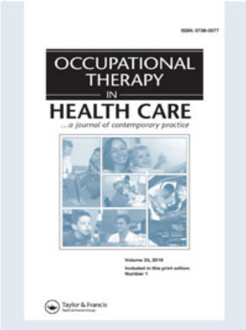

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[a]University of Michigan Transportation Research Institute, University of Michigan, Ann Arbor, MI, USA; [b]Center for Advancing Transportation Leadership and Safety (ATLAS Center), University of Michigan Transportation Research Institute, Ann Arbor, MI, USA; [c]Institute for Social Research, University of Michigan, Ann Arbor, MI, USA; [d]Monash University Accident Research Center, Monash University, Clayton, Australia; [e]Division of Geriatric and Palliative Medicine, Institute of Gerontology, University of Michigan, Ann Arbor, MI, USA; [f]Department of Epidemiology, Colorado School of Public Health, University of Colorado Anschutz Medical Campus, Aurora, CO, USA; [g]Department of Anesthesiology, Columbia University College of Physicians and Surgeons, New York, NY, USA; [h]Department of Epidemiology, Mailman School of Public Health, Columbia's Injury Control Research Center, Columbia University, New York, NY, USA; [i]Bassett Healthcare Network, Bassett Research Institute, Cooperstown, NY, USA

ABSTRACT

Evidence suggests that older driver safety may be improved by good vehicle maintenance, in-vehicle advanced technologies, and proper vehicle adaptations. This study explored the prevalence of several measures of vehicle maintenance and damage among older drivers through inspection of their vehicles. We also investigated the prevalence of in-vehicle technologies and aftermarket adaptations. Vehicle inspections were conducted by trained research staff using an objective, standardized procedure. This procedure, developed by a multidisciplinary team of researchers, was based on a review of inspection checklists used by automobile dealerships and the project team's expertise. The study used baseline data from vehicles of 2988 participants in the multi-site Longitudinal Research on Aging Drivers (LongROAD) study. Among this cohort, vehicles were well maintained, had little damage, and contained a range of advanced technologies but few aftermarket adaptations. Implications of study findings for occupational therapy practice are discussed.

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CONTACT Nicole Zanier nzanier@umich.edu University of Michigan Transportation Research Institute, 2901 Baxter Road, Ann Arbor, MI 48109.

*Howard Andrews, Marian E. Betz, Linda Hill, Vanya Jones, and Robert Santos.

Most societies around the world are aging, with increasingly larger proportions of populations being in the 65 or older age group (OECD, 2017). Unlike cohorts of older drivers in the past decades, the vast majority of the current cohort will hold driver licenses well into older adulthood (Sivak & Schoettle, 2012). At the same time, evidence suggests that medical conditions and increased medication use associated with aging can lead to declines in abilities necessary for safe driving (see e.g., Dickerson, Molnar, Bédard, Eby, Berg-Weger, et al., 2017). These declines, in conjunction with increased fragility and frailty (Li, Braver, & Chen, 2003; Meuleners, Harding, Lee, & Legge, 2006), contribute to a motor vehicle fatality rate per mile driven that begins to increase steeply after about age 74 (Insurance Institute for Highway Safety, 2017; Langford & Koppel, 2006; Tefft, 2017). Thus, older driving safety has become an important focus of research, programs practice, and policy.

There is general agreement that a multifaceted approach focusing on the driver, vehicle, and roadway is likely to be the most effective for achieving significant improvements in older driver safety (Classen, Eby, Molnar, Dobbs, & Winter, 2011; Dickerson et al., 2007; Dickerson, Molnar, Bédard, Eby, Berg-Weger, et al., 2017; Dickerson, Molnar, Bédard, Eby, Classen, et al., 2017; Eby & Molnar, 2008). One promising but relatively unexplored area for improving the safety of older drivers is vehicle maintenance. It is reasonable to think that a poorly maintained vehicle (e.g., one with broken headlights, inappropriate tire pressures, and/or nonoperational windshield wipers) should be less safe on the road. Although better vehicle maintenance has been proposed as one part of a systems approach to improving safety (Zein & Navin, 2003), and more specifically, tire pressure-related requirements and educational materials have been issued by the federal government (National Highway Traffic Safety Administration [NHTSA], 2001, 2005), few research studies have been conducted on the safety implications or prevalence of vehicle maintenance. Results from the few studies that have been done suggest that proper vehicle maintenance may be an important contributor to older driver safety (e.g., Bair, Huang & Wang, 2012; Blows, Ivers, Connor, Ameratunga, & Norton, 2003).

Research also suggests that the use of advanced technologies and aftermarket adaptations can benefit older drivers (see e.g., Bouman & Pellerito, 2006; Eby & Molnar, 2014; Eby et al., 2016; Koppa, 2004; Marshall, Chrysler, & Smith, 2014; NHTSA, 2007; Paris et al., 2014; Van Ranst, Silverstein, & Gottlieb, 2005). Advanced technologies are installed by the vehicle manufacturer either as standard or optional, while aftermarket adaptations are modifications or additional technologies/equipment added to the vehicle by the owner, often to help overcome some disability (Eby et al., 2018). However, like vehicle maintenance, there is little objective information on the prevalence of advanced technologies (e.g., backup cameras, blind spot warning systems) or assistive aftermarket adaptations (e.g., steering wheel knob, hand controls) in vehicles driven by older adults.

It is clear that more information about the vehicle maintenance habits of older drivers, and the prevalence of advanced technologies and aftermarket adaptations is warranted. Such information should be of particular interest to occupational therapy practitioners as it could provide valuable inputs into their approach for enhancing or enabling their clients' community participation. As described by the American Occupational Therapy Association (AOTA, 2014, p. S1):

> Occupational therapy practitioners use their knowledge of the transactional relationship among the person, his or her engagement in valuable occupations, and the context to design occupation-based intervention plans that facilitate change or growth in client factors (body functions, body structures, values, beliefs, and spirituality) and skills (motor, process, and social interaction) needed for successful participation. Occupational therapy practitioners are concerned with the end result of participation and thus enable engagement through adaptations and modifications to the environment or objects within the environment when needed.

Specifically, vehicle maintenance and condition, as well as aftermarket adaptations are relevant to at least two of the instrumental activities of daily living (IADLs; the activities to support daily life within the home and community) that occupational therapy practitioners consider an occupation and routinely assess. These are: driving and community mobility (i.e., planning and moving around in the community); and home establishment and management (i.e., obtaining and maintaining personal household possessions and environment including home, yard, garden, appliances, and vehicles).

The study reported here had two objectives: 1) to determine the prevalence of several measures of vehicle maintenance and damage among a large cohort of older drivers through inspection of their vehicles and 2) to investigate the prevalence of in-vehicle technologies and aftermarket adaptations in this cohort's vehicles. In this paper, we report findings from the study and discuss implications of these findings for occupational therapy practice.

Methods

Design

The study used baseline data from the multi-site Longitudinal Research on Aging Drivers (LongROAD) project, designed to explore older driver safety and mobility. Study participants were drawn from sites in five states across the United States (Ann Arbor, MI; Baltimore, MD; Cooperstown, NY; Denver, CO; and San Diego, CA). LongROAD data include both subjective and objective measures of health and functioning, driving patterns and behaviors, crashes, violations, and vehicle-related issues (e.g., presence of technology, maintenance). A full description of the study and measures can be found elsewhere (Li et al., 2017).

Procedure

Data for the present study were collected through a vehicle inspection conducted at baseline on the vehicles of all LongROAD participants by trained research assistants. A procedural manual and vehicle inspection form were developed by the multidisciplinary, experienced research team with expertise in health, aging, and driver safety. To ensure consistent data collection among sites, the procedural manual contained detailed instructions on how to accurately measure or determine the presence of elements of the vehicle inspection form. To further ensure consistency in data collection between sites, an in-person training session was held for all site data collection managers on the inspection procedures. Using a train-the-trainer model, these managers then trained inspectors at each site. The draft vehicle inspection form was pilot-tested with 56 older drivers recruited in roughly equal numbers from each of the sites but not part of the official study sample (mean age = 71.9 years; 53.4% men). The results of the pilot test were analyzed and feedback was gathered from inspectors at each site. This process resulted in minor modifications to the vehicle inspection form to improve consistency and clarity among sites.

The inspection form recorded data on four areas: general vehicle information (make, model, and year); maintenance (presence of dashboard maintenance reminders/warnings; tire tread depth and air pressure; properly functioning head, tail, high beam, reverse, brake, turn-signal, and hazard-warning lights; working front wipers and washer fluid); damage (condition of external and rearview mirrors; presence of cracks/chips in the windshield and windows; level of rust, scratches, dents, and major damage [such as resulting from a crash] to seven vehicle regions); and presence of 10 in-vehicle advanced technologies and 19 aftermarket adaptations. Only in-vehicle technologies that could reasonably be visually determined without driving the vehicle were included: adaptive cruise control, backup parking assist, voice control, night vision enhancement, navigation assistance, lane departure warning, blind spot warning, fatigue/drowsy driver alert, and forward collision warning. Vehicle adaptations included in the inspection were: convex/multifaceted mirrors, custom armrests, driver seat cushions, gas pedal block, hand controls, left foot throttle, modified secondary controls (wiper, horn, turn signal, cruise control, headlights), pedal extension, seat belt cushioning, push button ignition (aftermarket), seat belt extension, steering knob, spin pin, V-grip, palm grip, tri-pin, steering splint, amputee ring, and upper body support. The vehicle maintenance and damage categories were selected based on a review of inspection checklists used by automobile dealerships and the project team's expertise. The list of advanced technologies was developed based on previous research (Eby & Molnar, 2014; Eby et al., 2015) and represented a subset of technologies addressed in a questionnaire that was a separate component of the LongROAD study (Eby et al., 2018). The list of vehicle adaptations was developed based on the work reported by Bouman and Pellerito (2006).

Participants

LongROAD participants were recruited through the health care systems at each study site and received an incentive of up to $100 for their baseline participation. Participant inclusion criteria were age 65–79 years; a valid driver's license at enrollment; self-reported driving at least once per week; a score of ≥4 on the Six Item Screener (Callahan, Unverzagt, Hui, Perkins, & Hendrie, 2002), as determined by research staff to rule out significant cognitive impairment; consent to medical record review; driving a primary vehicle at least 80% of the time that was model year 1996 or newer; no plans to be out of the study area for more than 2 months each year; and plans to remain living in the study area for the next several years. Eligible individuals were scheduled for an in-person baseline session. At this session, written informed consent was obtained and data were collected, including the inspection of the participant's primary vehicle. Each site received approval for the recruitment and study procedures from its local institutional review board. Study data from all sites, excluding personally-identifiable information, were entered into a relational database through a secure Internet interface using software at a Data Coordination Center (DCC) located at Columbia University. The DCC sent data from all sites to the study lead authors for analysis. This paper focuses only on the vehicle inspection; fuller detail on other aspects of the overall study can be found at Li et al. (2017).

Data analysis

Descriptive data analytic techniques were used to examine the prevalence of maintenance, damage, in-vehicle technologies, and vehicle adaptations. Binary and linear regression analyses were conducted to assess effects of the following demographic categories: sex (men, women), age group

(65–69 years, 70–74 years, and 75–79 years), and household income (<$20,000; $20,000–$49,999; $50,000–$79,999; $80,000–$99,999; $100,000 or more) on specific inspection variables. The interaction between age group and sex was included in some models to determine if the effect of age group changed by sex, or vice versa. The interaction term was only added to the statistical models if there were independent statistically significant effects for both age group and sex. All analyses were conducted using SAS version 9.4. Proc Logistic was used for binary logistic regression models and Proc GLM was used for linear regression models.

Maintenance

Tread depth was measured in 1/32 inch increments. Based on NHTSA's (2013) recommendation of replacing tires when they reach 2/32 inch, depth measurements for each tire were categorized as poor (3/32 inch or less), fair (4/32–6/32), and good (7/32 or greater). An overall tire tread score for each vehicle was calculated by summing up tread depth values (poor = 3; fair = 2; good = 1) across all four tires. Tire tread scores could range from 4 to 12, with lower scores indicating better tread depth. Tire pressure was measured in pounds per square inch (PSI). For each tire, the vehicle manufacturer's recommended PSI was also recorded. These data were processed based on information from NHTSA (2005) to categorize each tire as underinflated (≤25% of recommended tire pressure); overinflated (≥25% of recommended tire pressure); or recommended (within ±25% of recommended tire pressure). All vehicle lights (head, tail, high beam, left/right turn signal, reverse, brake, and hazard) were classified as working/not working and as having glass that was broken/not broken. Wipers and washer fluid were recorded as working/not working. Mirrors were recorded as present/not present, and if present, as broken/not broken. Windshield and all other windows combined were coded as being either satisfactory, or as having cracks and/or chips. Also included in the maintenance category were data on the presence of 41 illuminated, dashboard warning lights.

Damage

Damage was categorized as rust, scratches, dents, and major damage. Damage data were collected from seven regions of the vehicle: driver side, passenger side, front bumper, rear bumper, hood, trunk/tailgate, and roof. There were significant missing data for roof condition because some sites had difficulty inspecting this part of the vehicle. Therefore, roof inspection data were not included in any analyses. Rust and scratches in each region were recorded using a four-point score (1 = none; 2 = minor; 3 = moderate;

and 4 = severe). More prevalent rust (i.e., a large area of the vehicle covered) or more prevalent scratches (i.e., scratching to an entire panel of the vehicle; scratches greater than 12 inches in length) resulted in a higher score. Dents were also recorded using a four-point score (1 = none; 2 = small; 3 = medium; 4 = large). Major damage was simply recorded as not present or present. Detailed instructions on how to accurately select a score for each damage category were described in detail in the LongROAD study procedural manual. For each category of damage, overall rust, overall scratch, overall dent, and overall major damage scores were derived by summing the scores for each region. Scores for overall rust, scratches, and dents could range from 6 to 24, while the major damage scores could range from 6 to 12. Vehicles with missing data for a damage category were excluded from analyses on that category.

Advanced technology and aftermarket adaptations

The presence of each of the 10 listed technologies and 19 aftermarket adaptations were recorded as either present or not present. Missing data for a technology or adaptation were recoded as the technology/adaptation not being present. Advanced technology and aftermarket adaptation overall scores for each vehicle were developed by summing the number of technologies and the number of aftermarket adaptations present in the vehicle. This advanced technology score could range from 0 to 10 and the adaptation overall score could range from 0 to 19.

Results

Demographics

A total of 2988 LongROAD participants' vehicles were inspected at baseline between July, 2015 and March, 2017. Participants were 53.0% women. The mean age of participants was 71.1 years (SD = 4.06, range = 65–79), with 41.5% in the 65–69 age group, 34.7% in the 70–74 age group, and 23.8% in the 75–79 age group. Household incomes were skewed toward higher incomes: <$20,000 = 4.6%; $20,000–$49,999 = 22.2%; $50,000–$79,999 = 24.9%; $80,000–$99,999 = 15.0%; and $100,000 or greater = 33.3%. The participants' education levels were 11.2% with a high school degree or less, 17.7% with some college but not a degree, 30.0% with an associates or bachelor degree, and 40.8% with an advanced college degree. Nearly 90% were White/Caucasian.

Table 1. Percent of all vehicles (number) with the top eight most frequently illuminated warning lights.

Name	Percent (Number)
Check engine	4.3% (127)
Tire pressure monitor	4.0% (118)
Change oil	2.0% (61)
Service vehicle soon	1.8% (53)
ABS trouble	1.1% (34)
Brake trouble	0.9% (28)
Low fuel	0.7% (22)
Airbag indicator	0.6% (19)

Maintenance

Headlights, tail lights, turns signals, hazard, reverse, and brake lights were inspected for functionality and broken glass. Data for each light type have been summed over the driver and passenger sides, front and rear, and center as appropriate. The percentage of operational vehicle lights (i.e., those that emitted light) ranged from 98.7% to 99.8%, depending on the light. Between 99.0% and 99.8% of lights were not broken, depending on the light. Similarly high levels of function were found for wipers (99.9%) and washer fluid (98.0%). Nearly all windshields (89.9%) and windows (99.6%) were free of cracks and chips. Nearly 100% of vehicles had all mirrors (driver, passenger, rearview) present, with intact lenses. Because of the lack of variance in these data, no statistical tests were conducted.

Warning lights on the dashboard of participants' vehicles were rarely illuminated (activated). Table 1 shows the number and percent of vehicles for the top eight most frequently activated lights. The most prevalent warning light was the check engine light, activated in 4.3% of vehicles. Because of the lack of variability in this measure, no statistical tests were conducted.

Tread depth

Tread depth was analyzed in two ways. First, we fit a binary logistic regression model using a dichotomized tread depth variable based on whether the tread depth in any of the four tires was 3/32 inch or less (poor) or tread depth in all four exceeded 3/32 inch (acceptable). Across the 2988 vehicles for which we had complete data, 5.5% ($n = 164$) had at least one tire that had poor tread depth. Results from logistic regression showed no significant main effects for sex or age group. A significant main effect was found by income, with the odds of the lowest income group having poor tire tread depth almost three times that of the highest income group (OR = 2.69, 95% CI: 1.50, 4.84).

The relationships between the demographics and overall tread score was next examined using a linear regression model. The computed overall tread score for each vehicle ranged from 4 to 12, with lower scores indicating

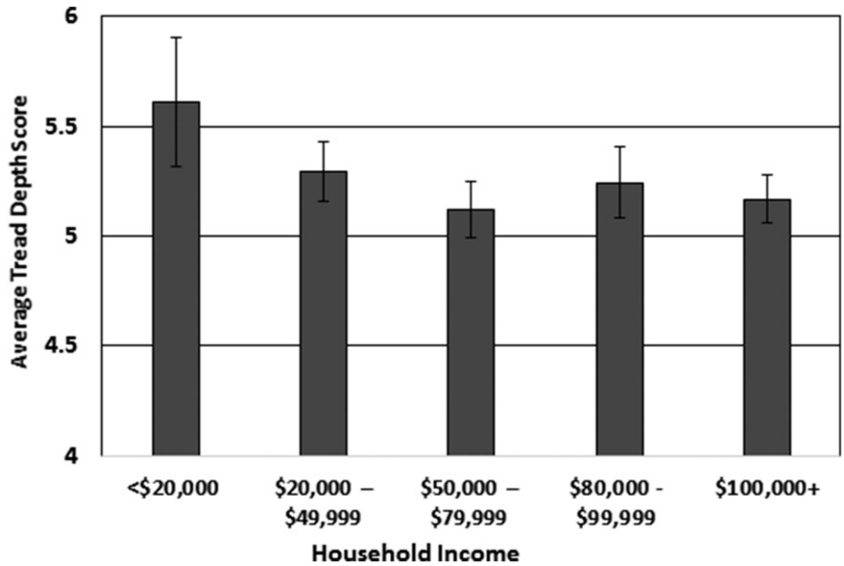

Figure 1. Average tread depth scores and 95% confidence intervals by household income.

greater tread depth. Of the vehicles in the analysis, 59.3% had a score of 4; that is, good tread depth on all tires, 38.8% scored between 5 and 9, and 1.8% had a score of 10 or more. Results showed no significant effects on tread depth scores by sex or age group. There was a significant difference found between the lowest and highest income groups (estimated difference = 0.46, 95% CI: 0.15, 0.77, $p = 0.0038$), with those in the lowest income group having higher tread scores. Figure 1 shows the average tread depth scores and confidence intervals for each income group. The scores in general were low, indicating that tread wear was minimal among the LongROAD cohort.

Tire pressure

Data on tire pressure were not available for 131 vehicles. Of the remaining 2857 vehicles, 15.0% ($n = 429$) had at least one tire improperly (i.e., either under- or over-) inflated, 6.8% ($n = 195$) had at least one tire underinflated, and 8.6% ($n = 245$) had at least one tire overinflated.

Binary logistic regression was used to examine the relationship between properly/improperly inflated tires and demographics. A vehicle with at least one tire over or under inflated was categorized as having improper tire inflation, while those with all tires at recommended pressure were classified as properly inflated. The effects of sex and age group were not significant. The effect of household income was significant with the odds of vehicle owners in the lowest income group having tires with improper pressure

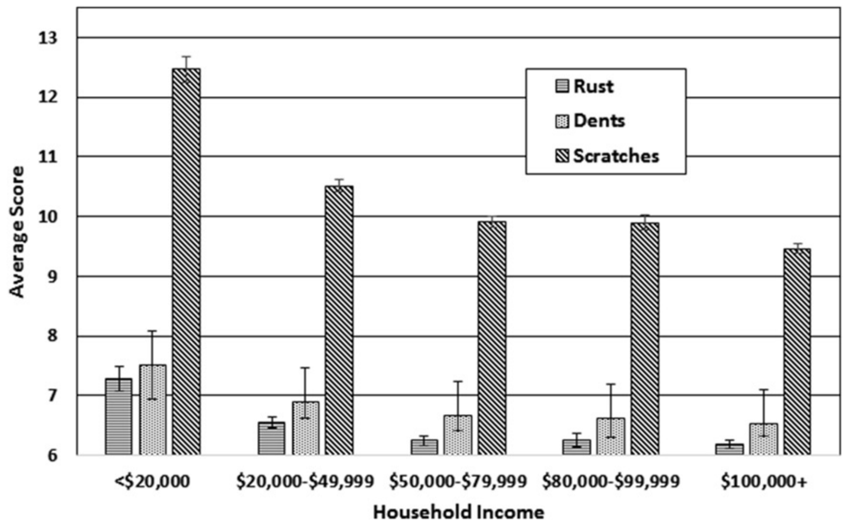

Figure 2. Average overall rust, dent, and scratch scores (95% confidence intervals) by household income.

being almost 4 times that of those in the highest income group (OR = 3.60, 95% CI: 2.31, 5.59).

Similar binary logistic models were fitted for to compare compared vehicles with at least one underinflated tire to those with no underinflated tires and vehicles with at least one overinflated tire to those with no overinflated tires. In both cases, there were no significant effects by sex or age group on either under and overinflated tires. In both cases, the effect of household income was significant. The odds of vehicle owners' in the lowest income category having at least one underinflated tire or one overinflated tire was about 3 times the odds of vehicle owners in the highest income category having such tires (Underinflated OR = 3.13, 95% CI: 1.75, 5.58; Overinflated OR = 3.34, 95% CI: 1.93, 5.76).

Damage

The average overall rust score was 6.34 (SD = 1.21, range= 6–21). There was a significant difference between men and women (estimated difference = 0.19, 95% CI: 0.11, 0.28, $p < .0001$), with men having higher rust scores than women. Participants in the lowest income group had significantly higher rust scores compared to the highest income group (estimated difference = 1.15, 95% CI: 0.93, 1.36, $p < .0001$), as did participants in the $20,000–$49,999 age group (estimated difference = 0.42, 95% CI: 0.30, 0.54, $p < .0001$). There were no significant differences in overall rust scores by age group. Figure 2 shows the overall rust scores by income.

Table 2. Regression summary of highest income level compared to other income levels on overall scratches score.

Household income	Estimated difference	p Value	95% Confidence interval	
<$20,000	2.92	<.0001	2.31	3.53
$20,000–$49,999	0.96	<.0001	0.62	1.31
$50,000–$79,999	0.40	0.0176	0.07	0.72
$80,000–$99,999	0.41	0.0376	0.02	0.79

The average overall dent score was 6.70 (SD = 1.29; range = 6–17). Results showed that income had a significant effect on dent score, with participants in the lowest income group having higher dent scores that those in the highest income group (estimated difference = 0.97, 95% CI: 0.74, 1.20, $p < .0001$). A similar result was found between the $20,000–$49,999 group and the highest income group (estimated difference = 0.34, 95% CI: 0.20, 0.46, $p < .0001$). Linear regression showed no significant effect on dent score by sex or age group. Figure 2 shows the overall dent scores by each income level.

The average overall scratch score was 10.0 (SD = 3.4; range = 6–24. Results showed a significant difference between men and women (estimated difference = −0.40, 95% CI: −0.64, −0.15, $p = 0.0019$), with women having higher scratch scores. There was also a significant difference by income. Table 2 shows the estimated differences, p-values, and confidence intervals between the highest income group and all other income groups on the scratch score. There were no significant differences in overall scratch scores by age group. Figure 2 shows the overall scratch scores by income.

The average major damage score was 6.04 (SD = 0.22, range = 6–9 out of 12). Only 3.0% of vehicles had any major damage and only 0.6% had major damage to more than one vehicle region. Because of the lack of variability on this measure, no further statistical analyses were conducted.

Advanced in-vehicle technologies

Overall, 52.6% of participants' vehicles had at least one advanced technology present, 26.6% had two or three technologies present, and 10.7% had more than three technologies. Figure 3 shows the prevalence of each technology recorded during the inspection and the percent of participants self-reporting each technology from previous work with this cohort (Eby et al., 2018). With the exception of voice control, there was good agreement between the technologies found during the inspection and what LongROAD participants reported in a questionnaire.

Results from the linear regression indicated that there were no significant differences in the number of advanced technologies by sex or age group.

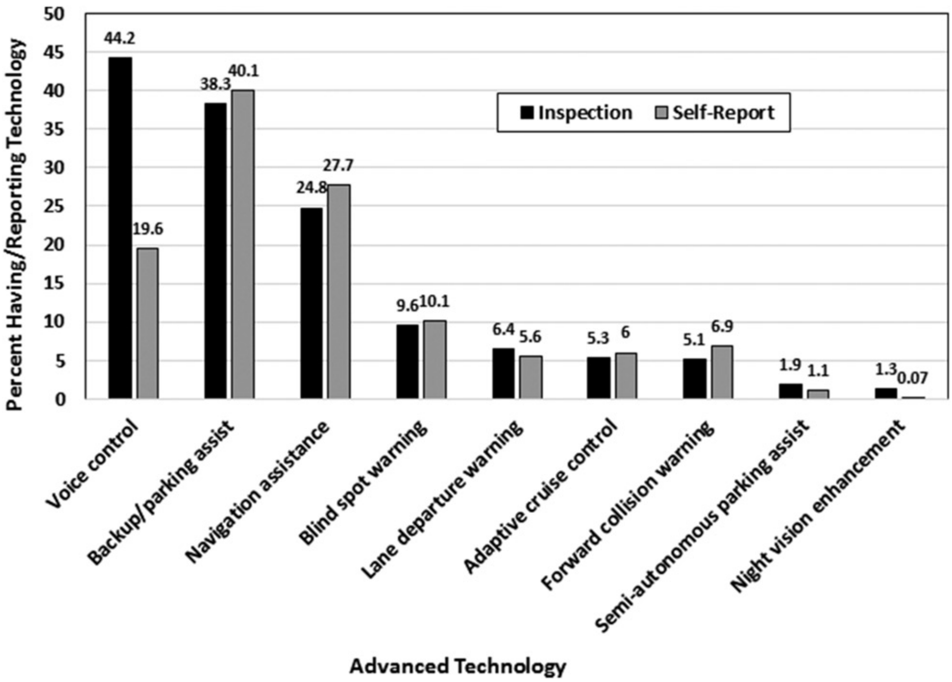

Figure 3. Advanced in-vehicle technology presence among LongROAD participants as determined by visual inspection and self-report.

Table 3. Regression summary of highest income level compared to other income levels on number of technologies.

Household income	Estimated difference	*p* Value	95% Confidence interval	
<$20,000	−1.54	<.0001	−1.86	−1.23
$20,000–$49,999	−1.08	<.0001	−1.26	−0.91
$50,000–$79,999	−0.64	<.0001	−0.81	−0.48
$80,000–$99,999	−0.30	0.0026	−0.50	−0.11

Analyses showed, however, that the presence of technology varied significantly by household income, with presence of technology increasing with increasing household income. Table 3 shows the estimated differences, *p* values, and 95% confidence intervals between the highest income group and all other income groups on the presence of technologies.

Aftermarket vehicle adaptations

Aftermarket adaptations were present in 21.7% ($n = 645$) of vehicles, with 3% of vehicles having two or more adaptations. Figure 4 shows the percentage of each adaptation in participants' vehicles among those who reported having at least one adaptation in the present study as compared to what LongROAD participants self-reported and presented by the authors in a previous paper (Eby et al., 2018). Adaptations that were not present in

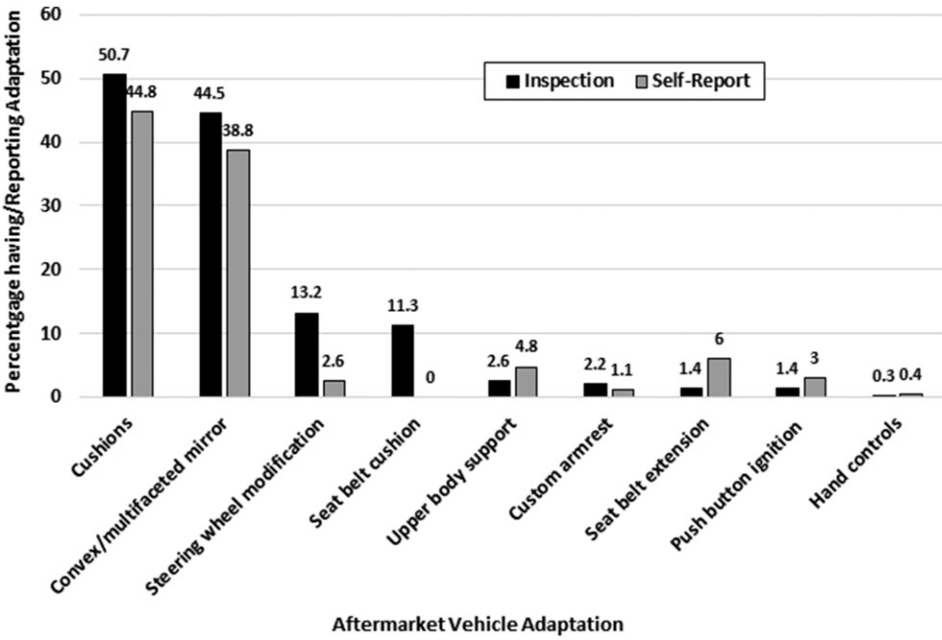

Figure 4. Aftermarket vehicle adaptation presence among LongROAD participants as determined by visual inspection and self-report (Eby et al.,2018).

any vehicle are not included in this figure. Steering knob, spin pin, V-grip, palm grip, tri-pin, steering splint, and amputee ring are combined into a single category called steering wheel modification. Visual comparison between the inspection and self-report results show generally good agreement for most of the adaptations.

Results of the linear regression showed that those in the 75–79 age group had significantly more adaptations than those in the 65–69 age group (estimated difference = −.10, 95% CI: −.15, −.05, $p < .0001$) and those in the 70–74 age group (estimated difference = −.05, 95% CI: −.10, −.002, $p = 0.0404$). Participants in the \$20,000–\$49,999 income group had significantly more adaptations than those in the highest income group (estimated difference = 0.10, 95% CI: 0.05, 0.15, $p = 0.0002$), as did those in the \$50,000–\$79,999 income group (estimated difference = 0.09, 95% CI: 0.04, 0.14, $p = 0.0005$).

Discussion

This paper reported on the observed maintenance and damage of vehicles, as well as the presence of in-vehicle technologies and aftermarket adaptations in a large cohort of older drivers. Results indicated that older drivers in the LongROAD cohort had well-maintained vehicles. Nearly all vehicle lights were working and free of broken glass. Nearly all mirrors were present and also free of broken glass. More than 98% of wipers and washer fluid systems were operational. Very few vehicle warning lights were activated. Overall, vehicle tires were also well maintained, with less than 6% having at least one tire with an unsafe tread depth and 15% having an unsafe tire pressure.

Analyses of the tire data, however, showed that tire maintenance was significantly worse for those in the lowest income group as compared to those in other household income groups. Such results suggest that older drivers with low incomes may be at higher risk for a tire-maintenance-related crash. This income result makes sense for tread depth. Maintaining proper tread depth involves the replacement of worn tires and this can be costly. Maintaining proper tire pressure involves regular monitoring of tires and adjusting pressure as needed, which does not necessarily require higher incomes to perform. However, there is evidence that as many as 38% of older drivers wait until vehicles are serviced to get tire pressures checked (Thiriez & Bondy, 2001). In addition, tire pressure monitoring systems are only required on vehicles that are model year 2007 or newer (NHTSA, 2005). It is likely that people with higher incomes may get their vehicles serviced more regularly and may have newer cars, leading to better monitoring of tire pressure. These results suggest that efforts should be made to better market existing resources on the importance of proper vehicle maintenance to lower income older adults, such as *Senior Driving.com: How to Maintain your Vehicle* (AAA, 2017) and *Tire Safety: Everything Rides on It* (NHTSA, 2001).

The LongROAD cohort of older drivers had vehicles with little vehicle damage. Scores for rust, dents, and major damage averaged close to the lowest possible score of 6, indicating that few vehicles had these types of damage. Scratches were the most common type of damage, with an average scratch score of 10 on a scale of 6–24. As with the other types of damage, those in the lowest income group had significantly more scratches on average than other income groups. Thus, for all types of damage, those in the lowest income group had significantly higher scores. It is possible that this result is related to lower income participants having older vehicles. Indeed, the average of model years for vehicles of participants in the lowest household income group was 2005.6 as compared to the four higher income categories: 2008.4, 2009.7, 2009.7, and 2009.9. As the cohort moves into future years, we anticipate that changes in damage scores may serve as a proxy for increasing challenges in safe driving and expect that these scores will begin to vary by other demographic factors and functional declines.

The vehicle inspection included the presence of advanced in-vehicle technologies and aftermarket vehicle adaptations. More than 50% of vehicles had at least one type of advanced technology while about 22% had at least one aftermarket adaptation. The presence of advanced technologies significantly increased with household income. This result was expected in that many of the advanced technologies in the inspection are available as options at additional cost. Thus, those with higher incomes are more able to afford many of these technologies. The study found that those in the oldest age group had more adaptations as compared to the youngest age group. This result could possibly be due to further declines in functionality in the oldest age group versus the youngest. The study also found that the presence of adaptations was higher for the second and third lowest income group as compared to the two highest. It is not clear why this was the case. These results suggest that better marketing of programs such as CarFit (AARP, AAA, & AOTA, 2018) and increased awareness of information such as *Safe Driving Tips for Seniors* (AOTA, 2004) could help older drivers make appropriate adjustments and adaptations to keep them driving safely.

We also compared the prevalence of technologies and adaptations measured from the vehicle inspection in the present study to self-report of these items from the same cohort of older drivers reported in a separate paper (Eby et al., 2018). In general, we found relatively good agreement for most advanced technologies and moderate agreement for the adaptations. The main difference in the two prevalence estimates for advanced technologies was for "voice control" for which the prevalence differed by nearly 25 percentage points. This discrepancy likely resulted from confusion between voice control technologies that allows a person to operate vehicle systems such as an on-board computer or navigation system (e.g., Jenness et al., 2016) and integrated Bluetooth technology that allows a driver to connect his or her cellular phone to the on-board computer and operate the phone through voice commands. In Eby et al. (2018), about 47% of the cohort reported having integrated Bluetooth which is very close to the percentage of 44% found in the inspection. Thus, in future analyses of the self-reported data, integrated Bluetooth and voice control technologies should be combined.

As expected, there was an 11.3 percentage point difference between the inspection and self-reported prevalence data for seat belt cushions because this modification was not asked about in the questionnaire. The study also found a discrepancy of 10.6 percentage points between the two prevalence measures for steering wheel modifications, with higher prevalence for the inspection measurement. Without further research, we cannot determine the reason for this difference, but we hypothesize that our older drivers likely did not view these relatively minor modifications (that can be done by the driver himself or herself) as being adaptations to a vehicle and, therefore, did not report them as adaptations.

Finally, the study found that among this large cohort of older drivers, vehicles were well-maintained, had little damage, contained a wide range of advanced technologies, and some aftermarket adaptations. A common theme was that the vehicles of older drivers with low household incomes were significantly different in many cases to vehicles used by older drivers in other income categories. For metrics that one would logically associate with traffic safety (tire tread depth, tire pressure, dents, scratches, major damage, and the presence of advanced technology), vehicles of drivers in the lowest income group had scores indicating that they were potentially less safe than vehicles of drivers in other income groups. As a practical consideration, this finding suggests the need for a renewed focus on efforts to improve vehicle-based traffic safety countermeasures targeted at low income older drivers.

Strengths and limitations

The strengths of this study included the use of a large sample of vehicles of older drivers who were recruited at five distinct geographic locations in the US, and objective examination of a wide range of maintenance, damage, technologies and vehicle adaptations. A limitation was that we did not know the history of the vehicle prior to the inspection; thus the vehicle may have been used by non-participants in areas that adversely impacted maintenance and damage. Participants may also fix damage to their vehicle between inspections. As this longitudinal study progresses, we will be able to account for many of these factors. Care should be taken in interpreting the findings from the regression analyses as the predictive power of the statistical models was not strong. Finally, the LongROAD cohort is relatively well-educated with high household incomes and, therefore, not representative of all older drivers. As such, these results may not generalize to all older driver populations. It should be noted that this study represents the baseline findings from an older driver cohort with relatively high functioning and overall health. It is not surprising that vehicle maintenance and condition was generally good. As the LongROAD study progresses, and the prevalence of age-related health conditions and functional deficits increase, we may begin to see more pronounced differences in vehicle maintenance, technologies, and adaptations, by age and sex.

Implications for occupational therapy practice

Current occupational therapy practice includes the assessment of several IADLs as part of its goal of habilitating, rehabilitating, and promoting health and wellness (AOTA, 2014). As discussed earlier, vehicle maintenance and condition come into play in at least two of the IADLs (driving/community mobility and home establishment/management), although vehicle maintenance/condition is hardly mentioned in the occupational therapy framework. At the same time, the importance of maintenance and management more generally is recognized in the framework, with those issues being the central focus of several IADLs (e.g., health management and maintenance, safety and emergency maintenance).

There is an opportunity in occupational therapy practice to more explicitly recognize the role of vehicle maintenance in its framework, either by discussing it more directly as part of an existing IADL or creating a new IADL with an exclusive focus on issues related to maintaining the vehicle. Similarly, given that occupational therapy practitioners are already directly involved in making recommendations about aftermarket vehicle adaptations, it makes sense to think about how this process could be better elucidated in the framework, and how prevalence data could inform occupational therapy practice. More generally, given the potential benefits that improved vehicle maintenance might have on older adult safety, knowledge about the vehicle maintenance habits of older drivers should be of great interest to occupational therapy practitioners, particularly among practitioners who have low income older adults as clients. Furthermore, such knowledge could provide a valuable context for understanding changes in performance skills (i.e., motor, process, and social interaction skills) and their underlying capabilities, thus leading to a better understanding of the interplay between the multitude of client and environmental factors that support or hinder occupational performance (e.g., see Chisholm & Boyt Schell, 2014). This approach is also relevant to the LongROAD study. While we saw high levels of vehicle maintenance among our relatively healthy sample at baseline, we would expect these levels to decline over time as participants age and begin to experience declines in performance skills and capabilities that could affect their ability to carry out occupations.

Conclusion

This study used visual inspection data to investigate the condition, maintenance, in-vehicle technologies, and assistive adaptations of 2988 older drivers' vehicles. Results showed that vehicles were well-maintained overall. However, the vehicles of low income older drivers were found to be potentially less safe with respect to tire maintenance, vehicle body damage, and the presence of in-vehicle technologies as compared to other drivers. Assistive adaptations were found in about one fifth of vehicles. Collectively, these findings identify an opportunity for occupational therapy practitioners to increase the safety and quality of life of their older adult clients by marketing programs such as *CarFit* and other materials that could educate older, particularly lower income, drivers on proper vehicle maintenance and assistive adaptations. These efforts would enhance driving and community mobility, and home establishment and management, two instrumental activities of daily living.

Declaration of interest

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of this paper.

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About the Authors

Nicole Zanier is a Research Technician Lead in the Behavioral Sciences Group at the University of Michigan Transportation Research Institute, Ann Arbor, MI.

Lisa J. Molnar, PhD, is an Associate Research Scientist in the Behavioral Sciences Group at the University of Michigan Transportation Research Institute, Ann Arbor, MI.

David W. Eby, PhD, is a Research Professor and Head of the Behavioral Sciences Group at the University of Michigan Transportation Research Institute, Ann Arbor, MI.

Lidia P. Kostyniuk, PhD, PE, is a Research Scientist Emerita in the Behavioral Sciences Group at the University of Michigan Transportation Research Institute, Ann Arbor, MI.

Jennifer S. Zakrajsek, MS, MPH, is a Lead Research Associate in the Behavioral Sciences Group at the University of Michigan Transportation Research Institute, Ann Arbor, MI.

Lindsay H. Ryan, PhD, is an Associate Research Scientist in the Survey Research Center at the Institute for Social Research at the University of Michigan, Ann Arbor, MI.

Renée M. St. Louis, MPH, is a Research Area Specialist in the Behavioral Sciences Group at the University of Michigan Transportation Research Institute, Ann Arbor, MI and a PhD candidate at the Monash University Accident Research Centre in Victoria, Australia.

Sergiu C. Stanciu is a Research Technician Lead in the Behavioral Sciences Group at the University of Michigan Transportation Research Institute, Ann Arbor, MI.

David J. LeBlanc, PhD, is an Associate Research Scientist and Head of the Engineering Systems Group at the University of Michigan Transportation Research Institute, Ann Arbor, MI.

Jacqui Smith, PhD, is a Professor of Psychology and Research Professor in the Institute for Social Research at the University of Michigan, Ann Arbor, MI.

Raymond Yung, MD, is Jeffrey B. Halter Professor of Geriatric Medicine, Director of Geriatrics Center, and Chief of the Division of Geriatric and Palliative Medicine at the University of Michigan, Ann Arbor, MI.

Linda V. Nyquist, PhD, is a senior research associate at the University of Michigan Geriatrics Center, Ann Arbor, MI.

Carolyn DiGuiseppi, MD, MPH, PhD, is Associate Dean for Faculty and Professor of Epidemiology at the Colorado School of Public Health, University of Colorado Anschutz Medical Campus, Aurora, CO.

Guohua Li, MD, DrPH, is the Mieczyslaw Finster Professor of Epidemiology and Director of the Center for Injury Epidemiology and Prevention at Columbia University.

Thelma J. Mielenz, PT, PhD, MS, OCS is an Assistant Professor and the Director of Education for the Injury Control Research Center and Co-Director of EPIC in the Department of Epidemiology at the Mailman School of Public Health, Columbia University, New York, NY.

David Strogatz, PhD, is the Director of the Center for Rural Community Health within the Bassett Research Institute, Cooperstown, NY.

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ORCID

Nicole Zanier http://orcid.org/0000-0001-9661-7512
Lisa J. Molnar http://orcid.org/0000-0002-9556-1761
David W. Eby http://orcid.org/0000-0001-8650-0628
Lidia P. Kostyniuk http://orcid.org/0000-0002-9704-6392
Jennifer S. Zakrajsek http://orcid.org/0000-0001-6997-4354
Lindsay H. Ryan http://orcid.org/0000-0001-8498-2539
Renée M. St. Louis http://orcid.org/0000-0002-4751-2420
Sergiu C. Stanciu http://orcid.org/0000-0001-7552-7016
David J. LeBlanc http://orcid.org/ 0000-0002-0280-5203
Jacqui Smith http://orcid.org/ 0000-0002-6499-103X
Raymond Yung http://orcid.org/ 0000-0002-8181-027X
Linda V. Nyquist http://orcid.org/ 0000-0001-7687-3391
Carolyn DiGuiseppi http://orcid.org/ 0000-0002-6440-7817
Guohua Li http://orcid.org/ 0000-0003-4732-2448
Thelma J. Mielenz http://orcid.org/ 0000-0001-5975-7209
David Strogatz http://orcid.org/ 0000-0002-5805-6280

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