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Associations between Visual, Hearing, and Dual Sensory Impairments and History of Motor Vehicle Collision Involvement by Older Drivers

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Abstract

Objectives—To examine the association between visual and hearing impairment and motor vehicle collision (MVC) involvement in older drivers.

Design—Retrospective cohort study.

Setting—North central Alabama

Participants—Population-based sample of 2,000 licensed-drivers, age 70 and older.

Measurements—Visual acuity was measured using the Electronic Visual Acuity test. Contrast sensitivity was measured using the Pelli-Robson chart. Presence of subjective hearing loss and other health conditions were determined using a general health questionnaire. Information regarding MVCs for all participants spanning the five years prior to study enrollment was obtained from the Alabama Department of Public Safety.

Results—Following adjustment for age, race, gender, number of miles driven, number of medical conditions, general cognitive status, and visual processing speed, older drivers having both visual acuity and hearing impairment (rate ratio RR 1.52, 95% confidence interval CI 1.01–2.30), contrast sensitivity impairment alone (RR 1.42, 95% CI 1.00–2.02), and both contrast sensitivity and hearing impairment (RR 2.41, 95% CI 1.62–3.57) had elevated MVC rates, compared to drivers with no visual or hearing impairments. Drivers with visual acuity loss alone or hearing loss alone did not have significantly different MVC rates when compared to the no impairment group after adjustment for multiple variables.

Conclusion—Older drivers with dual sensory impairment are at greater MVC risk than those with only a visual acuity or a hearing deficit alone. A combined screening approach of screening

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for both hearing impairment and visual impairment may be a useful tool to identify older drivers at risk for MVC involvement.

Keywords

driver safety; dual sensory impairment; vision impairment; hearing impairment

INTRODUCTION

For older adults, driving helps to maintain independence and quality of life.[1] However, older drivers have a higher risk of motor vehicle collision (MVC) related death compared to other age groups.[2] With the number of drivers ≥ 75 expected to increase 70% over the next 20 years, older driver safety is a public safety concern.[3] Developing sound methods to identify those at-risk older drivers remains a topic of great interest among clinicians and researchers alike.

Driving is a highly visual and cognitive task, there by most research on older driver safety has focused on visual function and cognition.[4] The specific visual and cognitive requirements for safe driving are yet to be clearly elucidated. Studies demonstrate only a weak correlation between visual acuity and driving safety.[5] Visual field loss is associated with elevated MVC rates but only when severe.[6,7] Deficits in contrast sensitivity are related to increased crash rate among drivers.[8,9] Both visual field and contrast sensitivity deficits influence the decision to self-restrict or quit driving by older drivers.[10,11]

While vision may provide much of the sensory input needed to drive safely, hearing is also relevant. It provides information about approaching vehicles, emergency vehicles, obstacles, and mechanical problems in the vehicle. With the exception of a few studies on older driver safety and hearing impairment, there is a paucity of research in this area. Ivers et al.[12] found that hearing loss in the right ear and visual acuity deficits in the right eye were associated with increased crash rate in drivers >49; however crash data were based on participants' self-reports, which are notoriously unreliable.[5] Gallo et al.[13] reported that hearing impairment was associated with self-reported "adverse" driving events in the past two years (defined as traffic tickets or MVCs). Other recent studies, however, have not demonstrated a correlation between hearing loss and driver safety,[14,15] although McCloskey et al.[14] reported that drivers wearing hearing aids were twice as likely to be involved in an injurious MVC than those without a hearing aid. Hickson et al.[16] found that older drivers with poor hearing had impaired driving performance in the presence of distracting events, compared to those with normal hearing or mild hearing impairment.

Dual visual and auditory impairment is relatively common in older adults, with estimates of 9–17%.[17,18] Dual sensory deficits in the elderly are associated with increased levels of social isolation,[17] functional impairment,[19,20] and mortality,[21] when compared to those with no or a single deficit. The purpose here is to examine whether older drivers with dual visual and auditory sensory impairment have a recent history of higher MVC rates compared to those with neither sensory impairment and those with a single sensory impairment.

METHODS

Subjects

This study involves a population-based sample of older drivers (N = 2,000) in an ongoing study on older driver safety at the University of Alabama at Birmingham (UAB).[22] Recruitment procedures, detailed previously,[22] are summarized here. The source population for the sample was adults aged ≥ 70 years old residing in or around Jefferson County.

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Potential participants were randomly identified from contact information available through a list of persons obtained from a direct marketing company (Pinpoint Technologies, Tustin CA). We confirmed driver's license status through the Alabama Department of Public Safety (AL DPS), and eliminated those who did not hold Alabama licenses. Potential participants were mailed a letter describing the study, which was followed by a telephone call from the coordinator, at which time eligibility of the individual was determined. Inclusion criteria were: (1) ≥ age 70, (2) held a current Alabama driver's license, (3) had driven within the last 3 months, (4) did not reside in a nursing home or other institution where driving opportunity was controlled, and (5) spoke English. Eligible individuals agreeing to participate were scheduled for an appointment at UAB. For those who declined to participate, basic demographic information (age, race/ethnicity, gender) and driving status were obtained. The study protocol was approved by UAB's Institutional Review Board. Each study participant signed a document of informed consent. All examiners were unaware of the crash histories of participants.

Procedures

Basic demographic information (age, gender, race) was obtained through interview. Each participant answered a general health questionnaire, which contained the question, "Has a doctor ever told you that you have hearing impairment?" The general health questionnaire also contained 16 other questions about chronic medical conditions (e.g. diabetes, heart disease, cancer), because many have been associated with crash involvement in elderly drivers and are potential confounders.[15]

For those participants who could identify an eye care provider and signed a medical release form, medical records from their most recent eye examination were obtained. These records provided information on the presence of common eye conditions (e.g. cataract, glaucoma, age-related macular degeneration (AMD)). These conditions were included in the study because they can cause impairments in visual acuity and contrast sensitivity.

Participants also underwent visual function assessment -- visual acuity and contrast sensitivity testing that was performed under binocular viewing, since driving is a binocular task. During testing participants wore the refractive corrections they typically used while driving. Visual acuity was measured using the Electronic Visual Acuity test[23] with scores expressed as Snellen fractions (e.g., 20/30) and converted to logarithm of minimum angle resolvable (log MAR) for analysis purposes. Contrast sensitivity was measured using the Pelli-Robson chart, [24] scored by the letter-by-letter method, and expressed as log contrast sensitivity.

We administered cognitive screening tests since they have been associated with MVC involvement in older drivers, [25,26] and thus would be used to adjust associations between visual, hearing, and dual impairment and MVC involvement. Visual processing speed while dividing attention was assessed using Trails B, a paper and pencil test, that also relies on executive control and working memory.[25] The ability to visualize missing information when only part of an object is directly visible was examined by the Visual Closure Subtest of the Motor Free Visual Perception Test.[25] The Mini-Mental State Examination (MMSE)[26] assessed general cognitive status.

Accident reports for the five years prior to participant enrollment were provided by the AL DPS (agency maintaining these records). These provided information about the number of MVCs incurred where the participant was the driver, and whether or not the participant was deemed at fault by the police officer who came to the scene. This information was used with self-reported driving exposure information (miles driven per week), obtained through the

Driving Habits Questionnaire,[27] to calculate the crash rate per million miles driven for each group in the study.

Statistical Analysis

Participants were stratified into four groups: (1) neither visual nor hearing impairment (no sensory impairment), (2) hearing impairment only, (3) visual impairment only, or (4) both visual and hearing impairment (dual sensory impairment). Vision impairment was defined as visual acuity worse than 20/40; a separate analysis was also conducted where visual impairment was defined as contrast sensitivity <1.5. These cut-points were chosen because many state re-licensure standards require a minimum visual acuity of 20/40, and because a contrast sensitivity of less than 1.5 can be considered abnormal for adults age 50 and older. Descriptive statistics were created for demographic and medical characteristics and compared between the groups using t and X^2 tests for continuous and categorical variables, respectively. Poisson regression was used to calculate rate ratios (RRs) and associated 95% confidence intervals (CIs) both overall and for at-fault MVCs. P-values ≤0.05 (two-sided) were considered statistically significant.

RESULTS

Table 1 presents relationships between demographic and medical characteristics among those with hearing impairment, vision impairment as defined by visual acuity, both types of impairment, or neither type of impairment. With increasing age participants were more likely to have sensory impairment -- hearing loss, visual acuity loss, or both. Hearing loss was more common in male and white participants, both as a single impairment or in addition to visual acuity loss, while female and African American participants were more likely to have visual acuity loss alone. Participants with hearing loss had on average more chronic medical conditions than those without hearing loss. Participants with visual acuity loss alone or in addition to hearing loss were more likely to have diabetic retinopathy or diabetic macular edema. There were no differences in the prevalence of single or dual sensory impairments among the groups for cataract, glaucoma, AMD, or intraocular lens placement.

Table 2 presents the distribution of demographic and medical characteristics according to vision impairment as defined by contrast sensitivity and hearing impairment. Similar to Table 1, increasing age was associated with more impairment. Men and white participants were more likely to have hearing impairment only or hearing impairment combined with contrast sensitivity loss, while female and African American participants were more likely to have contrast sensitivity deficits alone. Participants with hearing loss had more chronic medical conditions. Those with contrast sensitivity loss were more likely to have glaucoma and diabetic retinopathy or diabetic macular edema. Those with contrast sensitivity loss only or combined with hearing deficits were more likely to have AMD or unilateral or bilateral intraocular lenses than participants with no impairment or hearing impairment only. Those with dual impairment had the highest rates of AMD and intraocular lenses. There was no significant difference in the frequency of cataract between the no impairment group and the three impairment groups.

Table 3 shows MVC rates for the various groups. When vision impairment is defined in terms of visual acuity, for total MVCs, drivers with acuity loss alone and drivers with hearing loss alone had unadjusted MVC rates similar to drivers with neither type of impairment. Even after adjustment, these rates remained similar. Drivers with dual sensory impairment had a higher unadjusted total MVC rate compared to drivers with no sensory impairment but this association did not reach statistical significance. Once adjusted for multiple factors however, those with dual sensory impairment had an increased rate of total MVCs as compared to those with no impairments (RR 1.52, 95%CI 1.01–2.30).

For at-fault MVCs when vision impairment is defined by visual acuity, those drivers with hearing impairment alone had a significantly lower unadjusted rate for at-fault MVCs compared to those with no impairment (RR 0.71, 95%CI 0.54–0.93). Those with dual sensory impairment had a significantly higher unadjusted rate for at-fault MVCs as compared to drivers with no impairment (RR 1.71 95%CI 1.00–2.95). However, neither of these associations remained significant after adjustment.

When vision impairment is defined using contrast sensitivity, a similar yet more robust pattern of MVC associations emerge. For total MVCs, drivers with hearing impairment alone had a lower unadjusted total MVC rate than did those with no impairments (RR 0.83 95%CI 0.70–0.99). This association was non-significant after adjustment for multiple variables (RR 1.03, 95%CI 0.86–124). Drivers with contrast sensitivity impairment alone and those with dual impairment had significant higher rates of total MVCs compared to those with no impairments. These associations remained after adjustment for multiple variables (contrast sensitivity impairment alone: RR 1.42, 95%CI 1.00–2.02; dual sensory impairment RR 2.41, 95%CI 1.62–3.57).

For at-fault MVCs when vision impairment is defined by contrast sensitivity, drivers with hearing impairment alone had a reduced unadjusted rate of at-fault MVCs compared to drivers with no impairments (RR 0.73, 95%CI 0.56–0.95). After adjustment for other variables, the association was no longer significant. Drivers with contrast sensitivity impairment alone had a significantly higher unadjusted rate of at-fault MVCs (RR 1.66, 95%CI 1.02–2.68); their elevated rate ratio was only slightly lower after adjustment (RR 1.54, 95%CI 0.93–2.49) but was no longer significant. Drivers with dual sensory impairment had a significantly higher unadjusted at-fault MCV rate, an association that was maintained after adjustment (RR 2.06, 95%CI 1.13–3.76).

DISCUSSION

Older drivers having both vision and hearing impairment have higher MVC rates in the prior five years compared to drivers with neither type of impairment. This holds true regardless of whether vision impairment is defined in terms of visual acuity or contrast sensitivity deficits. Drivers with acuity and hearing deficits were nearly 1.5 times more likely to have been involved in a MVC in the past five years, whereas those with contrast sensitivity and hearing loss were more than twice as likely to have been involved in a MVC and to have an at-fault MVC, after adjusting for demographics and cognitive ability. These results are consistent with earlier studies reporting that older individuals with dual sensory impairment are at higher risk for greater health and social disparities,[17] poorer functional status,[19,20] and increased mortality[21] than those with no impairment or hearing impairment or visual deficits alone. However, there are no previous reports on dual hearing and visual impairment and its negative impact on older driver safety.

Our results also indicate that there is an association between contrast sensitivity impairment alone and a recent history of MVC. This finding reinforces those of previous studies.[8,9] Low contrast visibility situations are common during driving (inclement weather, dusk, dirty windshield). Older drivers with visual deficits tend to avoid challenging driving situations, many of which are low-contrast conditions.[10] However, despite this apparent self-regulation and avoidance of low contrast conditions, older drivers with contrast sensitivity impairment apparently remain at increased risk of MVC.

Visual acuity impairment alone did not place older drivers at increased risk of MVC. This is not surprising since studies have shown no or minimal associations between acuity deficits and MVC rates in the elderly. [5] Some older drivers with acuity impairment engage in self-regulation, avoiding risky driving situations or quit driving.[10,11] It is possible that acuity rescreening at license renewal removes drivers with significant visual acuity impairment from the roads.[28]

There was no significant elevation in adjusted MVC rates in older drivers with hearing loss alone. The extent or type of hearing loss, not addressed in this study, may be more relevant for older driver safety. A single sensory deficit in either acuity or hearing in older drivers does not appear to be sufficient to elevate MVC risk. Perhaps older drivers with only one sensory deficit compensate for their loss using another sensory modality. An older driver with only hearing loss may learn to rely more on visual cues while driving, whereas the visually impaired driver may do the opposite. These are hypotheses for further study.

Study strengths and limitations should be considered. A strength is that when assessing MVC associations with vision and hearing, the study design included measurements of and control for other factors known to affect MVC risk in older drivers such as driving exposure, cognitive functioning, and general health. Another strength is that MVC outcome was determined by state records and not through self-report. Limitations include using self-reported hearing impairment, although there is strong evidence that it is a valid estimate of the presence of hearing problems in older adults.[29,30] The use of retrospective MVC records is a limitation for understanding crash risk since vision, hearing, and the other exposure variables were assessed at the end of the MVC surveillance period. On going work is following this cohort prospectively to look at associations with future MVCs and to identify which screening tests are most effective in identifying older drivers at high-risk for future MVC involvement.

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Table 1

Baseline Demographic and Medical Characteristics Stratified by Age and Presence of Single or Dual Sensory Impairment, where Visual Impairment is defined by Visual Acuity Impairment

Characteristic	Neither Impairment (n=1248)	Hearing Impairment Only (n=589)	Visual Acuity Impairment Only (n=100)	Both Impairments (n=61)	*P* value
Demographics					
Age, No. (%)					
70–79	953 (76.4)	382 (64.9)	61 (61.0)	36 (59.0)	
80–89	279 (22.4)	195 (33.1)	33 (33.0)	19 (31.2)	<.001
90–99	16 (1.3)	12 (2.0)	6 (6.0)	6 (9.8)	
Sex, No. (%)					
Male	618 (49.5)	426 (72.3)	44 (44.0)	40 (65.6)	<.001
Female	630 (50.5)	163 (27.7)	56 (56.0)	21 (34.4)	
Race, No. (%)					
White	969 (77.6)	545 (92.5)	70 (70.0)	55 (90.2)	
African American	274 (22.0)	42 (7.1)	29 (29.0)	5 (8.2)	<.001
Other	5 (.4)	2 (.3)	1 (1.0)	1 (1.6)	
Medical Conditions					
Chronic medical conditions, mean (SD)	3.2 (1.8)	3.9 (1.9)	3.3 (1.8)	3.7 (2.0)	<.001
Eye conditions, No. (%)					
Cataract	673 (56.7)	313 (55.4)	56 (61.5)	30 (55.6)	.74
Glaucoma	238 (20.0)	87 (15.4)	16 (17.6)	6 (11.1)	.06
DR or DME	38 (3.2)	13 (2.3)	10 (11.0)	3 (5.6)	<.001
Age-related macular degeneration	196 (16.5)	112 (19.8)	20 (22.0)	15 (27.8)	.06
Intraocular lens	546 (46.0)	275 (48.7)	39 (42.9)	29 (53.7)	.43

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Table 2

Baseline Demographic and Medical Characteristics Stratified by Age and Presence of Single or Dual Sensory Impairment, where Visual Impairment is defined by Contrast Sensitivity Impairment

Characteristic	Neither Impairment (n=1262)	Hearing Impairment Only (n=605)	Contrast Sensitivity Impairment Only (n=88)	Both Impairments (n=45)	*P* value
Demographics					
Age, No. (%)					
70–79	965 (76.5)	395 (65.3)	50 (56.8)	23 (51.1)	
80–89	283 (22.4)	197 (32.6)	30 (34.1)	17 (37.8)	<.001
90–99	14 (1.1)	13 (2.15)	8 (9.1)	5 (11.1)	
Sex, No. (%)					
Male	608 (48.2)	432 (71.4)	56 (63.6)	34 (75.6)	<.001
Female	654 (51.8)	173 (28.6)	32 (36.4)	11 (24.4)	
Race, No. (%)					
White	977 (77.4)	561 (92.7)	63 (71.6)	39 (86.7)	
African American	279 (22.1)	41 (6.8)	25 (28.4)	6 (13.3)	<.001
Other	6 (.5)	3 (.5)	0 (0)	0 (0)	
Medical Conditions					
Chronic medical conditions, mean (SD)	3.2 (1.7)	3.8 (1.9)	3.8 (1.9)	4.1 (2.1)	<.001
Eye conditions, No. (%)					
Cataract	686 (57.4)	324 (56.4)	44 (52.4)	19 (43.2)	.25
Glaucoma	224 (18.7)	85 (14.8)	30 (35.7)	8 (18.2)	<.001
DR or DME	39 (3.3)	14 (2.4)	9 (10.7)	2 (4.6)	.001
Age-related macular degeneration	193 (16.1)	110 (19.1)	23 (27.4)	17 (38.6)	<.001
Intraocular lens	537 (44.9)	276 (48.0)	48 (57.1)	28 (63.6)	.01

Table 3

Motor Vehicle Collisions and Motor Vehicle Collision Rates According to Hearing Impairment and Vision Impairment

	Neither Impairment (n=1248)	Hearing Impairment Only (n=589)	Vision Impairment Only (n=100)	Both Impairments (n=61)
For Vision Impairment Defined by Acuity				
Total Motor Vehicle Collisions				
Number	434	186	35	25
Rate per 1,000,000 person-miles	5.6	4.8	6.4	8.1
Rate Ratio (95% Confidence Interval)				
Unadjusted	---	0.85 (0.71–1.01)	1.13 (0.80–1.76)	1.43 (0.96–2.14)
Adjusted†	---	1.05 (0.87–1.26)	1.04 (0.74–1.48)	1.52 (1.01–2.30)
At-Fault Motor Vehicle Collisions				
Number	203	73	18	14
Rate per 1,000,000 person-miles	2.6	1.9	3.3	4.5
Rate Ratio (95% Confidence Interval)				
Unadjusted	---	0.71 (0.54–0.93)	1.25 (0.77–2.02)	1.71 (1.00–2.95)
Adjusted†	---	0.91 (0.69–1.21)	1.08 (0.66–1.76)	1.69 (0.97–2.93)
For Vision Impairment Defined by Contrast Sensitivity				
Total Motor Vehicle Collisions				
Number	435	183	35	28
Rate per 1,000,000 person-miles	5.5	4.6	8.3	11.7
Rate Ratio (95% Confidence Interval)				
Unadjusted	---	0.83 (0.70–0.99)	1.50 (1.06–2.12)	2.12 (1.45–3.11)
Adjusted†	---	1.03 (0.86–1.24)	1.42 (1.00–2.02)	2.41 (1.62–3.57)
At-Fault Motor Vehicle Collisions				
No.	203	75	18	12
Rate per 1,000,000 person-miles	2.6	1.9	4.3	5.0
Rate Ratio (95% Confidence Interval)				
Unadjusted	---	0.73 (0.56–0.95)	1.66 (1.02–2.68)	1.95 (1.09–3.48)
Adjusted†	---	0.95 (0.71–1.25)	1.52 (0.93–2.49)	2.06 (1.13–3.76)
Total Motor Vehicle Collisions				

†Adjusted for age, race, gender, # of medical conditions, MMSE, MVPT and Trails B