ELDERLY VISION AND DRIVING: A LITERATURE REVIEW

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ABSTRACT

Purpose: Traffic fatalities in the United States totaled 42,636 in 2004. Much emphasis has been placed on visual acuity and perception, especially for older drivers. This review evaluates what factors are reliable predictors of driving ability in an older population. *Methods*: A literature review of current studies and traffic fatality statistics. *Results*: Numerous factors limit an elder driver's ability to operate a motor vehicle. However, many older drivers self regulate their driving by limiting their driving to daylight and short local drives. Current driving standards for aged drivers do not accurately assess driving ability. *Conclusions*: Due to the aging population in the United States, there is a need to develop testing that better evaluates a driver's ability to safely operate a motor vehicle. Current visual limitations on operator performance do not properly address this situation, and may limit drivers that could safely operate a motor vehicle. Many drivers with visual acuity worse than 20/40 are able to safely maintain vehicle control and can be safe, responsible drivers.

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Background and Statistics

According to the most recent comprehensive data available, a total of 42,636 people lost their lives in motor vehicle crashes in 2004, and another 2.8 million people were injured in the United States alone. On average, a police-reported motor vehicle crash occurred every 5 seconds, a person was injured every 11 seconds, and someone was killed every 12 minutes.[1] Alcohol was involved in 39 percent of fatal traffic accidents in 2004.[1]

There are over 26 million people age 70 and older in the United States, and 19.8 million were licensed to drive in 2003(latest data available).[2] This represents a 27-percent increase since 1993. This number is expected to increase with our aging population: from 1994 to 2004, the growth rate for this older segment of the population was 4 percent higher than the growth rate of the total population. Drivers 65 and older are expected to be one fifth of all drivers by 2030.[2] In contrast, the total number of licensed drivers increased by only 13 percent from 1993 to 2003. Older drivers made up 10 percent of all licensed drivers in 2003.[2]

To put elder driving in perspective, during 2004 there were 141,000 older individuals injured in traffic crashes out of 2.8 million total injuries. This accounts for only 5 percent of all the people injured in traffic crashes during the year. These older individuals made up 12 percent of all traffic fatalities, 11 percent of all vehicle occupant fatalities, and 16 percent of all pedestrian fatalities.[3] Most traffic fatalities involving older drivers in 2004 occurred during the daytime (81%), on weekdays (72%), and involved another vehicle (74%).[4]

In many ways, elder drivers are safer than their younger counterparts. The percentage of older drivers involved in fatal crashes in 2004 who had BAC levels of .08 g/dL or higher (5%) was lower than for any other group of adult drivers.[3] In two-vehicle fatal crashes involving an older driver and a younger driver, the vehicle driven by the older person was twice as likely to be the one that was struck (64% and 29%, respectively). In 44 percent of these crashes, both vehicles were proceeding straight at the time of the collision. In 27 percent, the older driver was turning left — 7 times more often than the younger driver.[3] Many older drivers are aware of this left turning risk, and will drive around the block and use a traffic light to turn left. Older drivers are less likely to be involved in a fatal accident where speeding is determined to be the cause.[Table 1]

Speeding Drivers in Fatal Crashes by Age and Sex, 2004

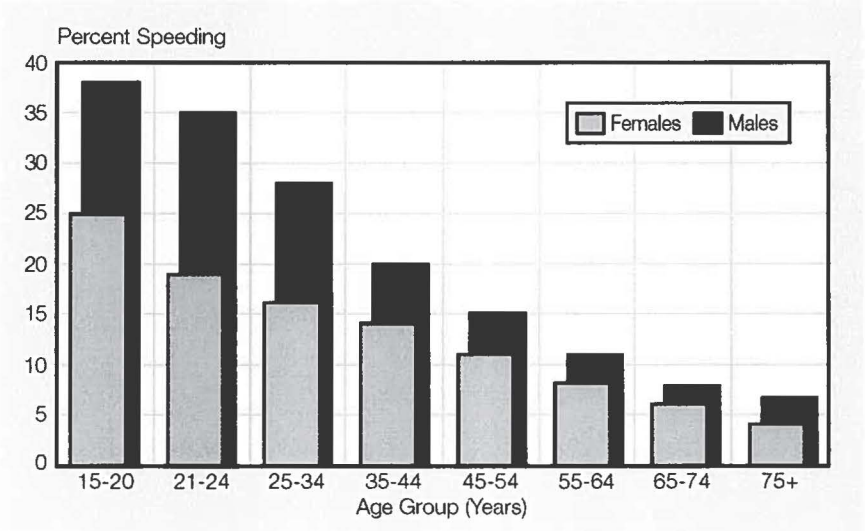


Table 1

Visual Difficulties Experienced by an Aging Population

Driving is a complex behavior that requires the utilization of a wide range of individual abilities. Identifying assessments that not only capture individual differences, but also are related to older adults' driving performance would be beneficial.

To determine what visual difficulties older adults experience while driving, a questionnaire was developed that assessed decreases in daily task performance and driving. The study group consisted of non-impaired and low-vision older adults. The majority of participants reported that they needed more time than in the past to perform tasks that require critical vision, regardless of their visual status.[5] All participants reported experiencing significant difficulties with static and dynamic acuity, peripheral vision, illumination problems, and contrast sensitivity.[5] Both non-impaired and low-vision older adult drivers reported experiencing difficulty with glare, peripheral vision, and night driving. Low-vision drivers reported experiencing unique difficulties with near acuity, distant acuity, and physical obstructions.[5]

A separate study tested several of these parameters. A large battery of vision functions, including spatial vision measures, glare tests, visual fields, stereopsis, color vision, temporal sensitivity, reading performance, and face recognition, was administered to a population of 900 community-living older observers (mean age, 75.5 years). A subsample (N = 596) was retested on average 4.4 years later. Each vision function was affected differentially by aging. Some functions show little change with age (e.g., standard clinically measured high contrast visual acuity), whereas others demonstrate drastic losses with increasing age.[6] For the oldest age group (>90 years), vision function losses

ranged from 1.2 times worse than young observers (critical flicker/fusion frequency) to 18 times worse than young observers (low contrast acuity in glare). Visual performance measures, such as reading or face recognition, are also significantly affected by aging even in those with intact visual acuity. The results demonstrate that low contrast vision functions can successfully predict subsequent loss of high contrast visual acuity.[6]

Impact of Increased Task Load

Multitasking has also been shown to have significant detrimental impact on driving performance.[7] Cognitive aging was shown to be the best predictor of the declines seen in driving performance under dual task conditions. Drivers reported significantly fewer signs, hit more road hazards, misjudged more gaps, and increased their time to complete the course under dual task (visual and auditory) conditions compared with single task condition.[7] Older participants also reported significantly fewer road signs and drove significantly more slowly than the younger participants, and this was exacerbated for the visual dual task condition. The results of the regression analysis revealed that cognitive aging (measured by the DSS and Trails test) rather than chronologic age was a better predictor of the declines seen in driving performance under dual task conditions. An overall z-score was calculated, which took into account both driving and the secondary task (summing) performance under the two dual task conditions. Performance was significantly worse for the auditory dual task compared with the visual dual task, and the older participants performed significantly worse than the young subjects. These results have implications for use of mobile phones or in-vehicle navigational devices while driving, especially for older adults.[7]

Impact of Luminance on Driver Recognition

All drivers exhibit decreased performance under low light conditions, and this impairment was greater for the older participants. These changes in drivers' recognition performance were more strongly predicted by contrast sensitivity than visual acuity measured under standard photopic conditions.[8] Contrast sensitivity was highly correlated with visual acuity measured under low-luminance conditions. Further analysis showed that recognition performance while driving is better predicted by combinations of two tests: either 1) photopic visual acuity and photopic contrast sensitivity, or 2) photopic and mesopic visual acuity.[8] These findings confirm that visibility is seriously degraded during night driving and that the problem is greater for older drivers. These changes in real-world recognition performance were better predicted by a standard test of contrast sensitivity than by visual acuity. Still better predictions can be obtained by the use of two vision tests together.[8]

Factors Associated with Decreased Driving

The are two main types of visual function loss that lead to driving cessation, shown by the Salisbury Eye Evaluation project, a cohort study of 2520 older adults followed for 8 years.[9,10] Data from this study shows that older adults with worse scores in multiple measures of vision are more likely to stop driving and that contrast sensitivity and visual fields are most associated with driving cessation. Older drivers with worse visual function were more likely to modify their driving by reducing mileage and avoiding high-

risk driving situations. The types of driving modification depended upon the type of visual function loss experienced. [9,10,11]

Visual Fields

A German study recognizes the fact that acuity and fields are important to driving safety, but does not study the actual risk.[12] Impaired visual processing caused by glaucoma may play a role in the etiology of car accidents involving older drivers. This study only addressed whether or not the glaucoma patients met the driving standards for Germany and Austria. 80 patients with overt glaucoma and 52 patients without glaucoma, all holders of a valid driving license, were enrolled. For each patient, the best corrected visual acuity was recorded and an examination of the central visual field was performed with automatic perimetry. In addition, a detailed questionnaire about the current driving habits of the patient was requested. 29 patients of 80 glaucoma patients were driving a motor vehicle with binocular congruent scotomas within the central 30 degrees visual field, which is not sufficient to meet the current legal requirements in Austria. In addition, 3 out of 29 impaired patients had a visual acuity that was below the mandatory legal requirements. A total of 39 glaucoma patients fulfilled legal requirements, showing only monocular or binocular central visual field defects that were not congruent. 12 patients with a valid driving license had already discontinued driving.[12]

Cognition

A French study also identifies impairment of cognitive performance to be associated with an excess accident risk.[13] Alterations in visual field and acuity increased the risk of traffic accidents. Drugs affecting vigilance and neurological, cardiovascular and osteoarticular disorders also increase accident risk. Cessation of driving or at least not driving alone limits the excess accident risk for drivers with dementia. Additionally, adjusting driving behavior in subjects with benign cognitive disorders also reduces accident risk. This study suggests that screening for these disorders in the elderly is a necessary public safety measure.[13]

Self-Regulating Ability

In evaluating gender differences in the relationship between night driving self-restriction and vision function in an older population, night driving self-restriction patterns (assessed by questionnaire) were examined cross-sectionally in relation to age, gender, health and cognitive status, depression, and vision function in a sample of 900 participants with an average age of 76 years. Among current drivers, women had slightly better visual function than men on most measures (low-contrast acuity, contrast sensitivity, low-contrast acuity in glare, low-contrast, low-luminance acuity, and glare recovery) but were twice as likely as men to restrict their driving to daytime.[14] Men showed significant associations with avoidance of night driving on four spatial vision measures (high- and low-contrast acuity, low-contrast, low-luminance acuity, and contrast sensitivity). For women, in addition to these measures, a significant association was seen for low-contrast acuity in glare. Neither men nor women showed significant associations between driving restriction and performance on the other vision measures examined (glare recovery time,

attentional field integrity, or stereopsis). The vision measures most predictive of self-restriction were contrast sensitivity for men and low-contrast acuity in glare for women.[14] Including both cessation and self-restriction, men over age 85 years are 6.6 times more likely than women to be driving at night. Men's night-driving cessation was associated with contrast sensitivity and depression, whereas women's night-driving cessation was associated with low-contrast acuity in glare as well as age.[14]

To explore whether elderly drivers of varying driving skill levels (1) differ in their perception of their driving evaluation performance and (2) determine if self-rated driving evaluation performance is related to cognitive ability, drivers 65 years or older where tested with a driving evaluation.[15] Sixty-five percent of drivers rated themselves as performing better on a driving test than others of their age. Another 31.9% felt they would perform the same as others of their age on a driving test. The data revealed that a full 50.0% of those considering themselves "a little better" and 52.9% of those considering themselves "a lot better" had unsafe driving performance.[15] It is significant that as self-rated driving evaluation performance increased, there was a significantly increased risk of unsafe driving ($p=0.02$) in the study population. Drivers who considered themselves at least a little better than others of their age were over four times more likely to be unsafe drivers compared to others who believed they were comparable to or worse than other drivers of their age. Older drivers assign high ratings to their driving performance, even in the presence of suspected skill decline. Cognitive ability was not related to self-rated driving evaluation performance, based on the MMSE.[15] This

demonstrates that although most older drivers will self-limit their driving, many do not recognize the amount of impairment they posses, and overestimate their abilities.

Steering Performance Variables

Two experiments explored the extent to which induced blur, reduced luminance, and reduced visual fields affect drivers' steering performance in a driving simulator. These studies were not performed on the elderly, and would be worth reproducing in the older population. The point is that visual acuity does not seem to affect the ability to steer a vehicle. In the first experiment, ten young participants (M = 21.2 years) drove at approximately 55 mph along a curvy roadway while being exposed to blur (0 to + 10 D), luminance (0.003 to 16.7 cd/m), and visual field (1.7 and 150 degrees) manipulations.[16] In the second experiment, a new group of ten young participants (M = 18.5 years) drove while exposed to seven visual field sizes (1.7 to 150 degrees).[16] Steering was shown to be sensitive to a reduced field size but not to the blur and luminance challenges. Acuity, on the other hand, was sensitive to the blur and luminance challenges but not to reduced field size. In normal young drivers, steering performance is remarkably robust to severe blur and to extremely low luminances.[16] These results support a key element of the selective degradation hypothesis advanced by Leibowitz and colleagues--that steering abilities are preserved at night even when the ability to recognize objects and hazards is not. Additional research should address the other element of this selective degradation hypothesis - that drivers fail to appreciate the extent to which their visual abilities are degraded at night.[16] This has also been suggested by other studies of older drivers.[15]

Useful Field of View

Deficits in Useful Field of View (UFOV) performance and poorer contrast sensitivity scores are also significantly correlated with overall driving performance as well as specific maneuver/skill combinations. In a small sample of drivers, mild to moderate peripheral visual field restrictions were adversely associated with specific driving skills involved in maneuvers for which a wide field of vision is likely to be important, even though most had good driving records.[17] Further studies using similar assessment methods of drivers with more restricted fields are necessary to determine the minimum field extent considered safe for driving.[17]

Another UFOV assessment study including objective measures of retrospective or concurrent driving performance included state-recorded accidents, on-road driving, and driving simulator performance.[18] This convergence of evidence across numerous studies using different methodologies confirms the importance of the UFOV assessment as a valid and reliable index of driving performance and safety. Recent prospective studies have confirmed a relationship between UFOV performance and future crashes, further supporting the use of this instrument as a potential screening measure for at-risk older drivers.[18]

Per mile traveled

The widespread claim that older drivers are overly involved in crashes has apparent support from crash data, especially when distance traveled is used as the exposure measure. However, independent of age, drivers traveling more miles will typically have

lower crash rates per mile than those driving less miles.[19] Dutch travel survey data from a large sample of respondents attempted to confirm previous research findings concerning the association between annual mileages driven and crash involvement. When the crash rates of drivers of different ages were compared after being matched for yearly driving distance, most drivers aged 75 years and above were indicatively safer than all other drivers. Only older drivers traveling less than 3000km per year (just over 10% of all older drivers in the survey) gave any indication of elevated crash rates.[19]

What Factors Reduce Fatality Rates

After teenage males, elderly individuals have the highest per capita motor vehicle fatality rate in the United States.[4] There has been only limited work examining the effect of state motor vehicle laws on older driver fatalities. State-level data from the 1985-2000 Fatality Analysis Reporting System was evaluated to examine the effects of changes in state laws dealing with license renewal, seatbelt use, speed limits, and driving while intoxicated on fatalities among drivers and others aged 65 and over. Negative binomial regressions were estimated using alternatively state and year fixed effects, or age and year fixed effects. In-person license renewal reduced fatalities among the oldest drivers, but vision tests, road tests and the length of the license renewal cycle generally did not.[20] In terms of policies that apply to all drivers, seatbelt laws, particularly with primary enforcement, were generally the only policies that reduced older driver fatalities. These results are noteworthy because a number of policies that have been effective towards increasing younger driver safety are not relevant for older drivers, implying that policymakers must think broadly about using state laws to improve older driver safety.[20]

A retrospective longitudinal study conducted January 1990 through December 2000 of all fatal crashes in the United States evaluated which state driver's license renewal policies are associated with the fatality rate among elderly drivers. These crashes were identified in the Fatality Analysis Reporting System, which involved either an older (ages 65-74 years, 75-84 years, and greater than 85 years) or middle-aged (ages 25-64 years) driver.[21] Two regression approaches were used to study the effect of state laws mandating in-person renewal, vision tests, road tests, and frequency of license renewal on driver fatalities, controlling for state-level factors including the number of licensed elderly drivers, primary and secondary seatbelt laws, maximum speed limit laws, blood alcohol level of 0.08, and administrative license revocation drinking and driving laws, per capita income, and unemployment rate. The first regression approach examined only elderly driver fatalities and the second approach examined daytime elderly driver fatalities and used daytime fatalities among middle-aged drivers as a general control for unobserved variation across states and over time. Among individuals aged 85 years or older, there were a total of 4605 driver fatalities and 4179 daytime driver fatalities during the study period. For this age cohort, after controlling for middle-aged daytime driver deaths, states with in-person license renewal were associated with a lower driver fatality rate with a 95% confidence interval. This was the only policy related to older drivers that was significantly associated with a lower fatality risk across both regression models. Thus, state-mandated vision tests, road tests, more frequent license renewal, and in-person renewal (for individuals aged 65-74 years and 75-84 years) were not found to be independently associated with the fatality rate among older drivers in the two models.[21]

Conclusion

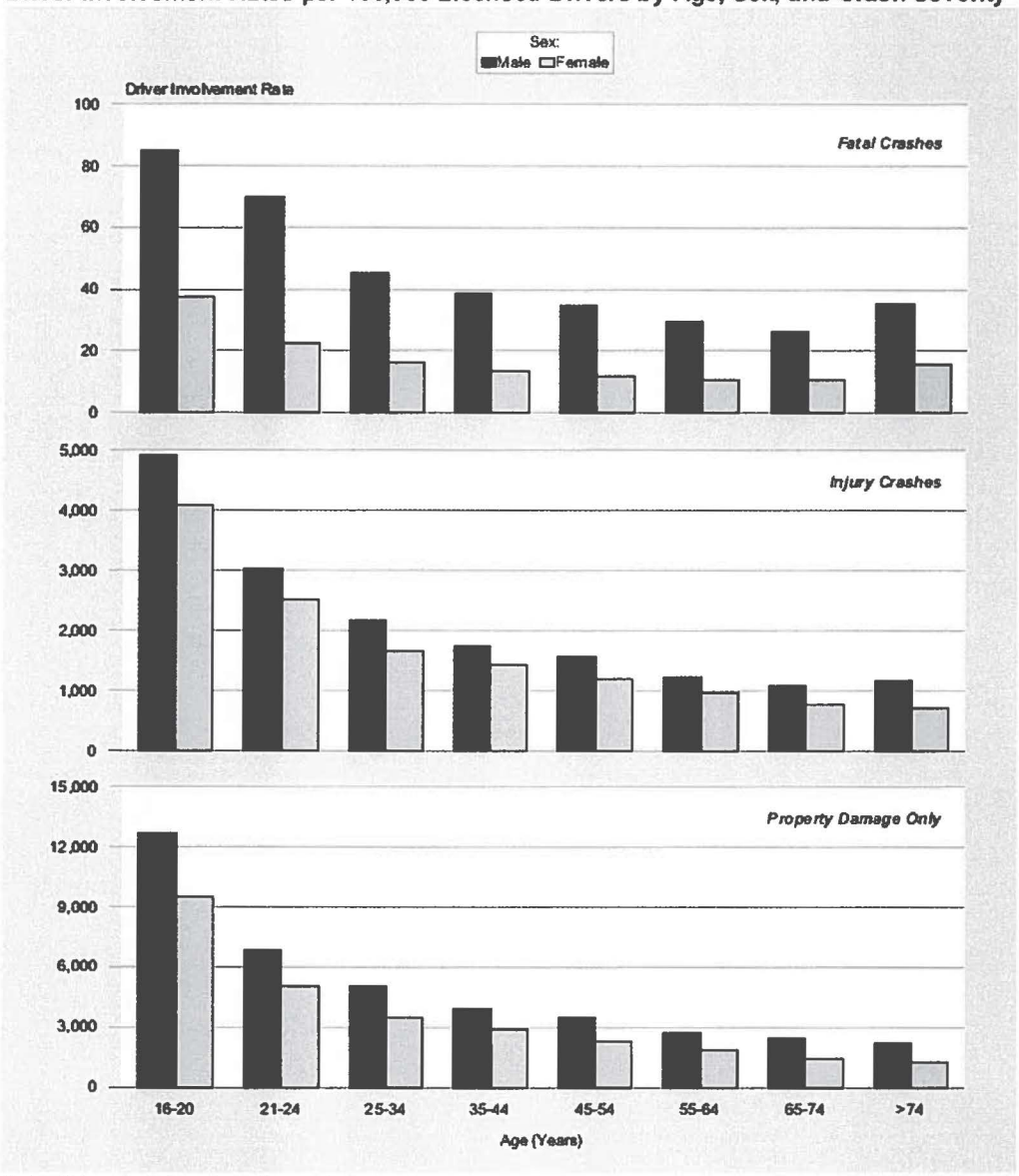
Nonstandard vision function measures show significant losses with age that cannot be predicted by standard clinical measures, and measures of low contrast vision function allow clinicians to identify and monitor those patients at high risk for future vision loss.[5,6,8,12-14] In-person license renewal was related to a significantly lower fatality rate among the oldest old drivers, and more stringent state licensure policies such as vision tests, road tests, and more frequent license renewal cycles were not independently associated with additional benefits.[21] Cognitive, rather than visual acuity decreases are an important factor in driving ability.[7,13]

Recently there has been much negative press coverage about older drivers and the dangers they pose on the road. Although deficits exist in visual function and cognitive ability, the 55 and older driver is still safer than any other age group per 100,000 licensed drivers. Table 2 next page

Elder drivers make an easy target, but the older driver is not the greatest threat on the road. Operating a vehicle under the influence of alcohol remains the greatest threat to road safety, and is still involved in nearly 40 percent of traffic accidents.

State lawmakers should consider non-standard vision testing such as contrast sensitivity and UFOV for driver's license renewal and in person renewal for drivers over 80 years old.

Driver Involvement Rates per 100,000 Licensed Drivers by Age, Sex, and Crash Severity



Notes: Drivers include motorcycle operators.

Table 2

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