

MEDICAL CONDITIONS AS A CONTRIBUTING FACTOR IN CRASH CAUSATION

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ABSTRACT

Between 2008 and 2010 CASR undertook a study to determine the proportion of casualty crashes resulting in admission to hospital that were directly associated with the effects of a medical condition or an acute medical event. The study involved examination of the hospital medical records for drivers, riders, pedestrians and cyclists involved in crashes on public roads in South Australia who presented to the Royal Adelaide Hospital for four hours or more during the three year period. A total of 1,490 medical records were accessed. These records were matched with a number of other data sources including Vehicle Collision Records generated by South Australian Police, licensing records from the SA Department of Motor Registration and drug and alcohol screening records generated by the Forensic Science Centre of SA. This detailed examination of the circumstances surrounding each person's involvement in a crash enabled identification of those crashes that occurred as the direct result of a medical condition or acute medical event, as opposed to those for which a crash participant's pre-existing medical condition(s) were unrelated. The study found that more than 10% of the crashes involved an active participant with a confirmed medical condition or acute medical event considered to be a contributing factor in the crash causation. This paper will outline the major findings of the study including the medical conditions found to have directly contributed to the crash, licensing considerations before and after crash involvement and the crash types commonly observed.

Key words

medical conditions, impairment, crash causation, casualty crashes, conditions to licence holding, fitness to drive

INTRODUCTION

Impairment as the result of a medical condition or acute medical event and the role that impairment takes in crash causation has been recognised as a road safety issue for more than three decades. Their contribution to the overall crash problem, however, have frequently been over-shadowed or seen as less important when compared to the risks posed by other road user groups including young drivers and those who are impaired as the result of alcohol. As the age of the road user demographic increases there has been a renewed interest in the role of medical conditions as an increasingly important area of research. This recognition has led to studies that have attempted to identify those medical conditions that pose the greatest risk to crash involvement.

These studies have been diverse in their approach and have included crash based study approaches [1-2], and studies that have examined specific medical conditions, in attempts to identify the risk ratios for individual conditions [3-4]. In some instances the research approach has been more generally focussed, emphasising the role of increasing age and the subsequent impact of multiple co-morbid medical conditions frequently seen in this group [5-9]. Among the important recent works addressing the issue of medical conditions in crash involvement has been those that have reviewed the literature of the current knowledge and those who have attempted to identify risk ratios for particular medical conditions, including Charlton et al and Dobbs [10-12]; and those that have undertaken analysis related to crashes where at-scene crash investigation and follow-up occurred, including Hanna's retrospective analysis in

2005-2007 that was based on the US National Motor Vehicle Crash Causation Survey (NMVCCS) [2]. The conclusions drawn from Hannah's analysis suggested that medical emergencies accounted for only 1.3 % of all drivers in the study. These conclusions are in contrast to the findings of an in-depth at-scene crash investigation study undertaken by the Centre for Automotive Safety Research (CASR) between 2002 and 2005 where it was found that 13% of the casualty crashes investigated occurred as the direct result of a medical condition or acute medical event [13]. It is likely that these contrasts in findings, however, relate to differences in methodology and selection criteria. Further research related to the complex role of medical conditions in crash causation, that is based on a comprehensive analysis of real crash data from multiple sources, has the potential to add to the current understanding of the role of medical conditions or acute medical events in crash involvement and has the potential to facilitate development of more targeted countermeasures.

Between 2008 and 2010 the Centre for Automotive Safety Research undertook a study of road users who were admitted to hospital as the result of crash involvement. The study involved examination of the circumstances surrounding drivers, motorcycle riders, cyclists and pedestrians involved in casualty crashes on public roads in South Australia who were admitted to the Royal Adelaide Hospital over the three year period between January 2008 and December 2010. The main purposes of the study were: 1. to determine the extent to which a pre-existing medical condition or acute medical event was a contributing factor in casualty crash causation and 2. to provide a new understanding of the types of medical conditions or acute medical events that are most likely to contribute to a persons involvement in a crash. A comprehensive set of data related to 1490 drivers, motorcycle riders, pedestrians and pedal cyclists formed the basis for this study. Four data sets were used in the conduct of the study: primary source hospital medical records, police crash data records, driver licensing records and forensic data related to alcohol and drug testing. This detailed examination of the circumstances surrounding each person's involvement in a crash enabled identification of those crashes that occurred as the direct result of a medical condition or acute medical event that was evidence based.

METHOD

The first step in the study involved identification of eligible participants through examination of the hospital medical records. During the course of the project 1490 individuals were identified as meeting the study inclusion criteria and their medical records were made available for examination under ethical approval. Data for each of these 1490 crash involved participants was then matched with three other data sources: police data related to this and previous crashes, licensing history data and forensic science data related to mandatory testing for alcohol and drugs. This linking of data provided a more complete understanding of the multiple factors that impact on a participants engagement in the road environment and their subsequent crash.

Medical records

All persons who present to the Royal Adelaide Hospital for medical care that is of four hours duration or more are formally admitted to the hospital and are required to undergo International Classification of Disease coding utilizing version ten, Australian Modification (ICD10-AM). Within the ICD10-AM are specific codes related to external sources of injury, some of which relate to road crashes. From these codes the

hospital coders were able to identify those individuals who presented as a result of a motor vehicle accident. Cases that met the criteria for possible inclusion in the study were then provided for examination by the researcher on a regular basis. The records examined included those documented at the collision scene, Emergency Department records and medical and allied health records generated throughout the in-patient period. The documentation found in the medical records following medical assessment was the key source of evidence used in determining whether a medical condition or acute medical event contributed to the crash causation. The details sought from the medical records included:

- date, time and exact location of the crash
- descriptions of any known crash mechanisms, including movements of vehicles leading to the crash
- information related to restraint use and airbag deployment
- primary at-scene medical assessments
- documentation related to pre-existing medical conditions and medication use at the time of the crash
- information related to alcohol or drug use where suspected or known
- injuries incurred in the crash
- diagnostic tests undertaken and the results of those tests
- medical interventions undertaken
- records related to previous hospital contact
- documentation related to medical assessments/conclusions that may explain or refute an existing medical condition or acute medical event in crash causation
- length of hospitalization as a result of injuries, and discharge destination

Police records

Identifiers found in the medical records, including date, time and location of the crash, enabled accurate matching of participants in the study with crash related records generated by South Australian Police (SAPOL) in 95% of the 1490 cases. Two discrete sources of information related to Police records were made available to the researcher for matching: Vehicle Collision Reports (VCR) and the Traffic Accident Reporting System (TARS). Information found in the Police crash records include:

- date, time and location of crash
- names and driver licence numbers of all those involved in the crash
- licence type(s) at time of crash
- brief description of the crash events
- information related to the road environment, including road configuration
- vehicle type and registration details
- injury status for those others involved in crash
- police allocated at-fault status for the crash
- previous crash histories including dates, locations, descriptions of those crashes, at-fault status for each crash and category of at-fault.

Licensing records

The licensing records related to the 1222 drivers and riders involved in crashes during the data collection period were sourced at the Department of Energy and Infrastructure. Successful matching of licensing records occurred for 95% of the 1222 drivers and riders with the remainder identified as either holding interstate or international licenses, or not found. Records were accessed in most cases by driver licence number identified in the SAPOL collision records.

Information collected from this source included:

- class and type of licence held at time of crash involvement
- identification of any conditions or restrictions to licensure, both before and after crash involvement
- infringement history, including identification of the type(s) of infringement
- history related to any previous disqualifications and reasons for those disqualifications, including suspensions that may have been imposed as a result of a medical condition before or after crash

Forensic Science records

Since 1972 those crash involved drivers, motorcycle riders, vehicle occupants and pedestrians over the age of 14 years, who present to hospital as a result of a crash, have been required to undergo mandatory testing for blood alcohol concentration in South Australia. Since July 2008 the mandatory screening has also included screening for three drugs: methamphetamine, Tetrahydrocannabinol (THC) and 3,4-Methylenedioxymethamphetamine (MDMA). These tests require a blood sample to be taken by hospital medical personnel within eight hours of being involved in the collision, with most occurring within the first one to two hours following the crash. The samples are sent to and tested by the South Australian Forensic Science Centre. The results of these tests were made available for those drivers, motorcycle riders and pedestrians identified within the study for matching. The records provided include the results following testing as well as the time that the sample was taken. Although testing is mandatory, it was noted that blood alcohol and/or drug testing results were not found in 50% of pedestrian cases. Successful matching of records from this data source occurred for 1204 of the 1490 participants (81% of cases).

RESULTS

In total there were 1490 case records made available for examination that met the selection criteria during the data collection period and all cases were examined and included in the study. The participant group consisted of 845 drivers of cars or trucks, accounting for 56.7% of the study group; there were 377 motorcycle riders who accounted for 25.3%, 207 pedestrians, 13.9% and 61 cyclists, 4.1%. There was one motorised mobility scooter (gopher) rider involved in the study.

Age and sex distribution

In 59.4% of the crashes in the study the active participant was aged between 20 and 50 years. Overall males were found to be involved as active participants in 70% of the crashes while women made up around 30%. Those aged 70 years or more accounted for 11.14% of the active participants in the study.

Injury severity and length of hospitalization

In 21% of cases the participant was hospitalised at the Royal Adelaide Hospital for less than 24 hours, with more than 60% of all those involved in the study being hospitalised for five days or less. In 45 cases (3%), the active participant who presented to hospital as a result of injuries incurred in the crash, died as a result of those injuries. Fatal outcomes were seen across all age groups, however, those over 70 years of age demonstrated a higher number of fatal outcomes per person involved in a crash when compared to younger groups; for example 7.2% of those crash involved participants aged 70 years or more were fatally injured compared to 2.5% of those crash involved participants who were less than 40 years of age.

Pre-existing medical conditions

In most cases the information regarding the presence of pre-existing medical conditions was based on self report. Much of the available information related to pre-existing medical conditions for participants was limited to a list of conditions. Details relating to the degree or level of impairment as the result of particular condition(s) were also infrequently documented.

It was found that more than 60% of all participants in the study had at least one pre-existing medical condition at the time of their crash involvement (898 participants), with 45% having three or more conditions and 5% who were known to have seven or more co-morbid conditions, some as many as twelve. The prevalence of pre-existing medical conditions was seen to increase with the age of the participant; for example it was noted that less than 50% of the participants under the age of 50 years had a known history of at least one pre-existing medical condition compared to more than 95% of those over the age of 70 years. Additionally those participants in the older age groups were found to have a larger number of co-morbid conditions, with 33% of all participants 70 years of age or older having five or more medical conditions compared to less than 6% of those under the age of 50 years.

Figure 1 provides information related to the most common pre-existing medical conditions found among all participants by road user type. Cardiovascular disease, including hypertension, cardiac conditions and hypercholesterolaemia were found to be the most common medical conditions, along with depression. These conditions were noted among all road user types but were particularly noted among drivers. Alcohol dependence and current regular illicit drug use have been included among the more intrinsic medical conditions identified. Although alcohol dependence was found across all road user types, 23% of all pedestrians were found to have alcohol dependence compared to 8% of drivers and 6.6% of motorcycle riders. Note that there are two conditions found in Figure 1 that have been described in acronym, these two conditions are NIDDM, non-insulin dependent diabetes and IDDM, insulin dependent diabetes.

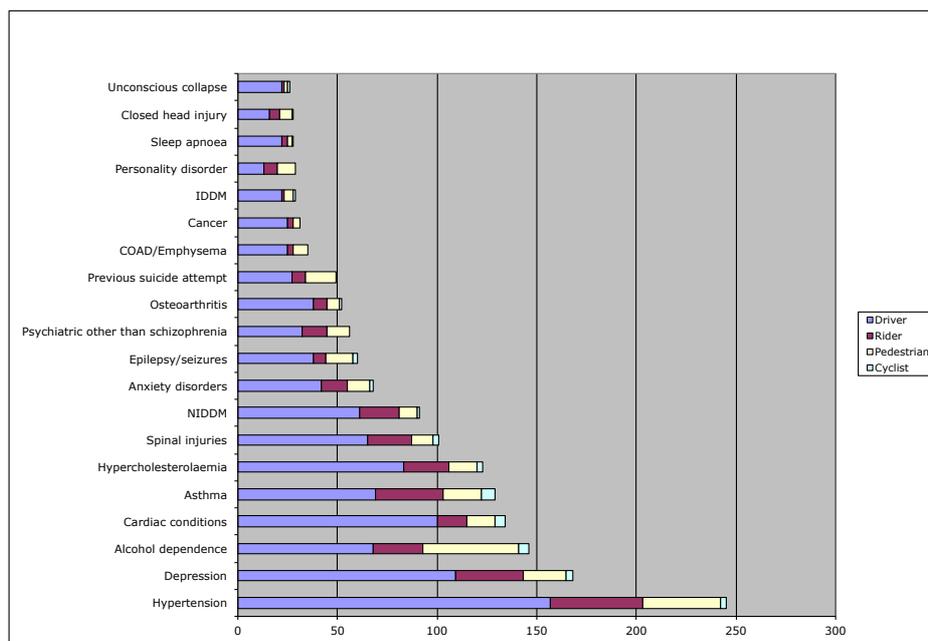


Figure 1: Most common pre-existing medical conditions found across all participants

Licence type and conditions to licence holding

Close to 80% of the drivers and riders were travelling on a full licence at the time of the crash, with 15% holding a provisional or probationary licence. There were fewer than 2.5% of drivers and motorcycle riders who were un-licensed or disqualified from driving at the time of the crash. It was found that 30% of all licence holders had at least one condition identified on their licence. Drivers were more likely to hold a conditional licence (32% of all drivers) compared to motorcycle riders (22%). The most common condition to licensing was the wearing of corrective lenses which was seen across both groups. Heart disease/hypertension was the most common medical condition specifically identified on licence conditions, with 90 licence holders (7.5%) falling into this group. This was followed by non-insulin dependent diabetes (2%), limb condition (1.8%), epilepsy (1.7%) and nervous/psychiatric disorders (1.6%). Although mental illness and alcohol dependence were identified among the leading pre-existing medical conditions for participants in the study, this status was less likely to be identified in conditional licensing records. For example, although there were 93 drivers or riders known to have alcohol dependence, only one of these licence holders had their alcohol dependence status identified in their licence records.

Medical conditions as a contributing factor in crash causation

Although an understanding of the participants pre-crash medical status, including the presence of a pre-existing medical condition(s), provides background information that may shed light on the person's abilities to perform in the road environment, these do not necessarily implicate that status as a contributing factor in their crash involvement. The medical records were examined in detail for documentation that supported or refuted a medical condition or acute medical event as a contributing factor in the crash. In many instances the medical documentation provided evidence of the role of a medical event in the lead up to the crash with conclusions drawn, however, this was not always the case. This led to formulation of a group of participants where a medical event's contribution to the crash could be concluded with a high degree of certainty and a group where the contribution of a medical event was likely but not certain, categorised here as possible.

In the 1490 cases examined in the study it was found that a medical condition or acute medical event was identified by the treating medical team as a contributing factor in the crash events with a high degree of certainty in 165 cases, accounting for 11% of all cases. A further 24 cases were identified as possible cases, that is that the crash was likely to have occurred as a result of a medical condition but with less certainty, giving a total number of 189 cases (12.7%). Participants identified as being involved in the crash as the result of a medical condition or acute medical event were categorised under thirteen broad headings:

1. loss of consciousness leading to crash
2. seizure event
3. mental illness
4. deliberate suicide attempt
5. general poor health and declining function
6. dementia or cognitive decline
7. hypoglycaemic event
8. sleep apnoea

- 9. cardiac even
- 10. CVA/stroke
- 11. other neurological condition or event
- 12. visual deficit
- 13. other

Figure 2 identifies the types of conditions and number of cases involved under the thirteen broad headings.

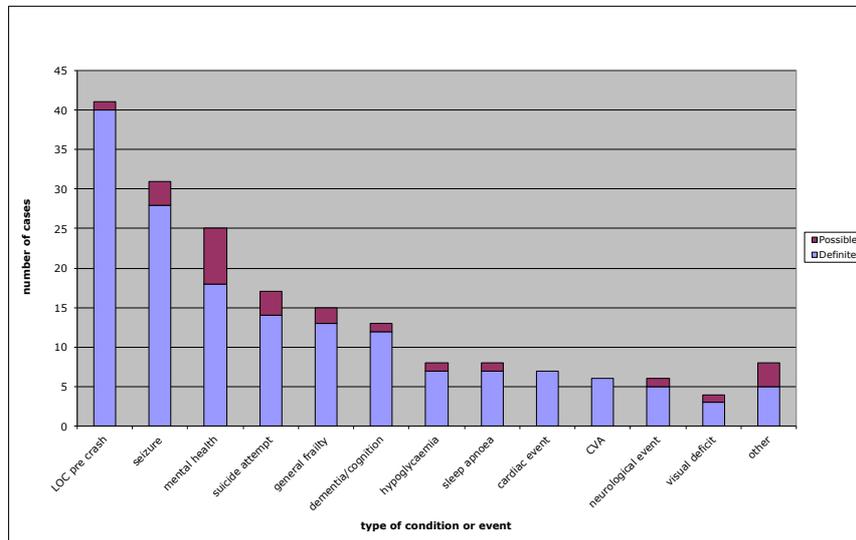


Figure 2: medical condition or acute medical event identified as contributor to crash

A medical condition or acute medical event was found to be a contributing factor in crash causation across all road user types, however, drivers were found to be more likely than all other road users to be identified as being involved in a crash because of these. A medical condition or acute medical event was found to be a contributing factor in crash causation for 18.1% of the drivers in the study. It was found that 9.7% of all pedestrian crashes were related to a medical condition or acute medical event, while 3.7% of all motorcycle riders and 1.6% of all pedal cyclists were found to be involved as the result of a medical condition.

Table 1 shows the breakdowns of those identified as being involved in a crash as the direct result of a medical condition or acute medical event by road user type.

Road user type	driver of car or truck	motorcycle rider	pedestrian	pedal cyclist	gopher rider	total
all cases in study	845	377	207	61	1	1490
medical condition certain	137	10	16	1	1	165
medical condition possible	16	4	4	-	-	24

Table 1: Numbers involved in crash as the result of a medical condition or acute medical event by road user

In addition to those involved in the crash as the result of a medical condition there were a group of participants who were involved in the crash due to impairment as the result of alcohol intoxication. Impairment as a result of alcohol was identified as the

leading contributing factor to crash causation in this study. There were 274 cases in the study where an alcohol level above 0.05 gm/100ml was identified, representing 18.4% of all cases. Alcohol intoxication was found to be a confounding factor in 19 of the 189 medical condition cases. In 16 of these cases the identified condition or event was related to mental illness and/or deliberate suicide attempts. In almost 60% of these cases the alcohol concentration was found to be 0.15 or above.

While acute alcohol intoxication is not considered a medical condition as such, most would agree that intoxication in a climate of alcohol dependence is. Alcohol dependence was identified in the medical records to be a pre-existing medical condition for 146 of the participants in the study. The incidence of alcohol dependence was found to be highest amongst the pedestrians in this group, with 23.2% of all pedestrians in the study known to be alcohol dependent. The incidence of known alcohol dependence was found to be much lower in drivers (8% of all drivers), motorcyclists (6.6% of all riders) and cyclists (8.2%). Of the 146 participants who were known to be alcohol dependent, 74 (50%) were known to have an alcohol level above 0.05 at the time of the crash. An alcohol reading was not recorded for 31 (21%) of the participants known to be alcohol dependent and so it might be expected that this 50% figure is conservative.

Age distribution

Age was seen to be an important factor when looking at those involved in the crash as the result of medical conditions. A medical condition or acute medical event was found to be a contributing factor in 9.17% of the crashes for participants 50 years of age or less. However, those participants 70 years of age or more were found to have a medical condition or acute medical event as a contributor in 34% of the crashes they were involved in. For those over 80 years of age this figure increased to 40.8% and those 90 years of age or more to 66.6%.

Crash type for those involved in crash as the result of a medical condition

Almost 40% of all participants involved in a crash as the result of a medical condition were found to have struck a fixed object, compared to 22.4% of all other participants. Hitting a parked vehicle was also a common occurrence among those in the medical condition group, with 9% of those in the medical condition group involved in this type of crash compared to 1.2% of all other participants. Those involved in a crash as the result of a medical condition were involved in half as many rollover crashes, 4.8% compared to 9.1% of all others.

At-fault status for crash

Those involved in a crash as the result of a medical condition were identified as at-fault by SAPOL in more than 95% of cases. This compared to 68.4% for all other participants. One of the categories used by SAPOL in allocation of at-fault status is 'sick, asleep or dead at the wheel'. This category of at-fault was used in Police records in less than 12% of those cases identified in the study as occurring as the result of a medical condition or event.

DISCUSSION

The purpose of this study was not to generate countermeasures for reducing the incidence or impact of medical conditions that result in crash involvement but rather to provide a new understanding of the types of medical conditions or acute medical

events that are most likely to contribute to a persons involvement in a crash. This data can then be used in conjunction with other research to formulate new countermeasures and inform on those already in place.

This study involved the examination of the circumstances surrounding the crash events for 1490 drivers, motorcycle riders, pedestrians and cyclists who required hospitalisation as the result of a crash. A medical condition of acute medical event was found to be a contributing factor in crash causation across all road user types, however, drivers of cars were found to be more likely to have a medical condition as a contributing factor to their crash than all other road user groups. There were two common themes among those drivers involved in crashes as the result of a medical condition: those who lost control of the vehicle due to an acute medical event and those who were experiencing functional impairment due to mental illness or cognitive deficits.

Those losing control of the vehicle due to an acute event included those experiencing a sudden loss of consciousness, those experiencing a seizure or those occurring as the result of a hypoglycaemic event or stroke. Although these crashes occurred as the result of a sudden/acute incapacitation there were a number of cases where the participant had some event or incident in the weeks preceding the crash that eventually played a role in their crash. Of the 41 drivers and riders who experienced a loss of consciousness prior to the crash there were ten drivers who had a self reported history of two or more episodes of unconscious collapse in the weeks and months preceding the crash. Similarly, among those who were found to have experienced a seizure there were at least ten drivers who had a history of unexplained unconscious collapse or episodes of unresponsiveness in the months preceding the crash. Of particular note amongst those experiencing a seizure was that in each of these ten cases the participant did not have an established diagnosis of epilepsy prior to investigations conducted following their involvement in the crash.

Functional impairment as the result of mental illness, deliberate suicide attempt or cognitive decline was found amongst pedestrian participants as well as drivers. In many of the cases that were identified as occurring as the result of mental illness there was documentation that described a demonstrable escalation in either their mental illness status or suicidal ideation before the crash event. These escalations in behaviours were noted by family members in some cases but also included medical documentation in those cases where the person presented to hospital in the days and weeks prior to the crash involvement.

Those identified as being involved in a crash as the result of a medical condition or acute medical event were seen across all age groups. However, those participants who were 70 years or older were found to be involved in a disproportionate number of crashes involving a medical condition or event. While those 70 years of age or older accounted for 11.4% of participants in the study, they constituted more than 30% of those involved in a crash as the result of a medical condition or event. Those identified as being involved in the crash as the result of mental illness or a deliberate suicide attempt were found to be younger, with most participants being between the ages of 20 and 50 years.

CONCLUSION

This study has shown, through detailed consideration of the medical records of road users admitted to hospital following a crash, that medical conditions are associated with the occurrence of 11-12% of their crashes. Loss of consciousness from undetermined causes, seizures, mental illness and deliberate suicide attempts were identified as being important. The occurrence of multiple medical conditions increased with increasing age with a corresponding increase in being involved in a crash as the result of a medical condition or acute medical event.

The findings of this study have implications for licensing authorities and for the management of licence holders with medical conditions by the treating medical personnel. The study findings also have implications for road safety practitioners in developing strategies to address an aging population. Some of the suggested implications from this study include:

- continuation of regular assessment of older drivers for medical fitness to drive, particularly for those demonstrating age related functional decline and those at increased risk as the result of the effects of multiple co-morbid medical conditions
- improved evidence based information available to licence holders, and the medical practitioners responsible for their care, that identifies the increased risks of driving with particular medical conditions.

ACKNOWLEDGEMENTS

The Centre for Automotive Safety Research and authors wish to acknowledge the following: Austroads, the South Australian Motor Accident Commission (MAC) and the South Australian Department for Transport, Energy and Infrastructure (DTEI) for providing financial support for this project. We would also like to acknowledge the Royal Adelaide Hospital, South Australian Police (SAPOL), the Forensic Science Centre of South Australia and the Safety and Regulation Division of DTEI for allowing access to data utilized in the development of this study. Acknowledgement also goes to Craig Kloeden of CASR for database development and support.

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