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Risks Older Drivers Pose to Themselves and to Other Road Users

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Abstract

Studies have shown that older drivers have high death rates and lower rates of involvement in crashes that kill others; but most studies have not considered drivers' responsibility for their crashes, and many have considered only one particular measure of risk. This study examines risks that drivers of various ages pose to themselves and to others on per-driver, per-trip, and per-mile bases, taking responsibility for crashes into account, using United States fatal crash data from 1999 through 2003 and travel estimates from 2001. Relative to other age groups, drivers aged 85 and older face the highest risk of their own death, whereas teens pose the greatest risk to passengers, occupants of other vehicles, and non-motorists. The oldest drivers pose more risk to other road users than middle-aged drivers do; the degree of excess risk depends strongly upon how risk is measured. These results demonstrate the importance of keeping clear what risk is most relevant when discussing measures targeting high-risk groups.

Introduction

Several studies analyzing driver death rates in relation to age have shown that driver death rates form a "U-shaped" curve wherein young drivers have high death rates, the rates decrease through young adulthood, level off in middle age, and increase to their highest levels at the oldest ages (e.g., Evans 2000; Williams & Shabanova, 2003; Braver and Trempe, 2004; Langford, Bohensky, Koppel, & Newstead, 2008). Examination of the impact of drivers of various ages on other road users such as pedestrians or occupants of other vehicles have found that the rate at which drivers are involved in crashes that kill other road users decreases with driver age across the entire age range (Williams & Shabanova, 2003), or increases somewhat for the oldest drivers (Evans, 2000; Braver & Trempe, 2004; Langford *et al.*, 2008). However, with the exception of

Williams & Shabanova, these studies have not analyzed responsibility for—as opposed to mere involvement in—crashes that kill other road users in relation to driver age, and none has done so while taking the amount of driving done by drivers of different ages into account.

Evans (2000) analyzed driver death rates per capita, per licensed driver, and per mile driven in relation to driver age and sex, and also analyzed the death rates of pedestrians in relation to the age and sex of the drivers involved in the crashes in which they were killed, using data from years 1994 through 1996. Evans reported that an 80-year old male driver has a 121 percent higher death rate per licensed driver and a 662 percent higher death rate per mile driven than a 40-year-old male driver, and reported similar patterns for females. However, when analyzing the rate of pedestrian fatalities in relation to driver age, Evans reported that on a per-driver basis, 80-year-old drivers of either sex were less likely than 40-year-old drivers to be involved in crashes fatal to pedestrians. When analyzed on a per-mile-driven basis, 80-year-old drivers had higher rates of involvement in crashes fatal to pedestrians than did 40-year-old drivers; however, the elevation was smaller than the elevation in their own death rates.

Braver & Trempe (2004) analyzed per-driver rates at which drivers, their passengers, occupants of other vehicles, and non-motorists were injured or killed in crashes involving drivers of various ages, using fatal and nonfatal crash data from 1993 through 1997, national travel estimates from 1995, and insurance data from years 1999 through 2001. They reported that relative to drivers aged 30 to 59, drivers aged 75 and older had elevated death rates; however, their risk of being involved in a crash resulting in the death of a non-motorist or an occupant of another vehicle was lower than that of drivers aged 30 to 59. They reported that the rate at which older drivers were involved in crashes resulting in injury to non-motorists was somewhat lower, and their rate of crashes resulting in injury to occupants of other vehicles was somewhat higher than was the corresponding rate for drivers aged 30 to 59; however, neither difference was statistically significant at the 95% confidence level. They also reported that drivers aged 85 and older had about double the rates of bodily injury liability and property damage liability, relative to drivers aged 30 to 59.

Langford *et al.* (2008) analyzed death rates of drivers, their passengers, and other road users in relation to driver age, using risk metrics of deaths per population, deaths per licensed driver, and deaths per kilometer driven, based on ten years of Australian data between 1988 and 2001, and concluded that drivers aged 80 and older were at increased risk of death under all three risk measures, but only posed increased risk to road users external to their own vehicle in terms of deaths per kilometer driven.

Williams & Shabanova (2003) analyzed per-driver death rates of drivers, their passengers, and occupants of other vehicles in relation to driver age, gender, and their assessment of driver responsibility for the crash, using fatal crash data and driver licensing data from years 1996 through 2000. The authors found that younger and older drivers were responsible for fatal crashes in which they were involved more frequently than were middle-aged drivers, and that they had the highest death rates per licensed driver; however, the per-driver death rate of occupants of other vehicles decreased with increasing driver age until reaching its minimum for drivers aged 40 through 49, and did not increase at older ages. The authors also noted that older

drivers were responsible for a much smaller number of deaths of occupants of other vehicles than younger drivers were.

Methods

Data

The data sources for this study were the National Highway Traffic Safety Administration's Fatality Analysis Reporting System (FARS) data on fatal motor vehicle crashes (FARS, 1999–2003), and the Federal Highway Administration's National Household Travel Survey (NHTS, 2001). FARS is an annual census of all crashes that involve a motor vehicle in transport, occur on a public roadway, and result in the death of a person within 30 days of the crash. FARS provides detailed information derived from police reports, and reviewed by specially-trained analysts, on all fatal crashes and all vehicles and people that they involve. The NHTS is a nationally-representative telephone survey of the travel behaviors of the United States population. In the NHTS, respondents record detailed information, about their travel on an assigned day, into a diary. These data then are weighted to produce statistical estimates of the travel patterns of the population. The last NHTS was conducted in 2001 and included approximately 176,000 people living in 67,000 households.

Analysis

The FARS database was queried, using statistical software SAS, to identify all drivers involved in fatal crashes in years 1999 through 2003, classify each as responsible or not responsible for the crash in which he or she was involved, and assign all road user deaths occurring in each crash to the responsible driver or drivers.

The responsibility of each driver was assessed using driver-related contributing factors coded in FARS. These are factors listed on police crash report forms as having contributed to the crash, and include a number of different factors related to the driver's condition (e.g., drowsy), behavior and performance (e.g., failure to yield right of way) and circumstances (e.g., vision obscured by an object). Each driver record in FARS may include up to four driver-related contributing factors. Following the method of Williams & Shabanova (2003), this study classified drivers whose FARS record included any behavior- or performance-related contributing factors (codes 18–60, see Tessmer, 2006, for definitions) as responsible for the crash.

In crashes involving only one vehicle, the driver automatically was considered responsible, irrespective of contributing factors coded in FARS. Unlike in Williams & Shabanova, in crashes involving non-motorists, driver responsibility was assigned as described previously, irrespective of the non-motorist's contribution to the crash. Equal responsibility was assigned to all drivers in crashes in which no behavior- or performance-related factors were coded in FARS for any of the drivers.

Fatalities were assigned to the driver or drivers considered responsible for the crash in which they occurred, who are referred to hereafter as *target drivers*. (Note. Langford et al., 2008, also used the term target driver to refer to the driver to whom a fatality was assigned; however, their

use of the term did not imply that the target driver was responsible for the crash.) Fatally-injured persons were classified as target drivers, passengers (of target drivers), occupants of other vehicles, and non-motorists, and were grouped according to the age of the driver to whom they were assigned (i.e., the target driver).

Because the primary matter of interest in this study is the relative safety of drivers of passenger vehicles (i.e., cars, pickup trucks, vans and minivans, and utility vehicles, see Tessmer, 2006, for a comprehensive list), deaths assigned to drivers of other types of vehicles were excluded. Note that deaths of occupants of other types of vehicles were included if they occurred in a crash in which a passenger-vehicle driver was classified as responsible.

The risks that drivers of a given age pose to themselves (target drivers), their passengers, occupants of other vehicles, and non-motorists were computed by dividing the annual average number of deaths assigned to target drivers of that age by the estimated exposure of drivers of the same age. Three age-specific measures of exposure were derived from NHTS data: the number of drivers, the number of passenger-vehicle-driver trips, and the number of miles driven in passenger vehicles. Stata statistical software was used to query and weight the NHTS data and to estimate standard errors.

The statistical significance of the difference between two rates was assessed at the 95% confidence level by computing the ratio of rates and assessing whether or not the confidence interval of the ratio included 1.0. The standard errors of rate ratios were estimated using first order Taylor series approximations of their log-transformed estimates, such that $SE\{\ln[(d_i/t_i)/(d_j/t_j)]\} = \{[SE(d_i)/d_i]^2 + [SE(t_i)/t_i]^2 + [SE(d_j)/d_j]^2 + [SE(t_j)/t_j]^2\}^{1/2}$, where d_i and d_j are the number of deaths assigned to target drivers in age groups i and j , and t_i and t_j are the exposure (i.e., number of drivers, trips, or miles) of drivers in age groups i and j . Confidence intervals of the natural logarithms of death rates and rate ratios were estimated using normal approximations. Death rates, rate ratios and confidence intervals were calculated using Microsoft Excel. Although figures herein show death rates by single year of driver age, statistical inference is based on the aggregate data presented in Tables 1 and 2, to allow adequate numbers of fatalities and travel survey responses for analysis.

Results

Road User Deaths

Table 1 shows the annual average number of deaths of target drivers, their passengers, occupants of other vehicles, and non-motorists, by the age group of the target driver to whom each death was assigned. Note that as the target driver's age increases, deaths of target drivers themselves account for a monotonically increasing proportion of all deaths for which the target driver is considered responsible, and after ages 30 to 39, deaths outside of the target driver's vehicle (i.e., occupants of other vehicles and non-motorists) account for decreasing proportions. Twenty-five percent of people killed in crashes assigned to target drivers aged 16 or 17, and 33% of people killed in crashes assigned to drivers aged 30 to 39, are outside of the target driver's vehicle, whereas only 10% of people killed in crashes assigned to target drivers aged 85 or older are outside of the target driver's vehicle. Also note the differences in the raw numbers of fatalities

across age groups: Drivers of ages 16 through 19 were responsible for more than twice as many deaths of road users outside of their vehicles as were all drivers ages 70 and older.

Table 1. Annual average number of deaths assigned to target drivers, by target driver age and type of road user killed (1999–2003).

Target driver age	Target drivers	Passengers	Occupants of other vehicles	Non-motorists	Total
Number of deaths (%)					
16 - 17	950 (41.3)	773 (33.6)	382 (16.6)	194 (8.4)	2,299
18 - 19	1,394 (43.6)	961 (30.1)	527 (16.5)	316 (9.9)	3,198
20 - 24	2,736 (45.1)	1,663 (27.4)	995 (16.4)	673 (11.1)	6,067
25 - 29	1,767 (45.5)	891 (23.0)	689 (17.8)	534 (13.8)	3,881
30 - 39	3,069 (48.0)	1,199 (18.8)	1,137 (17.8)	988 (15.5)	6,393
40 - 49	2,742 (53.0)	804 (15.5)	832 (16.1)	800 (15.5)	5,177
50 - 59	1,836 (55.9)	449 (13.7)	497 (15.1)	505 (15.4)	3,286
60 - 69	1,226 (58.1)	341 (16.1)	278 (13.2)	266 (12.6)	2,111
70 - 74	659 (60.6)	189 (17.4)	128 (11.8)	111 (10.2)	1,086
75 - 79	745 (64.4)	211 (18.3)	117 (10.1)	84 (7.2)	1,157
80 - 84	628 (67.4)	177 (19.0)	66 (7.1)	61 (6.5)	932
85+	515 (74.3)	110 (15.8)	41 (6.0)	27 (3.9)	693

Note. Target driver refers to the driver considered responsible for the crash in which the death occurred. **Data:** FARS 1999–2003.

Table 2. Estimated driver exposure by age (2001).

Driver Age	Drivers	Drivers (100,000s)	Trips (100s of millions)	Miles (billions)
	Unweighted N		Weighted estimates (SE)	
16 - 17	2,929	46.56 (1.61)	42.90 (2.09)	28.26 (2.30)
18 - 19	2,338	56.76 (1.95)	64.99 (2.99)	54.77 (3.26)
20 - 24	5,870	148.27 (2.90)	165.20 (4.21)	170.33 (6.96)
25 - 29	7,250	174.81 (3.05)	210.86 (5.18)	217.36 (7.52)
30 - 39	21,368	409.62 (4.32)	531.44 (8.03)	533.53 (11.48)
40 - 49	25,456	394.99 (3.80)	535.00 (6.66)	520.22 (11.39)
50 - 59	21,959	291.84 (2.93)	358.80 (5.10)	359.90 (9.74)
60 - 69	14,686	191.33 (2.97)	217.67 (4.41)	196.54 (6.23)
70 - 74	6,070	76.92 (1.64)	85.20 (2.22)	59.88 (2.73)
75 - 79	4,403	56.12 (1.38)	52.18 (1.81)	35.93 (2.40)
80 - 84	2,469	31.81 (1.03)	30.18 (1.37)	16.89 (1.19)
85+	1,024	13.08 (0.75)	10.84 (0.93)	5.38 (0.60)

Note. Numbers of trips and miles reflect passenger-vehicle travel only. **Data:** NHTS (with add-ons), 2001.

Travel Exposure

Table 2 shows the number of drivers in each age group, their number of driving trips, and the number of miles that they drove, as estimated from the 2001 NHTS data. It also shows the unweighted number of drivers whose responses were weighted to yield these estimates. It is clear that older drivers make fewer trips and drive fewer miles than younger or middle-aged drivers do. For example, 40,962,000 drivers in their thirties drove an estimated 533 billion miles in 2001, or an average of about 13,000 miles per driver, whereas 1,308,000 drivers aged 85 and older drove an estimated 5.38 billion miles, or about 4,100 miles per driver.

Deaths per Driver

Figure 1 shows the number of deaths of target drivers, their passengers, occupants of other vehicles, and non-motorists, by the age of the target driver to whom each was assigned, normalized by the estimated number of drivers of the target driver's age. The risks that drivers pose to road users of each of the four categories peak initially at driver age 19, decline steadily until around age 25, continue declining gradually until ages of approximately 65 to 70, begin increasing again around age 70, and increase more rapidly after age 75. Among drivers aged 70 and older, as age increases, drivers' risk of their own death increases more rapidly than does the risk that they will be responsible for the death of a passenger, and both increase more rapidly than do the risks that they will be responsible for the death of an occupant of another vehicle or a non-motorist. The inset in Figure 1 shows the death rates of occupants of other vehicles and non-motorists only, re-plotted on a vertical axis that facilitates visualization of their major trends.

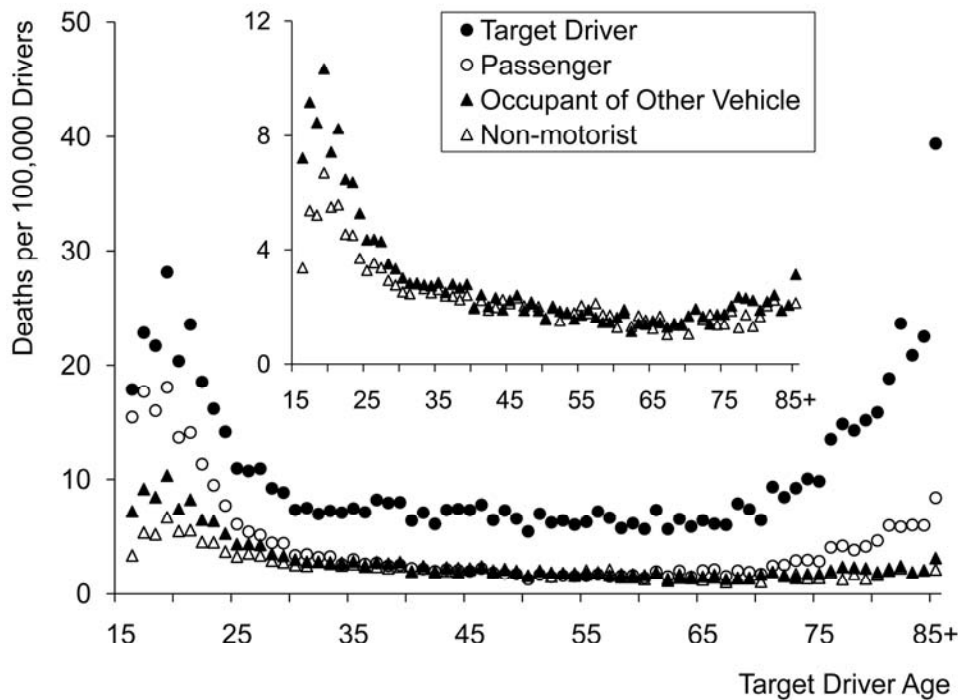


Figure 1. Road user deaths per 100,000 drivers, by target driver age and type of road user killed. The inset shows the death rates of occupants of other vehicles and non-motorists only. Target driver refers to the driver considered responsible for the crash in which the death occurred. Data: FARS 1999–2003, NHTS 2001.

The per-driver death rate of target drivers aged 85 and older is nearly double that of target drivers aged 16 to 17 (Rate Ratio [RR] 1.93, 95% Confidence Interval [CI] 1.66–2.24) and is over six times that of drivers aged 50 to 59 (RR 6.25, CI 5.48–7.14). The per-driver death rate of passengers of target drivers aged 85 and older is over five times that of target drivers aged 50 to 59 (RR 5.45, CI 4.74–6.27); however, it is much lower than that of target drivers aged 16 to 17 (RR 0.50, CI 0.43–0.59). The risks that drivers aged 85 and older pose to occupants of other vehicles and to non-motorists (see Figure 1 inset) are slightly higher than those posed by drivers aged 50 to 59 (occupants of other vehicles: RR 1.86, CI: 1.61–2.15; non-motorists: RR 1.19, CI 0.89–1.60). Sixteen- and 17-year-old drivers pose more than twice as much risk to occupants of other vehicles and to non-motorists as do drivers aged 85 and older. Drivers aged 80 to 84 pose significantly less risk to occupants of other vehicles and to non-motorists than do drivers aged 30 to 39 (occupants of other vehicles: RR 0.75, CI: 0.64–0.88; non-motorists: RR 0.79, CI 0.65–0.91).

Deaths per Trip

Figure 2 shows the number of deaths of target drivers, their passengers, occupants of other vehicles, and non-motorists, by the age of the target driver to whom each was assigned, normalized by the estimated number of trips taken in passenger vehicles by drivers of the target driver's age. The major trends in Figure 2 are similar qualitatively to those in Figure 1. The major difference observed when analyzing death rates on a per-trip basis is that the increasing death rates at the older target driver ages are steeper than they were on the per-driver basis.

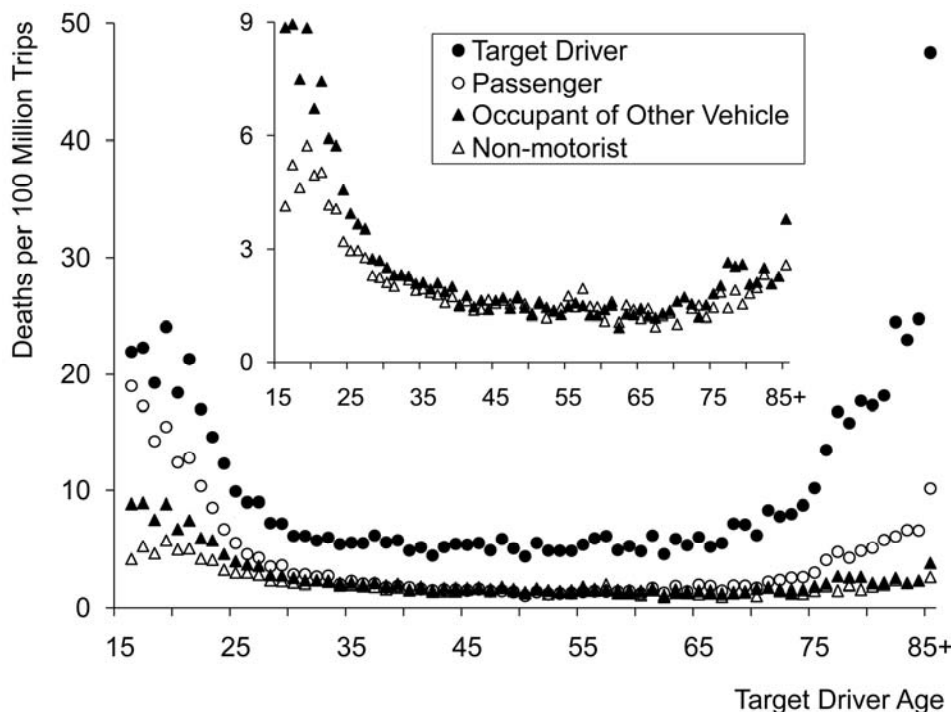


Figure 2. Road user deaths per 100 million driver trips, by target driver age and type of road user killed. The inset shows the death rates of occupants of other vehicles and non-motorists only. Target driver refers to the driver considered responsible for the crash in which the death occurred. Data: FARS 1999–2003, NHTS 2001.

The per-trip death rate of drivers aged 85 and older is over double that of drivers aged 16 to 17 (RR 2.14, CI 1.75–2.63) and is over nine times that of drivers aged 50 to 59 (RR 9.28, CI 7.73–11.14). The death rate of passengers of target drivers aged 85 and older is over eight times that of target drivers aged 50 to 59 (RR 8.09, CI 6.70–9.76). The per-trip death rates of occupants of other vehicles and non-motorists increase more substantially at the older ages than do the analogous per-driver rates (see Figure 2 inset). Per trip, the risks that drivers aged 85 and older pose to occupants of other vehicles and to non-motorists are still less than half of those posed by drivers aged 16 to 17 or aged 18 to 19; however, they are elevated more significantly relative to the risks posed by the lowest-risk drivers. On the per-trip basis, the risks that drivers aged 80 to 84 pose to occupants of other-vehicles and to non-motorists are slightly higher than but not statistically different from those posed by drivers aged 30 to 39 (occupants of other vehicles: RR 1.03, CI: 0.87–1.22; non-motorists: RR 1.08, CI 0.92–1.27).

Deaths per Mile Driven

Figure 3 shows the number of deaths of target drivers, their passengers, occupants of other vehicles, and non-motorists, by the age of the target driver to whom each was assigned, normalized by the estimated number of miles driven in passenger vehicles by drivers of the target driver’s age. The major trends in Figure 3 are similar qualitatively to those in Figures 1 and 2; however, the increases in death rates at the older driver ages are significantly steeper than they were in the per-driver or per-trip analyses. Most notably, on the per-mile basis, the increase in risk to occupants of other vehicles and to non-motorists that occurs after age 70 appears to mirror the decrease in risk that occurs between the ages of approximately 20 and 35 (see Figure 3 inset).

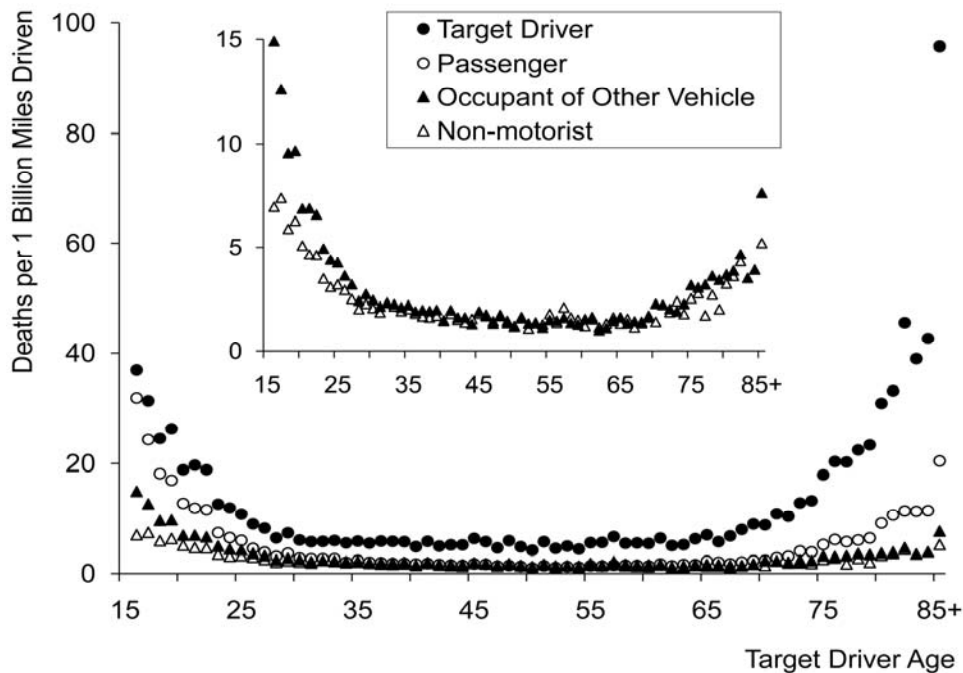


Figure 3. Road user deaths per billion miles driven, by target driver age and type of road user killed. The inset shows the death rates of occupants of other vehicles and non-motorists only. Target driver refers to the driver considered responsible for the crash in which the death occurred. Data: FARS 1999–2003, NHTS 2001.

On the per-mile basis, the death rate of target drivers aged 85 and older is nearly triple that of drivers aged 16 to 17 (RR 2.85, CI 2.16–3.77) and is nearly twenty times that of drivers aged 50 to 59 (RR 18.76, CI 14.84–23.73). The per-mile death rate of passengers of target drivers aged 85 and older is about sixteen times that of target drivers aged 50 to 59 (RR 16.35, CI 12.88–20.77). Per mile, the risks that drivers aged 85 and older pose to occupants of other vehicles and to non-motorists are lower than but not statistically different from those posed by target drivers aged 18 and 19 (occupants of other vehicles: RR 0.80, CI: 0.62–1.03; non-motorists: RR 0.87, CI 0.60–1.27).

Discussion

Principal Findings

This study adds to present knowledge on the risks associated with older drivers by (a) analyzing the risks that drivers of various ages pose to themselves, their passengers, occupants of other vehicles, and non-motorists; (b) taking into account drivers' responsibility for the crashes in which they were involved; and (c) comparing risks estimated on the bases of three different measures of exposure. The principal findings of this study are:

1. Drivers' risks to themselves and to other road users decline rapidly until around age 25, continue declining gradually until ages of approximately 65 to 70, begin increasing again around age 70, and increase more rapidly after approximately age 75.
2. Relative to other age groups, drivers aged 85 and older have the highest rate of their own deaths by all measures considered; approximately two to three times that of 16- and 17-year-old drivers, depending on the measure.
3. Relative to other age groups, teenage drivers pose the greatest risks to their own passengers, occupants of other vehicles, and non-motorists by all measures considered.
4. Older drivers pose more risk to their passengers, occupants of other vehicles, and non-motorists than the lowest-risk drivers do. The degree to which older drivers' risk to these categories of road users is elevated depends upon whether risk is measured on a per-driver, per-trip, or per-mile basis.

Relation to Other Research

Notwithstanding a number of methodological differences, the results of this study generally confirm those of several previous studies that have shown that older drivers do face increased risk of being involved in a fatal crash; however, the older drivers themselves bear the great majority of the increased risk themselves (e.g., Evans, 2000; Williams & Shabanova, 2003; Braver & Trepel, 2004; and Langford *et al.*, 2008). Li, Braver, & Chen (2003) analyzed older driver involvement in fatal and non-fatal crashes, and concluded that older drivers' increased *fragility*—their elevated risk of dying if they are involved in a crash—was the key factor

contributing to older drivers' high death rates, and that it explained more of the elevation in their death rates than did their rate of crash involvement.

The finding that older drivers have elevated rates of passenger fatalities may be attributable at least in part to their passengers being older and thus more fragile. In the data analyzed for the current study, the age of fatally-injured passengers was correlated very strongly with the age of the driver ($r = .73$). As an example, two-thirds of fatally-injured passengers of target drivers aged 80 and older were 80 years or older themselves, and fewer than 2% were 17 years or younger. For comparison, only 0.2% of fatally-injured passengers of target drivers aged 16 or 17 were 80 years or older, and 71% were 17 years or younger.

The elevation in older drivers' trip-based and mileage-based risks may be explained to some degree by the differences in the relative safety of the roads on which they drive. In a study of 1991 data from the state of Wisconsin, Dulisse (1997) reported that although drivers aged 75 and older posed significantly higher risk to other road users than did drivers aged 16 to 64, some of this risk was explained by confounding related to driver gender as well as a number of roadway- and vehicle-related factors. The proportion of trips or miles that drivers of various ages drive on various types of roads is not known; however, post-hoc inspection of the crash data in the present study suggests that age-related differences in the types of roads on which driving occurs may contribute to older drivers' elevated per-trip and per-mile risks. For example, only 8% of fatal crash involvements of drivers aged 80 and older occurred on Interstate highways, freeways, or expressways, as compared to 18% fatal crash involvements of drivers aged 30 to 59. Bagdade (2004) describes several low-cost road safety improvements shown to reduce older driver involvement in injury crashes.

In contrast to most previous studies, the death rates presented herein represent the risks that drivers of various ages will be involved in and responsible for crashes in which a particular type of road user is killed. Evans (2000), Braver and Trempe (2004), and Langford *et al.* (2008) report results that represent the risk that a road user would be killed in a crash in which a driver of a particular age group was involved, without regard to the driver's responsibility for the crash. Williams & Shabanova (2003) write, "A main contribution of responsibility analysis is to show the extent to which drivers of different ages affect people other than themselves" (p. 531).

In the data analyzed for this study, the proportion of fatal-crash-involved drivers within each age group who were classified as responsible for their crashes was greatest for drivers aged 85 years and older (75%) and drivers aged 16 to 17 years (70%), decreased monotonically as age moved away from either age extreme, and was lowest for drivers aged 50 through 59 (43%). As a result, the "responsibility-based" methodology of this study yields higher relative risks when comparing older drivers (or younger drivers) to middle-aged drivers. As an example, the per-driver death rate of occupants of other vehicles was 86% higher for target drivers aged 85 and older than for target drivers aged 50 to 59. In a separate analysis in which deaths were assigned equally to all fatal-crash-involved drivers irrespective of responsibility, the per-driver death rate of occupants of other vehicles was actually 24% lower for target drivers aged 85 and older than for target drivers aged 50 to 59. Results of this involvement-based analysis were concordant with those of Langford *et al.* (2008), who analyzed Australian data using an involvement-based method and computed risks on the basis of population, number of drivers, and number of kilometers driven.

In one of the few studies that did consider driver responsibility for fatal crashes in relation to driver age, Williams & Shabanova (2003) excluded crashes involving vehicles other than passenger vehicles, crashes involving more than two vehicles, and crashes involving non-motorists, due to difficulty in assigning responsibility in these crashes. To test the impact of having included these crashes in the present study, analyses were repeated using the responsibility-assignment methods and exclusion criteria of Williams & Shabanova. This resulted in the exclusion of 44,665 of the 173,955 deaths included in the original analysis. Within each road user category, the percentage of the deaths in the main analysis that was excluded under the Williams & Shabanova methodology increased almost monotonically as target driver age increased. As a result, all death rates calculated using the Williams & Shabanova methodology were lower than those reported here, and relative risks for older drivers compared to younger or middle-aged drivers were lower under the Williams & Shabanova methodology than those reported here. The general patterns of the results, however, remained the same.

Another difference between the current study and that of Williams & Shabanova (2003) is the source of information used to estimate the number of drivers in each age group. Williams & Shabanova used annual statistics that the Federal Highway Administration publishes on the number of licensed drivers in the United States. The Federal Highway Administration (2002) notes that these data may exclude deceased drivers and drivers with expired licenses, Braver and Trempel (2004) note that these data may include licensed drivers who no longer drive, and McCartt (2006) reports that these data under-count licensed drivers, particularly young drivers, in several states. The present study used self-reported driver status in the NHTS to estimate the number of drivers in each age group and compute per-driver death rates. Relative to estimates derived from the NHTS (2001), Federal Highway Administration (2002) reports 24% fewer drivers ages 16 and 17, 15% more drivers aged 80 through 84, and 61% more drivers aged 85 and older, whereas differences between the two data sources are much smaller for most other age groups. Using the NHTS rather than the Federal Highway Administration's annual statistics to estimate the number of drivers thus yielded per-driver death rates that are significantly lower for drivers aged 16 and 17, relatively similar for most middle age groups, and significantly higher for drivers aged 80 and older.

Limitations

A key limitation of this type of research is that data on fatal crashes and data on travel exposure were obtained from separate sources. The average travel exposure of drivers of the same age as the crash-involved drivers is known, but the travel exposure of those particular drivers is not, and it is possible that drivers involved in fatal crashes have different travel patterns than those who are not involved in fatal crashes. Janke (1991) described a "low-mileage bias," wherein drivers who drive fewer miles have higher per-mile crash risk than drivers who drive more. Langford, Methorst, & Hakamies-Blomqvist (2006) and Alvarez and Fierro (2008) provide more recent examples. These authors have suggested that per-mile crash rates exaggerate older drivers' risk because of the low-mileage bias; however, no published research has addressed whether or not the low-mileage bias applies to rates of fatal crashes. Answering this question would require individual-level driving exposure data for drivers involved in fatal crashes.

Another limitation of this study is that death rates were calculated using self-reported driving exposure data, which several studies suggest tends to be under-reported. Under-reporting of travel exposure would bias death rates upward. Bricka and Bhat (2006) report that in their review of past studies and in their own study, younger drivers (e.g., under age 25 or under age 30, depending on the study) are most likely to under-report their driving; however, the degree of under-reporting in the NHTS, and whether or not it varied systematically by age, is not known.

An additional limitation of this study is that five years of crash data and only one year of driving exposure data were used to estimate death rates. This is equivalent to assuming that risks were constant over the period from 1999 through 2003 and that variations in the annual number of fatalities occurred because of random variation and changes in exposure only, not because of changes in the underlying risks. Multiple years of crash data were used to obtain sufficient number of fatalities for analysis by age group for relatively narrow age groups; however, the 2001 NHTS was the only national travel survey conducted since the Nationwide Personal Transportation Survey of 1995.

Finally, it is important to recognize that the author's assignment of responsibility in this study is not based on in-depth study of crash causation. The author assigned responsibility to drivers for whom any behavior- or performance-related contributing factors were coded in FARS, drivers involved in single-vehicle fatal crashes, and drivers who struck and killed non-motorists. This methodology likely misclassifies drivers who were not actually responsible for their crashes as responsible, and vice versa, at least on occasion. For example, the author did not consider non-motorists' responsibility for crashes in which they were killed; drivers who struck non-motorists were classified as responsible, irrespective of the non-motorists' actions prior to the crash. This is equivalent to asserting that drivers have the ultimate responsibility not to strike non-motorists. In the data analyzed for this study, only 24 percent of drivers involved in crashes that resulted in the death of a non-motorist were assigned any behavior- or performance-related contributing factors. In the author's separate analysis of only the drivers whose FARS records included behavioral- or performance-related contributing factors, non-motorist death rates increased more steeply as target driver age approached either age extreme; however, the overall patterns were unchanged.

Summary

Older drivers face substantially elevated risk of being involved in and responsible for crashes in which they themselves die, and they pose more risk to other road users than the lowest-risk drivers do; however, the degree to which older drivers' risk to other road users is elevated depends strongly upon whether risk is being measured on a per-driver, per-trip, or per-mile basis. For example, the results of this study suggest that if a randomly-selected driver in his or thirties and a randomly-selected driver aged 85 or older were to drive equal numbers of miles, the older driver would be over 1500% more likely than the younger driver to be responsible for and die as a result of a crash, and about 220% more likely than the younger driver to kill an occupant of another vehicle or a non-motorist. However, drivers in their thirties drive approximately 217% more miles on average than drivers aged 85 and older do. Without statistical adjustment for what occurs naturally, a randomly-selected driver aged 85 or older is about 720% more likely than a randomly selected driver aged 30 to 39 to die in a crash, but only about 0.8% more likely to kill

an occupant of another vehicle or a non-motorist, over the course of a year. Finally, the public health impact of older drivers on other road users presently is relatively small. Drivers under age of 20 are responsible for more than twice as many deaths of occupants of other vehicles and non-motorists as are all drivers aged 70 and older.

Different measures of risk answer different types of questions. Older drivers' elevated per-mile risk of dying, which other studies have found to be attributable mostly to their fragility, suggests the need for measures to reduce older drivers' risk of dying when involved in a crash, such as improved vehicle occupant protection systems. Older drivers' elevated per-trip and per-mile risk to other road users, which may be confounded by factors such as the relative safety of the types of roads on which they drive, suggests the need for measures to reduce older drivers' risk of being involved in severe crashes. Examples of such measures might include road safety improvements or vehicle-based collision avoidance systems. One can argue that the risk older drivers pose to other road users outside of their own vehicles as measured on a per-driver basis is most relevant to policies related to regulating driving privileges. Although the oldest drivers pose significantly elevated risk to other road users in relation to the amount that they drive, they also drive much less. The product of this elevated risk and reduced exposure is that drivers aged 85 and older and drivers in their thirties have virtually identical risks of killing an occupant of another vehicle or a non-motorist over the course of a year. These results demonstrate the importance of keeping clear what risk is most relevant when discussing measures targeting high-risk groups.

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