Systematic Review of Driving Risk and the Efficacy of Compensatory Strategies in Persons with Dementia

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OBJECTIVES: To determine whether persons with dementia are at greater driving risk and, if so, to estimate the magnitude of this risk and determine whether there are efficacious methods to compensate for or accommodate it.

DESIGN: Systematic review of the literature.

SETTING: Case-control studies.

PARTICIPANTS: Drivers with a diagnosis of dementia.

MEASUREMENTS: Most studies used state and caregiver reported crash rates, performance-based road tests, and driving simulator evaluations as their outcome measures.

RESULTS: Twenty-three studies were included. Drivers with dementia universally exhibited poorer performance on road tests and simulator evaluations, although only one study using an objective measure of motor vehicle crashes was able to show that drivers with dementia were involved in more crashes than control subjects. No studies were found that examined the efficacy of methods to compensate for or accommodate their worse driving performance.

CONCLUSION: Drivers with dementia are poorer drivers than cognitively normal drivers, but studies have not consistently demonstrated higher crash rates. Clinicians and policy makers must take these findings into account when addressing issues pertinent to drivers with a diagnosis of dementia. **J Am Geriatr Soc 55:878–884, 2007.**

Key words: driving; dementia; motor vehicle crashes; systematic review

Persons aged 65 and older are the fastest-growing segment of the North American population, expected to be 25% of the total population by 2030.[1] This has resulted in a rapid increase in the number of older persons holding drivers' licenses. From 2005 to 2025, the number of licensed drivers aged 65 and older is expected to double.[2]

The desire to drive to maintain community independence and the symbolic importance of the ability to drive and hold a driver's license remain important concerns for older drivers and their families.[3] Loss of driver licensure can lead to direct health effects, with an increase in depression.[4,5] Increased loneliness, social isolation, stress on family and friends, and greater likelihood of institutionalization are linked to loss of the ability to drive in older persons,[6–9] particularly for rural dwellers.[10] Even for urban-dwelling older persons, public transportation does not adequately replace the mobility and freedom of operating one's own car.[11] Therefore, removal of driving privileges can be a sentinel event in the lives of many older persons.

One of the most important healthcare concerns facing today's older population is cognitive impairment. The prevalence of dementia, the most common form of cognitive impairment, is approximately 8% for persons aged 65 and older, increasing to 30% for those aged 90 and older.[1] Aspects of cognition that are crucial for driving and that are affected most with dementing illnesses are memory impairment, poor sequencing skills, impaired insight and judgment, apraxia, slowed processing time, and visuoperceptual deficits.[12] A recent study suggests that drivers with dementia will become more prevalent on the road as the population ages.[13] Given that many forms of dementia are progressive in nature, some have advocated for the suspension of driving privileges in all persons diagnosed with dementia,[14] although some studies have shown that many older persons in the early stages of dementia can safely operate a motor vehicle[15,16] and that a diagnosis of mild Alzheimer's disease does not preclude driving.[17]

Although there have been a few recent qualitative reviews[18–20] of the literature regarding driving and dementia, none have attempted to determine precisely the magnitude of the risk of crash in persons with dementia. Such information would facilitate rational policy and clinical decision-making. Therefore, the objective of this systematic review was to determine whether persons with dementia are at greater driving risk and, if so, to estimate the magnitude of this risk and determine whether there are efficacious methods to compensate for or accommodate it.

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METHODS

Search Strategy

Relevant data were gathered by performing systematic literature searches using the MEDLINE (January 1966 to November 2006), Embase, CINAHL, PsychInfo, Ageline, and Sociofile computerized databases. Pertinent articles were identified using the following exploded MeSH search terms (human and English language only): driving, motor vehicle crashes, accidents, dementia, Alzheimer, cognitive impairment and risk factors. The bibliographies of each identified, possibly pertinent article were hand searched to identify additional articles. The "gray literature" (technical and internal reports, non-peer-reviewed journals) was not systematically searched, because there is no accepted, comprehensive method of doing so. There was no correspondence with the authors of the reviewed papers.

Included trials met the following criteria: collected primary data, studied driver performance or crash rates in persons with dementia, and included a control group for comparison. Pertinent data (journal, year, quality score, study population, setting, outcome measures used, main findings) were extracted from each relevant article. Two independent reviewers extracted data from each article, with any differences resolved by collaborative review.

Quality Assessment

To judge the methodological quality of the included studies, the Newcastle-Ottawa (N–O) Quality Assessment Scale[21] (range 0–9, with higher scores indicating higher methodological quality) was applied to the pertinent studies.

Statistical Analysis

The Fisher exact test was performed to test the effect of methodological quality of the studies on the results.

RESULTS

Search Strategy

The initial search strategy identified 212 possibly relevant articles. After initial perusal of the titles and abstracts, 42 possibly met the inclusion criteria and were reviewed in full, and 28 were identified as meeting the inclusion criteria,[12,14,15,22–46] all using a case-control design. Five reports[42–46] appeared to study the same group of participants as previously included studies[12,15,22,38,39] and were excluded, leaving a total of 23 included studies (Tables 1, 2, and 3). A number of outcome measures were used in these studies, including state driving record (n = 3), caregiver-reported crashes (n = 3) and performance (n = 1), performance-based road evaluation (n = 11), driving simulator performance (n = 4), and score on a traffic sign recognition test (n = 1).

Quality Assessment

In general, the studies using state driving records as their outcome measure were of better methodological quality (mean N-O score of 7) than those using caregiver-reported crashes (mean N-O score of 5) or road (mean N-O score of 5) or driving simulator (mean N-O score of 4) evaluation. N-O quality score was not statistically related to the findings of the studies ($P = .89$).

Driving Risk

The results show that all studies (n = 16) that used a form of driver performance (road evaluation (n = 11) (Table 1), driving simulator (n = 4) (Table 2), caregiver report (n = 1)) as their outcome measure found that drivers with dementia performed significantly worse than control subjects. Likewise, all the studies (n = 3) using caregiver-reported crashes found that drivers with dementia crashed more often than controls (Table 3), although in studies (n = 3) that used state crash record as the outcome measure (Table 3), higher rates of crashes in patients with dementia were found in only one study.[38] Similar results were found whether studies enrolled drivers with Alzheimer's disease or those with mixed diagnoses.

Magnitude of Crash Risk

The studies using caregiver-reported crashes (n = 3) found a 2.5 to 8 times greater risk of crashes in drivers with dementia than in controls. For the one of three studies that found a positive association between crashes recorded on the state driving record and dementia, the estimate of crash risk in persons with dementia was a 2 to 2.5 times greater risk, slightly lower than the studies using caregiver-reported crashes.

Compensation Methods for Crash Risk

For drivers with dementia, the use of efficacious methods to reduce crash risk needs be considered, because loss of the ability to drive often has a significant effect on the quality of life of drivers and their families. Potential compensation and accommodation strategies for drivers with dementia include:

1. Retraining/education programs. No studies were found assessing the efficacy of retraining/education programs on improving the driving risk in persons with dementia.
2. Use of a copilot. No studies were found assessing the efficacy of having another person accompany drivers with dementia with respect to reducing their driving risk.
3. Use of on-board navigation and crash warning systems. No studies were found assessing the efficacy of these technologies on improving the driving risk in persons with dementia.
4. Use of restricted licensing. Although a previous study[47] has shown that, in a general sense, restricted licenses reduce crash rates, no studies were found that specifically examined whether accommodation through the granting of restricted or conditional licenses to certain drivers with dementia reduced their driving risk.
5. Use of self- and family-imposed driving restrictions. One study[48] has shown that drivers with dementia and their families can influence decisions regarding the amount they drive, but no study was found showing whether such methods affect crash rates.
6. Use of cognitive enhancers. No study was found testing the effect of cognitive enhancers such as acetylcholinesterase inhibitors (e.g., donepezil, galantamine) on the driving ability of patients with dementia.

Table 1. Summary of Studies Using Road Driver Performance as Outcome Measure

Study	Quality Score (0–9)	Study Population	Setting	Outcome Measure Used	Main Findings
Hunt 1993[22]	6	12 patients with very mild AD 13 patients with mild AD 13 unmatched controls	Missouri AD Research Center	Road performance	5 of 13 with mild AD failed test; all controls and those with very mild AD passed
Rebok et al. 1994[23]	5	10 patients with AD 12 unmatched controls	Maryland dementia clinic	Road performance	Worse performance in patients with AD; slowed reaction times, more false alarms, more pedal errors
Fitten et al. 1995[24]	6	25 patients with mild dementia 24 age-matched controls	California dementia clinic	Road performance	Worse performance in patients with dementia (no other pertinent details reported)
Cushman 1996[25]	4	32 patients with early AD 91 unmatched controls	New York Psychiatry Department	Road performance	More patients with AD failed test (no other pertinent details reported)
Hunt et al. 1997[26]	6	36 patients with very mild AD 29 patients with mild AD 58 unmatched controls	Missouri AD patient registry	Road performance	Worse performance in patients with AD; 41% vs 19% vs 3% failed road test ($P<.001$)
Wald 1998[27]	5	112 patients with dementia 50 unmatched controls	Canadian rehabilitation hospital	Road performance	Worse performance in patients with dementia (no other pertinent details reported)
Duchek et al. 1998[24]	6	49 patients with very mild AD 29 patients with mild AD 58 unmatched controls	Missouri AD patient registry	Road performance	Worse performance in patients with AD, especially focusing on visual attentional skills
Bieliauskas et al. 1998[29]	5	9 patients with AD 9 age-matched controls	Michigan AD Research Center	Road performance	More driving errors in patients with AD (mean 11 vs 4; $P=.001$)
Whelihan 2005[30]	6	23 patients with mild dementia 23 age-matched controls	Rhode Island memory disorder clinic	Road performance	Worse performance in patients with dementia (no other pertinent details reported)
Uc et al. 2005[12]	4	33 patients with mild AD 137 unmatched controls	Iowa Department of Neurology Registry	Road performance	Worse performance in patients with AD; impaired visual searching, recognition of road signs
Lincoln et al. 2006[31]	2	42 patients with dementia 33 unmatched controls	U.K. health institution	Road performance	Worse performance in patients with dementia (27% vs 0% considered unsafe)

AD = Alzheimer's disease.

Table 2. Summary of Studies Using Driving Simulator Performance and Other Miscellaneous Outcomes as Outcome Measures

Study	Quality Score (0–9)	Study Population	Setting	Outcome Measure Used	Main Findings
Harvey 1995[32]	4	13 patients with dementia 125 unmatched controls	U.K. health institution	Driving simulator performance	Worse performance in patients with dementia (no other pertinent details reported)
Rizzo et al. 1997[33]	5	21 patients with AD 18 unmatched controls	Iowa AD Research Center	Driving simulator performance	Higher simulator crash rate in patients with AD (29% vs 0%; $P = .02$)
Cox et al. 1998[34]	2	29 patients with AD 21 age-matched controls	Virginia Department of Neurology	Driving simulator performance	Worse performance in patients with AD; went off road more often, drove slower, applied less brake pressure, spent more time negotiating left turns
Rizzo et al. 2001[35]	3	18 patients with AD 12 unmatched controls	Iowa Department of Neurology Registry	Driving simulator performance	Higher simulator crash rate in patients with AD ($P < .05$)
Carr et al. 1998[36]	7	70 patients with AD 667 unmatched controls	Missouri AD patient registry	Traffic Sign Recognition Test	Poorer ability to name traffic signs in patients with AD
Ott et al. 2003[37]	5	27 patients with mild dementia 6 unmatched controls	Rhode Island Memory Disorder Clinic	Caregiver-reported driving ability	More-frequent crashes in patients with dementia (no other pertinent details reported)

AD = Alzheimer's disease.

Table 3. Summary of Studies Using State Recorded and Caregiver Reported Crashes as Outcome Measure

Study	Quality Score (0–9)	Study Population	Setting	Outcome Measure Used	Main Findings
Cooper et al. 1993[38]	8	165 patients with dementia 165 age-, sex-matched controls	Canadian dementia clinic	State driving record (5-year retrospective review)	Patients with dementia 2 times as likely to have had a crash
Trobe et al. 1996[15]	8	143 patients with AD 715 age-, sex-matched controls	Michigan AD Research Center	State driving record (7-year retrospective review)	No difference in crash rates (0.08 crashes per person year in both groups)
Carr et al. 2000[39]	6	34 patients with very mild AD 29 patients with mild AD 58 unmatched controls	Missouri AD Research Center	State driving record (5-year retrospective review)	No difference in crash rates (very mild, 9.7; mild, 10.6; controls, 9.1 crashes per million miles driven; $P > .05$)
Drachman et al. 1993[40]	6	130 patients with AD 112 age-matched controls	U.S. health institutions	Caregiver-reported crashes (previous 10 years)	Patients with AD 2 times as likely to have had a crash
Friedland et al. 1988[14]	4	30 patients with AD 20 age-matched controls	Maryland Neuroscience Laboratory	Caregiver-reported crashes (previous 5 years)	Patients with AD 5 times as likely to have had a crash (47% vs 10%; $P < .001$)
Zuin et al. 2002[41]	5	56 patients with dementia 31 unmatched controls	Argentine dementia registry	Caregiver reported crashes (past 3 years)	Greater crash involvement in patients with dementia (20% vs 6%; $P = .12$)

AD = Alzheimer's disease.

DISCUSSION

The results of this systematic review clearly demonstrate that persons with dementia do not perform as well as control subjects on tests of driver performance, including road and driving simulator evaluations. For example, in examinations of driving simulator performance, persons with dementia were more likely to drive off the road, drive much slower than the speed limit, and take more time when attempting left turns than age-matched controls.[12,34] Also, although studies using caregiver-reported crashes found that drivers with dementia have higher crash rates than nonimpaired subjects, studies using the state driving record outcomes did not consistently find the same result. Only one of three studies using state driving records showed a greater risk, the magnitude of this crash risk being 2 to 2.5 times that of controls.[38] There appeared to be no relationship between the methodological quality of the studies and their findings.

The reasons that only one study using state driving record could find higher crash rates in drivers with dementia are unclear. It may be due to collision rates, as recorded on state driving records, being relatively infrequent events even for drivers with poor skills and thus being an insensitive measure of driving risk. State-run databases are less likely to capture crashes of less severity (i.e., those with little property damage and no injuries) than are caregiver reports.[49] Also, state driving records reflect only citations and accidents within the state, with events occurring in neighboring jurisdictions or elsewhere often not being captured. Finally, citations and crashes within states may go unrecorded because of record-keeping oversights. Another possibility is that the studies using state-reported crashes recruited case subjects (drivers with dementia) from tertiary referral settings while identifying control subjects from the motor vehicle branch databases. Therefore, case subjects may have been better educated and more likely to have supportive caregivers than control subjects, possibly making them more likely to have lower crash rates. Also, drivers with dementia may restrict their driving, having less road exposure because of limitations placed by families and caregivers,[48] thereby reducing their chances of crashing.

All studies that used road performance and driver simulator testing showed that drivers with dementia performed worse than control subjects. This occurred despite differences in the driving tasks inherent to each of these methods. Road testing allows for more realism when testing driving ability but does not allow for purposely placing drivers in potentially dangerous situations, a procedure that can be done with the use of driving simulators.

No studies were found that examined the crash risk of drivers with mild cognitive impairment, a syndrome that often precedes the onset of dementia.[50] Given the results of this study, it is unlikely that case control studies using state-recorded crashes would be able to detect a greater crash risk in this population.

How should clinicians and policy makers use the results of this study? There is controversy regarding the appropriate outcome measure for determining driving ability. Some may argue that crashes are the events of most concern to society and are the most-objective and possibly the most-relevant measure of driving risk. From a societal perspective, older drivers are not overrepresented in the absolute number of actual crashes and should be allowed to continue until there is clear, incontrovertible evidence of lack of fitness to drive.[51] Others suggest that a diagnosis of dementia invariably leads to poor performance on road testing and driving simulator evaluations and is sufficient to deny driving privileges even in the face of a crash-free history.[14] This line of reasoning concludes that bad driving will often lead to crashes and that to allow persons to crash before taking action is inappropriate and possibly unethical. However, no study has demonstrated that poor performance on road testing or driving simulator evaluations is predictive of future crashes.

A number of international consensus groups[52–55] have reviewed these issues and have arrived at similar conclusions. They suggest that the diagnosis of moderate to severe dementia precludes driving and that persons with these conditions should have their driver's licenses revoked. Because some studies have shown that persons with mild dementia do not have higher crash rates than drivers without dementia,[15,23] a diagnosis of mild dementia is not, in itself, sufficient to lead to revocation of a driver's license. Rather, they recommend individual assessment of drivers with mild dementia and that a determination of the functional driving abilities with an on- and off-road comprehensive driving evaluation conducted by a health professional[56] is the fairest and most-appropriate method of assessing fitness to drive.

With regard to possible compensatory strategies to enhance the driving capabilities of persons with dementia, none seem to be reasonable evidence-based options. Recognizing that persons with dementia have underlying memory and cognitive deficits, often including difficulties with insight and judgment, attempts to upgrade their driving skills through refresher courses is not a reasonable option. This is especially true when it is considered that there is progressive deterioration in cognition over time in most persons with dementia. For persons who demonstrate significant improvements in their cognitive and functional status with the use of cognitive enhancers, it is reasonable that they undergo comprehensive on-road driving evaluations if they wish to continue driving.

With regards to the use of copilots, it has been estimated that up to 10% of drivers with dementia rely on copilots to continue driving.[57] Some have advocated for the use of copilots as a means of increasing the safety of drivers with mild dementia.[18,58,59] Although it is acknowledged that driving alone is a risk factor for crashing in drivers with dementia,[60] some authorities tend to dismiss the use of copilots as a compensation strategy.[52] Given that many crashes occur in a split second, without time to give instructions to drivers, this method of compensation would seem to be ineffective and unrealistic. With the information processing of most persons with dementia being impaired, the use of onboard technologies (e.g., early warning and onboard navigation systems) is unlikely to compensate for the driving deficiencies that drivers with dementia demonstrate, although further empirical research in this area would be beneficial. The use of restricted or conditional licensing is also not recommended.[61] Although many drivers with dementia perform adequately in routine situations, they do not perform as well in situations that are less predictable,

precisely the time when many crashes occur. Also, many persons with dementia do not have the insight to understand the rationale for the application of driving restrictions to them. The result is that they are less likely to adhere to any restriction applied.

Possible limitations of this study include that many studies did not report the spectrum of severity of dementia. Therefore, it is difficult to determine the precise magnitude of crash risk in drivers with dementia without stratifying by severity of disease, although it has been shown that crash risk is proportional to the severity of dementia.[52] Also, no study was able to determine the level of driving exposure in their populations. Therefore, individual risk of crash per mile driven cannot be determined from this study. It was not possible to conduct a formal meta-analysis of the results of studies using state crash record as their outcome, because there were only three such studies conducted in different settings. Finally, it was not possible to search the "gray literature" comprehensively for pertinent studies or correspond with the authors of the reviewed papers. Therefore, some studies that met the inclusion criteria may have not been identified.

Future research priorities for driving and dementia include the conduct of a prospective cohort study that will determine the crash risk in drivers with cognitive difficulties while simultaneously measuring their driving exposure and determining whether performance road tests and driving simulator evaluations are predictive of future crashes. Also, a randomized, controlled trial evaluating the benefits of cognitive screening programs in settings such as departments of motor vehicles is waiting to be done.

In conclusion, persons with dementia are poorer drivers than those who do not have dementia, although it is not as clear whether they are overrepresented in motor vehicle crashes. Clinicians and policy makers must take these findings into account when addressing issues pertinent to drivers with a diagnosis of dementia.

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