Sensory Impairment and Driving: The Blue Mountains Eye Study

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ABSTRACT

Objectives. This study examined the associations between vision, hearing loss, and car accidents.

Methods. A cross-sectional survey of 3654 people aged 49 years and older in the Blue Mountains, Australia, was used. Each subject had a detailed eye examination and interview.

Results. Self-reported car accident rates in the past year among 2379 current drivers were 5.6% for those aged 49 to 79 years and 9.1% for those 80 years and older. A 2-line difference in visual acuity was associated with increased risk of accidents (adjusted prevalence ratio [PR] = 1.6), as was visual acuity worse than 6/18 in the right eye (PR = 2.0), overall moderate hearing loss (PR = 1.9), and hearing loss in the right ear (PR = 1.8).

Conclusions. Sensory loss in drivers may be an important risk factor for car accidents. (*Am J Public Health.* 1999;89:85–87)

Drivers older than 79 years have a higher accident rate when the rate is measured as a function of exposure, have accidents with more severe and more often fatal consequences, and are more often judged as legally responsible for causing an accident than are younger drivers.[1] In recognition of the role that vision plays in driving, most countries include a test of visual acuity in the licensing procedure for car drivers. However, hearing impairment is not seen as a barrier to safe driving: in Australia, totally deaf individuals may hold a driver's license.[2]

We aimed to describe the driving habits of a defined older population living in the Blue Mountains, west of Sydney, Australia, and to examine the association between different types of visual impairment, self-reported problems with hearing, and self-reported car accidents.

Methods

The Blue Mountains Eye Study is a population-based survey of eye disease in 2 postcode areas in the Blue Mountains, west of Sydney, Australia. Details of the survey methods and procedures have been described elsewhere.[3–5] Briefly, all noninstitutionalized residents aged 49 years or older were identified by a private census. Of 4433 eligible residents, 3654 (82.4%) attended the eye examination.

Subjects completed an interviewer-administered questionnaire. They were asked about their driving habits, accidents in the last year, and hearing. A detailed eye examination was conducted, including subjective refraction,[4] the Humphrey 76-point suprathreshold screening visual field test (Humphrey Instruments, Inc, San Leandro, Calif),[5] and lens photography.[6,7] The contrast sensitivity of all subjects from the first postcode area (n = 2381) was measured with the Vectorvision CSV-1000 chart (Vectorvision, Inc, Dayton, Ohio).

Prevalence ratios[8–10] adjusted for age and sex were calculated; 95% confidence intervals are presented in this report. Appropriate clinical cutpoints were used to categorize all variables except for contrast sensitivity, which was dichotomized at the third quartile.

Results

There were 3654 participants in the Blue Mountains Eye Study; of these, 2379 (65.1%) reported that they were current drivers. People of both sexes tended to give up driving as they got older (31.6% of men and 29.8% of women aged 80 and over reported having given up driving, compared with 4.5% of men and 8.7% of women aged 49 to 59 years). There were few people driving with poor visual acuity and even fewer after refraction (Table 1).

Of people who had stopped driving, 51 (11.5%) reported that they had stopped because of problems with their vision. Their vision was worse than that of people who gave up driving for other reasons: best-eye visual acuity was 33.1 letters and 45.9 letters, respectively ($P = .0001$).

Of 2326 current drivers who answered questions about motor vehicle accidents, 134 (5.8%) reported an accident in the past 12 months. The percentage of people having car accidents was 5.8% for people aged 49 to 59 years, 5.5% for those aged 60 to 69 years, 5.4% for those aged 70 to 79 years, and 9.1% for those aged 80 years and over.

Table 2 shows associations between visual acuity, contrast sensitivity, hearing loss, and self-reported car accidents; some of these associations were statistically significant. Visual field was not associated with increased risk of accidents, nor was the presence of cataract (data not shown). Of study participants, 37.7% reported having hearing loss.

Discussion

Findings from past studies of vision and car accidents have been conflicting. Some studies have found that impaired visual acuity is predictive of road accidents,[11] while others have found only weak associations.[12,13] Some

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have suggested that tests of visual acuity are inadequate predictors of car accidents[12] and have proposed using visual field,[14] visual attention,[15] or a combination of measures.[16]

The New South Wales Roads and Traffic Authority requires that newly licensed drivers have a corrected visual acuity of 20/40 in at least 1 eye or 20/60 overall for the renewal of a license.[2] Our study found that most people in the community drove within the legal limits for visual acuity, or would have with a new spectacles correction.

Visual acuity worse than 20/60 in the right eye was associated with accidents, as was reduced contrast sensitivity in the right eye (at 1 spatial frequency). Hearing impairment in the right ear was also found to be associated with accidents. These findings highlight the important role that the right eye and ear may play in detecting hazards on the right side of a driver in a country with right-hand-drive vehicles traveling on the left side of the road. Davison found a similar result when looking at the visual acuity of British drivers, who also travel on the left side of the road.[17]

We found that difference in acuity between the eyes was associated with accidents, although previous research found that monocularity has minimal impact on driving performance.[18–20] A difference in acuity between the eyes may represent poor depth perception.

Visual field impairment was not associated with accidents. Perhaps our measure of visual field was insufficiently sensitive to detect an effect, given that other studies have found associations.[14,21]

The relationship between hearing loss and accidents is not clear. Colsher and Wallace noted that hearing plays a role in driving,[22] but Gresset and Meyer found that elderly drivers with hearing impairments were not at added risk of car accidents.[23] McCloskey et al. found that while impaired hearing was not associated with increased risk of accidents, wearing a hearing aid was.[12]

The main limitation of our study is that it was cross-sectional, meaning that it is difficult to assess temporal associations. We did not measure and control for variables such as driving experience and kilometers driven (also possible intervening variables), or type or severity of accident. Neither did we assess the cognitive function of drivers, which has been shown to be a good predictor of driving skills.[24] We used self-reports of car accidents rather than state records; Marottoli et al. suggested that self-reported accidents may be a reasonable alternative to state-recorded accidents.[25] It is likely that self-reporting of accidents may lead to differential underreporting of accidents by people with poor vision. We also relied on self-report of hearing impairment, which is likely to underestimate its prevalence.

This study found that after having their spectacles prescription updated, most elderly people living in an Australian community who still drove were within the legal visual acuity standard. Our results for both visual and hearing impairment on the right side need to be confirmed by studies finding an increased accident risk for impairment on the left side in countries with right-side driving. □

TABLE 1—Number and Percentage of Subjects Still Driving With Reduced Visual Acuity in the Better Eye: Blue Mountains Eye Study, Australia, 1992–1994

Age	Visual Acuity in Better Eye	Presenting Vision Women n (%)	Presenting Vision Men n (%)	Best Corrected Vision Women n (%)	Best Corrected Vision Men n (%)
49–59 y	<20/40	9 (2.3)	12 (3.0)	2 (0.5)	0 (0)
	<20/60	2 (0.5)	0 (0)	0 (0)	0 (0)
60–69 y	<20/40	8 (1.9)	25 (4.9)	2 (0.5)	0 (0)
	<20/60	1 (0.2)	9 (1.8)	1 (0.2)	0 (0)
70–79 y	<20/40	21 (9.1)	31 (9.7)	4 (1.7)	6 (1.9)
	<20/60	3 (1.3)	10 (3.1)	0 (0)	0 (0)
≥80 y	<20/40	8 (21.6)	14 (18.7)	3 (8.1)	3 (4)
	<20/60	2 (5.4)	0 (0)	1 (2.7)	0 (0)
Total	<20/40	46 (4.3)	82 (6.3)	11 (1.0)	9 (0.69)
	<20/60	8 (0.7)	19 (1.5)	2 (0.19)	0 (0)

TABLE 2—Association Between Tests of Visual Function, Self-Reported Hearing Impairment, and Self-Report of Car Accidents in the Past Year in Subjects Reporting They Are Still Driving: Blue Mountains Eye Study, Australia, 1992–1994

Variable	n (%)	Age/Sex Adjusted PR	Age/Sex Adjusted 95% CI	Age/Sex Adjusted P^b	Adjusted[a] PR	Adjusted[a] 95%CI	Adjusted[a] P^b
Visual acuity							
Best eye ≥20/40	2199 (94.5)	1.0	Reference		1.0	Reference	
Best eye <20/40–20/60	100 (4.3)	1.3	0.6, 2.6		1.3	0.6, 2.8	
Best eye <20/60	27 (1.2)	1.4	0.4, 5.4	.3	1.2	0.3, 5.0	.5
Right eye ≥20/40	2021 (86.9)	1.0	Reference		1.0	Reference	
Right eye <20/40–20/60	166 (7.1)	0.7	0.3, 1.5		0.7	0.3, 1.6	
Right eye <20/60	139 (6.0)	2.2	1.3, 3.5	.01	2.0	1.2, 3.5	.06
Left eye ≥20/40	2033 (87.4)	1.0	Reference		1.0	Reference	
Left eye <20/40–20/60	175 (7.5)	1.0	0.6, 1.9		1.1	0.5, 2.0	
Left eye <20/60	118 (5.1)	1.0	0.5, 2.1	.8	1.1	0.5, 2.4	.8
Difference between eyes							
<5 letters	1248 (52.5)	1.0	Reference		1.0	Reference	
5–9 letters	592 (24.9)	1.1	0.7, 1.6		1.0	0.6, 1.6	
≥10 letters	539 (22.7)	1.6	1.0, 2.3	.02	1.6	1.0, 2.4	.04
Contrast sensitivity[c]							
Best eye							
3 CPD	229 (14.8)	1.3	0.8, 2.2		1.3	0.7, 2.2	
6 CPD	249 (15.9)	1.3	0.8, 2.2		1.2	0.7, 2.1	
12 CPD	335 (21.4)	1.3	0.8, 2.1		1.4	0.8, 2.3	
18 CPD	392 (25.3)	1.4	0.9, 2.2		1.4	0.9, 2.3	
Right eye							
3 CPD	358 (23.2)	1.2	0.8, 1.9		1.2	0.8, 1.9	
6 CPD	408 (26.1)	0.9	0.6, 1.5		1.0	0.6, 1.5	
12 CPD	352 (22.6)	1.9	1.2, 2.9		2.0	1.2, 3.1	
18 CPD	299 (19.4)	1.2	0.8, 2.0		1.3	0.8, 2.2	
Left eye							
3 CPD	410 (26.5)	1.1	0.7, 1.7		1.0	0.6, 1.6	
6 CPD	353 (22.6)	1.0	0.6, 1.7		1.1	0.6, 1.7	
12 CPD	306 (19.6)	1.3	0.8, 2.2		1.3	0.8, 2.2	
18 CPD	549 (35.6)	1.2	0.8, 1.9		1.3	0.8, 2.1	

(Continued)

Contributors

Ms Ivers planned this study, analysed the data, and wrote the paper. Dr Mitchell designed the eye study, including the questionnaire, and examined all participants. Dr Cummings assisted with study design. Both

TABLE 2—*Continued*

Variable	n (%)	Age/Sex Adjusted PR	Age/Sex Adjusted 95% CI	Age/Sex Adjusted P^b	Adjusted[a] PR	Adjusted[a] 95%CI	Adjusted[a] P^b
Hearing loss							
Yes vs no	866 (37.5)	1.4	1.0, 2.0		1.5	1.0, 2.1	
None	1444 (63.4)	1.0	Reference		1.0	Reference	
Mild	559 (24.5)	1.2	0.8, 2.5		1.1	0.7, 1.7	
Moderate	187 (8.2)	1.9	1.1, 3.2		1.9	1.1, 3.3	
Severe	88 (3.9)	1.6	0.7, 3.6	.03	1.5	0.7, 3.4	.02
Moderate/severe vs mild	275 (33.0)	1.5	0.9, 2.5		1.7	1.0, 2.9	
Left ear only	171 (7.6)	1.2	0.6, 2.3		1.2	0.6, 2.4	
Right ear only	138 (6.1)	1.9	1.1, 3.4		1.8	1.0, 3.4	
Both ears	511 (22.6)	1.4	0.9, 2.1		1.3	0.9, 2.0	
Use of hearing aid[d]	103 (6.7)	1.6	0.7, 3.7		1.6	0.7, 3.6	
Trouble hearing conversation vs none	656 (28.8)	0.9	0.6, 1.4		1.0	0.7, 1.5	
Tinnitus vs none	511 (22.4)	1.3	0.9, 1.9		1.4	0.9, 2.0	

Note. PR = prevalence ratio; CI = confidence interval; CPD = cycles per degree.
[a]Adjusted for age; sex; past and current use of benzodiazepines, phenothiazines, and antidepressants; self-reported history of stroke, arthritis, angina, heart attack, hypertension, and diabetes; health status; and hearing impairment.
[b]*P* for trend.
[c]Reference group ≤2 units compared with >2 on a scale of 1–8.
[d]Vs no hearing loss.

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References

1. *Older Driver Risks and Countermeasures: Source Book.* Canberra, Australia: Federal Office of Road Safety; 1996. Publication CR 163.
2. *Drivers and Riders: Guidelines for Medical Practitioners.* 3rd ed. Sydney, Australia: Roads and Traffic Authority, New South Wales; 1993.
3. Mitchell P, Smith W, Attebo K, Wang JJ. Prevalence of age-related maculopathy in Australia: the Blue Mountains Eye Study. *Ophthalmology.* 1995;102:1450–1460.
4. Attebo K, Mitchell P, Smith W. Visual acuity and the causes of visual loss in Australia: the Blue Mountains Eye Study. *Ophthalmology.* 1996;103:357–364.
5. Mitchell P, Smith W, Attebo K, Healey PR. Prevalence of open-angle glaucoma in Australia: the Blue Mountains Eye Study. *Ophthalmology.* 1996;103:1661–1669.
6. Klein BE, Klein R, Linton KL, Magli YL, Neider MW. Assessment of cataracts from photographs in the Beaver Dam Eye Study. *Ophthalmology.* 1990;97:1428–1433.
7. Mitchell P, Cumming RG, Attebo K, Panchapakesan J. Prevalence of cataract in an Australian population: the Blue Mountains Eye Study. *Ophthalmology.* 1997;104:581–588.
8. Lee J. Odds ratio or relative risk for cross-sectional data? *Int J Epidemiol.* 1994;23:201–203.
9. Lee J, Chia KS. Estimation of prevalence rate ratios for cross sectional data: an example in occupational epidemiology. *Br J Ind Med.* 1993;50:861–862.
10. Lee J. Estimation of prevalence rate ratios from cross-sectional data: a reply. *Int J Epidemiol.* 1995;24:1066–1067.
11. Humphriss D. Three South African studies on the relation between road accidents and drivers' vision. *Ophthalmic Physiol Opt.* 1987;7:73–79.
12. McCloskey LW, Koepsell TD, Wolf ME, Buchner DM. Motor vehicle collision injuries and sensory impairments of older drivers. *Age Ageing.* 1994;23:267–273.
13. Gresset JA, Meyer FM. Risk of accidents among elderly car drivers with visual acuity equal to 6/12 or 6/15 and lack of binocular vision. *Ophthalmic Physiol Opt.* 1994;14:33–37.
14. Johnson CA, Keltner JL. Incidence of visual field loss in 20,000 eyes and its relationship to driving performance. *Arch Ophthalmol.* 1983;101:371–375.
15. Ball K, Owsley C, Sloane ME, Roenker DL, Bruni JR. Visual attention problems as a predictor of vehicle crashes in older drivers. *Invest Ophthalmol Vis Sci.* 1993;34:3110–3123.
16. Decina LE, Staplin L. Retrospective evaluation of alternative vision screening criteria for older and younger drivers. *Accid Anal Prev.* 1993;25:267–275.
17. Davison PA. Inter-relationships between British drivers' visual abilities, age and road accident histories. *Ophthalmic Physiol Opt.* 1985;5:195–204.
18. McKnight AJ, Shinar D, Hilburn B. The visual and driving performance of monocular and binocular heavy-duty truck drivers. *Accid Anal Prev.* 1991;23:225–237.
19. Wood JM, Troutbeck R. Effect of visual impairment on driving. *Hum Factors.* 1994;36:476–487.
20. Wood JM, Troutbeck R. Elderly drivers and simulated visual impairment. *Optom Vis Sci.* 1995;72:115–124.
21. North RV. The relationship between the extent of visual field and driving performance—a review. *Ophthalmic Physiol Opt.* 1985;5:205–210.
22. Colsher PL, Wallace RB. Geriatric assessment and driver functioning. *Clin Geriatr Med.* 1993;9:365–375.
23. Gresset J, Meyer F. Risk of automobile accidents among elderly drivers with impairments or chronic diseases. *Can J Public Health.* 1994;85:282–285.
24. Fitten LJ, Perryman KM, Wilkinson CJ, et al. Alzheimer and vascular dementias and driving. A prospective road and laboratory study. *JAMA.* 1995;273:1360–1365.
25. Marottoli RA, Cooney LM Jr, Tinetti ME. Self-report versus state records for identifying crashes among older drivers. *J Gerontol.* 1997;52:M184–M187.