Elderly Drivers and Emergency Department Visits

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Abstract

Background: Canadians are living longer and have more active lifestyles, which means that there are more elderly drivers and increasing road traffic injuries among this population. The primary objective of this study was to examine the injury profile and emergency healthcare utilization of older drivers (age ≥70) treated in an emergency department (ED) after a motor vehicle crash (MVC).

Methods: We conducted a retrospective cross-sectional study with data obtained by chart reviews of MVC related ED visits at Vancouver General Hospital, British Columbia from January 1, 2009 to May 31, 2014. Each older injured driver (age ≥70) was matched with 2 younger injured drivers (age <70) with the closest ED visit date and time. Data from medical records including demographics, crash circumstances, injury profile and ED care information were analysed using descriptive and logistic regression analyses.

Results and Conclusions: Elderly drivers were 2.41 times more likely to be admitted to hospital and sustained more injury after a crash compared to younger drivers. As expected, elderly drivers also had longer ED length of stay compared to younger drivers (median time: 184.5 versus 155 minutes) as well as higher rates of ambulance arrival (85.4% versus 68.3%), blood work requirement (63.5% versus 39.3%) and diagnostic imaging (78.1% versus 62.8%).

Implications: Compared to younger drivers, elderly drivers involved in MVCs sustain more serious injuries and have higher healthcare utilization. These indicate the need for programs to identify at risk elderly drivers and ED treatment protocol to care for the increasing older driving population.

Introduction

Currently, the leading cause of injuries requiring hospital care in the older adult population is falls. However, over the next few decades, we are likely to see increasing numbers of motor vehicle crash (MVC) related injuries as the older population continues to be active on the road. In the province of British Columbia (BC), the number of drivers aged 70 years and above is projected to increase by over 100% from 320,000 in 2012 to 670,000 by 2032 based on the current numbers of licensed drivers and their age distributions in 2002-2012 (data from Insurance Corporation of British Columbia). It is anticipated that emergency department (ED) visits by this driver group will also rise significantly.

The elevated crash and injury risks of elderly drivers have been studied previously (Bauza, Lamorte, Burke, & Hirsch, 2008; Newgard, 2008; Welsh, Morris, Hassan, & Charlton, 2006). These studies show that elderly drivers are more likely to be injured or killed in a crash and more likely to be hospitalized with longer length of stay compared to their younger counterparts. This is mainly due to the fact that older persons have decreased physiologic reserve to respond to injury in the event of a crash, even in crashes that are considered minor (Augenstein et al., 2005).

While crash rates per vehicle distance traveled are higher in elderly drivers with advancing age (Langford, Koppel, McCarthy, & Srinivasan, 2008; Ryan, Legge, & Rosman, 1998), some studies noted that fragility from aging is by far the most important factor for the increased risk of serious injuries and fatalities in this age group (Li, Braver, & Chen, 2003; Meuleners, Harding, Lee, & Legge, 2006). Using US national accident data, Li found that fragility started to increase at around age 60 and accounted for 60-95% of excess mortality rate per vehicle distance travelled. Among older drivers, significant increase in injury crash involvement did not begin until the age of 75 and explained at most 30-45% of the elevated fatal injury risk in this group of drivers. This is consistent with an Australian study (Meuleners 2006) which reported that fragility contributed to 47-95% of injury risk in drivers aged 65 and above. Although excess crash involvement was a major contributing factor for drivers aged 80 and above, fragility still accounted for about 60-70% of their fatal injury risk. In Canada, with data from police reports, Zhang (2000) also showed that pre-existing medical or physical conditions increased the risk of fatality by a factor of 3.5 - 5 for drivers age 75 and above (Zhang, Lindsay, Clarke, Robbins, & Mao, 2000).

Besides age related fragility, a number of additional factors can also affect injury outcomes in a crash. Zhang reported that higher fatal injury risk is associated with high speed roads (odds ratio= 7.9), head-on collisions (odds ratio= 55.1), single vehicle collisions (odds ratio= 6.7) and two vehicles turning collisions at intersections (odds ratios= 3.1 to 8.7). Fortunately, per capita serious crashes involving elderly drivers remain low. A more recent study on the patterns of crashes by elderly drivers has suggested that they are mostly involved in minor crashes (Trieu, Park, & McFadden, 2014). Rear-end collisions, same direction side swipes and right angle collisions (particularly right angle collisions at intersections) are most frequently observed in elderly drivers. A telephone survey by Betz (2010) indicated that most crashes involving elderly drivers occur under relatively safe conditions such as during the day, in good weather, and on dry roads (Betz & Lowenstein, 2010). The resulting injuries would be expected to be minor if not for the driver's advanced age and physical frailty.

Most prior literature on crash and injury rates of elderly drivers are based on data from police reports, hospital separations or surveys and have primarily focused on fatal and severe injury crashes. A recent study by Vogel and colleagues (2013) reported that the majority of older MVC patients treated in an emergency department sustained only minor injury and did not require hospital admission (Vogel, Ginde, Lowenstein, & Betz, 2013). However, many older MVC patients have moderate to severe pain when discharged home from the emergency department and may require ongoing medical care as outpatients (Platts-Mills, Hunold, Esserman, Sloane, & McLean, 2012). Our group also reported that, although not requiring hospital admission, drivers involved in minor injury crashes often have slow recovery (Brubacher et al., 2014). Details on patients with minor injuries (i.e. discharged from the ED), and information on their post ED care is not captured in hospital separation data and police reports.

The study by Vogel (2013) indicated that adults (age >65) have higher rates of MVC related ED visits and serious injury compared to the younger cohort (age 18-65). Older patients also require greater acute care and rehabilitation resources. The major limitations of Vogel's study are the lack of information on driver versus passenger status, crash circumstances and pre-crash health status. The recent decline in fatal and severe injury crash rates among elderly drivers is thought to be due, at least in part, to the improving general health status of older individuals and safer modern vehicles (Cheung & McCartt, 2011; Cheung, McCartt, & Braitman, 2008).

There is little data on emergency care utilization of elderly drivers after minor crashes. Given their age related fragility and higher likelihood of injury, we hypothesize that, after minor crashes, older drivers (age ≥70) will require more emergency care resources than younger drivers. Our primary objective was to provide current BC data on the emergency care utilization of elderly drivers (age ≥70) after motor vehicle crashes. Specifically this study (1) examined the injury profiles and emergency care utilization of elderly drivers compared to that of younger injured drivers, and (2) explored factors that are potentially associated with injury level of elderly drivers using hospital admission as surrogate indicator of injury severity.

Methods

Data and Population: This study was approved by the University of British Columbia Research Ethics Board and by the Vancouver Coastal Health Research Institute. We included all drivers aged ≥70 years (elderly drivers) who were injured in a motor vehicle crash and presented to Vancouver General Hospital (VGH) emergency department (ED) between January 1, 2009 and May 31, 2014. VGH is the largest level 1 trauma centre in British Columbia and the VGH ED has 85,000 visits annually including approximately 1100 injured drivers. Among these injured drivers, on average 55 per year were ≥70 years old. Injured drivers were identified through the VGH ED database. For comparison, we systematically identified drivers aged < 70 years (younger drivers) and presented to VGH ED during the same period. For each older driver, we selected 2 younger drivers who visited the VGH ED after a car crash at the closest date and time to the visit of the older driver. These drivers formed the younger driver comparison group. The matching of ED dates was done to control for unmeasured driving conditions (weather and seasonality) and trends in care utilization as well as for sampling efficiency. Ideally we should match crash characteristics and pre-existing health status; however, that information is not available until the charts have been reviewed.

Drivers who presented directly to VGH ED from crash sites by ambulance or were self-admitted within 2 days of an MVC were included in this study. Drivers who were transferred from other hospitals were excluded in order to avoid missing ED visit information and bias from over-inclusion of more severely injured cases. Motorcyclists and scooter users were also excluded in this study because they represented a different at risk population of road users.

Data for this study came from review of medical records. We collected demographics (age and gender), crash time and date, mode of ED presentation (self-admitted versus by ambulance), date and time of ED presentation, description of crashes (e.g. single versus multi-vehicle crash), pre-crash medications, pre-crash medical history, injury severity (maximum Abbreviated Injury Scale (AIS) score), injury area by body region, ED investigations, ED length of stay, and hospital admission. In order to standardize our injury classification we categorized injuries by anatomical location and used the maximum AIS score to indicate overall injury severity (Gennarelli & Wodzin, 2006; Greenspan, McLellan, & Greig, 1985).

Statistical analysis: For objective 1, we conducted cross-sectional descriptive analyses on the injury profiles, ED care utilization, hospital admission, pre-crash medical history and crash circumstances for both driver age groups. The medians and interquartile ranges (IQR) of age and ED length of stay (LOS) were determined. For categorical variables, we compared proportions with Chi square test and estimated the association by reporting crude odds ratios (OR) with 95% confidence intervals (CIs). For continuous variables, we used the nonparametric K test on equality of medians.

For objective 2, we examined the association between driver age groups and hospital admission by conditional logistic regression adjusted for gender, crash location (roads with low versus high speed

limits), crash type (single versus multi-vehicle), crash time (daytime versus night time, weekend versus weekday), and pre-existing health conditions. Potential risk factors for hospital admission were selected a priori according to bivariate analyses and theoretical considerations. An inclusive modelling approach was used to identify a parsimonious group of important factors independently associated with the likelihood of hospital admission. Factors that were statistically significant at the $p<0.10$ level on bivariate analysis were assessed during the model building process. Factors were considered for inclusion in the parsimonious model if they produced at least a 10% change in effect size for age group related outcome (i.e. hospital admission) odds ratio. We also conducted a subgroup analysis restricted to multi-vehicle crashes to examine the association between hospital admission and crash configuration (angle impact versus head on, rear-end, etc.). Conditional multivariable logistic regression on each outcome was conducted separately. All analyses were performed using Stata version 12.0 (Stata Corp., College Station, TX)

Results

Between January 1, 2009 and May 31, 2014, 238 elderly drivers aged ≥70 were treated for MVC related injuries. Of these drivers, 16 who were transferred from other hospitals and 3 who delayed their ED visits for more than 2 days after the crash were excluded. The remaining 219 injured elderly drivers were included for analysis and matched with 438 younger drivers who formed the comparison group.

The median ages were 78 (IQR:73-82) years and 38 (IQR:28-51) years for the older and younger driver groups respectively (**Table 1**). Male drivers were equally distributed in both age groups. As expected elderly drivers were more likely to have at least one pre-existing health condition (crude OR=10.3, 95% CI: 6.08-17.4), and have used at least one prescription medication during the 30 days prior to the crash (crude OR=6.08, 95% CI: 3.96-9.33). Compared to younger drivers, more elderly drivers were involved in daytime crashes (83.6% versus 69.4%) and in single vehicle crashes (27.9% versus 17.0%) but fewer were involved in rear-end crashes (14.8% versus 27.4%). The rates of seatbelt use were very high (>90%) in both age groups.

Table 1: Demographics and Crash Characteristics of Study Population

Demographics	**Younger (438) N (%)**	**Older (219) N (%)**	**Crude Odds Ratio (95% Confidence Interval) Ref = Younger drivers**
Age (median, IQR)	38 (28 - 51)	78 (73 – 82)	-
Male	217 (49.5)	124 (56.6)	1.35 (0.97-1.90)
Health conditions‡	192 (43.8)	193 (88.1)	10.3 (6.08-17.4)
Any pre-crash medications	193 (44.1)	182 (83.1)	6.08 (3.96-9.33)
Crash Characteristics			
Weekend crashes	120 (27.4)	62 (28.3)	1.15 (0.61-2.17)
Daytime (6am-6pm)	304 (69.4)	183 (83.6)	2.49 (1.59-3.88)
Single vehicle crashes	74 (17.0)	61 (27.9)	1.77 (1.22-2.56)
Angle impact crashes	186 (42.9)	94 (43.3)	1.01 (0.73-1.40)
Head-on crashes	25 (5.76)	18 (8.29)	1.50 (0.79-2.85)
Rear-end crashes	119 (27.4)	32 (14.8)	0.45 (0.29-0.67)
Unbelted drivers	24 (5.5)	8 (3.7)	0.66 (0.29-1.48)
Low speed road crashes	399 (91.1)	204 (94.0)	1.53 (0.80-2.97)

‡ Any pre-existing health conditions

The majority of drivers sustained only minor injuries (65%) or no documented injury (22%) while 17.4% of older and 10.5% younger drivers were classified as having moderate to severe injuries (max AIS score $\geq$ 2). Among those with higher injury levels, only one driver in the younger group was severely injured (max AIS score =5) and most were moderately injured (max AIS score = 2). Most drivers from both groups were treated and released from ED directly. Nevertheless, the unadjusted odds of hospital admission for elderly drivers (19.6%) were 2.66 times greater than for younger drivers (8.2%) (crude OR= 2.66, 95%CI: 1.69-4.40) (**Table 2**). However, 10 of the 43 admitted elderly drivers were admitted for acute exacerbation of pre-exiting medical conditions including seizures (1), syncope (5), stroke/angina (3) and brain lesion (1) rather than for their injuries sustained in the crash. Elderly drivers were also more likely than younger drivers to sustain torso injuries (crude OR=2.16, 95% CI: 1.46-3.20).

Table 2: Injury Profiles and Emergency Care Utilization

	Younger Drivers N (%)	**Elderly Drivers N (%)**	**Crude Odds Ratio (95% Confidence Interval)**
Injury Profiles			
Head and neck	164 (37.4)	77 (35.2)	0.90 (0.64-1.28)
Torso	67 (15.3)	62 (28.3)	2.16 (1.46-3.20)
Extremities	101 (23.1)	57 (26.0)	1.17 (0.81-1.70)
Back and spine	67 (15.3)	19 (8.7)	0.52 (0.31-0.90)
C-Spine fracture	7 (1.6)	6 (2.7)	1.73 (0.58-5.22)
Max AIS score ≥ 2	46 (10.5)	38 (17.4)	1.80 (1.13-2.89)
Hospital admission	36 (8.2)	43 (19.6)[#]	2.66 (1.65-4.28)
Emergency Care Utilization			
CT scan	119 (27.2)	104 (47.5)	2.42 (1.71-3.40)
X ray	248 (56.6)	157 (71.7)	2.04 (1.41-2.94)
Ultra sound	22 (5.1)	9 (4.1)	0.81 (0.37-1.79)
Echocardiogram	2 (0.5)	5 (2.3)	5.00 (0.97-25.8)
Any imaging	275 (62.8)	171 (78.1)	2.18 (1.48-3.12)
Bloodwork	172 (39.3)	139 (63.5)	2.62 (1.87-3.68)
Ambulance	299 (68.3)	187 (85.4)	2.58 (1.70-3.91)
ED LOS (median, IQR) [‡]	155 (101 -221)	184.5 (130 -257)	P< 0.0001*
Medications given in ED[†]	260 (59.4)	119 (54.3)	0.82 (0.60-1.13)

[‡] Length of stay (LOS) in minutes of those discharged from emergency department

[†] Any medications given at emergency department

[#] 10 of the 43 elderly drivers were admitted for other medical reasons (crude odds ratio became 2.03, 95%CI:1.22-3.6 when these 10 patients were excluded).

***** In comparison with younger drivers by nonparametric K-sample test on equality of medians

In terms of emergency care utilization, elderly drivers were more likely to be brought to ED by ambulance (crude OR=2.58, 95%CI: 1.70-3.91), to have longer ED length of stay (median LOS 184.5 versus 155 minutes), to require computerized tomography (CT) (crude OR=2.42, 95% CI: 1.71-3.40) or X-ray (crude OR=2.04, 95% CI: 1.41-2.94) imaging procedures, and to have blood work ordered (crude OR=2.62, 95% CI: 1.87-3.68) (**Table 2**).

Bivariate analyses of the association between hospital admission and potential risk factors indicated that (1) older age group, (2) being male, (3) pre-existing health conditions, and (4) single vehicle crashes were significantly associated ($p<0.05$) with an increased likelihood of being admitted to hospital while (5) seatbelt use and (6) crashes on low speed roads were associated with a decreased hospital admission rate. All significant factors from bivariate analyses (except seatbelt use) were also found to be significant predictors in the multivariable analysis on hospital admission (**Table 3**).

Table 3: Factors Associated with Hospital Admission of Drivers Treated in Emergency Department and Adjusted Odds Ratios

	All crashes		**Multiple vehicle crashes only**	
	All hospital admission	Crash related admission	All hospital admission	Crash related admission
Older driver	2.41 (1.28-4.56)	1.82 (0.93-3.58)	6.02 (1.89-19.1)	4.13 (1.24-13.7)
Male	2.44 (1.13-5.28)	2.39 (1.07-5.34)	4.33 (1.10-17.1)	4.93 (1.10-22.0)
Low speed road	0.30 (0.11-0.85)	0.34 (0.12-0.95)	0.14 (0.02-1.10)	0.17 (0.2-1.42)
Health condition	2.21 (0.95-5.17)	2.17 (0.91-5.14)	2..92 (0.86-9.87)	2.51 (0.68-9.19)
Single vehicle	5.57 (2.33-13.30)	5.44 (2.67-13.1)		
Crash type				
Angle crash			1.00	1.00
Head-on			7.37 (0.91-59.1)	9.25 (0.98-89.4)
Rear-ended			0.82 (0.22-3.03)	0.54 (0.12-2.39)
Other			0.23 (0.03-1.93)	0.24 (0.03-2.09)

Compared to younger drivers, the odds of hospital admission among elderly drivers were 2.41 times higher (OR=2.41, 95%CI: 1.28-4.56) after controlling for gender, low speed road crashes, pre-existing health conditions and single vehicle crashes. However, driver age group became non-significant when the 10 drivers who were admitted primarily for medical conditions were excluded from the analysis, although a trend towards a higher admission rate remained for the older driver group (**Table 3**).

In subgroup analyses restricted to multi-vehicle crashes, driver age group was a statistically significant factor for both 1) all hospital admissions, and 2) crash related admissions. Head-on collisions tended to be associated with a higher rate of hospital admission than other types of crashes (**Table 3**). It should be noted, however, that these estimates are not reliable and have wide confidence intervals because of too many uninformative sets in this sample. These results should therefore be interpreted with caution.

Discussion

Many have predicted an increasing number of road traffic injuries as older road users continue to be active on roadways (Bedard, Stones, Guyatt, & Hirdes, 2001; Lyman, Ferguson, Braver, & Williams, 2002). Emergency departments are likely to see more injured elderly drivers over the next few decades. Examining crash circumstances, injury profiles and care utilization will help understand and manage the increasing need of emergency care for this population.

The driving environment may explain some of the injury levels and crash profiles of the elderly drivers in this study. Most crashes occurred in the Metro Vancouver area, a major urban centre with heavy traffic volume and relatively low vehicle speed, particularly during the daytime hours. In this study, 94% of crashes by elderly drivers occurred on roads classified as low speed. Compared to younger drivers, there were significantly more daytime crashes in the elderly driver group (**Table 1**). The majority of crashes in both age groups involved another moving vehicle(s) but elderly drivers were more likely to be involved in single vehicle crashes compared to younger drivers (27.9% versus 17%).

Interestingly, we found that, compared to younger drivers, elderly drivers were less likely to be involved in rear-end collisions but more likely to be involved in head-on collisions (**Table 1**). Braitman and Kirley (2007) studied intersection collisions and reported that drivers aged >80 had fewer rear-end collisions compared to younger age groups (age 35-34 and 70-79) but had more failure-to-yield crashes (Braitman, Kirley, Ferguson, & Chaudhary, 2007). Their study was based on police reports and phone interviews with at fault divers. They defined rear-end crashes as occurring when the participant's vehicle ran into the other vehicle. Their "failure-to-yield crashes" would probably be equivalent to head-on collisions when both vehicles collided on the front ends. In our study, crash information was recorded by paramedics or triage nurses often based on patient's own description. Nevertheless, the crash involvement characteristics of elderly drivers in our study appear to be similar to that reported by Braitman and Kirley. Unfortunately information on whether or not crashes occurred at an intersection was not consistent recorded in hospital charts. It appears that elderly drivers in this study frequently drove in local roadways in the city, and were more often involved in low speed crashes. Starting up from a stop, going straight at stop signs, and negotiating turns present the most risk among elderly drivers (Preusser, Williams, Ferguson, Ulmer, & Weinstein, 1998). It is also known that elderly drivers are more likely to confuse gas with brake pedals and sometimes accelerate unintentionally (Freund, Colgrove, Petrakos, & McLeod, 2008). Underestimating the speed of an approaching vehicle is another common cause of intersection accidents among elderly drivers (Braitman et al., 2007; Scialfa, Guzy, Leibowitz, Garvey, & Tyrrell, 1991). In any case, most crashes involving elderly drivers in our study are probably minor since most occurred on low speed roads during the daytime hours as shown in **Table 1**.

Consistent with findings reported by others (Koppel, Bohensky, Langford, & Taranto, 2011; Yee, Cameron, & Bailey, 2006), elderly drivers in this study were more likely to sustain torso injuries compared to younger drivers although, in both age groups, we found a higher proportion of head & neck injuries than previously reported. The higher proportion of torso injury in elderly drivers could be due to age related osteoporosis which causes higher risk of rib fractures, particularly in head-on collisions. Younger drivers were however more likely to suffer head and neck injuries probably resulting from their higher rates of rear-end collisions.

Elderly drivers were more likely to be transferred by ambulance (**Table 2**). They were also more likely to require diagnostic imaging and bloodwork. The higher rates of emergency care in elderly drivers that we observed are also consistent with other studies (Lotfipour, Cisneros, & Chakravarthy, 2013; Vogel et al., 2013). However, we do not know whether the higher care utilization in the elderly driver group is because of worse injuries or because of increased health concerns related to advanced age. Overall, the hospital admission rate, a surrogate indicator of injury severity, was higher in elderly drivers even after excluding those admitted for pre-existing health conditions unrelated to injuries sustained in the MVC (although this association was no

longer statistically significant after these cases were excluded) (**Table 3**). Our findings are consistent with previous studies indicating that age related frailty is important for predicting injuries and requirement for hospital admission. Although 88% of elderly drivers in this study were reported to have at least one health condition, most of these conditions were probably not serious enough to affect their driving abilities or injury outcomes because less than 20% required hospitalization.

Limitations

In this study we matched elderly drivers with a comparison group of younger drivers according to dates of ED visit only. Better matching may have been achieved if we also matched for crash characteristics. With conditional logistic regression, the non-informative match sets were not used for estimation. It appears that crash type in this sample have a few of these concordant pairs potentially making the regression estimates unreliable. Nevertheless, the results still suggested that being older (age ≥70 years) is statistically significantly associated with higher injury severity by all measures.

Medical records typically have limited details on crash circumstances such as striking or struck vehicle status. Missing data or misclassification regarding crash types or vehicle speeds is also a concern. In this study, we carefully read all descriptions of injury mechanism from discharge notes, trauma team records, and ambulance records in order to minimize missing data, but misclassification could still occur. Instead of analysing vehicle speeds (which were inconsistently reported), we categorized crash locations into high speed roads (≥ 60km/hour) and low speed roads (<60km/hour) based on actual crash locations. However, some crashes on high speed roadways may still occur at low speed and vice versa.

Pre-existing medical history is based on triage nursing or trauma consultation notes. In some instances, this information may not be recorded in the medical record, especially for younger drivers and those with minor injuries. We considered the patients with no recorded pre-existing medical problems to be healthy. For simplicity, we have not grouped medication and medical history into specific health conditions such as cardiovascular or neurological conditions. This is unlikely to affect driving and injury outcomes if conditions are mild. In addition, we do not know whether self-regulation might play a role in our samples. Drivers with pre-existing health conditions may choose to drive if they feel that their conditions do not affect their driving ability or because of necessity.

This study examined injuries of elderly drivers resulting from mostly minor crashes occurring in an urban area. Our findings may not be generalizable to crashes that occur outside of major urban centres. Future research should also include trauma centres serving smaller urban and rural locations.

Conclusions

As expected, elderly drivers sustained higher rates of injuries when compared to younger drivers although most crashes and injuries in this study were considered minor. Compared to younger drivers, the odds of hospital admission among elderly drivers were about 2.41 times greater after adjusting for gender, pre-existing health condition and crash type. Elderly drivers were also likely to use more emergency care resources. Evaluation of injured elderly drivers may require specific considerations of changes in their physical conditions (i.e. frailty) as well as crash circumstances.

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