

Chapter 7 of [TRAFFIC SAFETY](#) (Copyright © 2004 by Leonard Evans), titled [Older Drivers](#), includes the subjects of this paper treated using post 2000 data.

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Risks older drivers face themselves and threats they pose to other road users

Leonard Evans^a

Background	Although there is an ever increasing literature on older drivers, there is no comprehensive up-to-date presentation of how older drivers are impacted by traffic safety, and how they impact the road safety of others.
Methods	This paper uses 1994–1996 US data to determine how many rates related to traffic safety depend on the age and sex of road users (fatalities, fatalities per licensed driver, etc.) Threats drivers pose to other road users are estimated by driver involvement in pedestrian fatality crashes.
Results	It is found that renewing the licence of a 70-year-old male driver for another year poses, on average, 40% less threat to other road users than renewing the license of a 40-year-old male driver. The fatality risks drivers themselves face generally increase as they age, with the increased risk of death in the same severity crash being a major contributor. If this factor is removed, crash risks for 70-year-old male drivers are not materially higher than for 40-year-old male drivers; for female drivers they are.
Conclusions	Most driver rates increase substantially by age 80, in many cases to values higher than those for 20-year-olds. Given that a death occurs, the probability that it is a traffic fatality declines steeply with age, from well over 20% for late teens through mid twenties, to under one per cent at age 65, and under half a per cent at age 80.
Keywords	Older drivers, road safety, traffic crashes, gender difference, driver licensing
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There is an extensive, and continually expanding, research literature on older drivers, reflecting concerns that projected increases in the older driver population will increase societal harm from traffic crashes. One recent review,¹ focusing on just one aspect of older driver research, lists 428 references. The older-driver literature contains many papers focusing on how specific variables vary with age. However, no one paper provides a comprehensive up-to-date presentation in a consistent formalism of how the most basic quantities related to traffic safety change as drivers become older.

This paper presents relationships between various male and female involvement rates related to traffic safety and driver age using 1994–1996 US data. The paper is self-contained—all the results presented flow directly from the data analysed, thereby facilitating comparison of how the various rates relate to each other. The results may be compared readily with earlier results^{2,3} based on 1980s data to gain insight into effects due demographic and other developments in the intervening decade. The presentation of the earlier work which is most convenient for

comparison with the present results is contained in Chapter 2 (Sex and Age Effects) of Ref. 4; this reference contains additional background to much of the material covered in this paper.

Driver risks in traffic are best separated into two distinct components: (a) risks to the drivers themselves, and (b) threats the drivers impose on other road users.

These components are of a different nature. There is near universal agreement that society should take stronger measures to prevent its members from doing things that endanger others than to prevent them from doing things that endanger only themselves. Public safety makes a stronger claim on public resources than does personal safety, which can be supported often using personal resources. Differences between the risks we assume ourselves and threats we pose on others impact legislation, licensing policy, police enforcement, and so on. Both components are examined by plotting a number of rates versus age and sex.

Data

The following data sets are used:

- 1 Fatality Analysis Reporting System (FARS), a census of all traffic crashes in the US since 1975 in which anyone was killed on a public road.⁵

^a General Motors Research and Development Center, Warren, Michigan, USA. Present affiliation: Science Serving Society (scienceservingsociety.com), Bloomfield Hills, Michigan, USA.

Reprint request to: Dr Leonard Evans, Science Serving Society, 973 Satterlee Road, Bloomfield Hills, MI 48304–3153, USA.

- 2 Bureau of the Census estimates of the resident population on 1 July by age (in one-year increments) and sex.⁶
- 3 Federal Highway Administration (FHWA) data giving numbers of driver licenses.⁷
- 4 National Personal Transportation Study (NPTS, run by FHWA) giving estimates of travel based on a diary approach.⁸
- 5 Deaths from all causes.⁹
- 6 Relationships between the risk of death from the same physical insult and sex and age, as previously published.^{4,10}

Relationships using the NPTS data are for 1995. For all other cases averages over the three years 1994–1996 are computed. The resulting relationships have a centre year of 1995, so that all the material presented may be interpreted as referring to 1995.

Unless stated otherwise, 'driver' means a driver of any motorized vehicle, including a motorcycle, truck, bus, etc. This choice insures a simple categorization of all traffic fatalities as either drivers or non-drivers; pedal cyclists are considered non-drivers. The dependence of driver fatalities on age and sex examined below thus reflects choice of vehicle, how it is used and what the consequences of a crash are, given that one occurs, all factors which are themselves influenced by age and sex.

This paper relies exclusively on cross-sectional analysis, in which consecutive points refer to a different set of people, not to the same set, or cohort, growing older. Examining cohorts as they age (longitudinal analysis) involves analysing data over as many years as the age dependence is examined.¹¹ In keeping with the practice in epidemiology, cross-sectional points are not generally joined by lines. However, the points are joined in a few cases to assist the eye in following the relationships.

Changing risks drivers face as they age

Figure 1 shows the average number of driver fatalities per year versus age and sex for 1994–1996. Normalizing Figure 1 by population generates Figure 2, which shows driver deaths per capita increase with age for males over about age 65 much more

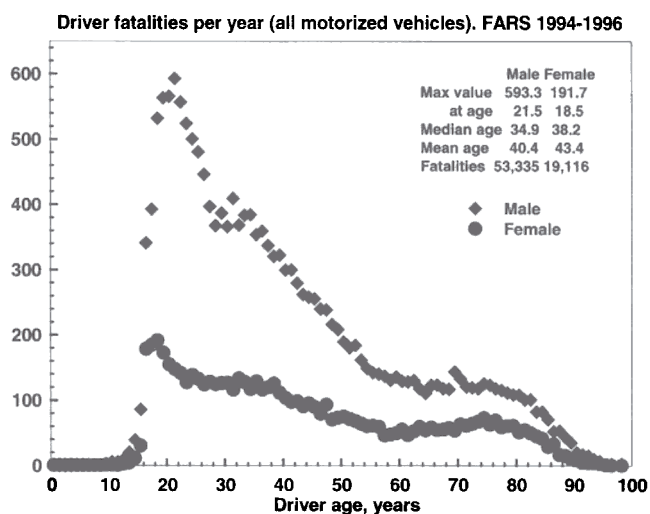


Figure 1 Average number of driver fatalities per year (all motorized vehicles) versus gender and age, based on Fatality Analysis Reporting System (FARS) 1994–1996

steeply than observed in 1980s data.⁴ The moderate increase for females over about age 65 in Figure 2 does not occur in the 1980 data.

The general pattern for driver fatalities per licensed driver (Figure 3) differs from that in Figure 2 only insofar as the fraction of the population holding driving licenses varies with age. In particular, older females are less likely than those in mid life to have driver licenses. Thus, in contrast to Figure 2, the rates in Figure 3 increase similarly with age for males and females older than about 65.

Figure 3 reflects only fatally injured drivers with valid licenses. The per cent of fatally injured drivers without valid driver licenses depends strongly on driver age (Figure 4). At very young and very old ages, a substantial majority of fatally injured drivers are unlicensed. As 15-year-olds cannot generally obtain licenses, nearly all 15-year-old drivers killed will be unlicensed. The increase at older ages is consistent with the interpretation that as licenses are revoked, many older drivers continue to drive and are consequently killed.

The number of driver fatalities per unit distance travelled shows further elevation above the average for older and younger ages. The increases at older ages and younger ages are so much larger than the increases in fatalities per licensed driver (Figure 3) because older and younger drivers travel less than average (Figure 6).

Increases with age like those in Figures 2, 3 and 5 have been incorrectly interpreted to reflect mainly the driver's risk of crashing. Such an interpretation misses the crucial point that the number of drivers of given age and sex killed is the product of two factors: (1) the number of involvements in very serious crashes and (2) the probability that involvement proves fatal.

The first factor reflects influences due to all use and behavioural factors, such as amount and type of driving, driver capabilities, type of vehicle driven, time of day, degree of intoxication, and driving risks. The second factor can be influenced also by such behavioural factors as safety belt wearing and alcohol consumption. Apart from such considerations, the probability that

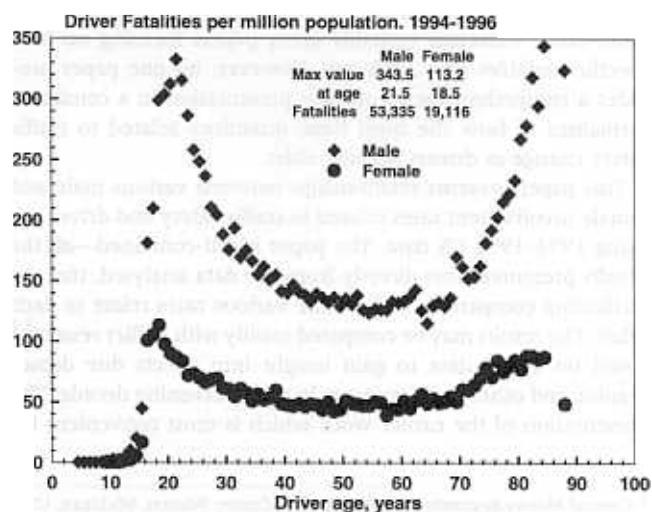


Figure 2 Driver fatalities (all motorized vehicles) per million population versus gender and age. Based on Fatality Analysis Reporting System (FARS) and US Bureau of the Census data, 1994–1996

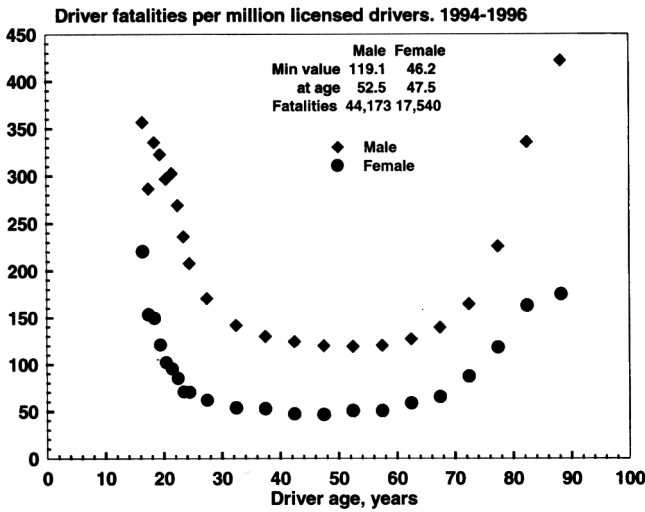


Figure 3 Fatally injured drivers (all motorized vehicles) with valid driver licenses per million licensed drivers versus gender and age. Based on Fatality Analysis Reporting System (FARS) and Federal Highway Administration data, 1994-1996

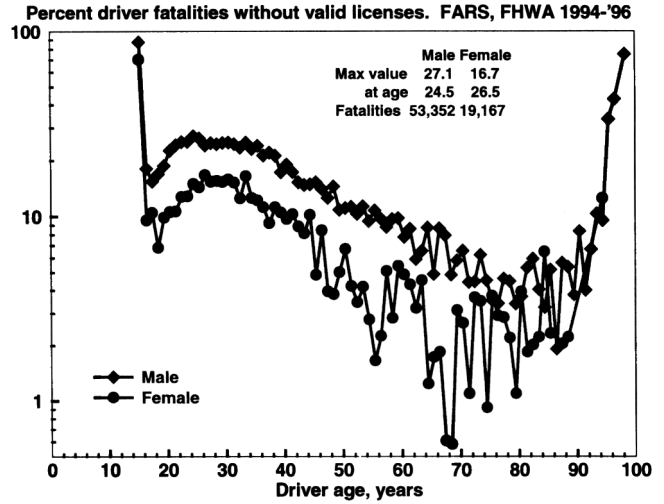


Figure 4 The per cent of fatally injured drivers without valid driver licenses at the time of their fatal crash. The denominator is those with valid or unknown license status. Based on Federal Highway Administration (FHWA) 1994-1996

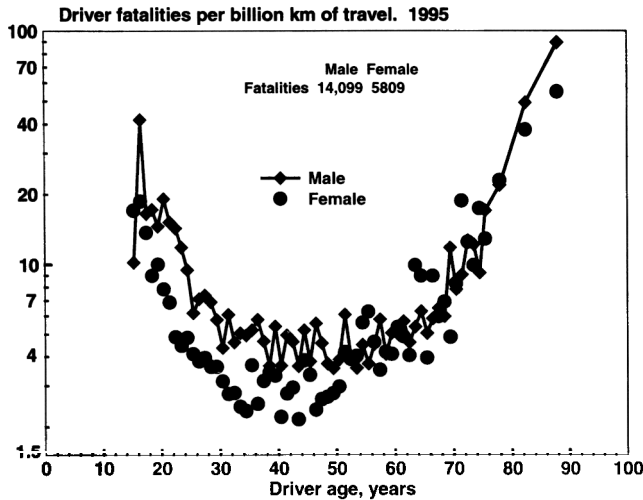


Figure 5 Driver fatalities (all motorized vehicles except large commercial trucks) per billion km of travel versus gender and age. Based on Fatality Analysis Reporting System (FARS) 1995, National Personal Transportation Survey (NPTS) 1995

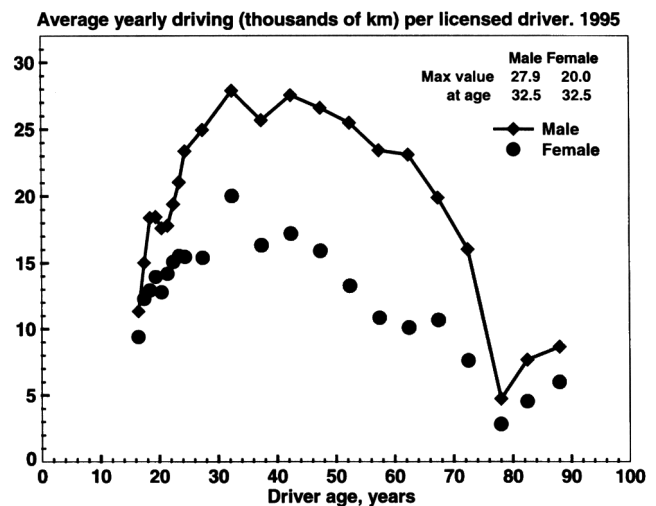


Figure 6 Estimates of distance driven per year, based on Federal Highway Administration (FHWA) 1995 and National Personal Transportation Survey (NPTS) 1995

a given crash results in death is essentially physiological rather than behavioural in nature, and for the present purposes can be adequately approximated by the relationships given on page 26 of ref. 4, which are:

$$R_{\text{males}}(A) = \exp 0.0231 (A - 20) = 0.630 \exp(0.0231 A) \quad \text{(Equation 1)}$$

and

$$R_{\text{females}}(A) = 1.3 \exp 0.0197 (A - 20) = 0.877 \exp (0.0197 A) \quad \text{(Equation 2)}$$

where $R(A)$ is the fatality risk to an individual of age A compared to the risk to an individual of age 20 when both are subject to the same physical insult, or impact. When driver age is 16-20, we assume $R = 1$ for males and $R = 1.3$ for females.

Fatality rates focus on the outcome, not the severity of the crash that led to death. Here we examine involvement rates in crashes of similar severity by considering crashes in a severity range greater than sufficient to likely kill 80-year-old male drivers, for which case R has a value of 4.0 (Equation 1). Consider the mix of crashes in which N fatalities occur to 80-year-old males. If these crashes were repeated keeping all factors the same except the drivers, then we would expect 0.25 N fatalities for 20-year-old male drivers and 0.325 N fatalities for 20-year-old female drivers (Equation 2). In order to obtain the same number of fatalities, 4.0 times as many crashes by 20-year-old male drivers, and 3.1 times as many crashes by 20-year-old female drivers are required. In this way we can use the observed numbers of fatalities to infer involvement rates in crashes in the severity range sufficient to likely kill 80-year-old male drivers.

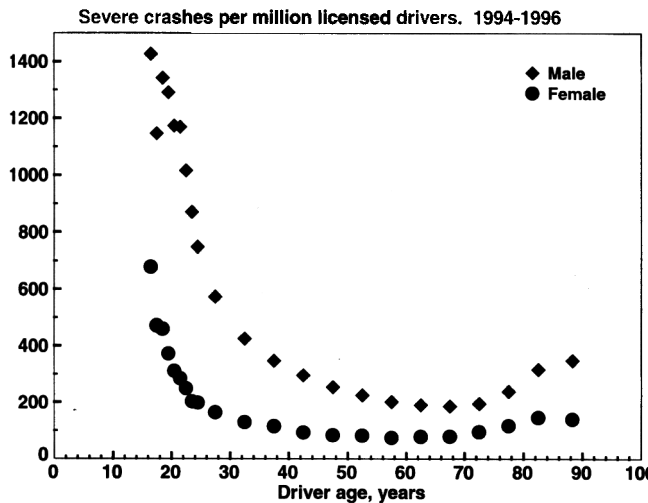


Figure 7 Estimated licensed driver involvements (all motorized vehicles) per million licensed drivers in crashes of sufficient severity to likely kill 80 year old male drivers versus gender and age

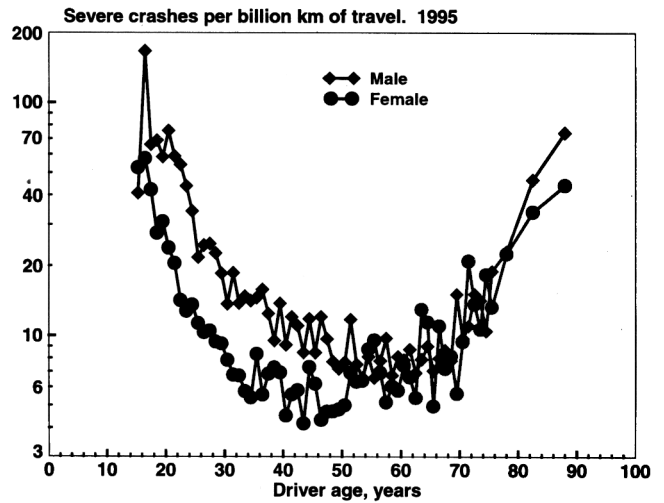


Figure 8 Estimated driver involvements (all motorized vehicles) per billion km of travel in single-vehicle crashes of sufficient severity to likely kill 80 year old male drivers versus gender and age

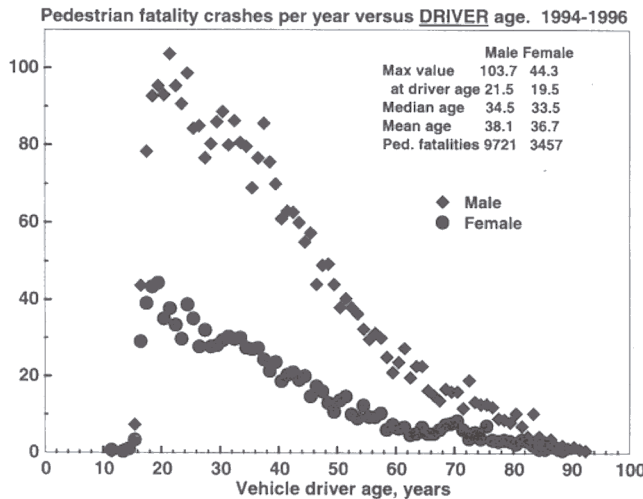


Figure 9 Number of single vehicle crashes per year in which one or more pedestrians were killed versus the age and gender of the driver. Fatality Analysis Reporting System (FARS) 1994-1996

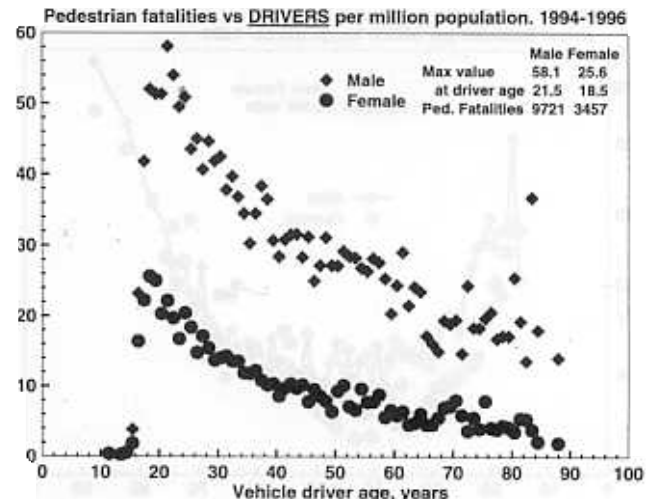


Figure 10 Number of single vehicle crashes per million population in which one or more pedestrians were killed versus the age and gender of the driver. Based on Fatality Analysis Reporting System (FARS) and census data for 1994-1996

Figure 7 shows the number of involvements in crashes in the same severity range per licensed driver versus age and sex. In contrast to the earlier Figures, the increase at older ages is much less, showing that a major component of increasing risk with increasing age is due to greater risk of being killed in the same crash.

Severe crash involvements per unit distance of travel (Figure 8) increase with increasing driver age for ages above about 60. However, the increase is smaller than in Figure 5; even at the oldest age plotted; the rates for males and females are still less than those for male drivers under 30.

Threat to other road users

The threat drivers impose on other road users is estimated by examining the number of crashes in which pedestrians are

killed as a function of the age and sex of the involved driver. Only single-vehicle crashes are included, so a typical case will be a car striking and killing a pedestrian but not injuring the driver. No assumption is made regarding responsibility in pedestrian fatality crashes; the FARS data show about one-third of fatally injured pedestrians have blood alcohol concentrations in excess of 0.1 per cent by volume, the legal limit for driver intoxication in most US states.

Figures 9-12 show the variables for crashes involving pedestrian fatalities corresponding to those above for driver fatalities. Pedestrian fatalities have been used^{4,12} to estimate exposure to crashes in general. The general correspondence between the plots for driver fatalities versus driver age and for pedestrian fatalities versus driver age add to the plausibility of the approach.^{4,12} Only one of the four relationships, namely

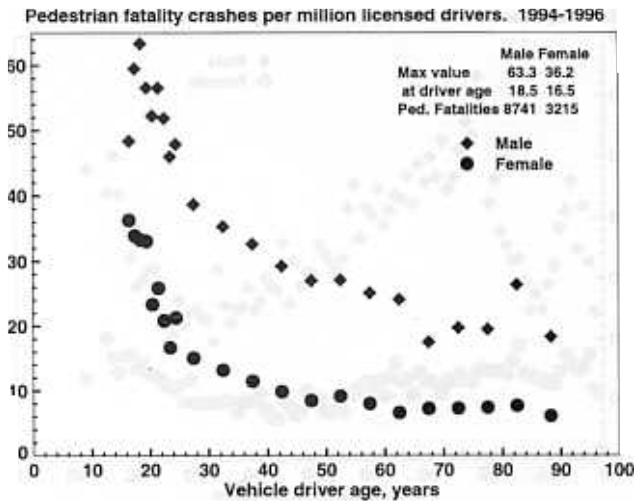


Figure 11 Number of single vehicle crashes per million licensed drivers in which one or more pedestrians were killed versus the age and gender of the driver. Based on Fatality Analysis Reporting System (FARS) and Federal Highway Administration data for 1994–1996

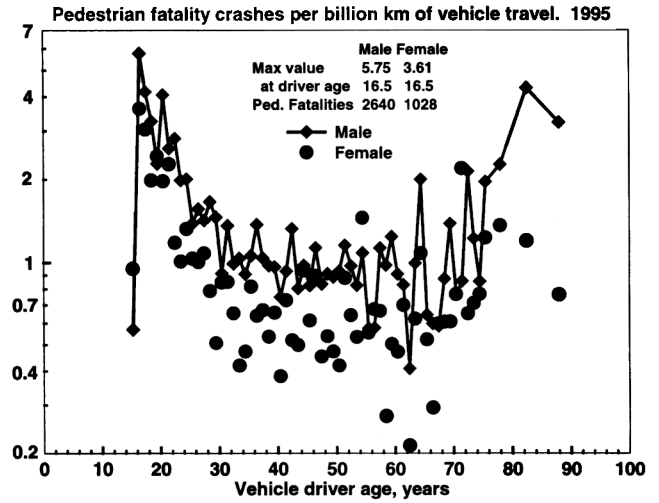


Figure 12 Number of single vehicle crashes per billion km of travel in which one or more pedestrians were killed versus the age and gender of the driver. Based on Fatality Analysis Reporting System (FARS), and National Personal Transportation Study data for 1995

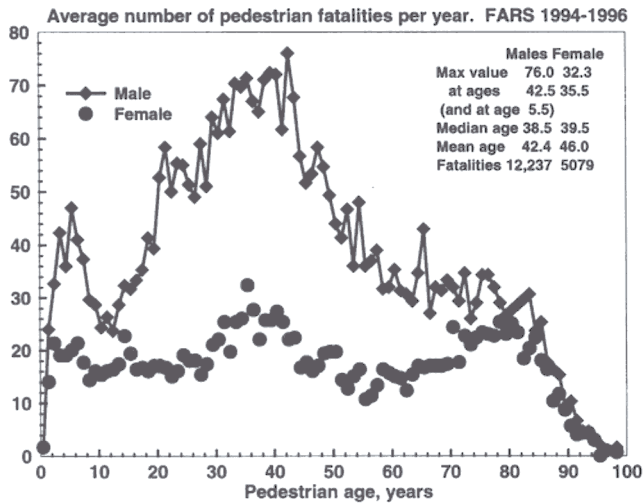


Figure 13 Average number of pedestrian fatalities per year versus gender and age, based on Fatality Analysis Reporting System (FARS) 1994–1996. Distinct maximum values occur for males at ages 5 and 42

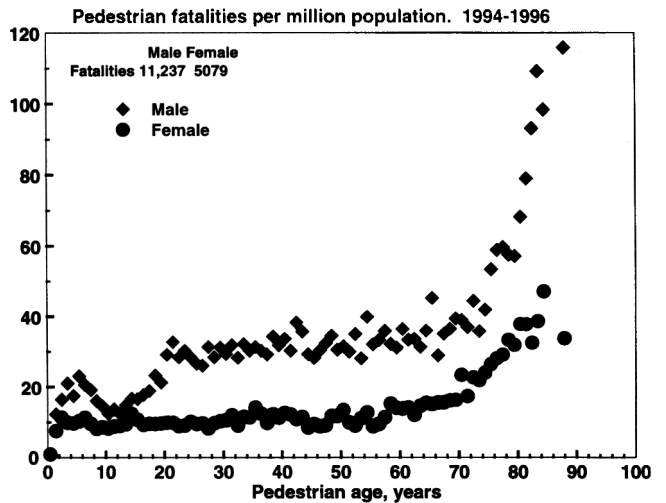


Figure 14 Pedestrian fatalities per million population versus gender and age. Based on Fatality Analysis Reporting System (FARS) and US Bureau of the Census data for 1994–1996

Figure 12, which shows pedestrian fatality crashes per unit distance of travel, indicates an increase with age for older drivers.

Note particularly that the number of pedestrian fatality crashes per licensed driver (Figure 12) does not increase at older ages. In terms of the decision to grant a license for a fixed period of time, a 20-year-old male is over 100% more likely to be involved in a crash in which a pedestrian is killed than is a male driver older than 70 years.

Pedestrian involvements in fatal and severe crashes

Above we examined the age and sex of drivers involved in crashes in which pedestrians were killed. We now examine the

age and sex of the pedestrians involved without regard to the characteristics of the involved drivers.

Figure 13 shows the distribution of pedestrian fatalities by pedestrian age and sex. The same data normalized by population are shown in Figure 14.

Figure 15 shows the ratio of male pedestrian deaths per capita to female pedestrian fatalities per capita. This figure, which uses FARS and Census data 1986–1996, is remarkably similar to Figure 6–5 (p.139) of ref. 4, thereby offering additional support for the interpretation given there. Figure 15 and Figure 6–5 of ref. 1 are derived using independent, non-overlapping data, and consequently reveal stable intrinsic large behavioural differences at a fundamental level between the sexes.

Part of the large increase in pedestrian fatalities per capita with increasing older ages in Figure 14 is due to the greater

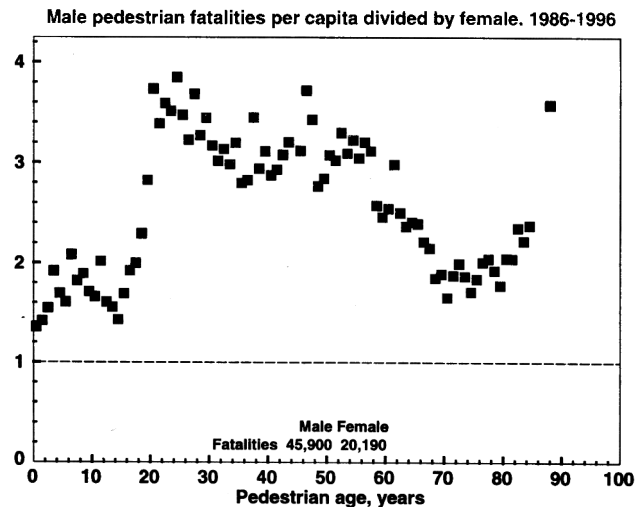


Figure 15 Number of male pedestrian fatalities per capita divided by female pedestrian fatalities (of the same age) per capita based on Fatality Analysis Reporting System (FARS) and census data 1986-1996

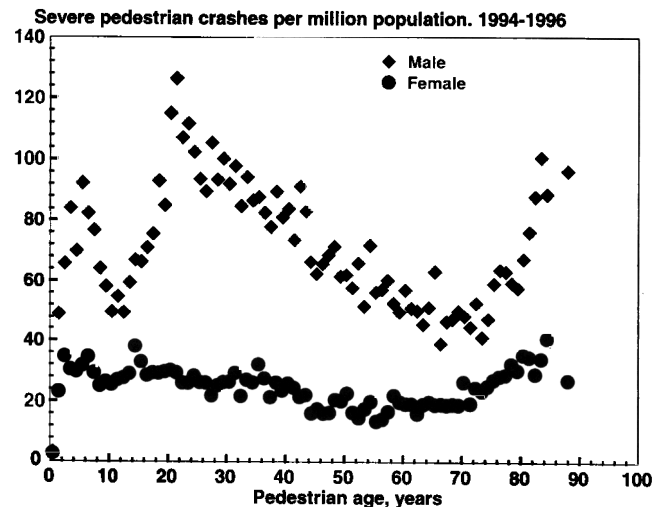


Figure 16 Estimated pedestrian involvements per million population in crashes of sufficient severity to likely kill 80 year old male pedestrians versus gender and age

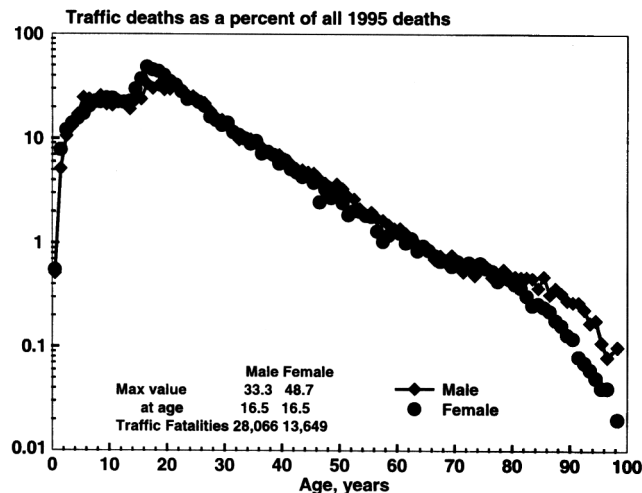


Figure 17 Traffic deaths expressed as a percentage (on a logarithmic scale) of total deaths from all causes (including traffic). All data are for 1995

likelihood that the older person is killed in a crash which a younger person would survive. In order to estimate the risk of involvement in a severe crash, as distinct from the outcome, we again use the relationships between risk of death from the same impact and sex and age given in Equations 1 and 2. Figure 16 shows the number of pedestrian involvements in crashes in the severity range equal to or greater than that necessary to kill an 80-year-old male pedestrian. Like the driver fatality data, the pedestrian fatality data show peaks at about age 21 for males. The increasing involvement in severe pedestrian crashes with increasing age at ages above about 65 is probably reflecting decreasing perceptual and agility skills, and also perhaps increased pedestrian exposure related to driving less.

Traffic deaths relative to all deaths

A noticeable feature of the ratio of traffic deaths to all deaths (Figure 17) is the lack of a clear difference between the sexes.

Indeed, from the twenties through the seventies the fraction of all deaths that are traffic deaths declines at an approximately constant rate of 8% per year for both sexes. The per cent of all deaths that are traffic fatalities fit extremely well the relationships $143.0 \exp(-0.0775 \text{ age})$ for males and $135.8 \exp(-0.0788 \text{ age})$ for females for ages from ages 27 to 70. Additional details on the topics covered here plus additional topics are available in a detailed technical report.¹³

Table 1 shows illustrative ages selected from the plotted data. Given that a death occurs in the teens through the twenties, the probability that it is a traffic fatality is over 20%. As drivers age, the risks from other causes of death increase much more rapidly than any increases of risk in traffic. Given that a 65-year-old dies, the probability that death is due to a traffic crash is less than one per cent. For an 80-year-old it is less than half a per cent.

Summary of main findings

Summary information from the graphs is presented below. When data are available in one-year increments, the values are computed by averaging over three years (that is, the value for 70-year-olds is the average of the values at 69.5, 70.5 and 71.5. When data are available only in 5-year increments, the average of two values is used (the value for 70-year-olds is the average of the values for 67.5 and 72.5. In some cases the estimates at age 80 are based on relatively small sample sizes.

Threats older drivers pose to others

The threats that 70-year-old drivers pose to other road users are compared in Table 2 to the threats posed by 40-year-old drivers and by 20-year-old drivers. The ages 40 and 20 were chosen to typify the generally safest age and a high risk age, respectively.

Renewing the license of a 70-year-old male driver for another year imposes, on average, 40% less threat to other road users than renewing the license of a random 40-year-old male driver. Renewing the license of a 20-year-old male driver compared to

Table 1 The per cent probability that a death is a traffic fatality in 1995. Illustrative values from Figure 17

Age	Male	Female	Total
0	0.51	0.55	0.53
5	24.61	17.27	21.57
10	20.72	24.21	22.19
15	23.77	37.06	28.09
18	32.24	43.62	35.03
25	22.63	22.21	22.52
30	13.13	14.13	13.40
40	6.33	6.18	6.28
50	3.32	2.42	2.99
60	1.39	1.24	1.33
65	0.88	0.85	0.87
70	0.66	0.67	0.66
80	0.48	0.40	0.44
90	0.27	0.12	0.17
95	0.11	0.04	0.05

Table 2 Threats 70-year-old drivers pose to other road users compared to the threats posed by 40- and 20-year-old drivers, as measured by involvement in single-vehicle crashes killing pedestrians. The first entry indicates that, on average, licensing a 70-year-old male poses 40% less threat than licensing a 40-year-old. Compared to licensing a 70-year-old male, licensing a 20-year-old poses 196% more threat to others

	Male		Female	
	Age 70 Age 40	Age 20 Age 70	Age 70 Age 40	Age 20 Age 70
Per licensed driver (Figure 11)	0.60	2.96	0.68	3.81
For same distance of driving (Figure 12)	1.14	2.98	2.02	1.87

Table 3 Threats 80-year-old drivers pose to other road users compared to the threats posed by 40-year-old and 20-year-old drivers, as measured by involvement in single-vehicle crashes killing pedestrians

	Male		Female	
	Age 80 Age 40	Age 20 Age 80	Age 80 Age 40	Age 20 Age 80
Per licensed driver (Figure 11)	0.74	2.40	0.70	3.67
For same distance of driving (Figure 12)	3.71	0.91	1.88	2.01

a 70-year-old male driver imposes an increased threat to others of 196%.

One of the reasons older drivers pose less of a threat per year to others is that they drive less (Figure 6). In terms of threats for the same distance travelled, the 70-year-old driver poses a 14% higher threat than the 40-year-old. The female threats, with values much lower at 40, proportionally increase more even though their values are lower than for males at essentially all ages.

Table 3 shows information parallel to that in Table 2, but for 80-year-old drivers. Granting a license for another year to an

Table 4 Risks faced by 70-year-olds compared to risks faced by 40- and 20-year-olds. The first entries indicate that, for males, a random 70-year-old in the population is 13% more likely to become a driver fatality than is a random 40-year-old, but a 20-year-old is 196% more likely than is a 70-year-old

	Male		Female	
	Age 70 Age 40	Age 20 Age 70	Age 70 Age 40	Age 20 Age 70
Driver fatalities per head of population (Figure 2)	1.13	1.96	1.19	1.61
Fatalities per licensed driver (Figure 3)	1.20	2.02	1.53	1.39
Fatalities for the same travel distance (Figure 5)	2.05	1.70	3.86	0.77
Severe crashes per licensed driver (Figure 7)	0.59	6.35	0.84	3.71
Severe crashes for same travel distance (Figure 8)	1.02	5.38	2.11	2.09

Table 5 Risks faced by 80-year-olds compared to risks faced by 40- and 20-year-olds

	Male		Female	
	Age 80 Age 40	Age 20 Age 80	Age 80 Age 40	Age 20 Age 80
Driver fatalities per head of population (Figure 2)	1.82	1.22	1.75	1.10
Fatalities per licensed driver (Figure 3)	2.21	1.10	2.82	0.76
Fatalities for the same travel distance (Figure 5)	7.62	0.46	11.0	0.27
Severe crashes per licensed driver (Figure 7)	0.87	4.36	1.27	2.45
Severe crashes for same travel distance (Figure 8)	2.98	1.85	4.97	0.89

80-year-old driver poses substantially less threat to other road users than granting a license to a 40-year-old driver.

Risks older drivers themselves face

In general, as drivers become older, most measures indicate increases in risk as they age. A major contributor to this is that the same severity crash is more likely to lead to the death of an older person. In terms of the measures which best reflect the behavioural aspects of driving, namely, driver involvements in severe crashes per unit distance of travel (Table 4), and crashes in which pedestrians were killed per unit distance of travel (Table 2), the values for 70-year-old male drivers are not particularly different from those of 40-year-old male drivers. (Many factors could contribute to a lack of difference, such as the older drivers confining driving to safer periods, less alcohol use, etc.). By age 80 (Tables 3 and 5) there is a substantial increase in risk of involvement; for female drivers increases are also substantial by age 70.

The above discussion has focused on how various measures depend on average chronological age. Not only do various measures of driver performance decline with age, but variability among individuals also increases, underlining the importance

of not judging an individual's fitness to drive on the basis of chronological age.

Conclusions

The relationships presented here suggest:

- 1 Licensing an older driver (data goes up to age 80) does not pose a greater threat to other road users than licensing younger drivers—indeed it poses substantially less risk than licensing a 20-year-old.
- 2 As drivers age, most measures indicate that they face an increased risk of becoming a traffic fatality, with the increase accelerating at very old ages.
- 3 Given that a death occurs, the probability that it is a traffic fatality declines steeply with age, from well over 20% for late teens through mid twenties, to under one per cent at age 65, and under half a per cent at age 80.

Acknowledgement

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