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Visual Processing Impairment and Risk of Motor Vehicle Crash Among Older Adults

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Context.—Motor vehicle crash risk in older drivers has been associated with visual acuity loss, but only weakly so, suggesting other factors contribute. The useful field of view is a measure that reflects decline in visual sensory function, slowed visual processing speed, and impaired visual attention skills.

Objective.—To identify whether measures of visual processing ability, including the useful field of view test, are associated with crash involvement by older drivers.

Design.—Prospective cohort study with 3 years of follow-up, 1990-1993.

Setting.—Ophthalmology clinic assessment of community-based sample.

Patients.—A total of 294 drivers aged 55 to 87 years at enrollment.

Main Outcome Measure.—Motor vehicle crash occurrence.

Results.— Older drivers with a 40% or greater impairment in the useful field of view were 2.2 times (95% confidence interval, 1.2-4.1) more likely to incur a crash during 3 years of follow-up, after adjusting for age, sex, race, chronic medical conditions, mental status, and days driven per week. This association was primarily mediated by difficulty in dividing attention under brief target durations.

Conclusion.—Reduction in the useful field of view increases crash risk in older drivers. Given the relatively high prevalence of visual processing impairment among the elderly, visual dysfunction and eye disease deserve further examination as causes of motor vehicle crashes and injury.

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OLDER PATIENTS, families, and state departments of motor vehicles often ask physicians to provide advice about the older adult's ability to drive safely. Even when a patient's visual acuity meets the minimum licensing requirements, there can be concern about whether an older driver is safe on the road. This is because many factors in addition to poor acuity hamper the ability to control a vehicle.[1] These factors include visual field loss,[2,3] contrast sensitivity deficits,[4,5] visual attention impairment,[5,6] cognitive impairment,[7-9] cardiovascular disease,[10] diabetes,[11,12] and medication usage.[13,14] Data on crashes and injuries in the older adult population underscore this issue's public health relevance. Older drivers incur more crashes and fatalities per mile driven than most other age groups,[15] and are more likely to suffer disabling conditions or die as a result of collisions than are younger adults.[16] For every 100 000 miles driven, the crash rate of older drivers is twice that of younger drivers.[16] While these trends are noteworthy, there are large differences in older adults' individual driving abilities, and the majority of older drivers have crash-free records.[17] Thus, any guideline for determining the appropriateness of driving for older adults must avoid age-based rules so that older drivers are not unjustifiably removed from the road.

A starting point for addressing the identification of unsafe older drivers is research to identify impairments and medical conditions that significantly elevate older adults' crash risks. Risk factors could then be used as the basis for physicians' recommendations to patients, families, and departments of motor vehicles,[18,19] and for developing interventions to reduce risks. In the present study, we focus on visual risk factors, because controlling a vehicle depends on visual processing skills, and earlier retrospective studies have indicated that visual processing deficits are strongly associated with a history of driving problems.[2,3,5,20] However, to our knowledge, few studies have attempted to identify the independent contribution of these deficits to increased crash rates by adjusting for other medical and functional impairments,[7,21] and no studies of visual processing impairment have done so prospectively while also adjusting for driving exposure. In the present study, a cohort of older drivers, including those both with and without a history of crashes in previous years, participated in visual functional evaluations. These assessments, along with demographic

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and general health information, mental status, and driving exposure, were then evaluated to determine which measures were independently associated with crash rates per person-mile of travel during a 3-year follow-up period.

METHODS

Subjects

This sample was originally assembled for the purposes of a case-control study on older drivers with a history of crash involvement.[5] The source for the sample was all licensed drivers in Jefferson County, Alabama, aged 55 years and older (N = 118 553). The goal was to enroll a sample of approximately 300 drivers that was balanced with respect to 2 variables: crash frequency during the previous 5-year period and age. To identify 300 individuals, the source population of older drivers in Jefferson County was first sorted into 21 cells, representing 3 crash categories (0, 1-3, and 4 or more during the previous 5 years) and 7 age categories (55-59, 60-64, 65-69, 70-74, 75-79, 80-84, and ≥ 85 years). Seventy-five drivers were randomly selected from each cell, and contact letters were sent to those listed in the local telephone directory. The goal was to enroll approximately 300 older adults in a 6-week period in 1990. Enrollment was terminated when 302 subjects were successfully recruited, even though there were additional names to contact for scheduling. Six of the 302 subjects who enrolled were excluded from analysis because they did not drive despite maintaining a current driver's license, and 2 subjects were excluded because they did not complete the protocol. The final sample consisted of 294 older drivers. Thirty-three percent of the sample had 0 crashes on record, 49% had 1 to 3 crashes, and 18% had 4 or more crashes during the previous 5 years. With respect to age, 11% to 19% of the sample was represented by each half-decade stratum as described herein. The focus of the present study is on the prospective 3-year follow-up of these 294 older drivers (subsequent to their 1990 assessments) in order to determine what visual characteristics were associated with future crash involvement.

Protocol

The protocol was approved by the institutional review board at the University of Alabama at Birmingham. Before participation, written informed consent was obtained from each subject after the nature of the study was explained. The protocol was completed in a single visit by each subject to the clinic in 1990, and consisted of assessments of visual sensory function, visual attention and processing speed, cognitive function, and eye health; a questionnaire about driving exposure; and a review of demographic and health information. Discussion of the study purpose, informed consent, and a review of chronic medical conditions were always addressed first. The eye examination was always last because it involved eye dilation. The questionnaire about driving exposure was completed during a rest period in the waiting room. All evaluations are summarized herein. The examiners were unaware of the crash histories of all subjects tested.

Data Collection and Measurements

The following visual sensory tests were administered because they represent major aspects of visual sensory function, are commonly used screening tools, and have been linked in varying degrees to driving problems in prior studies. All vision tests were performed under photopic conditions (100 candelas per square meter [cd/m^2]), except where noted. Visual acuity was measured using the Early Treatment of Diabetic Retinopathy Study chart[22] and expressed as log minimum angle resolvable (logMAR). Impaired visual acuity was defined as worse than 20/40, the legal limit for licensure in many states. Contrast sensitivity was measured using the Pelli-Robson chart[23] and expressed as log$_{10}$ contrast sensitivity. Impaired contrast sensitivity was defined as a score of 1.5 or lower. Stereoacuity (depth perception) was measured using the TNO test[24] and expressed as arcseconds. Impaired stereoacuity was defined as 500 arcseconds or worse. Disability glare was measured with the MCT-8000 (VisTech Consultants, Dayton, Ohio) and defined as the difference in visual acuity (logMAR) under conditions of glare vs no glare. Impairment was defined by values greater than 0. Visual field sensitivity was measured with a field analyzer's (Humphrey Field Analyzer; Humphrey Instruments Inc, San Leandro, Calif) 120-point screening program for the central 60°-radius field using the quantify defects option. A preset initialization value of 34 dB (both central and peripheral) was used, which served as a baseline, normal visual field against which performance was compared. This standard was based on the normal visual field sensitivity for adults in their 50s who have good eye health.[25] Background luminance was 10 cd/m^2. For each eye, visual field defect for the central 30°-radius field and the peripheral 30°-radius to 60°-radius field was expressed as the average defect depth of all points in the region. The eye with the smaller defect depth ("better" eye) was used in all subsequent data analysis. Impaired visual field sensitivity (for both the central and peripheral visual fields) was a loss of sensitivity of more than 1 log unit (10 dB). The standard protocols for all tests were followed as described in the manufacturers' manuals. All tests were administered binocularly, except the visual field test, in which each eye was tested separately. For all tests except visual field testing, subjects wore their habitual corrections because their everyday visual performance capabilities were of primary interest. With respect to visual field testing, the Humphrey Field Analyzer's validity rests on use of optimal optical correction for the near target distance so this was implemented in the protocol.

Visual attention and visual processing speed was assessed with the useful field of view test[26] (Visual Resources Inc, Chicago, Ill). The useful field of view is defined as the visual field area over which one can use rapidly presented visual information.[27,28] Unlike conventional measures of visual field area, which assess visual sensory sensitivity, the useful field of view test additionally relies on higher-order processing skills such as selective and divided attention and rapid processing speed. The test consists of a radial localization task in which a subject must identify the radial direction of a target (a silhouette of a car) presented up to 30° in the periphery, while simultaneously discriminating 2 targets presented in central vision (a silhouette of a car vs a truck). By varying the eccentricity of the peripheral target (at 10°, 20°, or 30°), the visual field area over which a subject can acquire information rapidly can be estimated. In some trials the peripheral target is embedded in distracting stimuli. Thus, the task has both divided attention components (ie, the subject must perform a central discrimination task at fixation while localizing a simultaneously presented target) and a selective attention component (ie, the subject indicates the radial direction of the peripheral target even though it is embedded in other distracting stimuli in the periphery). Another variable manipulated is the duration of the test display, which varies from 40 to 240 milliseconds. Performance is expressed as a function of 3 variables: the minimum target duration required to perform the central discrimination task (subtest 1), the ability to divide attention between central and peripheral tasks successfully (subtest 2), and the ability to filter out distracting stimuli (subtest 3). Performance in each of the 3 subtests is scaled from 0 to 30. In addition, performance in the 3 subtests is nonindependent because speed of processing is relevant to all 3 tests, and attention abilities are relevant to subtests 2 and 3. Performance in the overall useful field of view task is a composite score expressed as percent reduction (0%-90%) of a maximum 30° field size (maximum field size of the test apparatus screen at the viewing distance). Using a previously established cut point,[5] impaired useful field of view was defined as a 40% reduction or greater.

All subjects received a comprehensive eye examination by an ophthalmologist, which included direct and indirect ophthalmoscopy after dilation, biomicroscopy, applanation tonometry, a refraction for distance, and an assessment of external health. The primary diagnosis of each subject (other than refractive error) was noted (eg, cataract, age-related maculopathy, glaucoma, diabetic retinopathy).

Mental status was evaluated by the Mattis Organic Mental Syndrome Screening Examination,[29] specifically designed to assess cognitive function in the older population. This test, lasting about 20 minutes, provides a composite score of cognitive function that summarizes performance in several domains, including general information, abstraction, attention, orientation, verbal memory, visual memory, speech, naming, comprehension, sentence repetition, writing, reading, drawing, and block design. Composite scores range from 0 to 28, with lower scores representing higher functioning. Using a previously established convention, a score greater than 9 indicated cognitive impairment.[3]

The presence of chronic medical conditions (eg, heart disease, hypertension, arthritis, multiple sclerosis, depression, cancer, stroke, diabetes, Parkinson disease) was determined by a self-report checklist. Some of these conditions have been linked to increased crash risk in earlier studies,[15] and thus, their potential role as confounders needed to be evaluated. Prior work on the validity of self-report measures in the elderly suggests that there is a moderate to high level of agreement between self-report and medical record diagnoses.[30] For purposes of analysis, the chronic disease variable was defined as the presence of 1 or more chronic diseases vs none.

To estimate driving or on-the-road exposure, subjects were asked to fill out a brief questionnaire asking how many days per week they drove and how many miles per year they drove. Subjects were also asked if anyone had ever suggested that they limit their driving.

Outcomes

Information on the primary outcome of interest, the occurrence of a motor vehicle crash during the 3 years (June 1990-August 1993) following the clinic assessment, was obtained from the Alabama Department of Public Safety. Hard copy of each accident report was provided. At the end of the follow-up period, information on vital and driving status was obtained via a brief telephone interview. The Social Security Death Index was also used to augment vital status ascertainment.

Follow-up

Subjects for whom a crash report was obtained from the Alabama Department of Public Safety were considered to have experienced the outcome of interest. Crash-free subjects who died or reported stopping driving before the end of the follow-up period were considered censored. If information was not available on a subject's driving status prior to death, the date of death was taken to be the date of censoring. We found this assumption to be reasonable based on data from subjects for whom we had valid information on both date of death and date of stopping driving. A minority of subjects (4% of all subjects, 20% of subjects who were involved in crashes) were involved in more than 1 crash during the follow-up period. We considered only first events in the calculation of person-years. For each subject, person-years were accrued from the date of enrollment to the date of first crash, date of censoring event, or August 1993, whichever came first. To calculate person-miles of travel, the number of person-years was multiplied by the annual number of miles driven that was reported by each subject.[21,31]

Data Analysis

Cox proportional hazards modeling was used to calculate relative risks (RRs) and 95% confidence intervals (CIs).[32-34] To determine independent predictors of crash involvement, we first evaluated the univariate relationship between independent variables and crash occurrence. All variables that had significant associations ($\alpha = .15$) at the univariate level were included in a multivariable proportional hazards model. Each variable was then individually removed from the model, and likelihood ratio tests were performed to determine which variables were significant independent predictors of crash occurrence.[32] Variables not demonstrating significant independent associations were removed from the model, and point estimates and CIs were computed for the remaining variables. This process was repeated until the most parsimonious model was obtained. All multivariable models were additionally adjusted for age, sex, race, mental status, and the presence of any chronic medical conditions, since earlier work suggests that these variables are potential confounders.[15]

Interaction between covariates was assessed by entering multiplicative terms into the multivariable Cox model one at a time. The statistical significance of the interaction terms was assessed using the likelihood ratio test at the $\alpha = .05$ level.[32] Tests of linear trend were performed by entering a continuous variable into the Cox models and assessing the significance of the term using the Wald χ^2 test.

In Cox models, ties in follow-up time were handled using the Breslow method.[34] The appropriateness of this technique was assessed by comparing the results with models using the exact method; no meaningful differences were observed. The proportional hazards assumption was checked for each covariate by evaluating log cumulative hazard curves plotted against person-miles and by including multiplicative interaction terms between each covariate and a function of person-miles in individual models.[32-34] No variables were found to violate the proportional hazards assumption.

Several techniques were used to assess model fit. Martingale and deviance residuals were calculated for models and plotted against the rank of person-miles.[32,34] Influence statistics were also computed and evaluated to determine if any single observation had an undue influence on model coefficients. Because measures of visual processing were intercorrelated, we were attentive to the potential for colinearity during the modeling process. Where appropriate, variables thought to be colinear were analyzed both individually and together in multivariable models. Stability of the estimates, inflated SEs, and convergence difficulties were used to qualitatively assess the presence of colinearity.

RESULTS

The 294 drivers in this study accumulated 760.8 person-years of driving and 7 909 240 person-miles of travel. Fifty-six older drivers incurred at least 1 crash in the 3-year follow-up period, 11 of whom experienced 2 or more crashes. The majority of crashes (70%) involved failure to yield the right-of-way, failure to heed a stop signal, or misjudged stopping distance. The estimated annual crash rate was 74 per 1000 person-years of driving and 7.1 per million person-miles of travel.

Table 1 compares the demographic and driving characteristics of the study sample. Subjects who reported driving less than 7 days per week were 30% less likely to have incurred a crash compared

Table 1.—Distribution of Study Subjects, Crash Rates, Relative Risks (RRs), and 95% Confidence Intervals (CIs) by Demographics, Driving Characteristic, and Mental Status

Characteristics	No. (%) With Characteristic	Crash Rate*	*P* Value	RR	95% CI
Age, y†					
55-64	71 (24.1)	6.5			
65-69	71 (24.1)	6.5			
70-77	72 (24.5)	5.9			
78-87	80 (27.2)	10.8			
Sex					
Female	136 (46.2)	6.3	.52	Referent	...‡
Male	158 (53.7)	7.6		1.20	0.70-2.08
Race					
White	238 (81.0)	6.8	.30	Referent	...
Black	56 (19.0)	8.4		1.22	0.63-2.37
Driving, days per week§					
7	156 (53.1)	7.9	.14	Referent	...
<7	138 (46.9)	5.8		0.73	0.40-1.32
Crash in previous 5 years‖	189 (64.3)	8.6	.03	2.00	1.06-3.79
Driving limit suggested§‖	24 (8.2)	6.4	.89	1.07	0.44-2.63
Mental status¶					
≤9	230 (78.2)	6.9	.63	Referent	...
≥9	64 (21.8)	8.1		1.17	0.81-2.27
Chronic medical condition§					
None	42 (14.5)	6.3	.84	Referent	...
Any	252 (85.5)	7.1		1.13	0.53-2.19

*Crash rate per million person-miles of travel.

†Because the sampling strategy involved age and crash stratification, relative risks, 95% confidence intervals, and *P* values were not computed.

‡Ellipses indicate data not applicable.

§Self-reported.

‖Reference category is those without condition.

¶Higher values represent greater impairment.

with those who reported driving daily. Involvement in a crash in the 5 years prior to enrollment in the study was significantly associated with an increased crash risk (RR=2.0; 95% CI, 1.1-3.8).

Six subjects (2% of sample) were diagnosed as having glaucoma, 99 (33.8%) with cataract, 23 (7.8%) with age-related maculopathy, 5 (1.7%) with diabetic retinopathy, and 26 (8.8%) with other eye conditions. The 135 remaining subjects did not exhibit identifiable eye diseases. Because of the small number of subjects with these eye conditions, eye disease variables were not evaluated for associations with crash involvement.

Among the visual processing variables identified as potentially important determinants of crash risk, impaired useful field of view was the only one that demonstrated a marked elevation (Table 2). Older drivers with a 40% or greater reduction in the useful field of view were 2.1 times more likely to have incurred a crash during the follow-up period compared with those with less than 40% reduction. A significant linear trend (*P*=.03) was observed between crash risk and useful field of view reduction when this term was entered in the model as a continuous variable. For every 10 points of useful field of view reduction, older drivers had a 16% increase in crash risk.

In multivariable analyses, 2 variables were identified as having independent associations with crash risk. Older drivers with 40% or greater reduction in their useful field of view were 2.2 times (95% CI, 1.2-4.1) more likely to have incurred a crash during the follow-up period (Table 3). Older drivers who reported driving fewer than 7 days per week had a 45% (95% CI, 0.3-1.1) decreased crash risk compared with those who reported driving daily.

Further analyses determined whether 1 component of the useful field of view test was primarily responsible for the association between overall useful field of view score and crash involvement, or whether the composite, by aggregating across the subtests, provided a synthesis that could not be captured by any one individual component. Each subtest builds on skills evaluated in the prior subtest, and thus performance in the subtests is nonindependent. The 3 useful field of view test components (processing speed, divided attention, and selective attention) were evaluated separately in terms of an association with crash rate. The range of values for each component is from 0 to 30, with larger values representing greater impairment. To define impairment for each component, cut points were selected based on their distributions. Impaired performance in subtest 1 (visual processing speed) was defined as greater than 0, in subtest 2 (divided attention) as greater than 14, and in subtest 3 (selective attention) as greater than 28. Each component was individually evaluated in multivariable proportional hazards models adjusting for days driven per week, age, race, sex, chronic medical conditions, and mental status (Table 3). The overall composite useful field of view score was not included in these models, and the 3 components were not considered within the same model in order to eliminate colinearity problems. Speed of processing impairment (RR=1.49; 95% CI, 0.9-2.9; *P*=.18) and selective attention impairment (RR=1.10; 95% CI, 0.6-2.0; *P*=.68) were not significantly associated with crash occurrence. However, impairment in the divided attention task was associated with a 2.3-fold (95% CI, 1.2-4.4; *P*=.01) increased risk of crash involvement.

COMMENT

In this study, older drivers with a 40% or greater useful field of view reduction were more than twice as likely to have sustained a crash. A recent population-based study suggests that approximately 1 in 3 older adults has a 40% or greater reduction in useful field of view (G. Rubin, oral communication, 1996).

Driving fewer than 7 days per week was associated with reduced risk for crash involvement, implying a protection for those drivers who drive less than once a day. It is possible that older individuals who do not drive daily are also more likely to avoid driving in conditions that exceed their abilities. There is evidence that older adults who are aware of their visual processing limitations tend to self-regulate when and where they drive, avoiding the most difficult driving situations.[36] For those older drivers with dementia, voluntary reduction in exposure does not seem like a realistic approach. However, for many older adults self-regulation may be an effective means of enhancing safety while maintaining mobility, an issue that deserves further investigation.[36,37]

In recent years, there has been a surge of editorials in medical journals stressing that physicians need tools to assist them in identifying unsafe older drivers.[18,19,38-40] On the basis of available data,[5,7,9] one could argue that the heart of this assessment battery should be functional evaluations of skills relevant to driving. Our results suggest that a useful field of view assessment would be a good candidate for inclusion in a functional test battery. It remains to be determined whether this test battery, if proven to be useful, could be practically implemented in physicians' offices, or would be more appropriate in secondary or tertiary care clinics (eg, driver assessment clinics, eye care specialists, reha-

Table 2.—Distribution of Study Subjects, Crash Rates, Relative Risks (RRs), and 95% Confidence Intervals (CIs) by Visual Processing Variables

Characteristics*	No. (%) With Characteristic	Crash Rate†	*P* Value	RR	95% CI
Visual acuity					
Better than or equal to 20/40	257 (87.4)	6.9	.43	Referent	. . .‡
Worse than 20/40	37 (12.6)	10.0		1.45	0.58-3.64
Log_{10} contrast sensitivity					
>1.5	244 (83.0)	7.2	.76	Referent	. . .
≤1.5	50 (17.0)	6.2		0.87	0.35-2.17
Stereoacuity§					
<500 arcseconds	202 (68.7)	7.5	.42	Referent	. . .
≥500 arcseconds	92 (31.3)	5.7		0.76	0.36-2.74
Central 30°-radius visual field sensitivity‖					
0	257 (87.4)	7.1	.73	Referent	. . .
>10	37 (12.6)	7.0		0.99	0.36-2.74
Peripheral 30°-60°-radius visual field sensitivity‖					
0	183 (62.2)	7.6	.39	Referent	. . .
>10	111 (37.8)	5.8		0.77	0.42-1.40
Disability glare¶					
≤0	158 (53.7)	7.2	.83	Referent	. . .
>0	136 (46.3)	6.8		0.94	0.55-1.62
Useful field of view#					
<40.0	127 (43.1)	4.7	.02	Referent	. . .
≥40.0	187 (56.9)	9.8		2.08	1.15-3.44

*Higher values represent greater impairment except for contrast sensitivity, in which lower values represent greater impairment.

†Crash rate per million person-miles of travel.

‡Ellipses indicate data not applicable.

§TNO test.

‖Average defect depth (d).

¶LogMAR acuity with glare minus logMAR acuity without glare.

#Percent reduction in useful field of view.

Table 3.—Relative Risks (RRs) and 95% Confidence Intervals (CIs) for Motor Vehicle Crashes Among Older Drivers*

Characteristics	*P* Value	RR†	95% CI
Useful field of view‡			
<40.0	.01	Referent	. . .§
≥40.0		2.21	1.20-4.09
Driving, days per week			
7	.08	Referent	. . .
<7		0.55	0.28-1.08

*Multivariable analysis using Cox proportional hazards model.

†Adjusted for age, sex, race, chronic medical conditions, and mental status.

‡Percent reduction in useful field of view.

§Ellipses indicate data not applicable.

bilitation facilities, occupational therapy clinics).

This study has determined that a composite measure of visual processing impairment is a risk factor for future vehicle crashes by older drivers. The question that arises is to what extent can this visual risk be reduced, thus permitting affected older drivers to remain on the road safely? There are older adults whose visual and cognitive impairments are severe and irreversible, and for whom driving cessation is the only viable option. However, many drivers may have deficits that are at least partially reversible through treatment, which can lower their crash risk and allow them to preserve their access to driving. As our earlier work has indicated,[41] older adults with significant visual sensory impairment perform poorly on the useful field of view test because the test relies on adequate vision to detect and discriminate the visual test stimuli. Interventions to improve visual function in older adults (eg, cataract surgery, intraocular lens implantation, correction of refractive error) that dramatically improve vision may also reduce crash risk. With respect to improving visual processing speed and attention skills (2 key components of the useful field of view task), training studies in the laboratory have found significant and enduring improvement of these skills in some older adults.[42] This leads to the question of whether such a cognitive intervention would also improve driving skills. Preliminary evidence indicates that expansion of the useful field of view leads to a decrease in the number of dangerous maneuvers in an on-the-road test, as well as reduced stopping time in a driving simulator.[43] These interventions are practically feasible from an implementation standpoint and deserve further evaluation given the primacy of driving as a mode of travel in our society.

Several study limitations should be redressed in future work. It is possible that subject characteristics measured in 1990 changed during the follow-up period, thus introducing potential for misclassification with respect to the independent variables. Because of their participation in other research studies, repeat measurements for most independent variables were available for a large portion (60%) of the original 294 subjects. These data supported the conclusion that there was little change over the 3-year follow-up period with respect to the variables measured in this study. Another potential limitation is the small number of observed outcome events. During the 3-year follow-up period only a small percentage of subjects experienced a crash. In conjunction with the low prevalence of some variables of interest (eg, chronic medical conditions), this resulted in lack of precision in many of the point estimates. Data were not collected on medication use, which is believed to elevate older drivers' crash risk.[13,14] In addition, information about the functional characteristics of the subjects who refused participation is not available in this study. However, the prevalence of vision impairment in our older driver sample (13% having acuity worse than 20/40) was similar to population-based prevalence estimates for this age group.[44] Finally, about a quarter of our subjects had mild to moderate cognitive impairment as indicated by mental status testing, and there is no information available about the validity of their self-reports of driving exposure, a variable that is crucial in computing crash risk.

With the identification of a significant visual functional risk factor for an older driver's risk of crash involvement, there is reason for optimism that developing a test battery to identify high-risk older drivers is a realistic goal. Such a battery could allow physicians to give valid advice to patients, families, and licensing agencies about an older adult's fitness to drive. The other candidate components of such a battery remain to be determined, but several possibilities are suggested by previous work, such as evaluations of mental status, extremity problems, and use of some medications.[5,7,9,11,13] In addition to risk factor identification, the present challenges are to develop and evaluate an older-driver assessment battery to determine its validity and cost-effectiveness, and to evaluate interventions to reduce crash risk so that older adults may drive for as long as it is safely possible to do so.

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