The characteristics of fatal crashes in South Australia involving a delay in notifying Emergency Medical Services

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Abstract

This study examined the 191 fatal crashes and 218 fatalities occurring in South Australia in the period 2008-2009. A sub-set of these fatal crashes was identified where there was a delay between the time of the crash and the time Emergency Medical Services (EMS) were notified and subsequently dispatched to render medical assistance. It was found that 21.5% (N=41) of fatal crashes had an EMS notification delay exceeding 10 minutes; this accounted for 23.4% of fatalities (N=51). These fatal crashes were examined in more detail including injuries detailed by the forensic pathologist in available coroner reports. It was found that most of the crash notification delays occurred in rural areas and that 2.2% of all fatalities might have been avoided if earlier crash notification to emergency medical services had occurred. This paper will report on the characteristics of these fatal crashes, a mechanism by which crash notification delays might be reduced and factors that might affect successful reduction in delays.

Introduction

In South Australia, for the period 2008-2009, there were 191 fatal crashes; 115 fatal crashes in rural areas (133 fatalities) and 76 fatal crashes in metropolitan Adelaide (85 fatalities). The majority of fatalities were the result of cars colliding with fixed objects (36.2%, N=79) and car roll-overs (9.6%, N=21). While the 'fatal five[1]' are often implicated as causal factors in fatal road crashes and fatalities, an area not well studied in Australia that may influence the likelihood of a fatality, is the post-crash delay in the initiation of emergency medical response.

There is evidence to suggest that bystanders with the capacity to provide correct basic first aid techniques can improve the outcome of the injured patient (see Ryan et al., 1973, Ryan et al., 2004 and Ashour et al., 2007). However there are limitations to the type and extent of aid to which bystanders can and are willing to provide (Arbon et al., 2011). The need for experienced voluntary or professional emergency medical services to provide Basic Life Support (BLS) or Advanced Life Support (ALS) on demand and as necessary (e.g. Grantham et al., 2012), surpasses the extent and quality of treatment a bystander can provide. This extends to the continuity of care required during transportation of the injured from the scene of a serious crash to a hospital emergency department. Although the benefit of bystander first aid is not to be dismissed, the benefits of earlier medical response rests primarily with the emergency medical service consistent with Ryan et al., (1972, p1): "the ambulance service is the most important provider of medical treatment at the scene (of a crash) and during transport (to hospital)".

The main purpose of this study was to determine the extent to which delayed crash notification and subsequent response influences the likelihood of a fatality in a serious crash in South Australia, a mechanism by which this might be overcome and the limitations of such a mechanism.

[1] The 'fatal five' refer to the five human behaviours that increase the risk of a fatal crash and/or increase the risk of a fatality in road crashes namely (1) Speed (2) Alcohol/Drug Impairment (3) Fatigue (4) Inattention and (5) Not wearing a seatbelt (see Department of Energy and Infrastructure, 2005).

Impediments to prompt emergency response after a serious crash

According to Evanco (1996), the effectiveness of an emergency response to a crash or other incident can be measured by each of the elapsed times between the time of the crash and ultimately the delivery of the injured to hospital. The initial critical time period extends from the time of the crash until notification of the Emergency Medical Service (EMS) (the ‘accident notification time’). This includes “determination that an accident has occurred, the verification of the location and nature of the accident, and reporting of this information to the appropriate authorities” (Evanco,1996, p1-1).

NHTSA (2001) also refers to the initial period of time as the ‘notification time’, which incorporates the decision, contact and call period to emergency services. The decision period commences at the moment of injury and extends to the moment of recognition by a crash participant or a third party that emergency assistance is required. This period according to NHTSA (2001): “… varies greatly and is dependent on a number of factors including time of day, population density, traffic density, and random chance.”

The discrete events required for dispatch of EMS in South Australia are (SA Ambulance Service, 2013a,b):

- *t0* Crash Occurrence or Crash Time
- *t1* Recognition of crash by occupants or third party and contact made with Emergency Call Service (Triple Zero call centre) and call diverted to the relevant Emergency Service Organisation (ESO) or SA Ambulance Service Emergency Operation Centre (EOC) Emergency Medical Dispatch Support Officers (EMDSOs)
- *t2* SA Ambulance Service emergency medical dispatchers receive information from EMDSOs
- *t3* SA Ambulance Service medical response team dispatched
- *t4* SA Ambulance Service medical response team arrive at-scene
- *t5* SA Ambulance Service response team access injured patients

The discrete time elements *t0* – *t5* are those discussed in Akella et al. (2003), and are consistent with Evanco (1996) and NHTSA (2001).

The delay in crash notification to emergency medical services is particularly relevant for single vehicle, single occupant, night time crashes, on low volume roads in rural or remote environments. Further, issues relating to conveying the precise location of the crash to emergency medical services can also result in delays. This is particularly problematic in rural and remote areas or for those unfamiliar with the environment they are in.

Prompt medical access may also be impeded by actual travel delays and subsequent access delays by emergency medical services to the crash site. This is influenced by ambulance location and proximity to the crash site and limits to safe ambulance travel speed, but also by factors such as traffic volume, weather conditions, detours, road conditions and access to the accident site (Emergency Management Australia, 1992). Safe and unhindered access by EMS personnel to the injured occupants is also required before any aid can commence. This includes control of incidents such as fires or fallen power-lines and any other crash induced hazards, as well as difficulty in gaining physical access to the injured due to vehicle orientation or vehicle deformation.

Determining the delays associated with the initiation of an emergency medical response in South Australia

To determine the extent to which post-crash delays occur in the initiation of medical response, a retrospective analysis of all fatalities in South Australia for the period 2008-2009 was undertaken. Three related sets of data were examined: 2008-2009 South Australian Traffic Accident Reporting System (TARS) recorded crash times, SA Ambulance Service (SAAS) dispatch times to fatal crashes in 2008-2009 as well as available coronial files relevant to those crashes.

The crash times (*t0)* according to TARS were matched against the South Australian Ambulance Service (SAAS) motor vehicle accident (MVA) categorised dispatch times (*t3)* based on reported crash locations in each of the data sets. The SAAS dispatch times were used since SAAS notification times *(t1)* were unavailable. The delay in crash notification to the emergency call service/SAAS emergency operation centre (*t1-t0)* is the most critical period of time in the crash notification process. In the absence of this data, the difference between the dispatch time (*t3)* and the crash time (*t0)* was assumed to be a suitable alternative indicator of the crash notification delay. This delay *(t3-t0)* captures each of the delays following the crash including the crash notification period (*t1-t0).*

Information obtained by the emergency medical dispatch support officers from an emergency caller is electronically transferred to the emergency medical dispatchers immediately following the termination, or even prior to the termination of a call. Hence the delay *(t2-t1)* has a negligible effect on SAAS dispatch delays. Further, "the interval from the time an ambulance dispatcher is contacted until an emergency unit begins its response" (*t3-t2),* are typically less than one minute (Mayer, 1980, p80).

Therefore, it can be reasonably assumed then, that the SAAS dispatch time is largely dependent on the initial delay in crash notification (*t1-t0)* and that the measure (*t3-t0)* is a reasonable surrogate for this delay. Hence hereafter the period (*t3-t0)* incorporating each of the delays following the crash will be referred to as the 'EMS notification delay'.

In some crashes there was uncertainty in the reported crash times or the SAAS dispatch times were unknown; the EMS notification delays were able to be determined in 96.5% (N=111) of rural fatal crashes and 93.4% (N=71) of urban fatal crashes. The cumulative distribution of crashes according to EMS notification delay is shown in Figure 1.

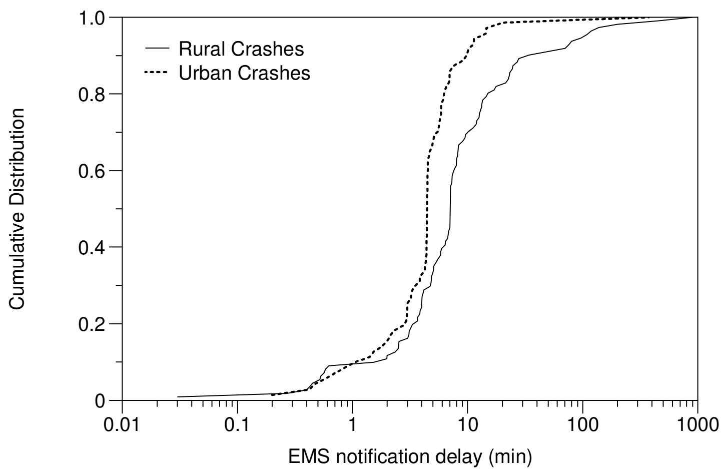

Figure 1. The cumulative distribution of EMS notification delays for fatal crashes in rural and urban areas.

Figure 1 indicates that the EMS notification delay was less than 5 minutes in around 34% of fatal rural crashes, was less than 10 minutes in 70% of fatal rural crashes and was less than 20 minutes in about 83% of fatal rural crashes. The EMS notification delay exceeded 20 minutes in the remaining 17% of fatal rural crashes.

There were fewer crashes with lengthy EMS notification delays in urban areas. The EMS notification delay was less than 5 minutes in around 68% of fatal urban crashes, less than 10 minutes in 91% of the crashes and less than 20 minutes for 99% of the crashes. In one urban crash the EMS notification delay was several hours after the crash occurred.

Table 1 shows the number of fatal crashes, fatalities, available coroner files and the corresponding EMS notification delay in crashes used in this study. In total there were 142 coroner files available for examination, of which 139 could be grouped within one of the three numerical delay categories, (1) 20 minutes or greater, (2) 10 minutes or greater (but less than 20 minutes) and (3) less than 10 minutes.

Fatal crashes with a delay exceeding 10 minutes in this study were considered as having a 'significant delay'. Crashes where the EMS notification delay was less than 10 minutes were deemed as having 'no delay' and coroner's files were not examined. The reason for selecting a threshold of 10 minutes was to allow a level of tolerance on crash reporting times relating to estimation and rounding errors that may occur during the crash reporting procedure by police. This is consistent with other studies such as Brodsky (1993) who also refer to notification delays in the context of exceeding 10 minutes.

In 41 of the 191 fatal crashes (21.5%) the EMS notification delay exceeded 10 minutes; these crashes accounted for 23.4% of all fatalities (N=51). Most of the delays occurred in rural areas where 43 of the 133 rural fatalities (32.3%) had an EMS notification delay exceeding 10 minutes compared to only 8 of the 85 urban fatalities (9.4%).

Table 1. Fatal crashes with a EMS notification delay

	Rural			Urban			Total
EMS notification delay	Fatal Crashes	Fatalities	Coroner Files	Fatal Crashes	Fatalities	Coroner Files	Coroner Files
20 mins or greater	20	25	18	1	2	2	20
10 mins or greater (< 20 mins)	14	18	5	6	6	0	5
Less than 10 mins	77	86	57	64	72	57	114
No dispatch time	2	2	1	1	1	1	2
Inconclusive delay*	2	2	0	4	4	1	1
Total	115	133	81	76	85	61	142

*In some fatalities the crash time was recorded as having occurred prior to EMS dispatch, in these fatalities where a EMS notification delay could not be verified by a coroner's file, the delay was categorised as inconclusive.

Table 2 shows the crash types where there was a significant delay in EMS notification. The majority of the fatal crashes involving an EMS notification delay involved a car colliding with a fixed object (41%), followed by car rollovers (15%) and motorcycles colliding with fixed objects (12%).

Table 2. Fatal crash types, locations and EMS notification delays

	Greater than 10 minutes		Greater than 20 minutes		Total
Crash Type	**Rural**	**Urban**	**Rural**	**Urban**	
Car v Fixed Object	6	1	9	1	17
Car Rollover	2		4		6
Motorcycle v Fixed Object		1	4		5
Car v Truck	2		1		3
Car v Car	1		1		2
Truck v Truck	1				1
Truck v Fixed Object			1		1
Car v Train	1				1
Car v Motorcycle	1	1			2
Car v Pedestrian		3			3
Total	14	6	20	1	41

Of the 34 rural fatal crashes with an EMS notification delay, 12 were inner rural crashes (within 100 km radius of the Adelaide CBD) and the remaining 22 were outer rural crashes, with six of these crashes occurring in a remote area of South Australia.

Determining the benefits of earlier medical response

In this study, a medical expert with over 50 years research experience in road safety and related areas examined, individually and in detail, the cases where there was a significant EMS notification delay and where a coroner's file was available. Each case was examined and then assigned a 'benefit' on the basis of earlier emergency medical response that could be achieved via more prompt crash notification. A 'likely benefit' was assigned if survival was likely if emergency medical assistance was provided earlier. A 'potential benefit' was assigned if there was a potential for survival based on prompt surgical intervention (or life could be sustained until surgery). Finally, 'no benefit' was assigned for fatalities where injuries were beyond the capability of medical or surgical intervention.

Results

Of the 25 fatalities with a significant EMS notification delay and a coroner's file available for examination, it was thought that 19 fatalities would not have benefited from earlier medical attention primarily due to multiple injuries incompatible with life. (Note: One of these fatalities may have benefited from earlier medical attention but more prompt crash notification could not occur due to the remoteness of the location, no mobile phone coverage or access to a fixed line phone network which resulted in a notification delay of 49 minutes.)

It was thought that three fatalities would have likely benefited from earlier medical attention, and an additional three fatalities potentially may have benefited from earlier medical attention. The vehicles involved in these fatalities were older vehicles with an average vehicle age of 19 years. The details of these crashes follow.

Likely Benefit - Three Fatalities

- Single vehicle, single occupant, unsealed road, inner rural; driver crashed a vehicle into a tree and bridge support and was trapped and hidden from other traffic and undiscovered for 15 hours before EMS notification. Driver died in hospital.

- Single vehicle, two occupants, urban[2], early morning: driver crashed a vehicle into a guard rail and trees before rolling over, driver and passenger trapped and hidden from traffic and undiscovered for 6 hours before EMS notification. Driver and passenger died at scene, passenger likely benefit.

- Single vehicle, single occupant, inner rural, early morning; driver crashed a vehicle into a tree and not discovered for 75 minutes before EMS notification. Driver died at scene.

Potential Benefit – Three fatalities

- Single vehicle, two occupants, urban, early morning; driver crashed a vehicle into guard rail and trees before rolling over, driver and passenger trapped and hidden from traffic and undiscovered for 6 hours before EMS notification. (Same crash as mentioned above). Driver and passenger died at scene, driver potential benefit.

- Single vehicle, early morning, inner rural; driver crashed a vehicle into a tree, driver and passenger trapped and undiscovered for 109 minutes before EMS notification. Driver and passenger died at scene, passenger potential benefit.

- Single vehicle, early morning, inner rural; driver crashed a vehicle into a tree, crash not discovered for at least 10 minutes before EMS notification. Driver and passenger died at scene, driver potential benefit.

To estimate the effectiveness or benefit of earlier medical attention, only the 139 fatalities in the sample with a coroner's file were included in the analysis. Fatalities (as shown in Table 1) categorised as 'inconclusive delay' or 'no dispatch time' were excluded from the sample for the analysis.

It was estimated that 2.2% of fatalities might have been avoided if earlier crash notification and emergency medical service dispatch had occurred. Additionally, a further 2.2% of fatalities potentially might have been avoided, through earlier surgical intervention. There were 133 fatalities where earlier medical attention would have had no benefit, this includes 114 crashes where the EMS notification delay was less than 10 minutes, where it was assumed that earlier medical attention in these cases would have had no benefit and the 19 fatalities where there was a delay exceeding 10 minutes and it was verified that there was no benefit to earlier medical attention. This is presented in Table 3.

The benefits of earlier medical intervention in this study were found to be limited to passenger vehicle driver and occupant fatalities. In this study 106 out of 139 fatalities with a coroner's file (76%) were relevant to passenger vehicle drivers or occupants. The benefits of earlier intervention for this sub-set of fatalities are also show in Table 3.

Table 3. A summary of the benefits of assigned with earlier medical attention

	Aggregated (Rural and Urban) Benefit		
EMS notification delay	**Likely**	**Potential**	**None**
Any fatality in sample	(3/139) 2.2%	(3/139) 2.2%	(133/139) 95.7%
Passenger vehicle driver/occupant fatalities	(3/106) 2.8%	(3/106) 2.8%	(100/106) 94.3%

[2] The location of the crash was defined as 'urban', however the road environment and surrounds at the crash site were characteristic of a rural environment, an 80 km/h tree lined road protected by guard rail with sparse open land either side of the road way. The crash most likely went unnoticed due to the features of the environment.

A similar study undertaken by Sihvola et al. (2009), found that 'very probable prevention' of fatalities may have occurred in 3.6% of all road fatalities and up to 4.4% of motor vehicle occupants in Finland. Similarly, no benefit was assigned where the fatality would have occurred regardless of immediate medical treatment and in cases where there was 'no indication of delays and injuries rated as six on the Abbreviated Injury Scale (AIS) injuries' (Sihvola et al., 2009, p101).

Reducing delays in crash notification – An Automatic Crash Notification System

Delays in crash notification can be reduced and issues relating to conveying precise location of crash can be overcome with a vehicle technology known as Automatic Collision Notification (ACN) or eCall. A basic ACN system consists of a programmed vehicle electronic control unit (ECU) consisting of a GPS and cellular communication system (generally part of a broader telematics system) connected to an external antenna and an airbag ECU.

Automatic Collision Notification "refers to technology designed to detect the involvement of a motor vehicle in a crash, to obtain information about the severity of the crash where possible, and to notify emergency response personnel either automatically or through a response centre." (Austroads 2004, p2)

Three key basic mechanisms of an ACN system are collision detection, location identification and subsequent notification of the collision and location. Sophisticated supplementary vehicle safety systems exist in most new cars today that enable detection of collisions of sufficient severity that warrant deployment of the required safety system (airbags, seat-belt pre-tensioners etc.). Location information and communication of this information can be enabled through an integrated in-vehicle telematics system.

Most ACN systems are integrated with vehicle telematics systems, and are monitored by a telematics service provider (TSP) on a paid subscription. The telematics system consists of a two-way communication device (integrated cellular phone system), a tracking device (Global Positioning System (GPS)) and programmed hardware that is integrated with specific components of the electrical system of the vehicle. The telematics hardware can be programmed to detect any specific vehicle electrical signal that can be used to classify 'events'.

In the case of a vehicle collision, the telematics hardware usually recognises such an 'event' through an airbag deployment (although systems can be programmed for other crash indicators), and the TSP is alerted. The vehicle telematics module automatically generates a short message service (SMS) text containing relevant information and this is transmitted through a cellular network such as the global system for mobile (GSM) communication network.

The information transmitted includes the location of the crash (GPS coordinates), unique vehicle ID, vehicle owner details and the event type. This information is transmitted to the TSP and voice communication is then attempted with the vehicle's driver through the vehicle integrated hands free cellular phone system. Based on communications with the driver (or other occupants) the TSP can directly assist the driver. The TSP operator will try to ascertain the wellbeing of the occupants, and they will ask whether they require emergency assistance. If no communication is established, or if the occupants request emergency services, the TSP emergency protocol is engaged.

Fatality Reductions expected by an Automatic Collision Notification system

The results presented in this study suggest that earlier ambulance dispatch through earlier crash notification might have some benefits and this could presumably be achieved with an Automatic

Collision Notification (ACN) system that is fully deployed and is able to detect and transmit the necessary information to the relevant agencies with little delay, in all serious crashes.

A number of studies have already examined the effect of an automated crash notification system and the likely effect on crash related fatalities. Evanco (1996) estimated an 11.9% reduction in all rural fatalities in the US based on 1990 rural statistical data, if all vehicles were fitted with a flawless ACN system with a crash to EMS notification time (in fatal crashes) of one minute. Clark and Cushing (2002) estimated a 1.5% – 6% decrease in vehicle driver and passenger fatalities in the US based on 1997 crash data and a notification time of one minute. Lahause et al. (2008) used a variation of the mathematical model by Evanco (1996) to estimate passenger vehicle occupant fatality reductions in Australia. Lahause et al. (2008) estimated that a fully deployed ACN system in Australia would result in a 10.5% reduction in fatalities in urban areas and a 12% reduction in rural areas (for passenger vehicle drivers and occupants) if crash notification times were reduced to one minute and the system was 95% effective.

As mentioned previously, Sihvola et al. (2009) examined fatalities in Finland to determine if there was a delay in notification or there were problems in locating the crash by the EMS, and determined whether rapid medical treatment may have improved the patient's outcome. Sihvola et al. (2009) estimated that 3.6% of all fatalities or 4.4% of vehicle occupant fatalities would probably have been avoided with eCall (the European name for ACN).

Chauvel and Haviotte (2011) analysed crashes in France between 2004-2011 involving vehicles that were already fitted with eCall to assess 'eCall usefulness'. The analysis of this sample was related back to all fatalities in France for 2009 and they estimated a 2.8% reduction in fatalities if eCall had been universally deployed.

Factors that may affect successful reduction of delays

The result that 2.2% of all fatalities might likely have been avoided with earlier crash notification through a fully deployed ACN system in South Australia assumes: (1) Flawless detection of a 'collision' (ideally ensured by the system and vehicle manufacturer). (2) The ability to receive satellite signals for location purposes (clear line of sight of the sky). (3) Successful transmission of the crash notification and location details to the relevant parties (cellular serviceability).

In this study it was found that in some fatal crashes, prompt emergency service notification was impeded by limitations in South Australia's communication infrastructure. The fixed line and mobile phone communication network is optimised on the basis of population density and although satellite phones are available, these are cost prohibitive and rarely accessed by ordinary vehicle drivers.

To examine the extent to which mobile communication infrastructure was problematic, serious and fatal rural crash locations were compared with the Telstra GSM mobile phone network coverage maps. This network was selected due to the fact that ACN systems that exist in Australia, albeit less than 0.06% of the registered vehicle fleet operate under the Telstra GSM network. (See Ponte et al, 2013). Telstra claims that this network covers 96 per cent of the population and more than 600,000 square kilometres (Telstra, 2012a). Additionally, these crashes were also compared with the Telstra Next G® network which claims that the coverage extends 2.1 million square kilometres and covers 99 per cent of the population (Telstra, 2012b).

In the period 2006-2011, there were 5,746 serious injury and 603 fatal crashes in South Australia. Rural crashes accounted for 44.7% of serious injury crashes and 57.5% of fatal crashes in this period. Given that mobile networks are focussed on population density, the urban area of South

Australia has good access to communication infrastructure and urban crashes were excluded from this analysis.

Each of the individual rural crash locations were examined against Telstra's State Coverage Maps (Telstra, 2012c) to determine the proportion of crashes that were included under different cellular coverage types. The results are shown in Table 4.

Table 4. Rural serious injury and fatal crashes in SA 2006-2011 and corresponding Telstra cellular coverage.

Cellular Type (coverage)	Serious Injury Crashes	Fatal Crashes
GSM handset	57.8% (1489)	63.1% (219)
GSM external antenna	71.1% (1829)	79% (274)
Next G® handset	77% (1982)	86.7% (301)
Next G® external antenna	83% (2137)	93.1% (323)
Coverage Unknown	12.3% (316)	1.2% (4)

Table 4 shows that a fully deployed version of the current Australia ACN system might have been successful in transmitting the crash notification and location details (and hence successfully reducing notification delays) in 79% of fatal rural crashes. The unfortunate reality is that for the period examined, each fatal crash notification might likely have been delayed in as many 36.9% of fatal crashes because a user with a GSM mobile handset would not have been able to access the GSM mobile phone network at the location of the crash. Additionally, even in locations where coverage would be expected, signal strength may have influenced the likelihood of successful access to the GSM mobile network.

If the current ACN systems were upgraded to a Next G system (with external antenna) a success rate of 93.1% might have been achieved, and newer generations of ACN systems in Australia, including handset based systems such as Ford's "SYNC® Assist" (see Ford, 2011) are likely to have improved cellular coverage based on 3G, Next G® or 4G network coverage. Table 4 is to some extent relevant for all mobile phone carriers. Where there is any cellular coverage, emergency calls (000 and 112) on mobile phones are carried to a network with sufficient coverage (Department of Broadband, Communications and the Digital Economy, 2012). Telstra currently has the highest claimed mobile phone coverage in Australia of 99%, followed by Optus with 96-97% and Vodafone Hutchinson Australia with coverage of 94% of the Australian population. (Australian Communications and Media Authority, 2013).

Limitations of the study

At the time of writing, 47% of rural and 75% of urban fatal crashes with an EMS notification delay greater that 10 minutes had no coroner files available to examine for the 2008-2009 period. Another limitation was a reliance on TARS reported crash times, which may not be recorded with precision or certainty or the notification delays were inconclusive. However, for the crashes identified as having a delay of greater than ten minutes, the delays calculated from the TARS record for each crash were consistent with information within the coroner's files. An assumption was also made that earlier medical attention would have been of no benefit in the fatalities where the notification delay was less than 10 minutes. It was also assumed that the difference between the SAAS dispatch time and the crash time *(t3-t0)* was a valid indicator of the crash-to-EMS notification delay.

Finally, there is also an underlying assumption that once notified, an SA Ambulance or medical retrieval team was able to attend the fatal crash site and could access the injured promptly and without further delay.

Discussion

Earlier crash notification and dispatch of medical emergency services to a crash involving life-threatening injuries has the potential, although modest, to reduce fatalities in South Australia by 2.2%. This was determined by examining mass fatal crash data to initially identify fatalities where there was a significant delay before the SA Ambulance Service was notified and able to dispatch an ambulance and then subsequently examining individual coroner's files to assess the likelihood that early medical attention may have prevented the fatality.

There were three fatal crashes, resulting in three fatalities that would have benefited from earlier medical attention. In addition, there were three fatal crashes, resulting in another three fatalities where there was some potential benefit, but this was on the basis of immediate surgical intervention. A fourth fatality may have possibly been prevented but it was found there was no cellular coverage for this particular crash and it was therefore assumed that there would be no benefit.

There were a number of fatal crashes with significant EMS notification delays where coroner's files were not yet available, and it is possible that in some of these cases earlier medical attention may also have influenced the outcome. A considerable number of fatalities with a crash-to-EMS notification delay of less than 10 minutes were also not considered in the analysis. It is possible that some of these shorter delays may have also benefited from earlier medical attention, but no benefit was assigned.

Particular crash types were highly represented in the sample: rural (or a rural environment), single vehicle crashes, older vehicles (average vehicle age 19 years old), at night or early morning crashes, hit fixed object crashes. These crashes were associated with a significant delay in EMS notification as a result of an initial delay in the recognition that the crash had occurred, which subsequently delayed the chain of events required to initiate an EMS response.

Automatic Collision Notification and the benefits of these systems are well documented in the literature, assuming full deployment and various levels of estimated cellular coverage or effectiveness. Estimated effectiveness levels from these studies varied from 2.8% (Chauvel and Haviotte, 2011) to 11.9% (Evanco, 1996).

A previous estimate for the benefit of ACN in Australia was calculated by Lahause et al. (2008) and they estimated a 10.5% fatality reduction in urban areas and a 12% fatality reduction in rural areas; that is 103.7 lives annually would be saved in Australia with full deployment of an ACN system that works in 95% of crashes. There is reason to believe this estimate may be prone to error, particularly given that Evanco's equation was used to estimate these benefits in Australia, and it was based on rural US data from 1990. The difference in the estimate of effectiveness is not attributable to their assumption that ACN systems would have coverage in 95% of crashes – such an assumption would have changed, in the present study, the estimate of effectiveness by less than one per cent.

The minimum effectiveness rate of an ACN system in South Australia (with full deployment) based on the study presented here is in the range of 2.2% - 4.4% of all fatalities (with a coroner's file) or 2.8% - 5.7% specifically for passenger vehicle drivers and occupants. This is consistent with the lower end of estimates found in the literature. If the assumption is made that these fatalities are representative of all 218 fatalities in SA for the years 2008-2009, then it is expected that ACN would have had the potential to save at least two or three but perhaps as many as four or five lives per year in 2008-2009 in South Australia.

According to BITRE (2011), 2,925 Australians were killed in road crashes between 2008 and 2009. Assuming the same effectiveness rates for South Australia could be applied across Australia, the analysis here suggests that ACN would have had the potential to save about 32 and possibly as many as 64 lives per year, nationwide in 2008-2009.

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