Determining the validity of the AMA guide: A retrospective analysis of the Assessment of Driving Related Skills and crash rate among older drivers

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Running title: Guide for assessing older drivers

Abstract

Background: Chronic health conditions associated with aging can lead to changes in driving ability. The Canadian Driving Research Initiative for Vehicular Safety in the Elderly (Candrive II) is a 5-year prospective study funded by the Canadian Institutes of Health Research aiming to develop an in-office screening tool that will help clinicians identify potentially at-risk older drivers. Currently, no tools exist to directly predict the risk of motor vehicle collision (MVC) in this population. The American Medical Association (AMA), in collaboration with the National Highway Traffic Safety Association, has designed an opinion-based guide for assessing medical fitness to drive in older adults and recommends that physicians use the Assessment of Driving Related Skills (ADReS) as a test battery to measure vision, cognition and motor/somatosensory functions related to driving. The ADReS consists of the Snellen visual acuity test, visual fields by confrontation test, Trail Making Test part B, clock drawing test, Rapid Pace Walk test, and manual tests of range of motion and motor strength. We used baseline data from the Candrive II/Ozcandrive common cohort of older drivers to evaluate the validity of the ADReS subtests. We hypothesized that participants who crashed in the 2 years before the baseline assessment would have poorer scores on the ADReS subtests than participants who had not crashed.

Methods: In the Candrive II/Ozcandrive study, 1230 participants aged 70 years or older were recruited from 7 Canadian cities, 1 Australian city and 1 New Zealand city, all of whom completed a comprehensive clinical assessment at study entry. The assessment included all tests selected as part of the ADReS. Data on crashes that occurred within 2 years preceding the baseline assessment were obtained from the respective licensing jurisdictions. Those who crashed were compared to those who had not crashed on their ADReS subtest scores using Pearson's chi-squared test and Student's *t*-test.

Results: Sixty-three of the 1230 participants (5.1%) were involved in an MVC within the 2 years preceding the baseline assessment. Contrary to what was expected based on the AMA guide, there were no statistically significant associations between abnormal performance on the tests constituting the ADReS and history of crash ($p > 0.01$).

Discussion: Although limitations are inherent in a retrospective analysis, we found that abnormalities on the subtests comprising the ADReS were not associated with a recent history of crash. This suggests the need for more sensitive tools to properly assess crash risk in older drivers, for prospective analyses of risk over time and for an evidence base to support influential clinical practice guidelines.

Keywords: Older driver; Geriatrics; Automobile driving; Health status; Clinical practice guideline

1. Introduction

In North America, people over the age of 65 represent the fastest-growing segment of the population, and this age group is predicted to constitute 20–25% of the population by 2030, compared to 13–14% of the population in 2009–10 (He et al., 2005; Statistics Canada, 2010). As a result, the proportion of older adults holding a valid driver's licence is expected to increase dramatically (Fildes, 2008; Ontario Ministry of Transportation, 2006; Ragland et al., 2004).

It is well known that driving is a demanding task that requires a high level of visual, cognitive and motor/somatosensory skills, and it is critical that those who maintain a valid driver’s licence be medically fit to operate a motor vehicle (Messinger-Rapport, 2002; Voelker, 1999). The impairments associated with chronic health conditions, which are much more prevalent with aging, often lead to changes in driving ability (Man-Son-Hing et al., 2007; Marshall, 2008). Thus, with the aging of the population, it is reasonable to expect an increase in motor vehicle collisions (MVCs) involving older drivers. Additionally, older drivers are more likely than younger ones to incur higher rates of serious injury and mortality when involved in an MVC (Koppel et al., 2011). Given the wide range in driving ability among older drivers, revoking a driver’s licence based solely on age would be unfair, would reduce freedom and independence (Dickerson et al., 2007) and would potentially increase the risk of depression (Fonda et al., 2001; Marottoli et al., 1997). This balance presents challenges to both medical professionals and licensing authorities, and an accurate screening protocol is critical for driving safety.

Although in many jurisdictions health care professionals are legally obligated to report drivers who are medically unfit to drive, there is little reliable scientific data upon which they can base this decision (Eby and Molnar, 2010). Few physicians are trained and confident to screen for drivers at risk for an MVC (Brooks et al., 2011; Jang et al., 2007; Miller and Morley, 1993), and many are unaware of their patients' cognitive, functional and driving status. In the 2007 survey of 460 Canadian family physicians, less than half of the respondents reported that they often obtain a history of driving crashes and infractions or perform cognitive testing as part of their assessments (Jang et al., 2007). Moreover, addressing the issue of driving with older patients is known to negatively affect the physician–patient relationship (Jang et al., 2007; Marshall and Gilbert, 1999).

Tools that have been proposed to have predictive value for determining medical fitness to drive, such as the Trail Making Test parts A and B, were not designed for this purpose, and their predictive ability is imprecise (Bédard et al., 2008, 2011; Molnar and Simpson, 2010). No evidence-based tools currently exist to directly predict crash risk for older drivers. In one response to this, the American Medical Association (AMA) and the National Highway Traffic Safety Association (NHTSA) have designed an expert opinion-based guide for assessing older people's fitness to drive (Carr et al., 2010). The guide provides physicians with a comprehensive set of tools with which they can assess, educate and counsel the older driver. The office test battery, called the Assessment of Driving Related Skills (ADReS), indirectly measures crash risk using tests of vision (Snellen visual acuity and visual field by confrontation), cognition (Trail Making Test part B and clock drawing test) and motor/somatosensory skills (Rapid Pace Walk test, manual test of range of motion and manual test of motor strength).

Past studies have examined subitems of the ADReS, providing some evidence of the association between the ADReS scores and crash risk. In the MaryPODS study of older drivers recruited from a Department of Motor Vehicles setting, evidence was found for a positive association between the Trail Making Test part B and poor driving performance (Staplin et al., 2003). Ball et al. (2006) found that subjects who took 147 seconds or longer to complete the Trail Making Test part B were twice as likely as subjects who took less than 147 seconds to have a crash. A score of less than 4 (on the Freund 7-point scale) on the clock drawing test has been linked to unsafe driving (e.g., driving violations in an on-road performance test) (Oswanski et al., 2007). Marottoli et al. (1994) found that a time greater than 7 seconds on the Rapid Pace Walk test was associated with having a crash, and Staplin et al. (2003) found times greater than 9 seconds to be associated with crash risk; other physical limitations such as a history of falls as well as lack of exercise have also been linked to crash (Marmeleira et al., 2009; Marottoli et al., 2007; Sims et al., 2001).

The AMA guide presents strong advice based on minimal empirical support (Molnar et al., 2006), while clearly stating that there is a need for more evidence-based studies to test the association between the ADReS scores and crash risk (Carr et al., 2010). The Candrive II/ Ozcandrive cohort of older drivers represents an appropriate population to test the association between older driver outcomes on a subset of the ADReS tests and crashes. The Candrive/Ozcandrive collaboration is a 5-year multicentre longitudinal study following 1230 older drivers from seven Canadian cities, one city in Australia and one city in New Zealand. In the current study, we used data from the Candrive/Ozcandrive common cohort to evaluate the validity of the ADReS. We hypothesized that participants who crashed in the 2 years before the baseline assessment would have poorer scores on the ADReS subtests at baseline than participants who had not previously crashed.

2. Methods

2.1 Recruitment/participants

Candrive, funded by the Canadian Institutes of Health Research, is an interdisciplinary research team interested in health-related safety and quality-of-life issues pertinent to older drivers. Subsequently an Australian team became an official collaborator, and sites were added in Melbourne, Australia and Wellington, New Zealand (Ozcandrive). A major objective of the Candrive/Ozcandrive collaboration is to develop a valid, easy to use in-office screening tool to help physicians identify older drivers who need further assessment of their driving (Marshall et al., 2013 in this issue). To this end, a prospective cohort study of drivers aged 70 years or more was designed. A total of 928 participants were recruited from seven cities (Candrive study sites) in the Canadian provinces of British Columbia, Manitoba, Ontario and Quebec, as well as an additional 257 participants from Queensland, Australia and 45 participants from Wellington, New Zealand (Table 1). Participants were recruited through local newspaper and radio publicity about the study, seniors' organizations and advertisements. The data for all 1230 participants were included in the analysis for the current study. The study was approved by the research ethics board at each institution involved in the Candrive II/Ozcandrive study, and informed written consent was obtained from each participant. As part of this consent, participants agreed to have driving records released to Candrive/Ozcandrive annually from provincial licensing bodies. This included access to traffic violations and collision records for the duration of the study and also records from the 2 years prior to enrolment.

2.2 Assessment

As part of the Candrive protocol, participants completed a comprehensive assessment at study entry. The assessment was performed by trained research staff and required approximately 2.5 to 4 hours to complete.

Demographic information, including age, gender and residency type, was obtained for all participants, and self-reported information on driving characteristics (frequency and kilometres driven), health conditions, balance difficulties, history of falls and participation in exercise and social activities was obtained via interview.

All data relating to the ADReS were extracted from the Candrive data set.

2.2.1 Vision tests

- Snellen visual acuity (Currie et al., 2000): Scores were recorded as the smallest row of letters that the participant could accurately detect (no errors) while standing 10 feet from the Snellen E chart. The test was completed for the left eye, the right eye and both eyes.
- Visual fields by confrontation (Kerr et al., 2010; Prasad et al., 2011): The tester and participant sat facing each other approximately 3 feet apart, with the participant's eyes fixed on the tester's eyes. A score of pass (no deficits) or fail (deficits) was assigned based on recognition of the correct number of fingers in the participant's peripheral vision/quadrants. The test was completed for the left eye and the right eye.

2.2.2 Cognitive tests

- Trail Making Test part B (Moses, 2004): For this study, participants' Trail Making Test part B scores were analysed. Trail Making Test part B was conducted after the Trail Making Test part A and a Trails B example. Although the time to completion and the total number of errors were recorded, only the time to completion is analysed as part of the ADReS.

- Clock drawing test (Nasreddine et al., 2005): This test was administered as part of the Montreal Cognitive Assessment (MoCA) (Nasreddine et al., 2005). Participants were required to draw a clock with the hands indicating 11:10. As indicated in the MoCA, the test was scored out of 3, with 1 point each for contour, numbers and hand position, instead of the Freund clock scoring as described in the ADReS.

2.2.3 Motor/somatosensory tests

- Rapid Pace Walk test (Staplin et al., 1999): This is a measure of lower limb strength, endurance, range of motion and balance. The participant was asked to walk 10 feet, turn around, and walk another 10 feet (total 20 feet) as quickly as possible. The total time to completion (in seconds) was recorded.
- Manual test of range of motion (Carr et al., 2010; Marshall et al., 2013 in this issue): Joint range of motion was assessed for the neck, shoulder flexion, elbow flexion, finger curl, ankle plantar flexion and ankle dorsiflexion bilaterally. Range of motion was scored as normal or abnormal.
- Manual test of strength (Carr et al., 2010; Marshall et al., 2013 in this issue): The participant was asked to move against resistance provided by the tester for the following muscle groups: shoulder adduction and abduction, wrist flexion and extension, hand grip, hip flexion and extension, ankle dorsiflexion and plantar flexion. Performance was scored

on a 5-point scale (Carr et al., 2010; Marshall et al., 2013 in this issue). A score of 5 was defined as normal, and a score of 4 or less as abnormal.

2.3 Crash data

A retrospective analysis was performed to determine the association between ADReS subtest scores and motor vehicle crash rate in the two years prior to the baseline Candrive II/Ozcandrive assessment. Data on crashes were obtained from the respective provincial jurisdiction by providing participant driver license numbers. Linkages between driver license numbers and participant study identification numbers indicated which study participants had experienced a crash. If the reports indicated that the participant was in any type of crash (at-fault or not at-fault), the participant was classified in the “collision” group; owing to the retrospective nature of the data provided, fault status for the collisions could not be assigned. All remaining participants were classified in the “noncollision” group.

2.4 Statistical analysis

Descriptive data were presented using means and standard deviations for continuous data and frequencies for categorical data. To compare those who were and were not involved in a collision, we used Fisher’s exact test or Pearson’s chi-squared test for categorical data and the independent samples *t*-test for continuous data. The data were analysed using SPSS version 20.0 (IBM Corporation, Armonk, NY). Given the large sample size and considerable number of comparisons investigated as per the ADReS subtests, significance was set at 0.01 for all statistical comparisons between participants with and without collision involvement to minimize Type I error (i.e., indicating that an ADReS subtest is an important predictor of crash because of a significant difference in scores between the two groups when in fact the subtest is not a predictor).

3. Results

All the participants were active drivers at study entry, with the majority driving more than 4 times a week. Of the 1230 participants, 63 (5.1%) were involved in an MVC within the 2 years preceding the baseline assessment; 3 of the 63 had 2 collisions each. There were no significant differences in demographic characteristics, driving frequency or driving distance between the participants involved in a collision and those who were not involved in a collision ($p > 0.01$) (Table 2).

There were no significant differences between those with and without crash involvement in self-perceived balance difficulties, self-reported history of falls or involvement in exercise or social activities ($p > 0.01$) (Table 3).

There were no significant differences between those with and without crash involvement in any of the ADReS subscores, including vision, cognitive and physical measures ($p > 0.01$) (Table 4).

4. Discussion

In this cross-sectional sample of older drivers recruited into a longitudinal study of driving, 5.1% were involved in a crash within the 2 years before entry into the study as reported by their licensing authority. This rate is comparable to that in other reports examining older drivers and crashes (2.8% to 13%) (Marottoli et al., 1994; Ontario Ministry of Transportation, 2006). In this study, we used licensing authority accident reports and avoided the confounding factor of self-reported crashes. Furthermore, provincial crash reports capture all collisions involving police reports and account for the most serious collisions, particularly those that involve substantial property damage and/or personal injury (Owsley and McGwin, 2010).

Overall, the participants involved in a crash did not significantly differ from those without crash involvement in demographic characteristics, functional status or ADReS scores. This is a novel finding as to our knowledge no other researchers have analysed the association of all ADReS scores with motor vehicle collisions in a large sample of older drivers. Still, while the participants involved in a collision did not differ significantly from those without collision involvement in weekly driving frequency (e.g., daily or less than daily), the difference between the 2 groups in self-reported distance driven annually approached significance ($p = 0.019$): namely, more of the participants involved in a collision reported driving > 15,000 kilometres annually. However, the accuracy of self-reported driving exposure has been questioned, and in-car recording devices have been advertised as more objective measures of real-world driving. Indeed, after comparing self-reported driving exposure (logs and diaries) to actual driving behaviour (in-car recording device), several investigators have found that older drivers' self-estimates of driving distance are inaccurate (Blanchard et al., 2010; Crizzle et al., 2012; Huebner et al., 2006; Marshall et al., 2007). Furthermore, in all of those studies, drivers were asked to estimate distance driven over 1 or 2 weeks, so the self-reported estimates of annual distance driven included in the present study are likely to be even more inaccurate and should therefore be interpreted with caution.

The ADReS remains cost-effective and easy to administer and score. Posse et al. (2006) tested its interrater reliability among a physician, nurse and occupational therapist and found an 82% agreement rate. However, our study demonstrates that the ADReS does not truly reflect driving performance, at least based on this retrospective analysis of collisions. Consequently, there remains a need for further evidence-based studies to predict crash risk for older drivers. While the AMA guide suggests that ADReS scores should be taken into account along with the patient's medical history and medication use, a more accurate and more sensitive tool would result in fewer subjective decisions, and physicians would be better equipped to identify older drivers who are at risk. Identification of these at-risk older drivers could lead to further comprehensive assessment where required; interventions that could prolong safe driving; as well as help them develop alternative community mobility strategies and prepare for the transition to driving cessation.

4.1 Limitations

It is important to consider the limitations inherent in this retrospective analysis. In older people, changes in health may occur over a short period, and our participants' ADReS scores after their crash may not truly reflect their functional/health status at the time of the crash. However, in general, health status and functional ability would be expected to remain stable or deteriorate rather than improve with aging.

The Candrive participants represent a convenience sample and were predominantly healthy and high functioning at the time of recruitment. As a large sample of healthy older drivers, there was demographic heterogeneity, and no particular health condition was overrepresented; in fact, health conditions may have been underrepresented. The fact that this cohort of active drivers was relatively healthy overall may have hindered our ability to demonstrate a significant association between the ADReS measures and crash. For example, the AMA guide suggests that a score greater than 3 minutes on the Trail Making Test part B indicates cognitive impairment (Carr et al., 2010). Only 5.4% (67/1231) of our participants (2 in the collision group and 65 in the noncollision group) took more than 3 minutes to complete this test.

A further limitation was the inability to specify at-fault vs. not-at-fault crashes. However, since there were no significant results for all crashes as an outcome, specifically identifying at-fault collisions may not have provided further validation of these measures. The act of being involved (at-fault or not) in a crash may still be considered a valid measure, since some crashes can be avoided with appropriate driving skills. However, results from the prospective follow-up of this cohort of older drivers, which will include identification of at-fault status by two independent collision experts, will help clarify the relationship between crash risk and the ADReS subtests.

The test measures highlighted in this study were based on the ADReS. However, the results for each test were selected from a larger collection of assessment measures. In the Candrive II/Ozcandrive assessment, the ADReS measures were administered in a different order and at a different timing than suggested in the AMA guide, and some were scored differently. For example, the clock drawing test was scored as a subset of the MoCA, and the scoring of the clock was different from that recommended in the ADReS. Also, the Trail Making Test part A was administered before part B, while the ADReS only recommends doing part B. This may have allowed the participants in our study to “warm up” to the task, which may have improved their scores. In the MaryPODS study, a relationship was found between part B scores and at-fault crashes when part A was not administered (Staplin et al., 2003).

5. Conclusion

In this retrospective analysis, abnormalities on the ADReS subtests were generally not associated with a government-documented record of crash in the 2 years prior to the assessment. This finding suggests the need for more sensitive tools to properly assess crash risk in older drivers, for prospective analyses of risk over time and for an evidence base to support influential clinical practice guidelines. Results from the prospective follow-up of this cohort of older drivers, which will include both prospective collision records and identification of at-fault status, will help clarify the relationship between vision, cognition and motor/somatosensory skills and fitness to drive.

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Conflicts of interest: None.

Table 1
Distribution of participants across the study sites.

	Country	City	No. of participants
Candrive	Canada	Victoria	125
		Winnipeg	125
		Ottawa	256
		Toronto	124
		Hamilton	122
		Thunder Bay	67
		Montreal	109
Ozcandrive	Australia	Melbourne	257
	New Zealand	Wellington	45
Total			1230

Table 2
Demographic and self-reported driving characteristics by collision involvement.[a,b]

	No collision (*N* = 1167)		Collision (*N* = 63)	
Characteristic	Mean (SD)	No. (%)	Mean (SD)	No. (%)
Age (yr)	77.1 (4.8)		76.0 (5.1)	
Gender				
Male		753 (64.5)		37 (58.7)
Female		414 (35.5)		26 (41.3)
Residence type				
Urban/suburban		1078 (92.5)		54 (85.7)
Rural		87 (7.5)		9 (14.3)
Driving frequency				
Daily		627 (53.7)		41 (65.1)
Less than daily		540 (46.3)		22 (34.9)
Distance driven annually (km)				
< 5,000		169 (14.5)		9 (14.3)
5,000–15,000		713 (61.2)		29 (46.0)
> 15,000		283 (24.3)		25 (39.7)

[a] Totals vary owing to missing variables.
[b] $p > 0.01$ for difference between no-collision and collision groups for all variables (Pearson's chi-squared analysis for categorical data, independent samples t-test for continuous data).

Table 3
Self-reported functional status by collision involvement.

	No. (and %) of participants[a,b]	
Characteristic	No collision (N = 1167)	Collision (N = 63)
Balance difficulties		
Yes	291 (24.9)	14 (22.2)
No	876 (75.1)	49 (77.8)
Falls in previous 4 months		
Yes	99 (8.5)	7 (11.1)
No	1068 (91.5)	56 (88.9)
Participates in exercise		
Yes	965 (82.7)	49 (77.8)
No	202 (17.3)	14 (22.2)
Participates in social activities		
Yes	778 (66.7)	42 (66.7)
No	388 (33.3)	21 (33.3)

[a] $p > 0.01$ for difference between no-collision and collision groups for all variables (Pearson's chi-squared analysis).
[b] Totals vary owing to missing variables.

Table 4
ADReS scores (visual, cognitive and motor assessment results) by collision involvement.[a,b]

Measure	No collision (*N* = 1167)	Collision (*N* = 63)
Visual assessment		
Snellen visual acuity (mean ± SD)		
Left eye	18.5 ± 10.0	18.9 ± 7.1
Right eye	18.1 ± 10.9	21.0 ± 16.3
Both eyes	14.0 ± 5.1	14.8 ± 4.7
Visual field by confrontation (no. [and %] of participants)		
No deficits	1084 (92.9)	57 (90.5)
Deficits	83 (7.1)	6 (9.5)
Cognitive assessment		
Trail Making Test part B (s) (mean ± SD)	102.6 ± 53.3	112.9 ± 119.0
Clock drawing test (no. [and %] of participants)		
Correct	807 (69.3)	40 (63.5)
Incorrect	358 (30.7)	23 (36.5)
Motor assessment		
Rapid Pace Walk test (s) (mean ± SD)	6.6 ± 2.2	6.6 ± 1.6
Range of motion (no. [and %] of participants)		
Neck rotation		
Normal	898 (77.0)	52 (82.5)
Impaired	268 (23.0)	11 (17.5)
Shoulder and elbow flexion		
Normal	1071 (92.0)	51 (81.0)
Impaired	93 (8.0)	12 (19.0)
Finger curl		
Normal	1110 (95.2)	62 (98.4)
Impaired	56 (4.8)	1 (1.6)
Ankle plantar flexion		
Normal	1147 (98.5)	63 (100.0)
Impaired	18 (1.5)	0 (0.0)
Ankle dorsiflexion		
Normal	1152 (99.0)	63 (100.0)
Impaired	12 (1.0)	0 (0.0)
Motor strength (no. [and %] of participants)		
Shoulder adduction and abduction		
Normal	931 (80.0)	51 (81.0)
Impaired	233 (20.0)	12 (19.0)
Wrist flexion and extension		
Normal	1069 (91.8)	61 (96.8)
Impaired	95 (8.2)	2 (3.2)
Hand-grip strength		
Normal	1109 (95.3)	62 (98.4)
Impaired	55 (4.7)	1 (1.6)

Hip flexion and extension		
Normal	950 (81.6)	52 (82.5)
Impaired	214 (18.4)	11 (17.5)
Ankle dorsiflexion and plantar flexion		
Normal	1101 (94.6)	61 (96.8)
Impaired	63 (5.4)	2 (3.2)

[a] $p > 0.01$ for difference between no-collision and collision groups for all variables (Pearson's chi-squared analysis for categorical data, independent samples *t*-test for continuous data).

[b] Totals vary owning to missing variables.

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