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Post-Crash Response Arrangements

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TITLE

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Summary

A comprehensive account is presented of post-crash response arrangements in New South Wales accompanied by an Australian and European overview. Post-crash response is rarely included in road safety strategies, possibly due to it often being seen as falling outside the responsibility of transport agencies, even though many of these have a leading role with road safety. Australian exceptions are the current NSW and SA road safety strategies, both of which include emergency response as actionable areas.

The effectiveness of an emergency response commences with notification of an emergency incident and, consistent with world's best practice, Australia has a single, national operator-assisted emergency call service that can be accessed from any fixed line or mobile phone. The service is used around Australia for requesting emergency service organisations' assistance in life or property threatening situations. An issue often highlighted as an impediment to emergency response in Australia is the communication of the precise crash location, particularly in rural areas. Programs that provide a consistent approach to identifying the location of emergencies, as well as technologies that improve location information, are assisting with overcoming this impediment.

A comprehensive review of the literature regarding emergency response times and advances in technology relevant to emergency response revealed that two different medical response philosophies exist: the Anglo-American "scoop and run" approach and the Franco-German "stay and stabilise" emphasis. Australia and NSW are more closely aligned with the former and this is reflected in the rescue arrangements adopted around the nation. The concept of the "Golden Hour" was found to have very little empirical basis, although much research supports the notion of minimising response times for improved outcomes.

There is strengthening confidence in vehicle based intelligent crash detection and communications technologies that have the potential to shorten response times, particularly for rural areas. E-Call technology, or Automated Call Notification (ACN) systems, are increasingly being made available in new vehicles. Such technologies also reduce the risks of miscommunication from manual relaying of information. A recent study in Australia found that 2.2% of all fatalities might have been avoided if earlier crash notification to emergency medical services (EMS) had occurred through a widely-deployed ACN system.

This report summarises some of the work undertaken by the European Commission as part of a project entitled "SafetyNet" that aimed to collate knowledge and data as a basis for future European safety policies. Data are reported for the top performing European countries in terms of road safety. In essence, the SafetyNet project highlighted that post-crash system performance is a critical determinant of fatalities and injuries resulting from road crashes. Several risk factors influence the severity of post-crash injuries, including (but not limited by) crash notification, difficulty in extrication of the injured from vehicles and lack of pre-hospital and hospital emergency care. It was found that common features of a better performing emergency/trauma management included shorter response times, higher levels of staff and standardisation of emergency vehicles.

It is evident from the literature that the area of post-crash response is complex such that meaningful comparisons both between countries and within countries are difficult to achieve. This is in part due to the differing arrangements in place regarding medical and rescue response, but also to the range, reliability and definition of data collected. However, some comparison concerning emergency response is possible.

Across various areas in Australia, it was found that there is a generally consistent approach to emergency medical response and road crash rescue, although some specific arrangements differ slightly. In each area, the Ambulance services are the primary medical responders for pre-hospital care and road crash rescue is undertaken by various rescue agencies. Comparisons between Australia and the top road safety performing European countries were difficult to make, as their approaches to emergency responses differ. However, some comparisons for certain indicators can be made and were discussed in this report.

Overall there was data that provided an insight into the scale of effort and performance on selected measures. However it was evident that individual circumstances in each jurisdiction lead to distortions of the data that makes meaningful comparison difficult. Even if performance measures are included in the databases, there is no guarantee that they are recorded consistently and regularly by rescue organisations. Extracting information specific to road crash rescue is also not straightforward. It is therefore difficult to perform such systematic analysis and modelling at a national level.

The activation of an appropriate emergency medical response in NSW, is guided by the NSW Trauma Services Plan, and Ambulance NSW is the designated provider of the pre-hospital component of care to an injured patient. The *NSW State Emergency and Rescue Management Act* 1989 specifies the legal frame-work and governance for rescue management in NSW. The system for activating an emergency response in NSW is highly structured but briefly summarised in the report.

There is scope for Transport for NSW to conduct a study to determine the effectiveness of a fully deployed ACN system in NSW, to improve the activation of emergency response in the State. The background and concept to such a study are discussed in the report.

Finally, a series of interviews with rescue organisations in NSW were able to provide further detail on emergency response arrangements. Consideration of how an organisation like Transport for NSW could assist with improving post-crash response proved more challenging and interviewees provided limited insight as to what additional initiatives could be pursued. Topics around traffic management and congestion arose and there was an appetite for evidence based adoption of ACN. There was acceptance by some interviewees that interstate comparisons and research with the monitoring data could be useful, especially in relation to understanding factors that affect response times.

Much more research is required regarding post-crash performance monitoring before any suggestions for improvement can be made. There is, however, a unique opportunity for Transport for NSW to take a lead in the collection and collation of the various types of performance data relevant to post-crash response. This would allow an independent and systematic analysis of the important performance indicators (as highlighted in this report), and would provide a sound basis for recommending response improvements.

Contents

1 Introduction

It is self-evident that the capabilities of emergency medical and rescue operations when responding to road crashes are critical in reducing a country's deaths and injuries on the road. However, the post-crash phase is rarely mentioned in many road safety strategy documents and, when there is coverage, it is often limited in detail.

For example, the World Health Organisation's (WHO) *Global Status Report on Road Safety 2013: Supporting a Decade of Action* states that road traffic injuries are estimated to be the eighth leading cause of deaths globally, on a par with diseases such as malaria, and also the leading cause of deaths for young people aged 15-29. Moreover, more than a million people die each year on the world's roads and current trends suggest that by 2030, road deaths will become the fifth leading cause of death unless urgent action is taken (ibid). The WHO report champions the post-crash phase as a fifth pillar to guide national road safety plans and activities over the coming decade. (The first four pillars are: road safety management; safer roads and mobility; safer vehicles and safer road users).

Under the WHO's *Global Plan for the Decade of Action for Road Safety 2011-2020* (2013a), countries are encouraged to integrate each pillar into their national road safety strategies, and to implement and report on each one. For the post-crash response pillar, the Action Plan's guiding statement is:

> "Increase responsiveness to post-crash emergencies and improve the ability of health and other systems to provide appropriate emergency treatment and longer term rehabilitation for crash victims." (p. 17)

This guiding statement highlights several post-crash strands, such as quality of emergency response, system capability (especially from the health sector), appropriate medical emergency treatment and rehabilitation. Consequently, seven specific actions follow this guiding statement, with the seventh being of most relevance to the present study:

> "Encourage research and development into improving post-crash response." (ibid)

Despite its place in the *Global Plan,* within Australia, emergency service response effectiveness does not feature in the *National Road Safety Strategy 2011-2020,* or in the current road safety strategies and action plans of Victoria, Tasmania, Queensland Western Australia, the Australian Capital Territory or the Northern Territory. This may be because, despite the clear implications of quality emergency services for road safety, they do not readily fit as an element of the Safe System approach used to underpin those strategy documents. It might also be the case that road safety is predominantly seen as belonging to the portfolio responsibilities of Ministers of Transport and/or Road Safety, whereas the post-crash phase is often considered to be under the control of Ministers of Emergency Services or Health. It can be argued that emergency service responses should be controlled under a mixed model jointly involving health and safety portfolios, although this can lead to emergency services not being properly funded (Al-Shaqsi, 2010).

The *New South Wales Road Safety Strategy 2012-21* discusses issues surrounding post-crash response and identifies two key action focuses, firstly better coordination across emergency retrieval and medical services and the Motor Accidents Authority, and secondly technological improvements, particularly automatic crash notification (ACN) systems and collision detection and avoidance systems.

Towards Zero Together South Australia's Road Safety Strategy 2020 similarly stresses a need for cooperation "…between health, road designers and vehicle regulators to ensure advantage is taken of

new technologies, which allow more rapid and accurate reporting and locating of crashes." (p.18). The development of the *Towards Zero Together* strategy was influenced by advice from an Adelaide Thinker in Residence, Professor Fred Wegman from the Dutch Traffic Safety Administration in the Netherlands. Professor Wegman's residency report, although presented to the South Australian Government, has nationwide implications. It called for a number of demonstration research projects, including a trial of e-Call systems of ACN technology in new vehicles.

Looking at various international road safety strategy documents, the European Union comments that,

> "While post impact care is acknowledged as a key road safety strategy, it is often neglected in national road safety plans and programmes in European countries. This may be because it is outside the direct responsibility of the lead agency for road safety, which is generally the Minister for Transport."

For example, Britain's *Strategic Framework for Road Safety* (2011, p.32) says little more than:

> "Other local public services, including the health services and the three emergency services are influential in improving road safety and also have statutory responsibilities."

Emergency services are not mentioned at all in the British *Update to the Strategic Framework for Road Safety Action Plan 2012.* Moreover, neither emergency services nor the post-crash phase rate a mention in *Canada's Road Safety Strategy 2015,* or *Safer Journeys — New Zealand's Road Safety Strategy 2010-2020* or the accompanying *Safer Journeys Action Plan 2013-2015*. In the United States, however, emergency medical services constitute the last of the '4Es of highway safety' (along with engineering, education and enforcement) in the Federal Highway Administration's *Strategic Highway Safety Plan and Emergency Services*.

Despite the apparent lack of formalisation of emergency response in many road safety strategic documents, Al-Shaqsi (2010) has summarised two distinct approaches to emergency care management, based on their respective philosophies: the Franco-German model and the Anglo-American model. The former is characterised by a 'stay and stabilise' emphasis, in which specialised trauma personnel with technological equipment attend an incident and prepare the patient for admittance to hospital where this is deemed necessary. The staff attending have the authority to make complex clinical judgments and administer appropriate emergency treatment, thus often bypassing the emergency department once an emergency patient reaches hospital. Al-Shaqsi (2010) notes the Franco-German model is common in Europe, particularly in Germany, France, Greece, Malta and Austria, and tends to be embedded in public health directions.

In contrast, the Anglo-American approach is characterised by a 'scoop and run' emphasis, in which the aim is to bring patients rapidly to hospital emergency departments with few pre-hospital interventions. The approach commonly exists in alliance with police and fire services, but the operations are overseen by trained paramedics and technicians and in a context in which trauma medicine is regarded as a separate medical speciality. Al-Shaqsi (2010) notes that the Anglo-American model is evident in the United States, Canada, New Zealand, the Sultanate of Oman and Australia, in which it tends to be embedded in public safety directions. However, the United Kingdom has since adopted an Emergency Care Practitioner Scheme that is now more akin to the Franco-German model (ibid). Al-Saqsi (2010) discussed how these two distinct approaches resemble the dichotomy of Basic Life Support (BLS) versus Advanced Life Support (ALS) systems. BLS is characterised by administering vital first aid such as resuming respiration and stopping bleeding followed by expedient transfer to hospital. In ALS approaches, substantial efforts are made at the crash site to stabilise the patient, ease pain and even administer some treatments, as well as discussing the patient's needs with a trauma centre, all before evacuation begins.

1.1 Purpose and structure of this report

This research was commissioned by Transport for NSW (TfNSW) to produce a comprehensive account of current post-crash emergency medical and rescue response arrangements. As well as reviewing literature on the topic, the work involved comparing NSW with other Australian states and territories and with five of the best performing nations for road safety in the OECD.

In this introductory chapter, the notion of post-crash response was examined in a broad policy context, particularly its status within road safety policy and strategic direction documents of Australian and some overseas jurisdictions. Chapter 2 provides some background information on the nature, structure and operations of emergency services in Australia to assist in providing a contextual understanding of the later chapters. Chapter 3, the literature review, first examines research into emergency response times, improvements in identifying locations of rural area crashes and technological advances, as these factors variously influence approaches to measuring post-crash emergency response. A 2006 study that reviewed and compared emergency response across five top performing OECD countries (in terms of road safety) is then examined. This is followed by an analysis of the literature on approaches in measuring emergency service response, with the chapter concluding with a summary of the key measurement issues as a prelude to the study's results. Chapter 4 and 5 present a summary of post-crash response arrangements in Australia and NSW respectively. Chapter 6 presents the outcomes of discussions with NSW rescue organisations as to the potential for further improving post-crash response in NSW. The final chapter provides an example of how modelling work on automated crash notification (ACN) could be conducted for NSW.

1.2 Methodology

The study evolved through a review of literature relevant to post-crash response approaches and arrangements. The review began with the issue of emergency response times and how response times are affected by such factors as geographical locality of a crash and technological capability, in order to fully appreciate the influences on post-crash response capability. For the reasons discussed below, the literature review was expanded to provide a detailed investigation of international and Australian emergency response to road crashes.

An initial plan was to hold in-depth discussions with selected rescue organisations internationally and from around Australia but this approach was changed to a focus on NSW rescue organisations given the difficulty in identifying and contacting the relevant people in organisations. Representatives were identified through the NSW State Rescue Board and in-depth telephone interviews conducted to determine an accurate picture of rescue arrangements within the state and if there was any scope for improvement that Transport for NSW could contribute to.

An example of a framework for modelling the benefits of ACN is provided to demonstrate the feasibility of exploring some scenarios in relation to post-crash response.

2 Background: Australia's emergency response arrangements

The following background coverage of national emergency response arrangements provides a contextual understanding for the literature review and results chapters.

2.1 National emergency call service

Consistent with world's best practice, Australia has a single, national operator assisted emergency call service number 000. This is the primary number that can be accessed from any fixed line or mobile phone, used for requesting emergency service organisations to assist in life or property threatening situations around Australia. Additionally, there are two secondary emergency service numbers: 112 (for use on digital mobile phones - particularly when there is no 000 mobile coverage) and 106 for the hearing impaired (Attorney-General's Department, 2013a).

The operators of the emergency call number for 000 (triple zero) and 112 are Telstra and the National Relay Service for the text emergency relay service, as specified in *The Telecommunications (Emergency Call Persons) Determination 1999* (Attorney-General's Department, 2013a). The obligations and requirements of the emergency call persons are specified in *The Telecommunications (Emergency Call Service) Determination 2002* (Attorney-General's Department, 2013a). The role of the emergency call person is to answer the emergency call, retrieve information from the caller and transfer the call to the appropriate state or territory Emergency Service Organisation (ESO), depending on the nature of the emergency.

2.2 Emergency service organisations

In the individual states and territories of Australia, the protection of life and property is the responsibility of the respective governments. The governments facilitate this protection by providing ESOs, namely Police, Fire (Metropolitan and Rural) and Ambulance services.

The protocol for initiating the emergency response to a road crash with serious injury would probably initially commence with a triple zero call being transferred to the relevant government appointed or contracted ambulance service. Pertinent information about the crash, including accurate location information, is retrieved from the caller to enable activation of an emergency medical response. This would proceed with the immediate coordination with the other relevant ESOs, either automatically (via shared electronic communication links (linked Computer Aided Dispatch (CAD) systems) or by manual communication (phone to phone) methods.

Recently, a number of technological advances have occurred that can now assist with improving location information obtained from a caller and relayed to the emergency call service. In situations where a location is not known, new systems have been put in place so that ESOs with appropriate capabilities can automatically retrieve enhanced location information from someone calling triple zero from a mobile phone based on the nearest cell tower sites (Communications Alliance, 2014).

Additionally, and independently, the "Emergency +" iOS and Android smartphone applications has been developed by the Triple Zero Awareness Working Group and can assist with making a triple zero call and displaying the GPS coordinates so the caller can read out their location (Attorney-General's Department, 2013b). The Productivity Commission (2015a) indicates that each of the jurisdictions in Australia have operational computer aided dispatch (CAD) systems for communications and dispatching that also aid with quicker dispatch of resources.

2.3 Improvements in identifying the locations of rural area crashes

Clearly, the sooner the precise location of a rural crash is made known to emergency responders, the shorter the overall response time.

NSW, in common with other Australian jurisdictions, has adopted the nationally consistent Rural Addressing Scheme. Rural addressing is a distance based numbering system that provides a simple, straightforward means to identify and locate rural properties. It is defined by the Australian Standard for Urban and Rural Addressing (AS4819). Under the scheme, addresses contain a rural number (a number based on the distance from a "predetermined start point" on the road such as a junction or intersection), the road name, road type, the property's gazetted locality and state. For example, a house rural number 679 means that the house is 6790 metres (6.79kms) down the road from the start point, on the left side.

In a more localised project (Kiely, Noonan, Parsons & Pettet, 2002), emergency location information in Bunbury, WA is placed on metal discs affixed to special marker posts along rural roads. The discs display the highway coding number, the common name of the road, a distance measurement, emergency phone contact numbers and a brief safety message about staying with your vehicle.

Emergency service assistance is frequently requested through calls made from mobile phones. The satellite technology in global positioning systems (GPS) enables the location of a mobile phone call to be automatically identified by an emergency service, thus enabling a more rapid emergency response. The automatic location of mobile phone callers has been shown to bring improved ambulance response times (Gossage, Frith, Carrell, Damiani, Terris & Burnand, 2008).

Recently, the Australian Communications and Media Authority (ACMA) (AMTA, 2013) proposed to improve the forwarding to ESOs of GPS-determined location information from mobile phone calls made to the triple zero number. ACMA indicated that while around 63 per cent of all calls to triple zero are made from mobile phones, in an estimated less than one per cent of cases the caller is too distressed or confused as to their whereabouts to give the call centre operator accurate location information. The figure of less than one per cent may be a substantial under-estimate as it seems probable that triple-zero callers involved in rural crashes may experience considerable difficulty in determining precisely where they are, while at the same time conveying the information speedily so as not to delay the ambulance or fire service response.

3 Literature review

A wide range of factors affect post-crash response capability and to varying extents, depending on local definitions and other circumstances. It is important to appreciate the range and depth of such factors as they ultimately affect the extent to which emergency responses can be measured for comparison and other evaluation purposes. First and foremost among the broad range of factors is the issue of response times, which, in turn, is affected by other factors such as response approach, issues of geographical locality and technological capability.

The review then looks at the European Union's 2006 SafetyNet project in some detail as the project also affords useful insights into issues surrounding measuring emergency service response. The final section of the review is devoted to how to best approach measuring emergency service response, drawing on the previous findings in the review.

Literature was sought from the following databases: ATRI, PubMed, TRID for literature up to 2012, using the search terms: emergency, accident or crash, response, ambulance.

3.1 Emergency response times

The published research literature on post-crash care responsiveness is almost exclusively focussed on improving response times and the factors influencing response times, and predominantly appears to be conducted outside of Australia. Variables such as time before the crash is discovered, the time it takes for the emergency vehicle to travel to the crash scene and the time emergency crews spend at the crash scene all affect the overall response time. Salvucci et al (2004) give other factors: the decision of the emergency service dispatcher as to whether a rapid or regular speed trip to the crash is called for, whether any specialist retrieval services or equipment are needed, and the distance to the most appropriate trauma centre for the case. Elvik et al (2009) add the availability of ambulances and ambulance personnel, and the accuracy of the description of the crash location. There are also grounds for considering the effect on response time of various environmental and behavioural factors, such as presence of sun glare and road rule compliance by both emergency vehicle drivers and other road users in their path (Yasmin, Anowar & Tay, 2012).

Since it was first coined probably in the late 1990s, the term "Golden Hour" has referred to the critical importance for patient survival of attending to injuries within one hour of their occurrence. Johnstone (2004) considers the term originated from an expert but still subjective view from the Maryland Institute for Emergency Services that most patients die of shock and could be saved if bleeding is stopped within one hour. However, Lerner and Moscati (2001) and also Berger (2010) concluded that no objective data exist to justify the concept. For Gonzales, Cummings, Mulekar, Harlan and Rodning, (2011) this term is misleading because it does not account for time lapsed within that hour in which successful medical attention is given. For example, in the case of severe haemorrhaging, the earlier care is received within the hour, the better the patient's chances of survival. For haemorrhagic patients, delays of one hour before hospital admittance often equate with mortality.

The critical nature of minimal overall response time is a powerful and pervasive notion. The Victorian Government's (2009) review into its State Trauma System, for example, was premised on "… the right patient be delivered to the right hospital in the shortest time." (p.3) There is ample data to support increased pre-hospital time in emergency situations increasing the chances of fatalities. For example, Akella, Bang, Beutner, Delmelle, Batta, Blatt, Rogerson and Wilson (2003) report that approximately 50% of crash fatalities occur within minutes of the injuries, 30% occur within hours, and 20% within days to weeks, which they say is consistent with data showing that more than 50% of crash fatalities occur before the victims arrive at hospital. European Transport Safety Council data yielded the following proportions: 50% of crash deaths occur within minutes, but 15% of deaths occur between 1

and 4 hours after a crash and 35% after 4 hours, such that there is not so much a single critical time period as a "chain of opportunities for intervening across a longer timescale" (SafetyNet, 2009).

Sánchez-Mangas, García-Ferrer, de Juan and Arroyo (2010) studied the records of 1400 crashes on motorways compared with other types of road in Spain, and which contained details on driving behaviours, road and vehicle factors and emergency services response times. The researchers estimated that reducing emergency response times from 25 to 15 minutes was statistically associated with a decrease in the probability of patient death by one third when averaged across both types of road. They also commented that their finding was consistent with much other literature showing a link between improved response times and reduced mortalities.

Gonzales, Cummings, Phelan, Mulekar and Rodning (2009) studied two years of police crash records and emergency services records in Alabama. They found that for fatal crashes, the mean rural response time was 10.7 minutes, but 6.5 minutes in urban areas. Also when there were road deaths, the mean emergency service time spent at the crash scene was 18.9 minutes in rural areas but 10.8 minutes in urban areas. Again, in fatal crashes the mean emergency services travel time to hospital was 12.5 minutes in rural areas, but 7.4 minutes in urban areas. Overall with road deaths, the mean total pre-hospital emergency service time was 42 minutes in rural areas, but 25 minutes in urban areas.

Henriksson, Öström and Eriksson (2001) studied 474 crashes in remote areas of northern Sweden. They calculated that, while 48% of those who died had non-survivable injuries and that 5% of victims were not located in sufficient time, 12% would have survived had they arrived at hospital sooner and that 32% would have survived had they been transported to a specialised trauma centre.

Other studies showing increased likelihood of mortality for rural area crashes include Mayer (1980); OECD (1999); Clarke & Cushing, (2002); and Travis, Clark, Haskins and Kilch (2012). Moreover, data in the *National Road Safety Strategy 2011-2020* show that road death rates per 100,000 population in Australian very remote areas are six times those in metropolitan areas. The work of Simpson, North, Gilligan, McLean, Woodward, Antonio and Altree (1984) illustrates that higher rural death rates are not due simply to distance from emergency hospital care, but are also linked to such factors as inadequate at-scene first aid administered by lay persons, and that some deaths prior to hospital admission can be prevented if specialised services are more readily available in rural and remote areas. Also, Elvik et al (2009) noted that in rural areas, single vehicle crashes are overrepresented, especially at night, and that the crashes are often severe with few if any people available to call for an ambulance.

To meet the emergency response time challenges posed by large rural and remote areas, determining where to locate various forms of emergency response teams is a critical logistical and cost-benefit issue. For example, North America's NHTSA (2012) conducted an analysis of the location of fatal road crashes with respect to coverage capability of existing emergency helicopter services. Not surprisingly, it found that the proportions of fatal outcomes from road crashes varied greatly between 100% helicopter service coverage in small states with large populations to less than 35% coverage in large predominantly rural states. Moreover, 64% of fatally injured patients whose vehicles crashed outside the 20-minute helicopter flight circles were coded as dead at the crash scene compared with 55% of patients inside the flight circles.

Gonzales et al (2011) studied the positioning of ambulances and ambulance stations in relation to the times of day emergency calls were received in Alabama, and average times required to travel to common call-out locations. They found that response times to road crashes could be improved in rural areas by locating ambulance stations where crashes tend to concentrate geographically and in the vicinity of major roads. Moreover, this can be achieved without adversely affecting response times for non-road crash emergencies.

In Britain, Bredmose, Forbes, Davies, Freij and Lockey (2008) studied inter-jurisdictional cooperation in the deployment of regional air and ground ambulances, using fictitious major incidents as described to paramedical response teams. The teams were asked to give calculated estimations of response times, which were independently verified by expert pilots and paramedics. It was found that response times were improved through inter-jurisdictional cooperation, particularly in relation to the deployment of doctors and flight paramedics, and that doing so had minimal cost implications where the air ambulances and teams were already existent.

In a very recent and sophisticated analysis, Clark, Winchell and Betensky (2013) examined the records of nearly 100,000 road fatalities and serious injuries. They concluded that rural/urban disparity in crash mortality is mostly independent of time delays and emergency services effects such type of transport and availability and quality of emergency care. In fact, they suggest that (p.146),

> "…most of the rural/urban difference in survival is determined before any emergency medical service response would be possible, possibly due to greater injury severity, even after controlling for identifiable personal and crash characteristics."

Nonetheless, they found that the effect of delay increases with time, even after an emergency intervention, which affords some validation of the 'Golden Hour' concept. They also concluded (ibid):

> "Our findings provide support for the principle of an inclusive regional trauma system that maintains and develops the capacity for smaller rural hospitals to provide initial hospital care rather than an exclusive model that favors longer transport times to more specialized centers."

Another recent study, which compared emergency helicopter evacuation with ground ambulance transport in Germany (Andruszhow et al 2013), examined relevant records of 13,220 patients with traumatic injuries (ISS ≥ 9), of which 37.7% were transported by helicopter. The helicopter-transported patients tended to have more serious injuries and required longer at-scene times for emergency medical procedures, but by the same token were more likely to develop multiple organ dysfunction syndrome and sepsis before or after hospital arrival. After adjusting for such variables, the study found that helicopter transported patients demonstrated a survival benefit over those transported by ground ambulances (the odds ratio for mortality in the helicopter group was 0.75).

In Sweden, Petzäll, Petzäll, Jansson and Nordström (2011) investigated the high speed driving of ambulances, in which thirty actual emergency ambulance trips at high speed were compared experimentally with ambulances driving the same routes at normal traffic speeds. (Emergency trips where the patient's condition was life threatening were excluded). Not unexpectedly, it was found that the average durations for the ambulances travelling at higher speeds in the actual emergencies were shorter than those travelling experimentally at normal traffic speeds. In urban areas the mean time saved was 2.9 minutes and a mean 8.9 minutes was saved in rural areas. Clearly, this shows that while high speed ambulance driving can substantially reduce response time in rural areas, for Australian remote regions this would depend on the proximity to the crash site of sealed roads that are relatively safe for high speed driving in emergency responses.

An allied issue to high-speed driving of ambulances is the use of flashing lights and sirens. Dami, Pasquier and Carron (2013) noted that decisions to use lights and sirens (and hence higher speed) on a trip may be unrelated to traffic conditions or patient injury severity, but simply based on a need to reduce travel times. On examining Swiss data from a year of ambulance trips, they concluded that there was minimal difference in mean travel time for when lights and sirens were used compared to not used, even for life-threatening emergencies. The authors speculated that the use of lights and sirens seems questionable in regards to the little travel time saved, while also noting that use of lights and sirens can increase the chance of crashes involving the ambulance as well as for other vehicles.

The travel times of ambulances can be assisted by the use of emergency vehicle pre-emption systems (EVP) that alter traffic signal timing so that a green light phase can be provided as an emergency vehicle approaches a signalised intersection (Green, Su & Luk, 2007). Among the advantages of EVP systems are that emergency vehicles do not need to proceed through red signals and that other vehicles ahead of the emergency vehicle can more easily move out of the way. They can also be installed at the exits of ambulance and fire stations to allow emergency vehicles to depart with minimum delay and can be installed on many busy routes. Once the emergency vehicle has passed, the system returns to normal operation. Green, Su and Luk noted that the number of installed EVP systems at the time was small; however this number may have improved since 2007. Nonetheless, while the researchers discuss some operational issues surrounding EVP systems, they report on an Adelaide trial that found they operated successfully 98% of the times they were activated. A similar trial by VicRoads in Melbourne was also highly successful (ibid). Green, Su and Luk (2007) noted that America's Federal Highway Administration reported that, with EVP systems, emergency response times could be reduced by 14% to 23%.

Recent advances in EVP systems place the EVP technology within the emergency vehicle such that the vehicle is able to detect an approaching signalised intersection, for example, and make sure a green light is showing by the time the emergency vehicle approaches the intersection. American experience is that such systems can reduce response times by up to 20%, and may turn out to be cheaper to set up and operate than other EVP system types (ibid).

In Massachussetts, a different approach involved Mango and Garthe (2007) retrospectively analysing a year of fatal crash records with regard to the appropriateness of the triage decisions made at the crash scene, the mode of emergency transport (air or ground ambulance) and the routes taken to the crash scene and then to hospital. It was hypothesised that more lives might have been saved due to shorter response times if more appropriate triage decisions and transport choices were made. Among the findings were that air and ground transport had been both underutilised, with the main reason being that they were never requested at the time. Overall, the study concluded that more appropriate triage decision making and emergency transport choices and routes would have been associated with a system wide increased lived-to-die ratio of 1.8 to 1.

In Western Australia, Fatovich, Phillips, Jacobs and Langford (2011) examined 1328 major trauma transfers to Perth by Royal Flying Doctor from rural and remote parts of the State over a ten year period. Over half of these cases involved road crashes. Major trauma was defined as an Injury Severity Score (ISS) greater than 15. Remoteness was quantified using the Accessibility/Remoteness Index of Australia (ARIA) classes: inner regional, outer regional, remote and very remote (ABS, 2013). As might be expected, after adjusting for ISS, patient age and duration of responses, the risk of patient death increased as remoteness increased. This was quantified as "…risk increasing by 87% for each 1000 km flown" (p.1818), but the researchers commented this figure is an underestimate when compared with the effect of remoteness as distinct from distance. The researchers concluded that remoteness, as measured by the ARIA, is a more critical factor for risk of patient death than distance travelled alone. There was in excess of a fourfold increase in the risk of a major trauma death in patients transferred to Perth from remote and very remote Western Australia.

Also in Australia, Shepherd, Trethewey, Kennedy and Davis (2008) found that helicopters under normal circumstances were faster than ground ambulances for distances over 100km. For travel involving shorter distances, the time taken in take-off and landing procedures and ground transfers can reduce the ability to respond quickly, thus rendering helicopter use not a cost-effective option unless the distance to hospital is 100km or more (Elvik et al 2009).

3.2 Technological advances relevant to emergency service response

Advances in intelligent ("smart") communications technologies are offering much promise in the quest to shorten response times, particularly for rural areas. E-Call technology or Automated Call Notification (ACN) technology is increasingly being made available in new vehicles. If the vehicle is involved in a serious crash, sensors involved in airbag deployment, for example, enable an emergency call centre or other authorised service provider to be automatically contacted, with data relating to crash location and crash severity automatically relayed. The call operator will then attempt to contact the driver, if there is no response the operator will call the emergency services on the driver's behalf. In Australia, ACN systems for some older models of Toyota and Holden vehicles are monitored via the telematics service provider 'Intelematics Australia'. However, the newer Ford System contacts the Triple Zero telephone number directly (or the 911 number in America). Since March 2014, all BMW vehicles (except the BMW Z4) have ConnectedDrive as a standard feature and hence also have BMW's ACN system 'Intelligent Emergency Call'. The BMW call centre in Manila in the Phillipines monitors these systems (BMW Group Australia, personal communication, 24 September, 2015).

Such technologies reduce the risks of miscommunication with manual relaying of information (Bachman & Prexiotti, 2001), although the availability and strength of the telecommunication signal can be an issue (Akella et al 2003) especially for rural and remote areas in Australia (Johnstone, 2004). Also, Elvik et al (2009) noted that ACN's effectiveness in reducing overall response time is mainly relevant to crash types in which the response time would normally be long, such as in rural crashes, those at night and in single vehicle crashes with no other people nearby. Moreover, shorter notification times through ACN may be of limited value as a long travel time to hospital can still outweigh any sooner at-scene treatment. Thirdly, when no adequate at-scene treatment is provided, including when inappropriate decisions are made to evacuate the patient as soon as possible, shorter notification times may still be of limited value (ibid).

American researchers (Clark & Cushing, 2002) developed a mathematical model based on data from over 30,000 crashes showing that shortening crash notification times to a minute or less would reduce crash deaths by between 1.5% and 6%. While this small percentage can represent many lives saved overall, when reporting this study, however, the IIHS (2002) commented that a minute or less is of little consequence when the response involves very long travel times for emergency services, especially in rural areas. Moreover, the IIHS noted, notification times are generally quite short anyway, false alarms are not unknown, and can be costly if vehicle owners have to pay a regular fee.

A later Finnish study (Virtanen, Schirokoff, Luoma & Kulmala, 2006) based on crashes totalling over 1000 fatalities produced similar main findings to the Clark and Cushing (2002) study: that ACN could reduce between 4% and 8% of road fatalities and between 5% and 10% of vehicle occupant fatalities in Finland. The benefit-cost ratio of ACN in the study was estimated to be between 0.5 and 2.3. While cautioning that different countries have different overall crash rates and emergency response systems, the Finnish authors noted how their results compared to ACN evaluations in other European countries. They noted that the crash fatality reduction potential in Germany was between 5% and 7% and in The Netherlands 7%. The rates in Sweden (2%-4%) and Great Britain (2%) were smaller, while the reduction for the European Union as a whole was greater (5%-15%).

Based on nearly 1000 fatalities on Australian roads, Lahausse, Fildes, Page and Fitzharris (2008) estimated that ACN had the potential to reduce passenger vehicle occupant fatalities by almost 11%. However, they then estimated ACN's benefit-cost ratio, based on the cost of purchasing and operating the technology over the life of vehicles fitted with ACN. Lahausse et al reported these analyses showed that without government support ACN would unlikely be cost-effective for mandatory installation in all passenger vehicles.

The Centre for Automotive Safety Research (CASR) at the University of Adelaide has been researching the potential benefits of ACN systems in Australia. Ponte, Anderson and Ryan (2013) estimated that ACN systems currently exist in less than 0.06% of the registered vehicle fleet in Australia. Nevertheless, CASR's research examined the 191 fatal crashes (218 fatalities) in South Australia for the period 2008-2009, to assess the effect of earlier emergency service dispatch, which could occur if an ACN system had been fitted to each crashed vehicle (assuming the availability of a mobile phone signal). This involved examining crash times, emergency medical service (SA Ambulance Service) dispatch times and coroner's files associated with these fatalities. There were 139 fatalities where there was enough information to make an assessment of the benefit of ACN and it was found that 2.2% of all fatalities might have been avoided if earlier crash notification to emergency medical services had occurred.

When studying USA traffic fatalities in 2005 to 2009 using survival analysis techniques, Wu, Subramanian, Craig, Starnes and Longthorne (2013) also determined modest benefits of earlier crash notification such as through ACN (approximately a 1.84% fatality reduction within six hours of a crash). This was after controlling for different conditions of collision notifications, emergency service arrival time and crash location.

The European Commission has adopted a proposal for all new models of passenger cars and light duty vehicles, by October 2015, to be fitted with 112 e-Call (112 is the emergency phone number standardised across Europe) (Kallas, 2013). The Commission estimates that up to 2500 road deaths in Europe per year will be prevented and that emergency response times will be reduced by 40% in urban areas and 50% in rural areas (ibid). However, the technology has been available for many years in some luxury cars. For example, BMW Assist has been available in US BMW cars since 1997. It is now included in nearly every BMW sold in the US.

Flanigan et al (2010) created a vision for the year 2030 for emergency response and rescue times (at least for North America), in which a range of intelligent technologies, when applied to vehicle to vehicle, vehicle to road infrastructure and vehicle to trauma centre communication contexts, are fully integrated across the whole transportation system. These technologies enable real-time transmission of data, permitting vehicles to perform calculations and issue driver alerts or other advice. It is also possible for vehicles to use the information relayed to them to actively control acceleration, braking and steering. Thus, the advanced communication technologies can be used to not only reduce the response times of emergency vehicles, but to issue advice and commands to non-emergency vehicles in their path so that emergency vehicles can proceed without being delayed by other vehicles' movements, thus also reducing the chances of those other vehicles colliding. The technologies include:

- ACN systems (as previously discussed in this paper), which could include images and video taken automatically of the crash scene and vehicle occupants and relayed to the emergency service call centre, hospital or trauma centre
- algorithms to predict the likelihood of crash injury (based on data collected by a crashed vehicle and transmitted shortly after the crash, for example data on passenger numbers, direction and speed of impact, and whether seatbelts were worn)
- (for air ambulances) synthetic vision, a kind of virtual reality display system for cockpits that uses GPS technology to draw highly accurate 3-D displays of terrain and obstacles, regardless of flight visibility or night conditions
- speech recognition for hands-free electronic record keeping (with 2-way dialogue capability)
- wireless sensor networks for patient vital signs monitoring and transmission to trauma centre

- wearable computers with augmented reality, for example vehicle specific diagrams could be available giving locations of recommended vehicle cut-points for quicker extrication of trapped crash victims
- mobile telemedicine, for example video guidance to emergency services personnel in performing emergency procedures such as airway intubation and ultrasound examination of the heart and major blood vessels.

CrashHelp, a new system allowing video transmission of relevant information via mobile phones has been piloted by CERS (2013) in Minnesota. Development of the system was informed by earlier work involving a literature review and case studies of gaps and opportunities in emergency medical services in rural areas across the United States, including analysis of response data, interviews and focus groups involving emergency services staff (Schooley, Horan, Botts, & Noamani, 2009). The aim of the study was to (p. vii):

> "…look from one end of service delivery (i.e. crash notification) to the other end of service delivery (i.e. definitive patient care and recovery) and to capture data across each service step, allow[ing] for holistic analysis of an incident and patient care."

The main gap identified that was that real-time crash and patient data utilised to the degree desired was so far non-existent. The identified opportunity, therefore, was a proposed Integrated Crash Trauma Information Network involving emergency responders, health care professionals and information technology systems to "…collect and share real-time data to be communicated and immediately utilized to aid in the treatment of trauma victims." The resultant CrashHelp system enables emergency responders to collect *multimedia* data about crash victims at-scene via mobile Smart Phone applications and send it directly into emergency rooms, thus providing hospitals with advance notification of crash severity and related patient information.

In reviewing the *Guidelines for Field Triage of Injured Patients,* the US National Expert Panel on Field Triage (2011) noted how emergent technologies are changing triage criteria in light of the more detailed patient information becoming available by those new technologies. This information includes non-invasive monitoring of heart rate complexity and variability, respiratory rate, tissue oxygenation and point-of-care lactate testing (ibid).

In Flanagan et al's (2010) future vision, the following elements might be evident (p.35):

- "To the extent possible, all emergencies will be detected in near real time with automated infrastructure-based, vehicle-based, or person-based sensors.
- Emergency dispatchers will receive a rich set of detailed information on the nature and scope of the event, which will give them enhanced situational awareness, enabling them to activate the most appropriate emergency services. Automated decision aids that use stored data or real-time information will be available.
- Dispatchers and responders will have immediate information on both weather and the environment in the vicinity of the emergency scene. Public safety agencies will have the ability to activate and direct technology assets to collect and provide additional event and scene-related information.
- Responders will be able to rapidly and safely travel to the scene by ground or air, bypassing congestion, and will be armed with real-time information provided via wearable computers.
- Responders, emergency vehicles, and emergency response devices will communicate cooperatively and be integrated with the roadway infrastructure, other entities (e.g., hospitals),

affected individuals (casualties), and their vehicles by using vehicle to vehicle, vehicle to infrastructure, and vehicle to driver technologies as well as future cyber technologies.

- Emergency responders will have real-time access to the equipment and expertise needed to locate, treat, triage, and transport injured victims rapidly and safely to the most appropriate medical facilities.
- Emergency response agencies will have information and tools needed to plan and execute evacuations if needed and rapidly restore the transportation system to its pre-emergency conditions."

3.3 SafetyNet's review and comparison of emergency response across five top performing OECD countries

As part of an initiative of the European Commission to develop a European Road Safety Observatory, a project entitled "SafetyNet" was established (Thomas, Morris, Yannis, Lejeune, Vis, Vallet & Supon, 2006). The project's purpose was to collate knowledge and data as a basis for future European safety policies (ibid).

In the project, seven work packages for three main road safety activity areas (macroscopic data, in-depth data, data application) were established. Work Package 3 (WP3), under the activity of macroscopic data, dealt with safety performance indicators (Thomas et al 2006) and included alcohol and drug use, speeding, protective systems, daytime running lights, vehicles (passive safety), roads and trauma management (Vis and Van Gent, 2007). Post-crash emergency response and trauma care came under the safety performance indicator of trauma management.

A minimum set of trauma management safety performance indicators were developed and introduced to establish an initial characteristic of a trauma management's system performance within participating European countries (Hakkert & Gitelman, 2007). These were based on the research literature (such as Commission of the European Communities, 2003[1]) that highlighted that a system's performance was a critical determinant of fatalities and injuries resulting from road crashes. The importance of improved post-crash medical care was also highlighted in Peden, Scurfield, Sleet, Mohan, Hyder, Jarawan & Mathers (2004) for example in their Figure 3.1 (p. 71). Several risk factors influence the severity of post-crash injuries including (but not limited by) crash notification, difficulty in extrication of the injured from vehicles and lack of pre-hospital and hospital emergency care.

Common features of a better performing trauma management (according to European Transport Safety Council, 2009; Hakkert & Gitelman, 2007) regarding emergency medical services were:

- shorter response times,
- higher levels of staff
- standardisation of vehicles.

A minimum set of trauma management safety performance indicators were developed and documented in Hakkert and Gitelman, (2007, p.13), these include (but are not limited by):

- Availability of EMS stations

[1] Page 8 of this report states "Several thousands of lives could be saved in the EU by improving the response times of the emergency services and post-impact care in the event of road traffic accidents. Conversely, poor post-impact care could lead to avoidable injury and disability"

- Availability and composition of EMS medical staff
- Availability and composition of EMS transportation units
- Characteristics of EMS response times
- Availability of trauma beds in permanent medical facilities.

Detailed explanations regarding the safety performance indicators and theory behind them are documented in Hakkert, Gitelman and Vis (2007). The recommended system for producing trauma management safety performance indicators, the data requirements and the calculation rules to be applied are documented in the manual (Hakkert and Gitelman, 2007) provided to European countries involved with the SafetyNet project. In total, twenty EU countries provided data for the project (Vis and Eksler, 2008). A comprehensive list of safety performance indicators for five of the better performing OECD countries (according to road deaths per 100,000 population) is shown in Table 3.1. This information has been derived from Vis and Van Gent (2007) for the countries Sweden (SE), United Kingdom (UK), Netherlands (NL), Norway (NO) and Germany (DE). It should be noted that in some cases, the totals for particular data in this table may not always be the sum of the particular data. For example for "Number of EMS staff in service" in Germany (DE), the total is higher than the sum of each of the particular EMS staff types.

Table 3.1
Post-crash trauma management safety performance indicators for five of the better performing OECD countries (derived and reprinted from individual country profiles presented in Vis and Gent, 2007 with footnotes reflecting comments provided by countries supplying the data)

General Data	SE (2003)	UK (2003)	NL (2005)	NO (2003)	DE (2003)
Road deaths per 100,000 population (per year of data)	5.9	6.1	4.6	6.1	8
Road deaths per 100,000 population (2011)	2.85	3.07	3.24	4.28	4.46
Population, million	8.94	57.85	16.3	4.58	82.54
Road length - total, km	212,000	392,321	117,430	91,825	626,981
Road length - public, outside built-up areas, km	98,000	249,649	63,280	90,663	231,500[2]
Vehicle-kilometres travelled, million	74,000	494,800	138,800	37,000	682,215
Data on Trauma management:					
No of dispatching centres	18	53[3]	24	44	270
No of EMS stations	275	979	51	200	1,832
Number of EMS staff in service:					
No of physicians	10	0	0	n.a.	17,000
No of paramedics	0	17,272	0	n.a.	22,000
No of nurses	2,000	0	1,400	n.a.	0[4]
No of medical technicians	2,000	9,630[5]	1,240[6]	n.a.	8,800
Total	4,010	26,902	2,640	n.a.	53,000

[2] Classified roads including motorways, without small rural roads

[3] For England and for Wales

[4] In general, nurses are not members of the EMS staff. EMS staff members are: medical technicians, paramedics, and physicians. In individual cases a nurse can work as a medical technician or a paramedic in an EMS-team. In these cases the nurse is counted among the medical technicians/paramedics.

[5] Ambulance support staff. Data reported for West Yorkshire,2004: 640 vehicles in total, including 123 emergency vehicles and 14 rapid response vehicles; there are 780 A&E staff. These serve a population of 2 million, road length of 36691 km.

[6] Ambulance Drivers

Table 3.1 continued

Number of EMS transportation units in service:	SE (2003)	UK (2003)	NL (2005)	NO (2003)	DE (2003)
No of BLSU (Basic Life Support Unit)	500	n.a.	0	604	2,673
No of MICU (Mobile intensive care unit)	0	n.a.	0	0	3,709
No of helicopters/ planes	10	14	4	19	91
Total	510	n.a.	654[7]	672[8]	7,600
No of EMS calls annually	600,000	5,340,000	n.a.	350,000	n.a.
Share of road accidents in EMS calls	2%	n.a.	n.a.	n.a.	n.a.
No of EMS rides annually	900,000	3,400,000	450,000[9]	n.a.	10,300,000
Share of road accidents in the EMS rides	1.50%	n.a.	n.a.	n.a.	2.70%
The demand for EMS response time, min	10 min for 80% of calls[10]	8 min for 75%[11]	15 min[12]	n.a[13]	15 min[14]
Percentage of EMS responses meeting the demand	n.a.	100%	n.a.	app. 90%	89.10%
Average response time of EMS, min	10-30 min	n.a.	n.a.	n.a.	7.8 min
Number of trauma beds in permanent medical facilities: In certified trauma centres	n.a.	n.a.	n.a.	n.a.	n.a.[15]
In trauma department of hospitals	n.a.	n.a.	n.a.	n.a.	134,815
Total	n.a.	n.a.	n.a.	n.a.	552,680
General Data:					
EMS stations per 10000 citizens	0.31	0.17	0.03	0.44	0.22
EMS stations per 100 km of rural road length	0.28	0.39	0.08	0.22	0.79
Percentage of physicians out of EMS staff	0.2	0	0	n.a.	32.10%
Percentage of physicians + paramedics out of EMS staff	0.2	64.2	0	n.a.	73.60%
EMS medical staff per 10000 citizens	4.48	4.65	1.62	n.a.	6.42
Percentage of MICU out of the total EMS units	0	0%	0	0	49%
Percentage of BLSU + MICU + Helicopters/ planes out of the total EMS units	100	21%[16]	0.60%	93%	85%
EMS transportation units per 10000 citizens	0.57	3.2[16]	0.4	1.47	0.92
EMS transportation units per 100 km of road length	0.24	1.74[16]	0.56	0.73	1.21
The demand for EMS response time, min	10 min for 80% of calls[10]	8 min for 75%[16]	15 min[17] for 95%	n.a.	15 min
Percentage of EMS responses meeting the demand	n.a	100%	n.a	app 90%	89.10%

[7] Including 650 ambulances
[8] Including 49 boats
[9] Excluding non-urgent transport of patients
[10] In general different rules exist for different regions.
[11] Of Category A; 14-19 min for 95% of Category B, C.
[12] In 95% of cases
[13] Standards are defined for urban and non-urban areas
[14] And to be met in 95% of all responses (general); differ in federal states;
[15] The term "certified trauma centres" is not common in Germany. Actually almost all big hospitals (e.g. hospitals of universities, hospitals in big cities) are centres, where any patient can be treated properly, not limited to injured patients. The number of these hospitals is not available
[16] For West Yorkshire, unavailable for the Country
[17] In 95% of cases

Average response time of EMS, min	10-30 min	n.a.	n.a.	n.a.	7.8 min[18]
Comments:				n.a	
Road accident emergency calls per 10000 citizens	13	n.a	n.a.	n.a	n.a
Road accident emergency calls per million vehicle-km travelled	0.16	n.a	n.a	n.a	n.a
Road accident emergency rides per 10000 citizens	15	n.a	n.a	n.a	33.7
Percentage of beds in certified trauma centres and trauma departments of hospitals out of the total number of trauma beds	n.a	n.a	n.a	n.a	24.40%
Number of the total trauma care beds per 10000 citizens	n.a	n.a	n.a	n.a	67

There are many issues with the data provided by each country. Hakkert, Gitelman and Vis (2007) highlighted that there was a lack of data for certain safety performance indicators for various countries, because generally these indicators were not used in decision making processes. Hence, in Table 3.1, there are number of indicators that have no data. Additionally, medical databases and trauma registries were generally not linked to road safety activities. The authors highlight the fact that decision making in the emergency medical treatment of road crash injuries could be significantly improved if the medical databases and trauma registries were integrated with road safety data systems.

Thomas et al (2009) advise caution in international comparisons of trauma management systems, as there are variations in definitions, legislations and systems used for post-crash emergency trauma care in different European countries, some of these are highlighted in the footnotes to Table 6.1. More information about country specific emergency management systems (EMS) can be found in Björnstig (2004) for Sweden, Black and Davies (2005) for the UK, Roessler and Zuzan (2006) for Germany, Dib, Naderi, Sheridan & Alagappan (2006) for the Netherlands and Langhelle, Lossius, Silvast, Björnsson, Kippert, Ersson & Søreide (2004) for Norway and Denmark.

Although the trauma management safety performance indicators can be used as a comparison between countries, combined indicators were developed using various ranking methods to provide an overall characteristic of trauma management safety relative to other countries (Hakkert, Gitelman & Vis, 2007). The combined indicators are based on the safety performance indicators available for each country to give an indication of the level of a country's system's performance relative to all other countries in the sample. The intent of the combined indicator was to describe the level of the EMS treatment potential, EMS response time and the treatment potential of permanent medical facilities (Hakkert, Gitelman and Vis, 2007).

[18] There are values for rural and urban areas

The five basic levels of the trauma management used to describe a country's relative system performance according to Vis and Eksler (2008) are:

- "high
- relatively high
- medium
- relatively low or
- low".

The methods used are documented in Hakkert, Gitelman and Vis (2007). The combined indicator results are presented in Vis and Eksler (2008, Table 7.3, p.22). For five of the better performing OECD countries (as shown in Table 3.1 of the present report), the following was described by Vis and Eksler (2008) for relative trauma management system performance, based on the combined indicators:

- consistently high levels of system performance was found in Germany
- relatively high levels was found in Norway and the United Kingdom
- relatively low levels were found in Sweden
- consistently low levels were found in the Netherlands.

On the basis of all the analyses conducted, the trauma management safety performance indicators that could be a considered a 'core set' according to Gitelman et al (2008) are:

- the number of EMS stations per area
- the number of EMS transportation units per road length
- the number of EMS transportation units per citizen
- percentage of physicians and paramedics out of the total EMS staff
- percentage of highly-equipped transportation units out of the total
- the demand for response time
- average response time of EMS
- percentage of EMS responses meeting the demand
- the number of trauma care beds per citizens.

This 'core set' of indicators constitutes a considered and highly informative approach for any future attempts at inter-jurisdictional comparisons of EMS capabilities. Their specificity goes some way towards overcoming some of Thomas et al's (2009) concerns about making international comparisons in this area. Also, as has been noted, even jurisdictions with otherwise commendable EMS performance records may not necessarily collect or have available data on some of these indicators, a circumstance that should serve to encourage those jurisdictions to do so.

3.4 Approaches to measuring the effectiveness of post-crash response

Various factors affect the outcomes of post-crash emergency medical and rescue operations, ranging through identification of the crash, response times, training of personnel, categorisation of patient injury severity, type of treatment at crash scenes, and transport to hospital-based emergency services. Such areas may well be considered for inclusion in a list of criteria for gauging the quality

and efficiency of emergency service response. However, the range of factors and the extent to which they apply to different emergency services can make comparisons procedurally challenging as well as yielding results that are inconclusive. Thomas et al (2009, p. 58) caution:

> "In general, international comparisons of trauma management systems should be performed with caution due to a variety of definitions, legislations and systems, which are available for both the emergency and in-hospital trauma care, in different European countries."

Nonetheless, based on best practice recommendations in post-crash care formed by the European Traffic Safety Council in 1999, Thomas et al go on to identify core features definitely associated with better performance in trauma management to form the basis for jurisdictional comparisons. They are:

- shorter response times
- higher competence among emergency service personnel
- standardisation of emergency service vehicles, and
- adequate hospital trauma care.

Gitelman, Auerbach-Hafen and Eksler (2007) iterate these features, but add establishment of national trauma management systems. The value of dedicated trauma management systems was demonstrated in a South Australian study by Brennan et al (2002). Over four years since its inception that system produced a statistically significant decrease in risk of death from injuries of equivalent severity among patients attending major trauma centres in the State.

Al-Saqsi (2010) noted that, due to their philosophical differences and the manner in which each operates, many studies (for example Nathens, Brunet & Maier, 2004) have shown conflicting results as to whether the Franco-German or the Anglo-American approach to EMS is the more effective. As mentioned in Chapter 1, Al-Saqsi discussed how these approaches resemble the dichotomy of Basic Life Support (BLS) versus Advanced Life Support (ALS) systems. However, he also reported that studies of ALS, typically in the Franco-German model in emergency care, have not yet shown it to be superior to BLS. Similarly, Elvik, Vaa, Hoyle and Sorensen (2009) concluded,

> "Most evidence indicates that advanced medical treatment at the accident scene may decrease survival chances, compared with a 'scoop and run' approach, when the treatment delays transport to definitive care." (p. 982)

Additionally, Jayaraman and Sethi (2010) from their review of ALS trials found that there is no benefit in training ambulance crews in advanced life support methods.

Contributing to the evaluation difficulty, as Elvik et al (2009) noted, is that prolonged on-scene time compromises rapid transport to hospital. In addition, while some injuries such as blunt trauma may benefit from ALS approaches, by contrast others such as cardiac arrest benefit from BLS with rapid transport to hospital. As well, there are different types of ALS treatments for the one injury, depending on various other factors present. Ryynänen, Irola, Reitala, Pälve & Malmivaara (2010) found that ALS improves survival of patients with heart conditions, but that BLS approaches are more appropriate for patients with penetrative injuries. Elvik et al (2009 also note that ALS is usually provided to more seriously injured patients, requiring studies to control for injury severity. Ambulance crews that do not include a doctor have fewer opportunities to declare a patient death, compared with crews that do; hence death rates across ambulance call outs may not be directly comparable for different crew compositions.

Whether ambulance staff have advanced medical training or not attracts various significant variables potentially influential on patient survival. Research from Poland (Aftyka, Rudnicka-Drożak, & Rybojad, 2013), for example, shows that paramedics are more likely to administer oxygen therapy and

analgesics, apply cervical collars, and perform electrocardiograms than nurses who participate in ambulance teams.

The NSW and South Australian road safety strategies make it clear that two prime areas for evaluating emergency service effectiveness are the quality of coordinating activities and technological advancements. For example, the NSW strategy notes that,

> "…the development and implementation of improved rescue response to road crashes is the responsibility of the NSW Police Force, while the NSW Ministry of Health is responsible for improving medical care given to casualties following a crash through the NSW Ambulance Service and Public Hospital Trauma Centres." (p.35)

The South Australian strategy does not name agencies requiring coordination, but instead refers to them generically (health, road designers and vehicle regulators). Nonetheless, considering that both states have large rural and remote geographical areas that pose significant challenges for emergency response effectiveness, it is vital that emergency responses in those states (and the rest of Australia) are not adversely affected by poor coordination across the agencies involved, or technological barriers or other impediments. For the various emergency service agencies particularly, Flanigan, Blatt, Russell, Batta and Lee (2010) note that these organisations often have diverse cultures, which may provide challenges for coordination and cooperation during emergencies. Moreover, rural services are more likely to depend on volunteers who may have less training and emergency experience compared to their urban counterparts (SafetyNet, 2009, p.6).

While various forms of ambulance service are often perceived as the emergency service most commonly responding to road crashes, fire crews are often among the first emergency services to arrive when a crashed vehicle catches fire, or when a vehicle needs to be cut apart to release its occupants. Fire crews are of no less importance, as ambulance crews may not be able to take action until a vehicle fire is extinguished or access to occupants is gained. Moreover, fire crews can support ambulance crews as they are trained in first aid. However, it is not unknown for cooperation and coordination across fire services to be lacking (for example where both metropolitan and country fire crews attend the same incident), but also lacking in terms of cooperation and coordination with ambulance services. The 2009 Victorian Bushfire Royal Commission, for example, noted that, at the time of the bushfires, Victoria's emergency management framework was trialling new operational arrangements across the Country Fire Authority and the Department of Sustainability and Environment, involving their co-location at a new integrated Emergency Coordination Centre in Melbourne. While it was conceded the bushfire outcomes would have been much worse had the agencies not been co-located, the Royal Commission nevertheless considered that the emergency arrangements still faltered because of:

- confusion about accountabilities and responsibilities
- leadership deficiencies
- inconsistent operating procedures across the agencies
- separate technology systems
- duplicate functions being performed
- no single agency or individual was in charge.

These are also relevant considerations for gauging the effectiveness of emergency service response.

In a not dissimilar vein, the Special Inquiry into the Margaret River 2011 Bushfire (Government of Western Australia, 2012) found major improvements were still needed in coordination of emergency response operations. Queensland Floods Commission (2012) also remarked on a need to improve

interoperability between relevant agencies, particularly a need for training standards for emergency call operators to be uniform across agencies. The Commission also called for common use of the Emergency Services Computer-Aided Dispatch (ESCAD) system as this assists when emergency calls have to be transferred to different operators at times of peak demand, as well as reducing congestion on radio networks.

The Queensland Commission also noted the existence of geographical locations where radio communications are either impossible or consistently difficult, particularly where analogue networks are used. The Commission recommended greater adoption of digital networks. The radio blackspot issue is exacerbated by radio bandwidth limitations. The Commission noted that all emergency services in Australia are moving towards 'complete interoperability' by 2020 in commonly using the 400 MHz spectrum. However, that is a narrow bandwidth catering for transmission largely of voice communications. Ideally, broadband should be the preferred standard for transmission of photos, videos, maps and other large files. The Commission (2012, p. 398) agreed that,

> "…as a result of insufficient spectrum for transmitting large files and/or during times of high demand, the network may become congested; that it may slow it or cause outages."

In Finland, Seppänen, Mäkelä, Luokkala and Virrantaus (2013) observed a search and rescue practice exercise. Based on theories of information, communication and trust, and questionnaires given to exercise personnel, they identified several factors that affect the formation of situational awareness and cooperation in emergency services work. These factors include:

- the minimum critical information needs for successful overall coordination (such as accident location and nature, and which hospitals are available)
- action-triggering information (such as presence of hazards, triage decisions made, and crisis support initiated), which various emergency personnel need in order to perform their core tasks
- the social context (such as the formal and informal interaction between medical agents, emergency response teams and radio operators)
- three interdependent levels of duties:
    - core duties that are required by law (such as duty to protect life)
    - specified duties depending on the circumstances of the incident and based on training and expertise
    - personal will and commitment towards cooperation and common goals in the emergency response
- a shared sense of trust among all response personnel involved that everyone will fully carry out their own professional tasks
- a shared sense of trust in the emergency response processes, which involves everyone understanding the responsibilities and future actions of the various agencies involved, but also identifying communication points for when it is important to share critical information and when they can expect to receive such information
- interoperability of information systems across agencies
- the sum total of the above, which is systems level trust in which all emergency personnel have a strong will to cooperate, they generate communicative actions and share information to support effective accomplishment of the common goals in the whole emergency response.

In the USA, Minge (2013) explored emergency service practices through a combination of literature review, agency surveys and follow-up interviews and identified a substantial list of emergency service system characteristics, and these could also be used in measuring emergency service response. Minge classified these characteristics into the following groups:

- crash detection and reporting (including automatic crash notification)
- reporting of the road conditions (including information content and means of transmission)
- dispatching of emergency response (including computer-aided dispatch)
- inter-agency communication systems
- equipment and preparation
- air medical transport
- management of the crash scene and transport
- use of telemedicine
- integration of data relating to crashes, patient care, outcomes and costs
- emergency service staffing issues (both paid and volunteer)
- emergency services on tribal (indigenous) lands
- interagency cooperation and coordination
- planning and innovation (especially in relation to improvement of rural response)
- care protocols and procedures.

WHO's (2013a) *Global Status Report* contains seven areas for which countries are asked to supply data to assist with measuring and comparing emergency response capabilities:

- whether or not a **Vital Registration System** (for accurate recording of deaths and death circumstances) is *functional* in the country (NB *not* whether it covers the whole country)
- whether or not an **Emergency Room-based Injury Surveillance System** is in place in the country (though the WHO report does not specify what comprises such a surveillance system)
- whether a standard **telephone number** exists for accessing emergency services
- the proportion of **seriously injured** who are transported by ambulances (based on expert opinion)
- the proportion of the population who are **permanently disabled** due to road crashes (but only if from a robust data source)
- formally recognised **emergency medicine training for doctors** (e.g. post-graduate qualification)
- formally recognised **emergency medical training for nurses**.

Data from WHO (2013b) for certain OECD countries in comparison with Australia are shown in Table 3.2.

Table 3.2
Emergency response capability data (WHO, 2013b)

	Sweden	United Kingdom	Netherlands	Norway	Germany	Canada	Australia
Vital Registration System	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Emergency room-based Injury Surveillance System	Yes	Yes	Yes	Yes	No	No	Yes
Emergency access telephone number	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Seriously injured transported by ambulance	≥ 75%	*	≥ 75%	≥ 75%	≥ 75%	≥ 75%	≥ 75%
Permanently disabled due to road crash	6%	*	*	*	*	*	*
Emergency training for doctors	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Emergency training for nurses	Yes	Yes	Yes	Yes	No	Yes	Yes

* Data not supplied by the country to WHO, or were not available.

It can be seen in Table 3.2 that in the areas highly relevant to achieving effective emergency responses, such as a vital registration system, surveillance system and a standard emergency telephone number, the data supplied showed some variability across the nations. Nonetheless, Australia's capabilities are broadly similar to the other countries, including with Canada, a country with comparable rural/remote area emergency service issues to Australia.

An earlier European Union (EU) report (Vis & Gent, 2007) sought road safety trauma management data from 27 EU countries over a much broader range of safety performance indicators than in the WHO (2013b) study. Vis and Gent's range of parameters is worthy of consideration when measuring emergency response effectiveness, including:

- population in the country
- total road length
- rural road total length
- vehicle kilometres travelled (in millions)
- number of emergency dispatching centres
- number of emergency service stations
- number of active emergency service personnel (broken down by doctors, paramedics, nurses and medical technicians)
- number of emergency service transportation units in service (broken down by basic life support units (BLSU), mobile intensive care units (MICU) and air transport)
- annual numbers of emergency service calls
- percentage of calls for road crash responses
- annual numbers of emergency service trips
- percentage of trips for road crash responses
- time goal for responding to emergency calls (in minutes)
- percentage of responses meeting the time goal
- average response time.

In 2008, Gitelman provided an updated report of data from the Vis and Gent (2007) study used to compile Table 3.1 in the present report. Among their findings were that:

- the number of emergency management service (EMS) stations per road length was highest in Germany, the United Kingdom, the Czech Republic and Bulgaria, and the lowest among Greece, the Netherlands and Malta
- the number of emergency management service (EMS) stations per 10,000 citizens was highest in Austria, Slovakia, Portugal, Finland, Norway and Estonia, and the lowest among Greece, the Netherlands and Malta
- the highest proportion of EMS staff per 10,000 citizens was reported in Austria, although Belgium, Germany, Estonia, Latvia, Slovakia and Bulgaria also performed well

- Austria and the United Kingdom have the highest number of EMS transportation units per 10,000 citizens
- Austria, the United Kingdom, Latvia and Slovakia have the highest number of EMS transportation units per 100 km of road length
- Germany, Malta and the United Kingdom had the highest proportions of doctors or paramedics out of all EMS personnel for each country
- Austria and the United Kingdom had the highest proportions of EMS transportation units per 10,000 citizens
- Average EMS response times ranged from 6 minutes in Belgium to up to 30 minutes in Malta
- Belgium, Denmark and the United Kingdom reported meeting their response time goal 100% of the time, with Germany, Austria, Poland and Norway doing so on 90% of occasions.

Gitelman (2008) then used all this information to produce rankings of overall trauma management performance on a five level scale, in which Austria and Germany rated consistently the highest level of EMS performance across all criteria.

Interestingly, while the two European Union reports (Vis & Gent, 2007 – Table 3.1; Gitelman, 2008) cover emergency response times, the later WHO *Global Report* (2013b) does not mention response times in its capability data collection. As noted in section 3.1 of this Chapter, within the emergency service industry, emergency response times have become an important benchmark for trauma service. However, Salvucci, Kuehl, Clawson and Martin (2004) have identified five key challenges when using response times to measure emergency service effectiveness. Firstly, they note the term "response time" has no universally accepted definition and is used to measure the sum total of a wide variety of different intervals within the response period, not all of which may be counted:

- recognising the emergency
- dialling the emergency telephone number
- answering the call, dispatching the response vehicle
- getting into and starting the emergency vehicle
- driving to the incident, reaching the victim(s)
- determining the problem and providing initial treatment
- transport to hospital, and finally
- the commencement of definitive care.

Secondly, response time measurements are commonly inaccurate, often due to clocks and watches not synchronised to an agreed time reference point. There can also be transcription errors and no automated methods of stamping time points. As well, exceptionally short and long calls can be omitted from statistical data.

Thirdly, different agencies may be involved in recording the times they spend on their task intervals within the total response time (e.g. operators recording the time spent in answering an emergency call or hospitals recording the time between a patient's arrival at the emergency ward and when they are treated). The resultant data may well be reported by individual agencies but is not always coordinated across different agencies to calculate overall response times.

Fourthly, notification of a crash does not always mean effective (and timely) action is taken, unless the responders know where the victim is located. (Although, since Salvucci et al (2004), technological developments are overcoming problems of identifying crash locations, thus contributing to improving response times).

Fifthly, response times are not the best measure of quality emergency response. Just because an emergency response is a quick one doesn't necessarily mean a high quality service is given (and vice versa). For example, a response rate goal of 90% completion of required actions within 8 minutes may not represent good pre-hospital care (Salvucci et al 2004). Pursuit of such goals for all or most emergencies creates economic disincentives to improve quality and maintain reasonable costs. Salvucci et al (2004) suggested the aim should be to pursue "smart" responses rather than simply rapid responses.

In 2005, Sasser, Varghese, Kellermann and Lormand studied the development of pre-hospital care systems, with particular attention to the key components of such systems. They commented that their analysis was informed by expert consensus obtained around the world, although they also noted the lack of empirical data on the benefits of many pre-hospital interventions. Nonetheless, the comprehensive range of elements they identified deserve consideration for inclusion among potential criteria when measuring the effectiveness of post-crash responses. Their elements essentially concern emergency service activity and equipment needed from the time of arrival at an incident scene, to the time of arrival at a trauma centre, but not during the time between the incident occurring and emergency service arrival. They include:

- assessment of overall scene safety (physical and environmental hazards)
- personal safety precautions (wearing gloves, etc)
- initial assessment of patient(s) (e.g. airway, bleeding, level of consciousness, triage for multiple patients)
- determining any need for additional help
- recognising at-risk patients and arranging their transport
- detailed patient assessment (e.g. head / spine / abdominal injury, shock)
- administration of at-scene emergency treatments, including pain management, immobilisation and detailed patient vital signs monitoring, as required
- planning and management of safe rescue/retrieval / extrication interventions
- management of crowds, traffic and other threats
- management of transport of patient(s)
- documentation of incident and at-scene treatments
- communication by radio / mobile phone to trauma centre.

A European Union analysis of post-impact care policy considers the following elements as essential policy components (among others) (SafetyNet, 2009):

- telephone notification of an incident requiring an emergency service
- in-vehicle emergency notification systems
- telephone answering by emergency services

- dispatching of emergency crews
- coordination between emergency services
- training of emergency service personnel
- the availability and response times of ambulances / helicopters, etc
- type of medical treatment at crash scene (basic vs advanced)
- staffing of ambulances (paramedics / nurses / physicians)
- triage approaches and hospital selection
- medical direction of pre-hospital care
- planning and care in multiple casualty crashes
- the legislative framework for pre-hospital care
- national trauma systems
- documenting and monitoring pre-hospital care, including the extent to which procedural protocols (where they exist) were followed.

Interestingly, despite their comprehensive listings, neither Sasser et al (2005) nor SafetyNet (2009) include incident evaluation by the response team as to whether the response could have been improved upon.

Another area for measuring the effectiveness of post-crash response is to retrospectively examine the outcomes of actual triage decisions according to a set of agreed criteria. The CDCP (2013) network in the United States, for example, has developed guidelines for making triage decisions. Steps 1 and 2 aim to identify the most seriously injured patients requiring transport to the highest level of trauma centre or emergency hospital care. The assessment criteria cover blood pressure <90 mmHg, a respiratory rate <10 or >29 breaths per minute and a Glasgow Coma Scale of less than 13, whether or not accompanied by severe head, neck or torso penetrating injuries. Step 3 requires transport to a trauma centre, but not necessarily with the highest care capability rating. Assessment criteria include falls of one storey or more, or a high impact vehicle crash resulting in certain injury patterns less severe than in steps 1 and 2. Step 4 requires transport to a trauma centre or hospital capable of thorough patient evaluation and management of potentially serious injuries.

Yet another evaluation perspective is provided by Gitelman et al (2007) who initially list:

- BLS versus ALS training for EMS teams
- type of evacuation (self, regular ambulance, mobile intensive care ambulance, helicopter)
- response times (travel to scene, time spent at-scene, travel to hospital)
- type of at-scene treatment provided
- the extent to which the treatment conforms to protocols where such protocols exist.

However, they also indicate that what happens after hospital arrival can be pre-determined by the above pre-arrival factors. Hence in evaluating pre-hospital emergency response, it is necessary to include factors after hospital arrival that are dependent on the antecedent factors. For example, the extent to which critical care patients arrive at specialised trauma centres rather than hospitals of lower emergency response capability may well depend on the type of care given at-scene and the time

spent at-scene. Gitelman et al (2007) suggest therefore, that evaluations of pre-hospital emergency response should consider outcome parameters such as death rates, numbers of hospitalisations in intensive care units and total length of hospitalisations. They go on to discuss in some detail how there are ultimately three major EMS characteristics that should be explored:

- time values associated with the initial treatment
- quality of the initial treatment, at-scene and during transportation
- quality of medical treatment in a medical facility.

Finally, the effectiveness of an emergency service response depends on various physical design features in emergency vehicles. The international organisation, EMS Safety Foundation, studied the best features in ambulance design from sources around the world. Those ambulance features most relevant to emergency response quality and safety included: high crashworthiness and occupant protection ratings, reduction of internal head-impact hazards, storage of heavy duty rescue equipment, location of lights and siren controls next to the steering wheel, hands-free communications systems and ergonomically designed portable equipment bags and oxygen tanks (Erich, 2013).

3.5 Overall key issues in measuring post-crash response

In sum, the literature review identified many issues that need to be considered in measuring post-crash response. Critically, while the concept of a 'Golden Hour" has been found to have little empirical basis, there are many factors that can affect response times and which consequently can confound attempts to compare and evaluate emergency responses in which response times are a key indicator. Chief among these factors is whether the response is one of administering basic life-support and care (BLS) followed by transport to hospital, or whether attempts are made to provide advanced care at the crash site before evacuation (ALS). The decision to go for BLS versus ALS can depend on factors as varied as the policy of the trauma system itself, the travelling time to hospital, coordination across different emergency services attending the one crash site and the types of injuries sustained by crash victims. As well as differences in defining the components of overall response time, there are also issues associated with measuring and recording the response times, as noted by Salvucci et al (2004).

Response times can also be influenced by presence or absence of technological advancements. For example, within the general vehicle fleet, vehicles fitted with ACN can immediately notify emergency services of a crash and its location. Within ambulance fleets, the ability to transmit journey details to traffic signal to ensure green signals are activated when an ambulance approaches is also likely to reduce overall response time. Ambulances equipped with broadband communications technology can rapidly supply trauma centres with patient images and other data in advance of the patient arriving.

The work of Thomas et al (2006) showed that in order to make valid and meaningful comparisons of post-crash response, there needs to be commonality in the performance indicators selected for measurement across jurisdictions. The core sets of indicators developed by Gitelman et al (2008), SafetyNet (2009), Sasser et al (2005) and Vis and Gent (2007) constitute the most feasible sets to date for making such comparisons, although in both there is some overlap and lack of commonality. Moreover, as noted, not all jurisdictions have sufficient, if indeed any, data concerning those indicators. Finally, as remarked on by CDCP (2013) and Gitelman (2007), there are potential parameters such as the triage decisions made after a crash and death rates among crash victims transported to hospital that have great potential to inform evaluations of post-crash response, but for which data can be hard to obtain.

Despite these issues, the following chapters indicate that the comparison and evaluation approaches used internationally can be applied to investigations of EMS response across Australian jurisdictions.

4 Results — emergency response arrangements in Australia

Using publically available data, this chapter compares the agencies responsible for post-crash EMS across Australian jurisdictions. First, focusing on ambulance services, it compares available equipment, staffing, response times and numbers of incidents attended across the jurisdictions. Note that these data concern all uses of ambulances and not just crash responses. The chapter then presents data concerning various other agencies responsible for road crash rescue.

4.1 Ambulance response in Australia

Within the various areas of Australia, there is generally a consistent approach to emergency medical response situations, although the specific arrangements may differ slightly. In each area of Australia the Ambulance services generally fall under the umbrella departments of health, these are shown in Table 4.1 (reprinted from Productivity Commission, 2015b) for the various jurisdictions of Australia. Interestingly, while most of the Ambulance providers are part of the Government department, both NT and WA contract the services of St John Ambulance, an incorporated not-for-profit organisation. The single ambulance service provided by St John Ambulance WA is responsible for the largest landmass worldwide (St John Ambulance, 2015).

Table 4.1
Ambulance service organisations
(reprinted from Productivity Commission, 2015b, Table 9A.31).

Area	Umbrella department(s)	Ambulance service provider(s)
NSW	NSW Ministry of Health	Ambulance Service of NSW — a division of the Ministry of Health reporting to the Minister for Health.
VIC	Victoria Department of Health	Ambulance Victoria — a separate statutory body reporting to the Minister for Health.
QLD	Queensland Department of Health	Queensland Ambulance Service — a division of the Department of Health.
WA	WA Department of Health	St John Ambulance — an incorporated not for profit organisation under contract to the WA Government.
SA	SA Health	SA Ambulance Service — an incorporated entity under the SA Health Care Act.
TAS	Tasmania Department of Health and Human Services.	Ambulance Tasmania — a statutory service of the Department of Health and Human Services.
ACT	ACT Emergency Services Agency within the Justice and Community Safety Directorate	ACT Ambulance Service — one of four operational services that comprise the ACT Emergency Services Agency, Justice and Community Safety Directorate (the other operational services are the ACT Fire and Rescue, ACT Rural Fire Service and ACT State Emergency Service). The Department reports to the ACT Minister for Police and Emergency Services.
NT	NT Department of Health	St John Ambulance — an incorporated not-for-profit organisation under contract to the NT Government.

The Australian Government Productivity Commission report on Emergency Management also lists the emergency management organisations responsible for medical transport and emergencies for each area of Australia, shown in Table 4.2 (reprinted from Productivity Commission, 2015a)**.** Air-rescue (fixed wing or helicopter) services operate under the respective ambulance services although the service arrangements differ between areas. The Productivity Commission (2015a) reports that in some jurisdictions the ambulance service funds their respective air-rescue service completely, or provides air ambulance personnel, the aircraft and crews on external contract. In other jurisdictions, most or all of the funding of the air-rescue services are external to the ambulance service (QLD, SA, WA and NT).

Table 4.2
Emergency management organisations responsible for medical transport and emergencies
(reprinted from Productivity Commission, 2015a, Table DA.1)

Area	Medical transport and Emergencies
NSW	Ambulance Service of NSW
	NSW Health
	Helicopter Rescue Services (under ambulance control)
VIC	Ambulance Victoria
	Metropolitan Fire Brigade
QLD	Qld Ambulance Service
	Queensland Government Air rescue service (QGAir), Public Safety Business Agency (PSBA)
	Department of Health
	Royal Flying Doctor Service
WA	St John Ambulance
	Department of Fire and Emergency Services
	Royal Flying Doctor Service
	Department of Fire and Emergency Services/St John Ambulance - Rescue Helicopter Service
SA	SA Ambulance Service
TAS	Ambulance Tasmania
ACT	ACT Emergency Services Agency
	ACT Ambulance Service
NT	St John Ambulance
	Royal Flying Doctor Service
	Territory Health Service
Aus Gov	Department of Health — National Incident Room
	Attorney-General's Department (Australian Medical Transport Coordination Group)

Table 4.3 shows the number of ambulance stations and locations in Australia. The data in this table may be loosely compared to Table 3.1 (notwithstanding different definitions) in this report, which shows the data on trauma management for the top five performing OECD countries. Such a

comparison would need to assume dispatching centres in the OECD report are equivalent to the communications centres in Australia, and EMS stations are the OECD equivalent to Australian response locations. On average, OECD countries have around 19 dispatch centres per 100 EMS stations, compared to around 4.5 communications centres per 100 response locations in Australia.

Table 4.3
Data on Trauma Management 2013-2014,
(reprinted from Productivity Commission, 2015b, Table 9A.39)

Ambulance stations and locations	*NSW*	*Vic*	*Qld*	*WA*	*SA*	*Tas*	*ACT*	*NT*	*Aust*
Response locations	245	261	265	190	111	49	8	9	1 138
Communication centres	5	–	7	1	1	1	1	1	17
Other locations	61	32	51	176	21	6	4	2	353
Total	311	293	323	367	133	56	13	12	1 508
Ambulance 1st responder locations	7	58	26	751	8	5	–	–	855
Third party 1st responder locations	22	73	–	–	14	4	–	–	113
Ambulances and other vehicles:									
Ambulance general purpose	924	547	860	480	236	110	27	32	3 216
Patient transport vehicles	117	58	105	35	21	13	4	3	356
Operational support vehicles	298	313	203	35	93	28	11	12	993
Special operations vehicles	93	18	17	3	44	3	–	1	179
Administrative vehicles	69	144	34	73	22	4	1	6	353
Other vehicles	67	40	46	23	14	6	4	5	205
Total	1 568	1 120	1 265	649	430	164	47	59	5 302

Table 4.4 shows the number aero-medical resources by jurisdiction, with the distinct operational differences in service provision. Additionally, Table 4.4 shows that QLD, NSW and WA have very high numbers of aero-medical resources compared to the other jurisdictions.

Table 4.4
Air ambulance medical resources, 2013-2014,
(reprinted from Productivity Commission, 2015b; Table 9A.40)

Aero medical resources (Number)									
Operated by State Ambulance Service:	*NSW*	*Vic*	*Qld*	*WA*	*SA*	*Tas*	*ACT*	*NT*	*Aust*
• Fixed wing	6	4	–	–	–	1	–	–	11
• Helicopter	10	5	–	–	–	–	–	–	15
Operated by other service providers:									
• Fixed wing	2	–	14	15	5	–	–	–	36
• Helicopter	4	–	13	4	3	1	1	–	26
Total	22	9	27	19	8	2	1	–	88

Table 4.5 shows the mix of ambulance staff throughout Australia by employment status. All of the ACT's ambulance stations are staffed by paid employees. NSW and QLD have very high levels of paid staff 91% and 89% respectively, while other jurisdictions have less than 50% of ambulance stations with paid staff.

Table 4.5
Ambulance stations and locations by staff employment status, 2013-14
(reprinted from Productivity Commission, 2015b, Table 9A.38)

Ambulance stations and locations	Unit	NSW	Vic	Qld	WA	SA	Tas	ACT	NT	Aust
With paid staff only	no.	223	168	237	30	40	12	8	4	722
With mixed paid and volunteer staff	no.	7	65	–	14	3	16	–	3	108
With volunteer staff only	no.	15	28	28	146	68	21	–	2	308
Per 100 000 people:										
With paid staff only	no.	3.0	2.9	5.1	1.2	2.4	2.3	2.1	1.6	3.1
With mixed paid and volunteer staff	no.	0.1	1.1	–	0.5	0.2	3.1	–	1.2	0.5
With volunteer staff only	no.	0.2	0.5	0.6	5.7	4.1	4.1	–	0.8	1.3

Table 4.6 shows the number of Ambulance personnel that might be involved in an emergency response, loosely comparable to the data on trauma management in Table 3.1. Table 4.6 also shows the differences in number of volunteer operatives compared to qualified (salaried) ambulance officers. NSW and QLD have very high numbers of qualified (salaried) ambulance officers compared to volunteer ambulance operatives. This is in contrast to WA and SA who have high numbers of ambulance volunteer operatives.

Table 4.6
Number of Ambulance Services Personnel, 2013-14
(reprinted from Productivity Commission, 2015, Table 9A.35)

Number of Emergency Services Personnel (Ambulance**)	*Unit*	*NSW*	*Vic*	*Qld*	*WA*	*SA*	*Tas*	*ACT*	*NT*	*Aust*
Qualified ambulance officers (salaried)	FTE	2 714	2 527	2 690	552	715	221	146	66	9 631
Clinical Other	FTE	53	12	–	1	44	2	–	–	112
Volunteer Ambulance Operatives	no.	109	674	122	3 050	1 283	511	–	–	5 749
Community first responders	no.	241	422	201	1 502	45	45	–	–	2 456
Total Emergency Response Personnel		3 064	3 623	3 013	5 104	2 043	777	146	66	17 836

**Data reported here includes only personnel that might be directly associated with an emergency medical response

Table 4.7 was calculated using data from Table 4.6. It is loosely comparable to the data in Table 3.1 from the OECD best performers "EMS medical staff per 10,000 citizens". However, the data in Table 4.7 refers to emergency services personnel as listed in Table 4.6, while Table 3.1 refers to paramedics, nurses, physicians and medical technicians that are involved in EMS. Definitions of EMS staff differ so it is difficult to compare, however in Australia qualified ambulance offers per 10,000 citizens range from 2.8 (in NT) to 5.8 (in QLD), this is compared to 1.62 (in NL) to 6.42 (in DE). Considering all emergency service personnel in Australia, EMS personnel per 10,000 are higher; 7.8 per 10,000 citizens Australia wide.

Table 4.7
Ambulance personnel per 10,000 population 2013-14.

Number of Emergency Services Personnel (Ambulance**)	*NSW*	*Vic*	*Qld*	*WA*	*SA*	*Tas*	*ACT*	*NT*	*Aust*
Qualified ambulance officers per 10,000 population	3.7	4.4	5.8	2.2	4.3	4.3	3.8	2.8	4.2
Emergency medical service personnel per 10,000 population	4.2	6.3	6.5	20.3	12.5	15.2	3.8	2.8	7.8
Population ('000) (30 June 2013)*	7407.7	5737.6	4658.6	2517.2	1670.8	513.0	383.4	239.5	23 130.9

*Australian Bureau of Statistics (2013)

Table 4.8 shows ambulance code 1 state-wide and capital response times. Code 1 response times refer to the time taken for an ambulance resource to arrive at potentially life threatening emergency situations using warning devices (Productivity Commission, 2015b). Response times are not strictly comparable as different jurisdictions commence from different time points, either from the first keystroke from the time transfer to dispatch has occurred or when a crew has been dispatched. This may be loosely comparable to "The demand for EMS response time", in Table 3.1. It is difficult to ascertain what proportion of responses to road crashes might be Code 1 (Emergency incidents - life threatening) or Code 2 (Urgent, for which response times are not reported), so these response times may only be of relevance in a very small proportion of all incidents reported.

Table 4.8
Ambulance code 1 response times (minutes), 2013-14
(reprinted rom Productivity Commission, 2015b, Table 9A.44)

Performance Indicator	Unit	NSW	Vic	Qld	WA	SA	Tas	ACT	NT
State-wide 50th percentile	minutes	10.8	11.1	8.2	8.8	8.8	11.4	8.2	7.6
State-wide 90th percentile	minutes	22.2	22.4	16.3	16.1	16.6	23.7	12.9	17.1
Capital city 50th percentile	minutes	10.6	10.8	8.2	8.4	8.6	10.4	8.2	8.3
Capital city 90th percentile	minutes	19.8	19.2	14.7	13.9	14.5	16.8	12.9	17.4

Table 4.9 shows the number of ambulance incidents, responses, patients and transport by jurisdiction. The number of road crash incidents is not generally reported, however as an example, according to SA Ambulance (2015), only 4% of their emergency responses related to road crashes.

Table 4.9
Reported ambulance incidents, responses, patients and transport, 2013-14
(reprinted from Productivity Commission, 2015b, Table 9A.33)

Incidents	*Unit*	*NSW*	*Vic*	*Qld*	*WA*	*SA*	*Tas*	*ACT*	*NT*	*Aust*
Emergency incidents	'000	480	322	318	93	116	39	15	na	1 382
Urgent incidents	'000	248	177	341	55	90	22	20	na	952
Non-emergency incidents	'000	–	346	237	105	61	12	8	–	769
Casualty room attendances	'000	–	–	1	–	–	–	–	–	1
Total incidents	'000	727	844	897	252	266	73	43	na	3 103
Incidents per 1000 people	no.	97. 4	145. 8	191. 1	99.	158. 6	142. 8	113. 1	na	134. 5

Incidents	*Unit*	*NSW*	*Vic*	*Qld*	*WA*	*SA*	*Tas*	*ACT*	*NT*	*Aust*
Responses:										
Emergency responses	'000	617	485	427	109	165	49	16	17	1 885
Urgent responses	'000	310	233	378	66	122	26	19	18	1 172
Non-emergency responses	'000	307	390	243	119	79	13	8	9	1 170
Total responses	'000	1 235	1 108	1 048	294	366	88	43	45	4 226
Responses per 1 000 people	no.	165. 4	191. 4	223. 4	115. 3	217. 9	170. 6	112. 5	184. 6	181. 2
Patients:										
Transported	'000	813	682	777	220	211	60	30	na	2 794
Treated not transported	'000	147	92	85	28	30	14	7	na	404
Total patients	'000	960	774	862	249	242	74	37	na	3 198
Patients per 1000 people	no.	128. 6	133. 7	183. 8	97. 5	144. 1	143. 3	97. 5	na	138. 6

4.2 Road crash rescue

There are a number of factors that might delay prompt medical access to an injured road crash victim. These include crash notification delays, ambulance travel delays and subsequent access delays by emergency medical services to the crash. Safe and unhindered access by ambulance personnel to the injured occupants is required before any medical aid can commence. This includes control of incidents such as fires or fallen power-lines or crash induced hazards. There may also be difficulty in gaining physical access to the injured due to vehicle orientation, vehicle deformation and entrapment (Emergency Management Australia, 1992).

Road crash rescue is a service provided by emergency service organisations that assist with State, Territory and the Federal Government's aim of reducing the trauma and costs of road crashes. This is achieved by providing rescue services that support and enable effective and efficient medical services (Productivity Commission, 2015a).

The role of a prepared, appropriately trained road crash rescue unit with an appropriately maintained and stocked vehicle fleet is described by Emergency Management Australia (1992). Some of the key elements to a road crash rescue involve:

- responding to an accident, liaising with other agencies and controlling hazards to ensure operational safety and the safety of others
- assisting emergency medical services gaining access to trapped casualties or assisting with first aid or basic life support if emergency medical services are not in attendance
- extrication of trapped patients in liaison with emergency medical services to facilitate rapid transport of severely injured casualties to a trauma centre or emergency medical facility

Across Australia road crash rescue is undertaken by various rescue agencies. The agencies for each jurisdiction of Australia are listed in Table 4.10. Generally, rescues are undertaken by fire service agencies (metropolitan or country) and various state emergency service agencies, but in some jurisdictions, police forces, ambulance services and volunteer rescue associations also provide rescue services.

It is important to emphasise that road crash rescue is just one type of emergency event that forms part of an emergency service organisation's activities. Other activities include response to fires, natural disaster events and natural events, land, vertical and marine rescues and various other events. Reported data relating to road crash rescues, including incidents, extrications and per population, per registered vehicles and per kilometres travelled are shown in Table 4.11 (reprinted from Productivity Commission, 2015b). These data were provided by fire rescue organisations (urban and rural, paid and volunteer) as well as State/Territory Emergency Services. There may be some differences in reporting between jurisdictions (see Productivity Commission, 2015b).

Table 4.11 shows non-fire rescue calls, reported road crash rescue incidents and reported road crash rescue extrications Australia wide for 2013-14. Around 38% of non-fire rescue calls were due to road crash rescue incidents and 38% of all road crash rescue incidents resulted in a vehicle extrication (See Table 4.11). The results differ considerably for each jurisdiction and it is not clear if valid comparisons can be made. For example, 23% of non-fire rescue calls in NSW and 99% of non-fire rescue calls in SA were due to road crash rescue incidents. Considering vehicle extrications, 86% of road crash rescue incidents Australia wide resulted in an extrication compared to only 7% in SA.

Table 4.10
Agencies responsible for road crash rescue in Australia.
(reprinted from Productivity Commission, 2015b, Table DA.1)

Area	Road crash rescues
NSW	Fire and Rescue NSW
	NSW Police Force
	Ambulance Service of NSW
	NSW State Emergency Service
	Volunteer Rescue Association
VIC	Metropolitan Fire Brigade
	Country Fire Authority
	Victoria State Emergency Service
QLD	Queensland Fire and Emergency Services
	Qld State Emergency Service
	Qld Ambulance Service
	Qld Police Service
WA	WA Police Service
	Department of Fire and Emergency Services
	St John Ambulance
SA	State Emergency Service
	Metropolitan Fire Service
	Country Fire Service
TAS	Tasmania Fire Service
	State Emergency Service
ACT	ACT Fire and Rescue

Area	Road crash rescues
NT	NT Fire and Rescue Service NT Emergency Services

Table 4.11
Reported non-fire rescue calls, reported road crash rescue incidents and reported road crash rescue extrications 2013-14 (reprinted and calculated from Productivity Commission, 2015b, Table 9A.13, 9A.19, 9A.20)

	NSW	Vic	Qld	WA	SA	Tas	ACT	NT	Aust
Non-fire rescue calls incl. road crash rescue	19 648	13 862	16 770	3 100	6 151	1 360	1 315	782	62 988
Road crash rescue (RCR) incidents	4 512	2 157	7 733	1 994	6 090	524	625	303	23 938
RCR Incidents per 100 000 people	60.4	37.2	164.9	78.2	363.1	102.0	162.7	124.9	102.7
RCR incidents as a % of all non-fire rescues	23%	16%	46%	64%	99%	39%	48%	39%	38%
Road crash rescue extrications	3 890	1 494	2 170	524	416	125	257	130	9 006
Extrication as percentage of all RCR incidents	86%	69%	28%	26%	7%	24%	41%	43%	38%
Extrications per 100 000 people	52.1	25.8	46.3	20.5	24.8	24.3	66.9	53.6	38.6
Extrications per 100 000 registered vehicles	76.2	33.3	58.6	24.5	31.4	28.2	92.0	85.4	51.1
Extrications per 100 million vehicle kilometres travelled	5.6	2.4	4.0	1.8	2.5	2.5	6.5	2.5	3.7

4.3 Data issues

The information provided in this section, while quite informative may not always be comparable. There are a number of caveats to the data which should be examined carefully when attempting detailed comparisons (the caveats are linked to the source data for each of the tables). Data is collected by various fire and emergency service organisations in each jurisdiction but not all data is collected by all of the agencies (Productivity Commission, 2015). Additionally, there may be some over counting due to a number of emergency organisations attending the same crash incident (Productivity Commission, 2015). Policies and processes differ between jurisdictions and hence definitions and data may also differ based on this. A summary of road crash rescue policies and calculation of road crash rescue incidences, by jurisdiction is show in Table 2 and Table 3 of Productivity Commission (2015).

4.4 Summary

Overall there is some data that provides an insight into scale of effort and performance on selected measures. However, it is evident that individual circumstances in each jurisdiction lead to distortions of the data which makes meaningful comparison difficult. Even if variables exist in the databases, there is no guarantee that they are recorded consistently and regularly by rescue organisations. Extracting information specific to road crash rescue is also not straightforward. It is therefore difficult to perform systematic analysis and modelling at a national level or indeed a state level where many rescue agencies are involved.

5 Results — emergency response arrangements in NSW road crashes

The following section provides an overview of emergency response arrangements to road crashes in NSW. The information is based on a combination of published documents and discussions with representatives from each of the rescue organisations.

5.1 Ambulance response

The role of the emergency call receiver is to answer a triple zero emergency call, retrieve information from the caller and transfer the call to the appropriate state or territory Emergency Service Organisations (ESOs), dependent on the type of emergency. For a medical emergency such as injury resulting from a road crash in NSW the call is likely to be transferred to one of NSW Ambulance's communication and control centres[19] for the designated area in which the crash occurred.

The activation of an appropriate emergency medical response in NSW, is guided by the NSW Trauma Services Plan (NSW Department of Health, 2009). Ambulance NSW is the designated provider of the pre-hospital component of care to the injured patient (NSW Department of Health, 2009). Under the plan, emergency calls are overseen by the Rapid Launch Trauma Coordinator (RLTC), whose role in conjunction with a retrieval consultant is to assess the level of emergency medical response required, whether there is a likelihood of major trauma and whether there may be a need to activate early transfer or aero-medical retrieval (NSW Department of Health, 2009). Even if a major trauma is not identified initially, The RLTC also liaises with the Ambulance NSW primary medical response, to facilitate and coordinate emergency resources that might be required under NSW Protocol T1 – Pre-hospital Management of Major Trauma (Ambulance NSW, 2012).

A retrieval consultant (a medical specialist with both hospital and pre-hospital experience) is responsible for specific clinical information or advice and the RLTC is involved in the tasking process. Clinical management or decision-making is referred to the retrieval consultant (who is contracted to Ambulance NSW) and resource tasking is the responsibility of the RLTC (NSW Department of Health, 2009; C. Deans, personal communication, May 5, 2015).

Ambulance NSW personnel arriving on-scene assess all trauma patients according to the Ambulance NSW Protocol T1 (Ambulance NSW, 2012). Protocol T1 is a comprehensive injury assessment protocol that defines the criteria for Major Trauma, the emergency actions and responses required and the designated trauma centres for hospital care, based on incident location and severity. The initial structure of the protocol includes (Ambulance NSW, 2012):

1. Scene assessment: precise location, incident type, hazards or access issues, casualty numbers, emergency services in attendance or requirements
2. Initial patient survey: control life threatening bleeding, initiate basic life support
3. A MIST report, the trauma triage tool used to define Major Trauma Criteria and emergency actions, type of transport required and level of hospital trauma service required. MIST is based on:
    a. Mechanisms of injury

[19] There is a requirement in the NSW State Emergency Rescue Management Act that the emergency service agency receiving the initial emergency call notify the NSW Police Force if the rescue of any person is likely to be required.

b. Injuries

c. Signs and symptoms

d. Transport

The over arching premise of the Protocol is to provide a comprehensive and structured assessment at an emergency medical incident to ensure early activation of the required emergency medical retrieval services, minimising at-scene time and optimising transport time to the required trauma service or hospital. Additionally, the protocol aims to improve efficiencies and coordination between primary emergency medical response, any required retrieval services and the designated trauma service destinations for casualties (Ambulance NSW, 2012). This is consistent with "… the key requirement of a trauma system is to deliver a patient to the appropriate level of trauma service in as timely a manner as possible, minimising the time from injury to when the patient can receive definitive trauma care; '*the right patient, to the right hospital, in the right time*'…." (NSW Department of Health, 2009).

5.2 Road crash rescue

As mentioned previously, there is generally a consistent approach to emergency response situations in Australia, although the specific arrangements in various jurisdictions differ. A summary of the emergency response arrangements in NSW is provided in this section.

The NSW State Emergency and Rescue Management Act 1989 (SERM Act) specifies the legal frame-work and governance for rescue management in NSW. The State Rescue Board (SRB) of NSW is the 'statutory body representing the crown' functioning under the SERM Act (Part 3, Div 1, s42(2)(b)). The composition of the board includes the Commissioner of the State Emergency Service, the State Emergency Operations Controller, a member of the NSW Police Force Senior Executive Service nominated by the Commissioner of Police, the State Superintendent of the Ambulance Service of NSW, the President of the Volunteer Rescue Association of New South Wales the Chairperson of Volunteer Marine Rescue NSW and the heads of any other volunteer rescue agencies approved by the Minister (SERM Act, Part 3, Div 1, s43(1)). The board is chaired by the Commissioner of the NSW Rural Fire Service[20] (SERM Act, Part 3, Div 1, s43(2)).

The function of the board is to 'ensure the maintenance of efficient and effective rescue services throughout the State' (SERM Act, Part 3, Div 2, s47). The particular duties of the board are specified in the SERM Act and include policy development for rescue services and making recommendations to the Minister for Police and Emergency Services regarding policy matters relating to rescue service provision within NSW (SERM Act, Part 3, Div 2, s48).

Only 'accredited' rescue units can provide rescue services in NSW under the SERM Act. An 'accredited rescue unit' is an emergency service formally approved by the Minister (SERM Act, Part 1, s3(1)), with authority to undertake rescue operations (in NSW) coordinated by NSW Police in particular areas of responsibility. Accredited (road crash) rescue units fall under one of five rescue agencies being: Fire and Rescue NSW, NSW Police Force, Ambulance Service of NSW, NSW State Emergency Service and the Volunteer Rescue Association. According to the NSW State Rescue Policy (Minister for Police & Emergency Services, 2014, Para 2.03), a rescue unit (and an activated rescue crew) must comprise of at least two qualified and current rescue operators (Minister for Police and Emergency Services, 2014, Para 2.03).

[20] The NSW Rural Fire Service in an emergency agency not currently accredited for rescue in NSW and hence the position of chair of the board is independent or neutral.

Regional and local rescue committees for each region and local government area are chaired by the Regional Emergency Operations Controller (defined in SERM Act, Part 2, Div 2 (22)) for each region and comprise of senior emergency service organisation representatives operating in the area. These committees are under the control and direction of the State Rescue Board. The role of the rescue committees is to assist the board in its functions, particularly assisting the board in recommendations of accreditation of rescue units to the Minister in particular regions or areas (SERM Act, Part 3, Div 2, 48A).

Other duties of the board include reviewing and distributing technical information, as well as providing advice and recommendations on rescue and communication equipment, assist with and monitor the training and standards involving the various agencies involved in rescue (SERM Act, Part 3, Div 2, 48).

The NSW State Rescue Policy, prepared by the NSW State Rescue Board in compliance with the SERM Act, refers to road crash rescue under 'general land rescue', defined as 'all rescue activities involving the safe removal of persons or domestic animals from actual or threatened danger' (Minister for Police & Emergency Services, 2014, Para 1.09).

A Road Crash Rescue is defined as "… any incident involving a motor vehicle to which an accredited rescue unit(s) was called-out by the Police or VKG[21] (either directly or by the Police or VKG through individual emergency service call centres, or directly by emergency service call centres notifying back to Police or VKG), whether the incident was classified as a single incident rescue or an emergency, and whether the unit was subsequently called-off or not" (Minister for Police & Emergency Services, 2014, Para 1.10).

The State Rescue Policy defines the standard response to a perceived or actual road accident rescue incident once an emergency call is received (NSW State Rescue Policy, 2.10):

- NSW Police Force: responsible for coordinating and determining action priorities for services involved in the rescue operation, including calling out accredited rescue units
- fire Service with operational jurisdictional provide necessary fire protection
- ambulance Service of NSW: Provide pre-hospital emergency medical services
- the accredited rescue unit in the area of the crash provide the required rescue

The accredited rescue units are ranked on the basis of primary accreditation (primary choice for rescue response) or secondary accreditation (secondary choice for rescue subject to unavailability of primary unit, or dual response as might be recommended by local and regional rescue committees) for particular areas of responsibility as determined by the State Rescue Board of NSW. The ranking or selection of the appropriate accredited rescue unit is guided by optimal response times for a particular incident scene (Minister for Police & Emergency Services, 2014, Para 2.13).

The current list of the NSW accredited land rescue units for each region and area in NSW can be found in NSW State Rescue Board (2014), Appendix B. Table 5.1 (reprinted from NSW State Rescue Board, 2014) shows the number of accredited units and type of accreditation, by rescue agency. The majority of the units for primary accreditation are attached to Fire and Rescue NSW and NSW SES. In cases where a primary unit is unavailable, Fire and Rescue NSW are by far the leading secondary

[21] VKG (Voice of King George) is the historical and long held call sign, acronym and name used in reference to the 24/7 NSW Police Radio Dispatch Centre.

accredited unit. Table 5.2 (reprinted from NSW State Rescue Board, 2014) shows the number of qualified rescue operators in each emergency organisation. Fire and Rescue NSW hold 59% of the NSW qualified rescue operators compared to 20% for the next lead rescue agency, the NSW SES. A map of the NSW Emergency Management Regions can be found in NSW Government, 2014.

Table 5.1
Accreditation by Rescue Agency for general land rescue including crash rescue
(reprinted from NSW State Rescue Board (2014), Table 9.3)

Rescue Agency	Primary	Secondary	% Primary	% Secondary
Fire & Rescue NSW	73	110	37%	92%
NSW State Emergency Service	71	8	36%	7%
NSW Volunteer Rescue Association	39	1	20%	1%
NSW Police Force	8	0	4%	-
Ambulance Service of NSW	6	0	3%	-
Total	197	119	100%	100%

Table 5.2
Number of Qualified Rescue Operators (30 June 14)
(reprinted from NSW State Rescue Board, 2014, Table 7.1)

Rescue Agency	General Land Rescue Operators	% of total
Fire & Rescue NSW	2,073	59%
NSW State Emergency Service	689	20%
NSW Volunteer Rescue Association	549	16%
NSW Police Force	140	4%
Ambulance Service of NSW	74	2%
Total	3,525	100%

Table 5.3 shows the number of road crash rescue incidents for 2012-13 and shows that Fire and Rescue NSW responded to 65% of all incidents requiring rescue compared to only 12% for NSW SES despite a similar number of accredited primary rescue units. Across all rescue incidents, around 85 - 87% of rescue incidents required extrication by an accredited rescue unit.

Table 5.3
Road Rescue Incidents in NSW 2013-2014 (reprinted from NSW State Rescue Board, 2014, Table 5.1)

Rescue Agency	Rescue Calls*	Rescue Incidents	Rescue Extrications
Fire & Rescue NSW	5836	2,844	2,444
NSW State Emergency Service	880	518	440
NSW Volunteer Rescue Association	807	487	433
NSW Police Force	1624	391	344
Ambulance Service of NSW	296	156	133
Other	-	7	7
Total	9443	4,403**	3,801**

* G. Mckinnon, personal communication, May 14, 2015

**Note: Productivity Commission (2015) reported 4512 rescue incidents and 3890 extrications for 2013-2014, NSW Fire & Rescue Annual Report 2013-2014 reported 4984 MVAs involving extrication.

5.3 Emergency response times comparison

It is interesting to note the differences between response times to major events for Fire and Rescue NSW and NSW Ambulance. The comparison between response times is shown below in Table 5.4. For each performance indicator Fire and Rescue NSW outperform NSW Ambulance. There are a number of reasons for this. For 2013-14, Fire and Rescue NSW had 3939 fire-fighting personnel (Permanent, Part-time and Other), compared to 3064 qualified ambulance officers, volunteers and community first responders. Fire and Rescue NSW had 337 fire stations compared to 274 ambulance response, first response and third party first response locations. Finally, Fire and Rescue NSW achieve these times, in response to 5870 state-wide structure fires compared to 479,544 emergency incidences for NSW Ambulance. (Note: this is assuming the 479,544 emergency incidences are code 1)

Table 5.4

(reprinted and calculated from Productivity Commission, 2015b, Table 9A.26 and Table 9A.44)

Performance Indicator	Unit	NSW Fire & Rescue Response to Structure Fires	NSW Ambulance Response to Code 1 Emergencies	Difference
State-wide 50th percentile	minutes	7.5	10.8	3.3
State-wide 90th percentile	minutes	15.4	22.2	6.8

6 Results — case study/modelling

As mentioned in the literature review, research on post-crash care responsiveness is almost exclusively focussed on improving response times and the factors influencing response times, and predominantly appears to be conducted outside of Australia. Consistently, the research has shown that improving emergency medical response times to road crashes will result in fewer fatalities. Two studies have been undertaken in Australia relating to ACN. Lahause et al (2008) estimated that a fully deployed ACN system in Australia would result in a 10.5% reduction in fatalities in urban areas and a 12% reduction in rural areas (for passenger vehicle drivers and occupants) if crash notification times were reduced to one minute and the system was 95% effective. There is reason to believe that this is optimistic, given the estimate is based on a variation of the mathematical model by derived by Evanco (1996) using US rural fatal crash data from the 1990s. Ponte et al (2013), conservatively estimated a reduction in all fatalities in South Australia of around 2.2% and a reduction 2.8% for occupant fatalities, based on a sample of Coroners' files, where it was already established there was a delay (greater than 10 minutes) between a crash occurring and notification of EMS. However, this study assumes no benefit for crashes where the EMS notification delay is less than 10 minutes and was limited to using EMS dispatch data rather than EMS notification data for fatal crashes.

There is scope for Transport for NSW to conduct a study to determine the effectiveness of a fully deployed ACN system in NSW. The background and concept to such a study are discussed in this section as an example of something that could be quantified from emergency performance data.

6.1 Background

Akella et al (2003) document the discrete time elements from the moment a crash occurs to the moment where an injured person can receive the most appropriate medical treatment within a local hospital or emergency hospital. These are:

- t0 Crash occurrence
- t1 Notification receipt by Emergency Response
- t2 Emergency Medical Service (EMS) notified
- t3 EMS dispatched
- t4 EMS arrival to crash scene
- t5 EMS gain access to patient(s)
- t6 EMS depart scene
- t7 EMS arrival at Hospital

If ACN has a benefit in a crash, it is initially through reducing the time between *t0* and *t1 to* initiate rapid medical response. However, the time between arriving at a crash scene and gaining access to patient(s) for pre-hospital care, the interval (*t5 - t4),* is highly dependent on the coordination and response of rescue services to assist - particularly for severe crashes with vehicle deformation and entrapment.

Figure 6.1 below (reprinted from Productivity Commission (2012), Figure 9.25) is somewhat consistent with Akella et al (2003) and provides a frame-work for measuring the performance of ambulance

response to an incident. However, it does not consider the incident time (the road crash) and the time the ambulance response centre receives a call *t1 - t0*. This is important when considering the effectiveness of a technology such as ACN that reduces this critical time interval. Ponte et al (2013) used *t3 - t0* to assess the benefits of ACN, (in absence of *t1* and *t2*), but this is a limitation of that study.

The treatment time, as depicted in Figure 6.1 is consistent with *t6 – t4* from Akella et al (2003) and influences *t5 – t4: the* time taken to access the patient(s), again which is dependent on rescue services. The Productivity Commission (2012) also presents a framework for performance indicators for road crash rescue in Australia. The road crash rescue framework presented in Figure 6.2 for performance effectiveness is linked to response and two critical attributes, response time and on-scene management. These are important attributes, but have not been collected or not yet been developed for reporting purposes (Productivity Commission, 2012). This may be something that TfNSW may want to take a lead on, in terms of data collection feasibility and reporting.

Figure 9.25 **Response time points and indicators for ambulance events**

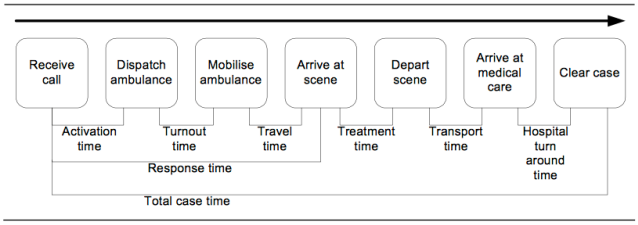

Figure 6.1
Response time and indicators for ambulance events
(Reprinted from Productivity Commission, 2012, Figure 9.25)

Figure 9.17 **Road crash rescue events performance indicator framework**

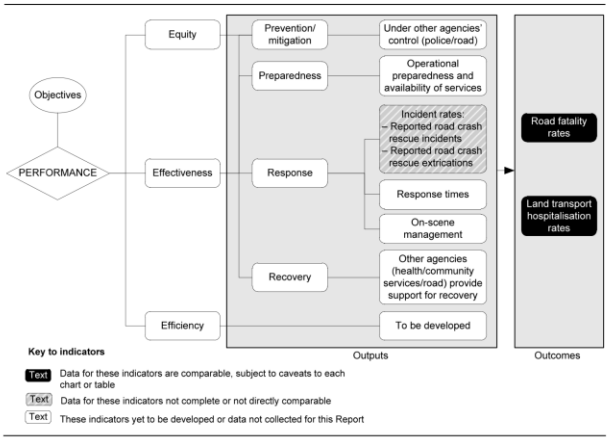

Figure 6.2
Road crash rescue events performance indicator framework
(Reprinted from Productivity Commission, 2012, Figure 9.17)

There is some information relating to activities of the NSW Ambulance Research Institute (ARI) who are "…. pursuing prospective research which maps the entire clinical journey of each patient requesting EMS via the Ambulance Service of NSW. Patients will be followed through the whole continuum from the pre-hospital stage, through the emergency department (ED) and thereafter until the final discharge from hospital after treatment is completed. For each patient, information will be combined via data linkage mechanisms, thus enabling comprehensive analysis…" (see The NSW Trauma Collaborative, n.d.). To date there have been no publications related to this research but there may be the potential for obtaining relevant performance data and cooperative research for Transport for NSW projects.

6.2 A method for measuring the effectiveness of ACN in NSW

A suggested study estimating the impact of ACN for fatal crashes in NSW is outlined.

6.2.1 Data

Data required for a sample of fatal crashes in NSW:

- best estimate of the time the crash occurred *t0*
- the time notification was received by an emergency response centre *t1*
- the time NSW Ambulance received notification *t2*
    - the time the accredited rescue unit received notification *t2**
- the time NSW Ambulance dispatched *t3*
    - the time the accredited rescue unit dispatched *t3**
- the time NSW Ambulance arrived at crash scene *t4*
    - the time the accredited rescue unit arrived at crash scene *t4**
- the time NSW Ambulance gained access to the injured *t5*
    - the time the accredited rescue unit enabled access to the injured *t5**
- the time NSW Ambulance departed scene *t6*
- the time NSW Ambulance arrived at hospital *t7*
- time to hospital treatment *t8*

ACN will minimise the time between *t0* and *t1* with the additional benefit of having the exact crash location and possibly reduced journey time t4 – t0 and hence t5 – t0.

6.2.2 Method

For each fatality:

Determining the times t1, t2 and t2* will establish the number and proportion of crashes where there was a delay between the time the crash occurred and the time an emergency call was made. It would be expected that single vehicle, single occupant crashes that occurred in rural or remote areas, on roads with or at times of low traffic volumes would stand-out.

Examining the injuries sustained by each fatally injured person and the time until death or the survival time, will indicate the proportion of fatalities that occurred instantaneously, the proportion that occurred within minutes of the crash injuries or within the hour or within several hours, whether the fatalities occurred pre-hospital, or in the hospital. Fatalities that occurred instantaneously or within a few minutes of a crash are unlikely to be influenced by improved response times. Coding the injuries according to injury severity score (ISS) or abbreviated injury scale (AIS) may assist with a statistical correlation between response time and a survivable injury.

Knowing *t5 – t0* and *t5* – t0* and whether or not the injured person was still alive at *t5,* a medical expert can estimate whether the person would have survived under various counterfactuals:

- better treatment at the crash
- quicker transfer to and treatment at hospital

Additionally, an estimate can be made at what time the ambulance would have arrived had it been notified immediately after the crash happened (i.e. the shortened period *t5 – t0* with an ACN system)

Knowing the possibly reduced *t5 – t0* (estimated with ACN) a medical expert can estimate whether or not the injured person would have still been alive at the earlier time (*t5*) and whether they would have survived if they received treatment similar to the treatment they actually received originally.

Again an estimate can be made as to whether they would have survived under similar counterfactuals:

- better treatment at the crash
- quicker transfer to and treatment at hospital

In principle this would give several different estimates of effectiveness.

For example, those that were alive at the earliest plausible time the ambulance could have arrived are an upper limit for the benefit. Those that were alive at the earliest plausible time the ambulance could have arrived and subsequently received the best plausible decision-making and treatment are a better estimate of the benefit.

This concept may provide a very good opportunity for a collaborative project with the NSW Ambulance Research Institute who already have an interest and foundation in the health outcome of patients requesting EMS through the NSW Ambulance Service. Further, the benefits of ACN might also be assessed for reducing injury severity in NSW as well as fatalities.

7 Interviews with representatives involved with post-crash response in NSW

Several interviews were conducted with representatives from accredited rescue organisations in NSW coordinated through the State Rescue Board. Interviews were conducted over the telephone according to the framework shown in Appendix A. The discussions were wide ranging covering topics on organisational roles, post-crash crash response, management and monitoring, national and international comparisons, technological solutions and co-ordination with other agencies. The following section aggregates these discussions into broad themes relevant to the study.

Organisations interviewed included the NSW Volunteer Rescue Association, NSW Police Rescue and Bomb Disposal Unit, the NSW State Emergency Service and Fire and Rescue NSW. A representative from NSW Ambulance also was also interviewed with respect to emergency medical response.

7.1 Opinions on post-crash response

Question: *What works well and what doesn't*

Some of the emergency organisations, particularly the volunteer based services indicated that rescue teams worked very well together. There was also a strong commitment to training (some have weekly sessions), maintaining rescue certification, maintaining skill levels and maintaining first-aid currency. This was considered essential for integrity of ability and capability, and a requirement by the State Rescue Policy.

Most of the emergency organisations were confident in the quality of their rescue equipment and considered it state of the art. The Australasian Road Rescue Organisation (ARRO) was often cited as a being a valued resource because it enabled a transfer of information from vehicle manufacturers to rescue agencies. Some organisations were involved in advanced training and cross-training. For example, the NSW Police cross train with NSW Ambulance who provide first aid training. NSW Ambulance (Paramedic) as a component of training undergo a simulation of a patient sitting in a damaged (crashed) vehicle or a scene with multiple patients. Assessment is made on how participants approach the scene in terms of site safety, reporting, patient management and extrication.

Several agencies indicated that communication systems worked well and most worked from linked Computer Aided Dispatch systems, although the system was more effective for those agencies that were directly linked to the system. Other agencies had different mechanisms for communication such as a reliance on dedicated phone calls but newer systems of communications were being phased in. One organisation indicated that in the past, organisations could communicate directly with police operators but this has now ceased due to the new police radio network.

Other issues that were highlighted include: the duplication of rescue service capabilities at crash scenes, the time rural volunteers are sometimes tied up at a crash site when police investigations are necessary and the consideration of Work Health and Safety (WHS) in the rescue context.

Question: *Additional capacity for post-crash response in NSW*

Most of the emergency agencies did not think additional capacity was required for post-crash response in NSW due to the structure provided by the primary and secondary response arrangements of the SRB. However, it was acknowledged that some agencies (particularly volunteer organisations) have an ageing rescue operator population and the younger rescue operators might be less likely to remain in country areas or volunteer based.

Some agencies believed there were gaps and thought there should be more inter-agency co-operation. There was also some discussion relating to higher level functioning and an idea within the SRB Policy Advisory Committee to define levels of response, such as Level 1 Crash Rescue and Level 2 General Land rescue, where for the latter, a higher level of competency would be required. This would allow agencies in certain locations to consider undertaking only a lower level accreditation, for example a Level 1 accreditation (for road crash rescue) so that additional resource capacity might become available in certain areas of NSW where it might be lacking.

Question: *What could improve post-crash response?*

Most agencies mentioned that improvement in traffic flow would assist in improved response times to incidents. A couple of representatives suggested that it might be beneficial to encourage more of the population to utilise more public transport in order to reduce congestion. A few mechanisms were already in place that allowed some agencies to activate green signals in certain areas of the road network. NSW Ambulance use motorcycle paramedics to overcome some traffic flow issues but these were not widespread. Issues with traffic flow were also highlighted when discussing coordination of resources. Some agencies when tasked for an emergency response by road were unable to provide estimated times of arrival to incidents due to traffic conditions and this may affect resource coordination and liaison.

A few agencies also mentioned that due to the role of NSW Ambulance in health overall and the high volume of taskings, improvements to the health system that shortened hospital waiting times for ambulances or efficiency improvements that freed up Ambulance medical resources could improve medical response to crashes.

Question: *The need for further research in the area of post-crash response?*

The responses varied considerably for this question. A few organisations believed further research was not required because training practices were sufficiently in-depth and subject to review. There was mention of research into a country NSW service delivery model examining 20m/40m/60m response. One organisation also indicated that it might be worth exploring relationships with the NRMA and NSW Crash Lab for knowledge transfer activities.

Some agencies thought further research was required, in particular, a better understanding of issues relating to post-crash response performance and factors that influenced response times. This acknowledged that beyond distances, response times could also be influenced by weather and the correct reporting of locations by the person making the emergency call.

When making interstate comparisons, one organisation queried why there should be so many emergency organisations in NSW and suggested that research examining rescue performance and post-crash response between jurisdictions would be beneficial.

Further research comparing the benefits of 'rapid extrication' and minimising on-scene time ('scoop and run' medical retrieval) compared to spending more time with a patient ('stay and play') to ensure a positive outcome for a patient, particularly when time to definitive care might be some time away, was also considered important.

7.2 Management and Monitoring

Question topic: *Performance monitoring*

In terms of operator rescue performance, a number of organisations indicated that there are clear requirements within the State Rescue policy regarding training, currency of skill and maintenance of accreditation. Therefore, specific auditing of individual performance was not seen as necessary per se but only in the context of SRB Policy requirements.

Most of the agencies stated that performance reviews of a rescue crew were only undertaken if an issue arose during a rescue. If there were issues with equipment or an issue with extrication with new vehicle types it would be reported and a review would be undertaken. An example was provided when the new Prius was released and rescue operators worked directly with Toyota on the issue.

In terms of specific record keeping, the linking of certain emergency services communication centres (Fire, Police and Ambulance) enables recording of much time-coded data such as emergency call times, unit notification times, dispatch times, scene arrival times, at-scene times and call-off times. Some organisations record additional time variables and some record less. Particular agencies are required to respond to particular indicators, as published in the Productivity Commission reports on Government Services. These are not necessarily specific to post-crash response but rather apply to emergency response in general.

Most agencies involved in the broad area of rescue do record specific tasks and functions performed and type of rescue performed on a monthly basis, as an indication of resource usage for internal purposes. However, only standard data required by the SRB and for individual agency annual reporting are routinely collected and reported. Data is also supplied on an annual basis for the Productivity Commission reports (as described in an earlier section of this report).

NSW Ambulance monitor a number of indicators under the health system, particularly relating to transport and destinations (e.g. Road transport direct to trauma service, aeromedical notifications), on-scene times (for example those exceeding 20 minutes) and other data for internal KPIs. Additionally, for NSW Ambulance paramedic response, some major trauma cases that are highlighted by road paramedics or supervisors are internally reviewed. This is to ensure everything was correctly undertaken with regards to patient treatment. In some cases trauma services might review reasons for extended at-scene times. All cases involving cardiac arrest are reviewed in a clinical review. Limited resourcing meant the ideal situation of reviewing all cases was not possible, hence prioritising of cases for review is necessary. As part of the general health data collection, all major trauma cases are de-identified and entered in the NSW State Trauma Registry.

Generally, additional monitoring was not considered necessary by most of the agencies, however it was not clear whether or not the post-crash response data recorded response times was monitored by individual agencies to determine whether there were issues that may affect response capabilities, particularly given some agencies were volunteers and "on-call" and some were 24/7 operators. Note that the State Rescue Policy refers to response time very generally: in Para 1.13: "Rescue units are to respond within accreditation limits, to any perceived or actual rescue incident in a timely and safe

manner." Para 2.08: "Land rescue units are to respond to any perceived or actual rescue incident in a timely and safe manner. " and Para 2.12: "The guiding principle is that the appropriate accredited rescue unit, with the shortest response time to the incident scene is to be responded." This may be something that needs to be evaluated further in the future.

The Ambulance Service did indicate that there was no feedback between the pre-hospital treatment they provide to road crash patients and the resulting patient outcome, unless an issue arose whereby treatment was scrutinised. It was felt that if such a data link existed, it was possible that this might highlight areas of improvement or potential deficiencies in pre-hospital treatment. The lack of feedback on patient outcome after a rescue was also highlighted by one of the rescue organisations.

7.3 Comparisons

Question topic: *National comparisons to post-crash response.*

One organisation had previously suggested that research examining rescue performance and post-crash response between jurisdictions would be beneficial. However, it was also indicated that the structure of agencies in different jurisdictions were not necessarily similar in nature so direct comparisons might be difficult. NSW Fire and Rescue considered Queensland Fire and Emergency Services most similar in structure but a direct comparison has not been made. Another difference between rescue functions is that country fire services provide rescue services in a number of jurisdictions but the Rural Fires Service NSW are not involved in rescue.

A number of agencies highlighted the Australasian Road Rescue Organisation (ARRO) organised agency team challenges and this may be one method of comparison of skills and techniques. One organisation was involved with knowledge transfer activities on management techniques with Victoria and on certain competencies with Queensland.

Regarding medical response, it was indicated that NSW Ambulance was generally well set-up in system response, identification, and individual management of patients and equipment and this was assumed to be similar to other jurisdictions.

Question topic: *International comparisons to post-crash response.*

Some agencies had no links to international agencies regarding post-crash response and could not indicate how they might compare to international post-crash response. Fire and Rescue NSW highlighted that they are one of two agencies in Australia (along with Queensland Fire and Emergency Services) that have United Nations international accreditation as a heavy rescue task force that can be deployed to any major disaster in the world. This recognition indicates that they are also well ranked internationally.

ARRO was discussed again as an organisation that taps into a global network of international rescue. This engagement assists with technical information and participation in international competitions. Some organisations have individuals that are considered world class based on these competitions. The NSW Police Force indicated that there were exchanges with police in New York and perhaps the biggest differences were issues relating to WHS where Australia was perceived as being more safety conscious.

Consistent with the Anglo-American approach, NSW Ambulance generally attempted to minimise time on scene and deliver to a major trauma service, although in some situations extended at-scene time was sometimes necessary for positive patient outcome.

7.4 Potential for Technological Solutions

Question: *What potential is there for technology to assist?*

Some of the technological solutions that were highlighted in assisting post-crash response included systems that enabled green corridor runs to improve rescue response times. Some agencies highlighted technological improvements assisting with actual rescue, such as electronic cutters that eliminated the need for carrying heavy hydraulic pumps and technologies that assisted with glass management.

Most of the organisations involved in rescue supported the idea of technology that automatically detected incidents and notified agencies near particular infrastructure, such as in tunnels to shorten notification and response delays however there was some cynicism about the effectiveness of such systems when there was traffic congestion preventing effective response.

One organisation indicated they had watching briefs for various technologies overseas. There was considerable support for Automatic Crash Notification systems for vehicles. It was considered potentially a very useful technology for providing good location details and identifying crashes that might have time-critical injuries. One organisation highlighted that some search and rescue tasks for missing persons (which can utilise a lot of resources) were actually road crashes. Had the crash been identified early through an ACN system, the search component could have been avoided. Another organisation indicated that they have previously come across crashes that had occurred many hours before, presumably something that could have been identified much earlier through an ACN system.

A number of agencies were interested in an evidence-based approach to the deployment of ACN. Concerns were raised regarding who would monitor the ACN systems and how minor crashes that required no response would be filtered from those that did require a response.

7.5 Coordination

Question: *What interactions exist with other rescue organisations?*

A number of the agencies indicated there was generally good coordination and a professional working relationship between all agencies responding to a road crash rescue. Some issues were raised regarding working relationships between various agencies but this was more of a historical issue and now all of the five rescue agencies were formally arranged for rescue through the VKG and NSW Police under the structure of SERM Act (and State Rescue Policy).

Generally all rescue agencies had a good working relationship with NSW Ambulance (as providers of medical assistance). Some agencies indicated there was a good working relationship with Police at scene particularly when rescue operators were known to police. Otherwise, there is a formal procedure where the rescue operator Captain liaises with Senior Police on–scene as part of the rescue process. An issue was highlighted where some agencies can provide dual roles at road crashes e.g. NSW Fire and Rescue can provide both Fire and Rescue capabilities, some Ambulance NSW can provide rescue and EMS response and Police can coordinate and can provide rescue and coordination but were required to act only in the task formally approved.

Interactions between other agencies also included ground level rescue operators and regional coordinators, as well as management committees and policy advisory committees and various working groups but these were not discussed in detail. NSW Fire and Rescue indicated their communications centre and CAD system was linked with other agencies including airports, major infrastructure and state rail and all incidents are flagged within their system. NSW Police explained that they undertake

cross training and coordinate with NSW Ambulance. Some agencies indicated that there was decreasing coordination in some areas, such as the police radio network being closed to most organisations.

Controlling and coordination of rescue activities is the responsibility of the senior police officer on site, even if he is not part of the accredited rescue unit or not part of the rescue. The responsibility for coordinating additional medical (air or road) resources is dependent on assessment by the initial paramedic road crew.

7.6 Can Transport for NSW do anything to improve post-crash response?

Personal opinion from one of the representatives was that the traffic system in the CBD was poor and due to this, response to incidents could be delayed. Therefore anything that could be done to improve this is seen as extremely beneficial. Another organisation indicated administration of driver reviver programs and other road safety initiatives might be of benefit but that there was generally not much scope to assist. From a volunteer perspective, the lowering of speed limits on rural roads was also identified as increasing response times.

One organisation indicated that facilitating opportunities to test, train and prepare for road crash rescue with various new transport infrastructure such as tunnels would be beneficial.

Question: *What would be suitable for inclusion in a holistic road safety strategy document?*

Few organisations commented on this, however one expressed a firm view that "*the key underpinning principles in any road safety strategy should be about patient / casualty care*".

8 Conclusions

Post-crash response is rarely included in road safety strategies possibly due to it often being seen as falling outside the responsibility of most leading transport agencies. Australian exceptions are the current NSW and SA road safety strategies, both of which include emergency response as actionable areas.

This project has provided a comprehensive overview of post-crash emergency medical and rescue response arrangements in NSW. It is evident from the literature that the topic is complex and meaningful comparisons both between countries and within countries were difficult to achieve. This is in part due to the differing arrangements in place regarding medical and rescue response, but also due to the range, reliability and definition of data collected. However, some indication of emergency response was possible and the European SafetyNet and Australian Productivity Commission information have been used extensively in this review.

Two underpinning medical response philosophies exist, corresponding to the Anglo-American “scoop and run” approach and the Franco-German “stay and stabilise” emphasis. Australia and NSW are more closely aligned with the former and this is reflected in the rescue arrangements that have been adopted. It is also interesting that the concept of the “Golden Hour” has little empirical basis, although much research supports the notion of minimising response times for improved outcomes.

Contact with rescue organisations in NSW yielded a detailed operational overview of emergency response arrangements. Consideration of how an organisation like Transport for NSW could assist with improving post-crash response proved more challenging and there was limited insight among interviewees as to what additional initiatives could be pursued. Topics around traffic management and congestion arose and there was an appetite for evidence-based adoption of ACN. There was acceptance by some that interstate comparisons, and research with the monitoring data could be useful, especially in relation to understanding factors that affect response times.

The review has identified that there is potential for further research. For example, within many of the emergency services organisations a significant amount of data is routinely collected, particularly relating to post-crash response. However, analysis of such data as a performance monitor and indicator or for comparison purposes is difficult. This may be due to issues relating to resources for collecting, collating and analysis, data consistency (across agencies) and data access for external organisations. On a national level the Productivity Commission (2012) has previously presented a road crash rescue frame-work for performance effectiveness particularly for response time and on-scene management but as of yet this has not been collected or not yet been developed for reporting purposes (Productivity Commission, 2012). There may be also a case for an emergency medical response performance frame-work for road crashes or perhaps as a minimum, the collection and reporting of data specifically relating to road crashes. Limitations associated with the trauma and emergency services databases could also be investigated further and it may be appropriate that identifying regions for enhanced data collection may provide sufficient data for further analysis of post-crash response factors.

There was an indication that the rescue organisations would agree with research that looked into specific topics such as performance comparisons between agencies on a State, National and International level. Additionally, the rescue organisations also supported an evidence based approach to deployment of technologies that might reduce response times to road crashes.

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Appendix A

Information circulated to representatives of NSW rescue organisations for indepth interviews

Background

It is self-evident that the capabilities of emergency medical and rescue operations when responding to road crashes are critical in reducing a country's deaths and injuries on the road. Under the WHO's Global Plan for the Decade of Action for Road Safety 2011-2020, post-crash response is named as a pillar for inclusion in national road safety strategies. Despite its place in the Global Plan, within Australia emergency service response effectiveness does not feature in the National Road Safety Strategy 2011-2020, or in the current road safety strategies of all states and territories with the exception of NSW and SA. Road safety is commonly seen as belonging to the portfolio responsibilities of Ministers of Transport and/or Road Safety, whereas the post-crash phase is often considered to be under the control of Ministers of Emergency Services or Health. There is a need for further research and investigation to see if there is benefit in approaching post-crash response from a more holistic perspective between organisations that deal with trauma from the road system.

The New South Wales Road Safety Strategy 2012-21 discusses issues surrounding post-crash response and identifies two key action focuses, firstly better coordination across emergency retrieval and medical services and the Motor Accidents Authority, and secondly technological improvements, particularly automatic crash notification (ACN) systems and collision detection and avoidance systems. This current research project was commissioned by Transport for NSW (TfNSW) to produce a comprehensive account of current post-crash emergency medical and rescue response arrangements. Work to date has involved discussions with some emergency response organisations, an extensive literature review and a comparison of NSW with other Australian states and territories and with leading road safety nations in the OECD based on available performance data. The study has maintained a focus on emergency response rather than the quality and type of medical care and rehabilitation

Interview Guide Sheet

Questions are a guide only. They should provide the basis for an exploratory discussion with key managers in organisations associated with post-crash response in NSW. The target interview duration should be approximately 1 hour.

Identify the purpose of the interview and clarify how the results will be used

Name the other organisations that will be interviewed

Number	Question
	Organisation Information and Background Context
	Obtain name, position and contact details
	Clarify role of the position
1	Can you please outline how your organisation is involved in the post-crash response to motor vehicle crashes?
2	In your role, to what extent do you consider emergency response to road crashes as distinct from all other emergency response activities?
3	What do you estimate is the proportion of time and resources taken up by post-crash response in your organisation (explore number of responses, training, equipment and capability)?
	Opinions on Post-crash response
4	What currently works well with post-crash arrangements in your organisation? What do you think are the reasons why this works well?
5	What currently does not work well with post-crash arrangements in your organisation? What do you think are the reasons why this does not works well?
6	Where do you think that additional capacity is required in the area of post-crash response in NSW?

7	What to your knowledge could improve post-crash response? Explore in relation to what “improve” means: • Faster response times • Better equipment • Advanced staff training • Better traffic management at incidents • Better traffic management to and from incidents
8	Do you think that there is a need for further research in the area of post-crash response?
	Management and Monitoring
9	To what extent are you able to monitor the post-crash response performance of your organisation? How accurate to you believe this monitoring is
10	What additional things would you like to monitor if you could?
11	Are you confident you can gauge the post-crash capacity and response for your specific area / region / state
12	Which of the following variables would you have an interest in: • The number of EMS stations per area • The number of EMS transportation units per road length • The number of EMS transportation units per citizen • Percentage of physicians and paramedics out of the total EMS staff • Percentage of highly-equipped transportation units out of the total • The demand for response time • Average response time of EMS • Percentage of EMS responses meeting the demand.
	Comparisons
13	Are you aware of any practices interstate that may be better than NSW in relation to post-crash response?
14	Are you aware of any practices internationally that may be better than NSW in relation to post-crash response?
15	Do you have any concept of how your organisation performs when compared to similar organisations nationally?
16	Do you have any concept of how your organisation performs when compared to similar organisations internationally?

	Technological Solutions
17	Are you aware of any technological solutions that may enhance post-crash response? Notification: Infrastructure based, Vehicle based, Person based (eg automatic crash notification, freeway management systems, call location identification, remote patient monitoring devices, video link ups etc)
18	Do you regard the effectiveness any of these to be supported by sound evidence?
19	Would you like to see the adoption of any of these in NSW?
	Coordination
20	What interactions do you have with other agencies (if any)?
21	Are there any formal procedures in place for coordination with other agencies?
22	Do you think there is a case for more coordination between agencies in relation to post-crash response? Can you provide any examples?
23	Do you think that there is a case for improved coordination across emergency retrieval and medical services?
24	Given that Departments of Transport tend to be the lead agency for road safety coordination and enforcement, do you think that there is anything further those departments can do in the area of post-crash response?
25	What would you consider to be suitable for inclusion in a holistic road safety strategy document (if anything)?
26	Did you have any additional comments that you would like to add?