

Visual Information Capabilities of Older Drivers

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NHTSA Workshop on
Headlamp Safety Metrics:
Balancing Visibility and Glare



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- Research to Prevent Blindness
- EyeSight Foundation of Alabama

Outline

- Rationale
- Approach
- Age-Related Vision Problems That Impact Older Driver Safety

Public Health

- In 1996 there were over 41,000 fatalities and 3.5 million injuries due to vehicle crashes in the U.S.



Injury Prevention

Primary

Operator Behavior

Prevent Crash Event
(Hazard Avoidance)

Before

Secondary

Occupant Protection

Prevent Injury
(Seatbelt, Airbags)

During

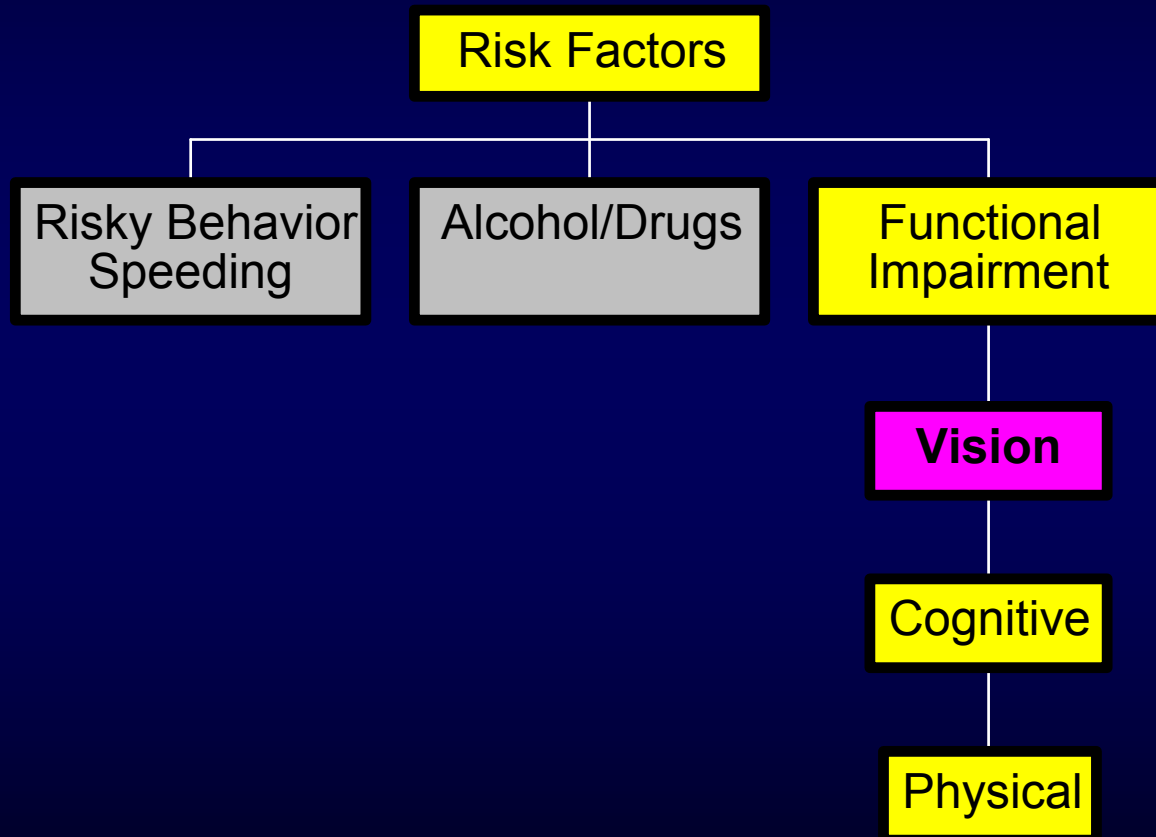
Tertiary

Trauma Care

Prevent Chronic
Disability
(Emergency, Surgery)

After

Operator Causes

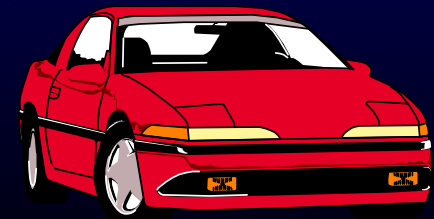


Older Drivers

- For every 100,000 miles driven, older adults have a higher crash rate than do other ages.
- Fastest growing group of drivers.
- More likely to suffer disabling condition or die from collision.

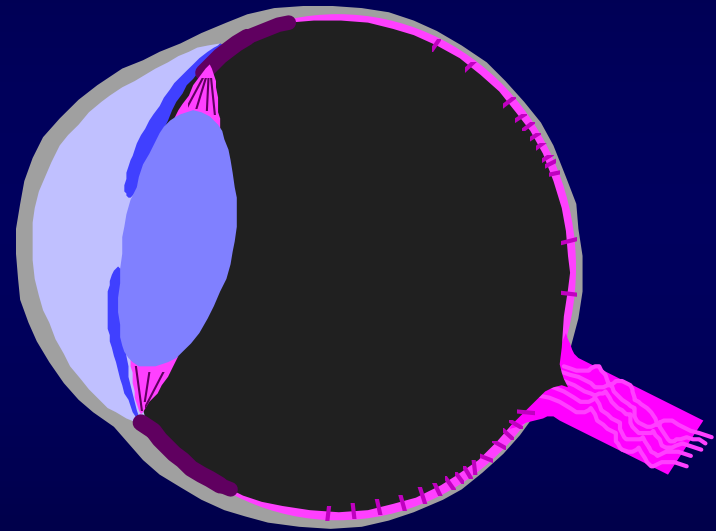
Driving and Quality of Life

- Driving is primary mode of transportation.
- Symbol of personal independence.
- Driving cessation is linked to depression and social isolation.
- The importance of safety must be balanced with the need for personal mobility.



Vision and Older Adults

- Vision impairment and eye disease are much more prevalent in later life.
- How does this impact visibility during driving?



Approach

- Review types of vision impairment in older adults that are associated with reduced driver safety and problems in driving performance.

Cataract

- Cataract is the most common, vision-threatening eye condition in older adults.
- Even though treatable, many older adults are on the road until the time of surgery.
- How does cataract impact driving habits and crash risk?

Overall Aim of ICOM Project

- Impact of Cataracts on Mobility (ICOM)
- Can cataract surgery and improved vision reduce crash risk, reduce driving difficulty, and expand driving mobility in older adults?



Study Design

**Visit 1
Baseline**

**Annual
Follow-up 1**

**Annual
Follow-up 2**

**Cataract
Surgery
N=187**



**Cataract
No Surgery
N=101**



**No Cataract
(Control)
N=102**



Illustration



Reduced visibility while driving (decreased in resolution, contrast sensitivity and increased glare).

Cataract elevates crash risk in older drivers.



Older Drivers and Cataract: Driving Habits and Crash Risk

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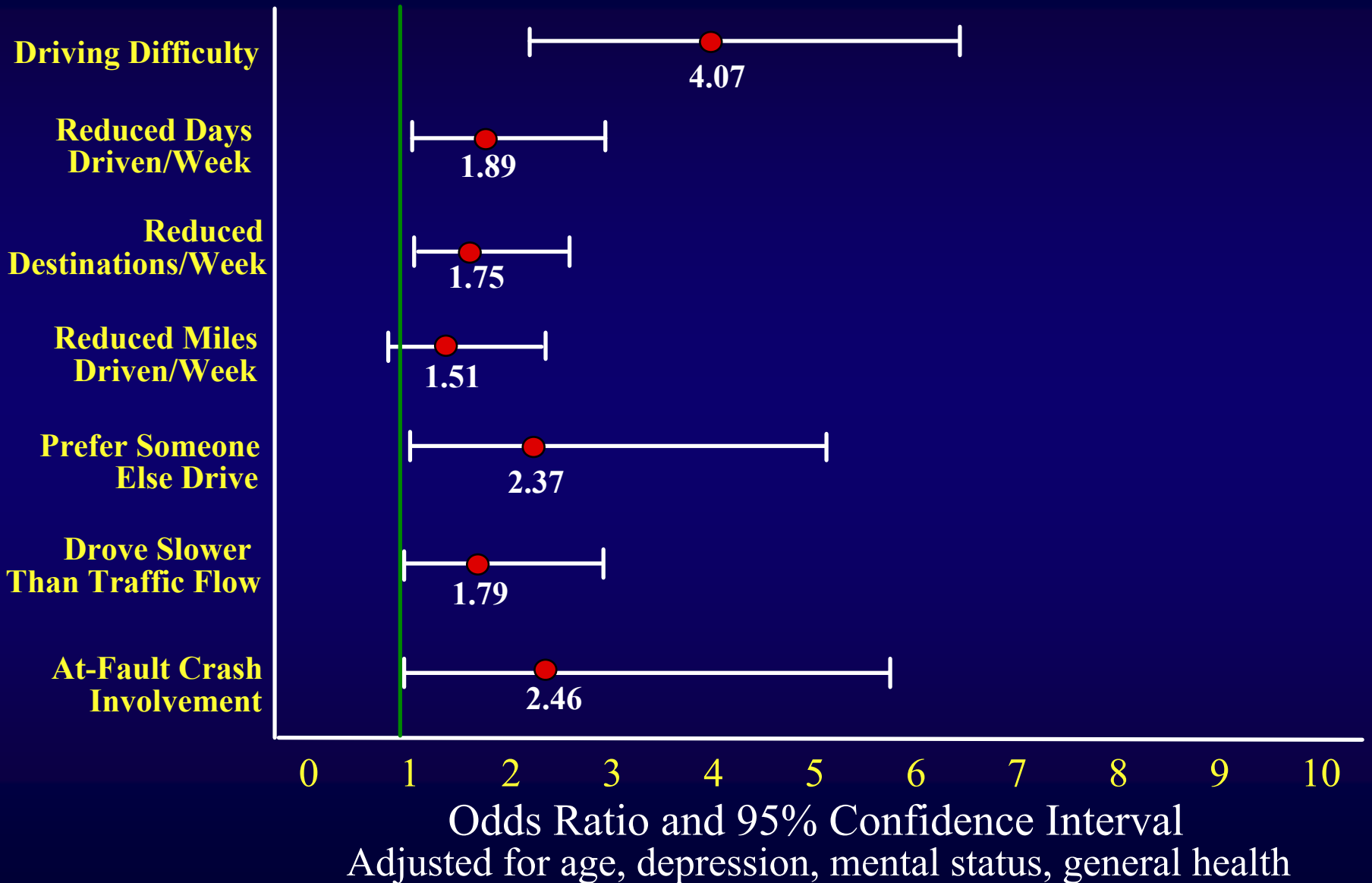
Background. Cataract is a leading cause of vision impairment in older adults, affecting almost half of those over age 75 years. Driving is a highly visual task and, as with other age groups, older adults rely on the personal automobile for travel. The purpose of this study was to examine the role of cataract in driving.

Methods. Older adults (aged 55–85 years) with cataract ($n = 279$) and those without cataract ($n = 105$) who were legally licensed to drive were recruited from eye clinics to participate in a driving habits interview to assess driving status, exposure, difficulty, and "space" (the distance of driving excursions from home base). Crash data over the prior 5 years were procured from state records. Visual functional tests documented the severity of vision impairment.

Results. Compared to those without cataract, older drivers with cataract were approximately two times more likely to report reductions in days driven and number of destinations per week, driving slower than the general traffic flow, and preferring someone else to drive. Those with cataract were five times more likely to have received advice about limiting their driving. Those with cataract were four times more likely to report difficulty with challenging driving situations, and those with driving difficulty were two times more likely to reduce their driving exposure. Drivers with cataract were more likely to have a history of at-fault crash involvement in the prior 5 years (adjusted for miles driven, age, sex, and education). Associations remained even after adjustments for the confounding effects of driving exposure, age, sex, and education.

Owsley et al. *Journal of Gerontology: Medical Sciences* 1999;54A, M203-M211.

Baseline Associations Between Cataract and Driving



Severely impaired contrast sensitivity is what elevates crash risk in older drivers with cataract.

Severe contrast sensitivity impairment is defined as Pelli-Robson score of 1.25 or worse.

Visual Risk Factors for Crash Involvement in Older Drivers With Cataract

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Michael E. Sloane, PhD; Gerald McGwin, Jr, PhD

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 Cataract on Mobility project. A series of logistic regression analyses were conducted to determine the relationship between visual impairment and crash involvement. The study was conducted in a community-based setting.

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 than those who were not involved in a crash. Drivers with a history of crash involvement were 8 times more likely to have a serious contrast sensitivity deficit than those who were not involved in a crash.

Owsley et al. *Archives of Ophthalmology* 2001; 119- 881-887.

Visual Predictors of Crash Involvement

<u>Variable</u>	<u>OR</u>	<u>95% CI</u>
VA 20/25-20/30	0.19	0.03-1.27
20/35-20/50	0.82	0.19-3.61
worse than 20/50	0.74	0.16-3.52
CS >1.35 - 1.50	3.18	0.71-14.17
>1.25 - 1.35	4.36	0.84-22.70
1.25 or worse	7.86	1.55-39.79
Dis Glare > 0.25	0.62	0.29-1.33

Adjusted for age, gender, cognitive status, driving exposure, other aspects of visual function.

Crash Risk When One Vs. Both Eyes Impaired

Visual Function	OR (95% CI)
VA 1 Eye Impaired	1.35 (0.58-3.15)
Both Impaired	1.01 (0.29-3.45)
CS 1 Eye Impaired	2.70 (1.16-6.51)
Both Impaired	5.78 (1.87-17.86)
DG 1 Eye Impaired	0.67 (0.30-1.48)
Both Impaired	0.46 (0.14-1.53)

Reference is no impairment in either eye. Adjusted for age, race, mental status, gen'l health, driving expos, and other visual functions.

Cataract surgery reduces crash risk by 50%.

Impact of Cataract Surgery on Motor Vehicle Crash Involvement by Older Adults

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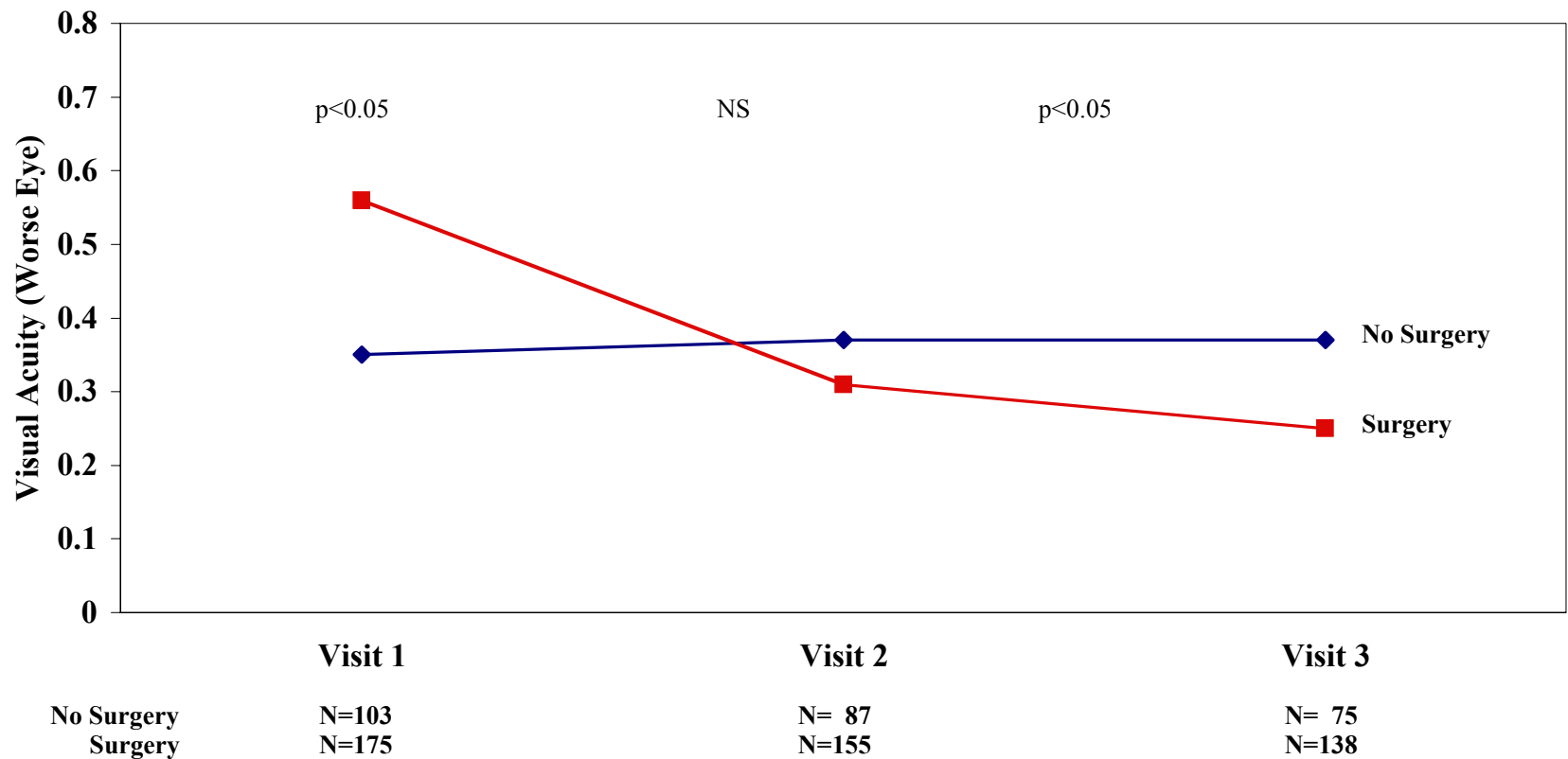
Context Motor vehicle crash risk in older drivers is elevated in those with cataract, a condition that impairs vision and is present in half of adults aged 65 years or older.
Objective To determine the impact of cataract surgery on the crash risk for older adults in the years following surgery, compared with that of older adults who have cataract but who elect to not have surgery.
Design, Setting, and Patients Prospective cohort study of 277 patients with cataract, aged 55 to 84 years at enrollment, who were recruited from 12 eye clinics in Alabama from October 1994 through March 1996, with 4 to 6 years of follow-up (March 1999).

Main Outcome Measure Police-reported crash involvement among patients who elected to have surgery (n = 103) and among patients who did not have surgery (n = 174) with the no surgery group. The odds ratio for crash involvement was 0.47 (95% confidence interval, 0.28-0.78).

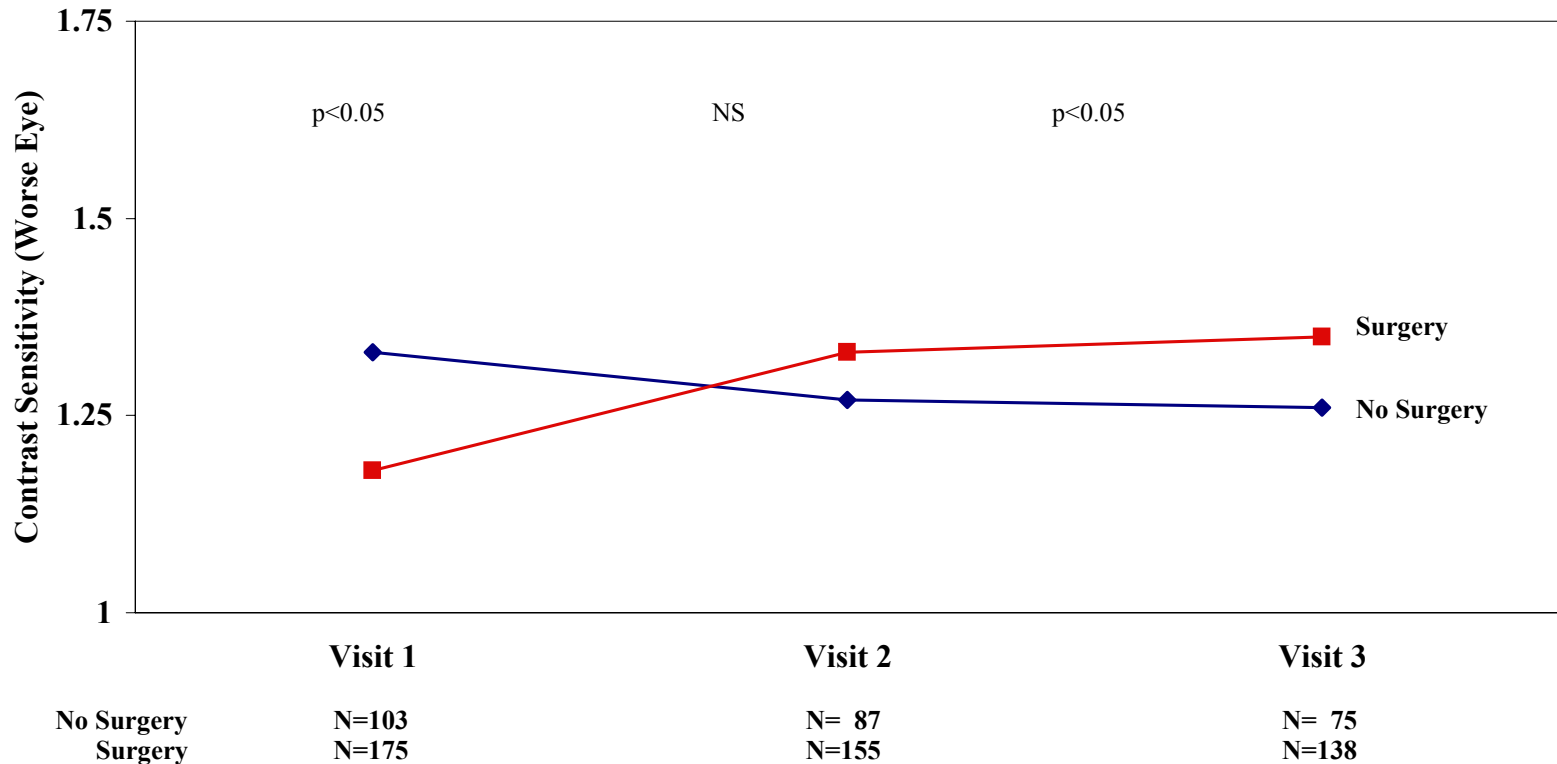
CATARACT IS THE LEADING cause of vision impairment in older adults in the United States.¹ Population-based studies indicate that approximately 50% of older adults aged 65 to 74 years have cataract, with a higher percentage of older adults aged 75 years and older having cataract.²

Owsley et al. *JAMA* 2002; 288: 841-849.

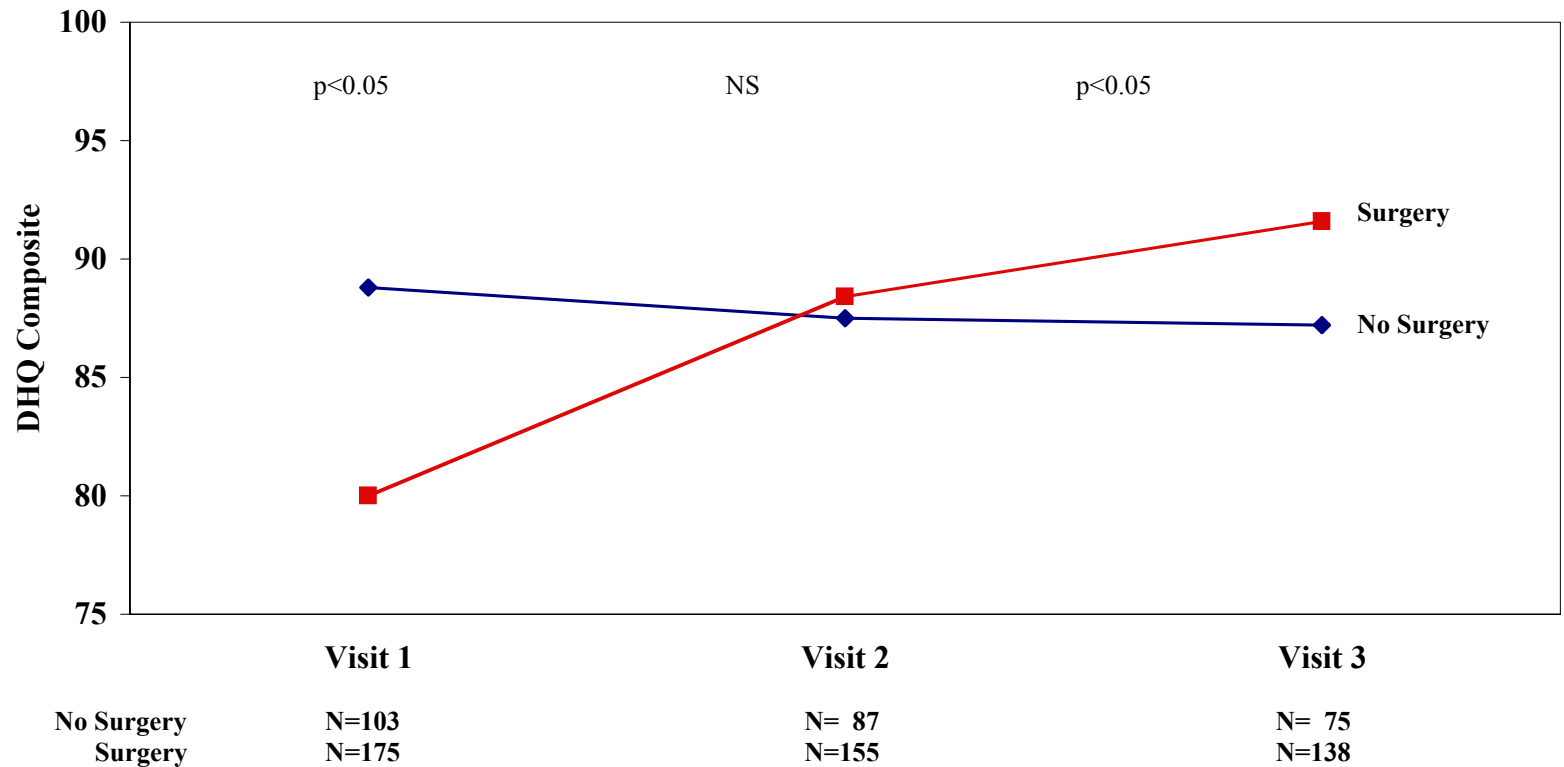
Visual Acuity over time

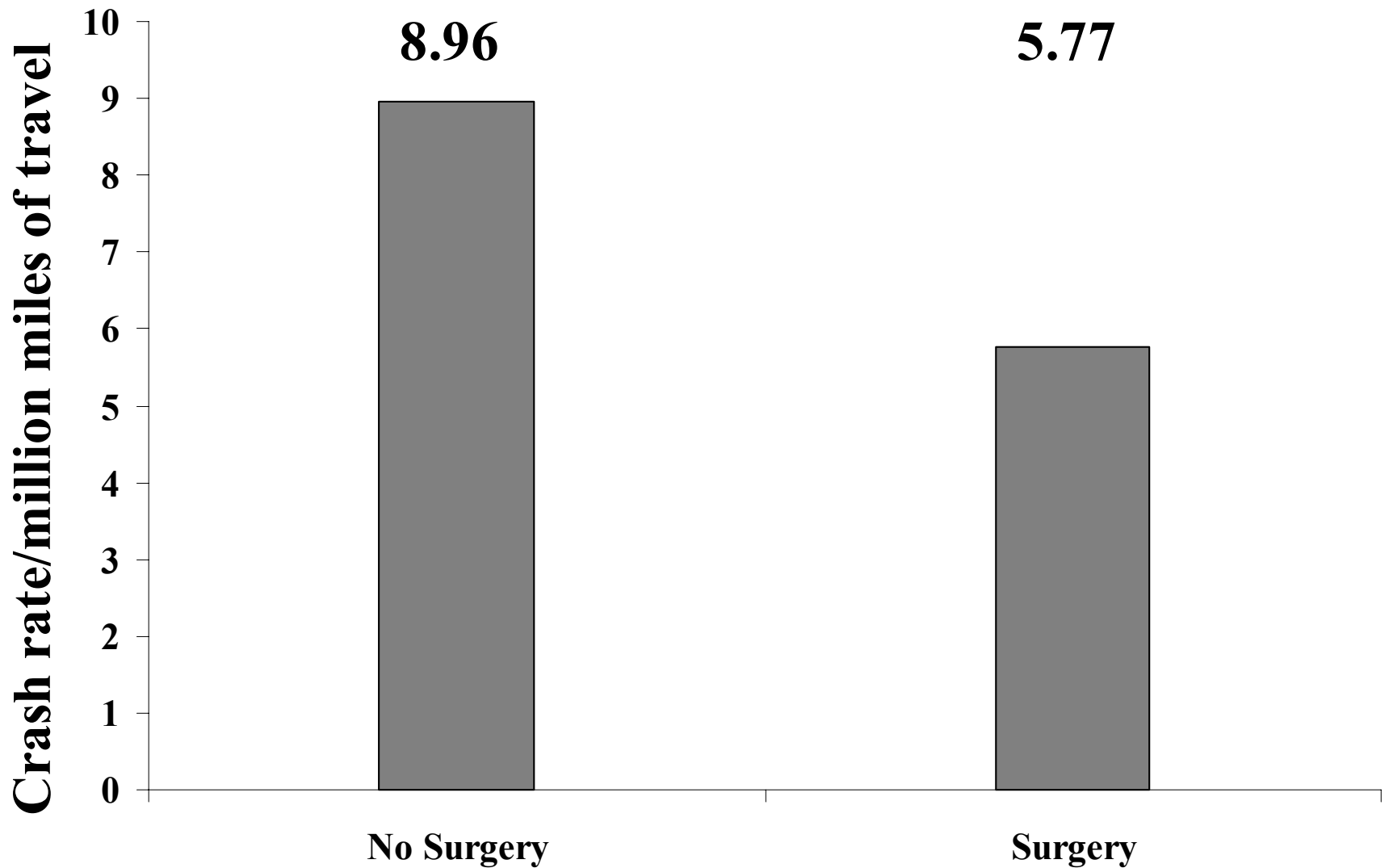


Contrast Sensitivity over time



Driving Difficulty over time





There was a **50% reduction in crash rate** when statistical adjustments carried out.

Glaucoma

- Persons with glaucoma report more difficulty driving than those free of disease.
- Glaucoma causes loss of peripheral vision.
- But relatively little is known about the driving habits and crash risk of those with glaucoma.

Visual Field Loss

- Severe binocular field loss doubles crash risk.
- Severe constriction in visual fields impairs driving performance (obstacle detection).

Objective

- Evaluate relationship between glaucoma and the risk of motor vehicle collision involvement in older drivers.
- Evaluate relationship between glaucoma and avoidance of challenging driving situations.

Study Design

- Retrospective cohort study.
- Those seen in three UAB-affiliated eye care practices between 1994-95.
- Follow-up until December 1999.

Study Cohort ₁

- ≥ 55 years old.
- Licensed to drive in Alabama.
- Those with glaucoma defined by:
 - ICD-9 codes of 365.1 and 365.2 and subsequent medical record confirmation.
 - Glaucoma was primary eye problem.

Study Cohort ₂

- Reference group were those with no diagnosis of glaucoma.
- No ocular diagnoses in medical record other than refractive error, dry eye, or early cataract.

Data Sources

- Medical record
- Telephone survey
- Alabama Department of Public Safety

Telephone Survey

- Conducted between February and June 2000.
- Respondent asked to reference answer to 1995.
- Content
 - Demographics
 - Alcohol use
 - Smoking
 - Medical co-morbidities
 - Driving habits

Driving Habits Questionnaire

- Driving exposure
 - Weekly mileage
- Driving avoidance
 - Night, fog, rain, alone, rush hour, highway/freeway, with children, high density traffic, passing cars, changing lanes, left turns, parallel parking.
 - Always, often, sometimes, rarely, never.
 - Avoidance = always or often.

Motor Vehicle Collision (MVC) Outcome

- All MVCs and At-fault MVCs.
- Crash rate
- Number of crashes during follow-up period (1994/95 thru 1999).
- Two denominators used.
 - Person-years of driving defined as period of time from subject's first exam to end of follow-up.
 - Person-miles of driving: product of person-years and each driver's estimated annual mileage.

Results: Total MVCs

<i>From State Records</i>	Total MVCs	Person-Miles of Driving	Crash Rate	Crude RR (95%CI)	Adjusted RR (95% CI)
Glaucoma	153	26,697,441	5.73	0.64 (0.46-0.90)	0.67 (0.47-0.97)
Non-Glauc	42	4,691,277	8.95	reference	reference
		Person-Time of Driving	Crash Rate	Crude RR (95%CI)	Adjusted RR (95% CI)
Glaucoma	153	3,165	4.83	.59 (0.41-0.84)	0.58 (0.40-0.85)
Non-Glauc	42	530	7.92	reference	reference

Results: At-Fault MVCs

<i>From State Records</i>	Total MVCs	Person-Miles of Driving	Crash Rate	Crude RR (95%CI)	Adjusted RR (95% CI)
Glaucoma	87	26,697,441	3.26	1.09 (0.62-1.92)	1.22 (0.67-2.22)
Non-Glauc	14	4,691,277	2.98	reference	reference
		Person-Time of Driving	Crash Rate	Crude RR (95%CI)	Adjusted RR (95% CI)
Glaucoma	87	3,165	2.75	1.04 (0.59-1.85)	1.07 (0.59-1.96)
Non-Glauc	14	530	2.64	reference	reference

Driving Avoidance ₁

<i>From Survey</i>	Glauc	No Glauc	Adjusted OR (95% CI)
Night	44.1%	29.6	2.06 (1.11-3.82)
Fog	49.1	27.0	3.80 (1.93-7.48)
Rain	32.6	20.9	2.99 (1.32-6.76)
Rush hour	42.7	32.2	2.24 (1.16-4.34)
Interstate/freeway	33.5	20.0	2.81 (1.28-6.46)
High density	37.2	21.7	2.88 (1.28-6.46)

Driving Avoidance ₂

<i>From Survey</i>	Glauc	No Glauc	Adjusted OR (95% CI)
Alone	9.2%	6.1%	1.32 (0.41-4.25)
With children	14.1	8.7	1.42 (0.55-3.68)
Passing cars	21.2	17.4	1.45 (0.59-3.54)
Changing lanes	19.4	16.5	1.94 (0.71-5.31)
Left turns	8.5	3.5	2.56 (0.69-9.52)
Parallel parking	28.8	27.0	1.20 (0.61-2.37)

Conclusions

- Older drivers with a Dx of glaucoma had rate of crash involvement that was 40-50% lower than that of drivers without glaucoma.
- For at-fault crashes, the crash rate for those with glaucoma was not different than for drivers without glaucoma.

Implications

- Older drivers with glaucoma as a group should not be considered as more unsafe on the road than older drivers free of glaucoma.
- Drivers with glaucoma appear to self-regulate their driving.
 - However, their reduced MVC rate cannot be explained by this self-regulation ---- avoiding challenging driving situations.

Future Directions

- Now examining how visual field loss and medication usage relates to MVC involvement, using this same cohort.
- Recently completed a study on how varying degrees of visual field loss impacts on-road driving performance.

Diabetic Retinopathy

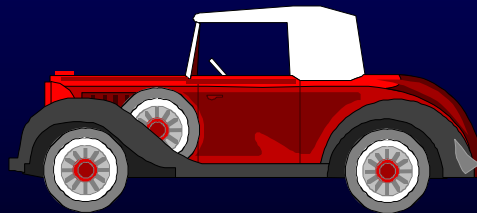
- Very few studies; those that do exist are inconclusive.
- Causes absolute and relative scotomas throughout the visual field.
- Several studies have addressed whether diabetes (not diabetic retinopathy) is risk factor for crash involvement. Contradictory results.

Age-Related Macular Degeneration

- No well-designed studies have focused on crash risk.
- No well-designed studies have focused on the use of bioptics by AMD drivers with severe VA impairment.
- Recent study on driving habits and quality of life in AMD patients presenting for low vision services at UAB Low Vision Clinic.

AMD, Driving, Quality of Life

- Those with advanced AMD who stopped driving experience decreased quality of life.
- About 20% of AMD patients (wt 20/100 BE) seen in low vision clinic reported that they still drove!



Visual Acuity

Visual Acuity

- Most ubiquitous visual screening test already in use, both at initial licensure and at re-screening.
- Studies are split, some finding association between VA and crash involvement while others don't.
- Even when positive finding, association is **WEAK**, suggesting that poor screening test.
- VA impairment is related to highway sign legibility.

Why poor association between VA and Crashing?

- Acuity tests do not reflect visual complexity of driving environment; other visual skills may be more important.
- Studies based on existing drivers; poor VA drivers may have been screened out already.
- Self-regulation: those with poor VA tend to stop driving.

Implication

- VA deficit is probably not a threat to safe driving until VA impairment worse than 20/80 or 20/100.

Visual Processing Speed and Attention

- Two of the most common visual problems of late adulthood are:
 - Slowing in visual processing speed.
 - Impaired ability to divide attention.
- Estimated that at least 1 of 3 older adults have severe deficits in these areas.
- Both of these abilities appear on face validity to be important in driving.

Related to Safety and Performance Problems

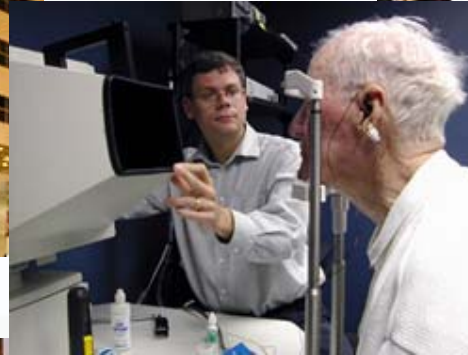
- Slowed processing speed and divided attention impairment are associated with an increased rate of crash involvement (2-fold elevation in crash risk)
- Also related to driving performance problems (e.g., obstacle detection).
- On a population-basis, they are probably more detrimental to safe driving than are visual sensory problems.

Summary

- Biggest visibility problem for older drivers stems from impairment in contrast sensitivity.
- Visual field loss does not threaten safe driving unless it is bilateral and severe.
- Acuity impairment to 20/80 to 20/100 is not a significant problem for older drivers unless the task is reading road signs.
- Slowed visual processing speed and impaired ability to divide attention are common in older adults and are major contributors to unsafe driving.

<http://www.eyes.uab.edu>

Eye
Vision



Clinical Research Unit
UAB Ophthalmology