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Prevalence, attitudes, and knowledge of in-vehicle technologies and vehicle adaptations among older drivers

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ABSTRACT

The purpose of the present study was to gain a better understanding of the types of in-vehicle technologies being used by older drivers as well as older drivers' use, learning, and perceptions of safety related to these technologies among a large cohort of older drivers at multiple sites in the United States. A secondary purpose was to explore the prevalence of aftermarket vehicle adaptations and how older adults go about making adaptations and how they learn to use them. The study utilized baseline questionnaire data from 2990 participants from the Longitudinal Research on Aging Drivers (LongROAD) study. Fifteen in-vehicle technologies and 12 aftermarket vehicle adaptations were investigated. Overall, 57.2% of participants had at least one advanced technology in their primary vehicle. The number of technologies in a vehicle was significantly related to being male, having a higher income, and having a higher education level. The majority of respondents learned to use these technologies on their own, with "figured-it-out-myself" being reported by 25%–75% of respondents across the technologies. Overall, technologies were always used about 43% of the time, with wide variability among the technologies. Across all technologies, nearly 70% of respondents who had these technologies believed that they made them a safer driver. With regard to vehicle adaptations, less than 9% of respondents had at least one vehicle adaptation present, with the number of adaptations per vehicle ranging from 0 to 4. A large majority did not work with a professional to make or learn about the aftermarket vehicle adaptation.

1. Introduction

The aging of the population is a global phenomenon. According to United States (US) Census Bureau data, 8.5% of the world's population was age 65 or older (hereafter referred to as older adults) in 2015 and projections show that 12% (1 billion people) will be older adults by 2030 (He et al., 2016). These percentages are much higher in developed countries. For example, in 2015, Japan's older adult population was 26.6% and the US older adult population accounted for 14.9% of the total population. Projections show that these percentages will continue to grow in the coming decades. The number of older adults who are driving is also increasing. Results from an analysis by the National Center for Statistics and Analysis (NCSA, 2017) indicated a 33% increase in the number of licensed older drivers in the US between 2006 and 2015, with 40.1 million licensed older drivers in the US in 2015. Despite the downward trend in older driver fatal crash rates, older drivers still have significantly higher fatal crash rates per mile driven than all but the youngest drivers (Insurance Institute for Highway

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Table 1
Questionnaire text used to describe technologies.

Technology	Text Used in Questionnaire to Describe the Technology
Adaptive cruise control	Conventional cruise control systems allow you to maintain a constant vehicle speed without keeping your foot on the accelerator pedal. Some vehicles also have adaptive cruise control; adaptive cruise control adjusts your vehicle speed automatically to maintain a constant gap or headway between your vehicle and the vehicle ahead.
Adaptive headlights	Adaptive (or "active") headlights can automatically change the direction of the light beam when you steer left or right on curved roads. On your vehicle, these headlights may be called "steerable headlights" or something similar.
Backup/parking assist	A backup/parking assist system helps the driver back up/park by either providing audible proximity alerts that sound to warn the driver when the front or rear of the vehicle is near an object, or by providing a rear-view camera with a grid, sounds, lights, or symbols to assist the driver in avoiding obstacles while reversing.
Blind spot warning	A blind spot warning system uses sensors to detect objects, such as other vehicles, that are to the left and right of the lane in which you are driving. The system can provide a warning when you are changing lanes or parking that there is a vehicle or other object next to your vehicle that you may not be able to see.
Cross traffic detection	A cross traffic detection system helps the driver back up by detecting traffic coming from the left or right and providing a warning and/or automatically stopping the vehicle if traffic is detected.
Emergency response	An emergency response system automatically calls emergency personnel when your vehicle is involved in a crash. Other systems will try to contact you first before calling emergency personnel.
Fatigue/drowsy driver alert	A fatigue/drowsy driver alert system uses various technologies to determine if you are getting fatigued or drowsy while driving and provides an alert to you that you may be getting too tired to drive safely.
Forward collision warning	A forward collision warning system uses sensors to detect objects, such as other vehicles, that are in front of your vehicle when you are driving. The system can provide a warning when you are about to collide with an object and, in some systems, apply the brake for you so that you do not hit the object.
In-vehicle concierge	An in-vehicle concierge system allows you to press a dashboard control button and connect with a person who can answer your questions, provide information, and provide other services while you are in your vehicle.
Integrated Bluetooth cell phone	An integrated Bluetooth cell phone system automatically connects with your cell phone and allows you to make and receive phone calls using the vehicle's speakers and dashboard interface without having to handle your cell phone.
Lane departure warning	A lane departure warning system uses sensors to detect your vehicle's position in the lane and provides a warning to you if you drift out of your lane.
Navigation assistance	A navigation system shows maps on a screen and/or provides step by step driving directions to help the driver get to a chosen destination.
Night vision enhancement	A night vision enhancement system uses infrared sensors to "see" objects such as people and animals at night and displays this information to the driver on a video screen in the vehicle.
Semi-autonomous parking assist	A semi-autonomous assistive parking system can steer the vehicle into a parking space by itself with little input from the driver, and in some cases this system can also detect a parking space automatically before self-parking.
Voice control	A voice control system allows you to control vehicle features such as the radio or navigation system, using commands that you speak out loud.

Safety, 2016). In 2015, 6156 older drivers were killed in traffic crashes and about 240,000 were injured (National Center for Statistics and Analysis, NCSA, 2017).

Automobile driving is a skilled activity that requires sound psychomotor, visual, and cognitive functioning. Because of age-related medical conditions, increased use of medications to treat these conditions, and general age-related declines, driving can become more difficult as individuals age (Dickerson et al., 2007; Eby et al., 2009). In part, because of the well-known negative impacts of driving cessation (see e.g., Chihuri et al., 2015) and in part because older adults' preferred method for mobility is the personal automobile (Kostyniuk and Shope, 2003; Zeitler and Buys, 2015), traffic safety and mobility professionals are interested in developing countermeasures to keep older adults driving for as long as they can safely operate an automobile. Recently, several authors proposed that in-vehicle technologies hold promise for helping older drivers stay on the road by assisting them in areas where they are experiencing functional declines (see e.g., Band & Perel, 2007; Eby and Molnar, 2014; Eby et al., 2015, 2016; Marshall et al., 2014; Meyer, 2009; Paris et al., 2014). The use of advanced, in-vehicle technologies could make driving safer and more enjoyable for older adults.

In addition to in-vehicle technologies, aftermarket automotive vehicle adaptations have been used for decades to assist drivers with functional impairments and make driving more comfortable (Bouman and Pellerito, 2006; Koppa, 2004; Mollenhauer et al., 1995; Mitchell, 1997). As described by Bouman and Pellerito (2006), adaptive devices are available to assist with a number of driving-related activities including ingress and egress (e.g., additional handles), safe and comfortable seating (e.g., seat cushions), steering (e.g., spinner knobs), throttle and braking control (e.g., pedal extension), and operating secondary systems (e.g., convex/multifaceted mirrors). The National Highway Traffic Safety Administration (NHTSA, 2007) recommends that drivers work with occupational therapists who can recommend appropriate vehicle adaptations based on the specific functional declines experienced. However, little formal evaluation has been conducted on the use of vehicle adaptations or how drivers go about getting these adaptations made.

The purpose of the present study was to gain a better understanding of the types of in-vehicle technologies being used by older drivers, as well as older drivers' use, learning, and perceptions of safety related to these technologies among a large cohort of older drivers at multiple sites in the US. A secondary purpose was to explore the prevalence of aftermarket vehicle adaptations, and how older adults go about making adaptations and how they learn to use them.

2. Methods

The study utilized baseline data from the multi-site Longitudinal Research on Aging Drivers (LongROAD) study. The LongROAD study was designed to explore several areas of older driver safety and mobility, including: protective and risk factors; medications; medical conditions; self-regulation; in-vehicle technologies and aftermarket adaptations; and cessation of driving. Study participants were enrolled in and around five cities distributed across the US (Ann Arbor, MI; Baltimore, MD; Cooperstown, NY; Denver, CO; and San Diego, CA). Data include self-reported health (i.e., mental, social, physical, cognitive, behaviors, conditions, and impairments and symptoms) and objectively measured health, functional abilities (i.e., cognition, psychomotor, and perception), and driving behaviors; medical record information; and violation and crash records.

Data for the present study were collected from a vehicle technology questionnaire (VTQ) administered to LongROAD participants at baseline. The list of specific technologies, vehicle adaptations, and topics addressed in the VTQ were developed by the research team, based on recent reviews of the literature and the project team's expertise (Eby and Molnar, 2014; Eby et al., 2011, 2015). The following in-vehicle