Post-impact care: How can New Zealand address the fifth pillar of road safety?

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An important note for the reader

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Executive summary

Post-crash response has been promoted by the World Health Organisation and United Nations as one of the five pillars of the *Global plan for the decade of action for road safety 2011–2020* and picked up in road safety circles as the fifth pillar of the Safe System approach to road safety. This has been confirmed in New Zealand by statistics from this study which show that improved post-crash care may have affected the outcome in 11% of a sample of fatal crashes investigated by the coroner.

Previous policy documents on post-crash trauma have discussed the total contribution that all partners can provide for improving its delivery. The health sector has its own established and evolving procedures to deal with trauma victims once they come under its care. This project sought to codify what the transport sector can do now and in the future (in partnership with the health and emergency services sectors) to improve its delivery. This project was aimed specifically at the role of the government land transport sector, both local and central, in improving outcomes of crash victims by facilitating their journey from the crash site to the hospital door. The project's methodology included:

- a comprehensive review of existing knowledge including technological developments
- a targeted online survey of frontline emergency workers from St Johns, Fire and Emergency NZ, Road Policing and a workshop of stakeholders and emergency services managers, to capture expert knowledge and perspectives on existing practices and directions for the future
- an analysis of a sample of fatal crashes to gain knowledge of how outcomes might have been improved by actions of members of the transport sector
- discussion of the accessibility of crashes to hospital via the emergency services
- an integration of these strands of information to produce a report that provides well-informed, practical recommendations for the transport sector partners.

The review of existing knowledge classified the work into the following broad categories.

Timely, accurate notification of crashes

How to detect and characterise the problem, notify and dispatch help?

Time to crash identification; ability to notify (network coverage/technology); information accuracy (location, severity, patient access issues)

Fast, safe travel to and from the crash site

How to assist in swift, safe road and air travel of emergency services and extraction of casualties?

Time to crash identification; ability to notify (network coverage/technology); information accuracy (location, severity, patient access issues)

Working together

What strategies, planning, research and communications activities might support post-crash care?

Post-crash care in road safety strategies and plans; coordination between organisations (policy alignment/data sharing); communications (tools/equipment/internal processes); training/education (agency/public)

The review and the statistical analysis were inputs to the design of the workshop and the online survey.

Of the 79 fatal crashes investigated, post-crash response-related factors may have impacted on the outcome of nine crashes. Of these nine crashes, eight had timeliness of response as a factor and for three, access to the crash site may have affected the outcome. Most crashes occurred in rural areas, and many far from hospitals. For three of the nine crashes, no one was able to call 111 making medical attention unavailable.

The accessibility analysis confirmed that ambulances are generally slower to reach rural crashes than urban crashes. Figures from the New Zealand Major Trauma Network showed that, including road trauma, 55% of trauma patients reach their first hospital in one hour and 85% in two hours. Further delay occurs if transfer to another hospital is needed. It is thus important to avoid delays related to congestion.

Overall, all three categories from the review of existing knowledge were consistently rated as important by both the stakeholder/manager group and the front-line staff. The two groups also agreed that timely, accurate information was the key area on which to focus improvements. Both groups placed high value on cross-agency working together (including communications and data sharing).

Between group differences revealed that the front-line staff placed higher value on efficient, safe travel. They also ranked inter-agency training for responders highly. The stakeholder/manager group valued post-crash care being embedded in road safety strategies and action plans, as well as improvements around travel and crash site information needs. Their workshop involved in-depth interactions and knowledge sharing, including from international best practice, which may explain these differences.

These are perceptions by experts ranking supplied options which were all generally considered important. Consequently, being relatively lowly ranked does not mean lack of importance.

Finally, the following recommendations were submitted for consideration by the NZ Transport Agency (the Transport Agency) and its partners. They have been selected as capable, if agreed, of implementation at reasonable cost.

1 Road safety strategies and action plans

That the road safety transport sector, through the National Road Safety Committee:

- Consider including post-impact care in future road safety strategies as a fifth pillar of the Safe System approach to road safety.
- Consider how post-impact care, as the fifth pillar of the Safe System approach to road safety, should be dealt with in the upcoming New Zealand Road Safety Strategy. This would include consideration of how action plans should be provided beneath the strategy for joint action with emergency services partners and integrated with the operational planning of the Transport Agency and Road Policing.
- Note that at present post-crash care is considered as an informal adjunct to other work. If progress is to be made it must feature formally in the planning documents of the appropriate authorities and allocated time in the work programmes of appropriate staff.

2 Working together

- The Transport Agency and Road Policing together explore opportunities to set up permanent regular channels of communication with Ambulance Services and Fire and Emergency New Zealand. This would be done in consultation with the Ministry of Health and ACC and road controlling authority (RCA) representatives. There would need to be expeditious means for joint decisions to be implemented and funded. It is important that front-line staff are involved in these interactions. Under this, the areas of importance previously mentioned could be considered. These would include the following practical issues which appear capable of being dealt with at reasonable cost.

- Training of Road Policing and RCA staff in dealing with post-crash situations including chains of command at crash sites.
- Smoothness of communication is crucial between the agencies in the event of a crash. The quality of this communication can have a dramatic impact on the time between crash and presentation of the victim at hospital
- Traffic management at crash sites and on routes to and from crash sites
- Provision of road infrastructure which as part of its design supports emergency services to carry out their work as efficiently and effectively as possible.
- Automatic crash notification devices are beginning to appear on vehicles in the New Zealand market. It is timely to discuss how best to deal with the notifications they provide and in what form to encourage their inclusion in New Zealand market vehicles, as well as the place of smart phone-related applications in this mix.
- How the landing requirements of helicopters can best be satisfied.
- To what extent post-impact care (as a bystander) can be improved and by what mechanisms.
- Coordinated communications systems - that the Transport Agency explore with Road Policing and Emergency Services partners future possibilities around shared communications channels between agencies for crash dispatch and between responders for better coordination focused on the event.

3 Cellular networks and digital radio networks.

That the Transport Agency consider:

- Exploring with the Ministry of Business, Innovation and Employment and the rural broad band initiative the notion of including a targeting to risk component to the rollout of cellular networks along highways. This is at present targeted only to tourist numbers and traffic volumes.
- Providing information to the public regarding where on the State Highway Network cellular networks exist. If this information is not available from network providers the technology exists to scan the network for cellular networks at the same time as other network scans (such as those for Kiwi Rap are carried out). A star rating similar to KiwiRAP could be considered. This would allow road users, where there is a choice, to choose a route where rescue was more probable in the event of a crash.
- Proactively joining with its partners to assist in planning for the inevitable rollout of cellular technologies with enhanced capabilities to improve crash notification.
- Discussing with operators interconnectivity of cellular networks and digital radio networks and the access of radio networks to 111 call centre operators.

4 Crash information

Existing data on the timeliness and effectiveness of the post-crash response is lacking, despite the Transport Agency's previous efforts to improve this situation. It is recommended that the Transport Agency consider:

- Reminding coroners of the agency's interest in and usage of coronial findings, particularly as they relate to post-crash response.
- Reinforcing their interest in the post-crash response and victims' injuries to the Police officers responsible for completing traffic crash reports.

- Investigating data sharing between the Transport Agency and Ministry of Health (particularly the Emergency Ambulance Services) so that the outcomes of non-fatal road crashes can be better investigated, including the quality of the post-crash response.

5 Emergency vehicle prioritisation

- That the Transport Agency consider, in consultation with RCAs and emergency services, whether there is a need to make more explicit provision in the Road User Rule (2004) for the use of emergency vehicle priority measures. Such a need would be predicated on the existence of locations where such measures would make a worthwhile improvement in emergency vehicle operations. This may require some trialling. If such a need was established the pertinent rules and the *Manual of traffic control devices* may require some amendments.

6 Inclusion of innovative emerging vehicle-related systems to facilitate rescue in the Australasian New Car Assessment Program (ANCAP)

- That the Transport Agency discuss with ANCAP how crash notification systems and the availability of digital vehicle data sheets might be included in ANCAP’s star rating system for vehicle safety.

7 Electric vehicle post-crash electric shock risk

There is a risk of post-crash electric shock associated with electric vehicles. Japanese NCAP tests electric vehicles for this risk. It is recommended the Transport Agency discuss with ANCAP the possibility of including similar tests into ANCAP testing and discusses with emergency service partners methods to minimise electric shock risk to crash responders.

Abstract

Post-crash care of victims is considered by the World Health Organisation to be the fifth pillar of the safe system approach to road safety. Timeliness and quality of transport of crash victims from the crash site to hospital door is crucial to medical outcomes. It is important that road controlling authorities (RCAs) and Road Policing work together with Emergency Services to provide the best possible outcomes for the available resources.

This report considers the roles of RCAs and Road Policing in facilitating transport of crash victims from the crash site to the hospital door. The report includes a literature and technology review, a crash analysis and estimates of the time from crash notification to hospital. Also considered are issues arising from a workshop of stakeholders and an online survey of front-line staff from Road Policing, St John and Fire and Emergency New Zealand.

Recommendations for future strategies and actions relate to the place of post-crash care in road safety planning, crash location technology, agencies working together, the need for mobile networks, effective communications and traffic management including crash site management and emergency vehicle priority schemes. Recommendations are also made regarding information available in crash reports on post-crash care.

1 Introduction

The post-crash care of victims has long been a key component of road safety initiatives, as after-crash trauma care can impact significantly on the severity of injury outcomes. This has been confirmed in New Zealand by statistics from this study which show that improved post-crash care may have affected the outcome in 11% of a sample of fatal crashes investigated by a coroner (see chapter 3). The speed at which victims can be transported to trauma centres is a crucial part of that care (Vanderschuren and McKune 2015). Since the 1990s, however, post-trauma care has been de-emphasised in road safety strategies, which have concentrated predominantly on preventing crashes and reducing crash trauma by safer vehicles, safer roads and safer human behaviour (rather than also improving the chances of survival of victims after a crash). This may be connected to the conservative (0.9%) estimate of its impact on road trauma made in the discussion document (National Road Safety Committee 2000) leading up to New Zealand's *Road safety to 2010*.

Since then post-crash response has been promoted by the World Health Organisation (WHO) and United Nations (UN) as one of the five pillars of the *Global plan for the decade of action for road safety 2011–2020* (WHO and UN nd) and in road safety circles as the fifth pillar of the safe system approach to road safety. Previous policy documents on post-crash trauma have also been of a holistic nature, discussing the total contribution that all partners can provide for improving the delivery of post-crash response. The health sector has its own established and evolving procedures to deal with trauma victims once they reach its care, whether that be via an ambulance, a rescue helicopter or more informal means.

This project focused on the role of the transport sector in improving outcomes of crash victims by facilitating their journey from the crash site to the hospital door. Though the transport sector does not have the background or expertise to influence these outcomes directly, it can be an active partner in initiatives that aim to improve the ability of paramedics and emergency services to reach crashes quickly, extract injured occupants, apply first aid procedures and provide transport to a hospital in time for trauma care to be applied effectively. It can also provide the most forgiving road environment possible to reduce the burden on overworked emergency services.

The research sought to codify what the transport sector can do now and in the future (in partnership with the health and emergency services sectors) to improve its delivery. For the purposes of this project the 'transport sector' means the central government transport sector (Ministry of Transport and the NZ Transport Agency (the Transport Agency), road controlling authorities (RCAs – NZ Transport Agency for state highways and territorial local authorities) the council-owned entity Auckland Transport and Road Policing. It also includes the network contractors of RCAs.

This report of the research includes:

- a comprehensive review of existing knowledge including technological developments
- a targeted online survey of frontline emergency workers from St John New Zealand (St John), Fire and Emergency (FENZ) and Road Policing and a workshop of stakeholders and emergency services managers. These initiatives are to capture expert knowledge and perspectives regarding the strengths and weaknesses of existing practices
- an analysis of a sample of fatal and serious crashes to gain knowledge of how outcomes may have been improved by actions of members of the transport sector
- discussion of the accessibility of crash victims to hospital via the emergency services
- an integration of these strands of information to produce a report that provides well-informed, practical recommendations.

2 Existing knowledge review

2.1 Introduction

2.1.1 Scope

This review considers the time between the event of a road crash and the arrival of a casualty at the door of the hospital or other medical treatment centre. It focuses on facilitation of rescue from road crashes in ways of interest to RCAs, such as the Transport Agency and other transport sector agencies. In considering post-crash care and related transport initiatives, medical technology is outside of scope, while transport and communications technology to facilitate the journey to hospital are in scope, as are the ways the emergency response teams and agencies work together.

2.1.2 Post-crash, pre-hospital care

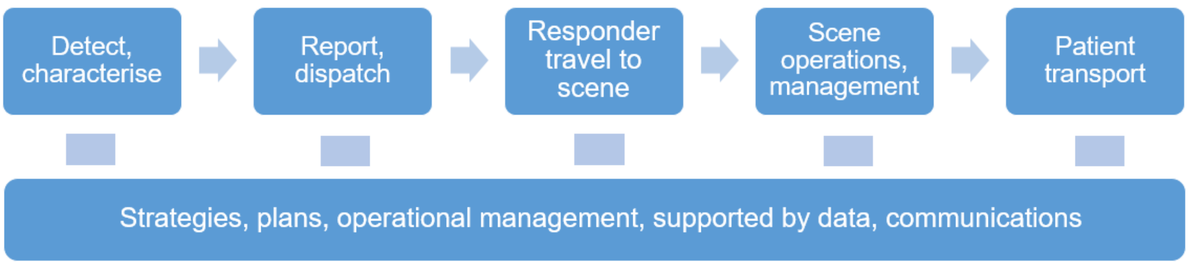
Post-impact care encompasses procedures to reduce the severity of injury consequences once a road traffic crash has happened. It is the chain of opportunities to help that begins with actions taken by the victims or bystanders, and includes emergency rescue, access to pre-hospital medical care, hospital care and helping victims to rehabilitate. It encompasses legal support and legislation, research and information, emergency responder training and equipment, injury care and mental health care (International Transport Forum and OECD 2016; SafetyNet 2009; WHO 2016).

Post-crash response is one of the five pillars of the *Global plan for the decade of action for road safety 2011–2020* (WHO and UN nd) The aim is to increase responsiveness to post-crash emergencies and improve the ability of systems to provide appropriate treatment for crash victims.

The plan identifies seven areas for focus: pre-hospital care systems (such as a single national emergency access number); hospital trauma care systems (such as designated trauma care centres); rehabilitation and support; road user insurance schemes to finance rehabilitation services; crash investigation and legal response; employment for people with disabilities; and research and development into improving post-crash response (such as training). Collection and analysis of data is critical for improving aspects of how the post-crash phase is handled, such as injury surveillance systems, trauma registries and quality improvement programmes (International Transport Forum and OECD 2016)

This review considers post-crash, pre-hospital response. This is a set of activities including emergency rescue, pre-hospital care and transport, which end when the patient is delivered to a medical facility (Wall 2013). Key and often integrated steps are detection, reporting, response of emergency systems, on-scene care (first aid, medical treatment, securing the crash site), care in transit (transportation and medical treatment to enable transport), transfer to definitive care and psychological support of victims. Functional steps for care after a crash are shown in figure 2.1.

Figure 2.1 Functional steps in response to a motor vehicle crash (from Flanigan et al 2010)



The SafetyNet report (2009) on post-impact care summarised its components:

- The role of the bystander in contacting emergency services, providing first aid and scene management (though with no strong evidence that first aid training or first aid kits in cars decrease pre-hospital mortality)
- Access to the emergency medical system – telephone notification; in-vehicle emergency notification systems; answering by emergency services (a variety of models exist but have not been studied); and emergency medical dispatch to prioritise speed and type of response and communicate with the scene and the receiving hospital (which requires a computer system, standard protocols, medical supervision, trained dispatchers and audit)
- Emergency rescue systems – coordination between emergency services to ensure fast care and transport; training of emergency personnel; and availability and response times of ambulances
- Aspects of pre-hospital medical care – triage protocols including deciding which hospital to go to (based on type of injury, available services, distance and times to travel, and regulations); planning for coordination of care in multiple casualty crashes; and legislative frameworks which affect what agencies can do
- Data and information systems – documenting injury consequences, and monitoring and evaluating post-impact care.

2.1.3 Potential for improved outcomes

Swift access of injured patients to advanced hospital trauma care services can improve outcomes but there is no precise measure to which this can be tied, though a number of articles have documented connections of various degrees of precision in their own specific contexts. For example Lilley et al (2017) quote studies by Celso et al (2006), McKenzie et al (2006) and Peleg et al (2004) claiming 10% to 25% improvements in injury survival resulting from timely presentation of patients to advanced hospital service. Morales et al (2016) considered it possible that a 10-minute reduction in medical response time could be statistically associated with an average decrease in probability of death by one third.

The opinion of a Professor Ian Civil, the National Clinical Lead of New Zealand's Major Trauma National Clinical Network, as stated in a personal communication, is pertinent in the New Zealand context.

> *While common sense and such data as is available suggest more prompt presentation of patients to a capable healthcare facility will reduce mortality the direct quantitation of this is hard to determine. In reality, a combination of time and medical treatment affect outcome and the effect is individualised to the crash victim. In some patients the injury can be simply treated but time is critical, in others treatment is complicated and a longer route but one which gets to definitive care directly is more important. The proportion of patients in each of these categories would affect the result of a simple time/distance equation.*

Effective management of casualties following a road crash is a key determinant of both the chance of survival and quality of life after injury. The SafetyNet (2009) report cites a 2001 Swedish study of fatal road crashes which concluded that 48% had non-survivable injuries, but of those with survivable injuries, 5% were not located in time, 12% could have survived if transported more quickly to hospital, and 32% could have survived if transported quickly to an advanced trauma centre. A 2007 study by Hakkert et al for the SafetyNet project on road safety performance indicators concluded that 35% to 50% of cases where deaths had occurred hours or days after the event could be considered treatable, and therefore could be influenced by an improved trauma management system. A 2011 US study found 39% of 98 motor vehicle deaths were potentially preventable if optimal medical treatment had been immediately available (Ray et al 2016).

The importance of emergency response has also been indicated in differences in survival between crashes in rural and urban areas (International Transport Forum and OECD 2016). Lu and Davidson (2017) looked at fatal motor vehicle crashes in Texas. They found that although fatal crashes were more concentrated in urban areas, the fatality rate was higher in rural areas. The total pre-hospital time (time from occurrence to hospital arrival) and the component time segments (activation time, ambulance response time, hospital transport time) were longer in rural areas. Champion et al (2005) noted that, typically, rural areas in the USA had a higher preventable mortality rate than urban regions. This may be due to time elapsed from the emergency call to the arrival of the ambulance, time for the ambulance to reach the hospital, or insufficient experience or training with certain trauma procedures due to infrequent occurrence in rural areas.

Ponte et al (2016) found the majority of South Australian fatalities with notification delays occurred in rural areas (87%), and 67% of these rural fatalities involved a single vehicle. More than half the single vehicle rural fatalities (58%) occurred late at night or early in the morning when traffic densities were low. The delays in notification were due to the crash going unnoticed for a time. Tziotis (2006) noted that in Australia, and particularly in New Zealand, a high proportion of fatal road crashes occurred in rural and remote areas (roads that traverse an environment with little or no abutting roadside development). Among risk factors, they found that key influences on the severity of outcome of road crashes included emergency response and retrieval times and the level of rehabilitation services available. The report summarised international literature evidencing a noticeably slower emergency response following rural crashes, due to slower notification and longer time for emergency services to arrive, with subsequent impacts on crash outcomes.

Injury is a leading cause of premature death and health loss in New Zealand. A five year (2007–2011) estimate of prehospital injury deaths shows 1,496 in the motor vehicle traffic category out of 6,449 in total (Lilley et al 2017). A study of pre-hospital trauma deaths (Falconer 2010) in the Otago and Southland regions, 2000–2004, found 10% had survivable injuries, 35% potentially survivable injuries and 55% non-survivable injuries. The majority were young and male, and 70% were the result of a motor vehicle crash. These results were similar to comparable international studies and suggest scope for improving pre-hospital care.

2.2 International strategies and institutional arrangements

Responders work against a backdrop of strategy and policy decisions and legislative requirements, in the form of whole of government and individual departments and agencies, as well as community expectations (Cattermole et al 2015). Post-trauma care and related transport initiatives require strategic planning and action within and across institutions to succeed.

Although post-crash care is one of the five pillars of the *Global plan for the decade of action for road safety 2011–2010*, many of the actions seem aimed at achieving some basic measures across countries. Some organisations are focusing on other pillars of road safety. For example the World Road Association (PIARC) produced a road safety manual aligned with key pillars of the UN decade of action, which contributed to the work of three pillars, but not pillar five, post-crash response (Permanent International Association of Road Congresses nd)

The *Road safety annual report 2016* (OECD and International Transport Forum 2016) provided a snapshot of countries' varied approaches to post-crash response. Countries that mentioned post-crash measures as part of their national road safety strategies included Cambodia, Chile, Greece, Malaysia, Mexico and Nigeria. Chile was developing a strategy based on the five pillars, including a revision of national post-crash protocols. Lithuania and Japan had goals to improve rescue services. It is not clear to what extent such strategies and goals were accompanied by action plans and budgets. New Zealand and the USA noted post-crash response in the context of research and data collection. Portugal attributed its decrease in traffic casualties in part to post-impact care but without specific details.

Some countries focused on matters pertaining to medical response. Jamaica's actions were first aid training and education of road users on the importance of post-crash care. Nigeria implemented a toll-free emergency number and a nationwide emergency call centre, with more ambulances and ambulance points on major corridors. Morocco focused on modernising the ambulance fleet and training staff in emergency care. Mexico aimed for top quality emergency and hospital services and rehabilitation and prevention programmes. Spain implemented a Road Traffic Accident Victims Unit in 2013 to support traffic casualties and their relatives. The Netherlands was regionalising its trauma care and introducing mobile medical teams (OECD and International Transport Forum 2016).

A number of European countries were considering technical responses. These include eCall, a mobile network-based crash notification system which is discussed in depth in section 2.3.4 and digital rescue data sheets, which are discussed in section 2.5.3.

Wall (2013) surveyed the Australian scene, finding that, as in the majority of countries around the world, most Australian road safety agencies did not include post-crash response in their strategies and plans, and published little data on such activity. The Productivity Commission published an annual number of road rescues. The *National road safety strategy 2011–2020* (Australian Transport Council 2011) mentioned post-crash response in passing. While many state and territory road safety strategies and action plans showed an absence of activity for post-crash response, it was considered in South Australia. Also, *Towards zero – road safety strategy to reduce road trauma in Western Australia* (WA Office of Road Safety 2009) noted that the government would monitor new vehicle technologies and the community should take first aid courses. The *NSW road safety strategy 2012–2021* (Transport for New South Wales, 2012) had a section on post-crash response with these actions:

- Establish a whole-of-government approach to post-crash response that identifies areas for improvement.
- Investigate options for automatic collision notification (ACN) systems.
- Educate drivers about the added risks of crashes in remote areas.
- Provide clearer advice to road users on what to do if they crash, and on safety near incident sites.

The strategy also looked at better coordination between emergency retrieval and medical services and the Motor Accidents Authority (Wall 2013; Wall et al 2014).

Wall et al (2014) suggested that lack of consideration of post-crash response might be because it does not easily fit as part of the safe system approach underpinning such strategy documents. It might also be that the post-crash phase is often considered more the remit of Ministers of Emergency Services or Health rather than of Ministers of Transport or Road Safety. For example, in 1997–98, of 243 Victorian road crash victims with fatal outcomes, 77% of patients were found to have experienced pre-hospital errors or inadequacies, most related to management and system deficiencies. One of 24 pre-hospital deaths was considered preventable and two potentially preventable. This was addressed by a Ministerial Task Force on Trauma and Emergency Services, followed by the introduction of a new trauma care system in Victoria (McDermott et al 2005).

According to the European Transport Safety Council (nd), 'Emergency response has not been getting the fair share of attention in terms of research, best practice exchange and measures in the European Union'. The council's three-year REVIVE project from 2016 aims to map emergency medical service and rescue and fire service practices in the EU, improve post-crash care provided by these services, and raise its profile on the national and European political agendas. This includes establishment of an international network of experts, researchers and practitioners in post-collision care and emergency response. There will be round tables in Europe, publication of case studies outlining best practice examples, and publication of a video and a synthesis report with recommendations. This will build on some previous work, including a 1999 report from the European Transport Safety Council on evidence-based actions and the 2009 SafetyNet report on post-impact care co-financed by the European Commission. One area for action the EU is focusing on is eCall, which is further discussed below.

The European Transport Safety Council released a proposal on reducing road traffic injuries (2016), the annual socio-economic cost of which it estimated to be equivalent to around 2% of GDP. Key recommendations on post collision care (and on research) were:

- Develop effective emergency notification and collaboration between dispatch centres, fast transport of emergency responders, liaison between services on scene, treatment and stabilisation of the casualty, and prompt transport to an appropriate medical facility.
- Promote a ‘casualty centred’ methodology which ensures a multi-service, unified approach.
- Encourage collaboration between vehicle designers, manufacturers and the emergency services to maximise the effectiveness and safety of intervention.
- Measure the quality of trauma care and outcome via audit and follow-up of a sample of casualties over time, and analyse data to inform policy and practices.

Wall et al (2014) looked at how the effectiveness of post-crash emergency response could be measured and the performance indicators available. They found a lack of published data on the effectiveness of different post-crash response treatments and systems (compared with well-developed datasets on crash events, vehicles and road users). Few jurisdictions around the world had performance indicators for response to crashes. WHO (2013) in its *Global status report on road safety* asked countries for basic data on whether they had a system for accurate recording of deaths and circumstances; an emergency room-based injury surveillance system; emergency medicine training for doctors and nurses; and a standard telephone number for accessing emergency services. It also asked about percentages of casualties transported by ambulance and permanent disability due to road crashes. Wall et al (2014) compared Australian data with some other OECD countries using these indicators, but with no consistent methodology for post-crash data collection within Australia or in other countries, it was difficult to draw meaningful results. A variety of definitions, legislation and systems also makes international comparison difficult.

2.2.1 Survey on the role of road safety agencies and road controlling authorities

To gain further information than was publicly available in reports, an email survey of international experts and practitioners was conducted. They were asked about the role of road safety agencies and road controlling authorities in improving the care of casualties from crash site to hospital door in their agencies and countries. Questions covered:

1. The role of road safety agencies, RCAs, and their partners, the police, in post-crash trauma care
2. The administrative mechanism by which this role was carried out in each country
3. Ways in which post-crash trauma care featured in the strategies and policies of each agency
4. Active management of the journey from crash site to hospital.

The amount of information provided varied from source to source, and is shown in table 2.1 where a blank cell signifies a nil return. These sources give an indication of the variation in international approaches to post-impact care. For example, the Finnish Transport Safety Agency did not take a significant role in this, contrasting with the Austrian Ministry for Transport, Innovation and Technology which for the first time included a chapter on post-accident care in its Austrian Road Safety Programme 2011–2020 (BMVIT 2011). The programme had six areas of focus:

1. Creation of the necessary infrastructure to implement eCall (ACN)
2. Giving emergency services priority access on high-traffic roads and clearing roads rapidly after crashes to prevent secondary crashes
3. Improving emergency services response times with quality assurance, communications and training
4. Improving emergency services quality
5. Supporting rescue from vehicles with the introduction of rescue cards (rescue data is discussed in section 2.5.3)
6. Educating motorists in first aid.

Table 2.1 International approaches to the role of road safety agencies and road controlling authorities in post-crash care

Country	Role	Administrative mechanism	Strategies and policies	Journey management
South Australia (SA), Australia	Post-crash trauma care is primarily the role of the emergency services (eg ambulance, police). Road safety agencies/RCAs have an indirect role.		Not specifically	Priority access to emergency vehicles may be given by overriding traffic lights to ensure police and ambulance vehicles get a run of green lights. SA Police can close roads to enable an aircraft to use the road in response to an emergency (eg rescue helicopter). The Act also sets out speed limits for emergency service speed zones.
Western Australia (WA), Australia	The Road Safety Commission (RSC) coordinates effort across government to reduce road trauma. Its aim is to support the state government's road safety strategy 2008–2020, *Towards zero* (WA Office of Road Safety 2009) and achieve a 40% reduction in people killed or seriously injured in crashes on metropolitan and regional roads.	The Injury Control Council of WA is in the RSC alliances group to influence road safety strategy. Road Trauma Trust Account funding enables the Injury Control Council to run Road Trauma Support WA (www.rtswa.org.au) and provide post-crash trauma care (eg information, counselling).	There is not much mention of trauma support in Towards Zero 2008–2020 (no mention of post-crash care or time to treatment). The Road Safety Information Centre, a team within the RSC, has aggregated health data which shows emergency response times to road crashes in regional and remote WA. Further data may come from the state trauma registry project.	The RSC has been exploring vehicle beacon technology to improve emergency response times, particularly in regional and remote WA. It is looking at rest areas that can double as landing strips for the flying doctors.
Austria		Austria took part in the SUPREME project to publish European best practices in road safety including post-crash care (European Commission and Directorate General for Mobility and Transport 2010). They are organising, with the European Transport Safety Council, a round table on post-crash care in Central and Eastern European countries within the REVIVE project.	The *Austrian road safety programme 2011–2020* (BMVIT 2011) has a section on post-crash care measures.	

Country	Role	Administrative mechanism	Strategies and policies	Journey management
Czech Republic	Neither road safety agencies nor road administration authorities have any explicitly defined special role in this system.	The main operational bodies for rescue are the fire and rescue brigades supported by local fire brigades, the Medical Emergency Service and the Police. Help can be required from armed forces, civil defence, local police, various rescue services, non-profit bodies.	The support of various forms of post-trauma care is included in the 2017 version of the National Road Safety Strategy 2011–2020[1], guarantor of which is the Road Safety Agency. There are also some references to the fifth pillar of the UN Decade of Action.	
Finland	The Finnish Transport Safety Agency does not have a very big role in this, only to prevent secondary crashes by traffic and road management, and to start internal and governmental communication if there are two or more deaths.			
Netherlands	Road authorities have no specific role for trauma management. The Ministry of Transport has a responsibility for road safety. Rijkswaterstaat (a Directorate General within the Ministry of Transport) maintains the national Road Accident Register.	Post-crash trauma care is carried out by medical bodies (hospitals etc) and operates under the Ministry of Health.	The Ministry of Health has the obligation to prevent severe injuries from any cause and has (implicitly) a role in reducing casualties in road crashes and providing care for the injured. However, there is no mention of this class of casualties in the Ministry's long-term policies and strategies. In the *Road safety strategic plan 2008–2020* (Ministry of Transport, Public Works and Water Management 2009) crash prevention, severity reduction (by technological means like airbags and seatbelts) and	Emergency vehicles act under rules for use of lights, sound and traffic behaviour. They can pass a red light or use the rescue lane on highways under certain rules. Rescue helicopters can land almost every-where with some exceptions (close to high voltage power lines, pipes and tubes for transport of flammable or dangerous substances etc). Rescue helicopters (Mobile Medical Team) are operated by the ANWB (national automobile club), not a government body. High-volume roads (highways and motorways) have rescue lanes. If absent, lay-bys are interspersed along the route.

[1] Pers comm, Professor Peter Hollo, Institute for Transport Sciences Ltd, Hungary

Country	Role	Administrative mechanism	Strategies and policies	Journey management
			improvement of infrastructure are significant.	Rijkswaterstaat staff assist at crash scenes by fencing off the site, use of variable message signs for speed reductions and information etc. Crash Investigation Teams are run solely by police. If needed, they can close a road section.
USA	Coordination and oversight of emergency medical services (EMS) is by state EMS offices. The state highway safety office plays a key role in coordinating with state EMS offices, law enforcement and other partners to ensure coordinated response to road crashes.	States are encouraged to develop strategic highway safety plans. Generally, development of plans is led by state highway safety offices, who convene partners including EMS, law enforcement and others in this process. The Federal Highway Administration (FHWA), developed an online guide for how to involve EMS in the plan process. The website, Saving Lives Together, has success stories. (https://safety.fhwa.dot.gov/shsp/ems/connection/)	NHTSA is the national leader for coordination of federal efforts to improve prehospital EMS. NHTSA's websites (www.ems.gov, www.911.gov) include information on programmes which support EMS system development. NHTSA's (2016) *The road ahead. National Highway Traffic Safety Administration strategic plan 2016–2020* set a goal to save an additional 500 lives by enhancing crash recognition, response and emergency medical care. It includes an objective to increase survivability from crashes through improved emergency response with a focus on improved 911 calling, EMS and ACN.	

2.3 Timely, accurate notification of emergency services

Improvement in communication from the moment of impact through to hospital arrival has the potential to improve outcomes for road crash victims. One important category of communication is timely and accurate notification that a crash has happened, where the incident is located, and what services need to be informed and to respond. With low population densities and long distances between urban areas, swift notification and dispatch of post-crash responders is especially important in New Zealand.

Principal methods of notification covered in this section are telephone, ACN, and other mobile methods of communication and notification. There are devices that fall outside these categories, for example Japanese cars are equipped with rescue flares that travellers can use to signal for help in an emergency and these may now be LED rescue flares (figure 2.2). There are also moves in New Zealand to trial the instrumentation of road crash barriers to provide prompt advice when they are hit eliciting a speedy response from the RCA which would call emergency services if required[2].

Figure 2.2 Examples of LED rescue flare and flashing light available internationally

2.3.1 Telephone

A phone call to a nationwide emergency number by occupants of the crashed vehicle and/or bystanders is the most common means of notification. Via an emergency call centre, the public are connected to emergency services, who subsequently advise the road agency. This system is low cost to road agencies and operates 24/7. It can verify an incident when multiple calls are received, and receive quick advice about incidents in high-traffic areas. It depends on public calls, and there is usually a need to verify information to clarify location, severity and extent, and to coordinate information between police, fire and ambulance call centres (Espada 2016).

Downsides include when multiple callers give discrepancies in details such as severity and even location for the same incident. Where a crash occurs in a remote area, the vehicle runs off the road, or is unobserved by passing traffic, there may be considerable delay in notification (Bahouth et al 2014). Decreased visibility, at night or in poor weather conditions, adds to the problem of detecting a crash (Champion et al 2005).

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[2] Pers comm, Russell Kean, Instrumentation Engineer, Opus WSP Research

2.3.2 The contribution of mobile phones

Widespread use of mobile phones has shortened the time to first notification of crashes (Bahouth et al 2014). A study of a UK county ambulance service (Wu et al 2012) found that mobile phone reporting compared with landline reporting of emergencies resulted in significant reductions in the risk of death at the scene. A consideration for New Zealand would be the extent of mobile phone network coverage along the road network outside of cities and towns (see the New Zealand Registry Services' National Broadband map at https://broadbandmap.nz/).

Ways to facilitate telephone notification of crashes would be to address gaps in the wireless internet coverage along highways, or place emergency phones along highways without mobile coverage. Roadside emergency phones are most often located on major traffic routes and offer direct connection to a call centre. There is a cost to install and maintain them, and they are becoming less used with the proliferation of mobile phones; however, they offer the benefits of being at known locations and not being reliant on mobile phone networks (Espada 2016). Tziotis (2006) noted that rural public telephones with satellite coverage were proven in reducing crash notification time on road crashes in remote and rural areas.

According to the Ministry of Business, Innovation and Employment (MBIE)[3], as at June 2015 the Government was investing 'up to $210 million to lift the Ultra-Fast Broadband (UFB) programme coverage to at least 80% of New Zealanders'. There was also $100 million for major improvement in rural broadband and $50 million for improved mobile coverage in 'blackspot areas' (ie where there is no coverage) along main highways and in popular tourist destinations adding up to a total of $150 million.

As at 2 June 2017, Crown Infrastructure Partners detailed on its web site[4] target coverage areas for RBI2 (Rural Broadband Initiative phase 2) and the mobile black spots (MBS). Both these initiatives will benefit mobile coverage on the road network and provide better internet coverage to households that might take a bystander role in rescue of crash victims.

As at 30 August 2017, Crown Fibre Holdings had contracted for[5]:

- improved rural broadband to be extended to more than 70,000 rural households and businesses (including commercial expansion by some of the mobile network operators)
- new mobile coverage for around 1,000 kilometres of state highways and more than 100 tourist destinations
- lifting nationwide geographic mobile coverage by 20% to 30% per cent (from approximately 50% currently)
- open access to Government-funded infrastructure (such as towers).

These contracts include an additional $140 million on top of the original $150 million, bringing the total funding for RBI2 and MBSF to $290 million[6]. The open access to government funded infrastructure may also provide an opportunity to extend these two initiatives to vehicle specific emergency communications.

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[3] www.mbie.govt.nz/about/whats-happening/news/2015/rois-for-ufb-rbi-mobile-black-spot-fund-expansion-programme-close-3-july Accessed 9 September 2016

[4] www.crowninfrastructure.govt.nz/tenders/ Accessed 9 September 2016

[5] www.crowninfrastructure.govt.nz/ufb-initiative/rbi2-mobile-black-spot-fund/ Accessed 9 September 2017

[6] www.crowninfrastructure.govt.nz/wp-content/uploads/2017/09/RBI2-MBS-and-UFB-expansion-fact-sheet-31-August-2017.pdf Accessed 9 September 2017

2.3.2.1 Targeting of mobile network coverage to risk

At present extension of mobile coverage along highways is predicated by increases in traffic flow and tourist numbers. It would be good if along with these metrics highway risk was given a weighting in the decision on where the next tranche of mobile coverage is placed. A mechanism for this to take place could be a topic for discussion between the NZ Transport Agency, MBIE, Accident Compensation Corporation (ACC) and Crown Fibre Holdings (which deals with wireless networks as well as high-speed fibre networks).

2.3.2.2 Public Information about the penetration of mobile networks on the road network

At present the public has access to information about the safety quality of the infrastructure on state highways via New Zealand's Road Assessment Programme (KiwiRAP)[7]. This information is presented as star rating maps of the road network. The ratings are updated regularly with part of the process being a vehicle surveying the state highway network. One way of collecting information to present to the public would be surveying the road network for the presence or absence of cellular networks. In New Zealand, apart from the odd exception (like older 2g only phones) modern phones will pick up all the networks and they will work on any network in emergency dial mode even if they are locked to a particular network for ordinary calls. A survey vehicle would need only one device equipped with three sim cards to connect with the three New Zealand networks and the ability to log the presence and strengths of the network along a route. This work could be done in conjunction with other surveys like those for KiwiRAP. Maps could be produced regularly showing the public where at least one network is present at an acceptable strength to report an emergency.

2.3.3 Emergency caller ID

In May 2017, emergency caller ID was introduced in New Zealand to improve accuracy in finding 111 callers, and speed up response and dispatch times for emergency services. It uses GPS tracking to trace the location of emergency callers. Previously, call centres for police, fire and ambulance had to manually request the information from telecommunications companies, which took time. Following the death of a man who called 111 and emergency services could not establish his location, a coroner in 2013 called for more cooperation between telecommunications companies and emergency services[8]. Now emergency responders can swiftly track the locations of callers without going to a telecommunications provider, if a caller does not know their exact whereabouts. Because the new system does not need a warrant or the caller's consent, the Privacy Commissioner had to amend privacy rules to allow it. In 2016 more than 80% of emergency calls were made from a mobile phone, and police recorded over 1,800 incidents where they made an information request to a network provider for a caller's location (Stewart and Weekes 2017).

2.3.4 Automatic collision notification

ACN systems are now provided in many new vehicles in overseas markets. These can summon help automatically when the vehicle occupant cannot. ACN is triggered automatically by a high-energy crash, for example initiated with the deployment of an airbag or other restraint system. This connects with an operator who can communicate with occupants or contact emergency services. Alternatively, an occupant or witness can push a button in the vehicle to request help or state that help is not required (Bahouth et al

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[7] www.kiwirap.org.nz/ Accessed 2 November 2017

[8] www.nzlii.org/cgi-bin/sinodisp/nz/cases/NZCorC/2013/67.html?query=Roach Accessed 21 December 2017

2014). Even if no passenger can speak, a minimum set of data is sent, including the exact location of the crash. ACNs require wireless network access.

There are a variety of ACN options, such as eCall in Europe, OnStar (General Motors) in North America, and other proprietary solutions from car manufacturers including BMW, Mercedes-Benz, Toyota/Lexus, Ford and Škoda. Owners of older vehicles can also use an aftermarket product like OnStar's FMV. Estimates suggest that there were more than 6 million vehicles with advanced ACN (AACN) and an equal number with ACN in the United States in 2011 and more worldwide (Bahouth et al 2014). ACN became a standard option in General Motors vehicles in 2007 (White et al 2011). In 2015 the European Parliament voted to require all new cars be equipped with eCall from April 2018, by which time it is expected that eCall will be functioning throughout Europe, and all eCall-equipped cars will connect to Europe's single emergency number (European Commission nd). There is limited deployment in Australia and New Zealand, tending to be in high-end vehicles and paid services with a private call centre to relay the message (Espada 2016).

It is claimed that eCall in the EU will cut emergency services response time by 50% in the countryside and 60% in built-up areas, saving hundreds of lives every year and reducing the severity of injuries in tens of thousands of cases (European Commission nd). eCall is also expected to facilitate faster clearance of crash sites, helping with congestion, fuel waste and carbon emissions (Martinez et al 2010). There are implementation issues and these are well described in documents from the Harmonised eCall European Pilot (HEERO nd). There are operational considerations for each European country. For example, in Italy the implementation of eCall is a shared responsibility among the Ministry of Infrastructure and Transport, the Ministry of Interior and the Ministry of Economic Development, with pilot projects carried out in certain provinces, and tests with appropriately equipped cars on certain motorways (OECD and International Transport Forum 2016).

Anecdotal evidence indicates how effective such a system can be. In 2015 in Oklahoma a woman drove off the road, down a steep ravine, through thick underbrush and into a creek bed. The OnStar system in her vehicle notified officials of the crash, but they were unable to find the wreck at first. After a series of pings from the system, they found her in wooded area 100 feet from the road. She was taken to hospital and was expected to recover (KWGS News 2015).

A range of studies have estimated the benefits of ACN. Some of these are listed in Bahouth et al (2014) and Ponte et al (2016). For example, Clark and Cushing (2002) suggested a fatality reduction in the USA of between 1.5% and 6% with ACN. Wu et al (2013) estimated a 1.8% fatality reduction in the USA with the full deployment of an ACN system. Chauvel and Haviotte (2011) examined crashes in France involving vehicles fitted with eCall and estimated that universal deployment in France might have a benefit of around 2.8% fewer fatalities. Sihvola et al (2009) evaluated the likely effect of an ACN system in Finland for road fatalities, using data from 2001–2003, and estimated that 3.6% of fatalities might have been avoided, and the total preventive effect on road fatalities could be higher. Modelling of an ACN system applied to 2011 data on the Korean freeway system suggested 9.4% to 15.4% of fatalities could be reduced (Jeong et al 2014). Effectiveness rates for serious injuries are not as well studied according to Ponte et al (2016), but estimates range from 0.1% increase (where fatalities change to injuries) to a 7% decrease in serious injuries (shifting to less serious injuries).

Lahausse et al (2008) estimated that ACN would provide an average three-minute reduction in the total crash-to-hospital time for Australian urban areas and six minutes for rural areas. Assuming all vehicles were fitted with ACN, these reductions would save an estimated 11% of passenger vehicle occupant fatalities (10.5% in urban and 12% in rural areas). Ponte et al (2016) looked at the potential of ACN in South Australia. In 25% of fatalities in the period 2008–2009 there was a delay in crash notification of over 10 minutes. They estimated the numbers likely to have survived through more prompt crash notification enabling quicker emergency medical assistance. The minimum effectiveness rate of an ACN system in South Australia with full deployment was likely to be 2.4% to 3.8% of all road crash fatalities involving all vehicle types and all vulnerable road users (pedestrians, cyclists and motorcyclists). Considering only passenger vehicle occupants, the benefit was likely to be 2.6% to 4.6% (two lives saved but perhaps as many as four lives per year in the study period).

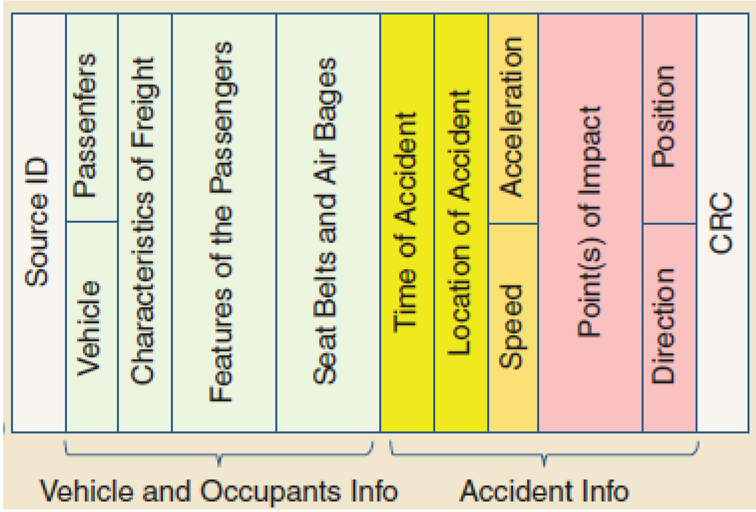
Some recent estimates of numbers of potentially preventable deaths are lower than earlier analyses. Reasons for this are unclear, but the use of mobile phones today may result in a shorter time for first notification to rescue services, so ACN provides less additional benefit (Bahouth et al 2014). Other explanations may lie in the different modelling methods used in different studies (for example the varying methods used in the Australian studies), which may result in optimistic or conservative figures, or in the varying characteristics of each country (Ponte et al 2016).

AACN not only notifies of a crash, but also allows prediction of the seriousness of a crash and the severity of injury from collision information. Vehicle telematics data transmitted immediately following a crash, for example giving impact severity and direction, can be used to indicate probability of injury, based on predictive algorithms (Bahouth et al 2014). An example is the urgency algorithm developed using the National Automotive Sampling System crashworthiness data system (Flanigan et al 2010). The private US company, OnStar, offers a package of services (connectivity, vehicle diagnostics, directions, theft alarm notification, roadside assistance, emergency assistance) including automatic crash response which alerts an OnStar advisor and predicts the severity of injuries. The OnStar advisor directs emergency services to the location and offers assistance to those in the vehicle until help arrives (OnStar nd).

In one study (Matsumoto et al 2016), a car equipped with AACN was made to collide with a wall. AACN information was sent to an operation centre seven seconds after the collision, demonstrating the feasibility of automatically alerting emergency services via AACN. This can help direct a more informed response. Dispatchers can decide on appropriate resources and equipment to send (Champion et al 2005; Smith 2016). More rapid and accurate identification of crash injuries using AACN can potentially save lives, and also reduce the overall cost of post-crash care by assisting with triage, for example identifying patients that do not need to be rushed to a trauma centre (Bahouth et al 2014). Since the AACN crash message includes the make and model of the vehicle, it would be possible for rescue teams to have extrication information such as air bag location and vehicle cut points before arriving at the scene, and for immediate dispatch of the necessary equipment and teams to perform the extrication (Champion et al 2005).

For an ACN or AACN system to work, new cars must be equipped with the devices (for example the EU and the automotive industry came to an agreement on this), they must have wireless network access, and all rescue services and emergency centres must be able to receive and process the data. A next important step is to link AACN in a system to make the information available to each member of the rescue chain. In future, as well as injury prediction data, this might include on-scene telemetry, video and telemedicine (Ray et al 2016). This requires the establishment of common metrics, so a call from any manufacturer or service provider has a common format and definition, and dispatch protocols that allow for the capture and use of this data. The Centres for Disease Control in the USA has drafted a revised triage protocol that incorporates vehicle crash information (Bahouth et al 2014, citing Sasser et al 2012). The information transmitted could include specific data about the vehicle, its occupants and the crash, see figure 2.3.

Figure 2.3 Essential information to be transmitted in future emergency services (Martinez et al 2010)



These systems can become outdated, as evidenced by General Motors removing 500,000 subscribers from the OnStar service because they were equipped with analogue communications systems, incompatible with the newer digital infrastructure (White et al 2011). The impact is limited by factors including market penetration of new vehicles with ACN, cost to retrofit for older vehicles where possible, cost if paying an annual subscription for a private service, and means to successfully transmit information to emergency services, such as good network coverage along highways. ACNs rely on wireless network access. For instance, in the South Australia study, one case was identified where early emergency medical assistance may have prevented the fatality but there was no network coverage to enable notification. There was an additional fatality where patchy network coverage affected the ability to make the emergency call. Ponte et al (2016) examined cellular coverage in Australia and found that between 4.7% and 29.9% of serious rural crash locations had no coverage, depending on network type. Effectiveness levels may also diminish as other technology increasingly prevents crashes, such as collision avoidance systems. There is confidence in ACN in the USA and Europe, but the benefits have not yet been fully determined due to limited deployment.

Cairney et al (2010) found it difficult to estimate the benefits of ACN systems, and placed low confidence on studies done in places with different road conditions to Australia. However, the report cited a study by Virtanen et al (2005) in Finland, which estimated that ACN would save between 4% and 8% of road deaths. On the assumption that 4% to 8% of fatal crashes would become serious injury crashes, the annual benefits to Australia would be valued at between $105 million and $211 million each year. The break-even costs would be $50 – $115 per vehicle. Cairney et al (2010) also found it difficult to obtain direct costs for the technology, as it is often included in packages with other functions and features, and there is sometimes an initial cost and an annual subscription thereafter. Based on costs available at the time of the report, they found a benefit-cost ratio below one. This did not include savings associated with other functions included in vehicle packages with ACN, such as fuel economy, stolen vehicle tracking, battery monitoring or fleet management. It also did not include the costs of establishing the necessary communications infrastructure.

Technologies for ACN have the potential for both false alarms and real emergencies when the alarm does not get through. The former is mainly discussed in the literature on use of mobile phones, while the latter is touched on in discussion of patchy network coverage such as in rural areas.

2.3.5 Linking mobile devices and automatic notification

Smartphones are now equipped with significant processing power, high-quality movement sensors, GPS and SMS functionality, key components of an ACN, plus microphones and video. Sandsjö et al (2016) explored the feasibility to develop smartphone-based ACN. They developed a functional ACN app for cyclists, available from Google Play, and a prototype for horse-back riders. White et al (2011) also described how smartphones could automatically detect traffic crashes using accelerometers and acoustic data, immediately notify a central emergency dispatch server, and provide situational awareness through photographs, GPS coordinates, voice over internet protocol communication channels and data recording. They also demonstrated possible approaches to prevent false positives when a phone is dropped.

Possible false positives, the newness of this approach, and the phone not being permanently in the vehicle are drawbacks to the use of smartphones. The advantages are the large and growing base of smartphone users, the low cost of smartphones compared with other systems, and the ability to provide a service for other types of vehicle, such as bicycles, and for existing vehicles, and the possibility of avoiding the complications related to equipping vehicles from the wide range of sources providing imports to New Zealand with automatic notification device compatible with our systems. Because each smartphone is associated with its owner, this could also aid in casualty identification and in obtaining electronic medical records during a rescue. Smartphones have the ability to provide rich data for crash analysis, a variety of network interfaces to send information to emergency responders, and Bluetooth wireless interfaces that can communicate directly with the computers in many newer cars (White et al 2011).

Other possibilities for emergency communications post-crash are analogue and digital mobile radio. A range of radio services are provided in New Zealand and abroad by communications companies such as TeamTalk[9] and Tait[10]. It was announced on 19 December 2017 that TeamTalk and Tait had agreed to a partnership to build new nationwide Tier III Digital Mobile Radio network[11]. Mobile radio enables voice and data communications and can be integrated with GPS and the internet. Repeater sites are designed to withstand power outages. Where network infrastructure is unavailable, portable radios can also operate in direct mode so radio users with line of sight can continue talking to each other, several miles apart. Radio networks used for critical communications provide dedicated channels for the organisations that use them, with dedicated linking infrastructure between sites, often designed with redundancy, as well as the capacity for autonomous local communications. Trunk radio is used for work and emergency vehicles in remote areas.

It is possible that the introduction in future of inter-vehicular networks will further improve responsiveness. Cars involved in a crash might send information about the crash to nearby vehicles and to the nearest wireless base station, with data channelled to the appropriate emergency services, and surrounding vehicles immediately notified of the hazard (Martinez et al 2010). Cooperative intelligent transport systems that facilitate wireless communication between vehicles, roadside infrastructure and businesses are discussed in section 2.4.2.

LoRa networks[12] are being installed in New Zealand by organisations such as KotahiNet and Spark. LoRa is a long range (~30 km), low power wireless platform. It uses the unlicensed industrial, scientific and medical radio bands for transmitting small, occasional messages (eg one message per hour) from sensors or other low power devices to LoRa gateways. The LoRa gateways are, in turn, connected to the internet. Using

[9] www.teamtalk.co.nz/mobile-radio Accessed 9 September 2017

[10] www.taitradio.com/ Accessed 9 September 2017

[11] www.nzx.com/announcements/311857 Accessed 22 December 2017

[12] www.3months.com/blog/the-lora-network-and-what-it-means-for-nz-businesses Accessed 9 September 2017

internet of things technology, it would be possible to install a small, low powered unit in a vehicle containing a triaxial accelerometer similar to those in air bags, a GPS unit storing the vehicle's last known location and a LoRa transmitter/receiver. If the vehicle were involved in a crash, sudden deceleration or rolling would be detected by the accelerometer, triggering the transmitter to send a short message (time, date, licence plate number, last known GPS coordinates) to the nearest LoRa gateway and onto the relevant people. The device would continue transmitting until the message was acknowledged. The owner of the vehicle would pay a network subscription (currently $1 per month per unit using KotahiNet). Opus WSP Research[13] is investigating the installation of LoRa gateways to service remote infrastructure monitoring sensors.

2.4 Fast, safe travel to and from the crash site

2.4.1 Road-based emergency services

Speed of transporting patients to hospital depends in part on the degree to which medical interventions are undertaken at the scene. The European Transport Safety Council (2016) called for the EU to stimulate the evaluation of different types of pre-hospital care and set up a common casualty-centred approach to achieve a quick, safe rescue. Al-Shaqsi (2010) summarised two approaches to emergency care: the Franco-German 'stay and stabilise' model common in Europe, particularly in Germany, France, Greece, Malta and Austria; and the Anglo-American 'scoop and run' model, where patients are brought rapidly to hospital with few pre-hospital interventions. This model is evident in the USA, Canada, New Zealand, Oman and Australia. The United Kingdom has an Emergency Care Practitioner Scheme like the Franco-German model. Studies have shown conflicting results as to which approach is more effective (Wall et al 2014). Choice of medical approach in turn affects expectations on road services as to the speed of transportation to hospital.

Timely response also depends on the availability of ambulances and related services. The SafetyNet report (2009) drew on a 2004 research overview indicating that, in general, road traffic deaths increased with increasing ambulance response time, which was strongly related to population density, and the proportion of fatal crashes was lowest where ambulance availability was best.

It may be that forward planning of routes for road-based response to emergencies might be of use, particularly in larger emergencies with multiple casualties. Vitetta et al (2007) used a path choice generation model to simulate the behaviour of emergency vehicle drivers at an urban level during an evacuation. The intent was to design optimal paths for emergency vehicles and to reduce evacuation times. However, a crash may happen anywhere on the road network, making pre-planning of routes complex.

Among a variety of recommendations aimed at preventing crashes in rural and remote areas, Tziotis (2006) discussed road safety auditing and risk assessment to identify hazards and deficiencies with associated treatments, such as treatment of blackspots. While such measures to improve road safety would be aimed principally as crash prevention measures, road improvements would also have the effect of improving the safety and speed of emergency responders travelling to and from, and working at, the crash scene.

2.4.2 Traffic control measures

Traffic management for emergency response can encompass clearance operations, emergency call-out and provision of warning information for road users. This supports quick action by emergency services

[13] Pers comm, Russell Kean, Instrumentation Engineer, Opus Research

(police, fire, ambulance), as well as protects the crash area and warns motorists to prevent further crashes or congestion (Espada 2016).

Long-standing priority measures include sirens and flashing lights, the requirement for other road users to make way, and exemptions granted to emergency vehicles from some of or all the road rules. Other measures focus on pre-emption of traffic signals, with route guidance measures in limited application (Espada 2016). Technologies have been successfully implemented to improve the response time of emergency vehicles by up to 14% to 25%, as well as reducing emergency vehicle crashes (Luk et al 2008, citing Federal Highway Administration 2006).

Traffic signal and control measures give emergency vehicles priority on the way to the crash or the hospital. Emergency vehicle pre-emption schemes are illustrated in table 2.2.

Table 2.2 Emergency vehicle priority measures (table adapted from Espada 2016

Measure	Description
Localised schemes: special phase for intersections near emergency vehicle stations	The phasing and/or timing of traffic signals close to an emergency vehicle station are pre-empted on demand to provide controlled, priority access to the intersection or to clear queues before the vehicle arrives at the intersection. This may be activated by phone call or push button, and is used where the exit from the station leads onto the intersection or joins the road near the intersection.
Active pre-emption of traffic signals when a vehicle is detected prior to arrival at an intersection	When an emergency vehicle is detected, eg through in-vehicle transmitter/ transponder, a green phase is provided as soon as is safe. There are three methods to detect the arrival: strobe, siren or radio activated. Active detection is not common in Australia or New Zealand. Espada (2016) cited Bean and Studwick's (2006) reporting of the trial of a VicRoads system with strobe activation in Melbourne. The VicRoads system was considered a success and found to be reliable, with improved safety, reduced response times and positive feedback from users. Luk et al (2008) cited Asakura et al (2002) on a similar system installed in Tokyo.
GPS tracking, with GPS units in-vehicle and at an intersection	This detects position and speed, estimating the time of arrival of the emergency vehicle at the intersection, and ensuring it receives a green phase. This alters the signal timings in advance, allowing other vehicles to move out of the way. If the route is unknown, the system can predict possible routes and implement a pre-emption strategy on each route. A trial in Illinois, USA, found it reduced response time by 20% (Espada 2016, citing Proper et al 2001).
Pre-determined route pre-emption plans	Manually operated signal coordination systems help an emergency vehicle progress along a pre-defined route. Emergency crew phone the traffic management centre to activate the desired route pre-emption plan. It is susceptible to unforeseen circumstances, such as traffic congestion, which can be ameliorated through emergency services and traffic management staying in contact. This is more suited to fire engines than ambulances because the former have slower acceleration and benefit more from good signal progression, and they usually depart from a fixed base rather than an on-road callout. Luk et al (2008) cited Baskerville describing in 2006 how a low-cost, scheme was implemented in Adelaide. Operators expressed satisfaction with it. Its use was considered better than nothing.
Route guidance	The intent is to provide the shortest path to the incident site based on traffic information. In New Mexico, USA, this was found to reduce response time by 10% to 15% (Espada 2016, citing Proper et al 2001).

Speed of response can be facilitated by provision of emergency lanes, for example on motorways. Certain lanes can be marked with a sign indicating they should be cleared in case of emergency vehicles approaching (Björnstig 2004). The emergency lane may also operate as a traffic lane during peak periods. The absence of an emergency lane on a part-time or full-time basis, such as in tunnels or on bridges where there are physical or cost constraints, may require other measures to manage safe response during crashes (Espada 2016).

These may include emergency stopping bays or traffic management devices such as a lane management system (LUMS) and variable speed limit (VSL). As well as providing access, these measures protect the incident site, crash victims and responders. A LUMS is used to control vehicle movements, and can be used to quickly and safely create an emergency lane, as well as divert traffic off the motorway in the case of a major event. The VSL sign group immediately upstream of the crash can be set to the safest speed limit, with VSL sign groups further upstream adjusted in increments as buffer speed signs. The smart motorways initiative in Australia involves implementation of an integrated package of intelligent transport systems tools. These include variable speed limits, lane control including provision of emergency lanes, incident detection and traffic flow data, traveller information and closed circuit television surveillance (Espada 2016).

Co-operative intelligent transport systems facilitate wireless communication between vehicles (V2V), between vehicles and roadside infrastructure (V2I), and between vehicles and businesses (V2B). In addition to data collected directly from vehicles, travel time and traffic data may be collected through fixed road infrastructure, such as inductive loop detectors, wireless vehicle detection systems and weigh in motion. This enables real-time updates of the road environment for vehicles and for traffic management centres. As well as co-benefits for fuel efficiency and safety systems to prevent crashes, the travel time and traffic data has the potential to improve response times by clearing a path for emergency vehicles, helping with the dispatch of emergency services and providing real-time travel information regarding congestion into the emergency vehicle. Substantial work has been done internationally on developing low latency, short range communications for V2V and V2I. Europe and the USA are looking at deploying V2V and V2I. Japan has deployed vehicles and roadside infrastructure with some of this functionality. Examples of V2B connectivity include Australia’s Intelligent Access Program (satellite tracking and wireless communication technology for remotely monitoring road network activity of heavy vehicles) and provision of route information to vehicles via private services. An ACN system might build on existing systems such as the Intelligent Access Program (Espada 2016). V2V communication in future could potentially allow direct warning to drivers of a crash ahead or the approach of a fast-moving emergency vehicle. Smart signs at intersections could indicate from which direction an emergency vehicle was approaching (Flanigan et al 2010). There is some cross-over with notification technologies, for example sensors placed on a structure such as a median barrier might transmit the information of a collision, alerting authorities to a crash.

Although similar in concept to existing internet wireless connections, cooperative intelligent transport systems technology will be faster and more secure. Radio spectrum will need to be allocated to ensure sensor technologies used by advanced driver assistance systems do not experience interference. Communication between vehicles and infrastructure will depend on access to an internationally harmonised radio spectrum. The US, the European Union and Japan are standards setters, each proposing to use a different part of the radio spectrum and different communication protocols. New Zealand might need to select one of these frequency ranges to use (MBIE is responsible for policy advice on the allocation of a radio spectrum). There would potentially also be an issue of incompatibility between different standards, where New Zealand has vehicles built to more than one jurisdiction’s standards. Ideally, if there were a divergence in standards, devices should be sufficiently smart to adapt to local conditions, much as mobile phones work in many countries (NZ Government 2014).

Factors to consider when deciding on measures to take, as well as reduction in response time, are improvement of driver safety, reduction of emergency vehicle involvement in crashes, and better journey comfort for those inside the ambulance (Green et al 2007). Measures are ranked in table 2.3.

An Alabama survey of emergency service responders (Griffin and McGwin 2013) asked questions on road design, response to emergency calls, in-vehicle technology and public education. Congestion was found to result in an average of nearly 10 minutes of extra response time. The most effective in-vehicle technology for reducing response time was considered a pre-emptive green light device, though few had one in their vehicles. Public education on how to react to approaching emergency vehicles was stated as having the greatest potential impact on reducing emergency response time. A paper by Djahel et al (2013) proposed a framework in which the traffic management system can adapt by adjusting traffic lights, changing related driving policies, recommending behaviour change to drivers, and applying security controls. The choice of adaptation would depend on the emergency severity level.

Table 2.3 Ranking of methods and technologies to support emergency vehicle response (Luk and Green 2007)

Priority measures & technologies#	Effectiveness	Level of demand in future	Possibility of implementation	Cost of implementation	Overall score##
Passive signal priority	Medium	Low	Low	Low	** (7)
Active unconditional signal priority	Medium	High	High	Low	**** (11)
Active conditional signal priority	High	High	High	Medium	**** (11)
Gating using signals	High	Medium	Medium	Low	*** (10)
Bus advance measure	Medium	Medium	High	Medium	*** (9)
Bus/tram lane	High	Medium	High	High	*** (9)
Integrated multi-modal transport	High	Medium	Medium	High	*** (8)
Contactless smart card	High	High	High	Medium	**** (11)
HOV lane (with minimal enforcement)	Medium	Medium	Medium	Low	*** (9)
HOV enforcement technology	Low	Medium	Medium	Medium	** (7)
Access control for HOV lane	Medium	Low	Medium	Medium	** (7)
On-ramp HOV metering	Medium	Medium	Medium	Medium	** (7)
Route pre-emption plan for EVs	Medium	Medium	Medium	Low	*** (9)
EV detection at signals	Medium	Medium	High	Medium	*** (9)
GPS tracking of EVs	Medium	Medium	High	Medium	*** (9)
Route guidance for EVs	Medium	Low	Low	Medium	** (6)

The measures in this table are compiled from those reported in Green, Su & Luk (2007) and from previous sections in this report.

To determine an overall score, Low = 1, Medium = 2, High = 3 (except Low cost, which has a score of 3); the stars are allocated as follows: ** for scores < 8; *** for scores between 8 and 10; **** for scores > 10

Road authorities also have clearance time to consider. Lee and Fazio (2005) found that factors affecting this included day of week, urban or rural area, off or opposing-lane crash, number of vehicles involved, heavy vehicle involvement and response time. They recommended focusing on factors that significantly reduce traffic crash clearance times on motorways in peak periods and placement of adequate resources (ambulance, tow truck, equipment) in locations where particular types of crash (injuries, fatalities, heavy vehicle, multiple vehicle) cluster.

2.4.3 Provision of helicopter landing sites

Sources differed on the effectiveness of helicopters in post-crash response and this may vary by country. SafetyNet (2009) cited research that suggested using helicopters to transport patients did not greatly influence their probability of survival. A more recent report (International Transport Forum and OECD 2016) considered that helicopter services in higher income countries were proving effective by providing rapid long-distance transport to specialised medical treatment and avoiding delays with traffic congestion.

Helicopter ambulance services can provide a swift trip to a trauma centre for seriously injured patients, and can be useful where there is difficulty with road-based access. This relies on the ability of the aircraft to land near the crash site. In an example of what can otherwise happen, in February 2017 a Palmerston North rescue helicopter was unable to land near to a Tararua District crash site due to poor weather. It landed instead at a nearby town and a St John ambulance was dispatched. One person died at the scene, one was critically injured and another had minor injuries. Paramedics drove the two survivors to the waiting helicopter to be flown to Palmerston North Hospital (Stuff 2017).

If the helicopter is unable to land close to the scene, transport time may be increased due to transfer of the patient between vehicles. A study in Norway (Nakstad et al 2011) evaluated how the distance from the scene to the landing site affected on-scene time. In 75% of cases, the aircraft landed less than 50 m from the scene, and in 7% the distance exceeded 200 m. Usually, the helicopter could land close and landing site location did not contribute to a delay in arrival of the patient at hospital. In future, technology may be available to allow helicopters to see outside regardless of visibility conditions (Flanigan et al 2010).

To ensure safety, designated landing zones can be provided. In New Zealand, formal helicopter landing pads must go through a Civil Aviation Authority approval process.

GIS-based (geographic information system) methods can be used to determine the optimal placement of new helipads to minimise overall rescue time. These compare geographic locations of requests for scene responses with the locations of existing helipads, transport networks and hospitals (Caprì et al 2009; Foo et al 2010).

Where a helicopter pilot has to evaluate possible landing sites alone, this can be time-intensive, fuel-costly and challenging when operating in poor visibility. Peinecke (2014) proposed a method for pre-selecting a list of possible landing sites, and presenting a choice of possibilities to the pilot that could be ordered by means of wind direction, terrain constraints and proximity to a target site, calculated automatically from terrain databases and sensor-collected data. Doherty et al (2013) used two GIS methods to identify helicopter landing areas from available geographic data. The first model was derived from predefined feature constraints based on helicopter landing area requirements. The second used a machine learning technique. The two approaches produced a GIS product to support the identification of suitable landing areas in rescue situations.

US researchers developed an Atlas and Database of Air Medical Services (ADAMS) (www.adamsairmed.org) which displays, online in a GIS map, the locations of air medical base helipads and their coverage areas, as well as communication centres and receiving hospitals. Researchers anticipated dispatchers using AACN crash information to rapidly assess the need for an air response and using ADAMS to make sure air medical services and nearest trauma centres were on alert. This would give a near-parallel rather than serial response and get appropriate responders to the scene sooner. ADAMS is also a research tool, for example contributing to research by the Association of Air Medical Services examining the potential of using auto launch/early activation policies, and collecting information that can be used to improve services. An overlay of fly circles on the map around air medical base locations indicates time to rescue. For example, in 2005 about 33% of the interstate and US highway system was located within 10-minute fly circles and about 82% within 30-minute fly circles (Champion et al 2005).

2.5 Working together: road crash management and communications

Multiple organisations are involved in post-crash response. Table 2.4 (compiled in relation to Australia) gives an indication of the complexity involved. Therefore, good communications are important between the various organisations, as is interoperability between their various fixed and mobile systems, to enable the smooth running of rescue operations.

Table 2.4 Typical agency roles and responsibilities in responding to a crash (Espada 2016)

Stakeholder	Roles and responsibilities[1]	
Police	Provide emergency call centre, coordinates communications. Assume role of Incident Commander, supervise response actions. Secure incident scene, safeguarding property. Perform first responder duties. Assist responders in accessing the incident scenes.	Control arrival and departure of incident responders. Police perimeter of incident scene and impact area. Conduct crash investigation. Perform traffic control. Establish emergency access routes. Ensure responder safety.
Fire and rescue	Rescue/extricate victims. Extinguish fires.	Contain or mitigate the release of hazardous materials.
Emergency medical services	Provide triage, medical treatment to those injured at the incident scene. Determine destination and transportation requirements for injured victims.	Transport victims for additional medical treatment.
Road agencies (Similarly for local authority for non-state roads and toll road operators for toll roads)	Protect incident scene. Implement traffic control strategies and provide supporting resources. Monitor traffic operations. Disseminate motorist information. Mitigate incidental vehicle fluid spill confined to the roadway. Assess and direct incident clearance activities.	May perform first responder duties (service patrol). Clear minor incident (service patrol). Perform incident detection and verification (service patrol/TMC). Develop and operate alternative routes. Assess and perform emergency roadwork and infrastructure repair. Inform road users with updated traffic information.
Towing and recovery	Recover vehicles and cargoes. Remove disabled or wrecked vehicles and debris from incident scene.	Mitigate non-hazardous material (cargo) spills.

2.5.1 Interoperability

Travellers need to be able to call emergency services with their own equipment, whether mobile phone or an on-board emergency system or in some cases, radio equipment. Emergency services need to be able to access the relevant information about the vehicle, passengers and freight. While mobile phone networks, radio networks and vehicle emergency systems are not the responsibility of a road agency, traffic management centres operated by road agencies must be able to accept information from these systems (Espada 2016).

Interoperability is needed between emergency responders. For example, the Queensland Floods Commission of 2012 remarked on a need to improve interoperability between agencies, and called for common use of an emergency services computer-aided dispatch system, which assists when emergency calls have to be transferred to different operators at times of peak demand, as well as reducing congestion on radio networks (Wall et al 2014). Emergency management includes management at the scene and at the operations centre, for example coordinating response in a crash involving multiple casualties such as a bus. Technologies to support communications between responders at the scene, those en route and those at receiving hospitals may include interoperable communications over an IP network or even portable wireless mesh networks (Flanigan et al 2010).

2.5.2 Working together to detect and respond to crashes

Verification of traffic crashes may be done by the relevant emergency services communication centre (police, fire, ambulance), with advice from the first on-site emergency service responder. Other methods to verify incidents include CCTV in traffic control centres or aerial surveillance by traffic reporting services. The Austroads *Guide to traffic management* (Espada 2016) recommends these steps for incident detection and verification:

- Maintain strong working relationships with emergency services and media traffic reporting services to ensure rapid exchange of information. Establish protocols on exchanging data.
- Encourage provision of real-time data on traffic incidents from emergency services despatch systems.
- Provide detection and surveillance capability for locations across the network with high incident rates (vehicle detectors to monitor traffic speeds and flow, software to automatically alert of potential crashes and trigger visual monitoring, CCTV).
- Provide location reference markers at regular intervals on high traffic routes to enable more accurate location of incidents, or ensure all responders have GPS devices.
- Consider alternative or complementary detection methods, including automatic crash detection, video detection, use of mobile phones or toll tags to provide more accurate, timely data
- Provide systems for rapid incident detection in tunnels.
- Provide traffic information to emergency services, eg electronic real-time congestion maps, to enable them to choose less congested access routes
- Deploy incident response services in high incident times and locations, which can act as first responders and provide information to traffic and emergency control centres, with good communication channels
- Build a traffic incident watch capability with road agency staff, police patrols and professional drivers
- Educate the travelling public about how and what to report on traffic incidents
- Monitor and report time taken to detect and verify crashes, and seek innovations to reduce this time, including time taken to be notified by emergency services.

2.5.3 Management and communications at the scene

To achieve rapid removal of casualties to hospital, all the road and emergency services must work together to secure the scene and remove people safely without causing injury either to casualties or others (Calland 2005). Dami et al (2009) described how Swiss emergency services successfully handled a 72-car pileup in 2008 that caused one death and injured 26. The relatively light toll was attributed to reduced speeds, the effectiveness of the first responders and excellent collaboration between rescue groups. They used an on-site medical command and control system, so that, two hours after the crash, the injured had been evacuated and aid on the site had ended.

Shepherd’s US study (2005) found that better coordination was needed between transportation and emergency services, with key, feasible short-term initiatives to improve coordination being:

- Improve interoperability of communication and other information technologies.
- Increase participation in multi-agency operations planning for all types of hazards.
- Include more transportation topics in training for emergency response personnel and vice versa, perhaps through interagency training programmes.

International Transport Forum and OECD (2016) also recommended interdisciplinary training to enable effective multi-agency response to road crashes. Shepherd (2005) further recommended organisational design changes to create horizontal links – shared information systems, task forces and teams.

Cattermole et al (2015) noted that coordinated inter-agency response is important to keep road users, causalities and responders safe. For example, in Queensland between 2005 and 2009 there were three fatalities and 145 injuries of traffic controllers who were road/railway workers or police. People at the scene may include police, fire, ambulance, traffic response, official response teams for environmental issues, volunteer services, tow truck operators and media. A survey of 720 Queensland emergency responders identified issues with: passing motorist behaviour and response to emergency vehicle and scene perimeter lighting; and with cross-agency interoperability, collaboration and communication. A follow-up study (Cattermole et al 2015) examined this via interviews with urban operational experts (police, fire, traffic response), identifying issues and possible solutions, outlined in table 2.5.

Table 2.5 Response issues and possible solutions identified by operational experts in Queensland (Cattermole et al 2015)

Decision making issue identified	System support solutions suggested by participants
Interoperability – misunderstanding roles and responsibilities of TIM responders from other agencies, not being aware of other agency requirements in the environment, non-alignment of agency practices	Improved training opportunities – inter-agency exercises as well as training focused on interoperability issues raised
Communication – intra-agency communication issues, especially at district borders, incident scene communication within and across agencies, inter-agency communication ability	Investigation of communication technology that better meets incident management requirements
Technology – several examples of where current technological advances provide solutions to TIM issues but there has been no uptake	UK and US examples of technology linking TMC to GPS offering emergency responders the quickest routes to incidents and reducing impact of congestion New technology for training includes virtual training environments and the use of YouTube A review of technology relation to communication is required
Vehicle lighting – when responders with amber flashing lights are the only ones at the scene or the only lights visible to oncoming motorists, the warning is not motivational/significant enough to reduce motorist driving speeds.	

Note: TIM = traffic incident management; TMC = traffic management centre

The traffic crash management environment can be thought of as a single system. However, it is supported by policies and directives from separate agencies, each focused on one aspect rather than the whole system. Some policies and practices may be incompatible. The Queensland study (Cattermole et al 2015) found frustrations when other agencies' actions at the scene were detrimental to their own agency's requirements. Communication issues related to intra- and inter-agency communication in general, as well as at large incident scenes. For example, one participant noticed another agency choosing a non-optimal route to an incident, but was unable to contact them to correct their decision, so they arrived at the scene 15 minutes later than the other agencies. Cattermole et al considered that, in future studies, it would be useful to map relevant agency policies, regulations and legislation to see how this affects the system.

There are a variety of policies and practices of other agencies that impact on road services. For example, while the decision about which care facility to travel to is made by medical professionals, it impacts on the journey to hospital and must be communicated to road (and/or air) traffic management. There is research, for example, on which patients would benefit from being transported directly to a specialised trauma centre (Candefjord et al 2016) and the importance of national organisations and guidelines. There is also research on improved care at the scene and triage using telematics. These potential interventions have a limited evidence base, but advancements are likely to come from improvements in information sharing (Ray et al 2016).

All participants in the Queensland study (Cattermole et al 2015) suggested communications technology enabling multi-agency communication. In addition to technologies already discussed above, there are some others with future potential to help with scene management.

For example, provision of precise information about modern vehicles would aid swift, safe extrication of trapped victims. Advances in vehicle safety have led to increased use of reinforcing elements in vehicle bodies, meaning average rescue time for new model cars is significantly longer (BMVIT 2011). In Germany, since January 2013, digital rescue data sheets giving specific information about vehicles, such as structure, airbag location and fuel type, have been available to all emergency rescue personnel. Using the licence plate, a rescue data sheet is accessed online. This system can be transferred to other countries as many rescue data sheets are available in multiple languages. The system (DAT FRS, Deutsche Automobile Treuhand Feuerwehr Rettungsdaterblatt System, Fire Rescue System data sheet) is designed to allow integration of the rescue sheets into the European eCall system (OECD and International Transport Forum 2016).

In future, information about the vehicle could be combined with customised information about passengers. Morales et al (2016) developed a low-cost app that allows users to generate information about the vehicle and its usual passengers and allows emergency services to access the information. Information could include type of fuel, a 3D model of the chassis including materials and strengths, security features of the vehicle such as antiroll bars, and health information of passengers. Their tests found the app reduced average rescue time by 14%. There is cross-over with the types of information that might be supplied by AACN.

Another example is the potential for use of unmanned aerial vehicles or drones with next-generation emergency services. Drones have been used in disaster and rescue management (Norzailawati 2016). Their application is expanding into many areas, such as environment monitoring, reconnaissance and surveillance, aerial photography, search and rescue, delivering medical supplies and emergency coordination. Drones currently in development can carry passengers. Examples of use might include: monitoring of roads for problems; surveillance of a crash scene to aid site management; checking the best route through traffic for an ambulance; or an ambulance stuck in traffic sending lifesaving equipment such as a defibrillator on ahead (pers comm, staff at InternetNZ 2017). In such cases, drones would need to be connected to emergency services or RCA communications systems to pass on any useful information. In New Zealand, the Civil

Aviation Authority is considering how to deal with drones, which will utilise that middle space below planes but above the road, and have the potential to cause privacy, security and safety issues if not appropriately controlled and integrated into existing transport and other networks.

2.6 Role of the New Zealand transport sector

The health system and emergency services are key players in New Zealand (and other jurisdictions) in the care of people after a road crash. However, there is a role for road safety agencies, RCAs and Road Policing in facilitation of rescue from road crashes. This includes working with other national and international agencies, and consideration of the use of a range of transport and communications methods and technologies, where these can be supported at reasonable cost. There is also scope for including post-crash response within transport sector strategies and plans in order to achieve goals for safer road travel.

The National Road Safety Committee, serviced by the Ministry of Transport is a group of government agencies with responsibilities for road safety and is the main public sector forum for agreeing, coordinating and communicating high level strategy between agencies on road safety issues. Members include the Ministry of Transport, the Transport Agency, NZ Police and the ACC. Associate members include Local Government NZ, the Energy Efficiency and Conservation Authority, and the Ministries of Justice, Health and Education and MBIE (NZ Government nd). This group developed and is responsible for implementing the Safer Journeys Road Safety Strategy (National Road Safety Committee 2010) and its action plans (National Road Safety Committee 2016). These do not feature post-crash response. There is consideration in the strategy of promotion of vehicle safety systems to consumers with a focus on emerging advanced safety technologies.

The SafetyNet report on post-impact care (2009) praised New Zealand for its setting of specific targets to reduce the number and length of hospitalisations and its prioritisation of improving trauma management systems in its *Road safety to 2010* strategy. As part of the Global Plan for the Decade of Action for Road Safety, governments are encouraged to nominate national focal points to facilitate coordination, information sharing and joint planning at a national level. New Zealand is not listed as having nominated a focal point (WHO nd).

The Ministry of Transport provides expert policy advice to the government and the Transport Agency operationalises transport policy and delivers land transport programmes and activities. One core aim of both organisations is that the transport system is safe (Ministry of Transport and NZ Transport Agency, 2011) driven by a Safe System approach to road safety. NZ Police provide road policing services, including a visible road safety presence. Local government is responsible for developing, maintaining and operating local roads, local planning and road safety works, and has a role in integrated land transport planning.

The Transport Agency is responsible for providing access to the land transport system, national planning and investing in land transport networks, and managing the state highway network. Its activities take in regulating access and use, and providing national activities such as education programmes. A focus on post-crash response would fit within two of the Transport Agency's key goals for the next 10–20 years to: 'Deliver solutions that contribute to improved safety and public health outcomes and reduce environmental harms' (NZ Transport Agency 2017). Objectives under safe transport choices are that people will be able to make smart, safe choices about their driving, vehicles, routes and timing, with success indicators including the percentage of new vehicles with a 5-star safety rating and the number of deaths and serious injuries on open roads. Objectives under safe highway solutions are that highway journeys become safer, with success indicators including a reduction in deaths or serious injuries in crashes on state highways. While the focus is on measures such as safer speeds, post-crash response would align with these goals and objectives.

Two relevant areas where the Ministry of Transport is focused are: investigating and implementing intelligent transport systems; and improving safety across the transport system. New Zealand has one of the highest recorded levels of fatalities per kilometre travelled within OECD countries, and the Ministry aims to reduce the numbers of deaths and serious injuries across the transport system by 20% or more by 2025 (Ministry of Transport 2015). Its road safety policy advice covers the four dimensions of the Safe System: safe roads and roadsides; safe speeds; safe vehicles; safe road use. It would be possible to consider how post-impact care fits within this, for example within improving roads and roadsides, availability of safer vehicles, or adoption of cost-effective technologies that reduce harm.

The *Intelligent transport systems technology action plan 2014–2018* (NZ Government 2014) sets out the government's proposed actions to encourage development and deployment of intelligent transport systems in New Zealand, with the Ministry of Transport leading implementation. Actions include a review of transport regulation to identify unnecessary barriers, exploring uses of transport data, and looking at interoperability of technologies. This plan reviews some of the same technologies discussed above (real-time information when crashes occur, advanced driver assistance systems, unmanned aerial vehicles used for emergency management) without consideration of their uses in post-crash response. The document notes the government's role in:

- monitoring international developments in such technologies and their applicability to the New Zealand transport system
- facilitating demonstration trials to ensure that technologies can operate in New Zealand conditions, and publicise them to potential user
- adopting standards, in conjunction with international forums and bodies, which ensure the widest range of technologies can be used in New Zealand.

2.6.1 Other initiatives

The advent of electric vehicles has produced the necessity to prevent lithium -ion battery related post-crash risks including electric shock and fire. Such dangers could apply to both occupants and rescuers and could impede rescue efforts. Japanese NCAP[14] includes risk of post-impact electric shock in its testing of electric vehicles. It may be worth considering whether inclusion of such testing in the Australasian New Car Assessment Program (ANCAP) would be feasible.

2.7 Linkage to workshop and on-line survey

The review of existing knowledge classified the work done into the following broad categories.

2.7.1 Timely, accurate notification of crashes

How to detect and characterise the problem, notify and dispatch help?

This had the following major components:

- Time to crash identification
- Ability to notify (network coverage/technology)
- Information accuracy (location, severity, patient access issues).

[14] www.beta-cae.com/events/c5pdf/2A_3_ujihashi.pdf Accessed 29 October 2017

2.7.2 Fast, safe travel to and from the crash site

How to assist in swift, safe road and air travel of emergency services and extraction of casualties?

- Time to crash identification
- Ability to notify (network coverage/technology)
- Information accuracy (location, severity, patient access issues)

2.7.3 Working together

What strategies, planning, research and communications activities might support post-crash care?

- Post-crash care in road safety strategies and plans
- Coordination between organisations (policy alignment/data sharing)
- Communications (tools/equipment/internal processes)
- Training/education (agency/public).

These were used as the major inputs to the design of the workshop and the on-line survey.

3 Crash data analysis

3.1 Objective

This was to draw conclusions from existing data, and provide recommendations on improving the post-crash response and data needs related to the post-crash response. To do this, it was necessary to:

- identify data sources with information relevant to post-crash response
- determine methods to link data sources
- produce a dataset of crashes (fatal or serious injury) containing information on the post-crash response
- analyse data and identify any patterns that exist.

3.2 Data collection

3.2.1 Identification of data sources

Several data sources have been identified as relevant to the project objectives, and these are briefly described below. Some of the data sources can be linked by crash, but this is not always necessary to extract useful information about the emergency response.

3.2.1.1 Traffic crash reports (TCRs)

TCRs are completed by an attending police officer at the scene of all road crashes. They record details of the crash including where and when the crash happened, as well as information regarding how and why the crash happened. They are usually accompanied by a diagram showing the assumed movements of vehicles before, during, and after the crash. Sometimes they also contain witness accounts or driver statements.

TCRs are scanned, coded by the Transport Agency and stored in the CAS database. As such, much of the information contained in a given TCR can be obtained through CAS database queries. However, the original documents are still valuable for the written descriptions and diagrams. There is no CAS coding for injury type or details of the post-crash response (eg which hospital the victim was sent to), so the scanned TCRs need to be viewed individually to see if this information has been recorded.

3.2.1.2 Crash Analysis System (CAS)

CAS includes tools to provide access for researchers and other authorised parties to the database of road crashes. The database contains records of fatal, injury and non-injury crashes that have been captured in TCRs (section 3.2.1.1). It is therefore not a complete record of crashes on New Zealand roads, but the incidence of reporting does increase with increasing crash severity, with 100% reporting of fatal crashes. The TCRs are coded into CAS by the Transport Agency including geocoding of location to grid coordinates, and assignment of movement and factor codes that classify these aspects of the crash.

Of particular interest to this study are:

- movement codes that define the principal movements of the vehicle(s) during the crash, eg head-on on straight, lost control turning right, hit driver’s side during U-turn
- factor codes that identify reasons why the crash occurred. These include factors relating to the road user (eg alcohol, unlicensed, inexperienced), driving (eg failed to give way, failed to notice bend, speeding), the vehicle (eg brake failure, tyre blowout), and the environment (eg heavy rain, uneven road surface)

- the street location and time of the crash, which can also be used to link records to other datasets, such as coroner’s findings and media reports
- the grid reference coordinates
- the number of fatalities, severe injuries, minor injuries, and non-injuries involved in the crash (quantified in terms of the number of people whose most severe injury is within that category).

The CAS data on its own does not provide a means of assessing any aspect of the post-crash response.

3.2.1.3 Coroner’s findings

Road fatalities may be referred by the police to the coroner, who, if they have jurisdiction, may then choose to open an inquiry, or alternatively not to investigate the death. The coroner’s role is to confirm the identity of the deceased, determine how they died and what lead to their death. More broadly, the coroner also has a responsibility to the state to identify the factors contributing to deaths and to make recommendations to try to prevent similar events in future.

The Transport Agency provides guidance for coroners in relation to road deaths, with a two-page flier, *Safer journeys for coroners* (NZ Transport Agency 2012). Among other suggestions, the flier states that coronial findings are most helpful when they identify the adequacy and timeliness of the crash response. From our review of more than 100 coronial findings, this suggestion is only occasionally followed. In some circumstances where the coroner does not comment on the crash response, the reason may be that death was instantaneous or unavoidable, but unless this is explicitly stated it is usually not inferable from the text of the findings.

In general, the coroner’s findings on road deaths are a very valuable source of information, with the written findings distilling a large amount of evidence down into a few paragraphs of facts. Typically, the findings detail the time and place of the crash, the personal background (if relevant) of those involved, the activities of the individuals leading up to the crash (often including the reason for the road journey), any relevant impairments of those involved, which elements of the environment and vehicles were factors, and usually the extent and nature of the injuries sustained.

There is a publicly accessible online searchable database of New Zealand Coroners Court findings, hosted by the New Zealand Legal Information Institute (2017). There is no formal categorisation of road fatalities, but many are identifiable using search terms such as ‘car crash’, ‘highway’, ‘road crash’.

3.2.1.4 Media reports

The New Zealand media regularly reports on fatal road crashes and crashes that they consider story-worthy, such as those involving public figures or unusual circumstances. Reporting may be performed by the individual media outlets or come from news agencies such as AP and Reuters.

Media reporting of road traffic crashes often includes sources such as police statements, police interviews, witness interviews, personal observations of the scene and activity, and in the case of non-contemporary reports, coroner’s findings and legal findings.

In the context of post-crash response, media reports sometimes contain valuable information on the nature of the emergency response, especially as this is usually something that can be witnessed, either by the reporter or the public (whereas the crash itself usually has a much smaller set of witnesses available to talk). Occasionally reports will mention the speed of the emergency response, or some other useful information about the response.

3.2.1.5 Serious Crash Unit (SCU) reports

These detailed crash reports are the result of an investigation by NZ Police's SCU. These specialist crash investigators are deployed following the most serious road crashes, which includes all fatal crashes. They perform a forensic analysis of the crash scene based on scientific principles that goes well beyond what a standard TCR will consider. For example, they may perform in situ measurements of road surface skid resistance, and calculate vehicle velocities based on tyre skid marks. These reports will usually be furnished with several photographs, maps, drawings, and witness statements.

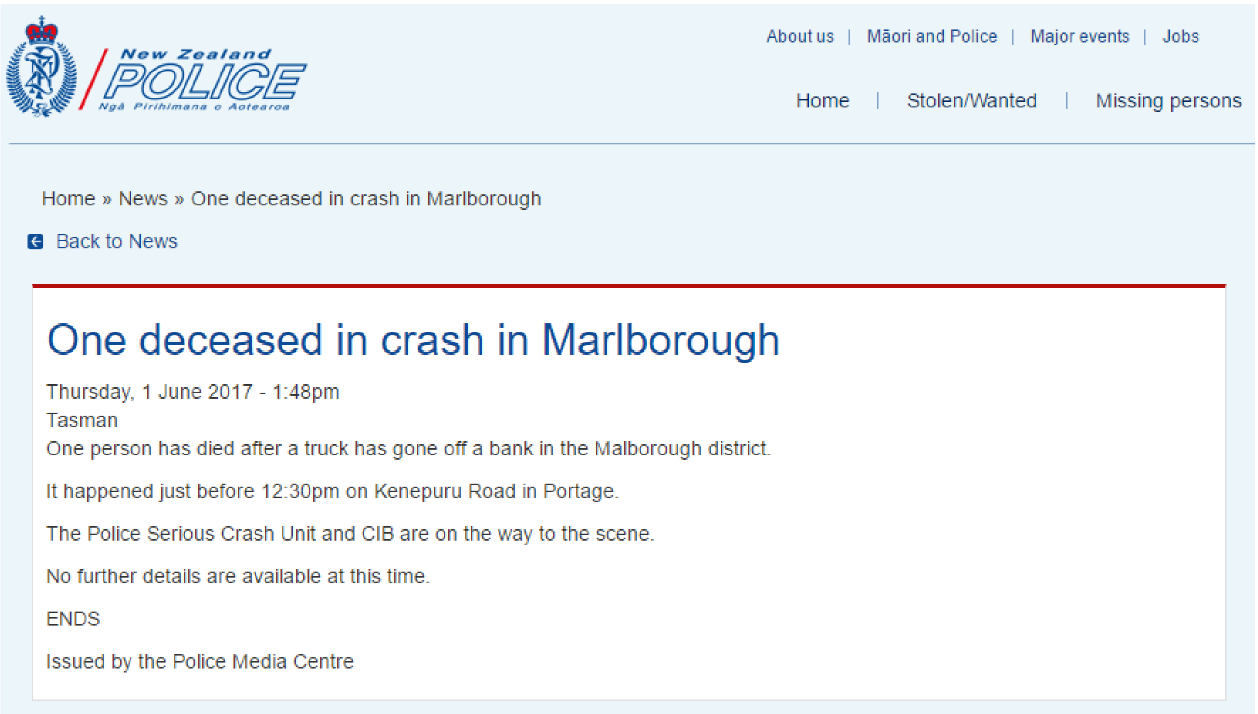
SCU reports are most valuable in determining the cause of crashes, but rarely contain information about the post-crash response. However, the forensic approach is valuable in determining the timing of events, especially in crashes where the victims were undiscovered for some time. There are examples where the SCU scene investigation has been able to determine whether victims exited their vehicles under their own power after a crash, or were thrown clear of the vehicle during the crash.

Selected SCU reports have been consulted for this study, where available.

3.2.1.6 Police Media Centre

The NZ Police maintain a website that provides news and traffic alerts, which include reporting of serious and fatal crashes. Reporting usually includes the location and time of the crash, along with limited information about the nature of the crash and injuries, and often the attendance of emergency services. The crash reports are generally published soon after the crash (sometimes within the hour), while clean-up and investigations are still ongoing. Once police can release the names of any deceased, a separate news report is made.

Figure 3.1 Police media release



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One deceased in crash in Marlborough

Thursday, 1 June 2017 - 1:48pm
Tasman
One person has died after a truck has gone off a bank in the Malborough district.

It happened just before 12:30pm on Kenepuru Road in Portage.

The Police Serious Crash Unit and CIB are on the way to the scene.

No further details are available at this time.

ENDS

Issued by the Police Media Centre

3.2.1.7 Emergency Ambulance Services (EAS) reportable events

The EAS oversees both road and air ambulance services, as well as the ambulance communications centres. As part of their performance and quality management responsibilities they track and perform regular reviews of 'reportable events', which they publish as quarterly reports (Ministry of Health 2017). A reportable event is any incident that results, or could have resulted, in moderate harm, serious harm, or death to a patient as a direct result of the provided health care rather than any underlying condition.

Most of the events identified in these reports are either not related to road crashes, or at least not identifiable as such. Some reports do explicitly state that they involve road crashes, and these can contain information very relevant to the study objectives. In the majority of cases the events are not distinguishable between near-miss incidents and those that led to harm, but the data is equally valuable irrespective of the final outcome.

The reports are anonymised and are not linkable to other datasets.

3.3 Fatal crashes dataset

After reviewing all the available data sources, it was concluded that a dataset could be constructed for fatal road crashes, but that there would be insufficient evidence of the post-crash response to construct a similar dataset for severe injury crashes. The majority of post-crash response information comes first from the coroner's findings, and second from media reports, and severe injury crashes do not receive the former at all, and only sometimes the latter. Police Special Crash Unit reports are also usually only produced for fatal crashes.

3.3.1 Construction of dataset

The fatal crashes dataset constructed for this study consists of a sample of 85 fatal crashes from New Zealand public roads over the last 10 years[15].

The database was constructed in several steps, each of which is described below.

3.3.1.1 Sample of coroner's findings

After reviewing all of the data sources, it was concluded that only the coroner's findings (section 3.2.1.3) and media reports (section 3.2.1.4) contained information on the emergency response. Consequently, the basis of our dataset was the coroner's findings for road crashes over approximately the last 10 years, to which we linked additional data where possible.

Coroner's findings do not represent a random selection of road fatalities. They are a sample of approximately 20 fatalities per year that is biased towards crashes involving multiple fatalities, crashes involving factors that are topical (eg cycle deaths, tourist crashes), and crashes where the cause of death was ambiguous. Findings may also be published several years after the fatal crash. For example, in one jurisdiction the coroner chose to emphasise the risks to cyclists by simultaneously publishing findings for several fatal crashes involving cyclists over the previous five years. Highlighting specific at-risk road users in this way is an important and valuable function of the coroner, but it is not conducive to building an un-biased sample of road deaths.

To maximise the utility of the database we based our sample around the coroner's findings, accepting that this introduced a selection bias, but not one that should influence the outcome of our analysis into post-crash response.

To the extent possible, the qualitative coroner's findings were coded into fields and categories in a fatal crash database (table 3.1).

[15] Over the 10 years up to 2016 New Zealand has averaged 333 road deaths per year

Table 3.1 Coding of coroner's reports into the fatal crash database

Field	Information contained
Coroner's finding title	Surname of deceased, finding ID code, date of finding. Hyperlink to online coroner's finding.
Date of crash	Date of the road crash
Location	Written description of crash location (usually a road name, but sometimes no better than coroner jurisdiction)
Number of fatalities	The number of fatalities due to this crash, across all vehicles
Number of people involved in crash	The number of people involved in the crash, across all vehicles. Usually only the number of people in a vehicle whose occupant(s) died is reported.
Single/multi vehicles crash	Either 'single', 'multiple', or 'unknown'
Place of death	At scene. In (named) hospital at a stated time after the crash. In ambulance.
Nature of the emergency response	Very often this is unknown. If it is likely that the crash was witnessed (urban daytime or multiple vehicles involved) then this is recorded. Any specifics about the emergency response, eg 'ambulance in attendance'.
Speed of emergency response relevant to outcome?	Very rarely described in the report but occasionally possible to infer from injuries, nature of response, and place of death. Where there is any information given this is summarised, and may note the speed of the response, the extent to which the injuries were survivable, pre-existing conditions, delay in hospital care, etc.
Crash factors	These are inferred from the coroner's description of the crash, and occasionally are explicit within the findings.
Possible mitigation	These follow logically from the crash factors and are sometimes suggested by the coroner.
Summary of crash	A one sentence summary of the crash based on the coroner's description of events.

3.3.1.2 Linking to CAS data

A query of the CAS database (section 3.2.1.2) was used to obtain records for all New Zealand fatal road crashes from January 2000 to December 2016.

This dataset was matched with the coroner's report data on a record by record basis, matching on date and location. Where there was ambiguity, either from several possible matches or because of data quality issues (coroner's reports frequently misstate the date of the crash), further identification was possible by comparing CAS movement and factor codes to the coroner's finding crash description and factors. Every record could be linked to a CAS crash ID using this process.

The integration of CAS data within the crash dataset provided confirmation of various entries (such as the number of fatalities and injuries, the vehicles involved, and the suspected crash factors) and some additional information. The CAS time and location data was precise, with time to the nearest few minutes, and location given as distance along a road from a landmark/intersection, as well as a grid reference. The speed limit was also available.

3.3.1.3 Extension with media reports

As discussed in section 3.2.1.4, media reports often provide valuable witness accounts of the post-crash scene and activity. Using the information in the combined coroner and CAS dataset, news stories can be searched for online. The database fields of most use for using as search terms to find a news report on a specific crash, are given in table 3.2 in approximate order of decreasing importance.

Table 3.2 Matching news reports to database records

Information to search/search terms	Primary source
Date of crash)	CAS data
Location of crash (region, street name, landmark)	CAS data, online maps
Victim's name	Coroner's findings
Type of vehicles involved (eg motorbike, SUV, truck)	Coroner's findings, CAS data
Crash descriptions (eg head on, went over bank, caught fire)	Coroner's findings, CAS data
Victim descriptions (eg tourist, drunk driver, celebrity)	Coroner's findings

Identifying media stories and confirming they relate to a given crash was a very time-consuming process. News reports were investigated mostly for crashes where there was already some indication that the post-crash response may have been relevant to the medical outcome.

We also used search terms in internet search engines to try to identify news stories that specifically mention the post-crash response. For example, search terms such as 'ambulance', 'help', 'emergency services', or 'medical care' combined with 'arrived', 'long wait', 'too late', 'slow' retrieved incidents of particular interest to this study.

3.3.1.4 Review scanned traffic crash reports

For most of the crashes in the dataset, electronic copies of the original TCR forms were retrieved. In the clear majority of cases the TCRs provided no addition information relevant to the current study; however, sometimes the extent of injuries was noted. In a few cases the TCRs included information such as whether death was likely to be instant, or the nature of the emergency response (ambulance, helicopter, etc) and the destination hospital. In some cases, SCU crash reports were also viewed, and generally did not provide useful information on the post-crash response, but sometimes indicated whether victims survived the initial impact and whether restraints were worn.

3.3.1.5 Classification of post-crash response

After data had been aggregated across all sources we added a final coding of each crash record to categorise the crashes in terms of the post-crash response (table 3.3). Some of the classifications are objective (died at scene, died instantly), but the most relevant classifications are inherently subjective, and based on very sparse data and descriptions. If aspects of the emergency response could not be identified with any confidence (which is a common situation) then these were coded as 'unknown'. Where there was some implicit indication or weak evidence then a value of 'probably' or 'unlikely' was assigned. Values of 'yes' or 'no' were assigned where this was explicit from the evidence, or otherwise clear.

Note that while the database is structured by crash, the extent and circumstances of injuries are likely to be different for each person involved in the crash, and therefore sometimes there is not a single classification for a crash. In cases where some victims died instantly while others did not, the coding refers to the latter.

Table 3.3 Classifications of post-crash response

Category	Possible values	Comment
Died at scene (objective)	Yes/no/some	'No' or 'some' indicates that at least one victim died after leaving the crash scene.
Died instantly (objective)	Yes/probably/unlikely/no or unknown	If 'no' then at least one victim survived the initial crash.
Crash witnessed (objective)	Yes/no/unknown	'Yes' if the crash was noticed by someone capable of contacting emergency services.
Fast response (subjective)	Yes/probably/unlikely/no or unknown	'Yes' if the speed of response does not appear to have been unusually long. This relies heavily on context.
Response a factor (subjective)	Yes/probably/unlikely/no or unknown	'No' or 'unlikely' if there is evidence or implication that the response did not affect the victim's outcome.
Speed of response a factor (subjective)	Yes/probably/unlikely/no or unknown	'Yes' or 'probably' if there is evidence or implication that the speed of the response could have impacted on the outcome.
Access to scene a factor (subjective)	Yes/probably/unlikely/no or unknown	'Yes' or 'probably' if there is evidence or implication that emergency services had unusual difficulty in accessing the crash scene.
Difficult access to scene (subjective)	Yes/no/unknown	Similar to above, but only considers whether access to the scene was difficult, not whether it was a factor in the outcome.

Where there was additional information relevant to the post-crash response then this was summarised in an additional text field.

3.3.2 Data analysis

The dataset consists of 85 fatal crashes. Of these, six are identified as not being relevant to this study, either because they did not occur on public roads (five crashes, mostly motorsport related), or because the death was not due to the crash (one crash, a heart attack). Therefore, 79 fatal crashes were analysed. A 'fatal crash' is a road crash in which at least one person died within 30 days of the crash, as a result of injuries sustained.

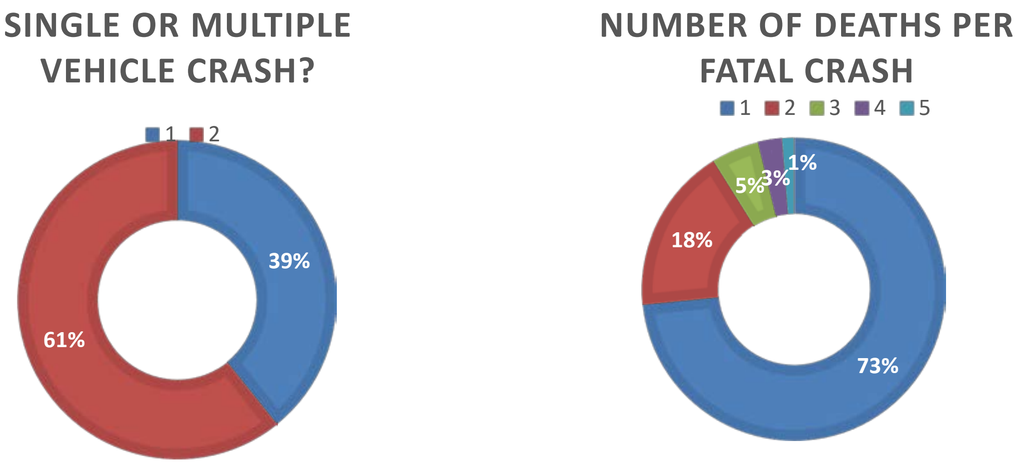
It should be recalled from section 3.3.1.1 that the fatal crashes dataset was largely constructed around the available coroners' reports, and is therefore not a random sample. The proportions given in the following sections may not be representative of the population of fatal New Zealand road crashes. Statistical testing does feature in this descriptive analysis where proportions quoted are the actual proportions in the database.

3.3.2.1 General

Multiple 'vehicle' crashes made up approximately 60% of the fatal crashes in the dataset (figure 3.2 (A)). In this classification, pedestrians are considered separate entities (eg car vs pedestrian is a multiple vehicle crash).

Each crash was further classified with the number of deaths it caused, and the proportion of each classification is given in figure 3.2 (B). In nearly 75% of fatal crashes there was a single death, in 18% there were two deaths, and crashes with three or more deaths made up 9% of the total. It might be expected that the coroner's decision to investigate a crash could be influenced by the number of deaths it caused, and this is borne out by the data. A similar analysis performed on all fatal road crashes in New Zealand between 2000 and 2016 reveals that 90% of fatal crashes had just one death, 8% had two and just 2% caused three or more deaths.

Figure 3.2 General characterisation of fatal crash dataset

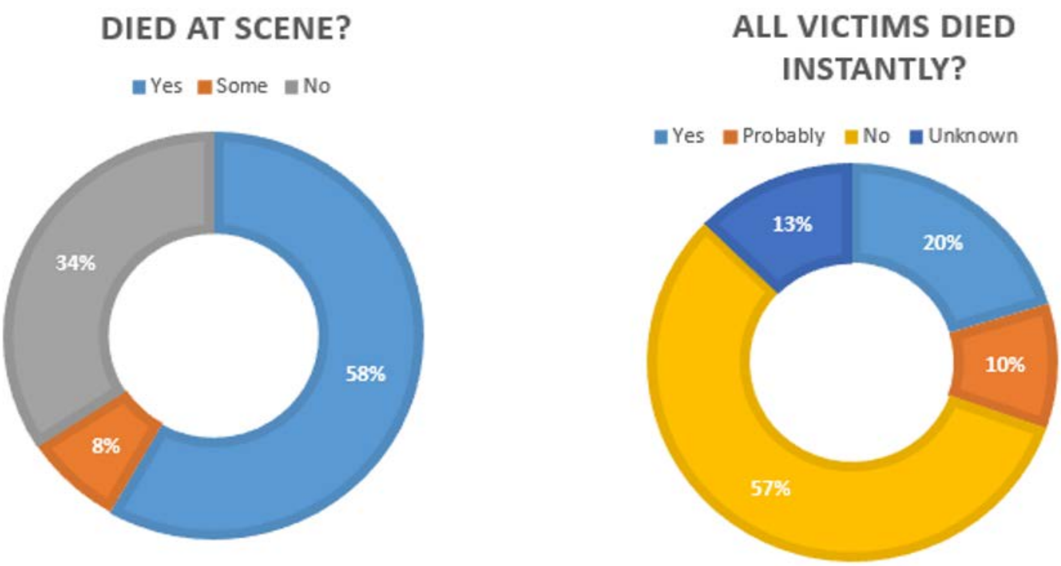


(A) (B)

In the fatal crashes dataset, it was possible to categorise the place of death for all 79 records as being either at the crash scene or not at the crash scene (for example, in hospital, ambulance, or at home). In six crashes with multiple fatalities, some victims died at the scene while others did not, and these are coded as 'some' (see figure 3.3).

Of particular interest to this study is if the victims of each crash died instantly (or very soon after the crash). This classification has been made using information from TCRs, coroners' findings and media reports. Where it is not explicit, some interpretation has been necessary, resulting in classifications of 'probably', 'unlikely', and 'unknown'. In the fatal crashes dataset, 30% of the crashes probably resulted in instant death for all victims, whereas in 57% of the crashes at least one person survived beyond the impact before later succumbing to injury (figure 3.3 (B)). For 13% of the crashes there was insufficient information to decide either way.

Figure 3.3 Place and timing of death within fatal crashes dataset



3.3.2.2 Post-crash response

The post-crash response could not have been a factor in crashes where all deaths occurred instantly or near instantly. Removing these crashes, as well as those classified as 'unknown', from the dataset left 45 road crashes where death was not instant (table 3.4) and the post-crash response was relevant.

Table 3.4 Classification of 45 fatal road crashes where death was not instant

Category	Number of crashes per classification (out of 45)				
	Yes	Probably	Unlikely	No	Unknown
Crash witnessed	40	0	0	4	1
Received a slow response	9	0	4	7	25
Access to scene difficult	5	0	36	0	4
Response a factor	7	2	15	7	14
Response time a factor	6	2	13	9	15
Access to scene a factor	3	0	17	16	9

About 90% of the non-instant death crashes were witnessed by someone who would probably have been capable of calling emergency services[16], including crash victims who were not seriously injured and third parties (this information comes from TCR comments, CAS locations and coroner's reports). Conversely, four fatal crashes (9%) were not witnessed and this is explicit from the evidence.

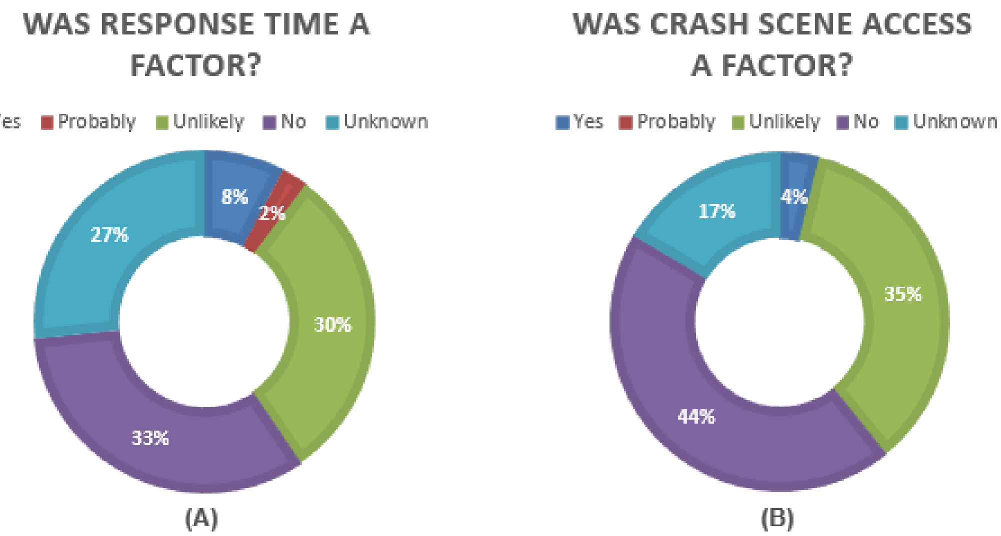
These four unwitnessed crashes clearly did not receive a fast response from emergency services, in addition to five more crashes that were witnessed (second row of table 3.4). The details of these crashes will be considered individually in section 3.3.3. The timeliness of the emergency response was one of the most elusive information in the classification of crashes. The assumption is that a significantly slow response will have been explicitly noted as such by one of the sources.

Similar logic applies where access to the scene is unusually difficult – if this was a significant factor it is likely to have been explicit in at least one of the sources. In total, five crash scenes were identified as being difficult for emergency services to access, and these are discussed individually in section 3.3.3.

The final three categories in table 3.4 are (row 4) whether any aspect of the response, (row 5) specifically the timeliness of the response, or (row 6) specifically the access to the scene were factors in the outcome. These are inherently subjective, but where possible we have relied on expert opinion (usually from the coroner or attending police officer) or witness evidence (as recorded in TCRs, coroner's findings, or media reports) to make the classifications. Aspects of the emergency response were likely to be a factor in nine crashes, with response time a factor in eight and access to the scene a factor in three (see figure 3.4). There is some overlap between the sets.

[16] These crashes all occurred between 2008 and 2016, when mobile phone ownership was common in New Zealand (Statistics NZ 2013), though it is not possible to say with certainty whether a mobile phone or landline phone was available in all instances.

Figure 3.4 Proportion of all studied crashes (n=79) where aspects of the response may have affected the outcome



The reasons for the 8% of crashes where time was a factor and the 4% of crashes where site access was a factor are summarised in section 3.3.4, after a detailed examination of individual crashes in the following section.

3.3.3 Case studies of crashes where the post-crash response was a factor in the outcome

The following eight case studies follow from the fatal crashes identified in the previous section, where either the timeliness of the response, or access to the crash scene, was deemed to have potentially affected the victims' outcome. The exact crash locations have been omitted deliberately and none of the crashes were in urban areas.

Fatalities: 1	**Place of death: Air ambulance**	**Witnessed: Yes**
Factors:	Difficult access to scene, timeliness of response	
Crash description:	Motorcyclist crossed the centre line and collided head-on with car in opposing lane at approximately 6.50pm.	
Post-crash response:	An ambulance with paramedics and a doctor quickly arrived at the scene. The doctor determined a rescue helicopter was needed due to the severity of injuries. The helicopter arrived at 8pm but victim's condition (pneumothorax) had deteriorated such that he was unable to be flown above 500 m, so the decision was made to transfer by ambulance to the local hospital, 30 minutes away, and continue treatment en route. From that hospital a second helicopter was used to transport the victim to a major hospital, and it was on this helicopter the victim died at 10.45pm.	
Summary and recommendation:	Initial access to the scene was without issue, but access for the type of assistance that the victim needed (a swift extraction to a major hospital) was complicated by the remoteness and high altitude of the crash scene. It is not clear what could have been done to improve this situation.	

Fatalities: 1	**Place of death: At scene**	**Witnessed: No**
Factors:	Timeliness of response	
Crash description:	A drunk driver drove off the road and ended up upside down in a ditch filled with water, and was not discovered until the following day.	
Post-crash response:	The crash occurred late at night and was not discovered until a member of the public noticed the car at 10.30am the following morning. The crash itself may have been survivable, but the victim was immersed in water.	
Summary and recommendation:	It is possible that a better outcome would have occurred if the crash had been witnessed and emergency services contacted. On-board car telemetry systems could warn authorities of a heavy impact or a vehicle overturning.	

Fatalities: 1	**Place of death: At scene, from injuries**	**Witnessed: No**
Factors:	Timeliness of response (probably)	
Crash description:	A man drove over edge of steep slope on a twisty road, his car rolled down a long bank and was only discovered the following day by chance.	
Post-crash response:	The crash occurred late at night in a nature reserve and the body was not discovered until the following day. Evidence suggests that the victim was able to climb free of the wrecked car before succumbing to injury some time later.	
Summary and recommendation:	It is possible that a better outcome would have occurred if the crash had been witnessed and emergency services contacted. On-board car telemetry systems could warn authorities of a heavy impact or a vehicle overturning.	

Fatalities: 3	**Place of death: At scene, from injuries**	**Witnessed: No**
Factors:	Timeliness of response (probably)	
Crash description:	Four teenagers in a car, drunk and driving very fast, left the road on a bend and rolled into a tree. Wreckage found several hours later upside down.	
Post-crash response:	At least one occupant survived the initial impact but was unable to call for help (unconscious). Occupants spent two to three hours upside down in the car before being discovered early the next morning and emergency services called, but three victims had already died. It is possible a faster response could have saved more victims.	
Summary and recommendation:	It is possible a better outcome would have occurred if the crash had been witnessed and emergency services contacted sooner. On-board car telemetry systems could warn authorities of a heavy impact or a vehicle overturning.	

Fatalities: 1	**Place of death: At scene, from drowning**	**Witnessed: Yes**
Factors:	Timeliness of response, difficult access to crash scene	
Crash description:	Car lost control on sudden change to gravel (in 100 km/h zone) and went into the river, where the driver drowned before he could be extracted.	
Post-crash response:	Witnesses tried to rescue the man, who was stuck underwater, but were not able to get him out in time. By the time the man was extracted by emergency services it was too late.	
Summary and recommendation:	It is unlikely the outcome would have been different unless, by very fortuitous circumstances, suitable rescue equipment was extremely close to hand. It is not clear what road network improvements could have facilitated this.	

Fatalities: 1	**Place of death: Hospital, of injuries**	**Witnessed: Yes**
Factors:	Timeliness of response	
Crash description:	A nine year old girl walked into the path of a motorcycle.	
Post-crash response:	The crash was witnessed and the initial response was a single paramedic. There were some failures in assessing the extent of the victim's shock. An ambulance and helicopter were later dispatched, and the victim taken to Rotorua hospital by air. Later review has determined that an ambulance would have been preferable (to continue treatment en route), that Waikato hospital was more suitable for treating the patient's specific injuries, and that time at the scene should have been 15 to 20 minutes rather than the 45 minutes it actually took.	
Summary and recommendation:	The emergency response was not optimal and it is possible this contributed to the outcome. Timeliness, on-scene decision making, and choice of transport to hospital were identified as factors, which are likely to have already been considered by ambulance services in their review. It is unlikely the road network influenced these factors.	

Fatalities: 1	**Place of death: At scene, of injuries**	**Witnessed: Yes**
Factors:	Timeliness of response	
Crash description:	A drunk man and his friend in a land cruiser lost control and crashed.	
Post-crash response:	Witness called 111 but got no answer, so called other first aiders. Local firefighters and ambulance arrived reasonably promptly, and then a helicopter was called. The man died while waiting for the helicopter and it was suggested his outcome might have been better had he been transported by ambulance.	
Summary and recommendation:	The emergency response was potentially slowed by the lack of response to a 111 call, and the decision to airlift has been questioned. It is unlikely the road network directly contributed to either of these factors.	

Fatalities: 1	**Place of death: At scene, of injuries**	**Witnessed: Yes**
Factors:	Timeliness of response, difficult access to scene	
Crash description:	Motorcyclist ran wide in a corner and crashed into a fence post.	
Post-crash response:	Witness dialled 111 from mobile phone (after travelling to find reception). Emergency services took 1.5 hours to reach the scene after being given the road's colloquial name which was not recognised by the computer system. Dispatchers initially sent a helicopter and ambulance to an area 100 km to the south. The victim died before help arrived. The coroner stated the error might have resulted in a 20-minute delay, but this was unlikely to be the difference between life and death in this case.	
Summary and recommendation:	Mobile phone coverage may have improved since the crash, but was critical in this case in reporting and then locating the crash scene. The use of a colloquial road name was not handled effectively by the dispatch computer system (although there was also human error) and this may be an aspect the Transport Agency could assist with.	

3.3.4 Additional case study not related to post crash response

In addition to the previous case studies of post-crash response, we have identified an additional incident where the quality of the response was relevant, but only prior to the crash, which was fatal. This has not been included in the post-crash database, but is presented here because the findings apply generally to emergency response to incidents on the road.

Pre-crash response:	The victim had called 111 from a mobile phone at least twice prior to the collision to report that he was drunk and disoriented and walking along a dark highway. Witnesses in passing cars also reported to the police that a man was walking along the highway and leaping out in front of cars. His first call was dropped between the Telecom Emergency Exchange and the Police Communicator. His location was subsequently narrowed down to somewhere within a 15 km long section of SH1 and a police officer dispatched, but the man was struck shortly before the officer arrived. It appears the injuries sustained were not survivable.

3.3.5 Findings and conclusions

It is notable that most of the crashes identified in section 3.3.3 (having a sub-optimal post-crash response) occurred on rural roads.

3.3.5.1 Un-witnessed crashes

In three cases the crash was not witnessed and was not discovered until it was already too late for the victims, who otherwise may have had a better outcome. This is a situation that is much less likely on urban roads or state highways, where traffic is higher and there are more residents to witness the crash or come across the scene in a timely manner. In the full fatal crash dataset there are an additional three unwitnessed crashes, all of which were on rural roads:

- A severe crash in a remote location, the car caught fire (probably on impact). It is unlikely the outcome would have been different even if the crash had been witnessed.
- A severe crash in a remote location, the car hit a tree at speed, probably killing all five occupants instantly. The car was not discovered for several days.
- A scooter crash late at night on a rural road near Hastings. The body was not discovered until 3am, and it is unknown whether the crash was survivable.

Therefore it appears, aside from any other risk factors they introduce, remote and rural roads present an additional risk of a crash going undiscovered until it is too late to help the victims. It is not clear how this situation could be improved without the use of an in-car telemetry and emergency communication system, such as the eCall system the European Union is planning to implement on all new cars from 2018 onwards.

3.3.5.2 Remote location

In a further three cases the crash was witnessed and an attempt made to contact emergency services, but the remoteness of the location contributed to the poor outcome. While it appears to be generally accepted that crashes in remote areas will take longer to respond to, in these crashes the remote location contributed to an abnormally poor response.

In two crashes 111 was not immediately contactable, either because they did not answer the phone call or because there was no mobile phone reception at the scene. In both cases this led to a delay in help arriving at the scene, but in one of these cases it was further complicated by the emergency services being unable to locate the scene due to their computer system not recognising the colloquial name for the road. In the remaining case the nature of the victim’s injuries prohibited extraction by helicopter, but the crash scene was far from the nearest hospital with appropriate facilities.

Providing ubiquity of mobile phone coverage across the entire road network would be an obvious mitigating step, and it is likely that coverage has greatly improved since many of these crashes occurred. GPS locating systems (such as the eCall system) may also have been beneficial in some cases.

3.3.5.3 Mode of transport to hospital

In three crashes, two of which were remote, there may have been crash scene management or injury assessment issues that led to a sub-optimal choice of transport to hospital. In two cases the coroner stated that using an ambulance to transport the patient to hospital, although taking longer, would have allowed paramedics to continue treatment en route. In the third case airlifting was initially considered too dangerous to be an option, and it is less clear what the solution could have been given that urgent treatment was required.

The information that ambulance transport was preferred in all three cases may be relevant for the Transport Agency, in that it cannot be assumed helicopters can replace ambulances for all callouts where road access is difficult.

3.3.5.4 Factors absent from dataset

There are some factors that were expected but were not cited in the source material for the fatal crashes dataset. It was anticipated there would be some evidence of slow response times from ambulances, either where the ambulance was stuck in traffic, where ambulance resources could not keep up with demand, or where the scene was particularly remote. Notwithstanding the remote crashes discussed in section 3.3.4.2, which were problematic for additional reasons, the slow arrival of emergency services was not explicitly mentioned in the source documents. There was also little evidence to suggest that the emergency response to major crashes was particularly weak; in contrast to the findings from the EAS reportable events data analysis (section 3.4.4).

3.3.5.5 Additional findings

There is additional information within the dataset that does not relate directly to post-crash response, but suggests areas for improvements that might reduce the need for emergency services to respond.

- Tourists were involved in at least 12 of the 79 fatal crashes studied (15%), which contributed 24 of the total 111 deaths in the dataset (22%). This is a seemingly high proportion of crashes, and a very high proportion of the deaths. In crashes involving a tourist the average is two deaths per crash, whereas in crashes not involving a tourist it is 1.3 deaths per crash. It is noted that these proportions are subject to selection bias (sections 3.3.1.1 and 3.3.2.1) and that no causality is implied. Coroners have also remarked on the apparently high number of tourist road deaths, and called for more to be done to research, and ultimately reduce, these fatalities.
- The coroner explicitly noted that safety belts were not worn in 9 of the 79 crashes (11%), and it is possible the actual number was higher (restraint usage is usually recorded in TCRs but was not tabulated in CAS output). In several cases the coroner considered the outcome would have been much better had restraints been worn, and this was borne out in crashes where those wearing safety belts remained inside the vehicle and survived, in grim contrast to the unrestrained passengers. It is notable that three out of the nine crashes where unworn safety belts were a factor also involved tourists, suggesting this is an area of education that could be improved.

3.4 Emergency Ambulance Services ‘reportable events’

The ambulance service ‘reportable events’ records are available online (Ministry of Health 2017) and contain reportable events and near misses for St John and Wellington Free Ambulance (WFA) where an investigation has been completed.

3.4.1 Locating and compiling data

The National Reportable Events Policy (Health Quality and Safety Commission 2012) is a recent initiative[17], and therefore data is only available for the period 2013 to 2016. Road traffic crashes are not specifically identified within the reports, but sometimes relevant keywords are mentioned, so some road traffic injuries have been identified using the following search terms (where * denotes a wildcard):

*crash, accident, collision, car, truck, *bike, *cycle, pedestrian, road*

A dataset of reportable events has been compiled from the reports explicitly referring to road crashes. The dataset contains only eight records for the four-year period, but the information provided is highly relevant to an analysis of post-crash emergency response.

3.4.2 Classification of events

We have added a final coding of each report record to categorise the events in terms of their impact (or potential impact) on the post-crash response (table 3.5).

Table 3.5 Classifications of reportable events

Category	Possible values	Comment
Impact on victim	Delayed care, insufficient care, [or both], none	The impact of the event on the victim. In the current dataset this was a delay in medical attention or insufficient medical attention or both.
Contributing event	Delayed arrival, under resourced at scene, [or both], N/A	The event that impacted on the victim's care. In the current dataset this is either the late arrival of a service, or an inadequate level of service at the scene.
Cause of event	Misidentified severity, resource management, [or both], unknown, N/A	The cause of the event, as determined from the 'root causes' field of the event reports. In the current dataset these can be summarised as either a misidentification of the incident severity or urgency, or a failure of resource or asset management.
Location where impact experienced	At scene, In ambulance, at hospital, other	The location where the event caused the negative (or potentially negative) impact.
Mode of response	Ambulance, air, other [named] unknown	The primary mode of emergency response, if known.

3.4.3 Data analysis and findings

A dataset of EAS incidents relating to road crashes has been constructed and coded for factors of relevance to post-crash response (see section 3.4). Table 3.6 is a summary of this dataset, showing all records and the most relevant fields.

[17] In June 2017 this policy was revised and renamed the National Adverse Events Reporting Policy 2017 (Health Quality and Safety Commission 2017).

Table 3.6 Road crash-related reportable events from the ambulance service

ID	Year	Event summary	Impact on victim	Contributing event	Cause of event	Mode of response
1	2016	Crew slow to arrive at helipad to respond to road crash.	Delayed care	Delayed arrival	Unknown	Helicopter
2	2016	Ambulance attends road crash en route instead of designated incident.	None	N/A	Resource management	Ambulance
3	2016	Road crash not identified as a major incident, causing delays for seriously injured patients.	Delayed care, Insufficient care	Under resourced at scene	Misidentified severity	Ambulance, Helicopter
4	2016	Road crash with multiple serious injuries was under resourced.	Delayed care, Insufficient care	Under resourced at scene	Misidentified severity	Unknown
5	2016	A senior clinician was near a major road crash and not used, delaying the arrival of a resource to provide advanced care.	Delayed care, Insufficient care	Under resourced at scene	Resource management	Senior clinician
6	2016	Ambulance staff were exposed to methamphetamine while treating a patient after a motor vehicle crash.	None	N/A	N/A	Ambulance
7	2015	Delay in responding to a fatal road crash involving nine patients.	Delayed care, Insufficient care	Under resourced at scene	Misidentified severity, Resource management	Ambulance
8	2013	Ambulance dispatch entered job as non-urgent, but was in fact car vs. pedestrian with serious injury.	Delayed care	Delayed arrival	Misidentified severity	Ambulance

Of the eight reported incidents related to road crashes, two are not relevant to this study. Incident 2 involved dispatch of an ambulance to an urgent ‘unknown’ incident, with the ambulance instead attending a road crash that it encountered en route. Incident 6 involved exposure of ambulance staff to a methamphetamine at a crash scene.

The remaining six incidents all resulted in a delay in providing care to road crash victims[18]. In four of these incidents there was apparently also an inability to provide the desired level of care to all patients. Note that these two factors can be related, for example both can result from insufficient medical personnel at the scene.

Of the six relevant incidents that resulted in a delay in providing care to some or all victims, only two were directly due to the late arrival of emergency services. In incident 1 the reason for the delay is unknown, and in incident 8 the reports cite a misidentification of the severity of the crash as the reason. The remaining four incidents (3, 4, 5 and 7) were apparently responded to in a timely manner, but for various

[18] The absence of reportable events other than those resulting in a delay is notable. This may be an accurate representation, but could also be an artefact of the way in which the data was retrieved (ie the search terms used to extract road crashes are more likely to pick up events where the place of origin of the medical emergency was important to the event, therefore highlighting delays). However, it is noted that delays in responding to emergencies do make up a majority of the non-road-related reported events as well.

reasons were under resourced, which resulted in delays providing the appropriate level of care to every victim. Each of these four incidents relates to a major road crash with multiple victims and severe injuries.

Looking deeper into the causes, a misidentification of the severity of the emergency is cited on four occasions, and poor resource management blamed on two occasions (including incident 7, which includes both as causes). In general, the misidentification of severity appears to be fundamentally a consequence of a communications failure between scene management and the ambulance communications centre.

In a broad sense, it is notable that of the thousands of ambulance service responses to road crashes each year, only one or two per year have been explicitly identified as reportable events. Considering those incident reports collectively, a picture arises that suggests major crashes stress the emergency response system to a far greater level than other incidents. Four of the six reportable events identified as relevant were major crashes with multiple casualties, but the information about the severity of the crash was somehow lost between the responders at the scene and the dispatchers in charge of allocating resources. Consequently, the resourcing at the scene was insufficient, which resulted in a delay in providing adequate care to some patients.

The EAS reportable events include recommendations and any remedial actions taken. From these we have identified several recommendations that are common to multiple events in the dataset, or which would appear to apply across several events relating to road crashes:

- Review major incident standard operating procedures.
- Implement major incident training for dispatchers, including following up on missing information.
- Ensure stronger management involvement within the communications centre.

Recommendations identified by EAS that are particular to one or two reported events and are relevant to road crashes include:

- Introduce a national air desk with oversight on dispatch of helicopters.
- Provide 24/7 availability of a clinical support officer in communications centres.
- Provide satellite phones for use in remote areas.
- Improve computer-aided dispatch systems to include national (non-local) resources.

3.4.4 Conclusions

From the analysis of ambulance service reportable events a pattern has emerged that indicates a vulnerability to major crashes. Between 2013 and 2016 six reported events had a negative impact on road crash victims. Of these, four events involved the response to major crashes with multiple victims and severe injuries. In all four there was a communication failure between the scene management and the dispatcher in identifying the scale of the crash, resulting in the scene being under resourced, leading to delays in medical care to some of the crash victims.

The EAS has itself identified recommendations for each reportable event. We have summarised the key recommendations relating to road crash events as follows:

- Review major incident standard operating procedures.
- Implement major incident training for dispatchers, including following up on missing information.
- Ensure stronger management involvement within the communications centre.

3.5 Possible future actions

Analysis of the fatal crash dataset compiled for this study leads to the following conclusions and recommendations.

3.5.1 Improve data on post-crash response

Existing data on the timeliness and effectiveness of the post-crash response is lacking, despite the Transport Agency's previous efforts to improve this situation. It is recommended the Transport Agency consider:

- reminding coroners of the Transport Agency's interest in and usage of coronial findings, particularly as they relate to post-crash response
- reinforcing their interest in the post-crash response and victims' injuries to the police officers responsible for completing TCRs
- investigating data sharing between the Transport Agency and Ministry of Health (particularly the EAS) so that the outcomes of non-fatal road crashes and the quality of the post-crash response can be better investigated.

3.5.2 Identified weaknesses in the post-crash response

The dataset, which consists of 79 fatal crashes, included eight crashes where the timeliness of the response was identified as a factor in the outcome, and three crashes where access to the crash scene was identified as affecting the outcome. Most of these crashes occurred in rural environments, with many in particularly remote locations, far from hospitals. Of the nine crashes where the post-crash response may have affected the outcome:

- Three crashes were not witnessed by anyone able to call emergency services and as a result the victims did not receive any medical attention at all. A measure that would reduce the likelihood of this situation is an in-car emergency communications system, such as the planned European eCall system.
- Three crashes were in very remote locations, directly contributing to a slow or compromised response. Ubiquitous mobile-phone coverage would assist here, as would GPS locating systems similar to eCall.
- Three crashes were identified where the mode of transport to hospital was possibly not optimal, and in all three cases it was considered that ambulance rather than helicopter would have enabled treatment of injuries en route to hospital. It therefore cannot be assumed that helicopters can replace ambulances for all callouts where access by road is difficult.

3.5.3 Emergency Ambulance Services

For the EAS, several recommendations for road crash response follow from their own event reporting:

- Review major incident standard operating procedures.
- Implement major incident training for dispatchers, including following up on missing information.
- Ensure stronger management involvement within the communications centre.

It is accepted that these actions are not incumbent on the Transport Agency; however, it may be appropriate for the Transport Agency to work with the EAS to ensure the best possible post-crash response is provided to road users.

4 Accessibility of crash sites to hospital trauma services

4.1 Introduction

This chapter looks first at the accessibility of the sites of 276 fatal road crashes occurring in 2016 in terms of emergency services travel time to the crash. Three quarters of the crashes occurred on rural roads (> 70 km/h speed limit), with the remainder occurring on urban roads.

The analysis uses the point locations of crashes (from CAS) and Ministry of Health supplied locations of ambulance stations and helicopter rescue bases to estimate by GIS processing the distance and travel time from the nearest helicopter and land ambulance rescue services to the crash site.

For helicopter rescue, straight line distance was used and road distance was used for land ambulance services. Helicopter or air rescue flight time was estimated using a cruising speed of 212.5 km/h based on the average cruising speeds of the helicopters of Auckland Rescue Helicopter Trust and Westpac Rescue Helicopter. Seventeen helicopter rescue providers and 130 land ambulance e stations were included.

This analysis is subject to the following approximations and is thus indicative rather than precise.

- All ambulance journeys are assumed to begin at an ambulance station. This was not always the case.
- Ambulances using their sirens to gain priority are not considered.
- The analysis does not consider rescues that use both air and land modes.
- The analysis uses a global average speed for land rescues and thus does not allow for temporal variations, congestion etc.

4.2 Travel by air and land rescuers to the crash site

Table 4.1 presents descriptive statistics on the time taken and distance covered from base to crash site for air rescue and land rescue.

Table 4.1 Descriptive statistics: distance and travel time of rescue for road crashes

Descriptive statistic	Road type	Air rescue		Land rescue	
		Distance base to crash site (km)	**Time base to crash site (min)**	**Distance station to crash site (km)**	**Time station to crash site (min)**
Mean	Rural	49	14	14	12
	Urban	23	6	8	10
Standard deviation	Rural	35	10	10	7
	Urban	22	6	14	13
Median	Rural	42	12	12	10
	Urban	14	4	4	6
Maximum	Rural	166	47	74	45
	Urban	97	27	68	68

For air rescue, on average, the estimated mean flight time from the base to the crash site was 14 minutes for rural road crashes and six minutes for urban road crashes.

For land ambulance rescue the estimated mean road travel time from the station to the crash site was 12 minutes for rural road crashes and 10 minutes for urban road crashes.

The median distance for both air and road rescue was lower than the mean distance for both urban and rural crash sites. This indicates a positive skew in the distributions. This was especially evident in the case of urban road crashes. The same can be said for times.

Overall, the results confirm that crash sites are more accessible to ambulance services in urban areas than in rural areas. The differences between land rescue and air rescue may relate to the much greater number and geographical spread of ambulance stations and the possibility that cases warranting a helicopter turnout may be more serious.

4.3 Travel from crash site to hospital door

The same methods cannot be readily used for the journey to the hospital door from the crash site. These journeys are more complex. There are 20 major trauma hospitals where road crash patients may be taken. Of these, seven are tertiary major trauma hospitals where the most serious cases are taken.

It is not possible to make a meaningful call from the crash data whether a case would go to a tertiary hospital or not and around 20% of all trauma cases are taken to a hospital and then transferred to another one.

To get an idea of times to the first hospital (but only for all trauma cases, not just road crash victims) we can use the figures from the *2015–2016 Annual report* of the Major Trauma National Clinical Network (2017b).

The figures show that with some relatively small regional differences overall 55% of patients reach their first hospital in one hour and 87% within two hours. Given that around 20% are then transferred, this means in approximately 20% of cases the time to the final destination hospital is much longer, This can amount to a delay of many hours[19].

The Major Trauma National Clinical Network is working to reduce these figures and the transport sector can assist by acting to avoid congested travel conditions through active cooperation between the RCA, Road Policing and emergency services to minimise any disruption to travel times related to the crash and to where possible to prioritise the travel of the emergency vehicle.

4.4 Conclusion

The crashes considered above were fatal indicating that at least one victim could not be successfully rescued.

Overall, the results confirm that emergency transportation rescue and trauma hospital services are more accessible in urban areas than in rural areas.

Given the already long travel times related to some crashes, there is clearly a real need to avoid congested travel conditions through active cooperation between the RCA, Road Policing and emergency services to minimise any disruption to travel times related to the crash itself and where possible to prioritise the travel of the emergency vehicle.

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[19] Pers comm, Professor Ian Civil

5 Input from stakeholders and emergency service personnel

5.1 Introduction

The views of those they would be working with represent an important input to the role the transport sector might take in future post-crash care. These are sector stakeholders, emergency services managers and frontline emergency service staff.

Stakeholder and manager input was obtained by holding an interactive workshop involving members of the project steering group, representatives of sections of the health sector interested in post-crash care and operational managers from St John, Fire and Rescue New Zealand and Road Policing.

Front-line staff input was via an on-line survey of staff from St John, Fire and Rescue New Zealand and Road Policing.

5.2 Stakeholder workshop

5.2.1 Purpose and methodology

The purpose of the workshop was to:

- assist in prioritising this research based on expert input about existing gaps within New Zealand
- ensure any recommended actions were practical, achievable and complementary to existing practices
- understand and share different inter-agency needs and perspectives.

The workshop attendees included representatives of the government transport sector (the Transport Agency, Ministry of Transport), emergency services (St John, NZ Fire Service, NZ Police) and health sector agencies (National Ambulance Sector Office of Ministry of Health, Auckland District Health Board, Auckland University Faculty of Medical and Health Sciences, Northern Region Trauma Network, Major Trauma Clinical Network).

Road Policing, while listed above as an emergency service is also an active member of the government transport sector.

The workshop procedure gave a background on the key points of international and national findings from the existing knowledge review, as well as updates on the state of practice in New Zealand from the stakeholders who were attending. This was followed by two interactive sessions to identify gaps, prioritise areas of importance and discuss relevant, practical, complementary solutions.

5.2.2 Priorities in New Zealand

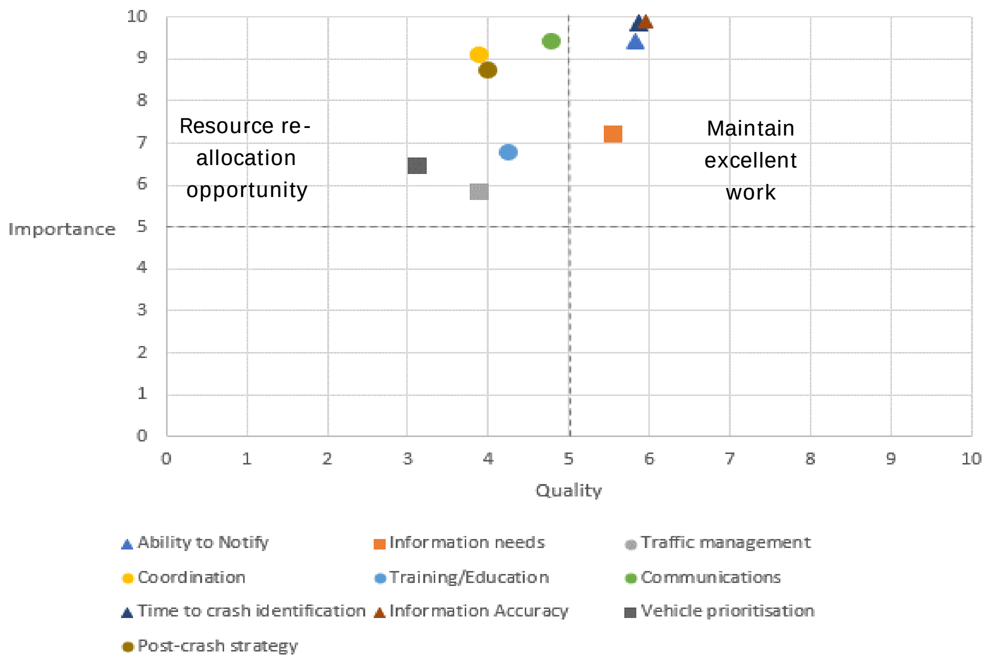
For the purposes of the workshop, the areas that were discussed and evaluated were broadly grouped into three categories with some underlying qualities (see table 5.1).

Table 5.1 Service areas and service quality categories

Broad service areas	Service qualities (with some examples)
Timely, accurate notification	Time to crash identification
	Ability to notify (network coverage/technology)
	Information accuracy (location, severity, patient access issues)
Fast, safe travel	Information needs (route planning tools/information to public/digital rescue data)
	Emergency vehicle prioritisation (prioritised lanes/signals "green wave"/access for helipad locations)
	Traffic management (police and RCAs/technology/smart motorways)
Working together	Post-crash care in road safety strategies and plans
	Coordination between organisations (policy alignment/data sharing)
	Communications (tools/equipment/internal processes)
	Training/education (agency/public)

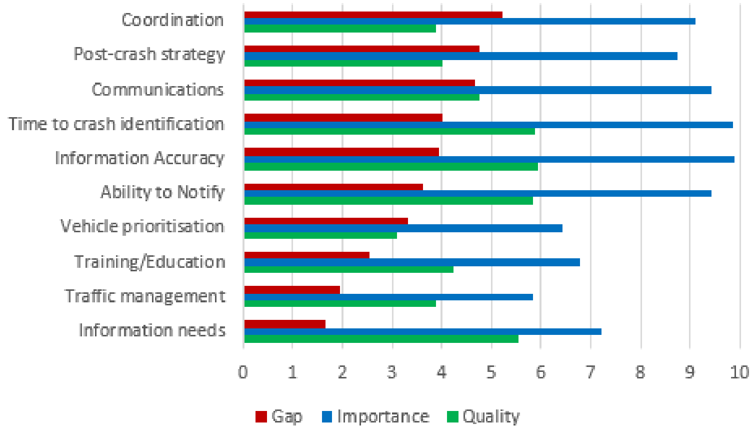
The workshop was split into two break-out groups for an interactive session to discuss the three broad service areas. In each break-out group, stakeholders wrote two numbers (each between 0 and 10) on a coloured post-it note and placed it on a matrix. The first number indicated the importance (higher numbers indicated a greater ability to save lives). The second number indicated the quality of the existing service in New Zealand. The results for each service area were discussed within the group and then between the groups. The resulting priority matrix (see figure 5.1) was shown to help focus more in-depth discussions among workshop participants. The perceived gap between importance and existing quality of delivery (calculated post-workshop) also enabled a ranking of the services (see figure 5.2). Based on the gap analysis, coordination, post-crash strategy and communications were three critical areas to improve.

Figure 5.1 Priority matrix for indicating importance and existing quality of services



Ability to notify was recognised as primarily a technology-based area in terms of poor network coverage, and that other ongoing programmes of work were already working towards this (such as the Mobile Black Spot Fund and Rural Broadband Initiative run by MBIE (nd).

Figure 5.2 Service qualities ranked by the perceived gap between the importance and existing quality of service (from largest gap to smallest gap)



5.2.3 Timely, accurate notification

Timely, accurate notification was clearly identified as the most important area (generally scored as a 9–10) in terms of the ability to reduce serious trauma, with its three factors ranked as the most important.

For time to crash identification, the number of crashes that are not identified quickly may be quite small, but the issue is important, as the consequences in terms of the impact and preventable trauma are high.

In terms of accuracy, participants noted that identifying the physical location of a crash was sometimes a challenge. The actual call location was recognised as a key issue in terms of identifying an accurate crash location (even though the process of address verification with first responders was robust, the first responder information was sometimes inaccurate). This was viewed as very important, as there was a need to mobilise the 'right resources the first time, based on the right information'.

In discussion, workshop participants generally agreed that time to detect and respond was the most critical category. Time to intervention was more crucial than time to get the person to hospital. However, time was not the only factor; it was also about getting the right resources and skills to the right place.

To summarise the detailed discussion, there was a need to:

1 Identify new ways to improve time to crash identification (and monitor the success of this).

2 Coordinate with partner agencies already working on removing black spots on the network (in terms of post-crash needs) and identify interim solutions.

3 Identify better methods to verify crash addresses.

5.2.4 Fast, safe travel

The qualities of fast, safe travel were generally ranked at a quite neutral level of importance, and were also the lowest in terms of the gap between importance and quality. In terms of the detailed discussion, there was a need to:

1 Improve emergency vehicle prioritisation and the engineering of control devices that can improve access to the crash location were probably the most relevant (especially in urban locations).

Meeting participants noted that, of emergency calls to crashes, the majority needed transport (and 38% did not need to be transported).

5.2.5 Working together

The largest gaps between importance and current delivery quality all came in the working together group, indicating this could be a fertile area to promote.

Overall, inter-agency communication was ranked third equal out of 10 in terms of importance, which included elements like data sharing and policy alignment (to ensure different agencies were not working against each other in certain situations). Training and education were ranked as least important here (although coordinated agency training was seen as more important than training for the public).

The more detailed discussion revealed that, overall, agencies did have common underlying goals, but there was a need to:

1. Develop a joint inter-agency vision together
2. Close the gap between the intent to coordinate and the capability (for example, there is an intent to share data, but the systems and tools are currently incompatible)
3. For the transport-based agencies (the Transport Agency, Ministry of Transport, RCAs), move from working together (which is in the overarching strategy) to operationalising key actions and resources to work together
4. For the health and emergency services sector agencies, consider transport agencies in working towards a wider set of stakeholders around decision making (ie for strategy and post-crash care interventions).

5.2.6 Possible actions

The workshop was split into three break-out groups for another interactive session. Participants were asked to rate options for possible changes to support post-crash response. They were asked to consider the effective potential and value of each option, and the practicality of implementation in New Zealand, and invited to add other new suggestions.

5.2.6.1 Timely, accurate notification

There were two options in this category that rated top with participants. One was to build traffic incident watch capability with road agency staff, police patrols and professional drivers. The other was to ensure that responders are equipped with good communications and GPS capabilities to give accurate location data. For instance, currently ambulances have GPS, some fire engines have GPS, otherwise they use maps on a tablet and draw on local knowledge.

Another option that rated highly for value and effectiveness, but lower for practicality of implementation, though this might be addressed over time, was to investigate options for an ACN. A fourth option that rated well was providing detection and surveillance capabilities for locations across the road network with high incident rates or locations such as tunnels (eg software alerts, CCTV). This was considered of lower value now, but expected to be of high value in future.

In summary, options that rated well were:

- traffic incident watch capability
- good communications and GPS capabilities.

Options that rated well, and may rate increasingly well for the future, were:

- ACN
- surveillance capability for locations on the road network.

5.2.6.2 Fast, safe travel

In this category, the highest rated option was to use lane management systems with electronic signage for the creation of emergency lanes, for isolating a crash site, for managing speed reduction, and for informing other travellers. Next highest rated option was implementing traffic management to prioritise emergency vehicle response, particularly traffic signal pre-emption methods to ensure emergency vehicles receive a green phase through lights. Participants considered that its benefits would be faster, safer travel, particularly in urban areas, while the barriers would be funding and consideration of wider network effects.

Participants also liked the idea of introducing digital rescue data sheets with online information about cars (eg structure, security measures) or even information customised by individual travellers (eg vehicle modifications, age and medical conditions of usual occupants). These would be available to emergency responders to aid extraction of victims. However, workshop participants found it difficult to assess this option. If it was effective, it might be relatively easy to implement.

In summary, options that rated well were:

- lane management systems
- traffic signal pre-emption to prioritise emergency vehicles.

An option that may rate increasingly well if more were known about it was:

- digital rescue data sheets.

5.2.6.3 Working together

The highest ranked option in this category was participation in multi-agency, inter-disciplinary training in post-crash response, which received full marks for effectiveness and value. Participants considered that the barriers to this were money and time, but argued that training to standards of practice needed to be part of agency strategies so that such training activities would have to take place. This contrasts with the first session on priorities for New Zealand, where training and education were ranked as a less important priority, showing that there were some differences of opinion across the break-out groups.

This next highest ranked option was the recommendation to include post-crash response in agency strategies and plans, establish targets for improvement, collect and analyse data to inform actions, and measure and evaluate results.

Workshop participants also liked four other suggestions from the list, and considered all of these to be essentially one recommendation on working together across agencies (incorporating: reviewing transport policies, practices and regulations for compatibility with other relevant agencies; ensuring interoperability of communications/IT; maintaining strong working relationships with emergency services and other agencies to ensure rapid exchange of information; and considering ways to strengthen coordination between agencies). Incompatible practices and policies mentioned by participants included speed bumps on roads slowing emergency vehicle progress, and conflicting procedures, for example at the scene where safety might require the lane to be closed while RCAs might want to clear the road as soon as possible. This emphasis on the importance of working together aligns with the findings from surveys and interviews with Queensland emergency responders (Cattermole et al 2015).

Participants considered that a common view of outcomes across all agencies would be a huge step in the right direction. In respect of working together, the workshop participants pointed out projects relevant to this field. They mentioned a Ministry of Health project underway on rural first response, a recent review of Prime (Primary Response in Medical Emergencies) by the Ministry of Health, NZ Police looking at network communications when out in the field, and a review underway of the emergency call system managed by

Spark. For larger incidents, they thought coordination could be expanded to embrace the Ministry of Civil Defence and Emergency Management, and the New Zealand Defence Force.

An example of where a change in policy can affect the road network is the new major trauma triage policy (Major Trauma National Clinical Network 2017a). This is activated when a patient meets the criteria to be transported to hospital for major trauma and is transported to the closest appropriate medical facility for life saving treatment. This has changed where patients are transported. Other policies, such as for burns treatment, may change or increase transport around the country. There is also increasing use of air transport every year. Auckland, Wellington and Christchurch communications centres are using increasingly intelligent systems for triage etc.

In summary, options that rated well were:

- multi-agency, inter-disciplinary training
- including post-crash response in agency strategies and plans
- cross-agency working together.

5.2.7 Further discussion

The workshop discussed the aim of reduction in social cost stemming from road crashes. As some of the participants were from a health services background, there was discussion of the triple aim: improve the patient experience of care (quality, safety, satisfaction); improve health and equity for populations; with best value for resources.

Many participants noted the key differences between urban and rural crashes, which present different issues and need to be considered differently. For example, a green wave of lights allowing fast passage of emergency vehicles is most relevant in a congested city area. The longer the time to reach a rural crash, the more important the role of bystanders and first responders in providing crucial first aid on scene and on route, ie maintaining an open airway for a patient.

5.3 On-line survey of frontline emergency workers

5.3.1 Survey procedure

Two surveys (version A and version B) were provided to staff from St John, FENZ and Road Policing members of NZ Police. These surveys were sent using internal email lists and focused on staff that would be more likely to have post-crash experience. The two versions differed only on a minor point of wording. Version A, sent to St John, asked how strongly respondents thought improvements would ‘lead to reduced harm or death’, whereas version B (sent to FENZ and NZ Police) questioned how strongly they thought improvements would ‘lead to reduced harm or improved life safety’. These differences were to better align the questions to the internal cultures of the three organisations involved in the survey.

The content of the surveys was designed to mirror the ‘broad service areas’ used in the earlier stakeholder workshop (see table 5.1).For each of these thematic categories (phrased as timely, accurate notification of crashes; agencies working together; efficient, safe travel to and from crash sites) three ranking questions were asked, followed by an open-ended question as to what was one thing the respondent would like to see done to improve the respective category. Finally, respondents were asked an open-ended question as to what had already been done, in any category that had resulted in improvement (see appendix A for a full description of the questions).

5.3.2 Respondent characteristics

A total of 433 useable responses were received from all agencies[20]. NZ Police and St John accounted for the majority of respondents (respectively, 46.2%, N = 200, and 35.6%, N = 154), while FENZ were 18.2% (N = 79) (see figure 5.3)[21].

Job roles were predominantly first responders and communications (80.8% and 19.2%, respectively, N = 433) (see figure 5.4). Taking the agencies separately, 99.4% of St. John respondents were first responders with 0.6% communications; N = 153 and N = 1, respectively, 98.7% of FENZ respondents were first responders with 1.3% communications; N = 78 and N = 1, respectively and 59.5% of NZ Police were first responders with 40.5% communications; N = 119 and N = 81, respectively.

Experience relating to emergency response to crashes also tended to be high, with 61.0% of respondents declaring more than 10 years' experience (N = 264), and 16.6% with between 6 and 10 years' experience (N = 72). 20.4% of respondents had between one and five years' experience (N = 97) (see figure 5.5).

Figure 5.3 Organisational affiliation

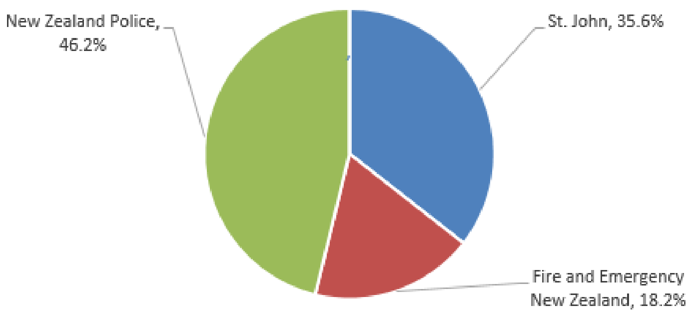
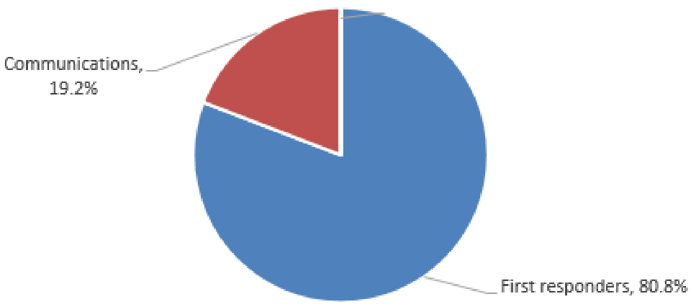


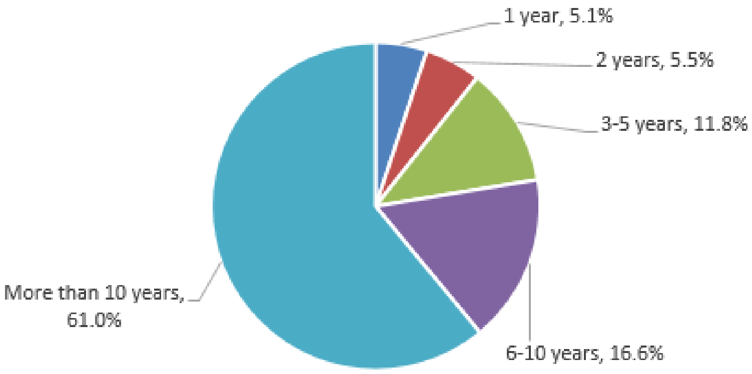
Figure 5.4 What best describes my main role in an emergency response to crashes



[20] There were 131 responses excluded based on a high rate of missed entries, consistent identical scores, or all extreme (ie 10) scores on at least 7 out of 9 ratings.

[21] For subsequent rating and content analysis, two responses were excluded due to being from 'other' organisations (Westpac Rescue Helicopter Trust, Auckland Rescue Helicopter Trust) – although their qualitative responses were reviewed.

Figure 5.5 Years of experience with emergency response to crashes



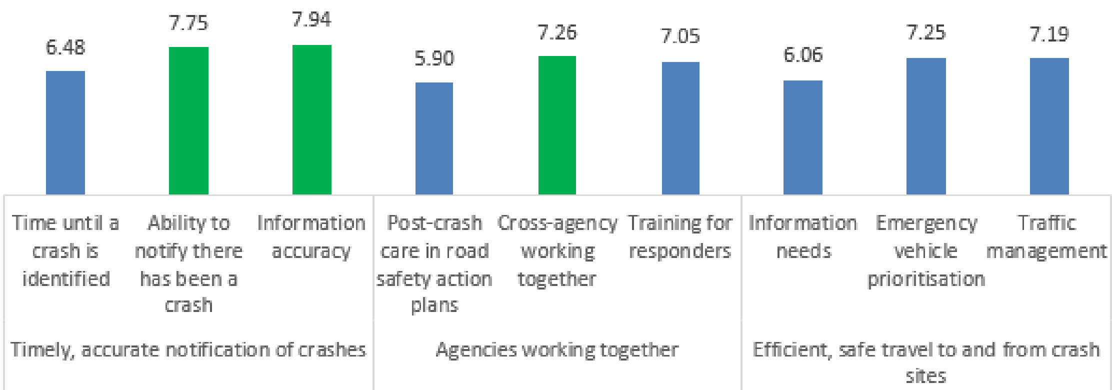
5.3.3 Rating interventions

5.3.3.1 Overall

Three thematic categories of rating-scale questions were put to respondents. These were; ‘timely, accurate notification of crashes’ (category 1); ‘agencies working together’ (category 2); ‘efficient, safe travel to and from crash sites’ (category 3). See appendix A for a full description of the questions. The categories were chosen for their potential for transport sector participation after input from the previous workshop.

Within each category, respondents were asked how strongly they thought an improvement would lead to ‘reduced harm or death’, or ‘reduced harm and improved life safety’ on an 11-point Likert scale (from 0 = low, 5 = moderate, to 10 = high). Three options for improvement per category were put forward for rating (see figure 5.6). All categories received high ratings by agency staff, with the minimum mean rating of 5.9 on ‘post-crash care in road safety action plans’ (still a better than ‘moderate strength’ rating). As the rating related to whether improvement would lead to reduced harm, or improved life safety in the future, this meant that overall the respondents judged all categories could still be improved.

Figure 5.6 Overall mean ratings per category and strength of improvement (on a scale 0–10; with the top three ranked items denoted in green)



The top three options rated for strength of intervention were ‘information accuracy’ (M = 7.98, SD = 2.06), ‘ability to notify there has been a crash’ (M = 7.75, SD = 2.10), and ‘cross agency working together’ (M = 7.26, SD = 1.98) (denoted in green on figure 5.5). ‘Emergency vehicle prioritisation’ came very close to third (M = 7.25, SD = 2.23).

In each category the least effective, lowest strength interventions were 'time until a crash is identified' (M = 6.48, SD = 2.49), 'post-crash care in road safety action plans' (M = 5.9, SD = 1.77), and 'information needs' (M = 6.06, SD = 1.97). Notwithstanding receiving the lowest scores, however, all three exceeded a score of 5 on the scale, still denoting judgements that greater than 'moderate strength' improvements are possible.

5.3.4 Between group differences

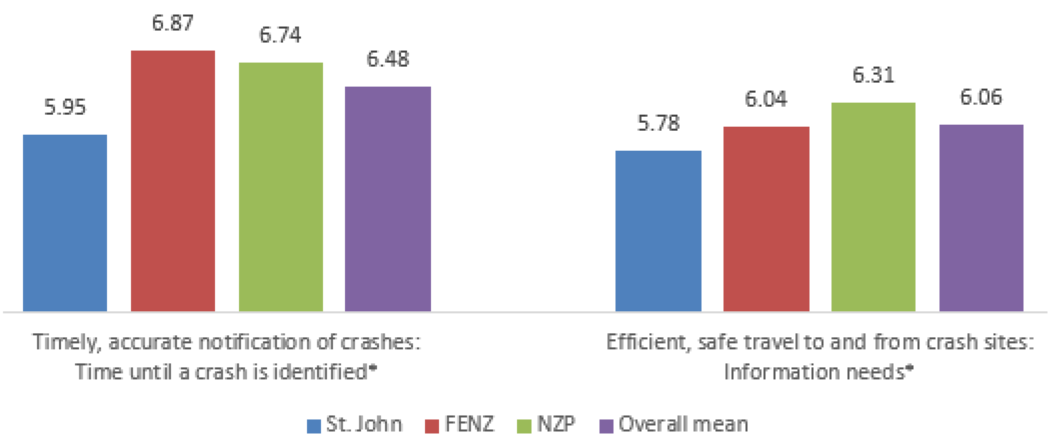
5.3.4.1 Between roles

A preliminary comparison was made between respondents who identified as 'management/ strategy' and 'other', and front-line respondents (first responders and communications). An independent means T-test indicated a significant difference only on the question of 'time until a crash is identified', with 'management/ strategy' and 'other' respondents rating this a higher strength intervention than front-line staff (M = 7.48, SD = 1.97 versus M = 6.48, SD = 2.49) (t [464] = -2.61, p = .024). Subsequently the 'management/ strategy' and 'other' responses are excluded from analysis due to having been represented in the earlier stakeholder workshop. There was no significant difference in scores between first responders and communications.

5.3.4.2 Between organisations

On the questions of 'time until a crash is identified' and 'information needs' significant differences between organisations were observed in the responses given by St John, FENZ and NZ Police staff (as determined by one-way ANOVA, per question respectively, F [2, 430] =5.726, p=.004 and F [2, 430] =3.525, [=.030) (see appendix B). Figure 5.7, denoting where a significant difference was detected, shows the mean score per organisation, compared with the overall mean score.

Figure 5.7 Mean response score per emergency service compared with overall mean (*p<.05)



In all organisations, respondents rated intervention as better than 'moderate strength'. In relation to 'information needs' St John gave a slightly lower than average score (-.28 difference score) while NZ Police gave a higher than average score for the strength of intervention (+.25 difference score). However, in context of an 11-point Likert scale this difference can be considered minor.

In relation to 'time until a crash is identified', however, differences can be considered more noteworthy. St John respondents gave a lower than average score (-.53 difference score), whereas FENZ and NZ Police gave higher than average scores (+.39 and +.26, respectively). These differences are reflected in the later qualitative analysis where both FENZ and NZ Police respondents were more likely to raise concerns about arriving later to crash scenes, not from their own slowness but from late or imperfect notification.

> *A recent example I attended was highly likely to turn into a crime scene yet police were very slow to be notified of the details of the crash and only once a single officer arrived late in the scene were police notified that this was a significant crash that required more resource.*
>
> *Frequently FENZ do not seem to arrive until after Police, Ambulance and frequently even tow trucks!! (Particularly in the cities).*

5.3.5 Qualitative responses

5.3.5.1 Coding responses

Respondents answered open-ended questions at four points during the surveys; once each after the respective thematic categories: timely, accurate notification of crashes (category 1); agencies working together (category 2); and efficient, safe travel to and from crash sites (category 3). The fourth open-ended question was asked at the end of the survey. The first three questions asked what was one thing the respondent would like to see done to improve the respective category, while the fourth asked what had already been done, in any category, that had resulted in improvement (see appendix A).

From the initial pool of 433 respondents, a random selection from each of the three main groups was made (40% from each of St John, FENZ and NZ Police respectively, N = 62, N = 32, N = 79). Inclusion in this sample required having completed at least two out of four of the qualitative questions (excluding ‘I don’t know’ type responses). Response rates across this sample, and per question were 91.2% (timely, accurate notification of crashes), 76.4% (agencies working together), 75.5% (efficient, safe travel to and from crashes), and 73.7% (what is something that has already improved). This resulted in 551 completed, written responses.

These 551 responses were then coded against each of the nine detailed questions (see appendix A) by an expert evaluator. Two additional code categories were added (other, and no response, respectively). Where a high number of responses were coded to a particular category (>20%) these were subsequently reviewed for where more detailed coding would extract insight. This resulted in eight additional categories, subclassifying aspects of ‘information accuracy’, ‘cross-agency working together’, and ‘emergency vehicle prioritisation’, and a 9th for policy-related responses.

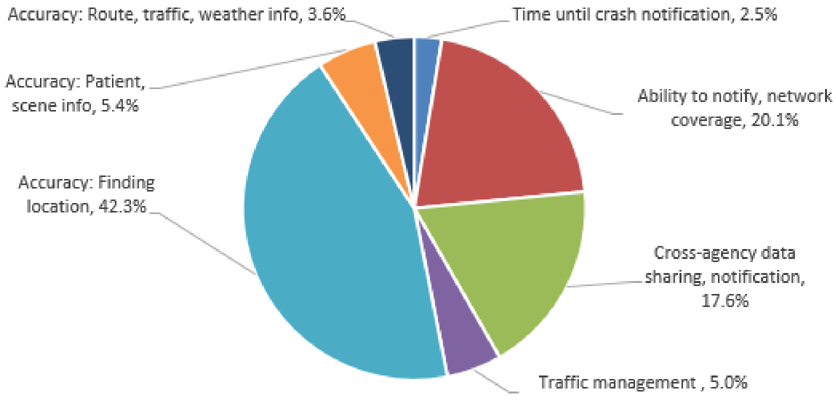
5.3.5.2 Thinking about timely, accurate notification that a crash has occurred

In category 1, respondents predominantly recommended ‘information accuracy’ improvements (51.2%, see figure 5.8). Within this were ‘accuracy of patient or scene information’ (5.4%), ‘accuracy of route information’ (including traffic and weather; 3.6%), and 42.3% focused specifically on accuracy regarding finding the crash location:

> *We are often sent to a crash when the location provided is completely incorrect.*
>
> *Often rurally, [people calling in crashes] don’t know where they are.*
>
> *Accurate location is a big thing. A lot of time is wasted finding the crash because of inaccurate details obtained from a very distressed caller.*

Suggestions focused on closer cooperation with national telecommunications providers, so GPS coordinates could be automatically forwarded to both communications and first responders when emergency calls were made. This was particularly because people calling 111 did not know how to extract the GPS coordinates from their phone. Thankfully these concerns should be assuaged to a large extent by the recently introduced Emergency Caller ID system described in section 2.3.5.

Figure 5.8 Response to 'timely, accurate notification a crash has occurred'



Where 'cross agency data sharing, notification' featured in 17.6% of responses, these tended to focus on the sharing of accurate information, including quicker relay of information. Respondents from both NZ Police and St John saw room for improvement in police/ambulance communications, including timeliness and quality of the information sharing:

> *The information passed to us is often limited and with a time delay, this has been up to half an hour...*

Improved communication could speed police arrival at crash scenes. FENZ respondents had similar communication concerns about their own ability to arrive promptly at a scene.

In terms of the quality of information, communicating details such as the severity of the crash and crash location would also help inform the appropriate level and type of resources required for a safe, effective crash response.

Comments regarding the 'ability to notify there has been a crash' (20.1%) centred around problems of communications coverage in rural locations, recommending wider coverage of cellular and radio networks. The 2.5% of responses which focused on 'time until crash notification' suggested improvements to rural communication networks and the use of automatic collision detection in vehicles. With regards to traffic management (5.0%), NZ Police wanted both better warning to public vehicles of the existence of crash scenes in rural locations, and:

> *Quicker response from road crews to block/divert and sign roads, so that Police can be freed to attend the actual scene rather than stand on cordons for sometimes hours.*

5.3.5.3 Thinking about agencies working together

The second thematic category (see figure 5.9), 'cross agency working together' (56.2%) saw respondents cite problems coordinating multiple services, including the earlier mentioned delays in notifying of crashes. Within this was a desire for better cooperation and a clearer chain of command at crash scenes (19.7%):

> *All responding services [need to] know each other's roles and assist each other where appropriate. Particularly in remote rural areas.*

The need for better information sharing between services was a common theme, including the request for common communications between agencies (16.8%); more accurate information sharing between agencies (7.3%); and more information sharing in general (12.4%):

We need to have a shared communication stream between ALL agencies during road trauma events. Communication delays are chronologically large because we all use independent radio systems.

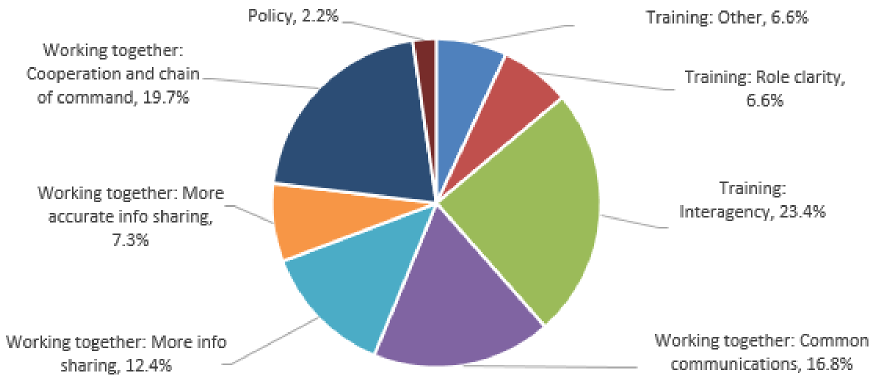
Victims get asked to repeat the incident by each multi agency which can become frustrating for [them].

It would be helpful to be able to communicate directly with crews in other emergency services. There is often considerable delay in relaying messages through the various communication centres.

A single centralised emergency services communications centre, rather than multiple centres, was a common recommendation. Other recommendations included sharing GPS locations so that first responders can better coordinate, and harmonising technical terms between services:

More of a universal vernacular/language used, ie 'status of patient', 'sitreps'

Figure 5.9 Response to 'agencies working together'



Comments regarding training accounted for 36.6% of responses. These were predominantly requests for more interagency training (23.4%) in general, then for training focused on clarifying the first responders role at a multi-agency scene (6.6%); better understanding of other agencies' procedures and capabilities was seen as beneficial. Meanwhile 'other training' needs (6.6%) included more advanced trauma first aid training requested by NZ Police for the rural policing teams, and:

Council/construction staff to be emergency first aid trained as if they are the first on site, this may help keep a victim alive until ambulance can arrive.

Training in human factors and driving under pressure to ensure responders do not add to the problem - i.e. that they travel to the scene, approach the scene and park at the scene in a calm careful and composed manner.

Finally, policy-related remarks (2.2%) suggested crash scene safety be raised in priority over maintaining traffic flows, and recommended emergency services be consulted more in transport infrastructure design:

Median barriers are great for preventing further harm to drivers however create issues for us gaining access when we need to be on the opposite side of the road, maybe more places we could turn to gain quicker access.

5.3.5.4 Thinking about efficient, safe travel to and from the crash site

'Emergency vehicle prioritisation' accounted for 51.4% of comments in the third thematic category (see figure 5.10). Most mentioned was the need for public education (20.1%) to help the public react appropriately when confronted with emergency vehicles – giving way or slowing and pulling over so emergency vehicles can pass. Multiple respondents observed that the public would often act confused, especially at intersections, or give way but in a dangerous manner likely to cause another crash. In other comments members of the public did not give way on the open road, forcing emergency vehicles to overtake at high speed:

> *...Public education programme (TV/newspaper Campaign) that targets road users in what to do in the event of an emergency vehicle under lights travelling up behind them. Slow, pullover and let past at the first and safest opportunity.*

> *In Germany as part of your road [code], new drivers learn how to position their car if they hear emergency services on a motorway. This clears a motorway in minutes. We need to teach drivers in their practical driving license test more about emergency vehicle prioritization, safe travel and scene safety at an accident.*

> *Public awareness to move to the left when an ambulance is behind. For major crashes, digital signage could indicate – keep fast lane clear, ambulance approaching etc.*

> *I believe that Korea has an emergency signal that 'bleeds over' all radio channels to alert drivers of emergency vehicles; this would work well and could be inter agency wide.*

Other comments under emergency vehicle prioritisation were the need for dedicated lanes for emergency services (16.0%). Congestion was given in multiple responses for delays in both emergency services and associated traffic control and support services reaching a crash scene:

> *Priority access lanes on motorways as they clog up very quickly sometimes which adds 5-10 minutes to response times.*

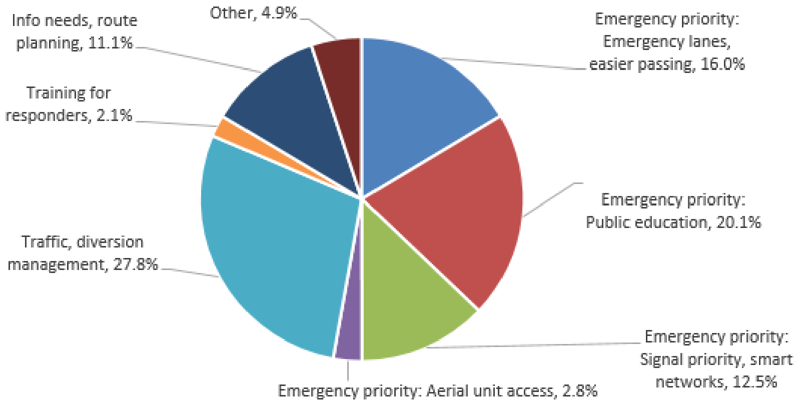
> *...Big gains will be with non-emergency vehicles - tow trucks, traffic control etc. Canterbury has been placing these on the motorway north at peak times to facilitate a quicker response to a crash and this has delivered good results.*

Further suggestions relating to 'signal priority, smart networks' (12.5%) included smart traffic signals to stop all other traffic moving through intersections, therefore giving priority to emergency services – especially so they did not have to travel through an intersection against the current flow of traffic (through a red light). Providing priority for traffic control and towing vehicles was also seen as beneficial, 'as they currently do not have any legal recognition', which led to their being delayed. Smart networks were seen as a method by which to prioritise emergency services, and warn other road users of their approach:

> *Smart traffic signals would help first responders get to the crash a lot faster and would improve safety for first responders on their way to the crash as they would not have to go through red traffic lights.*

'Other' emergency vehicle priority responses (2.8%) commented on the need for 'better resourced helicopter evacuations', and 'better aerial access to remote areas', including the suggestion that more medical facilities needed provision for aerial units to land.

Figure 5.10 Response to ‘efficient, safe travel to and from the crash site’



Comments regarding ‘traffic, diversion management’ (27.8%) centred on the need for quicker despatch of traffic management services, and recommended greater use of smart signs – especially temporary use of smart signs around crash scenes by roading contractors:

> *These signs only ever seemed to be used for major incidents such as flooding or weather events. For instance, once notified by Police Comms, TOC[22] should locate nearest signs and display a warning.*

> *Faster response of traffic control to areas needing diversion. Front line responders are often caught up with directing traffic rather than either being at a scene or patrolling to prevent further incidence.*

> *Better and more detour routes available. In Northland, detour routes are often either non-existent, miles out of the way, or winding metal back roads that cause more crashes. Heavy motor vehicles are a real problem for this also, and often end up just parked up until the road can be cleared.*

> *Fire and Emergency NZ and the Police do not have the gear to do traffic management, this creates a very dangerous scene for us first responders.*

Some friction was also cited with local officials and council over detour choices – a conflict between the needs of the crash response teams and the immediate safety of the site versus overall transport efficiency. Additional training was recommended for local officials and officers to help them better understand crash scene dynamics and first responder needs.

Accounting for 2.1% of comments, ‘training for [first] responders’ was seen as beneficial – for example, with more electrical vehicles in use, two respondents commented the need for additional training on how to make them safe at a crash scene, and ‘I understand earth straps are required before we even attempt to effect rescue which we do not have’. ‘Other’ comments (14.9%) included a request for ‘stretchers that could perhaps accommodate child car seats’, ‘use of drones to get medical supplies to crash sites’, and generally greater consultation with emergency services in infrastructure design:

[22] Traffic Operations Centre

Median barriers are great for preventing further harm to drivers however create issues for us gaining access when we need to be on the opposite side of the road, maybe more places we could turn to gain quicker access.

5.3.5.5 What has already changed for the better

On the final open-ended question (see figure 5.11), when asked 'what is something that has already changed in your organisation (or a partner organisation) that you think improved life safety outcomes', 45.1% of comments focused on 'cross agency working together'. These were predominantly general comments regarding improved inter-agency cooperation. Specific, positive improvements were then the introduction of a database ('better linking ambulance, fire, and police to send event notifications'), and in one jurisdiction, creation of a TOC with ability to update first responders as a situation changed. Comments by FENZ and St John respondents were particularly positive about closer cooperation between their services:

Working together with the Fire Service has dramatically improved patient outcomes, whether in a resuscitation scenario, or in assisting us to move seriously ill obese patients.

Having fire department attend our code purples (cardiac and respiratory arrest) as they normally arrive before us and resuscitation is well under way by the time we get there. Thus better chance of a more positive outcome.

It is interesting that this contradicts other concerns about FENZ arriving after the others.

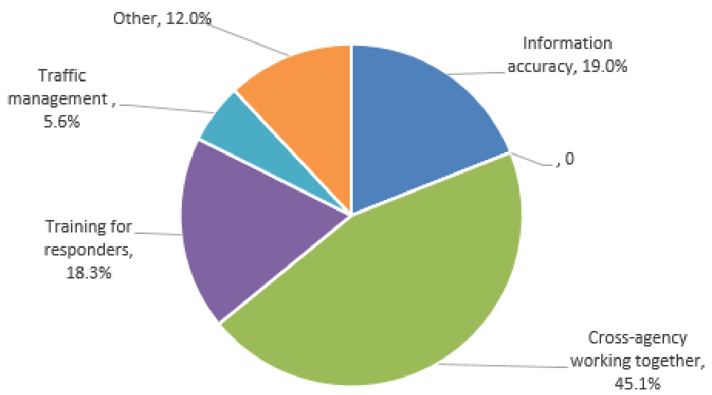
FENZ respondents were positive about having received this training and being able to provide support to St John, especially where FENZ sometimes had resources closer to a scene. And closer cooperation was seen as both generally beneficial by respondents from all services, and as giving specific benefits:

More open relationships between the services, joining together for familiarisation of equipment and service strengths and weakness.

The Police - practically in the Wellington District now work in closely with TOC. We now have direct communications with their centre - which has camera's available to assist in updating us as we are heading to an incident.

Multiple respondents also commented on a greater focus on crash victim needs and priorities, with less focus on conflict between which service has control of a scene ('rather than fighting between ourselves as to who has control etc, we work together, which is far more efficient').

Figure 5.11 'What is something that has already changed?'



'Information accuracy' related comments (19.0%) tended to focus on the introduction of a portable call location to help identify 111 callers' probable locations, increasing use of 111 callers' GPS location through their mobile phone, and improving capture of electronic data for sharing with other services: Again, these concerns may now be lower owing to the recent introduction of the Emergency Caller ID system in New Zealand.

> *[We have] better access to technology via iPhones to be able to take photos, access Google maps and facetime other units if necessary.*

'Training for responders' comments (18.3%) included an increased emphasis on health and safety within the services 'paying off' with better safety at crash scenes. More first aid training particularly was a frequent comment (eg fire crews training as medical first responders), including:

> *Advanced first aid training for Police Highway Patrol staff who are more likely to come across crashes involving life threatening injuries as they usually work in areas with high speeds.*

Positive 'traffic management' (5.6%) improvements included NZ Transport Agency Canterbury placing non-emergency support vehicles (such as tow trucks and other traffic management resources) at strategic locations during peak times to facilitate quick response to crashes ('they don't have to try and make their way through the resulting congestion from the city'). Skill levels and more qualified staff in traffic management (eg 'qualified in Traffic Controller Basic and STMS[23]') were also seen to have improved. 'Other' comments (12.0%) included the perceived benefits of the Safer Journeys programme, better equipment for FENZ and NZ Police (eg FENZ being equipped with defibrillators, NZ Police patrol cars being equipped with 'really good well stocked first aid kits'), and general infrastructure improvements. These general infrastructure improvements included a greater use of road-centre barriers to separate flows of traffic (reducing crashes), and other policy initiatives, such as:

> *Rostering to risk on certain highways at certain times of the day/night and if weather changes.*

> *The crash section which attended most of the crashes. Staff were trained in this area, and dealt with the crash and the prosecution.*

5.4 Comparison between opinions expressed in the workshop and the survey

Overall, all service areas were consistently rated as important by both the stakeholder/management group (made up of organisational leaders focused on policy, management and governance), from the workshop and the frontline staff members from the online survey. There was also agreement between the two groups that timely, accurate information was the key area for a focus on improvements. The only difference was that the frontline group gave a lower rating to the time until a crash is identified.[24] The other area of consistency was both groups placed a high value on cross-agency working together (including communications and data sharing). Table 5.2 shows the relative ranks in terms of importance. Three of the top four factors were consistent across the different organisational levels, indicating strong

[23] Senior Traffic Management Supervisor

[24] In terms of reliability, this difference was also found in a sample of management/strategy members that did fill in the survey (but were excluded from the main analysis).

buy-in and desire for actions and interventions. In terms of difficult or step changes to improve post-crash care, these would-be areas to prioritise.

Table 5.2 Relative rank of service areas by operational and leadership groups

Rank	Frontline group Ability to reduce harm/death (if improved)	Stakeholder/manager group Importance in saving lives[25]
1	**Information accuracy**	**Information accuracy**
2	**Ability to notify there has been a crash**	**Time until a crash is identified**
3	**Cross-agency working together**	**Ability to notify there has been a crash**
4	**Emergency vehicle prioritisation**	**Cross-agency working together**
5	Traffic management	Post-crash care in road safety action plans
6	Training for responders	Information needs
7	Time until a crash is identified	Training/education
8	Information needs	Emergency vehicle prioritisation
9	Post-crash care in road safety action plans	Traffic management

Note: The top four service areas are in bold, with green font where they are both listed consistently.

When examining differences between the groups, the frontline group placed higher value on efficient, safe travel (vehicle prioritisation and traffic management). The frontline group also ranked inter-agency training for responders more highly, but this difference was in part because this category for the stakeholder/manager group also included public education (eg first aid training). It would be important to ensure operational front-line staff are involved in improving delivery around travel improvement technology and ITS solutions (such as the green wave for emergency vehicles). It would also be important to have their inputs to improve inter-agency responder training, as their experience provides detailed insights into constructive areas to focus on (eg around roles and responsibilities), emerging issues, and to enable faster knowledge-sharing on what is working that could be fast-tracked.

The stakeholder/manager group valued post-crash care being embedded in road safety strategies and action plans, as well as improvements around travel and crash site information needs (such as around route planning and digital rescue data). This workshop involved in-depth interactions and knowledge sharing, including from international best practice, which may explain these differences. For example, a digital rescue database showing the safe, efficient way to extract trapped passengers does not appear to be used in New Zealand currently, so the value of this easily implementable solution was more apparent to the stakeholder/manager group.

5.5 Overall take out from the two exercises.

Overall the rankings in table 5.2 can be taken as indications of the perceived importance of the service areas from an operational perspective and a strategic/ policy perspective. The differences in ranking between the two groups have high face validity given the two different perspectives. For instance, policy/strategy people will value the presence of post-crash care in road safety plans as they will see this as an important part of a mechanism which finally ends up as better operations out on the road, while frontline staff would be less likely to make such a connection.

[25] Note that the sample size for the stakeholder group was small. Communications was only examined separately in the stakeholder workshop. Training included public education and agency training in the stakeholder workshop.

It also has face validity to look at the operational perspective and the strategic perspective as equally important. Making this assumption an approximate overall ranking can be made by taking the average of the ranks for each attribute in table 5.2. Doing this yields the ranking in table 5.3.

Table 5.3 Overall relative rank of service areas giving ranks by operational and leadership groups equal weight

1	Information accuracy
2	Ability to notify there has been a crash
3	Cross-agency working together
4	Time until a crash is identified
5	Emergency vehicle prioritisation
6	Traffic management/training for responders
7	Information needs/road safety action plans

It must be remembered that all these service areas were generally considered important to the participants so being relatively lowly ranked does not necessarily mean lack of importance. These rankings will now feed into the final discussion in chapter 6.

6 Discussion

6.1 Introduction

In road safety the responsibility for strategy sits with the Ministry of Transport which services the National Road Safety Committee whose functions are described in section 2.6 of this report. The Road Safety Strategy to 2020 – Safer Journeys – is produced by the Ministry on behalf of the Minister of Transport under the auspices of the National Road Safety Committee and in consultation with the public. There are action plans sitting beneath the strategy which turn the higher-level aspirations in the strategy into actions.

The Transport Agency is responsible for the operational side of road safety and has its own targets and action plans associated with operational outcomes it has identified.

Road Policing is responsible for the smooth flow of traffic on the road given the road infrastructure provided by the RCAs, for the policing of road user behaviour and traffic control and reporting associated with incidents on the road including crashes.

Where the responsibility for specific actions related to post-crash care lies would be subject to negotiation between the Ministry, the Transport Agency and Road Policing under the umbrella of the National Road Safety Committee to which they all belong.

This section will discuss the post-impact care functions of transport sector participants in the light of the learnings from the foregoing sections of this report. It is structured around the areas in chapter 5 in the order given by the rankings of table 5.3. It must be remembered that this is a ranked list of items chosen from areas all ranked of high priority by survey participants.

6.2 Crash information accuracy

This is obviously important in a wide variety of ways from accurate location of the crash, accurate information of the state of the injured parties, accurate information on the right routes for vehicles to take to and from the crash and accurate information on the crash risk of the network to allow prioritisation of measures to assist post-crash recovery to risk. The crash analysis, workshop and online surveys all indicate that improved accuracy of crash information would improve post-crash outcomes, in particular, information on exact crash location.

6.3 Ability to notify there has been a crash.

This is particularly crucial and the crash data analysis showed the sad consequences of a crash not being found until help is too late. Various methods to improve this situation have been discussed like ACN systems, simple LED flares to attract the attention of passers-by and improved cellular and trunk radio networks. Road user information on where cellular networks exist to allow this to be taken into account in route choice is also a fairly simple option.

6.4 Cross-agency working together

Very little work in the post-impact care area is the sole responsibility of any one agency Therefore cooperative work between agencies is crucial to future progress. There is scope to improve this over a large number of areas previously discussed in this document. It is now up to the players to get together and provide an environment in which working together can be enhanced in the interests of post-crash care. It is important that front-line staff are involved in these interactions.

6.5 Time until a crash is identified

This crucial component in the ability to reach a survivor in time to improve outcomes is highly related to ability to notify a crash and relates to the efficacy of communication networks which in turn is highly dependent on the availability of appropriate technology and on agencies working together.

6.6 Emergency vehicle prioritisation

This is a measure highly rated by operational personnel. However, it is to all intents and purposes non-existent in New Zealand apart from priority traffic signals outside some emergency vehicle stations and the ability of emergency vehicles to use special vehicle lanes at times of emergency and the ability to carefully cross an intersection at up to 20 km/h. Further work would be required to ascertain to what extent its extended use is justified in a New Zealand context.

6.7 Traffic management

This can mean traffic management at and around a crash site or the management of the progress of emergency vehicles to and from the site.

It includes provision of road infrastructure which is as part of its design supports emergency services to carry out their work as efficiently and effectively as possible.

Again, this requires a cooperative effort between all parties including a well-defined command structure at the site.

6.8 Training/education for responders

There is an obvious need for this to streamline the operation of crash sites and traffic management in the vicinity and in specific cases like the need pre-empt electric shock risk in the case of crashed electric vehicles. Transport sector candidates would be members of Road Policing and RCA field staff. There is also a need to consider the extent to which response to the occurrence of crash injury should be included in driver education or overall road user education

6.9 Information needs

This is a case of identifying exactly what information not available now is required and may be practically acquired at reasonable cost and planning for its future acquisition. The statistical analysis identified a number of information needs associated with crashes.

6.10 Road safety action plans

This was not the highest ranked of the service areas discussed, but is in fact of crucial importance. That is because without an action plan nothing can really be done, so an action plan is crucial to the effective carrying out of any action. It may be that people are sceptical of action plans because they are aware of some cases where they have not actually been implemented.

7 Recommendations

The following recommendations are submitted for consideration by the Transport Agency and its partners. They are transport sector specific and underpinned by the more detailed results found in the preceding sections of this report and should be read in conjunction with the detail of the report. They have been selected as capable of being considered and if agreed, implemented, at reasonable cost.

1 Road safety strategies and action plans

That the road safety transport sector, through the National Road Safety Committee, consider including post-impact care in future road safety strategies as a fifth pillar of the Safe System approach to road safety.

That the road safety transport sector, through the National Road Safety Committee, consider how post-impact care, as the fifth pillar of the Safe System approach to road safety, should be dealt with in the upcoming New Zealand Road Safety Strategy. This would include consideration of how action plans should be provided beneath the strategy for joint action with emergency services partners and integrated with the operational planning of Transport Agency and Road Policing.

That the road safety transport sector, through the National Road Safety Committee, note that at present post-crash care is considered as an informal adjunct to other work. If progress is to be made it must feature formally in the planning documents of the appropriate authorities and allocated time in the work programmes of appropriate staff.

That the road safety transport sector, through the National Road Safety Committee, note that at present post-crash care is considered an informal adjunct to other work. If progress is to be made it must feature formally in the planning documents of the appropriate authorities and allocated time in the work programmes of appropriate staff.

2 Working together

That the Transport Agency and Road Policing together explore opportunities to set up permanent regular channels of communication with EAS and FENZ. This would be done in consultation with Ministry of Health and ACC and representatives of RCAs. There would need to be an expeditious means for joint decisions to be implemented and funded. It is important that front-line staff are involved in these interactions.

Under this the areas of importance mentioned earlier in this report could be considered. These would include the following practical issues which can be dealt with at reasonable cost:

a Training of Road Policing and RCA staff in dealing with post-crash situations including chains of command at crash sites

b Smoothness of communication between the agencies in the event of a crash. The quality of this communication can have a dramatic impact on the time between crash and presentation of the victim at hospital

c Traffic management at crash sites and on routes to and from crash sites

d Provision of road infrastructure, which as part of its design supports emergency services to carry out their work as efficiently and effectively as possible

- e ACN devices are beginning to appear on vehicles in the New Zealand market. It is timely to discuss how best to deal with the notifications they provide and in what form to encourage their inclusion in New Zealand market vehicles including the place of smart phone related applications in this mix
- f How the landing requirements of helicopters can best be satisfied
- g To what extent post-impact care (as a bystander) can be improved and by what mechanisms

3 Coordinated communications systems

That the Transport Agency explores with Road Policing and emergency services partners future possibilities of shared communications channels between the agencies around crash dispatch and between responders, for better coordination focused on the event.

4 Cellular networks and digital radio networks.

That the Transport Agency consider:

- a Exploring with MBIE and the rural broad band initiative the notion of including a targeting to risk component to the rollout of cellular networks along highways. This is at present targeted only to tourist numbers and traffic volumes
- b Providing information to the public regarding where cellular networks exist on state highways. If this information is not available from network providers the technology exists to scan for cellular networks at the same time as other network scans (such as those carried out for KiwiRAP). A star rating similar to KiwiRAP could be considered. This would allow road users, where possible, to choose a route where rescue was more probable in the event of a crash
- c Proactively joining with its partners to assist in planning for the inevitable rollout of cellular technologies with enhanced capabilities to improve crash notification
- d Discussing with operators interconnectivity of cellular networks and digital radio networks and the access of radio networks to 111 call centre operators.

5 Crash information

Existing data on the timeliness and effectiveness of the post-crash response is lacking, despite the Transport Agency's previous efforts to improve this situation. It is recommended the Transport Agency consider:

- a reminding coroners of the Transport Agency's interest in and usage of coronial findings, particularly as they relate to post-crash response
- b reinforcing their interest in the post-crash response and victims' injuries to the police officers responsible for completing TCRs
- c investigating data sharing between the Transport Agency and Ministry of Health (particularly the EAS) so the outcomes of non-fatal road crashes can be better investigated, including the quality of the post-crash response.

6 Emergency vehicle prioritisation

That the Transport Agency consider, in consultation with RCAs and emergency services, whether there is a need to make more explicit provision in the Road User Rule (2004) for the use of emergency vehicle priority measures. Such a need would be predicated on the existence of locations where such measures would make a worthwhile improvement in emergency vehicle operations. This may require some trialling. If such a need was established the pertinent rules and the *Manual of traffic control devices* (NZ Transport Agency 2008) may require some amendments.

7 Inclusion of innovative emerging vehicle-related systems to facilitate rescue in ANCAP.

That the Transport Agency discuss with ANCAP how crash notification systems and the availability of digital vehicle data sheets might be included in ANCAP's star rating system for vehicle safety.

8 Electric vehicle post-crash electric shock risk.

There is a risk of post-crash electric shock associated with electric vehicles. Japanese NCAP tests electric vehicles for this risk. It is recommended the Transport Agency discuss with ANCAP the possibility of including similar tests into ANCAP testing and discuss with emergency service partners methods to minimise electric shock risk to crash responders.

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Appendix A: Version A survey questions

Category	Category question	Detailed question	Question type
Timely, accurate notification of crashes	Thinking about timely, accurate notification that a crash has occurred: If the following areas were improved, how strongly do you think the improvement would lead to reduced harm or death?	Time until a crash is identified (especially in rural or less populated areas), eg ACN in cars, surveillance capability on the road network.	Scale
		Ability to notify there has been a crash, eg network coverage for mobile phones, alternatives like emergency phones or radio technology.	Scale
		Information accuracy (location, severity, patient access issues), eg good communications and GPS capabilities.	Scale
		What is the ONE thing you would like to see done around timely and accurate crash-notification that would reduce harm or death? (you do not have to use any of our examples)	Open-ended, text
Agencies working together	Thinking about agencies working together: If the following areas were improved, how strongly do you think the improvement would lead to reduced harm or death?	Post-crash care in road safety action plans.	Scale
		Cross-agency working together, eg data sharing, inter-agency communications technology.	Scale
		Training for responders, eg multi-agency, inter-disciplinary training around communications, safe travel, site safety and first aid.	Scale
		What is the ONE thing you would like to see done around working together that would reduce harm or death? (you do not have to use any of our examples)	Open-ended, text
Efficient, safe travel to and from crash sites	Thinking about efficient, safe travel to and from the crash site: If the following areas were improved, how strongly do you think the improvement would lead to reduced harm or death?	Information needs, eg route planning tools, digital rescue data sheets (online data about vehicles to aid victim extraction).	Scale
		Emergency vehicle prioritisation, eg traffic signals that prioritise emergency vehicles, (green wave), emergency lanes, provision of helipads.	Scale
		Traffic management (police and RCAs) eg smart motorways to help control traffic around the crash site.	Scale

Category	Category question	Detailed question	Question type
		What is the ONE thing you would like to see done around efficient, safe travel that would reduce harm or death? (you do not have to use any of our examples)	Open-ended, text
What has been effective	Still thinking about timely, accurate notification; working together; and efficient, safe travel:	What is something that has already changed in your organisation (or a partner organisation) that you think improved life safety outcomes?	Open-ended, text

Appendix B: Differences between responses from organisations

		Df/sample size	F	Sig.
Category 1: Timely, accurate notification of crashes	Time until a crash is identified	2, 430	5.726	0.004*
	Ability to notify there has been a crash	2, 430	2.175	0.115
	Information accuracy	2, 430	.659	0.518
Category 2: Agencies working together	Post-crash care in road safety action plans	2, 430	.909	0.404
	Cross-agency working together	2, 430	.749	0.473
	Training for responders	2, 430	.799	0.451
Category 3: Efficient, safe travel to and from crash sites	Information needs	2, 430	3.525	0.030*
	Emergency vehicle prioritisation	2, 430	1.555	0.212
	Traffic management	2, 430	1.025	0.360
* = p<.05				

Appendix C: Summary of possible actions from the literature

These possible actions for post-impact care are suggested by the international literature. They are divided in three functional categories but there is some cross-over between categories.

C1 Timely, accurate notification

How to detect and characterise the problem, notify and dispatch help?

- Provide detection and surveillance capability for locations across the road network with high incident rates or locations such as tunnels (eg software alerts, CCTV or other visual monitoring).
- Build traffic incident watch capability with road agency staff, police patrols and professional drivers.
- Provide location reference markers at regular intervals on high traffic routes to enable more accurate location of incidents, as for example in use on state highways.
- Ensure responders are equipped with good communications and GPS capabilities to give accurate location data.
- Provide emergency phones or radios at high-incident locations or locations with no mobile phone coverage.
- Investigate options for, and value of, ACN systems. Consider how to support existing proprietary ACN systems or consider a nationwide arrangement such as eCall in Europe.
- Introduce LED flares as part of vehicle safety equipment.
- Explore the possible role of trunk radio in crash notification.
- Liaise with relevant agencies to understand the ability of cellular networks and/or radio to support detection and notification technologies. Consider cellular network availability along the road network outside urban areas for mobile phones and ACN.
- Consider if detection technology (eg LED flares, ACN) should be required as part of an ANCAP rating or warrant of fitness.
- Explore other technologies (eg technology where ‘pings’ from location devices may be picked up 30 km away via the internet, ACN equivalent in mobile phones)

C2 Fast, safe travel to and from the crash site

How to assist in swift, safe road and air travel of emergency services and extraction of casualties?

- Implement traffic management to prioritise emergency vehicle response. Evaluate the options: pre-determined route plans; special phase for intersections near emergency vehicle stations; active pre-emption of traffic signals providing a green phase when an emergency vehicle is detected; GPS tracking to ensure the emergency vehicle receives a green phase.
- Offer real-time traffic information or route guidance to emergency services, enabling best choice of access route and supporting triage decisions such as choice of hospital.

- Provide real-time information to the travelling public about traffic congestion so they can choose a route that avoids the crash site, and warning as they approach a crash site or as an emergency vehicle approaches them (radio, mobile app, road signs, in-vehicle communications).
- Design roads to facilitate ease of passage for emergency vehicles. Where required, make roads more emergency vehicle friendly.
- Provide emergency lanes or laybys on high-volume or high-risk roads. Emergency lanes may be permanent or available at certain times or in specific situations.
- Use lane management systems with electronic signage for creation of emergency lanes, for isolating a crash site, for managing speed reduction, and for informing other travellers.
- Consider the role of cooperative intelligent transport systems (with wireless communication between vehicles and roadside infrastructure, businesses and other vehicles), smart motorways and advanced traffic management in post-crash response.
- Provide best practice traffic and road management to secure the crash site and prevent secondary accidents. Ensure lighting used on scene is current best practice.
- Ensure effective communications on scene between multiple responders. Look at ways to minimise any negative impacts of crash investigation or scene clearance on emergency vehicle access.
- Introduce digital rescue data sheets with online information about cars (eg structure, security measures) available to emergency responders to aid extraction of victims. Consider extending this so that individual vehicle owners can add data (eg vehicle modifications, age and medical conditions of usual occupants). Consider if this should be part of an ANCAP rating or warrant of fitness.
- Consider the possible uses of unmanned aerial vehicles for scene and traffic management, in cooperation with the Civil Aviation Authority, and with other potential drone users such as ambulances.
- Evaluate whether existing helipads built as part of roads, eg on the Coromandel loop, have provided good outcomes. Use the results of this evaluation to decide whether to provide more (or different) places within road networks for air ambulance landings. Liaise with the Civil Aviation Authority to ensure helicopter landing sites are appropriately approved, designed and placed.

C3 Working together

What strategies, planning, research and communications activities might support post-crash care?

- Include post-crash response in agency strategies and plans. Establish targets for improvement. Collect and analyse data to inform actions. Measure and evaluate results.
- Review goals, policies, practices and regulations for their effect on post-crash care and for compatibility with other relevant agencies, consulting with those agencies.
- Include safe, fast emergency access as criteria for road design and upgrades.
- Consider interoperability of communications/IT. Ensure that traffic management centres operated by RCAs or local authorities can accept information from other emergency systems and centres. Ensure technological innovations enhance and maintain interoperability.

- Maintain strong working relationships with emergency services and media traffic reporting services to ensure rapid exchange of information. Have protocols for exchanging data, both in planning/ monitoring and in real-time situations.
- Consider ways to strengthen coordination between agencies. Review liaison points between road controlling authorities and other emergency services, eg what are the implications for road transport agencies when emergency services change policies or practices? Coordinate with other research and data collection activities, eg national trauma registry, academic research.
- Participate in multi-agency, inter-disciplinary training in post-crash response.
- Educate the traveling public about post-crash response. This may include: the risks of crashes in remote areas; what equipment to have in the car; what to do in the event of a crash; how to detect and report traffic incidents, eg signs a car has run off the road; appropriate ways to react to approaching emergency vehicles; how to pass by an incident scene without obstructing emergency services.
- Monitor international developments, including policy and technology developments.
- Undertake demonstration trials of technologies likely to improve post-crash care.
- Collaborate with international agencies, and with manufacturers and providers where appropriate, to establish common technology standards and data metrics for interoperability.

Appendix D: Glossary

AACN	advanced automatic collision notification
ACC	Accident Compensation Corporation
ACN	automatic collision notification
ADAMS	Atlas and Database of Air Medical Services
ANCAP	The Australasian New Car Assessment Program
CAS	NZ Transport Agency's Crash Analysis System
CCTV	closed circuit television
EAS	emergency ambulance services
EMS	emergency medical services
FENZ	Fire and Emergency New Zealand
FHWA	The Federal Highway Administration
GIS	geographic information system
GPS	global positioning system
KiwiRAP	New Zealand's Road Assessment Programme
LED	light-emitting diode
LoRa	low power long range
LUMS	lane management system
MBIE	Ministry of Business, Innovation and Employment
MBS	mobile black spots
MBSF	Mobile Black Spot Fund
MoT	Ministry of Transport
NCAP	The European New Car Assessment Programme
NHTSA	National Highway Traffic Safety Administration (US)
OECD	The Organisation for Economic Co-operation and Development
PCL	portable call location
PIARC	Permanent International Association of Road Congresses
RBI2	rural broadband initiative (phase 2)
RCA	road controlling authority
RSC	Road Safety Commission (Australia)
SCU	Serious Crash Unit
TCRs	traffic crash reports
the Transport Agency	NZ Transport Agency
TOC	Traffic Operations Centre
UFB	ultra-fast broadband

V2V	wireless communication between vehicles
V2I	wireless communication vehicles and roadside infrastructure
V2B	wireless communication between vehicles and businesses
VOIP	voice over internet protocol
VSL	variable speed limit
WA	Western Australia
WFA	Wellington Free Ambulance
WHO	World Health Organisation