd 2008). Another study found, through a review of cases, that air transport significantly improved patient survival rates (Spencer-Jones, Varley et al. 1993). However, the cases were motorcycle crashes in connection with a motorcycle race event on the Isle of Mann which is isolated by sea from major hospitals. As the route was clearly being monitored for crashes during the race the results cannot be generalised to most motorcycle crashes which can happen on any road at any time.

A systematic review of the literature was conducted on the costs and benefits of helicopter emergency medical services (HEMS) (Taylor, Stevenson et al. 2010). Of the 15 research articles included in the review, only 4 considered the impact exclusively on trauma patients. Two of these demonstrated improved survival from the use of helicopters and two showed that HEMS was considerably more expensive than ground transportation without a significant improvement in patient outcome. From the articles included, observational data indicated that benefits of helicopter retrieval of injured patients were most obvious in rural areas. The authors noted, however, that the context of the use of helicopters for emergency medical services is crucial to the costs and the benefits and that as studies varied in their contexts (geographically and in terms of the trauma care systems of which the helicopter services were embedded) that conclusions about their costs and benefits at this stage is problematic. The findings suggest, however, potential for improved outcomes with motorcycle crashes which occur in rural and remote areas.

GPS units in ambulance vehicles

Emergency service response times are well known to be longer in rural areas. Long distances, emergency services availability and their unfamiliarity with remote rural areas are generally recognised as contributing factors to this problem (Gonzalez 2009). A study found the mean response time for all emergency service calls before GPS utilisation (finding the fastest route available) was 8.5 minutes and 7.6 minutes after GPS utilisation (p=0.0012). Data indicated that longer travel distances in rural settings are impacted the most by GPS utilisation wherewith emergency service personnel are generally less familiar with the roads (Gonzalez 2009).

Conclusion

The predominant finding of the review is that despite injuries to motorcyclists representing an increasing proportion of road trauma in industrialised countries, there is currently a lack of evidence about the effectiveness of interventions that aims at improving emergency response to motorcycle crashes. Despite a lack of rigorous evaluation of Bystander Assistance Programs, designed to train and empower motorcyclists to manage a crash scene until emergency services arrive, these courses tend to be well-received among riders with indications of their use in a crash situation. Communication and in-vehicle technology is also a promising area for improving the reporting of and response times to road trauma, although its use has not directly been tested in the event of serious motorcycle crashes.

3.3 Survey of motorcycle riders in Victoria

A total of 401 Victorian riders aged 18 years and over participated in the survey as part of this study. This represents 70.1% off the 569 eligible riders invited to participate. As shown in Table 48, most were males (59%) with more than half (53%) aged between 25 and 44 years. More than a quarter (28%) of respondents were aged 25-34 years. Scooters and off road bikes were the most common bikes used by respondents followed by sports and standard bikes. A third of riders reported riding between 2 and 5 years with almost another third riding for at least 20 years. A smaller proportion (8%) were less experienced riders with up to 1 year riding experience. Just over 10% reported having a membership of a motorcycle club.

Table 48: Demographic characteristics and riding history of surveyed riders

	n (%)
Gender	
Male	236 (58.85)
Females	165 (41.15)
Age group	
18-24	52 (12.97)
25-34	114 (28.43)
35-44	97 (24.19)
45-54	92 (22.94)
55+	46 (11.47)
Type of bike frequently used on public road	
Sports (including Super sports /super motard)	71 (17.71)
Cruiser	41 (10.22)
Standard (including Naked)	58 (14.46)
Touring (including Sports tourer)	39 (9.73)
Adventure/ adventure tourer/ dual sport	9 (2.24)
Off road - Trail/ enduro/ motorcross	82 (20.45)
Scooter	82 (20.45)
Moped	2 (0.5)
Other	17 (4.24)
Years of riding	
up to 1 year	33 (8.23)
2-5 years	134 (33.42)
6 to 9 years	39 (9.73)
10-19 years	71 (17.71)
20-29 years	57 (14.21)
30+ years	67 (16.71)
Membership of a motorcycle club	
Yes	48 (11.97)
No	353 (88.03)
Total	401 (100)

More than half of the riders who participated in the survey (58.1%) reported receiving medical or first aid training, with over a quarter receiving the training within the year prior to the survey (Table 49). Among those who reported obtaining medical or first aid training, 90 % reported receiving standard first aid and only 9% receiving motorcycle specific first aid training.

Table 49: Medical or first aid training

	n (%)
Received Medical or first aid training	
Yes	233 (58.1)
No	168 (41.9)
Total	401 (100)
Last received training	
12 months	64 (27.5)
2-3 years	81 (34.8)
4-5 years	33 (14.2)
6-10 years	25 (10.7)
More than 10 years ago	30 (12.9)
Total	233 (100)
Type of training*	
Qualified health practitioner/paramedic	18 (7.8)
Completed motorcycle specific first aid training	21 (9.0)
Completed standard first aid training	211 (90.6)
Other	6 (2.6)
Total	233 (100)

*Some respondents reported receiving more than one type of training

Table 50 shows previous experiences with crashes resulting in serious motorcyclist injury. Almost 1 in 5 respondents reported having been involved in a serious motorcycle crash where someone was injured with three quarters of those injured being riders. A larger proportion of respondents (36%) reported having been present at the scene of a serious motorcycle crash where someone was injured. Just over a third of those (34%) reported providing first aid to the injured person. Just under half of respondents (46%) said that they would know what to do if no one else was around at the scene of a serious motorcycle crash before emergency services arrived. A similar proportion reported being unsure about what to do and the rest (10%) reporting not knowing how to proceed in those circumstances.

Table 50: Previous experiences with crashes resulting in serious motorcyclist injury

Experience type	n (%)
Involvement in a serious motorcycle crash where someone was injured	
Yes	80 (20.0)
No	321 (80.0)
Total	401 (100)
Person injured	
Rider	61 (76.3)
Pillion passenger	5 (6.2)
Driver of the other vehicle	6 (7.5)
Passenger in the other vehicle	5 (6.2)
Other (specify)	3 (3.8)
Total	80 (100.0)
Present at the scene of a serious motorcycle crash where someone was injured	
Yes	146 (36.4)
No	255 (63.6)
Total	401 (100)
Provided first aid to the injured person	
Yes	50 (34.2)
No	96 (65.8)
Total	146 (100)
Would know what to do at the scene of a serious motorcycle crash before emergency service arrive	
Yes	184 (45.9)
No	41 (10.2)
Not sure	176 (43.9)
Total	401 (100)

Among the 146 respondents who reported being present at the scene of a serious motorcycle crash where someone was injured, 37% of those who received medical/first aid training reported providing first aid to victim compared to 27% in those who did not report receiving the training (Table 51). In addition, 62 % of those who received medical/first aid training reported that they would know what to do at the scene of a serious motorcycle crash compared to 23% in those who did not report receiving the training (Table 52).

Table 51: Provision of first aid to the injured motorcyclist by history of medical or first aid training

Provision of first aid at the scene	Medical/first aid training					
	Yes		No		Total	
	n	(%)	n	(%)	n	(%)
Yes	38	(37.2)	12	(27.3)	50	(34.2)
No	64	(62.8)	32	(72.7)	96	(65.8)
Total	102	(100.0)	44	(100.0)	146	(100.0)

Table 52: Knowledge of what to do at the scene of a serious motorcycle crash by history of Medical or first aid training

Would know what to do at the scene of a serious motorcycle crash	Medical/first aid training					
	Yes		No		Total	
	n	(%)	n	(%)	n	(%)
Yes	146	(62.7)	38	(22.6)	184	(45.9)
No	10	(4.3)	31	(18.5)	41	(10.2)
Not sure	77	(33.0)	99	(58.9)	176	(43.9)
Total	233	(100.0)	168	(100.0)	401	(100.0)

Participants were also presented with a crash scenario and were asked about what they would do if they came across a motorcycle accident where an injured rider is lying on the road, assuming that they have secured the scene and ensured their safety and that of those involved including the injured rider. Results are shown in Table 53. Almost a third (30%) of respondents said that they would call the emergency services but do nothing else so as not to interfere. This proportion was lower (24%) among those who received medical/first aid training compared to those who did not (40.5%). Nearly three quarters of respondents (73%) correctly said that they would not remove the helmet of an unconscious injured rider, but fewer (61%) knew they should not do this even if the injured rider was conscious. The decision not to remove helmet of injured rider did not vary greatly between those who received medical/first aid training and those who did not. Over three quarters of respondents (77%) incorrectly said that they would apply Cardio Pulmonary Resuscitation (CPR) if the injured were not breathing. This proportion was lower (66%) in those who had not received medical/first aid training compared to those who had **(**85%). Regarding the last question of the crash scenario, similar proportions of those who reported receiving medical/first aid training (92%) and those who did not (93%) said that they would apply pressure on the nearest artery if the injured were bleeding heavily.

Table 53: Crash scenario responses by history of medical/first aid training

Crash Scenario	Medical/first aid training					
	Yes		**No**		**Total**	
	n	(%)	n	(%)	n	(%)
Call the emergency services and do nothing else so I don't interfere.						
Agree	55	(23.6)	68	(40.5)	123	(30.7)
Disagree	155	(66.5)	76	(45.2)	231	(57.6)
Don't know	23	(9.9)	24	(14.3)	47	(11.7)
Total	233	(100.0)	168	(100.0)	401	(100.0)
If they were unconscious I would carefully remove their helmet.						
Agree	41	(17.6)	17	(10.1)	58	(14.5)
Disagree	167	(71.7)	125	(74.4)	292	(72.8)
Don't know	25	(10.7)	26	(15.5)	51	(12.7)
Total	233	(100.0)	168	(100.0)	401	(100.0)
If they were conscious and wanted to take off their helmet, I would help them remove it.						
Agree	65	(27.9)	39	(23.2)	104	(25.9)
Disagree	142	(60.9)	103	(61.3)	245	(61.1)
Don't know	26	(11.2)	26	(15.5)	52	(13.0)
Total	233	(100.0)	168	(100.0)	401	(100.0)
If they were not breathing I would apply Cardio Pulmonary Resuscitation (CPR).						
Agree	198	(85.0)	111	(66.1)	309	(77.06)
Disagree	11	(4.7)	19	(11.3)	30	(7.48)
Don't know	24	(10.3)	38	(22.6)	62	(15.46)
Total	233	(100.0)	168	(100.0)	401	(100.0)
If they were bleeding heavily I would try to apply pressure.						
Agree	214	(91.8)	157	(93.4)	371	(92.5)
Disagree	8	(3.4)	3	(1.8)	11	(2.7)
Don't know	11	(4.8)	8	(4.8)	19	(4.8)
Total	233	(100.0)	168	(100.0)	401	(100.0)

Two thirds of respondents (66%) said they would attend a motorcycle specific first aid training program on what to do before professional help arrives at a motorcycle crash if such programs were readily available. About, the same proportion (69%) said that such training programs should be included in the licensing process for riders (Table 54).

Nine out of 10 respondents said that they would be prepared to assist a crashed motorcyclist if they could get first aid advice over the phone and 72% said that there is a need for emergency phones to be placed along key motorcycle routes in areas, for example, where the mobile phone service is out of range. A lower proportion (58%) of respondent said that they would install an automatic crash notification and GPS location system to relay information to emergency services if such technology was available for their bikes.

Table 54: Views on strategies to improve first response to motorcycle crashes

	n (%)
Would you attend a motorcycle specific first aid training program on what to do before professional help arrives at a motorcycle crash if such programs were readily available?	
Yes	263 (65.6)
No	34 (8.5)
Don’t know	104 (25.9)
Would you be prepared to assist a crashed motorcyclist if you could get first aid advice over the phone?	
Yes	364 (90.8)
No	14 (3.5)
Don’t know	23 (5.7)
Would you install an automatic crash notification and GPS location system to relay information to emergency services if one were available for your bike?	
Yes	232 (57.9)
No	52 (12.9)
Don’t know	117 29.2)
Is there a need for emergency phones to be placed along key motorcycle routes in areas, for example, where the mobile phone service is out of range?	
Yes	288 (71.8)
No	47 (11.7)
Don’t know	66 (16.5)
Do you believe that motorcycle specific first aid training should be included in the licensing process for riders?	
Yes	277 (69.1)
No	65 (61.2)
Don’t know	59 (14.7)
Total	401 (100)

More than two in three respondents believed that motorcycle specific first aid training should be offered to other service providers, road users and members of the community (Table 55). The vast majority of these (over 9 in 10) believed that such training should be offered to emergency personnel (police, ambulance paramedics and fire brigade). More than two in three believed that it should be offered to truck drivers, long distance bus drivers and service station attendants located on key motorcycle recreational routes. Over half said that it should be offered to Australian Post riders (53%) and residents in key motorcycle recreational areas (58.6%).

Table 55: Views on other recipients of motorcycle first aid training

	n (%)
Should motorcycle first aid training should be offered to others?	
Yes	278 (69.3)
No	41 (10.2)
Don’t know	82 (20.5)
Total	401 (100)
If yes, who should be offered the course?*	
Police	264 (95.0)
Ambulance Paramedics	263 (94.6)
Fire Brigade	255 (91.7)
Australian Post	146 (52.5)
Truck drivers	190 (68.3)
Long distance coach drivers	181 (65.1)
Service Station attendants on key motorcycle recreational area	189 (68.0)
Residents in key motorcycle recreational area	163 (58.6)
Others	40 (14.4)
Total	278 (100)

*Some respondents reported more than one provider

3.4 Consultations with emergency services and motorcycle community representatives

Two series of consultations with various emergency agencies and motorcycle rider groups were carried out. Consulted organisations included Ambulance Victoria, Alfred Hospital Trauma Centre, Emergency Services Telecommunications Authority, the Metropolitan Fire Brigade in Melbourne, the Accident Scene Management Australia Ltd, Australian Government Motorcycle Safety Consultative Committee, Australian Motorcycle Council, Motorcycle Riders Association (Victoria), Victorian Motorcycle Council (VMC), Honda Australia Motorcycles & Power Equipment, VicRoads Motorcycle Advisory Group (MAG), the Independent Riders' Group and the Yarra Ranges Shire Council.

At the onset of the project initial consultations were undertaken with relevant organisations to identify current processes for providing emergency response as well as all relevant data sources available to examine the circumstances and outcomes of motorcycle crashes in Victoria. Another phase of consultations was undertaken to discuss factors that influence crash outcomes in motorcyclists, suggestions on how to improve emergency response to motorcycle crashes in Victoria and to gain insights into the feasibility of these strategies.

3.4.1 Provision of emergency services to crash sites

The process of emergency response to a crash from time emergency call is received to hand over at the receiving hospital can be broken down into 5 phases: call received; resource dispatched, at location, depart location and at destination (see Figure 30).

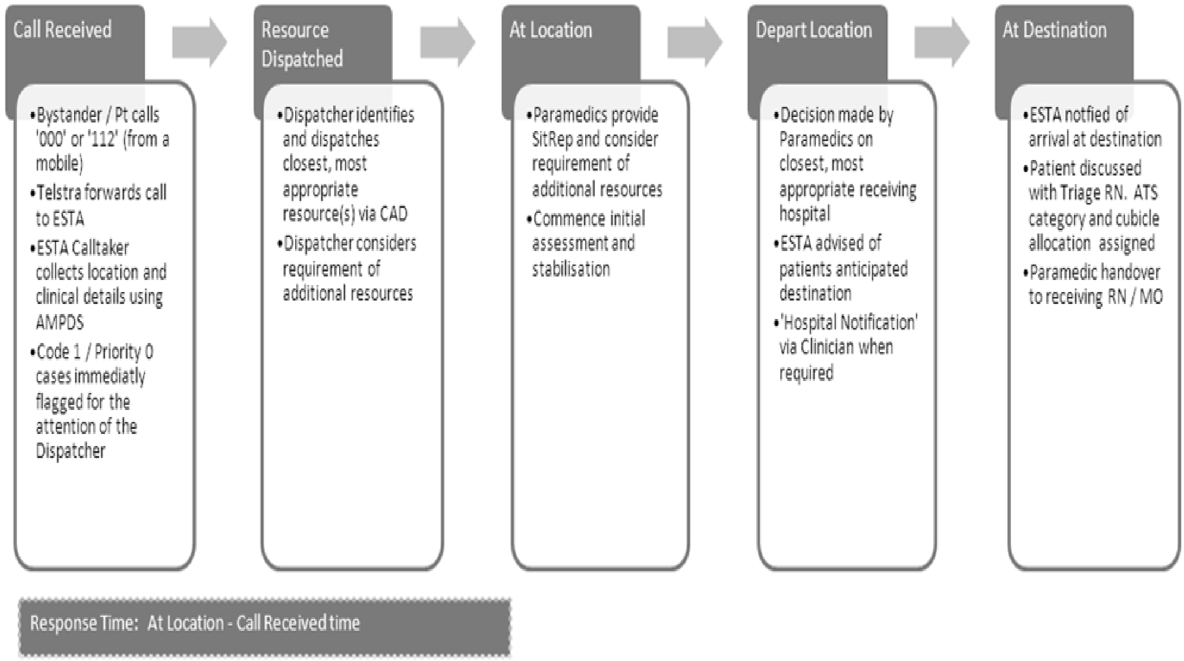

Figure 30: Process of emergency response following 000 call. ***(AMPDS Advanced Medical Priority Dispatch System; CAD Computer Aided Dispatch; ESTA Emergency Services Telecommunications Authority; SitRep Situation Report; Pt call point call; RN Registered Nurse; MO Medical Officer; ATS Australasian Triage Scale)***

1. Call Received

At the scene of a motorcycle crash, either the patient or a bystander will call ‘triple zero’ (or call ‘112’ from a mobile phone). All triple zero calls are initially answered by a Telstra operator who determines from the caller if they require “Police, Ambulance or Fire”. If the caller requests ambulance, the Telstra operator forwards the call to the most appropriate Ambulance Operations / Communications Centre. In the state of Victoria, the responsible agency is the Emergency Services Telecommunications Authority (ESTA).

The ESTA Calltaker answers all requests for emergency ambulance attendance. The two primary objectives for the Calltaker are to determine where the emergency is and the nature of the emergency:

Verification of Location:

The first question asked of the caller is ‘where do you need the ambulance?’ The Calltaker will then use the information provided to go through a short location verification process. If the caller provides a full street address for the emergency the Calltaker will confirm this address including the state as well as confirming the nearest cross streets. The Calltaker makes use of the Call Line Identification (CLI) which provides billing details (biller's name and address) of most phones used to call triple zero.

Clinical Questioning:

To ascertain what emergency units will be dispatched the Calltaker will proceed to ask a short series of scripted questions relevant to the complaint based on prompts by the Advanced Medical Priority Dispatch System (MPDS). A brief explanation of questioning relevant to a transport related crash follows.

I. Initially the caller will be asked how many people are injured, the age and gender of the patient(s) and whether they are conscious and breathing

II. The Calltaker will ask if any chemical dangers or other hazards exist at the scene

III. The Calltaker will establish if anyone is trapped in or was ejected from the vehicle

IV. The Calltaker will ask if the patient(s) is/are completely awake and enquire as to the extent of injuries and whether or not there is any serious/uncontrolled bleeding

V. Immediately at the conclusion of this brief questioning the Calltaker 'accepts' the event into the Computer Aided Dispatch system (CAD) and the answers provided by the caller determine a response code (urgency) which sends the event through to other emergency services if required

VI. As the dispatcher is receiving the event through a computer-assisted dispatch system, the Calltaker is providing instructions to assist the patient while the ambulance is enroute. The instructions provided by the Calltaker are determined by the information provided by the caller

VII. If the patient's condition is serious, the ambulance Calltaker will remain on the line with the caller until the crew(s) arrives, providing both instructions for the patients care and updates via CAD to the crews attending the incident

If the condition of the patient (or the mechanism of injury) is determined to require an urgent response, the ambulance Dispatcher is alerted to the location and the nature of the case, while the Calltaker continues to gather further details. The Dispatcher is then able to dispatch a resource immediately, even prior to the Calltaker hanging up the phone.

2. Resource Dispatched

Once the Calltaker has entered all required information, AMPDS suggests the response urgency and the number and type of units dispatched are determined by an AV response grid. The Dispatcher then dispatches the closest, appropriate resource as suggested by the Computer Aided Dispatch (CAD) system.

The designated ambulance crews receive immediate notification of the case via pager. Details such as: case number, relevant time stamps, case nature, location, closest crossroad, map reference and additional comments are available on the alphanumeric pager. The crew then confirms details and advises the Dispatcher that they are 'mobile' - on the way to the incident location.

Most transport crashes are responded to 'Code 1', under emergency (lights and sirens) conditions due to the potential for serious injury. Paramedics utilise hard copy maps (MelWays, VicRoads, CFA Spatial VicMaps) to navigate to the scene of a crash.

3. At Location

On arrival at the incident site, Paramedics advise ESTA that they have arrived and provide a 'situation report' (SitRep) as soon as they have had time to assess the scene. The SitRep assists ESTA to decide the resources required, such as other emergency services organisations (ESOs) and additional ambulance resources (intensive care assistance, rotary wing support, additional stretcher carrying capacity, duty manager).

At the location, the patient undergoes a complete and systematic assessment, management of injuries is commenced and pain relief provided as necessary.

4. Depart Location

Following initial assessment and stabilisation, the ambulance and patient depart the location of the incident. ESTA are advised that the crew are departing location, the clinical urgency of the patient, and the anticipated destination. The destination is decided by the attending Paramedics, based on the clinical condition of the patient and location of the nearest receiving hospital or designated trauma centre. Children under the age of 15 years will always be transported to a facility that receives children.

Under some circumstances, the Paramedics may decide to notify the hospital via a ‘Clinician’ based at ESTA of their impending arrival to expedite reception of the patient on arrival at the receiving hospital. If the patient meets certain ‘time critical’ criteria, the Paramedics may decide to bypass closer hospitals, preferring to transport the patient directly to one of the three designated ‘Trauma Centres’ - The Alfred Hospital, The Royal Melbourne Hospital or The Royal Children’s Hospital (only receives paediatric patients).

5. At Destination

Paramedics notify ESTA as they arrive at the patient destination. The Paramedics then initially describe the patient to the triage nurse, who assigns an Australian Triage Scale (ATS) category and bed location to the patient based on clinical acuity and need. The Paramedics then ‘handover’ the patient to the receiving nursing and medical staff, describing the nature of the crash, patients past medical history, any physical injuries sustained, vital signs, and any treatment initiated prior to hospital.

3.4.1 Barriers to effective response and strategies to enhance emergency response to motorcyclists involved in crashes

Interviewed stakeholders identified gaps in the system described above, specifically in relation to the capacity of emergency services to reach crash sites outside the metropolitan areas in a timely manner. The issues identified related to:

- delays in reporting of crashes
- the time required for emergency services to reach crash sites in remote locations
- the difficulties in locating the crash site in areas that are not within established road networks
- provision of appropriate first aid prior to the arrival of emergency teams.

Overcoming delays in reporting crash incidents

The key factor attributed to delays in reporting motorcycle crashes was the lack of mobile or other communication services in the remote areas favoured by recreational motorcycle riders (e.g. the Yarra Ranges). Proposed remedies include the installation of mobile phone towers or emergency satellite phones to provide the emergency services and the general public with essential communication services in these regions.

Mobile phone towers

The installation of additional mobile phone towers would benefit the local residential communities in addition to road users and bush walkers in the case of emergencies, however these are commercial decisions and apparently to date requests to the telecommunications companies have been denied.

Emergency satellite telephones

Telstra Mobile Satellite network can provide high quality reliable communications in these areas. Emergency satellite telephones can also be solar powered to provide 24 x 7 roadside communications in areas that have limited or no access to mains power nor any terrestrial type of telephone services. The limitation of using solar power would be to require the emergency phones be located with a clear line of sight to the sky.

The option of installing emergency satellite telephones has previously been investigated by the Shire of Yarra Ranges with the support of the local Police, Victorian State Emergency Service (SES), Country Fire Authority (CFA) and Metropolitan Ambulance Service (MAS). A grant for the purchase and installation of two fixed satellite phones was obtained from the Federal Government (Emergency Management Australia, Local Grants Scheme), but those funds do not cover their long term maintenance and monitoring.

Delays in the reporting of motorcycle crashes may also occur when there are no witnesses able to report the crash. This may involve multi-vehicle crashes where all parties are too injured to call for help, but most commonly involves a motorcyclist who was riding alone.

Overcoming delays in emergency services reaching crash sites

Delays in reaching a crash site can be due to the caller who reported the situation not being able to provide clear details of their actual location. This is particularly a problem in rural or forestry areas. Many people who request EMS response are often unsure of their exact location, or not able to clearly indicate their location to the ESTA Calltaker. Inability to locate a patient in remote or isolated areas is commonly related to confusion regarding location, particularly for the 'Sunday rider' who may be in an unfamiliar locality and not necessarily have been paying attention to recently passed streets or landmarks. On many occasions, it will come down to the calltaker problem solving based on the information the caller is able to provide and utilising map book. In many instances, callers can be stressed and emotional when confronted with a severe road trauma. Whilst calltakers are trained to control calls to elicit answers to the scripted questions, callers who have difficulty focusing and answering the questions asked of them, particularly those related to the location of the crash, can inadvertently delay a response. Emergency services and rider groups interviewed pointed to a number of areas as specified below that need further considerations in order to improve the speed of emergency services reaching the location of motorcycle crashes.

Personal tracker devices.

There are positioning applications currently available on many mobile phones. There are also personal trackers that are satellite based and not reliant on mobile phone services. For example, the SPOT tracking device uses the GPS satellite network to acquire its coordinates, and then send its location – with a link to Google Maps™ – and a pre-programmed message via a commercial satellite network. Unlike Personal Locator Beacons, SPOT does more than just call for help. SPOT 2® provides five primary functions:

1. OK button - The ability to inform people via email or SMS you are OK.
2. Help button - The ability to inform people (that you nominate) via email or SMS, you need help from them if it is not a life threatening situation (e.g. vehicle breakdown).
3. Custom Message button – Pre program a custom message, e.g. completed task.
4. SOS (urgent) button - The ability to inform company control centres or Emergency Services that you need urgent help. With SPOT® on tracertrak® this can report direct to you control centres or others via SMS and email to take immediate local action.

5. Live Tracking - The ability to live track people / vehicles in the field with the device giving you updates approximately every 10 minutes.

Mobile phone call location service

Emergency services are able to determine the location of a call from a fixed line telephone due to provisions under Federal Government legislation. This saves time in ensuring that emergency services have precise information as to their required destination.

However emergency services cannot automatically determine the location of a mobile phone caller. This is because the Act has not been extended to require provision of automatic location information for mobile phone services. Instead, emergency services have to make a time consuming specific request to the telecommunications companies to undertake a triangulation process to determine the location.

In addition, if a caller's own mobile service provider does not have coverage in an area, emergency calls will be picked up if there is any other service provider with coverage. However, if the connection is lost or the caller hangs up, Emergency Services cannot call them back, which would be possible if the call was handled by the caller's own service provider. It is important to consider the feasibility of in-vehicle technology that will notify emergency responders of the location when the vehicle is involved in a crash.

Telematics Service Provider (TSP) is technology built into a motor vehicle (BMWs initially) to notify emergency responders when the vehicle is involved in a moderate to severe crash, to shorten the time to emergency medical services. The three key features of the system are: the provision of GPS coordinates of the crash, voice communication with those in the vehicle, and useful data about the vehicle which can be relayed without voice communication. The system, termed "BMW assist", was offered for 4 years after purchase, and has been described as being operational but no evaluation of its effectiveness has been published (Jolly 1997; Augenstein 2007).

GPS navigation devices

Ambulances do not always have in-vehicle GPS navigation devices, with many still relying on street directory maps. According to a number of respondents GPS devices should be installed in all ambulance service vehicles to ensure drivers can better co-ordinate with ESTA location advice. Ambulance Victoria is currently piloting GPS technology in some vehicles.

Road names, distance markers and other location signage

Signage in the road network including road names, roadside distance markers and other signage can be critical in enabling an emergency caller to be accurately located. This is all the more important in areas that are not within urban road grids. It is therefore important to increase road signage in known motorcycle crash risk areas.

Road distance markers are uniquely identified posts, set one kilometre apart on all major roads. The maintenance of the network of road distance markers is critical to their value as an emergency location marker. The existence and potential value of roadside distance markers as a means of precisely identifying their location in case of emergency should be promoted to the community.

Emergency markers

Emergency markers are green signs with white writing that are about the same size as a street sign. They may be found fixed to existing structures, such as a buildings or lamp posts, or attached to purpose-built bollards. These markers are intended to be used to help the Emergency Services Telecommunications Authority (ESTA) identify the location of emergency calls. As at 1 January 2011, there were in excess of 1,000 Emergency Markers installed throughout Melbourne and rural Victoria

These signs include a unique alphanumeric number (e.g. LYS 201) that is linked to ESTA's computer-aided dispatch system. This reference number will help emergency services arrive at the required location as quickly as possible. They are supported by GPS co-ordinates and directional instructions enabling ESTA conductors to provide directional information to police, fire, ambulance and the State Emergency Service advising them of obstructions such as locked gates, road closures and quickest access points. There is a need for more emergency markers, particularly in remote and regional areas using crash risk profiles to establish priorities.

Emergency services locations

Some interviewed stakeholders also suggested that time delays in emergency services reaching and returning from crash locations to take critically injured riders to a major trauma centres may be reduced by establishing mobile units such as motorcycle paramedics in high motorcycle crash risk times/regions including the Yarra Ranges, and alpine areas. The premise of using paramedics on motorcycles is that motorcycles can get through traffic quicker and are better able to reach off-road crash sites than ambulances. The suggestion is that these paramedics could be assigned patrols in those areas during high crash risk times.

Provision of appropriate emergency first aid training to non-medical first responders

Emergency first aid treatment for trauma victims

ESTA operators follow PROQA treatment protocols that are based on the Medical Priority Dispatch System™ (MPDS) used to provide advice over the phone to a caller on how to help a trauma victim while waiting for emergency services. It is an international system using a set sequence of questions and advice determined by the International Academy of Emergency Medicine Despatch (IAEMD). In the case of severe trauma, MPDS advised ventilation first (i.e. Expired Airways Resuscitation (EAR), also known as artificial respiration or mouth to mouth resuscitation) and cardiopulmonary resuscitation (CPR) as the second choice to be used only if there are no signs of circulation.

However, there are grounds for concern that the standard first aid training for non-professionals promotes CPR as the primary treatment in emergencies. CPR involves applying at least 100 chest compressions of about 5 cm depth per minute to create artificial circulation. CPR is applied on the assumption that the person is in cardiac arrest. However, with trauma victims, if they are not breathing but have a pulse, EAR may be more appropriate to avoid exacerbating potentially fatal internal injuries. It is important that current first aid protocols be reviewed to make a definitive ruling on the appropriateness of mouth to mouth EAR rather than CPR for trauma victims who are not breathing but have a pulse.

Emergency Medical Response (EMR)

The EMR (Emergency Medical Response) teams of the Metropolitan Fire Brigade are trained to secure the scene and provide first response medical treatment until other emergency services arrive. This service is not currently available in rural or regional areas, although its extension to the Country Fire Authority (CFA) could have a number of significant benefits. CFA units are more broadly distributed in regional and remote areas than are ambulance services and may reach crash sites sooner than ambulance services. They are also more mobile because while an ambulance crew will stay with casualties until they have been admitted to a trauma centre, fire service units can move on to another emergency once the ambulance has arrived. Ambulance Victoria and Country Fire Authority are currently running a joint pilot project involving Emergency Medical Response teams in regional areas.

Motorcycle Specific Emergency First Aid Training

Emergency first aid training courses for the general public are offered by a number of different providers (e.g. Red Cross and First Aid Training Melbourne CBD). General first aid courses do not address specific issues related to motorcyclists. Two organisations have been identified as offering motorcycle specific emergency first aid training (i.e. Accident Scene Management Australia (ASMA) and St John Ambulance NSW).

The Bystander Assistance programme provided by ASMA, is designed to empower motorcyclists to take charge of a crash scene until emergency services arrive. The course covers the specifics of motorcycle trauma that aren't taught in standard first aid classes. Courses range from basic programs for the motorcyclists through to professional classes for emergency responders.

Summary of required strategies, as proposed by relevant stakeholders, to improve emergency response to motorcyclists involved in crashes

In order to address the identified gaps in relation to delays in reporting, locating and responding to crashes as well as the provision of appropriate first aid, interviewed stakeholders highlighted the following strategies that they believed have the potential to improve first response motorcyclists involved in crashes:

- Investigate future plans by Telstra and other providers for the installation of mobile phone towers in identified motorcycle crash risk areas.
- Review project proposal prepared by Yarra Ranges Council for a satellite phones trial on the Warburton -Woods Road & Marysville – Woods Point Road between Reefton, the Lake Mountain turnoff and Woods Point. Consider extension of this project to other motorcycle high crash risk areas including public roads and off-road sites.
- Raise rider awareness of strategies to reduce the risks of riding alone. This includes encouraging riders to ride with at least one other rider; the importance of following Search And Rescue time protocols (advising someone of their trip details and expected time of arrival, so that search and rescue can be initiated if they fail to arrive on time) and the possibility of mobile phones operating on the International Emergency number 112, which will divert their call to 000 in Australia even when signal from own service provider is unavailable.
- Promote riders' awareness of technology options such as global positioning devices to ensure their location can be accurately established and conveyed to emergency services.
- Request the Australian Communications and Media Authority (ACMA) to amend telecommunications legislation to require mobile phone service providers to provide mobile phone call locations to emergency services as is currently required for fixed line services.
- Install emergency markers along popular motorcycle routes and in off-road riding areas.
- Install GPS devices in all ambulance service vehicles to ensure drivers can better co-ordinate with ESTA location advice.
- Review road signage maintenance protocols in remote and regional areas using crash risk profiles to establish priorities.
- Review road distance marker network to identify and rectify gaps in provision in remote and regional areas using crash risk profiles to establish priorities.
- Conduct cost benefit analysis of emergency services locations based on time to treatment and crash risk profiles to establish priorities and gaps in provision in remote and regional areas.
- Review options to extend the Emergency Medical Response program to the Country Fire Services in Victoria.

- Consult with Ambulance Victoria quality review team to review the specific advice provided in relation to motorcycle crash victims - particularly details relating to helmets and resuscitation.
- It is critical that current first aid protocols be reviewed to make a definitive ruling on the appropriateness of mouth to mouth (Expired Air Resuscitation) rather than CPR for trauma victims who are not breathing but have a pulse. The outcomes should be incorporated into all first aid training courses.
- Review options to support the delivery of motorcycle specific emergency first aid training for motorcyclists, with a particular focus on recognition of signs of serious injury, i.e. restricted breathing, internal bleeding, spinal, chest and head injury.
- Consider potential for motorcycle specific first aid programs to be subsidised from the Motorcycle Safety Levy.
- Develop education materials for the rider community to encourage best practice protocols for the management of group rides. This includes the need for the appointment of a training first aid person on every group ride and the development of first aid kits appropriate for motorcycle trauma for road and off-road riders.
- Consider the inclusion of first aid and crash site scene management training for all road users as a part of the licensing process.
- Promote awareness of the Good Samaritan law that a volunteer will not be held personally liable for any injury resulting from their attempts to provide assistance in good faith, without financial reward and within the boundaries of their roles and responsibilities. Wrongs and Other Acts (Public Liability Insurance Reform) Act (2002).

4. SUMMARY AND DISCUSSION

Circumstances of crashes involving motorcyclists

Between 2001 and 2010, 19418 crashes involving motorcyclists were reported to the Victorian police. These crashes resulted in 20368 motorcyclist casualties (19427 motorcycle riders and 941 pillion passengers). This represents an average of just over 2000 motorcyclist casualties reported to the police per year. An examination of other population-based datasets (such as Ambulance Clinical Information System, Emergency Minimum Dataset, State Trauma Registry and National Coroner's Information System) showed that over the 5-year period from July 2005 to June 2010, there were 20,357 motorcycle-related ED presentations, 9,012 hospital admissions with a length of stay >24 hours, 1,166 hospitalised major trauma cases, and 239 motorcycle-related deaths in the state. There was no evidence of a significant increase in motorcycle-related injury in Victoria in the 5-year timeframe with approximately 250 major trauma cases and 50 deaths per year. Similar results were reported in a recent study from New South Wales which found the observed increase in motorcycle crashes to be offset by the greater increase in motorcycle registrations in that state (de Rome and Senserrick 2011).

Overall, nearly half (49.6%) of motorcycle crashes reported to the police in Victoria between 2001 and 2011 were single vehicle crashes involving only the motorcyclist. This finding represents a challenge to reporting and locating this type of crashes by emergency teams, particularly in rural areas. Around 40% of police reported crashes involving motorcyclists in Victoria occur in rural areas. While the most common locations for sustaining motorcycle-related major trauma were Gippsland (particularly Phillip Island), and the Southern Metropolitan Melbourne (predominantly Casey, Frankston and Greater Dandenong) areas, using mapped data, crashes resulting in major trauma were also common in the Yarra Ranges and on the Mornington Peninsula. This was consistent with police crash records.

The profile of motorcycle-related injury cases in all population-based datasets examined in this study demonstrated a consistent pattern. Injured motorcyclists were predominantly young, male and healthy prior to injury, findings that are consistent with previous studies (Hinds et al 2007; Lin & Kraus 2009). The majority of injured motorcyclists were motorcycle drivers, with pillion passengers accounting for 3 per cent of major trauma cases and 1 per cent of hospital admissions. Pillion passengers were over-represented in coroner's records, accounting for 20 per cent of motorcycle-related deaths. The reasons for this are not clear but suggest greater vulnerability of pillion passengers. Potentially, this could reflect lesser uptake of preventive measures such as helmets and protective clothing, or a more vulnerable position on the motorcycle. According to police crash data, while helmet use status was unknown in 27% of cases, 70% of motorcycle riders were reported to have worn a helmet at the time of the crash compared to only 64% of pillion passengers. It is important to note that the overall helmet wearing rates, as reported in police crash data, are much lower than those reported in NSW (de Rome & Senserick, 2011). This might be due to the high proportion of unknown in the Victorian data due to police officers attending those crashes not recording the information on helmet use. For this reason, it is important to also examine the proportion of those reported not to have worn a helmet (3.1%), which is similar to that reported in NSW. The proportion of those reported not to have worn a helmet in the police data analysed in this study was much higher in pillion passengers (8.1%) compared to riders (2.9%).

Injuries sustained by motorcyclists involved in crashes

The profile of injuries sustained by motorcycle crash victims in Victoria differed depending on the dataset examined. While, the most prevalent injury for motorcycle-related emergency presentations were upper extremity injuries, mainly to the shoulder, for cases admitted to hospital, lower extremity were most common, followed by upper extremity injuries, with head injuries accounting for only 12 per cent of hospital admissions. Almost half of major trauma cases had sustained serious chest injuries, while almost one third had sustained serious lower extremity injuries. The chest injuries most commonly sustained were a haemopneumothorax, lung contusions or lacerations and multiple rib fractures (not involving lung injury). The most prevalent lower extremity injuries sustained were pelvic fractures, fractures of the tibia or ankle, fractures of the femur and fibula fractures. More than a quarter of major trauma cases sustained a serious head injury (intracranial injury and/or skull fracture). Multiple injuries, followed by head injury, were the most common causes of death reported by the coroner. Similar patterns of injury to motorcyclists were reported elsewhere (Pedder and Hagues 1979; Hurt et al 1981; Otte and Middelhauve 1987; Sosin et al 1990; Hell and Lob 1993; Ankarath and Giannoudis 2002; ACEM 2004; Chen 2006; WHO 2009).

Early management of injured motorcyclists

The analysis of ambulance data and the State Trauma Registry shows that most major trauma cases were transported to hospital by ambulance and the median time from receipt of the '000' call to ambulance arrival at the crash scene was 16 minutes.

The major factors contributing to response time were the place of injury, region in which crash occurred and the time of call. Compared to "on-road" incidents, crashes occurring on farms resulted in significantly longer response times, while those occurring at homes, and athletic/sports arenas were associated with shorter response times. These findings could reflect the difficulty of identifying or accessing the crash location. Homes and defined athletic/sports areas are likely to be easily located and accessible for ambulance crews, relative to places like farms. Response times were significantly shorter for crashes occurring in metropolitan Melbourne, most likely due to the shorter distances to cover relative to regional Victoria. Response times were highest for calls to '000' made during daylight hours, which most likely reflect the peak hours for calls to '000', and high levels of congestion on the roads.

The median time spent at scene by the ambulance was 27 minutes. The factors most predictive of time at scene were the type of transport used (road vs. helicopter), the location of the crash, and the physiological state of the patient. The time spent at scene was highest for helicopter transport cases, cases with a severe head injury, and hypotensive patients. The latter reflects the need to stabilise the patient for transport. Adjusting for these factors, the time spent at scene for ambulances attending motorcycle-related major trauma cases in metropolitan Melbourne were shorter than for cases occurring in regional Victoria.

The median time from departure of the scene to arrival at hospital was 34 minutes. Consistent with response times and time spent at scene, location of the crash was an important predictor of transport time from the scene to hospital with regional cases requiring longer transport times than metropolitan cases, cases occurring on farms requiring longer transport times than "on road" crashes, and all other times of the day resulting in shorter transport times than cases where the ambulance left the scene of injury in the afternoon. Adjusting for other factors, transport by air was associated with longer transport times.

Overall, the median time from injury to definitive care was 2.0 hours for motorcycle-related major trauma cases. Through multivariate analysis, the strongest predictor of time to definitive care was inter-hospital transfer. Cases requiring inter-hospital transfer resulted in an almost eight-fold increase in the meantime to definitive care. Consistent with other pre-hospital and transport outcomes, transport by air ambulance, a farm location (relative to "on road"), and crashes occurring in regional areas were associated with a longer time to definitive care.

Together, these findings highlight the challenges of transporting seriously injured motorcycle crash victims. Half of the crashes resulting in major trauma and death occur in regional Victoria, with many occurring in difficult to access locations. These facts, combined with the finding that most occur in the afternoon, when road traffic congestion is likely to be high, create a challenging environment for timely transport of seriously injured motorcyclists. Seventy per cent of deaths occurred at the roadside, with only two occurring en route to hospital. Four per cent of major trauma cases arriving at hospital subsequently died, a much lower in-hospital death rate than is observed for the wider major trauma population (12%) reflecting the relatively better outcomes for motorcyclists once they receive the required care.

Long term outcomes

Overall, the vast majority of hospitalised, injured motorcyclists survived their injuries. Motorcycle-related trauma victims tend to be young, healthy and working prior to injury. The types of injuries sustained, including head and limb fractures, have the potential for lifelong disability and the burden of non-fatal injury must be considered. The long term outcomes data from the VSTR and VOTOR provides a unique insight into the impact of motorcycle-related injury on the individual.

Ongoing functional limitations were prevalent even at 12-months post-injury. One in five major trauma survivors, and 26 per cent of orthopaedic trauma patients, had fully recovered by 12-months post-injury. The return to work rate at 12-months post-injury was 67 per cent for motorcycle-related major trauma cases, and 76 per cent for motorcycle-related orthopaedic trauma. Both motorcycle-related major trauma and orthopaedic trauma patients continued to have physical and mental health scores significantly below population norms. These findings highlight the burden of non-fatal motorcycle-related injury.

Strategies to improve emergency response to motorcycle crashes

It is argued that the type of injuries sustained by motorcyclists as well as the use of full faced helmets, chin straps, and some types of protective clothing meant that there are several unique aspects of airway, circulatory and spine management for motorcycle crash casualties (Branfoot 1994; Hinds, Allen et al. 2007). Knowledge of what to do with protective clothing in the event of injuries to the extremities, and even locating an injured motorcyclist who has crashed in a remote location, present unique considerations in developing strategies to improve the outcome for the injured motorcyclist.

Provision of first aid training

First-aid programs for motorcyclists as first-responders have attracted growing support within the US, UK and Australia. These Bystander Assistance Programs are designed to empower motorcyclists to manage a crash scene until emergency services arrive and train riders in the area of the specifics of motorcycle trauma that are not taught in standard first aid classes. (ASMI 2011). While their effectiveness has not been evaluated, these courses tend to be well-received, with indications that within two years the training has been used in a crash situation (a car or motorcycle) by over one in four attendees, and 2.5% have even benefitted personally from being able to use the knowledge in a crash in which they were injured (Roberts-Sanfelipo 2005).

Consultations with stakeholders, as part of this study, identified two organisations that have been offering motorcycle specific emergency first aid training - Accident Scene Management Australia (ASMA) and St John Ambulance who has been running a Motorcycle First Aid course in NSW for some years in consultation with the Motorcycle Council of NSW (MCC). ASMA has been offering a number of courses, including “crash course for the motorcyclist" through to "professional classes for emergency responders”, since early 2011 in most states and territories, including Victoria.

The survey of riders undertaken as part of this investigation revealed that while more than half of participants (58.1%) reported obtaining medical or first aid training, only 9% of those actually received motorcycle specific first aid training. The survey of riders revealed that generally first aid training, even if not specific to motorcycle crashes, seems to improve knowledge about what to do in the event of a crash. However, there are grounds for concern that standard first aid training does not address motorcycle specific issues including the removal of helmet and the application of the appropriate resuscitation method.

Consideration should be given to expanding motorcycle specific first aid training programs and their inclusion as part of the licensing schemes of riders. The survey of riders revealed a high level of acceptance of this proposition among those interviewed. Two thirds of respondents (66%) said they would attend a motorcycle specific first aid training program on what to do before professional help arrives at a motorcycle crash if such programs were readily available and about the same proportion (69%) said that such training programs should be included in the licensing process for riders. In addition, the literature review suggests that the provision of first-aid training as a requirement for newly licensed drivers (including motorcycle riders) has the potential to improve the outcomes for those injured in road crashes (Adelborg, Thim et al. 2011).

The review of the literature also indicated that there may be some merit in training commercial drivers, particularly heavy vehicle drivers, in first-aid, due to their coverage of the road network. The survey of riders shows that about two in three respondents believed that motorcycle specific first aid training should be offered to other service providers, road users and members of the community. While reliance on taxi and truck drivers has proved useful in developing countries (Arellano, Mello et al. 2010; Geduld 2011), to date there is limited application of this approach in industrialised countries. In addition, several jurisdictions have evaluated first-aid training for professional non-medical first responders, such as police and fire-fighters, and observed reductions in time from the event to definitive care. While there is evidence that this approach reduces time to definitive care, results are mixed in terms of improved survival rates and no studies have examined the specific impact on motorcycle crashes. Similarly, evaluation studies of community-based first-aid training have not provided clear support for this approach, in part because of the rarity of the medical emergency events in small communities and the difficulty in being able to measure a difference in outcomes (Larsson 2002; Jayaraman 2009; Rørtveit 2010).

It is important to note that a fairly consistent finding from several process evaluations and qualitative reviews of first-responder training is the perceived need of the non-medical persons (professional or general members of the community) to be adequately trained in managing their emotional response, as much as having the knowledge and skills to respond to the physical emergency (Elmqvist 2010).

Improving Emergency Services response times

The literature review indicates that communication technology is a promising area for improving the reporting of and response times to road trauma, although its use has not directly been tested in the event of serious motorcycle crashes. There is support for the implementation of eCall, communication technology based on vehicle-based sensors used to trigger an emergency transmission. However, it seems that that the technology is not yet appropriate for adaptation from other motor vehicles to motorcycles (ACEM 2010). Other technologies include vehicle to vehicle communication systems, that enable real-time transmission of data such as GPS coordinates, speed and throttle position to emergency services; and hybrid wireless mesh networks which can relay information such as GPS coordinates and alert messages on a large scale. While it is argued that these technologies could be most beneficial in rural areas where the first on the scene are often volunteers with minimal training (Flanigan 2010), there is little evidence to support their suitability to motorcycle crash events.

It is important to support the adaptation of communication technology currently available for cars to motorcycles in order to better locate crashes, particularly in rural and remote areas. Over half of riders (58%) who participated in the survey said that they would install an automatic crash notification and GPS location system to relay information to emergency services if such technology was available for their bikes

Some stakeholders, interviewed as part of this study, also pointed to the potential use of personal tracker devices which include positioning applications currently available on many mobile phones and other personal trackers that are satellite based. They also pointed to the need for more mobile phone towers and emergency satellite telephones in identified motorcycle crash risk areas. This was supported by findings from the rider's survey where nine out of 10 respondents said that they would be prepared to assist a crashed motorcyclist if they could get first aid advice over the phone and 71% said that there is a need for emergency phones to be placed along key motorcycle routes in areas, for example, where the mobile phone service is out of range.

Other stakeholders also highlighted the importance of raising rider awareness of strategies to reduce the risks of riding alone. This includes encouraging riders to ride with at least one other rider, the importance of following Search And Rescue Protocols and the possibility of mobile phones operating on the International Emergency number 112, which will divert their call to 000 in Australia even when signal from own service provider is unavailable. Other important elements that allow an emergency caller to be accurately located, according to some interviewed stakeholders, include emergency markers, clear signs showing road names, roadside distance marker and other signage on the road network, particularly in rural areas.

5. CONCLUSIONS

While the analysis of most relevant population-based datasets shows no evidence of a significant increase in motorcycle-related injury in Victoria in recent years, half of the crashes resulting in major trauma and death during this period occurred in regional Victoria, with many occurring in difficult to access locations. This highlights the challenges of transporting seriously injured motorcycle crash victims – particularly as multivariate analyses indicate that motorcycle crashes occurring in regional areas of Victoria were associated with a longer response time and overall time to definitive care.

Despite injuries to motorcyclists representing an increasing proportion of road trauma in industrialised countries, there is currently a lack of evidence about the effectiveness of interventions that enhance emergency response to motorcyclists involved in crashes. The review of the literature, undertaken as part of this study, was largely limited by the lack of documented studies on the effectiveness of strategies to enhance the capacity of first responders and professional response teams with respect to motorcycle crashes. The absence of randomised trials in this field is no surprise given the ethical and financial constraints in assigning individuals, or even communities, to randomly receive or not receive first-aid treatment or training. Somewhat surprising, however, is that despite a number of programs and initiatives being trialled and even adopted on a large scale, there is a paucity of even non-randomised observational studies that evaluate outcomes of these programs in terms of impact on injury outcomes and quality of life.

Research is therefore needed to understand what works, to what extent and in what context, in terms of strategies to improve the impact of first-responders and professional responses to trauma resulting from motorcycle crashes. The evidence from research in motor vehicle crashes and other medical emergencies is far from definitive, but provides some promising strategies that are worthy of consideration and if adopted, even on a limited scale, should be coupled with robust evaluation.

One strategy which has great potential and is well accepted among motorcycle riders and major stakeholders is the provision of motorcycle specific first aid training programs to motorcyclists with suggestions to include them as part of the licensing schemes of all motorcyclists. Other suggested strategies to improve emergency response time, particularly in rural areas, include better mobile and satellite phone coverage as well as improved road emergency markers and other relevant road signage. Another area which requires further support is the adaptation of various communication technology systems (such as vehicle-based sensors, vehicle to vehicle communication and hybrid wireless mesh networks) to motorcycles as they have the potential to enhance emergency response in rural areas.

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Appendix I : List of relevant data sources identified

Data Source	Summary	Status
Computer Aided Dispatch (CAD) data – Ambulance Victoria	Contains data relating to dispatch (case nature / urgency / location / geospatial information) and time stamps of all time intervals	Ongoing
Head Injury Database - Epworth	Records data from the ABI rehabilitation units located at Epworth hospital	Ongoing
ISCRR Compensation Research Database - Monash University	Contains client compensation and health service utilisation data	Ongoing
Medicare – Federal Government	Contains comprehensive health service utilisation and health costs	Ongoing
National Coroners Information System (NCIS) – Victorian Institute of Forensic Medicine	Contains information about every death reported to an Australian coroner since July 2000.	Ongoing
National Trauma Registry – National Trauma Research Institute (NTRI)	Will contain data of all trauma patients who present to participating trauma services within Australia	Under development
Transport Accident Commission Claims – Transport Accident Commission	Contains data relating to compensation client experiences and satisfaction	Ongoing
The Alfred Hospital's Intensive Care Traumatic Brain Injury (TBI) Database	Collects data about TBI admissions to the Alfred Hospital's ICU	Unclear
The Royal Children's Hospital (RCH) Trauma Registry – RCH	Contains data of all trauma patients (Paediatric Only) who present to RCH	Ongoing
The Royal Melbourne Hospital (RMH) Trauma Registry – RMH	Contains data of all trauma patients (Adult Only) who present to RMH	Ongoing
TraumaNet – The Alfred Hospital	Contains data of all trauma patients (Adult Only) who present to The Alfred Hospital	Ongoing
Victorian Admitted Episode Dataset (VAED) – Department of Health	Contains de-identified administrative and clinical data on all patients admitted to the majority of Victorian hospitals	Ongoing
Victorian Ambulance Clinical Information System (VACIS) – Ambulance Victoria (AV)	Contains administrative and clinical data of all patients attended by AV	Ongoing
Victorian Adult Burns Service Register – Alfred Hospital	Contains data relating to all patients managed by the Victorian Burns Unit at the Alfred Hospital suffering burns from all causes	Ongoing
Victorian Emergency Minimum Dataset (VEMD) – Department of Health	Contains de-identified administrative and clinical data on all patients who present to the majority of Victorian hospital Emergency Departments	Ongoing
Victorian Orthopaedic Trauma Outcomes Registry (VOTOR) – Monash University	Contains data of all patients who are admitted with orthopaedic injury to four health services within the state of Victoria	Ongoing
Victorian State Trauma Registry (VSTR) – Monash University	Contains data of all major trauma patients who present to all trauma services within the state of Victoria	Ongoing
VicRoads Crash Data	Contains data about crashes occurring on public roads in Victoria where at least one person is killed or injured.	Ongoing

Appendix II: Summary of included original studies and literature reviews

Intervention approach	Relevant articles (author, year)	Study type	Location	Key finding	Emergency event	Comment
Understanding the problem						
Injury patterns	(Hinds, Allen et al. 2007)	Literature review - PubMed, EMBASE and the Cochrane library supplemented by hand searching bibliographies of retrieved articles	International	Examines the patterns of major injuries incurred by motorcyclists, and the unique aspects of airway, circulatory and spine management. Evidence that helmets should be removed (but only with the proper equipment – bone saw – and by trained personnel) and the "speed hump: cut from the leathers if airway problems are detected. Leathers act as fracture splints, particularly for pelvis and lower extremities. Removal or extensive cutting away of the lower portion of leathers should only take place in a medical facility and in anticipation of circulatory deterioration.	MC crashes	Findings are directed at the trained medical and para-medical staff attending the scene. They do not cover lay-person bystander responses.
	(Mikocka-Walus, Gabbe et al. 2010)	Retrospective analysis of patient records (major trauma) and coroner records (deaths) looking at on-road off-road injury differences	Victoria	Based on 1157 hospitalized major trauma survivors and 344 deaths due to motorcycle-related injuries there was no overall significant change over the 7-year study period. When examining on-road vs off-road injuries (using population numbers as the denominator) there was found to be a significant decrease in on-road injuries and a significant increase in off-road injuries. This different was not significant when employing number of registered motorcycles as the denominator. The majority (77%) of fatalities occurred at the scene of injury.	MC crashes	Important to current review is that approx 24% of all MC injuries (9% of all MC related fatalities) were in connection with off-road cases and that this proportion has increased in recent years. Statistics are not adjusted for exposure/participation
	(Newgard 2007)	Review of data from several sources to provide estimates of exposure and compute fatality rates	USA	A trend was found of an increase in fatality rates from 1995-2004 and a higher proportion of riders over 40 years of age. Among fatalities a high proportion killed among 30-39 and 40-49 year olds had a BAC over 0.08%. Helmet wearing was fairly constant over the study period - just over 50%.	MC crashes	US data so some differences in riding behaviour patterns (particularly helmet wearing and BAC) to Australian context.
First response						
General overview	Mabbott (2001)	Review of the literature on lives potentially saved if first-aid were rendered more quickly.	International	The six research papers reviewed have shown a clear case for the reduction in roadside fatalities through the early intervention of laypersons. Authors suggest that around 7% of lives could be saved by early intervention.	MVC	Included studies were from 1974-92. No literature search method provided. Covers several relevant issues but acknowledges there is only "soft" evidence to date.
	Swor (2006)	Prospective observational study with 681 (identified through hospital records) bystanders who called "911" following a cardiac arrest event.	USA	Of the cardiac events included 17% survived to hospital admission and 6.7% survived to hospital discharge. Of those who had some training in CPR (just over half) 35% attempted CPR. Of those who did not initiate it (n=297) 39% said they panicked, 11% said they were not confident they could do it, and 2% feared they would harm the patient.	Cardiac arrests	Convenience sample and limited to cardiac arrest events. Barriers to performing CPR may provide some insight to concerns that need to be addressed in first-aid training.
General overview	Wenzel (1997)	Immediate post-test and 6 month follow-up test of knowledge and skills test of CR skills of 113 medical students.	USA	Mouth-to-mouth ventilation skills 6 months after training were unpredictable; there was only a 5% chance that a given student would achieve the same mouth-to-mouth ventilation performance in both the Basic Life Support class and 6 months later.	Basic Life Support	Limitations of the testing procedures are mentioned. Follow-up was only for 6 months. Sample was limited to medical students.

Emotional preparedness	(Elmqvist 2010)	Qualitative study – interviews with 18 informants: four patients, one next of kin, eight policemen, two firemen and three ambulance staff	Norway	Considers the emotional response to the first-responder experience from the patients' and the first-responders' experiences. Managing the chaotic environment, feelings of helplessness, the importance of touch and calm speech, addressing fear and anxiety, while waiting for further help to arrive – were all highlighted as important elements. Concludes that these aspects should be covered as part of training with lay or paramedical first-aid providers.	Medical emergencies/trauma patients	Qualitative study with 18 participants. Useful for concepts only.
MC riders as first-responders	Roberts-Sanfelipo, 2005 ASMI, 1999	Cross-sectional survey of 846 MC riders	USA: 14 states	Bystander assistance training found relevant and likely to be used by nearly 1/3 of those trained within last two years. 29% reported using the training in a crash or other situation. 5% had been involved in a crash themselves and nearly 50% of these reported using the information (a great deal, i.e. 10 on a scale of 1 to 10) in their own crash. Authors concluded that increased confidence, a focus on securing the scene and focusing on life threatening injuries have all helped to improve outcomes. Similar findings in smaller, earlier study	MC crashes	Long-term follow-up on usefulness of training program to MC riders. Injury outcomes not measured. Focus on knowledge of securing the scene, managing life threatening injuries, and increasing confidence to act, a have all helped to improve outcomes.
	Accident Scene Management Australia, 2011, React First UK)	Not a study – just an overview		Description of course and content: when and how to remove a casualties helmet and managing scene safety. Heavy leathers, armour and helmets means that delivering essential lifesaving first aid to bikers involves many additional considerations.	MC crashes	
All licensed drivers	Adelborg (2011)	Pre-post survey of first-aid knowledge and self-reported skills by115 respondents.	EU	Mandatory course in first aid for learner drivers appeared to lead to improved knowledge of first –aid and basic life support as well as confidence in own ability to respond in an emergency. Some deficiencies in knowledge areas identified including 23% knowing when to activate emergency medical services and 64% knowing how to recognise a cardiac arrest.	All MVCs	Evaluation used only a small convenience sample. No indication of how long the knowledge and confidence levels were maintained post program.
	Arbon (2007)	Population-based emailed survey of 773 government workers regarding first-aid training use and preparedness.	ACT, Australia	One quarter had health care qualifications, the majority, 89%) had not provided first-aid at the scene of a motor vehicle crash. Securing the scene, providing comfort, aiding with breathing and stabilising fractures and wounds were most frequently cited.	All MVCs	Only 6.8% response rate and sample (self-selected gvt employees) was biased in terms of health workers. Good review of literature – but study of limited value.
Community-based programs	(Rørtveit 2010)	5 year follow-up study of community teams trained in defibrillation	Norway	Training volunteer community teams in isolated areas (Islands in Norway) to be able to administer CPR and use defibrillators in the event of cardiac arrest. Teams were sustained for 5 years without any cardiac arrest events. No evidence of impact as no cardiac events in that time.	Cardiac arrest	Population of remote areas too low to be able to monitor effectiveness of training. Cost-effectiveness should be examined.
	(Ashour 2007)	Review of case records for ambulance retrieved patients who died: 188 cases, 112 where autopsy was performed and linkage to hospital records could be done.	Victoria	Examined whether bystander intervention have been helpful. The analysis of individual records suggests that 5 patients (of 112) might have been saved by bystander first-aid if available – due to airway obstruction or significant bleeding and there was a delay in calling for an ambulance. Relatively few trauma victims received bystander first-aid and the effect on survival is uncertain. Findings were consistent with an earlier Victorian study (around 2% preventable deaths due to airway obstruction).	MVC	Only fatalities were examined – not cases where lives were saved. No data were presented about the type of bystander and the first-aid training they had received. Authors concluded that further education of the public on the importance of CPR administration may achieve higher participation of bystanders.

Community-based programs	Chan (2007)	Review of records of first responder trained group (Hatzolah) over its first 11 years of operation.	Victoria	Median response times were three minutes where Melbourne Ambulance Service recorded a median response time of eight minutes. Main emergency areas were falls, chest pain and respiratory distress. Motor vehicle trauma only accounted for 3.8% of the 2318 cases seen in the 11 years.	Any medical emergency	A review of cases seen by Hatzolah group – no comparison group or pre-post measures. Comparisons are made using data from other studies. Limited application to the motorcycle crash event.
	(Larsson 2002)	Population survey (ages 18-75) of bystander first-aid training and use of it (n=1907)	Sweden	Majority had never had any training (61%) – however a higher proportion of young participants had received this training – with armed forces, schools, employers and Red Cross as the most common ways training was received. 41% were receptive to participating in training,. Of those trained 70% said never used it. Those who were present and been trained 20% gave first-aid.	Any medical emergency	Concluded that there are gaps in training – with more people willing to be trained than currently are, knowledge and confidence drops off after 5 years.
	Mc Cabe (2011)	Pre/post survey of 178 participants on feasibility, effectiveness and impact of mental health disaster preparedness	Maryland, USA	The study explored a model of collaborative planning and training between health jurisdictions, faith-based communities, and academic and centres to enhance the capacity of rural communities to respond to the psychological needs of disaster survivors. Results suggest support for and feasibility of an innovative model of capacity building at multiple levels of societal impact, including neighbourhoods, communities, regions and the state.	Post traumatic mental health issues	Model is not directly related to first-responder capacity but may be of interest as an approach build capacity within rural communities. Limited evaluation, however, as only a one group design.
Train the trainer approach	(Peterson 1999)	Survey of 500 participants of the training	Iowa, USA	Results indicated an immediate improvement in knowledge and confidence regarding administrating emergency trauma care (likelihood of stopping if first at the scene) and how to prioritise the action to be taken. There was evidence of retention of knowledge after 6 months. No evidence of change in "chain of survival" i.e. injury outcome/fatality.		No impact or outcome data – i.e. no evidence of the use of training.
Technology & communication						
In-vehicle technology	ACEM (2010)	Literature review	International	International review of available literature, with ten articles included, indicated that the majority of articles on eCall technology indicate a large variability in the findings regarding potential benefits, greatest benefit appears to be linked with rural, night-time and single accidents (linked with difficulties locating them) and in this way potential to benefit motorcycle crashes is promising, however technology to date is based on cars (airbag deployment etc) so not yet adapted to motorcycle crashes.	MVC	Review was about the applicability of the technology to motorcycle crashes – but all evidence and technology to date is based on cars. Most studies included in the review lacked strong research design.
Sensor Networks	Dilmagahini (2008)	Pilot evaluation of a mesh communication network to assess any system issues	USA	Using a real mesh network and simulated campus disaster scenario, explored and evaluated the network performance to identify vulnerabilities of the system off-line and to develop what-if scenario and ways to improve network survivability for disaster scenarios. Identified that the users should send fewer large (information) packets to prevent bottlenecks across the network and improve response times. In disaster scenarios where responders communicate different types of data, video, digital maps and voice over the same network, different types of services should be defined to meet each application needs specifically.	Disaster scenarios	Limited applicability to motorcycle crash scenario – at this stage its application has been limited to a small geographic area (university campus).

Professional services						
Non-medical emergency services	(Alonso-Serra 1997)	Survey of law enforcement agencies (police) about their role and response to providing pre-hospital emergency care.	USA	80% had responded to such a situation and 50% had provided patient care. General trend to feel it interferes with regular duties but is important skill to have.	Medical emergencies	77% response rate, No evidence of impact on injury outcomes
	(Hawkins 2007)	Survey of Law enforcement personnel (n=420)	USA	80% reported routinely attending to a medical emergency. 91% of law enforcement agencies provide officers with some level of medical emergency training. Only one-third of officers' vehicles carry automatic external defibrillators (AEDs)	Medical emergencies	57% response rate. Just assessing need for first-aid training, not its effectiveness.
	Smith & Peeters (2001) Also covered by Smith & McNeil (2002)	Non-randomised controlled trial , 161 patients in intervention area and 268 in control area – assessing time to EMS arrival at scene and time to defibrillation	Victoria	Training of fire officers to administer defibrillation to people with cardiac arrest as an approach to having more trained personnel and defibrillators in the system and therefore reducing response times. The mean response time to arrival at scene was reduced by 1.6 mins ($p<0.01$) and notably a large reduction in prolonged responses (>10 min) to cardiac arrests was also observed in the pilot area (2%) compared with the control area (18%), ($p<0.01$). Mean time to defibrillation was reduced (approaching significance) by 1.43min, ($p=0.068$.	Cardiac arrest	Limited to defibrillators and the importance of this being applied within the first 5-10 minutes. Results cannot be translated to the motorcycle crash scenario, but the model of increasing the capacity of emergency responders to reduce response times might be relevant.
	Smith & Rich (2001)	Qualitative – 9 focus groups with fire officers concerning training as medical first-responders	Victoria	Overall response to the first-responder program was positive – less than one in 10 felt the training was a misdirection from their core duties. After 12 months most fire officers had attended 1-5 medical emergencies. Most felt greater confidence in applying first-aid skills. Commonly reported deficiency was skills to manage the stress of the situation and the anxiety of attending friends/relatives. Detailed feedback on course components is provided.	Medical emergencies	Limited to qualitative and process evaluation - except for finding that training had been used several times by most trainees within 12 months. Fewer fire officers in rural areas so perhaps impact would be less in these areas.
Pre-hospital trauma system	(Marson 2001)	Retrospective analysis of patient records - pre-post analysis with trauma management system as the intervention.	Brazil	System being examined consists of full-time physician coordinator, responsible for the triage, dispatch of the ambulances and coordination of the attendants via radio or cellular phone. Coordinates teams which are distributed at three strategic points in the city to provide maximum coverage with shortest possible response time. Findings showed a reduction from 7.1% to 5.9% (but not stat sig) in the number of deaths from motor vehicle crashes after the pre-hospital care system had been introduced.	MVC	Study relates to the introduction of a city-wide trauma system – not directly about first response – and not about rural events.
Pre-hospital trauma system	Stiell et all (2008).	Before and after controlled trial	Ontario, Canada	Ontario Pre-hospital Advanced Life Support (OPALS) a Major Trauma system, evaluated to see the extent to which advance life support (airway management and intravenous fluids administration) operating at a system wide level saves lives. Study found there was no benefit of fluid therapy or other advanced life support. Furthermore, there was evidence that patients with head injury with a Glasgow Scale score of less than 9 were likely to have a higher mortality rate than those administered basic life support.	Medical emergencies/trauma patients	Authors noted that the findings could not be extrapolated to rural areas

Transport to definitive care						
Helicopter retrieval	(Shepherd 2008)	Case review of 171 patients	Australia	Comparing helicopter retrieval versus ambulance of medical emergencies/trauma patients with injury severity scores were 12.5 on average and 29% had an ISS >15. While air transport was shown to be significantly faster for distances greater than 100km, there was no significant difference between the air and road groups in terms of outcome or fatality rate.	Medical emergencies/trauma patients	Authors concluded that there was no sign of a survival benefit attributed to the addition of a doctor and time to definitive care does not improve if the distance is less than 100km.
	(Spencer-Jones, Varley et al. 1993)	Analysis of records from 300 helicopter retrievals of injured MC riders in connection with competition event over 10 years	Isle of Mann, UK	In all – concludes that there was an improvement in patient survival rates for those airlifted attributed to presence of highly trained personnel during transit and reduced time to definitive care.	MC crashes in connection with competition event.	Racing even on the Isle of Mann provide a unique context. Translation to rural context and general road use is of limited value.
GPS unit in ambulance	(Gonzalez 2009)	Pre-post study comparing response times with (n=791) and without (n=893) GPS units set to finding the fastest route	Alabama, USA	The mean response time for all EMS calls before GPS utilisation was 8.5 minutes and 7.6 minutes after GPS utilisation (p=0.0012). Data indicated that longer travel distances in rural settings are impacted the most by GPS utilisation. It is assumed that EMS personnel have less familiarity with the roads and, consequently, travel times are increased without the aid of GPS.	All medical emergencies	Impact on survival not assessed.
Helmet removal and neck injuries						
Helmet removal	(Branfoot 1994)	Literature review	International	Incidence of cervical spine injuries due to MC crashes is low in survivors - approximately 1%; but up to 9% among those who have died. Conclusion was that the threat to breathing and therefore life is generally greater when head injuries are severe and that, as spinal injuries are rare, it is generally advisable to remove the helmet if the injured motorcyclist appears to have restricted breathing or if the casualty is vomiting.	MC crashes	This article is now somewhat dated
	Waninger (1998)	Literature review on helmet removal in neck injured motorcycle riders, football and hockey players using Medline, sportsdiscus and hand searching of key titles.	International	Five quasi experimental studies were included in the review. No study supported the removal of helmets in the pre-hospital setting. One study examined the removal of motorcycle helmets using cadavers and surgically created spinal injury at C5-C6 due to the action causing unacceptable cervical movement – and its removal should not be done unless airways problems exist.	Neck injury	Review found very little in this area and none of strong research methods. Review is now somewhat dated.
	Waninger (20045)	Update on above literature review using Medline, sportsdiscus and hand searching of key titles – but limited to football players.	International	Fourteen studies were included and confirmed that there is no support for helmet removal except with airways difficulties. Findings indicate that health care specialties that treat these injuries need to be aware of the guidelines for managing helmeted athletes. Diagnosis of injury type and location via specialised hospital equipment is also discussed.	Neck injury	Review limited to football players and it was noted that risk of further injury by removing the helmet is linked with the type of football helmet.