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An examination of the environmental, driver and vehicle factors associated with the serious and fatal crashes of older rural drivers

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ABSTRACT

Motor vehicle crashes involving rural drivers aged 75 years and over are more than twice as likely to result in a serious or fatal injury as those involving their urban counterparts. The current study examined some of the reasons for this using a database of police-reported crashes (2004–2008) to identify the environmental (lighting, road and weather conditions, road layout, road surface, speed limit), driver (driver error, crash type), and vehicle (vehicle age) factors that are associated with the crashes of older rural drivers. It also determined whether these same factors are associated with an increased likelihood of serious or fatal injury in younger drivers for whom frailty does not contribute to the resulting injury severity. A number of environmental (i.e., undivided, unsealed, curved and inclined roads, and areas with a speed limit of 100 km/h or greater) and driver (i.e., collision with a fixed object and rolling over) factors were more frequent in the crashes of older rural drivers and additionally associated with increased injury severity in younger drivers. Moreover, when these environmental factors were entered into a logistic regression model to predict whether older drivers who were involved in crashes did or did not sustain a serious or fatal injury, it was found that each factor independently increased the likelihood of a serious or fatal injury. Changes, such as the provision of divided and sealed roads, greater protection from fixed roadside objects, and reduced speed limits, appear to be indicated in order to improve the safety of the rural driving environment for drivers of all ages. Additionally, older rural drivers should be encouraged to reduce their exposure to these risky circumstances.

1. Introduction

Older drivers (i.e., 65 years and older) are involved in fewer motor vehicle crashes than other age groups, but have an increased risk of death and serious injury when they are involved in an accident (Ryan et al., 1998; Baldock, 2004; Langford and Koppel, 2006; Meuleners et al., 2006; Hanrahan et al., 2009; Thompson et al., 2010). This increased risk of injury is believed to be caused by greater frailty, such that older people have a lowered tolerance to physical trauma and sustain more severe injuries than younger persons in comparable crashes (Viano et al., 1990; Li et al., 2003).

Regardless of age, drivers who live in rural areas are at a higher risk of serious or fatal injuries following a crash than drivers who reside in urban areas, despite the lower crash rates in rural areas (Maio et al., 1992; Borgialli et al., 2000; Brown et al., 2000; Donaldson et al., 2006; Muelleman et al., 2007; Thompson et al., 2010). Thompson et al. (2010) examined the crash rates, as well as the serious and fatal injuries, of drivers from rural and urban areas of South Australia across a range of ages. This study found that rural drivers who were aged 75 years and older had the lowest number of crashes when they were compared to all other age groups and to urban residents, but the highest likelihood of serious or fatal injuries following a crash. Indeed, they were more than twice as likely to be involved in crashes that resulted in a serious or fatal injury than urban drivers of the same age. This rural–urban differential has been attributed to a range of factors, including higher speed limits (Gonzalez et al., 2007), delays in the delivery of medical care after a road accident (Muelleman and Mueller, 1996), the reduced availability of trauma medical care (Muelleman et al., 2007), and greater alcohol usage (Borgialli et al., 2000) in rural areas.

According to the South Australian Department of Planning, Transport and Infrastructure licensing figures for 2009, 28% of licensed older drivers (aged 75 years and over in South Australia) reside in rural areas. Thus, it is important to understand why older rural drivers have a higher likelihood of serious or fatal injuries

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in a crash than those who live in urban areas. Their increased likelihood of serious or fatal injury may be explained by the tendency to be travelling at higher speeds when they crash (due to higher speed limits) or the issues relating to medical care discussed above. However, the intention of the present study was to determine whether there are other factors involved that have not previously been identified and which, along with speed limits, could be adjusted to make rural driving environments safer for older drivers. To determine what these other factors may be, the first aim was to identify any environmental (time of day/light, road and weather conditions, road layout, type of road surface, horizontal and vertical road alignment, speed limit), driver (type of driver error, crash type) and vehicle (vehicle age) factors that are more frequently involved in the crashes of older rural drivers than their urban counterparts. The second aim was to determine whether those factors that are more commonly associated with the crashes of older rural drivers are also associated with a greater likelihood of serious or fatal injuries for crashes in general. This was done by examining injury severity in younger drivers (16–74 years) for whom frailty does not contribute as much to injury severity levels.

It is possible that the higher speed limits found in rural areas (resulting in higher travelling speeds) may be the predominant reason why there is an increased likelihood of older rural drivers being seriously or fatally injured following a crash and, in addition, speed may mediate the effects of other environmental factors (e.g., the consequences of crashing on an unsealed road will differ depending on whether the car is travelling at a low or high speed). In addition to the mediating effect of speed, there may also be other interactions among the environmental factors, such that one may mediate the effects of another. For example, an unsealed road is also likely to be undivided, which may play a role in the higher injury severity in crashes on these roads. Consequently, the final aim of this study was to determine whether those factors that were more common in the crashes of older rural drivers also made independent contributions to the likelihood of serious or fatal injuries for older drivers. To do this, each of the factors that were more common for older rural drivers was entered into a logistic regression model to predict injury severity for older drivers.

2. Method

2.1. Materials

Crash data for the years 2004–2008, inclusive, were acquired through the Traffic Accident Reporting System (TARS), which is a database of all police-reported road crashes in South Australia that is managed by the Department of Planning, Transport and Infrastructure (DPTI). For a crash to be included in the database, at least one of the persons involved (e.g., the driver, other vehicle occupants, pedestrians) must have been injured, $3000 or more worth of damage must have been caused to the vehicle(s), and/or one of the vehicles must have been towed away. If any of these criteria are met, then a driver is legally obliged to report the crash to the police. The TARS database records information relating to: the nature, cause, time and location of a crash; details of all drivers and any injured occupants or pedestrians who were involved in the crash; and the severity of any resulting injuries. It is a particularly useful database because, in addition to crashes in which people are injured, it records crashes where there is only property damage; therefore providing a comprehensive picture of the overall crash involvement of older rural drivers.

2.2. Measures

The data that were extracted from the TARS database and used in the analyses only included crashes where the driver involved was driving a car or comparable light passenger vehicle (e.g., utility, van, station wagon) because the circumstances of crashes involving other vehicles (e.g., taxis, trucks, motorcycles) may be fundamentally different. Background information on the driver and specific details of the crash were obtained. The background information on the driver included their *age* (in years) and *residential postcode* (4 digit code), with the latter being used to determine whether the driver lived in a rural or urban area of South Australia and to group into "rural" or "urban" drivers for the purposes of statistical analyses. Crashes in which the driver lived interstate or their postcode was not recorded were excluded for present purposes.

The details of the crash that were extracted included the postcode of the crash location, the severity of the driver injury and the year when the crash occurred, as well as the environmental, driver and vehicle factors involved. The *postcode* of the crash location was used to determine whether it occurred in a rural or urban area of South Australia. *Driver injury severity* refers to the degree of injury incurred by the driver involved in the crash and was recorded as one of five levels of severity: property damage only (no injury), injury requiring treatment from a private doctor, injury requiring treatment at a hospital, injury requiring admission to a hospital, and fatal injury. For the purposes of this research, a serious injury was defined as one requiring admission to a hospital.

The information relating to the environmental factors that was obtained included the level of ambient light, road and weather conditions, road layout, road surface, horizontal and vertical road alignment, and speed limit at the crash location. The *levels of ambient lighting* were recorded on the TARS database as being daylight, dawn/dusk, or night. The *road conditions* were recorded as wet or dry, while the *weather conditions* were recorded as raining or not. The *road layout* where the crash occurred was classified as one of 15 types in the TARS database, such as a cross-road or freeway (for a full list see Table 3 in Section 3), and the *road surface* was classified as sealed, unsealed or unknown. The *horizontal road alignment* at the crash location was classified as straight road, curved road with view open, curved road with view obscured, or unknown. The *vertical road alignment* was categorised as being level, on a slope, at the crest of a hill, at the bottom of a hill, or unknown. *Speed limit at the crash location*, was recorded in terms of kilometres per hour.

The information relating to the driver factors that was obtained included the type of driver error and the type of crash. *Driver error* was classified by the TARS database into 29 possible types, such as inattention or no error (for a full list see Table 5 in Section 3). Each driver that was involved in a crash was assigned one of these error-types by the investigating police officer. It is worth noting that some of the "errors" listed in the TARS database may reflect intentional driver choices rather than "errors" (e.g., excessive speed); however the term "error" was retained in order to remain consistent with the terminology used in the database. *Crash type* was classified as one of 13 possible categories in the TARS database, such as side-swipe or head-on crash (for a full list see Table 5 in Section 3). Also, the vehicle information that was obtained was the year of vehicle manufacture. This was subtracted from the year of the crash occurrence in order to calculate the *age of the vehicle* (in years) at the time of the crash.

In order to analyse the crash data in terms of the age group of drivers involved in the crashes, it was necessary to base the analysis on crash-involved drivers rather than crashes. One of the consequences of using these data is that, for crashes involving multiple drivers, each driver had a separate entry in the database. Thus, a single crash that involved two drivers counted as two crashes. For analyses focusing only on drivers aged $\geq$75, crashes would only be