Visual Risk Factors for Crash Involvement in Older Drivers With Cataract

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Background: The Impact of Cataracts on Mobility project has previously demonstrated that older drivers with cataract have an elevated risk of motor vehicle collision.

Objective: To examine what types of visual impairment serve as a basis of the increased crash risk of older drivers with cataract.

Methods and Design: A cross-sectional analysis was performed on 274 older drivers with cataract and 103 older drivers free of cataract recruited through 12 eye care clinics for the purposes of the Impact of Cataracts on Mobility project, a prospective study on driving mobility in older adults with cataract. Tests measured visual acuity, contrast sensitivity, and disability glare for each eye separately using habitual distance correction. The dependent variable was involvement in at least 1 state-recorded, at-fault vehicle crash during the 5 years prior to study enrollment.

Results: Logistic regression evaluated associations (odds ratios [ORs]) between visual function and crash involvement. Better and worse eye models defined on the basis of visual acuity were developed. Associations between each type of visual function and crash involvement were adjusted for age, sex, driving exposure, cognitive status, and other types of visual function. For both the better and worse eye models, contrast sensitivity was independently associated with crash involvement, whereas visual acuity and disability glare were not. Drivers with a history of crash involvement were 8 times more likely to have a serious contrast sensitivity deficit in the worse eye (defined as a Pelli-Robson score of 1.25 or less) than those who were crash-free (OR=7.86; 95% confidence interval [CI], 1.55-39.79); this association was weaker for the better eye but still statistically significant (OR=3.78; 95% CI, 1.15-12.48). Crash-involved drivers were 6 times more likely to have severe contrast sensitivity impairment in both eyes (OR=5.78; 95% CI, 1.87-17.86) than crash-free drivers. A severe contrast sensitivity deficit in only 1 eye was still significantly associated with crash involvement (OR=2.70; 95% CI, 1.16-6.51).

Conclusion: Severe contrast sensitivity impairment due to cataract elevates at-fault crash risk among older drivers, even when present in only 1 eye.

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OLDER PEOPLE are the fastest-growing group of drivers on the road, representing a larger percentage of the driving public than ever before and driving more miles per year than previous cohorts of older adults.[1] Older drivers have a higher crash rate per mile driven compared with other age groups. For every 100000 miles driven, the crash rate of older adults is twice that of younger drivers.[1,2] Once they are involved in a crash, older drivers are more likely than younger adults to receive injuries that lead to disabling conditions or death.[3-5] Motor vehicle collision is the second most common reason for older adults' visits to emergency departments for injuries.[6] A growing body of research has indicated that the causes of crashes by older drivers are multifactorial but largely due to driver error stemming from functional impairments, including sensory, cognitive, and physical deficits.[1] Of particular concern is vision impairment because numerous studies find links between visual problems and increased crash involvement, self-reported driving difficulty, poor driving simulator performance, and poor on-road driving.[7]

Cataract is a highly prevalent condition among older persons, with almost half of adults exhibiting early cataract by age 75 years and approximately one quarter with more advanced cataract.[8,9] This condition is typically bilateral, seriously compromises visual acuity and contrast sensitivity, and increases disability glare.[10] Although effective treatments for cataract are now available through advances in surgical procedures and intraocular lens design, many adults must cope for an extended period with cataract-induced vision impairment until surgical removal. In the United States, this usually takes place when functional limitations become serious,[11] and for many patients, visual acuity has declined to 20/40 or worse by the time of surgery. The implication is that many older adults with cataract are driving with impaired vision.

Prior studies have indicated that older drivers with cataract report more driving difficulty than those without cataract,[12-14] and that they avoid visually challenging situations such as driving at night, during inclement weather, and at rush hour.[15] Furthermore, drivers with cataract are more likely to stop driving compared with those without cataract,[16] and those who do continue to drive reduce their driving exposure (miles per week).[12] Cataract surgery with intraocular lens implantation and subsequent improvement in vision is associated with decreases in reported difficulty when compared with presurgical reports.[17-19]

The Impact of Cataracts on Mobility (ICOM) project is an ongoing prospective study on the effects of cataract surgery on driving mobility in older adults.[12] We demonstrated earlier from the baseline presurgery data that older drivers with cataract have an elevated crash risk; they are 2½ times more likely to have a recent history of crash involvement than those without cataract, even after adjustments for driving exposure and comorbid medical conditions.[12] The purpose of this article is to examine what types of visual impairment mediate the increased crash risk of these drivers.

SUBJECTS AND METHODS

SAMPLE

The ICOM sample consisted of 274 older adults with cataract in 1 or both eyes and 103 older adults who did not have cataract in either eye, as described previously.[12] Those with cataract ranged in age from 55 years to 85 years (mean ± SD, 71 ± 6 years), with 46% female, 86% white and of non-Hispanic origin, and 14% African American. The noncataract subjects ranged in age from 55 years to 79 years (mean ± SD, 67 ± 6 years); 52% were female, with 84% white and 16% African American.

All subjects with cataract were required to meet the following inclusion criteria: (1) cataract in 1 or both eyes with best-corrected visual acuity of 20/40 or worse in 1 or both eyes as indicated by the medical record; (2) no previous cataract surgery in either eye; (3) a primary diagnosis of cataract in the medical record; (4) living independently in the community; and (5) legally licensed to drive and drove during the 5 years prior to enrollment. Among participants, bilateral cataracts were present in 97% of subjects according to the medical record from the most recent eye examination (within 1 month of enrollment). In the right eye, 47% had nuclear sclerotic cataract, 7% had cortical cataract, 7% had posterior subcapsular cataract, and 39% had a combination of at least 2 types. The breakdown was similar in the left eye, with 51% nuclear sclerotic, 6% cortical, 5% posterior subcapsular, and 36% combination. Seventy-five percent of subjects with cataract had no additional ocular conditions other than refractive error; 9% had early nonexudative age-related maculopathy, 8% had primary open-angle glaucoma, 3% had diabetic retinopathy, 1% had a combination of 2 of these problems, and 4% had another ocular condition. Subjects who were cataract-free had to meet the same inclusion criteria as the subjects with cataract, except that they were required to be free of cataract and to have a best-corrected visual acuity of 20/25 in each eye, according to medical record review. No cataract-free subjects had secondary eye conditions other than refractive error.

Subjects were recruited through 10 ophthalmology practices and 2 optometry clinics in Birmingham, Ala. All persons meeting the inclusion criteria were contacted by their eye care specialist through a letter describing the study, followed by a telephone call from the study coordinator. Those who agreed to participate were scheduled for an appointment at the clinical research unit in the Department of Ophthalmology, University of Alabama at Birmingham (UAB). The study protocol was approved by the Institutional Review Board for Human Use at UAB.

Information on key variables was obtained by telephone from those who chose not to participate in the ICOM project to facilitate generalizability of the findings. As described in detail previously,[12] "refusers" who had cataract were on average 3 years older, had slightly worse visual acuity, were more likely to have low driving exposure, and were less likely to have been involved in a crash in the previous 5 years compared with participants who had cataract. Refusers who were eligible for the study as noncataract subjects were more likely to have poor health than enrollees with cataract.

PROCEDURE

After the purpose of the study was explained, each subject was asked to sign a document of informed consent before enrolling. Demographic data and driving status during the prior 5 years were confirmed through interview. Three types of visual function were assessed: acuity, contrast sensitivity, and disability glare. Test examiners were masked to the crash histories of all subjects. All measurements were made while subjects wore the lens correction they typically used during the performance of everyday distance activities, including driving. Each eye was assessed separately. Distance acuity was measured using the Early Treatment Diabetic Retinopathy Study letter chart and its standard protocol, and was expressed as log minimum angle resolvable.[20,21] For each eye, visual acuity measurements were grouped into 4 categories: 20/25 or better, 20/25 to 20/30, 20/35 to 20/50, and worse than 20/50. These cut points were chosen because they were the approximate quartiles of the acuity distribution and included the practically significant cut point for driving licensure in many states (20/40 to 20/50). Contrast sensitivity was measured with the Pelli-Robson Contrast Sensitivity Chart and its standard protocol[22,23] and was expressed as log contrast sensitivity; cut points for data analysis were also based on quartiles (better than 1.50, 1.50-1.34, 1.24-1.35, and 1.25 or worse). Disability glare was estimated with the Brightness Acuity Tester (BAT)[24,25] as the subject viewed the Pelli-Robson Chart. Disability glare was defined as the Pelli-Robson score without the BAT minus the Pelli-Robson score with the BAT, and was dichotomized according to whether the subject's disability glare was 0.25 or greater, based on the 50% point of distribution.

Cognitive status was assessed because it is known to be associated with crash involvement in older drivers[26,27] and, thus, could be a confounding factor. It was evaluated by the Mattis Organic Mental Syndrome Screening Examination,[28] specifically designed to assess cognitive function in elderly people. This 20-minute test, described in detail in our previous articles,[29,30] provides a composite score of mental status that reflects performance in 14 domains of cognitive functioning. Composite scores range from 0 to 28 with lower scores representing a higher degree of function; subjects with scores of 9 or higher were classified as cognitively impaired. An estimate of general health was provided through a questionnaire[12] that asked about the presence vs absence of problems in 17 areas (eg, heart disease, cancer, diabetes, and stroke).

Crash data for the 5 years prior to enrollment were obtained from the Alabama Department of Public Safety, the state agency in charge of compiling such records. At-fault crash involvement was defined as participation in at least 1 crash in the previous 5 years in which the subject was deemed at least partially at fault. To determine whether a driver was at least partially at fault, 3 judges (C.O., B.T.S., and J.W.) independently evaluated the details surrounding each crash, which were described and diagrammed on each accident report provided by the state. Judges were unaware of which driver was the study subject in multiple vehicle collisions, and of drivers' visual and medical characteristics. The 3 judges agreed on at-fault determination in 83% of the crashes; in cases of disagreement, further discussion always led to consensus. Driving exposure information (estimated miles driven per week) was obtained from each subject by administering the Driving Habits Questionnaire.[12] Subjects were classified into 2 categories according to whether they drove more or less than the median number of miles (150 miles) driven per week based on the distribution of all subjects. Although this was a self-report measure, prior studies indicate that older adults can provide valid estimates of driving exposure.[31]

STATISTICAL ANALYSIS

The primary aim of this article is to identify what type of vision impairment was mediating the elevated crash risk observed in the original sample[12]; thus, all major analyses were performed on the combined sample of subjects with cataract and those without cataract. As a preliminary step, we examined the distributions of visual function in both the cataract and cataract-free groups for the better and worse eyes separately to verify that the subjects with cataract had poorer visual function scores than those without cataract. The better vs worse eyes were defined in terms of visual acuity. Descriptive statistics were generated for demographics, cognitive function, general health, and driving exposure for at-fault crash-involved and not-at-fault crash-involved subjects, and were compared using χ^2 and *t* tests as appropriate. For the relationship between visual function and at-fault crash involvement, unadjusted odds ratios (ORs) and 95% confidence intervals (CIs) were computed separately for each measure of visual function (visual acuity, contrast sensitivity, and disability glare). Preliminary analysis indicated that the visual function measures did not meet the assumptions of the logistic regression model (ie, the log odds are assumed to be a linear function of the risk factor). Therefore, visual function variables were entered as a series of categorical variables rather than continuous measures. Analyses were performed with adjustments for age, sex, race, cognitive status, general health, and driving exposure because these factors can affect crash risk.[1] All inferential analyses were conducted using separate unconditional logistic regression models for the better and worse eyes. To determine the independent effect of visual function on at-fault crash involvement, measures of visual function (visual acuity, contrast sensitivity, and disability glare) were evaluated simultaneously with additional adjustments for age, sex, race, cognitive status, general health, and driving exposure. These multiple visual function models were also evaluated separately for the better and worse eyes. Finally, the effect on crash risk of vision impairment in both eyes and in only 1 eye was evaluated using logistic regression.

RESULTS

Subjects incurred a total of 46 at-fault crashes during the 5 years prior to enrollment. Ten percent (39 of 377) of the sample subjects incurred at least 1 at-fault crash in the previous 5 years. Of these 39 subjects, 33 had 1, 5 had 2, and 1 had 3 at-fault crashes.

Table 1 lists the associations between at-fault crash involvement and demographic variables, cognitive status, general health, and driving exposure. Crash-involved drivers were more likely to be men ($P = .004$). There was a nonsignificant tendency for crash-involved drivers to have lower cognitive status ($P = .07$). Age, race, general health, and driving exposure were not significantly related to crash involvement.

As one would expect from our knowledge of the visual consequences of age-related cataract, those with cataract were much more likely to exhibit poorer visual function in both the better and worse eyes than were those free of cataract. **Table 2** lists the distribution of visual acuity, contrast sensitivity, and disability glare scores for subjects with cataract and those without. The prevalence of poor vision scores is higher in subjects with cataract than those free of cataract, consistent with what we have previously reported for this sample.[12] Visual acuity and contrast sensitivity for both the better and worse eyes were correlated (Pearson $r = -0.62$ and -0.72, respectively), consistent with previous studies.[28] In comparison, disability glare was more modestly correlated with visual acuity ($r = 0.11$ and 0.29, respectively) and contrast sensitivity ($r = 0.07$ and -0.22, respectively).

As we have demonstrated previously for this sample,[12] crash-involved drivers were approximately 2½ times more likely to have cataract than were crash-free drivers

Table 1. Associations Between At-Fault Crash Involvement and Demographics, Cognitive Status, General Health, and Driving Exposure*

	Crash-Involved Subjects	Non–Crash-Involved Subjects	Total	P†
Total	39 (10)	338 (90)	377	
Age, y				
50-59	4 (10)	16 (5)	20	.29
60-69	11 (28)	123 (36)	134	
70-79	23 (59)	180 (53)	203	
80-85	1 (3)	19 (6)	20	
Sex				
F	10 (26)	170 (50)	180	.004
M	29 (74)	168 (50)	197	
Race				
White	32 (82)	291 (86)	323	.49
African American	7 (18)	47 (14)	54	
Cognitive status‡				
≤8	29 (74)	289 (86)	318	.07
>8	10 (26)	49 (14)	59	
General health				
No. of medical conditions, mean (SD)	4.0 (2.1)	3.8 (1.7)	4.0 (2.1)	.65
Driving exposure				
<150 miles/wk	20 (51)	134 (40)	154	.16
≥150 miles/wk	19 (49)	204 (60)	223	

*Data are presented as number (percentage) unless otherwise indicated.
†*P* values were determined using the χ^2 test, except for the general health variable, for which an independent, 2-sample *t* test was used.
‡Cognitive scores based on the Mattis Organic Mental Syndrome Screening Examination.[28]

Table 2. Distribution of Visual Acuity, Contrast Sensitivity, and Disability Glare in the Cataract and No-Cataract Groups, for Worse Eye and Better Eye Separately*

	Cataract Group	No-Cataract Group	P†
Worse eye			
Visual acuity			
20/25 or better	3 (1.1)	48 (46.6)	<.001
20/25-20/30	31 (11.3)	36 (35.0)	
20/35-20/50	98 (35.8)	17 (16.5)	
Worse than 20/50	142 (51.8)	2 (1.9)	
Contrast sensitivity			
≥1.50	23 (8.4)	61 (59.2)	<.001
>1.35-1.50	57 (20.8)	34 (33.0)	
>1.25-1.35	85 (31.0)	7 (6.8)	
≤1.25	109 (39.8)	1 (1.0)	
Disability glare			
<0.25	111 (40.5)	68 (66.0)	<.001
≥0.25	163 (59.5)	35 (34.0)	
Better eye			
Visual acuity			
20/25 or better	53 (19.3)	83 (80.6)	<.001
20/25-20/30	100 (36.5)	18 (17.5)	
20/35-20/50	75 (27.4)	2 (1.9)	
Worse than 20/50	46 (16.8)	0 (0.0)	
Contrast sensitivity			
≥1.50	40 (14.6)	63 (61.2)	<.001
>1.35-1.50	72 (26.3)	33 (32.0)	
>1.25-1.35	108 (39.4)	6 (5.8)	
≤1.25	54 (19.7)	1 (1.0)	
Disability glare			
<0.25	225 (82.1)	95 (95.2)	.01
≥0.25	49 (17.9)	8 (7.8)	

*Data are presented as number (percentage). *P* values were determined using the χ^2 test.

(OR=2.46; 95% CI, 1.00-6.16). This association between cataract and crashing is the starting point for the present analyses. We were interested in determining what aspect of vision is mediating this increased crash risk. **Tables 3**, **4**, **5**, and **6** summarize results that address this question. Table 3 indicates the relationship between crash involvement and various types of visual function (visual acuity, contrast sensitivity, and disability glare) in the better eye. Contrast sensitivity of 1.25 or less was the only variable crudely associated with crash involvement (OR=2.65; 95% CI, 1.06-6.61). After adjusting for demographics, cognitive function, general health, and driving exposure, this relationship became stronger (OR=4.97; 95% CI, 1.69-14.63). In addition, after these adjustments, visual acuity in the range of 20/35 to 20/50 was associated with crash involvement (OR=3.17; 95% CI, 1.15-8.69). Although not statistically significant, there was also a possible relationship between visual acuity worse than 20/50 and crashing (OR=3.12; 95% CI, 0.96-10.14).

Table 4 lists the analogous crude and adjusted analyses for the worse eye, which generated results qualitatively similar to those for the better eye. Once again, the only crude association between visual function and crashing was contrast sensitivity of 1.25 or less (OR=3.38; 95% CI, 1.21-9.47), which was strengthened by adjusting the association for demographics, cognitive function, general health, and driving exposure (OR=7.06; 95% CI, 1.88-26.52). There were no significant associations, either crude or adjusted, between crashing and visual acuity or disability glare.

The independent contributions of visual acuity, contrast sensitivity, and disability glare are displayed in Table 5 for the better and worse eyes separately. A contrast sensitivity score of 1.25 or less was the only independent predictor of crash involvement when adjusted for other aspects of visual function. The relationship was about 2 times stronger for the worse eye (OR=7.86; 95% CI, 1.55-39.79) than for the better eye (OR=3.78; 95% CI, 1.15-12.48). These general results remained even when subjects with secondary eye conditions (4.7% of the overall sample) were deleted from the analysis.

The question arises whether impairment in both eyes is required to generate an increased crash risk, or whether impairment in only 1 eye should also warrant concern. To address this question, impairment was defined for each visual function (Table 6), and then the effects of impairment in 1 eye and both eyes on crash risk were evaluated for each visual function. Contrast sensitivity impairment in both eyes was strongly associated with crash involvement (OR=5.78; 95% CI, 1.87-17.86). Although the *P* value is 50% smaller, contrast sensitivity impairment in a single eye was also significantly related to crashing (OR=2.70; 95% CI, 1.16-6.51). With respect to visual acuity and disability glare, impairment in both eyes or a single eye was not related to crash involvement.

As previously reported for this sample of older drivers,[12] the presence of cataract is a risk factor for at-fault crash

Table 3. Relationship Between Visual Function in the Better Eye and At-Fault Crash Involvement*

	Crash-Involved Subjects	Non–Crash-Involved Subjects	Total	OR (95% CI), Unadjusted	OR (95% CI), Adjusted†
Total	39 (10)	338 (90)	377		
Visual acuity					
20/25 or better	9 (23)	127 (38)	136	Reference	Reference
20/25-20/30	13 (33)	105 (31)	118	1.43 (0.62-3.32)	2.13 (0.85-5.34)
20/35-20/50	11 (28)	66 (19)	77	1.92 (0.79-4.67)	3.17 (1.15-8.69)
Worse than 20/50	6 (16)	40 (12)	46	1.73 (0.62-4.98)	3.12 (0.96-10.14)
Contrast sensitivity					
≥1.50	8 (21)	95 (28)	103	Reference	Reference
>1.35-1.50	9 (23)	96 (28)	105	0.89 (0.35-2.29)	1.31 (0.46-3.69)
>1.25-1.35	10 (26)	104 (31)	114	0.91 (0.36-2.29)	1.57 (0.54-4.55)
≤1.25	12 (31)	43 (13)	55	2.65 (1.06-6.61)	4.97 (1.69-14.63)
Disability glare					
<0.25	35 (90)	285 (84)	320	Reference	Reference
≥0.25	4 (10)	53 (16)	57	0.62 (0.21-1.80)	0.72 (0.24-2.15)

**Data are presented as number (percentage). OR indicates odds ratio; CI, confidence interval.*
†Adjusted for age, sex, race, cognitive status, general health, and driving exposure.

Table 4. Relationship Between Visual Function in the Worse Eye and At-Fault Crash Involvement*

	Crash-Involved Subjects	Non–Crash-Involved Subjects	Total	OR (95% CI), Unadjusted	OR (95% CI), Adjusted†
Total	39 (10)	338 (90)	337		
Visual acuity					
20/25 or better	4 (10)	47 (14)	51	Reference	Reference
20/25-20/30	2 (5)	65 (19)	67	0.24 (0.05-1.25)	0.40 (0.06-2.17)
20/35-20/50	13 (33)	102 (30)	115	1.00 (0.36-2.79)	1.86 (0.53-6.49)
Worse than 20/50	20 (51)	124 (37)	144	1.26 (0.49-3.34)	2.24 (0.67-7.56)
Contrast sensitivity					
≥1.50	3 (8)	81 (24)	84	Reference	Reference
>1.35-1.50	8 (21)	83 (25)	91	1.56 (0.49-4.97)	3.01 (0.75-12.10)
>1.25-1.35	9 (23)	83 (25)	92	1.76 (0.56-5.47)	3.82 (0.94-15.62)
≤1.25	19 (49)	91 (27)	110	3.38 (1.21-9.47)	7.06 (1.88-26.52)
Disability glare					
<0.25	22 (56)	157 (46)	179	Reference	Reference
≥0.25	17 (44)	181 (54)	198	0.67 (0.34-1.31)	0.80 (0.40-1.62)

**Data are presented as number (percentage). OR indicates odds ratio; CI, confidence interval.*
†Adjusted for age, sex, race, cognitive status, general health, and driving exposure.

involvement (OR=2.46; 95% CI, 1.00-6.16). To determine whether contrast sensitivity impairment is the mediator of this effect, the visual function models listed in Table 5 were recomputed with the addition of "cataract group/no cataract group" as a variable. The association between cataract group and crash involvement became nonsignificant (worse eye, OR=1.26; 95% CI, 0.28-5.59; better eye, OR=1.39; 95% CI, 0.42-4.62). This implies that the presence of contrast sensitivity in the model was primarily responsible for the change in the association between cataract and crash risk. Furthermore, after adding cataract status to the models in Table 4, the associations between contrast sensitivity and crash risk (worse eye, OR=7.56; 95% CI, 1.47-38.99; better eye, OR=3.32; 95% CI, 1.00-11.83) remained statistically significant.

COMMENT

Older drivers with serious impairment in contrast sensitivity due to cataract have an elevated risk of motor vehicle collision. In this study, drivers with a history of crash involvement were almost 6 times more likely to have serious contrast sensitivity impairment (Pelli-Robson score ≤1.25) in both eyes compared with those who were crash-free, adjusting for demographics, cognitive difficulties, and other forms of vision impairment. Our findings further indicate that contrast sensitivity impairment need be present in only 1 eye for collision risk to be elevated; crash-involved drivers were almost 3 times more likely to have a Pelli-Robson score of 1.25 or lower in only 1 eye compared with crash-free drivers. The results of this study are consistent with earlier studies reporting crude associations between contrast sensitivity deficits and crash involvement,[28,32] traffic violations,[33] and difficulties in driving performance by drivers with simulated cataract.[34] However, these prior studies did not adjust for a variety of confounding factors known to affect crash risk. Our results go beyond previous studies in establishing that serious contrast sensitivity impairment in 1 or both eyes due to cataract is an independent threat to road safety.

Neither impaired visual acuity nor increased disability glare from cataract were independently associated with crash involvement in this study, and even their bivariate associations with crash involvement were generally nonsignificant. It is interesting to contemplate this finding; scrutiny suggests that safe driving may not require keen

Table 5. Multiple Visual Function Models for Better Eye and Worse Eye, Examining Relationship Between Vision and At-Fault Crash Involvement*

	Better Eye, OR (95% CI)	Worse Eye, OR (95% CI)
Visual acuity		
20/25 or better	Reference	Reference
20/25-20/30	1.88 (0.72-4.88)	0.19 (0.03-1.27)
20/35-20/50	2.54 (0.87-7.47)	0.82 (0.19-3.61)
Worse than 20/50	1.75 (0.45-6.85)	0.74 (0.16-3.52)
Contrast sensitivity		
≥1.50	Reference	Reference
>1.35-1.50	1.18 (0.41-3.36)	3.18 (0.71-14.17)
>1.25-1.35	1.21 (0.40-3.68)	4.36 (0.84-22.70)
≤1.25	3.78 (1.15-12.48)	7.86 (1.55-39.79)
Disability glare		
<0.25	Reference	Reference
≥0.25	0.68 (0.22-2.12)	0.62 (0.29-1.33)

*Odds ratios are adjusted for age, sex, race, cognitive status, general health, driving exposure, and the 2 other visual functions not being evaluated. OR indicates odds ratio; CI, confidence interval.

Table 6. Association Between At-Fault Crash Involvement and Impairment in Only 1 Eye and Both Eyes*

	OR (95% CI), Crude	OR (95% CI), Adjusted†
Visual acuity‡		
No impairment	Reference	Reference
Impairment in only 1 eye	1.70 (0.83-3.50)	1.35 (0.58-3.15)
Impairment in both eyes	1.53 (0.58-4.03)	1.01 (0.29-3.45)
Contrast sensitivity§		
No impairment	Reference	Reference
Impairment in only 1 eye	2.23 (1.05-4.74)	2.70 (1.16-6.51)
Impairment in both eyes	3.59 (1.49-8.63)	5.78 (1.87-17.86)
Disability glare‖		
No impairment	Reference	Reference
Impairment in only 1 eye	0.66 (0.33-1.36)	0.67 (0.30-1.48)
Impairment in both eyes	0.49 (0.16-1.49)	0.46 (0.14-1.53)

*OR indicates odds ratio; CI, confidence interval.
†Adjusted for age, sex, race, cognitive status, general health, driving exposure, and the 2 other visual functions not being evaluated.
‡Acuity impairment defined as worse than 20/50.
§Contrast sensitivity impairment defined as score ≤1.25.
‖Glare impairment defined as glare score ≥0.25.

spatial resolution, and prior research supports this contention.[35-39] Although excellent visual acuity assists in reading distant road signs,[40-42] as with other aspects of mobility,[43-45] lower spatial frequencies appear to be more critical in navigating a vehicle. Severe deficits in acuity (20/100 or worse) may elevate crash risk, but it is common for older adults with cataract to undergo surgery and intraocular lens insertion before their visual impairment progresses to this stage. In our sample, which was recruited through eye care clinics, about 80% of those with cataract had visual acuity better than 20/100 in either eye. Another factor potentially underlying the lack of a relationship between visual acuity deficits and crash involvement is that those with severe acuity impairment may have already stopped driving, either voluntarily or because of state laws.

Glare problems are often discussed as a serious threat to the safety of older drivers.[46,47] However, no studies have demonstrated that increased disability glare is independently associated with either crash involvement or self-reported difficulty in driving. The failure to confirm an association between road safety and disability glare in the present study and others[28,38] may be due to several factors, including difficulty defining glare, trouble measuring its psychophysical effects, and a poor understanding of what people mean when they say they have "glare problems."[25,48,49]

Crash risk was higher in the analyses based on the worse eye compared with those of the better eye (Tables 3-5). This appears to be inconsistent with a previous report indicating that the eye with better function is more predictive of patients' performance in visual tasks typical of daily life (mobility, face recognition, reading).[50] Following the logic of previous studies, one would have expected the ORs for the association between crash involvement and contrast sensitivity in the worse eye to be weaker than for the better eye, but the result was dramatically reversed. These findings underscore the need for an improved understanding of the visual requirements of everyday tasks and the role of interocular differences in visually impaired persons.

Contrast sensitivity loss can be a consequence of other relatively common eye conditions in the older population, such as age-related maculopathy,[51] glaucoma,[52] and diabetic retinopathy.[53] It remains to be determined whether contrast sensitivity impairment caused by these conditions also threatens driver safety, although the cause of the deficit would seem to be less important than the presence and severity of the impairment itself. Further work should address the relationship between driver safety and other common eye conditions that impair vision in older people. The present results call into question the heavy emphasis on acuity testing as the visual screening method at driver licensing sites, and add to the growing body of evidence that other types of visual processing deficits have greater influence on crash risk than does acuity impairment.[36,38,39]

A strength of this study is the measurement of, and adjustment for, other factors known to affect crash risk in older drivers, such as driving exposure, cognitive status, and general health. In addition, the role of specific visual function types was evaluated in terms of each function's contribution independent from other forms of vision impairment. Another strength is that the crash outcome variable was defined by state records; self-report of crash involvement is known to be unreliable in the older adult population.[54,55] One limitation is the use of retrospective crash data because visual function was measured at the end of the period in which crashes were surveyed. Finally, this study did not address the differential effects of various types of age-related cataract on driver safety, an issue worthy of investigation because certain types of lens opacity (eg, posterior subcapsular) are reportedly more visually disabling than others.[56]

For most patients, cataract surgery has a dramatic effect in improving vision,[10] and thus one wonders to what extent postsurgical improvement in contrast sensitivity, visual acuity, or other aspects of vision brings about a reduction in crash rate. As with many medical procedures, cataract surgery is closely scrutinized in terms of its cost vs benefit to the patient's quality of life and well-being. Driving mobility is an important aspect of quality of life in many societies. The patients in this sample are currently being followed prospectively to examine whether cataract surgery indeed lowers crash risk and, if so, to identify visual mechanisms underlying enhanced road safety.

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