

Original Research Article

Impaired Knowledge of Driving Laws Is Associated with Recommended Driving Cessation in Cognitively Impaired Older Adults

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Key Words

Cognitive impairment · Driving performance · Driving license · Road traffic · Knowledge of driving laws

Abstract

Background/Aims: The present study examined if knowledge of driving laws independently predicts on-the-road driving performance among cognitively impaired older adults. **Methods:** The current study consisted of retrospective observational analyses on 55 cognitively impaired older adults (77.9 ± 6.4 years) that completed an on-the-road driving evaluation, a 20-item knowledge test of driving laws, and a brief cognitive test battery. **Results:** Logistic regression found poorer performance on the knowledge test was significantly associated with greater likelihood of recommended driving cessation beyond important demographic and cognitive variables ($p < 0.05$). **Conclusion:** Cognitively impaired patients' ability to drive may be related to their knowledge regarding common driving laws, in addition to their current level of cognitive functioning.

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Introduction

With the increasing age of the American population, the number of licensed drivers with cognitive impairment is likely to rise [1, 2]. Drivers with dementia pose a serious risk of harm to themselves and others, with an elevated risk of crashing relative to non-demented coun-

terparts [3]. However, despite these risks, persons with dementia often continue to drive [4, 5]. As such, to maintain the safety of the road, most countries have initiated procedures to identify factors that increase accident risk and driving impairment among persons with dementia [6].

Past work has identified a growing number of demographic and psychosocial predictors of driving cessation and driving impairment among older adults with cognitive impairment, including advancing age, urban living, lower income, less education, and increased number of medical conditions [7–14]. Furthermore, several studies have found lower scores on the Mini Mental State Examination [7, 15], and deficits in visuo-attentional and executive function are associated with poorer driving performance [16, 17].

There is reason to believe that a patient's knowledge of common driving laws may also influence driving performance. For example, past work has shown drivers with dementia perform significantly worse on a traffic sign recognition task than healthy older drivers [18, 19]. Additionally, persons with dementia performed worse on a written knowledge test of driving laws than healthy controls independent of their level of cognitive impairment [20]. Such findings suggest that direct assessment of driving knowledge among patients with dementia may provide useful information when evaluating driving fitness, though no study has examined whether knowledge of driving laws corresponds to on-the-road performance in cognitively impaired older persons. The purpose of the current study was to examine whether patients' knowledge of driving laws independently predicts expert-recommended driving cessation based upon an on-the-road assessment. We hypothesized that poorer performance on the written knowledge test would be associated with increased likelihood of recommendation to discontinue driving. Follow-up analyses were then performed to determine cognitive, medical and demographic differences between patients who were and were not advised to discontinue driving.

Methods

Participants

The current analyses consisted of 55 persons from the Center for Senior Health at Summa Health System in Akron, Ohio, USA, referred for an on-the-road driving evaluation. Based upon a comprehensive geriatrician evaluation, all participants had a working diagnosis of dementia or mild cognitive impairment (MCI). Participants of the current study reflect the dementia population receiving evaluation and treatment at that facility. Based upon geriatrician evaluation and reported family concerns, patients were initially referred to a licensed occupational therapy (OT) for assessment of their instrumental activities of daily living at this facility. Based upon the OT assessment, patients were then referred for an on-the-road driving evaluation at a professional driving school. Retrospective observational analyses were conducted on 55 consecutive cases that were referred and completed the on-the-road evaluation.

Participants were 77.9 ± 6.4 years of age (mean \pm SD), and 45.5% were female. Within the sample, 43.7% had a working diagnosis of Alzheimer's disease, 21.8% dementia not otherwise specified, 16.4% vascular dementia, 10.9% mild cognitive impairment, 5.4% either Parkinson's disease or frontal lobe dementia, and 1.8% mixed dementia (see table 1 for participant demographic and medical characteristics).

Procedures

Patients were referred to the Center for Senior Health at Summa Health System for cognitive and memory complaints. Based on a routine geriatrician evaluation and presenting

Table 1. Demographic, clinical, and driving characteristics of 55 cognitively impaired older adults

Demographic characteristics	
Age, years ¹	77.85 ± 6.39
Female, %	45.5
Education, years ¹	13.41 ± 2.75
Medical characteristics, % yes	
Hypertension	67.3
Cholesterol	52.7
Diabetes	23.6
Stroke	18.2
Sleep apnea	9.1
CABG/bypass surgery	12.7
Test performance ¹	
SBT	7.85 ± 5.78
CDT	4.82 ± 1.63
Rules of the road	88.82 ± 8.44
Driving cessation, % yes	
On-road recommendation	34.5
CABG = Coronary artery bypass graft. ¹ Mean ± SD	

complaints of the family, patients were then referred and completed an OT assessment. As part of the assessment, patients were administered cognitive tests, including the Short Blessed Test (SBT) and the Clock-Drawing Test (CDT). Based on the results of this assessment, the licensed OT then referred the patient for an on-the-road assessment to be conducted at a professional driving school by a certified driving rehabilitation specialist. Driving recommendations made by the certified driving rehabilitation specialist (i.e., continue or discontinue driving) were used in the current analyses.

Measures

Knowledge Test

A knowledge test of common driving laws was created by licensed occupational therapists and consists of 20 multiple-choice questions abstracted from the manual of the Ohio Bureau of Motor Vehicle rules. Examples of questions include, ‘Unless it is posted otherwise, the speed limit in a residential area is...?’; ‘The speed limit in a school zone is...?’ For each question, the patient is asked to select from four options. The test concludes with pictures of five road signs and the patient is asked to identify the meaning of each sign. Examples of signs include a yield sign, no parking sign, left turn only sign, no U-turn sign, and a pedestrian walking sign. Percent correct is used as the dependent variable. The internal consistency reliability of this measure was Cronbach’s $\alpha = 0.36$. Decreased internal consistency reliability is consistent with other measures of driving law knowledge [20].

Cognitive Measures

Short Blessed Test. The SBT is a very brief, 6-item, screening tool used to diagnose cognitive impairment [21]. It was used to assess orientation, memory, and concentration. Patients are asked to report the current year, month, time of day, count backward from 20 to 1, recite the months backwards, and memorize a phrase [22]. Higher scores indicate poorer performance with scores of 0–4 representing normal cognition, 5–9 reflective of questionable impairment or early dementia, and scores ≥ 10 indicative of dementia [22].

Clock-Drawing Test. The CDT was used to assess deficits in visuospatial and executive function. It is a valuable screening tool commonly used to detect visual-spatial dysfunction among patients with dementia [23]. It was scored on a scale of 1–7, with higher scores representing better performance. This test demonstrates strong specificity among dementia patients in both in- and outpatient settings, as it has been shown to correctly classify 77% of patients with Alzheimer’s disease, 89% of patients with mixed dementia, and 78% of normal elderly in these settings [24].

Demographic and Medical History

Demographic characteristics and medical history were collected through a review of the medical charts (table 1).

Statistical Analyses

A hierarchical binary logistic regression was performed to examine the independent contribution of the knowledge test on recommendations for driving cessation (1 = yes; 0 = no) among the current sample of older adults with cognitive impairment. Age, gender, and education were controlled for and entered into the first block of the model. Cognitive predictors, namely the SBT and the CDT, were entered into the second block of the model. The knowledge test was entered into the third block of the model to determine its incremental predictive validity over cognitive and demographic variables. χ^2 and independent-sample t-tests then determined cognitive, medical and demographic differences between patients who were and were not advised to discontinue driving.

Results

Cognitive and Driving Characteristics of the Sample

Consistent with their diagnoses, participants exhibited significant levels of cognitive impairment on testing. The average SBT score was 7.85 ± 5.79 [22]. Within the sample, 38.2% scored 0–4 points on the SBT, 18.2% scored 5–9 and 43.7% had a score ≥ 10 . Recommendation for driving cessation was common in the current sample (34.5%; 19 of 55 patients). The sample averaged 88.82% on the knowledge test.

Medical, Demographic, and Cognitive Differences

χ^2 statistics were conducted to identify medical and demographic differences between patients who were and were not advised to discontinue driving based on their performance during the on-the-road assessment. There were no significant differences between males and females [χ^2 (1, n = 55) = 1.81, p = 0.18]. Similarly, there were no differences between patients on any of the medical variables, namely: hypertension [χ^2 (1, n = 55) = 0.22, p = 0.64], coronary artery bypass graft surgery [χ^2 (1, n = 55) = 0.13, p = 0.72], cholesterol [χ^2 (1, n = 55) = 0.00, p = 0.99], diabetes [χ^2 (1, n = 55) = 2.76, p = 0.10], stroke [χ^2 (1, n = 55) = 0.11, p = 0.74], or sleep apnea [χ^2 (1, n = 55) = 0.52, p = 0.47].

Independent-sample t tests were then performed to examine differences on the cognitive tests and the knowledge test between patients advised or not advised to discontinue driving based upon the on-the-road assessment. The t-tests revealed significant differences on the SBT [t(53) = 2.28, p < 0.05] and on the knowledge test [t(53) = -4.11, p < 0.05]. In each case, persons with poorer test scores were more likely to be advised to discontinue driving. No such pattern emerged on the CDT [t(53) = -0.79, p > 0.05].

Table 2. Logistic regression analysis examining the predictive validity of the knowledge test on driving cessation among 55 cognitively impaired older adults (full model)

Predictors	B	SE B	Wald's χ^2	d.f.	p	e ^B	
Constant	-2.91	7.46	0.15	1	0.69	0.06	
Age	0.15	0.07	4.80	1	0.03	1.11	
Gender	-1.62	0.89	3.29	1	0.07	0.20	
Education	0.17	0.16	1.09	1	0.30	1.19	
SBT	0.12	0.08	2.64	1	0.10	1.13	
CDT	-0.18	0.26	0.48	1	0.49	0.83	
Knowledge test	-0.13	0.05	7.20	1	0.01	0.88	
Test			χ^2	d.f.	p		
Overall model							
Likelihood ratio test			24.14	6	0.00		
Goodness-of-fit test							
Hosmer & Lemeshow			10.11	7	0.18		
Nagelkerke R ² = 0.49.							

Knowledge of the Rules of the Road Is an Independent Predictor of Driving Cessation

Finally, a hierarchical binary logistic regression was performed to identify the predictive validity of the knowledge test on driving cessation (yes or no). Age, gender (1 = males; 0 = females), and education were entered into the first block of the model. A test of this model against the constant was not statistically significant [χ^2 (3) = 5.86, $p > 0.05$].

The SBT and the CDT were then entered into the second block of the model. After controlling for age, gender, and education, this block was statistically significant [χ^2 (2) = 9.29, $p < 0.05$; Nagelkerke R² = 0.33]. The model correctly classified 69.1% of the cases. The Wald criterion demonstrated that age made a significant contribution to the prediction [B = 0.15, odds ratio (OR) = 1.16, χ^2 (1) = 5.63, $p < 0.05$], as did gender [B = -1.75, OR = 0.17, χ^2 (1) = 4.79, $p < 0.05$], and the SBT [B = 0.17, OR = 1.18, χ^2 (1) = 5.84, $p < 0.05$]. Older age, being female, and worse performance on the SBT was associated with increased odds of being advised to discontinue driving.

The knowledge test was then entered into the final block of the model. After controlling for the demographic, and cognitive variables, this block was statistically significant [χ^2 (1) = 9.00, $p < 0.01$], as was the full model [χ^2 (6) = 24.14, $p < 0.01$, Nagelkerke R² = 0.49]. The full model correctly classified 78.2% of the cases. The Wald criterion demonstrated that age made a significant contribution to the prediction [B = 0.15, OR = 1.17, χ^2 (1) = 4.80, $p < 0.05$], as did the knowledge test [B = -0.13, OR = 0.88, χ^2 (1) = 7.20, $p < 0.05$]. Older age and worse performance on the knowledge test were associated with increased odds of recommendation to discontinue driving (table 2 for a summary of the full model).

Discussion

Consistent with past work, recommended driving cessation was common among cognitively impaired older adults who were referred due to concerns by a geriatrician and occupational therapist. Previous work has identified a growing number of predictors of driving ability in this population, including severity of cognitive impairment. The current study ex-

tends the literature by demonstrating that knowledge of driving laws, independent of cognitive function and demographic variables, is also associated with recommended driving cessation after an on-the-road evaluation. The implications of these findings warrant brief discussion.

The current findings demonstrate that poorer performance on a knowledge test of common driving laws was associated with increased odds of being advised to discontinue driving in persons with cognitive impairment. Prior work has shown that dementia patients consistently perform worse on knowledge tests than healthy elderly [18–20, 25]. However, this is the first study to show that knowledge of driving laws is associated with poorer on-the-road performance independent of cognitive ability. Interestingly, a past study found nearly 25% of healthy controls failed a written test of driving laws, suggesting that even healthy older drivers may be at risk for reduced knowledge and potentially reduced driving performance [20]. When drivers reach a certain age in the United States, shortened valid licensing periods [26, 27], in-person renewals, and vision tests are required [28]. Written knowledge tests are not yet routine and are often only administered in specific circumstances (i.e., post-traffic violations or medical reports) [26, 29]. In fact, some states administer knowledge tests as a means to help identify impaired reading, comprehension, or perceptual skills, and knowledge of driving laws is often a secondary concern [30]. However, previous work suggests that knowledge of driving laws deserves attention, as one study found a trend between knowledge tests and reduction in fatal crash risk among a healthy elderly community sample [31]. Future research examining the benefits of a knowledge test in predicting on-the-road performance in other samples would help validate its clinical utility for identifying at-risk drivers with cognitive impairment.

Consistent with past work, the current findings demonstrate that cognitive function was an important contributor to driving performance. Research has shown neuropsychological tests assessing attention, visual scanning, processing speed, visuospatial abilities, and executive function [32–34] predict on-the-road test performance in patients with dementia [35, 36]. Our study suggests that global cognitive screening measures may also have clinical utility in the assessment of driving fitness, though past findings are inconsistent [37, 38] and prospective studies examining the utility of such screening measures on driving performance are needed.

Limitations of the current findings deserve mention. First, the current study cannot provide mechanistic explanations for the association between written testing of driving laws and poorer driving performance in persons with cognitive impairment. Additionally, the current study utilized cross-sectional data, and prospective studies are needed to determine whether cognitive tests and knowledge of driving laws predict driving cessation over time, particularly in transitioning from healthy to pathological cognitive aging. Future studies should also examine driving cessation rates and predictors of driving cessation in other medical populations (i.e., cardiovascular disease or other chronic illness) to determine whether cognitive impairment and driving knowledge in those populations are both associated with poor driving performance. Finally, the current study lacks detailed quantification and assessment of past driving experiences, including history of crashes or near-crash incidents, so the implications of impaired knowledge in terms of driving safety remain to be elucidated.

A final aspect of the study warranting brief discussion is the measure of driving laws. Consistent with past studies [20], our driving knowledge measure exhibited low levels of internal consistency. Past researchers have speculated that the primary reason for the low internal consistency of similar measures is a result of decreased reliability of the actual state driving examinations from which the items were pooled [20]. Since the current knowledge test consisted of only 20 items drawn from a larger Bureau of Motor Vehicle manual commonly used to assess driving knowledge, a larger item sample would increase the internal consistency of this measure. Prospective studies utilizing comprehensive examinations of

patients' knowledge of driving laws would help validate our findings; however, more intensive knowledge tests may not be practical for everyday clinical use.

In summary, poorer knowledge of driving laws was independently associated with the recommendation to discontinue driving in patients with dementia and mild cognitive impairment. Future studies should examine the benefits of adding evaluation of knowledge of common driving laws to screening evaluations of older drivers who may be at risk due to cognitive impairment.

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Disclosure Statement

There is no conflict of interest.

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