Older-Driver Risks to Themselves and to Other Road Users

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Risks drivers face themselves and impose on others are examined in terms of the dependence of various crash and fatality rates on age and sex. Some measures of crash involvement increase with age, but their values remain below those for drivers in their late teens and early twenties. If a 16-year-old male driver's crash risk declines by 7 percent throughout his life, his longevity increase will be greater than the longevity increase that a 65-year-old driver obtains by reducing crash risk to zero. Reducing the younger driver's crash risk by 12 percent improves pedestrian safety more than reducing the older driver's crash risk to zero. Compared with the other risks of death as one ages, traffic risk plays an ever-diminishing role; if an 18-year-old dies, the probability that death is due to a traffic crash is almost 50 percent; for a 65-year-old, it is less than 1 percent. Much larger than any increase in driver risk with increasing age is a decline in driving. Thus, the older-driver problem may be one of reduced mobility more than one of reduced safety.

The following three effects appear to be beyond dispute:

1. As drivers age, various capabilities relevant to driving decline: the physical (ability to rotate neck, muscle control), the sensory (visual acuity, hearing), and the cognitive (memory, information processing).
2. As drivers age, their crash rates increase.
3. In the United States, changing demography, increased longevity, and increased universality of driving (especially by women) will result in an enormous increase in older drivers.

These three effects have generated concern that in the future the United States will be faced with a major older-driver problem. The purpose of this paper is to examine the magnitude of this problem, relying mainly on a summary of research findings (*1*) reported in three publications (*2–4*).

Increasing driving risk with increasing age is best separated into two distinct components: (a) increased risks faced by older drivers, and (b) increased risks that older drivers impose on other road users. Legally and philosophically, these risks are of a different nature. There is nearly universal agreement that the measures society takes to prevent its members from doing things that endanger others should be stronger than those 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 those we impose on others affect legislation, licensing policies, police enforcement, and so on.

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INCREASED RISKS DRIVERS FACE AS THEY AGE

Figure 1 shows car-driver fatalities per million population in the early 1980s, as determined using data from the Fatal Accident Reporting System (FARS) (*5*) and Bureau of the Census (*6*). It is clear that for men the rate increases steeply at older ages; at 80, the rate approaches the peak value attained at 19. Part of the reason for the increase in the rate for older men but not for older women is the lower percentage of older women who had driver licenses in the period covered by the data (*7*). Note that changes in the proportion of the population that is old, in the absence of other changes, are not expected to change Figure 1 because the rate is already normalized for population.

Figure 2 shows the number of car-driver fatalities per licensed driver. The oldest age plotted, for drivers 70 and older, is the category used in the driver's license data. It is desirable that organizations tabulating data avoid such broad aggregation when substantial quantities of data are available at older ages. Driver fatalities per licensed driver increase for drivers of both sexes at older ages. Rates for men are considerably higher than those for women. Two factors that contribute to this difference are that men traveled more during the period covered by the data and that when men and women traveled together, men were more likely to drive.

Because the patterns in Figures 1 and 2 depend directly on such changing social features as the number of persons obtaining licenses, the amount of driving, and the occupant who is driving, it is preferable to look at the rate per unit distance of driving. This is shown in Figure 3, computed using distance-of-travel estimates from the 1983 Nationwide Personal Transportation Study (*8*). The rate in Figure 3 is not expected to change in any obvious way in response to increasing numbers of older drivers, increasing likelihood of obtaining a license, increasing travel, or increasing tendency for women to drive.

The U-shaped patterns in Figures 1–3 contribute to the general concern about increasing crash involvement with age. Such concern finds additional support in research showing various changes in mental and sensory functions as humans age (*9–11*). Declines with age have been found for such driving tasks as reading signs at night (*12*), perceiving and reacting to roadway hazards (*13*), and general driver performance (*14*). Ranney and Pulling (*15*) find that reaction times for skills related to vehicle control increase with age.

Involvement rates in fatal crashes do not correctly reflect such changes because of the strong influence of age on fatality risk when a crash occurs. The number of drivers killed is the product of two factors: (a) the number of involvements in

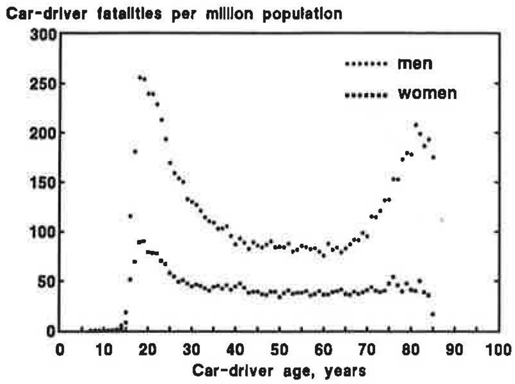

FIGURE 1 Driver fatalities per million population versus age and sex (*1,2*).

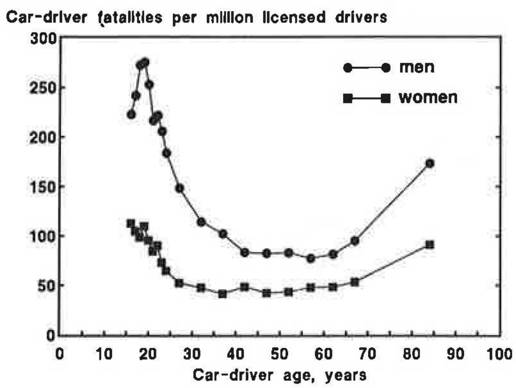

FIGURE 2 Driver fatalities per million licensed drivers versus age and sex (*1,3*).

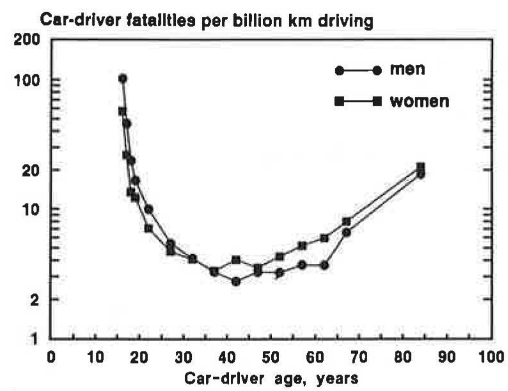

FIGURE 3 Driver fatalities per billion kilometers traveled versus age and sex (*1*).

serious crashes, and (b) the probability that involvement proves fatal. The first factor reflects influences due to all use and behavioral factors, such as type of driving, driver capabilities, time of day, degree of intoxication, and driving risks; it specifically includes all the factors likely to lead to declining driver performance. The second factor is primarily a physiological one. To examine separately the first of these factors, crash involvement, requires quantitative information about the second.

Age and Risk of Death

The effects of age on risk of death were studied using data from more than 80,000 vehicle occupants killed in crashes (*4*). By focusing on vehicles containing two occupants of different ages, at least one of whom was killed, and by using the method described by Evans (*16*), it is possible to extract the influence of age on relative risk of death for similar crash experiences. The results for 10 categories of male occupants are shown in Figure 4; these occupants were killed by a wide range of impact mechanisms. For example, car-occupant fatalities are usually associated with impact on the vehicle interior, but motorcyclist fatalities come from impact with objects unrelated to the vehicle. The absence or presence of steering wheels, safety belts, helmets, cushioning effects of motorcyclist drivers in front, and so on all affect the details of the injury insult. Given these differences, the extent to which the 10 plots in Figure 4 show similar features suggests that the effect displayed is due essentially to differences in basic susceptibility to trauma as a function of age, with the specific nature of the traffic crash being of secondary importance. That is, we expect that fatality risk would similarly depend on age for other types of potentially fatal physical insults, such as severe falls or blows from objects, including vehicles (the present method cannot be applied to investigate pedestrian fatality risk).

Figure 5 shows corresponding results for women; there are insufficient data to perform the analysis for motorcycle drivers; hence the 8 rather than 10 plots.

By collecting data of common ages, the information in Figures 4 and 5 is summarized in Figure 6. These data can be represented in convenient analytical form as

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

and

$$R_{\text{women}}(A) = 1.3 \exp 0.0197\,(A - 20) = 0.877 \exp(0.0197A) \quad \text{for } A \geq 20 \quad (2)$$

where A is age in years and R is the probability that a given impact will prove fatal relative to the probability that the same impact will kill a 20-year-old man. Once age exceeds about 20, fatality risk grows at an approximately uniform rate of 2.3 ± 0.2 percent per year for men and 2.0 ± 0.2 percent per year for women. At age 70 the risk is about three times what it is at age 20. Additional evidence supporting the greater fatality risk to women is provided by Foret-Bruno et al. (*17*), who found that women are about 20 percent more likely to be injured than men. They also found explanations of the difference in terms of differences in bone strength in tests using cadavers.

Involvement in Severe Crashes

Fatality rates focus on the outcome, not the severity, of the crash that led to death. Here, involvement rates in crashes of similar severity are examined by considering crashes in a severity range greater than or equal to that sufficient to kill 80-

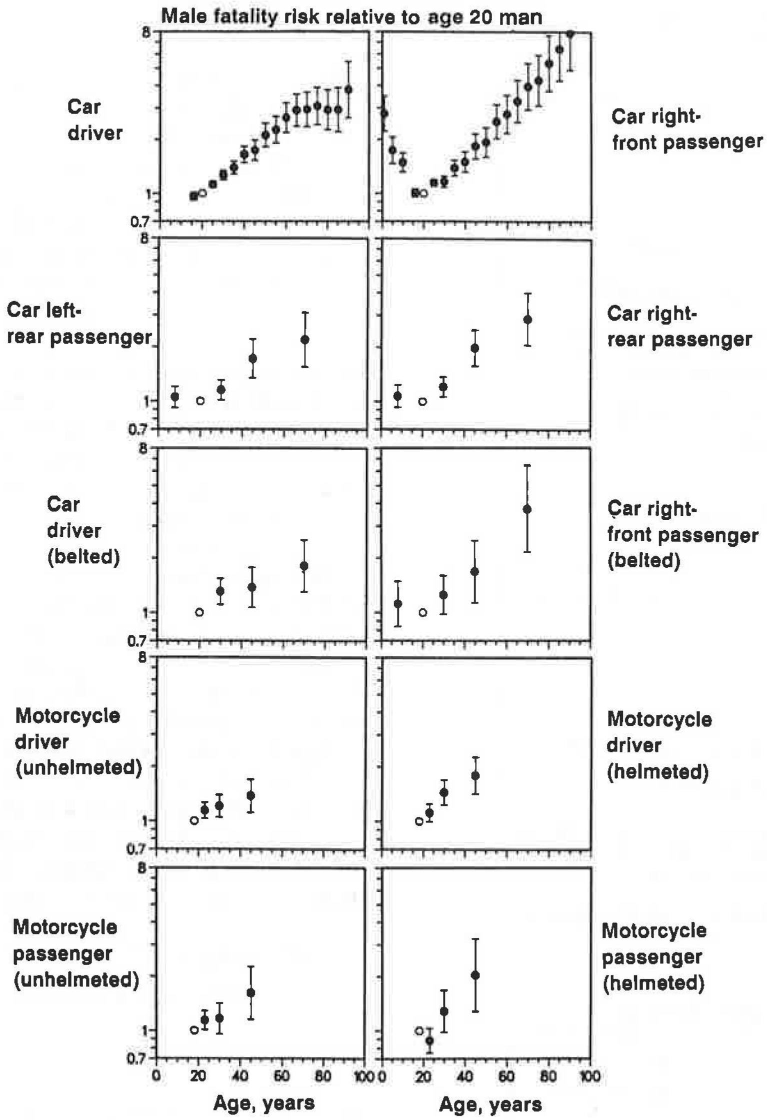

FIGURE 4 Fatality risk from similar physical insult for men of different ages compared with that for men 20 years old (*1*).

year-old men drivers, for which case *R* has a value of 4.0 (Equation 1). Consider a set of crashes in which *N* fatalities occur to 80-year-old men. If these crashes were repeated, keeping all factors the same except the drivers, 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). 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 kill 80-year-old men drivers.

Figure 7 shows the number of involvements per capita in crashes severe enough to kill 80-year-old men by driver age and sex. In contrast to Figure 1, there is now only a slight increase with age for older men. Note how much lower the rate at older ages is than it is at younger ages. Thus, a large mechanism generating the upward trend in Figure 1 is the greater likelihood that a crash proves fatal. An increase in crash involvement risk also contributes. Severe crash involvements per licensed driver (Figure 8) barely exceed their minimum values as drivers age.

The rate most indicative of driver behavior is severe crash involvements per unit distance of travel, shown in Figure 9. Here, an increase occurs as drivers increase in age beyond 50 or so. For men and for women, the rate for drivers 70 and older is a factor of about 3 times the minimum rate but still much less than the rates for drivers in their late teens and early twenties. This increase in rate most likely reflects deteriorating skills important for safe driving. Indeed, the increase may underestimate the decline in performance, because one of the most pronounced changes that occurs as drivers age is that they drive less—especially in higher-risk travel, such as at night.

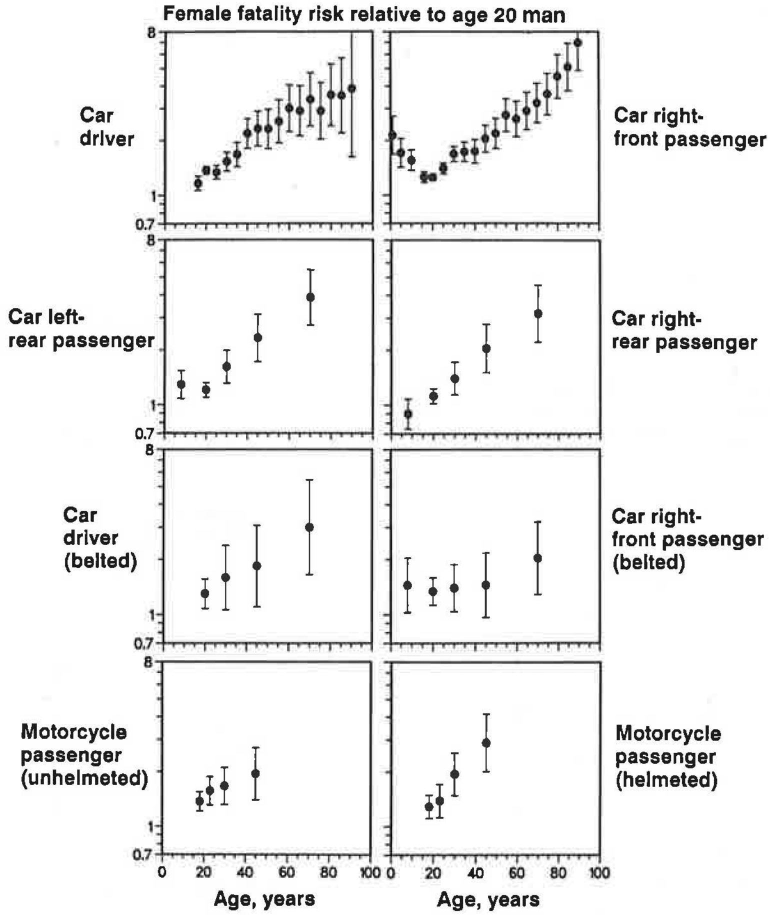

FIGURE 5 Fatality risk from similar physical insult for women of different ages compared with that for men 20 years old (*1*).

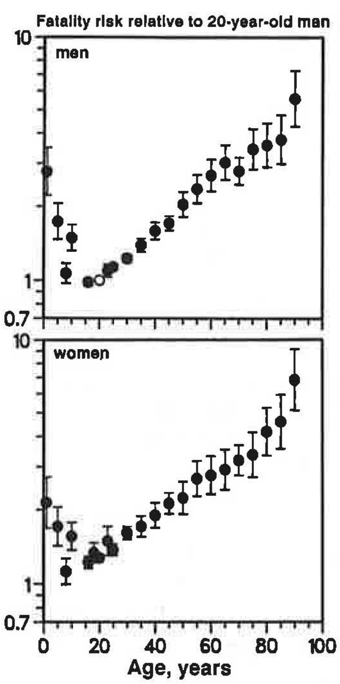

FIGURE 6 Fatality risk from similar physical insult by age for men and women (*1*,*4*).

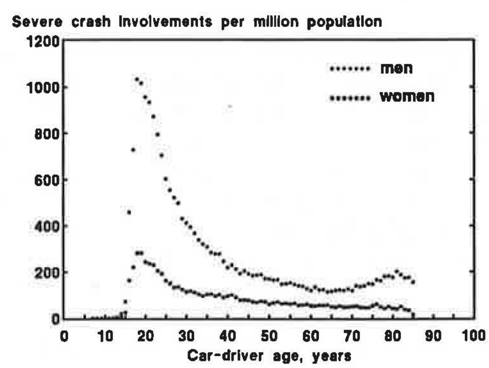

FIGURE 7 Estimated driver involvements per million population in crashes severe enough to kill 80-year-old male drivers versus age and sex (*1*,*2*).

INCREASED RISKS TO OTHER ROAD USERS

The threat to other road users is investigated by examining the number of crashes in which pedestrians are killed as a function of the age and sex of drivers of any type of motorized vehicle involved in the crashes. Attention is confined to single-vehicle crashes because when more than one vehicle is involved, it is not always possible to determine which vehicle

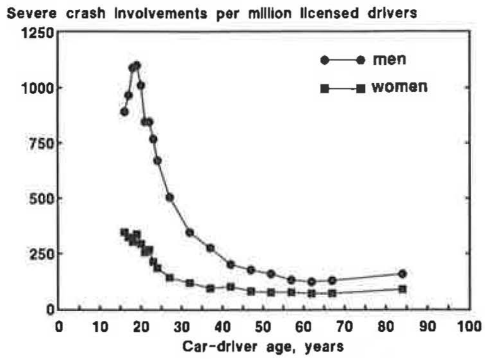

FIGURE 8 Estimated driver involvements per million licensed drivers in crashes severe enough to kill 80-year-old male drivers versus age and sex (*1,2*).

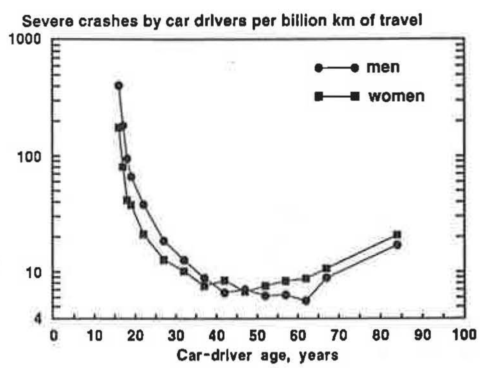

FIGURE 9 Estimated driver involvements per billion kilometers traveled in crashes severe enough to kill 80-year-old male drivers versus age and sex (*1*).

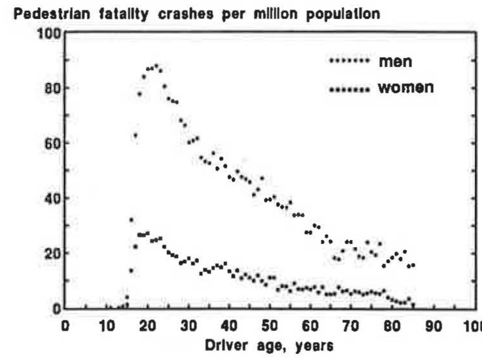

FIGURE 10 Single-vehicle crashes per million population in which pedestrians were killed versus age and sex of driver (*1,3*).

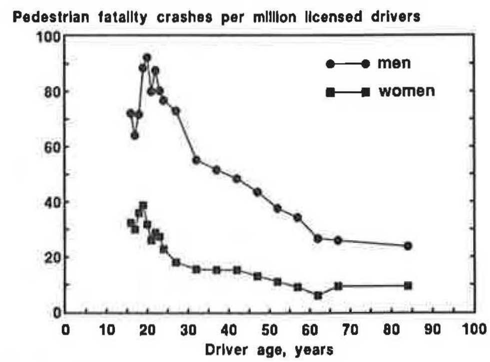

FIGURE 11 Single-vehicle crashes per million licensed drivers in which pedestrians were killed versus age and sex of driver (*1,3*).

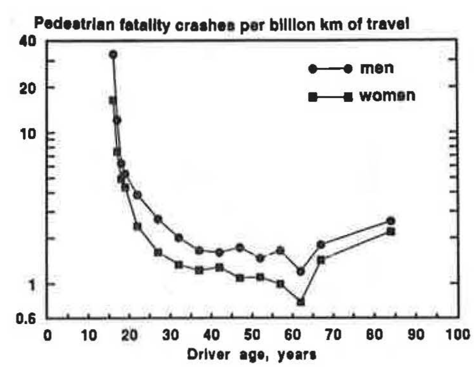

FIGURE 12 Single-vehicle crashes per billion kilometers traveled in which pedestrians were killed versus age and sex of driver (*1,3*).

struck the pedestrian. In addition, involvement in multiple-vehicle crashes poses threats to drivers different than those of single-vehicle crashes in which pedestrians are killed; the drivers of cars in single-vehicle pedestrian-fatality crashes usually are not seriously injured. No assumption is made regarding responsibility in pedestrian fatality crashes; about one-third of fatally injured pedestrians have blood alcohol concentrations (BACs) in excess of 0.1 percent (*18*).

Figures 10–12 show the variables for crashes involving pedestrian fatalities corresponding to those for driver fatalities in Figures 1–3. The only curve that suggests any increase in threat to other road users as drivers age is Figure 12, which shows pedestrian fatality crashes per unit distance of travel. Here the increase is small and applies only at ages above about 60; it is overshadowed by the much greater values associated with young drivers of either sex.

TRAFFIC RISKS COMPARED WITH OTHER RISKS AS PEOPLE AGE

A large factor contributing to the increase in driver deaths per unit distance of travel as drivers age is increasing risk of death, given involvement in a crash. The increasing risk of death with increasing age from the same physical insult applies in general, and not just to traffic accidents. Another traffic situation in which increasing risk of death is important is pedestrian accidents; at age 80 pedestrian fatality risk per capita for men and women is more than twice that at any age below 65. At age 70, the number of male pedestrian fatalities is about two-thirds the number of male driver fatalities; for women, the numbers of driver and pedestrian fatalities are similar (*2*).

Although risks in traffic increase with age, they do so much less rapidly than does the risk of death from all other causes combined (*19*). Figure 13 shows the probability in terms of age and sex that a death is any type of traffic fatality. The peak at about age 10 is due primarily to pedestrian fatalities. The difference in Figure 13 between the sexes is small because the increased risk men face in traffic (as pedestrians as well as drivers) is approximately in proportion to the increased risk to men from death from all causes; the greater risk of death for men from nearly all causes leads to male life expectancy at birth being 6 years less than it is for women. If an 18-year-old dies, the probability that death is due to a traffic crash is almost 50 percent. By age 65, the probability that death is due to a traffic crash is less than 1 percent; by age 75 the probability drops to below half a percent.

Figure 14 shows increases in longevity calculated to result if all traffic fatalities were eliminated, without anything else changing (*3,20*). For boys at birth the increase is 242 days, or two-thirds of a year; for girls, 111 days. At age 65 the increases are 15 days for men and 12 days for women; at age 75, 9 days for men and 6 for women.

To place these longevity values in a different perspective, the data in Figure 14 are used for some back-of-the-envelope calculations based on a hypothetical intervention (say, a novel driver training program) that would permanently reduce an individual's risk in traffic by some percentage. The comparisons are confined to male drivers, not only in the interest of simplicity but also because males make up a larger portion of the traffic-safety problem and nearly all are licensed, thereby making present results more representative of likely future results. If the intervention were to generate a lifelong 1 percent reduction in traffic fatality risk for a 16-year-old male road user (that is, at every age his risk would be 1 percent lower than it would have been without the intervention), what corresponding reduction in older-driver risk would be necessary to give that older road user an identical longevity increase? The answer is obtained by taking the ratios of the longevity increases in Figure 14; for a 65-year-old road user, the reduction is 15 percent. That is, reducing a 16-year-old road user's risk by 1 percent gives that individual the same longevity increase as reducing his risk by 15 percent at age 65. Corresponding estimates for ages 70 and 75 are 19 percent and 24 percent, respectively. The longevity increase from eliminating traffic fatality risk at age 65 (an unattainable goal) can be achieved by a reduction in traffic risk of under 7 percent

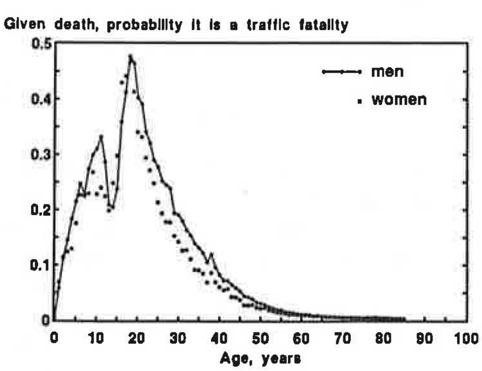

FIGURE 13 Probability that death is due to a motor-vehicle crash versus age and sex (*1,3*).

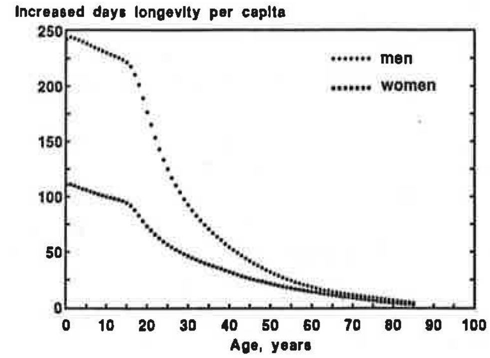

FIGURE 14 Calculated increases in longevity (in days) per capita assuming elimination of motor-vehicle crashes (*1,3*).

for 16-year-old road users (a possible goal, at least in principle). Confining the analysis to drivers of any vehicle rather than to all road users shows that a 1 percent permanent reduction in risk for a 16-year-old driver produces the same longevity extension as 16, 21, and 28 percent risk reductions for 65-, 70-, and 75-year-old drivers, respectively.

We can apply similar calculations to examine how the risks faced by pedestrians are affected by reductions in the crash rates of older and younger drivers. From the data used to produce Figure 10, we calculate that a 1 percent permanent reduction in crash risk for a 16-year-old male driver prevents the same number of pedestrian fatalities as a 9 percent reduction in crash risk for a 65-year-old male driver, an 11 percent reduction for a 70-year-old driver, and a 14 percent for a 75-year-old driver. The unattainable goal of eliminating 65-year-old drivers' crashes into pedestrians is calculated to reduce pedestrian fatalities by a lesser amount than reducing by 12 percent the 16-year-old drivers' rate of crashes with pedestrians.

The differences for female road users are similar to the corresponding differences for men, though in some cases smaller. A cursory examination of Figure 10 shows that eliminating the risks that older female drivers impose on other road users would produce modest benefits compared with reducing by even a small fraction the risks that younger male drivers impose on others.

Those calculations are on a per-driver basis. Even with the demographic changes under way in the United States, there will still be many more younger than older drivers for some time. Hence, reducing the risk for all 16-year-old drivers compared with reducing the risk for all 65-year-old drivers will further increase the already substantially larger safety benefits shown to be associated with reducing younger- rather than older-driver risk.

DISCUSSION AND CONCLUSIONS

Although drivers over about 50 are increasingly more likely to be killed per unit distance of driving than 40-year-old drivers, a large factor contributing to this is not increased crash risk but increased risk of death when a crash occurs. That is, a physiological factor associated with aging plays a role comparable to that due to declines in driving skill (Figures 3 and

6). Although the risk of death from the combined effects of all traffic crashes increases at older ages compared with the other risks of death as one ages, risk in traffic plays an ever-diminishing role.

The graphs that best reflect the behavioral aspects of driving—namely, driver involvements in crashes in the same high severity range per unit distance of travel and in crashes in which pedestrians are killed per unit distance of travel (Figures 9 and 12)—show remarkably similar features. Drivers from about 30 to 60 have the lowest involvement rates. As age decreases below 30, rates increase quickly. For ages greater than about 60, rates increase somewhat, but much less rapidly than as one approaches the younger ages in the graphs.

Taking the most extreme crash-rate comparison, Figure 9 shows that, compared with driving at the age of minimum crash-rate per unit distance of travel, drivers in the 70-and-older age category experience a threefold increase in risk. Similar increases in risk are found by Brorsson (*21*) in Swedish data; indeed, many of the patterns in the Swedish data are similar to those reported here. A factor-of-3 difference in risk is substantial, but it is of a magnitude common to many traffic situations and should not necessarily be viewed as a strong case for denying a driver's license. If having an above-average risk were sufficient grounds to deny a driver's license and each driver's risk were known accurately, such a criterion would inexorably lead to the licensing of only one driver: the one with the lowest risk.

The following examples put a factor-of-3 difference in risk in perspective. A formula (*1*) derived by Nilsson that builds on his earlier work (*22*) indicated that traveling 80 km/hr compared with traveling 60 km/hr increases the fatality risk by a factor of 3. An unbelted driver in a small car is 3 times as likely to be killed in a crash as is a belted driver in a large car (*23*). In the United States, the overall fatality rate was a factor of 3 higher 30 years ago than it is today, and many countries today have rates more than a factor of 3 times the present U.S. rate. Driving 300 km generates 3 times the fatality risk that driving 100 km does. The data of Borkenstein et al. (*24*) indicate that driving with a BAC between 0.05 and 0.09 percent, which is legal in nearly all of the United States, doubles crash risk. Driving with a barely illegal level of 0.1 to 0.149 percent BAC increases risk by a factor of more than 10; driving at above 0.2 percent BAC increases risk by a factor of more than 40.

Much of the data do not depend on demography or social custom in any large or direct way, so their broad qualitative features are expected to remain approximately invariant in time. The effects they represent seem more akin to laws of nature than to observations local to a specific time or place. Their broad features cannot be canceled by interventions—there is no conceivable treatment that would render the graphs of these data straight lines parallel to the age axis. In any event, straightening the curves does not seem a more worthy societal goal than seeking safety measures that reduce risks to all ages in similar proportions if such measures generate greater net reductions in harm.

To acknowledge that the broad shape of Figure 9 is close to being a law of nature is not to conclude that interventions aimed at specific ages cannot make important contributions. Some interventions meant specifically for young drivers have been discussed (*1*), including changes in the advertisement and taxation of beer and in the movies that portray the life-threatening use of vehicles as heroic, humorous, or harmless. These efforts are intended to reduce the magnitude of younger drivers' overinvolvement relative to that of 40-year-old drivers. To expect young-driver rates to drop to the same values as those for 40-year-old drivers in the same society at the same time is unrealistic. Present U.S. rates for 20-year-olds are lower than those for 40-year-olds at earlier periods in the development of U.S. motorization and lower than present 40-year-old rates in many countries.

Corresponding comments apply to older drivers. Research should focus on discovering more specifically why crash risk increases with age and then on formulating specific countermeasures. However, it is unrealistic to expect rates for older drivers to become identical to minimum rates. It might be a law of nature that the oldest drivers have rates well above the minimum, but it is not a law of nature that they should be 3 times the minimum. Any measure that can reduce them to, say, 2.5 times the minimum is of high importance. We already know that the mix of crashes in which older drivers are involved differs substantially from the mix for younger drivers; the older driver's crash is more likely to be multiple vehicle, especially side impact (*25*), but less likely to be a rollover, involve alcohol, or occur at night (*26*). Such differences are relevant to deciding where to focus age-specific interventions.

Many measures for improving older-driver safety may improve safety for all ages in the same proportion. Any such change, no matter how much it reduces older-driver risk, will leave the shape of all the curves displayed in this paper unchanged. Consequently, if the focus is exclusively a comparison with drivers with the minimum risk (the usual metric), the older-driver problem will remain unaltered independent of how much it really changes.

The information presented shows that the major contribution to traffic losses comes from young drivers; the younger-driver component will remain overwhelmingly the major component even after major changes in the demographic composition of the population. Minor reductions in young-driver crash risk generate much larger safety benefits in terms of increased driver longevity and reduced harm to others than do much larger reductions in older-driver crash risk. Thus, whereas there certainly are safety problems associated with driver aging, their magnitude is much less than the problems associated with younger drivers. If limited public resources are available for interventions to reduce driver risk, then the younger-driver problem appears to have a substantially stronger claim. The question of using personal resources, or resources of organizations supported by specific groups of drivers, to reduce the risks to specific groups of drivers is an entirely different matter.

This discussion, being an overview, 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 increases (*27*), underlying the importance of not judging an individual's driving ability on the basis of chronological age.

Much larger than any proportionate increase in driver risk with increasing age is the decline in distance of driving. For example, male drivers 70 and over drive, on average, 9300 km/year compared with 31 000 km/year for 35- to 39-year-old drivers; the corresponding values for female drivers are 4300 km/year and 12 600 km/year, respectively (*8*). As mental and sensory abilities decline, the dominant response is to drive less, especially under conditions of elevated risk, rather than a net increase in risk from driving. Largely because of decreased driving, driver fatality risk per year increases only moderately with increasing age, and the threat to other road users declines. The transportation aspect of the problem of aging may thus be one of reduced mobility more than one of reduced safety.

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Publication of this paper sponsored by Task Force on Safety and Mobility of Older Drivers.