This systematic review synthesizes the research on interventions used by occupational therapy practitioners to address cognitive and visual function, motor function, driving skills, self-regulation and self-awareness, and the role of passengers and family involvement in the driving ability, performance, and safety of older adults. After a comprehensive search of the research literature, 29 studies were reviewed and synthesized into five themes: (1) educational interventions including family education, (2) cognitive–perceptual training, (3) interventions addressing physical fitness, (4) simulator training, and (5) behind-the-wheel training. Outcome measures used in the studies included changes in knowledge through speed of processing, physical and cognitive skills predicted to reduce crash risk, simulated driving, and real-world driving. The studies demonstrated low to moderate positive effects for interventions used by occupational therapy practitioners to improve older driver performance.


The *Occupational Therapy Practice Framework: Domain and Process* (3rd ed.; American Occupational Therapy Association [AOTA], 2014) identifies the activity of driving as an instrumental activity of daily living within the domain and scope of occupational therapy practice. As a form of community mobility, driving may be considered an enabling activity that allows older people to shop, attend medical appointments, and engage in social activities to support healthy aging in place.

Older adults may experience a gradual decline in sensory, physical, or cognitive areas of their functioning or sudden changes as a result of illness or injury (Lindstrom-Forneri, Tuokko, Garrett, & Molnar, 2010). Retaining driving privileges may become more important with older age because of the benefits of community participation for maintaining health and well-being and the potential difficulties and inconvenience of accessing alternative modes of transport. To promote health and healthy aging, occupational therapy practitioners work with older drivers to ensure these drivers self-monitor their driving health and address physical and cognitive changes resulting from aging, injury, or disease. When needed, occupational therapists also assist older adults’ transition from the role of driver to passenger by helping them find and plan use of alternative transportation options or modify their patterns of performance to support continued engagement in meaningful occupations and roles within their communities (AOTA, 2010).

This review focused on the following question: What is the evidence for the effectiveness of interventions to address cognitive and visual function, motor function, driving skills, self-regulation and self-awareness, and the role of passengers and family involvement in the driving ability, performance, and safety of older adults? This review provides evidence for occupational therapy practitioners working with this population to guide intervention and discusses ways to apply the results to clinical practice, research, and education.
Background and Statement of the Problem

According to the National Highway Traffic Safety Administration (NHTSA, 2013), 35 million drivers were age 65 yr or older in 2011, constituting 16% of all licensed drivers (latest data available). In 2011, the first wave of the baby boomer generation entered the 65-and-older age group, and the number of older drivers is expected to steadily increase over the next decade. By 2020, it is estimated there will be more than 40 million drivers age 65 or older (NHTSA, 2010). In 2011, 17% of all U.S. traffic fatalities involved people in this age group. Although fatalities from crashes involving older drivers declined 3% between 2010 and 2011, statistics have shown that as drivers age, their potential of dying in a crash increases, often because of increasing frailty and an inability to recover from physical injuries resulting from a crash. Fatal crashes remain highest in drivers age 85 and older and among female drivers ages 80–84 (NHTSA, 2013).

Many diseases of aging can have a negative influence on driving performance. Older adults, who may be experiencing gradual decline in sensory, physical, or cognitive areas of their functioning, continue to attach significant meaning to the ability to drive. The risk of a motor vehicle crash increases as functional abilities decrease, and this change can occur with declining health or may accompany normal, healthy aging in the oldest of drivers. Impairments from medical conditions in many body systems are associated with increased risks of motor vehicle accidents (Carr, Schwartzberg, Manning, & Semppek, 2010; Eby, Molnar, & Pellerito, 2005).

Although older drivers typically adapt their driving patterns and behaviors through a self-regulation process, some older drivers may benefit from occupational therapy intervention to reduce their crash risk by improving their knowledge, skills, and behaviors. Occupational therapy practitioners can promote healthy aging by encouraging older drivers to monitor their driving health and address physical or cognitive changes resulting from aging, injury, or disease. Interventions to reduce the risk of motor vehicle crashes among older drivers have targeted multiple factors, including the vehicle, the roadway, and the driver. Driving cessation is recommended only after the driver’s safety and performance cannot be improved by other means (Carr et al., 2010). The objective of this review was to synthesize the research literature to identify interventions within the scope of occupational therapy practice that were effective in maintaining, restoring, or improving driving performance in older adults.

Method

This review was completed as part of AOTA’s Evidence-Based Practice Project focusing on driving and community mobility for older adults and updated the previous work on this question completed by Hunt and Arbesman (2008). A detailed description of the specific methodology for the systematic review can be found in “Method for the Systematic Reviews on Occupational Therapy and Driving and Community Mobility for Older Adults” in this issue (Arbesman, Lieberman, & Berlanstein, 2014). The literature search focused on Level I–III studies (Sackett, Rosenberg, Muir Gray, Haynes, & Richardson, 1996) published between 2005 and April 2011. Search terms for the participants’ age (i.e., aged driver, aging, elderly, elderly driver, older driver, and senior driver) ensured that the articles reviewed focused on interventions used with drivers age 65 and older. Interventions addressed cognitive and visual function, motor function, driving skills, self-regulation and self-awareness, and the role of passengers and family involvement in the driving ability, performance, and safety of the older adult. The articles selected for review described interventions within the scope of occupational therapy practice as defined in the Framework (AOTA, 2014). Age criteria combined with the intervention terms used to search the literature yielded 1,609 possible citations. A total of 47 articles were identified as relevant to the question. After careful review and confirmation by the AOTA consultant, only 29 articles met the inclusion criteria. An occupational therapy graduate student worked with the author to review several articles and complete individual critical appraisals of select research. Supplemental Table 1 summarizes selected studies on interventions addressing the driving ability of older adults (available online at http://otjournal.net; navigate to this article, and click on “Supplemental”).

Results

Many of the articles reviewed described programs that incorporated more than one type of intervention such as classroom-based education and on-road training or cognitive–perceptual training and simulator training. Interventions were considered both individually and in combination. The articles reviewed were primarily Level I evidence (19 articles), with 5 Level II studies and 3 Level III studies. Two Level IV articles were reviewed because they offered the best evidence at present on an intervention used by occupational therapists. Five intervention themes emerged from the research: (1) education, including family education; (2) cognitive–perceptual training; (3) interventions addressing physical fitness; (4) simulator training; and (5) behind-the-wheel training.

Education

Nasvadi (2007) studied the effects of participation in the AARP’s 55-Alive mature driver education program on
self-reported changes in driving behaviors 1–5 yr after attendance. This study provided limited evidence that classroom educational sessions alone improved drivers’ knowledge. One Level I randomized controlled trial (Jones, Cho, Abendschoen-Milani, & Gielen, 2011) found classroom education did not significantly change driving habits. Several Level I studies provided strong evidence that classroom educational sessions combined with on-road training can improve driving knowledge and on-road driving performance (Bédard et al., 2008; Korner-Bitensky, Kua, von Zweck, & Van Benthem, 2009; Marottoli, Ness, et al., 2007) and significantly reduce unsafe driving actions in certain areas of a road test (Bédard et al., 2008; Marottoli, Allore, et al., 2007). Studies exploring the effectiveness of classroom education have not found a significant reduction in subsequent incidence of crashes in the older adult population (Korner-Bitensky et al., 2009). No studies have investigated combined classroom education and on-road training in reducing crash risk (Korner-Bitensky et al., 2009).

Many occupational therapy practitioners nationwide are involved in the CarFit Program, hosting events to educate older adults about the safety features of their vehicles and strategies to improve their personal fit to these safety features. Limited evidence from 1 Level I study (Gaines, Burke, Marx, Wagner, & Parrish, 2011) and 1 Level IV study (Stav, 2010) indicates that 60%–70% of CarFit participants implement one or more vehicle adjustments suggested while participating in an event. The implications of participation in CarFit programs for actual driving performance and crash risk are unknown.

Imposing driving restrictions on drivers with declining skills, such as only driving during daylight hours in vicinities close to home, is often considered to extend the driving life of older adults who may be experiencing age- or health-related declines in their driving abilities. One Level III study (Freund & Petrakos, 2008) provided limited evidence that these restrictions result in safety profiles similar to those of safe drivers, good compliance with restrictions, and no incidents of reported traffic violations or crashes.

Educational interventions for drivers with disabilities (e.g., stroke or low vision) have limited evidence supporting them. Combining in-class and on-road training significantly increased traffic theory knowledge and driving performance of clients with stroke in a Level II study by Söderström, Pettersson, and Leppert (2006), but this study had methodological design flaws that could have influenced its results. A systematic review of drivers with low vision (Strong, Jutai, Russell-Minda, & Evans, 2008) found limited evidence that education improved drivers’ self-awareness and driving performance but did not reduce crashes.

Family Involvement
Families and caregivers of drivers with dementia may need to assist the driver to decide when and how to reduce or stop driving to protect themselves and others. Stern et al. (2008) developed a support group intervention approach for caregivers using the workbook At the Crossroads: Family Conversations About Alzheimer’s Disease, Dementia and Driving (Hartford Financial Services Group, 2000). The approach had moderate evidence of its effectiveness. Caregivers who participated in the training demonstrated greater self-efficacy, discussed driving cessation or limitations with the at-risk driver, and showed increased awareness and use of a cessation agreement or advance driving directives form with their loved one. This study did not explore ability of the caregiver intervention to reduce the risk of motor vehicle crashes.

Cognitive–Perceptual Training
Although equipment modifications can be made to vehicles to adapt them for drivers with physical impairments, interventions addressing cognitive and perceptual impairments are more challenging. The progressive nature of some diagnoses such as dementia may make the resulting cognitive impairments less responsive to intervention. Improvements in cognitive skills in people with dementia may not be possible, and driving rehabilitation services focus on assessing when driving cessation is required. In people with general age-related declines or more stable cognitive impairments, interventions addressing the cognitive–perceptual performance skills of driving may improve their behind-the-wheel performance, reduce their crash risk, and prolong their driving and community mobility.

Three Level I studies (Ball, Edwards, Ross, & McGwin, 2010; Edwards, Delahunt, & Mahncke, 2009; Edwards, Myers, et al., 2009) and 1 Level III study (Cassavaugh & Kramer, 2009) investigated the effectiveness of computer-based cognitive speed-of-processing training on simulated driving performance, at-fault crashes, and driving cessation. Moderate evidence from several Level I studies indicates that cognitive–perceptual training, typically involving programs similar to the Useful Field of View (UFOV), can result in positive changes in driving performance.

Ball et al. (2010) provided moderate evidence in a Level I study that short-term (twice weekly for 5 wk) speed-of-processing and reasoning training resulted in a significantly lower rate (approximately 50%) of at-fault motor vehicle crashes per year of driving exposure and miles driven over a 6-yr period. The computer-based intervention involved visual attention skills and, similar to the UFOV, required participants to quickly identify and locate...
visual targets in increasingly demanding visual displays. The ability to program computer-based cognitive–perceptual training software to adapt to the participant’s responses ensures that participants are constantly receiving a just-right challenge to their capabilities. Similar computer-based speed-of-processing training programs have shown delayed driving cessation in 40% of drivers over a 3-yr follow-up period (Edwards, Delahunt, et al., 2009) and delayed driving mobility declines in older drivers with poor UFOV scores (Edwards, Myers, et al., 2009).

Cassavaugh and Kramer’s (2009) Level III study provided limited evidence that computer-based cognitive speed-of-processing training could improve response times and performance on a driving simulator. The eight-session training focused on visual tracking using a racing wheel to control the horizontal movement of the cursor on the computer screen and pedals to control its vertical movement, a visual–selective attention task similar to the UFOV, a visual–spatial task requiring the participant to report whether a target on the screen was in the same location as it was two trials previously (i.e., two-back running memory task), and a dual-attention task pairing the visual tracking with either the selective attention or the two-back spatial memory task. Improved response times and performance were seen in simulated driving.

Moderate evidence from a Level I study (Horswill, Kemala, Wettin, Scialfa, & Pachana, 2010) showed that video-based hazard perception training improved the latency of hazard perception ability in older drivers. This study trained older drivers to identify potential hazards while observing a 17-min video of real driving depicting a variety of hazardous situations. Drivers in the trained group also heard an expert driving instructor giving a running commentary on the footage, indicating what he was paying attention to and giving general advice about anticipating hazards. Training instructions told the drivers watching the video to focus not only on what they could see but also on what they could not see and thought might happen, tapping into anticipatory awareness. Drivers who received training were significantly faster, 513 ms (half a second) on average, in identifying potential hazards. Whether the improvements observed result in lasting or meaningful changes to real-world driving safety is unknown. Horswill et al. (2010) predicted that a car going less than 40 mi per hour travels approximately 29 ft in those 513 ms, enough distance for the driver to engage in action to avoid a crash.

Cognitive–perceptual retraining has also been used with clients with disabilities to improve their potential to maintain or return to the task of driving. Adults who sustain a right hemisphere stroke may experience perceptual impairments such as neglect or hemianopsia. Therapists seek clinic-based interventions to address these perceptual impairments and their effect on driving. A systematic review found that UFOV training improved on-road performance in drivers with right hemisphere stroke (Strong et al., 2008); however, a Level I study (Crothy & George, 2009) provided moderate evidence that the Dynavision Light Training Board did not significantly improve the on-road driving performance of drivers after stroke. This study had limitations because the study group varied in time since stroke (1 mo to >2 yr), and there was no standardized screening of visual neglect, visual attention, or motor severity.

A systematic review of drivers with low vision found limited evidence of the effectiveness of a binocular telescopic lens or visual field enhancement systems (i.e., prisms) on driving performance of people with low vision (Strong et al., 2008). Readers are referred to the occupational therapy comprehensive review of interventions to promote driving for older adults with low vision published in a previous issue of the American Journal of Occupational Therapy (Justiss, 2013).

Physical Fitness

Flexibility, coordination, and speed of movement have been associated with older drivers’ on-road performance. Several studies looked at the influence of short-term home- or community-based fitness programs on older driver safety. Marottoli, Allore, et al. (2007) conducted a Level I study that involved a graduated exercise program focused on axial and extremity conditioning, coordination, and strength in drivers age 70 or older who were labeled at risk because of two or more physical impairments but had no substantial visual or cognitive impairments. The intervention stabilized driving performance, resulting in fewer critical errors during a behind-the-wheel assessment 3 mo postintervention (Marottoli, Allore, et al., 2007). No studies have investigated the potential of physical fitness interventions to reduce crash risk (Korner-Bitensky et al., 2009).

Two studies used fitness programs involving simultaneous cognitive and physical fitness tasks to address older driver skills. There is moderate evidence from a Level I study (Marmeleira, Godinho, & Fernandes, 2009) that physical tasks requiring simultaneous cognitive–perceptual skills improved simulator driving performance. The cognitive–perceptual tasks in the program included activities that required use of peripheral vision such as maintaining several balloons in the air; tasks that targeted speed of processing such as responding to different auditory or visual signs with fast and specific psychomotor responses while walking; and activities that focused on response inhibition such as maintaining balloons in the air and rapidly catching specific colored balloons in response to an auditory cue. Caragata, Tuokko, and Damini (2009) found physical tasks mimicking driving
using driving props improved self-reported driving skills and confidence. The tasks used in this training program included activities such as turning one’s neck and torso to locate road signs held by the instructor or placed at various locations around the room and making driving-related decisions such as imitating checking the rearview mirror, braking, or steering in response to tape-recorded roadway sounds.

**Simulator Training**

Driving simulators have advanced significantly in their ability to provide opportunities for simulated yet realistic driving practice. The ability to select and adapt scenarios that challenge behaviors critical to safe driving while keeping both the potentially at-risk driver and the therapist safe is promising. The high cost of these state-of-the-art systems and the potential for drivers to experience simulator sickness have restricted their use in research and clinical intervention. Limited evidence from 1 Level II study (Romoser & Fisher, 2009) indicated that simulator training with active personalized feedback improved identification of peripheral hazards at intersections during simulator drives or improved perception of skills, receptiveness to changing driving behaviors, and performance of secondary looks during real-world driving. Strong evidence from several Level I studies indicates that simulator training with drivers with stroke can improve simulator-based driving performance (Strong et al., 2008), improve behind-the-wheel driving performance maintained at 6 mo (Akinwuntan et al., 2005), and improve anticipation and perception of signs, visual scanning behavior and communication, quality of traffic participation, and left turns (Devos et al., 2009).

**Behind-the-Wheel Training**

Driver rehabilitation typically involves behind-the-wheel training sessions with a driver rehabilitation specialist. The coaching provided by the therapist during these sessions has been explored for its effectiveness in changing the driver’s performance. One Level II study (Stanton, Walker, Young, Kazi, & Salmon, 2007) provided evidence that coaching focused on approaching and negotiating hazards to reduce crash risk can significantly improve driving behaviors and skills. This study used a distributed practice schedule of six observed 45-min drives over 8–12 wk.

Several Level I studies provided strong evidence that combining behind-the-wheel training with classroom educational sessions can significantly increase road test scores and resulted in 36% fewer critical errors, predicted to equal a 9.5% reduction in crash risk (Marottoli, Ness, et al., 2007). Another Level I study also found that instructor feedback during behind-the-wheel training significantly reduced unsafe driving actions that were sustained 4–8 wk postintervention (Bédard et al., 2008). Limited evidence from 1 Level II study (Romoser & Fisher, 2009) suggests that personalized feedback on peripheral hazards at intersections significantly increased secondary looks in 35% of simulator drives and 38% of community drives.

Limited evidence from 1 Level II study showed that behind-the-wheel training with drivers who had sustained strokes significantly improved driving performance and knowledge of traffic theory. This study combined behind-the-wheel and classroom sessions, making it difficult to separate the influence of each individual intervention on performance (Söderstrom et al., 2006).

**Limitations**

This systematic review has several limitations that must be considered when interpreting the results and their implications for practice. Sample size was limited in several studies, and some studies eliminated drivers with lower cognition—a group of drivers that cause particular concern because they may not be able to self-regulate their driving. Several studies had high dropout rates because of the rigor of the protocol or in some cases because of sickness from the driving simulator. In the studies that explored interventions for drivers poststroke, there was variability in the length of time since stroke. Improvements observed might have been a result of natural recovery of function and not intervention. Several studies lacked detail on the training programs, and protocols that combined interventions were not always designed to enable a clear interpretation of which components were effective. Finally, the outcome measures used in some studies limited interpretation, and limited or no long-term follow-up makes it difficult to know whether some clinical improvements resulted in meaningful changes to real-world driving.

**Discussion**

The ability to access and participate in community activities and services is vital to healthy aging. Older drivers’ ability to continue to safely drive can be affected by physical and cognitive changes associated with normal aging or with illness and injury. A range of interventions used by occupational therapists to promote improvements in the visual, motor, cognitive, and perceptual skills related to driving have demonstrated effectiveness. These interventions range from classroom driver education that promotes knowledge and self-regulatory behaviors to simulated and real-world driving interventions that require integration of cognitive, emotional, and physical skills. The evidence from this
systematic review provides guidance and recommendations for research and implications for occupational therapy practice and education.

**Recommendations for Future Research**

The role of occupational therapists in the area of older driver rehabilitation has been nationally recognized; however, occupational therapy research in the area of older driver safety remains limited. Additional research is needed to support the efficacy of interventions focused on delaying driving cessation and returning drivers with injuries or illness to independent driving. Occupational therapists working in driver rehabilitation must partner with researchers to clarify the type, combination, quantity, frequency, and duration of effective interventions related to the driver. Reliable and valid outcome measures are needed, such as standardized behind-the-wheel tests and collection of real-world driving data (e.g., interior- and exterior-mounted cameras and computerized car driving data recorders). These measures, combined with crash data, can provide insight into the clinical relevance and significance of driver-related interventions. Additional evidence on the efficacy of person-related interventions will support advocacy efforts for reimbursement of driver rehabilitation.

**Implications for Occupational Therapy Practice**

Several interventions explored in this systematic review hold promise:

- Occupational therapy practitioners should consider the use of visual, cognitive, motor, and educational interventions when working with older drivers on community mobility issues.
- Educational programs focused on awareness and self-regulatory behaviors are recommended. All occupational therapists should discuss driving with their clients and families along with strategies to reduce their risk of crashes or injuries.
- Group- and individual-based physical fitness programs that simultaneously challenge cognitive–perceptual skills may prolong driving years and delay cessation. Fit and flexible drivers may be more able to visualize risks and respond quickly while driving. Supporting the health and wellness of older drivers can be incorporated into occupational therapy practice or community service projects.
- Computer-based programs focused on increasing speed of processing are expanding and becoming more accessible to older adults. Occupational therapists need to be aware of the products and their potential usefulness in prolonging safe driving in older adults. Continued research is needed on the effectiveness of these new tools as they are developed.
- Evidence is emerging that hazard perception training, whether done in a clinical setting, with a simulator, or during behind-the-wheel training, can help drivers learn to anticipate hazards and where to focus their attention while driving. Therapists should provide client-centered coaching and feedback.
- Personalized feedback on driving performance using videotaped drives also holds promise. With the advances in technology, dash-mounted video cameras can be incorporated into behind-the-wheel training and reviewed with drivers after their session to offer feedback and suggestions for the next session. Coaching and feedback on performance, whether it be in a simulator or real-world on-road training, have strong evidence supporting their effectiveness.
- Occupational therapy practitioners should support caregivers as they address issues of driving cessation with drivers with dementia by offering psychoeducational support groups, possibly in collaboration with colleagues in social work or psychology. The planning needed to maintain community participation post–driving cessation requires cognitive skills that may be challenged. Occupational therapy practitioners may need to change the approach from remediation to supporting active engagement by helping the driver with dementia and his or her family transition to alternative forms of transportation to foster community participation and preserve roles outside the home.

**Implications for Occupational Therapy Education**

The Accreditation Council for Occupational Therapy Education standards require professional preparation programs to teach students about occupational therapists’ and occupational therapy assistants’ role in driver rehabilitation. Faculty must ensure the curriculum includes person-related driving interventions supported by evidence. Many academic programs have occupational therapy and occupational therapy assistant students engage in health-promotion projects during their studies. Students can be encouraged to identify opportunities to address driving health and older driver safety through community CarFit events and exercise groups in senior centers using activities similar to those described by Marmeleira et al. (2009) and Caragata et al. (2009).

**Conclusion**

Evidence supporting occupational therapy interventions focused on the driver has increased since the initial review of this topic was completed (Hunt & Arbesman, 2008). Strides have been made in educating future occupational
therapy practitioners about occupational therapy’s role in driver rehabilitation through educational standards, and AOTA has worked to build the profession’s capacity to meet the growing need for older driver evaluation and rehabilitation. Changing demographics and reimbursement structures require occupational therapy practitioners to be cognizant of the best available evidence supporting their selected interventions. We must continue to research the most efficacious methods to support older drivers’ ability to maintain their driving skills and community mobility and participation for as long as safely possible.

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References


*Indicates studies that were systematically reviewed for this article.


