RESEARCH BRIEF

In-Vehicle Technology Use and Associated Factors Among Older Drivers

January 2023

Previous research using data from the AAA Longitudinal Research on Aging Drivers (AAA LongROAD) study has shown that many older drivers infrequently use available in-vehicle technologies, which may limit their safety and mobility benefits. This study examines the prevalence and frequency of use of in-vehicle technologies among a subset of AAA LongROAD participants as well as the relationships between technology use frequency and perceived cognitive and physical functions, driving-related abilities, self-reported driving behaviors, and other measures. Results indicate participants used the technologies that only alert the driver of unsafe driving conditions (e.g., blind spot warning) more often than those with other functions (e.g., parking assist). Greater cognitive concerns and avoidance of challenging driving situations were associated with less frequent use of some technologies, while greater perceived physical function, driving-related abilities, and driving comfort and space were associated with more frequent use of other technologies.

METHODS

Data for this study are from the AAA LongROAD study, a multisite prospective cohort study designed to collect data on the health, behavioral, environmental, and vehicle technology factors influencing older adults' driving and safety (Kelley-Baker et al., 2017; Li et al., 2017). More specifically, the present study used data collected from the Year 3 follow-up (June 28, 2018–May 20, 2020), which consisted of a telephone interview during which a series of questionnaires were administered regarding participants' driving, health, and functioning.

Table 1 lists and describes the health- and driving-related variables used in the present study. To measure participants' perceived cognitive concerns and physical functions, some Patient-Reported Outcomes Measurement Information System (PROMIS) survey items were used. The measurements were scored using PROMIS (HealthMeasures, n.d.) and American Psychiatric Association guidelines (n.d.) for the specific PROMIS survey items. The collected scores were standardized to the general population, with a score of 50 indicating the mean in the general population and 10 as the standard deviation to derive PROMIS T-scores (Table 1). Participants self-reported their avoidance of driving in various situations, frequency of engagement in various driving errors, lapses, and violations, as well as the number of crashes they were involved in over the past year as a driver. The telephone interviews at Year 3 also collected perceived driving space, safe-driving abilities, and driving comfort.

Additionally, a vehicle technology questionnaire was administered to participants who had changed their primary vehicle since their Year 2 follow-up, which addressed presence and frequency of use of various in-vehicle technologies (Kelley-Baker et al., 2017). Four technologies were excluded from the current study because they were always on and the question asking how often they were used was not prompted (cross-traffic detection, adaptive headlights, emergency response, and backup/parking assist). Table 2 lists in-vehicle technologies used in the present study with brief descriptions of their primary functions. The full list of technologies assessed along with the descriptions that were provided to participants are included in Eby et al. (2021).

Descriptive analyses were conducted to examine prevalence and frequency of use of the in-vehicle technologies. A Spearman correlation (r_s) matrix was constructed to assess the associations between in-vehicle technology use frequency and the health and other driving-related variables in Table 1. The strength of estimated association was assessed using Dancey & Reidy's (2007) categorization.

RESULTS

The demographics of participants who changed their vehicle in Year 3 are shown in Table 3. Nearly 80% of them were aged 70–79 and 90% were white. Four in ten had a master's, doctoral, or professional degree, and about a third had an income of $100,000 or more.

Participants' health and cognition, and prevalence of crashes, violations, errors, lapses, and driving avoidance behaviors

Study participants who changed their primary vehicle in Year 3 reported less cognitive concerns compared to the general population (Table 1). Their self-reported physical function was typical of the general population. Few (12.42%) participants reported being involved in a crash(es) as a driver in the past year. Additionally, nearly 95% reported having 'never' or 'hardly ever' engaged in any of the driving violations, errors, and lapses listed in the questionnaire. Among 10 examined challenging driving situations (e.g., driving at night, on busy roads), participants, on average, reported avoiding three for various reasons, including self-regulation due to physical and/or cognitive health declines.

Driving space, ability, and comfort

Participants reported, on average, having driven in four of the six driving spaces examined in the study. The average self-rating across five driving-related abilities (e.g., see at night or remember things) was 5.88 (on a 7-point scale from poor to *excellent*) as shown in Table 1. Their average self-rated level of comfort driving in various situations was 5.60 (on a 7-point scale from *not at all comfortable to completely comfortable*).

Presence and frequency of use of in-vehicle technologies

As shown in Table 2, the most prevalent in-vehicle technology among those who changed their primary vehicle in Year 3 was integrated Bluetooth cell phone, which 94% of participants reported having, followed by navigation assistance at 60%. In contrast, 5% had semi-autonomous parking assist in their vehicles, and only 3% of participants had night vision enhancement.

Participants tended to use the technologies that only warn of unsafe driving situations more often than technologies with other primary functionality (i.e., taking actions to assist vehicle operations, providing services or information). For example, most participants with forward collision warning in their vehicles reported always using it (Figure 1). The analysis showed similar results for blind spot warning and lane departure warning. On the other hand, fewer than 10% of participants with semi-autonomous parking assist reported always using it. About a third of participants who had an integrated Bluetooth cell phone system reported always using it.

Associations between cognitive concerns and frequency of in-vehicle technology use

Frequency of use of a majority of the in-vehicle technologies examined in this study was not significantly associated with participants' cognitive concerns, including technologies that provide alerts of unsafe driving situations (Table 4). In contrast, the results for technologies that take actions to assist drivers with vehicle operations—adaptive cruise control and semi-autonomous parking assist—were statistically significant. Participants with greater cognitive concerns tended to use adaptive cruise control less frequently, although this correlation was weak ($r_s = -0.29$). On the other hand, those with greater cognitive concerns tended to use semi-autonomous parking assist more frequently, and this correlation was moderate ($r_s = 0.49$).

Participants' self-reported cognitive concerns were significantly associated with frequency of using a fatigue/drowsy-driving alert system. Participants with greater cognitive concerns tended to use this system less often. The estimated correlation magnitude was moderate ($r_s = -0.59$). Frequency of using integrated Bluetooth cell phone technology was also significantly associated with self-reported cognitive concerns: participants with greater cognitive concerns tended to use it less frequently, however, the correlation was weak ($r_s = -0.16$).

Associations between physical health and frequency of in-vehicle technology use

In relation to physical health, only the use frequency of two technologies were significantly associated: fatigue/drowsy driving alert and navigation assistance (Table 4). Participants with better self-reported physical health tended to use both technologies more frequently. The correlation for fatigue/drowsy-driving alert was moderate to strong (r_s = 0.65), while that for navigation assistance was weak (r_s = 0.25).

Associations of driving safety measures (crash, violations, errors, lapses) and driving avoidance behaviors with frequency of in-vehicle technology use

There was no significant association between self-reported crashes and in-vehicle technology use frequency. Likewise, self-reported driving errors, lapses, and violations were not significantly associated with frequency of use of any of the in-vehicle technologies (Table 4). Driving avoidance behaviors, however, were associated with the frequency of using adaptive cruise control, voice control, and integrated Bluetooth cell phone technologies. Participants who reported avoiding a greater number of challenging driving situations tended to use these technologies less frequently, though the correlations were weak (Table 4).

Associations between driving space, comfort, and perceived abilities and frequency of in-vehicle technology use

Frequency of use of only three of the technologies examined in this study was significantly associated with participants' driving space (Table 4). The frequency of using adaptive cruise control, navigation assistance, and integrated Bluetooth cell phone among the sample tended to increase with greater driving space, although the correlations were weak.

Additionally, participants with greater perceived driving-related abilities tended to use in-vehicle technologies more frequently (Table 4). Frequency of using adaptive cruise control and navigation assistance were positively associated with perceived driving ability, but the correlations were weak. Likewise, frequency of using voice control and integrated Bluetooth cell phone technologies were positively associated with driving ability, but the correlations were weak. Meanwhile, the correlation between frequency of using fatigue/drowsy-driving alert technology and driving ability was strong with high statistical significance ($p < 0.01$) (Table 4).

The frequency of using four technologies was significantly associated with perceived driving comfort (Table 4). Participants with greater comfort in challenging driving situations tended to use adaptive cruise control, navigation assistance, voice control, and integrated Bluetooth cell phone more frequently than those with lower driving comfort, although the correlations were weak.

DISCUSSION

This research brief examined the prevalence of in-vehicle technology, frequency of their use among older drivers, and associations with older drivers' self-reported health, driving safety, driving avoidance behaviors, and other driving-related measures. Descriptive analyses showed that participants tended to use in-vehicle technologies that alert them of unsafe driving situations (e.g., forward collision warning, blind spot warning) more often than those having other primary functionality (e.g., taking actions to assist drivers' vehicle operations, providing services or information). In general, greater self-reported cognitive concerns and driving avoidance behaviors in challenging situations were significantly associated with lower use of some technologies. Additionally, greater physical function, driving comfort, perceived driving-related abilities, and driving space were associated with higher use of some technologies. Meanwhile, the associations with self-reported driving safety measures (i.e., number of crashes, driving errors, lapses, and violations involvement) were not significant.

These findings suggest that some in-vehicle technologies may be beneficial to older drivers in terms of expanding their driving spaces (e.g., long-distance driving, driving beyond their neighboring towns). However, this study also showed that those with poorer perceived cognitive health (indicated by greater cognitive concerns reported by participants) were less likely to use in-vehicle technologies. These findings suggest that the benefit from in-vehicle technologies might be limited to those who perceive good physical and cognitive function, feel comfortable with driving in various situations, and/or rate their driving-related abilities as good, although further research is needed to confirm this.

Also, the findings might be related to the human-machine interface (HMI) design and ease of use of the in-vehicle technologies, as older drivers might be reluctant to learn and use new technologies with complex features and functions. Likewise, Voinescu et al. (2018) suggested that older adults with lower cognitive abilities might prefer simpler HMIs with fewer features and functions. Many researchers also have recognized the impact of cognitive and sensory functional changes on technology usability among older populations (Bruder et al., 2014; Williams et al., 2013; Farage et al., 2012). As multiple studies have addressed, however, most guidelines and principles for in-vehicle technology designs did not adequately account for older drivers' sensory, physical, and cognitive limitations (Molnar & Eby, 2017; Young et al., 2017). Thus, further research is needed to investigate how older drivers' cognitive, physical, and sensory functions are associated with HMI designs as well as their perceptions and actual use of in-vehicle technology.

Additionally, the use of some in-vehicle technologies might be related to the degree to which they control the vehicle. A 2020 national survey by the AAA Foundation for Traffic Safety (Kim & Horrey, 2022) showed that more than a third of drivers were concerned about lack of control for Level 2 vehicles, which are equipped with technologies supporting both steering and braking/acceleration (Society of Automotive Engineers International, 2021). This proportion increased for higher levels of vehicle automation. Unlike other types of in-vehicle technologies examined in this study, adaptive cruise control and semi-autonomous parking assist engage in momentary control of the vehicle, and a large proportion of participants reported never or rarely using these technologies. This could be because they do not feel comfortable allowing their vehicles to take even partial control.

One of the potential benefits from this emerging technology is traffic safety enhancement by reducing crashes and injury severity (Benson et al., 2018; Milakis et al., 2017). However, this study did not find significant associations between in-vehicle technology use and driving safety measures. It could be because of the relatively short timeframe to self-report crashes or violations (i.e., reporting any over the past year before the survey). Also, this study used data from fewer than 400 participants, which were not nationally representative due to the sampling method. Considering that crashes are relatively rare events, a larger or national scale study with a longer time period is needed for more reliable investigation on this topic.

In addition to the aforementioned limitations, this study used self-reported data that may be subject to social desirability bias, recall bias, and be influenced by participants' understanding of the survey questions. Further, to reduce survey burden and fatigue, the number of questions in the survey and in regard to each in-vehicle technology was limited and may not have fully characterized the nature of the technology use. For example, a high proportion of drivers reporting 'always' using blind spot warning technology does not necessarily indicate they always paid attention to or appropriately responded to the alerts provided by the technology. Additional questions or measurements would be needed for a more nuanced examination of use of in-vehicle technologies. Compared to a nationally representative cohort of older drivers, AAA LongROAD participants had higher income, education attainment, and better health; reported driving behaviors, however, were similar (Kelley-Baker et al., 2017).

In addition to verifying the associations found in the current study, future research should explore potential mechanisms whereby frequency of in-vehicle technology use moderates the relationship between perceived cognitive and physical functioning and driving performance and safety as well as utilize objective measures of health and driving measures from the AAA LongROAD study.

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Table 1. Self-reported health and driving related measures included in this study (n=324)

Measure	Description	Mean (SD†)	Range of values
Cognitive concerns (PROMIS* Applied Cognition–General Concerns 4a T-Score)	Standardized sum of scores for four perceived cognitive concerns, each measured on a 5-point scale (*never, rarely, sometimes, often,* or *very often*). The survey items include: In the past 7 days, • My thinking has been slow • It has seemed like my brain was not working as well as usual • I have had to work harder than usual to keep track of what I was doing • I have had trouble shifting back and forth between different activities that require thinking Higher score represents more concerns (Cella et al., 2007; HealthMeasures, n.d.)	31.70 (5.17)	~20 to ~80
Physical health (PROMIS* Physical Function 4a T-Score)	Standardized sum of scores for four perceived physical functioning questions (e.g., ability to run errands and shop; survey items listed in Mielenz et al. (2019)), each measured on a 5-point scale (*without any difficulty, with a little difficulty, with some difficulty, with much difficulty,* or *unable to do*) Higher score represents better functioning	49.87 (7.38)	~20 to ~80
Crashes	Self-reported number of crashes in past year (Year 3)	0.15 (0.43)	Any positive integer
Driving errors, lapses, and violations	Average reported frequency of engagement in 26 driving errors, lapses, and violations at various situations/locations (e.g., pass a slow driver on the right, disregard the speed limit on a residential road), each measured on a 6-point scale (*never, hardly ever, occasionally, quite often, frequently,* or *nearly all the time*) (Betz et al., 2018)	1.58 (0.29)	1 (*never*) to 6 (*nearly all the time*)
Driving avoidance behaviors	Sum of affirmative responses to 10 self-report items regarding avoiding driving in various situations (Molnar et al., 2017): • At night • Making left hand turns across oncoming traffic where there are no left turn arrows • In bad weather such as heavy rain, fog, or snow • On busy roads • In unfamiliar areas • Driving alone • At night in bad weather • In rush hour traffic • On the freeway • Backing up	3.14 (2.14)	0 to 10
Driving space	Sum of affirmative responses to six self-report items regarding where driven in past 3 months: immediate neighborhood, beyond the neighborhood, neighboring towns, more distant towns, outside the state, and outside the USA (Owsley et al., 1999)	4.13 (0.92)	0 (*not driven any*) to 6 (*driven all given spaces*)
Perceived driving-related abilities	Average rating of five safe-driving-related abilities (e.g., ability to see at night, ability to remember things) (survey items listed in Molnar et al. (2019)), each measured on a 7-point scale	5.88 (0.65)	1 (*poor*) to 7 (*excellent*)
Driving comfort	Average rating of driving comfort level in 10 situations (see the list for driving avoidance behaviors, above), each measured on a 7-point scale (Molnar et al., 2019)	5.70 (0.91)	1 (*not at all comfortable*) to 7 (*completely comfortable*)

* Patient-Reported Outcomes Measurement Information System

† SD stands for standard deviation

Table 2. In-vehicle technologies examined in this study and the descriptions (n=324)

Primary Functionality	Technology	Prevalence: n (%)	Average frequency of use* (SD†)
Technologies that alert drivers to unsafe driving situations; drivers must take action to mitigate potential hazards**	Forward Collision Warning	72 (22.22%)	4.42 (1.28)
	Blind Spot Warning	61 (18.83%)	4.67 (0.98)
	Lane Departure Warning	96 (29.63%)	4.10 (1.44)
Technologies that take action to assist drivers with vehicle operations	Adaptive Cruise Control	131 (40.43%)	3.04 (1.33)
	Semi-Autonomous Parking Assist	17 (5.25%)	2.35 (1.54)
Technologies intended to support drivers for safe vehicle operations	Fatigue/Drowsy Driving Alert	15 (4.63%)	3.93 (1.58)
	Night Vision Enhancement	11 (3.40%)	3.36 (1.58)
Types of technologies intended to support drivers with services or information	Navigation Assistance	194 (59.88%)	3.20 (1.55)
	Voice Control	161 (49.69%)	2.34 (1.38)
	Integrated Bluetooth Cell Phone	306 (94.44%)	3.08 (1.60)
	In-Vehicle Concierge	70 (21.60%)	1.60 (0.77)

* Frequency of use scale: 1 = never, 2 = rarely, 3 = sometimes, 4 = often, 5 = always.

** The description of Forward Collisions Warning provided to participants acknowledged that some systems could brake in addition to warning, which was less common when the questionnaire was designed.

† SD stands for standard deviation

Table 3. Demographic distribution (n=324)

Variables		n	%*
Age	65–69	47	15
	70–74	138	43
	75–79	108	33
	≥ 80	31	10
Gender	Male	159	49
	Female	165	51
Race	White, Non-Hispanic	293	90
	Black, Non-Hispanic	12	4
	Other, Non-Hispanic	11	3
	Hispanic	8	2
Education	Less than a college degree	104	32
	Associate or bachelor's degree	90	28
	Advanced degree	128	40
Income	Less than $50,000	81	25
	$50,000–$79,999	91	28
	$80,000–$99,999	42	13
	$100,000 or more	102	31
Site	Colorado	53	16
	New York	79	24
	Maryland	56	17
	Michigan	90	28
	California	46	14

* Each variable may not sum up to the respective total due to missing values or rounding.

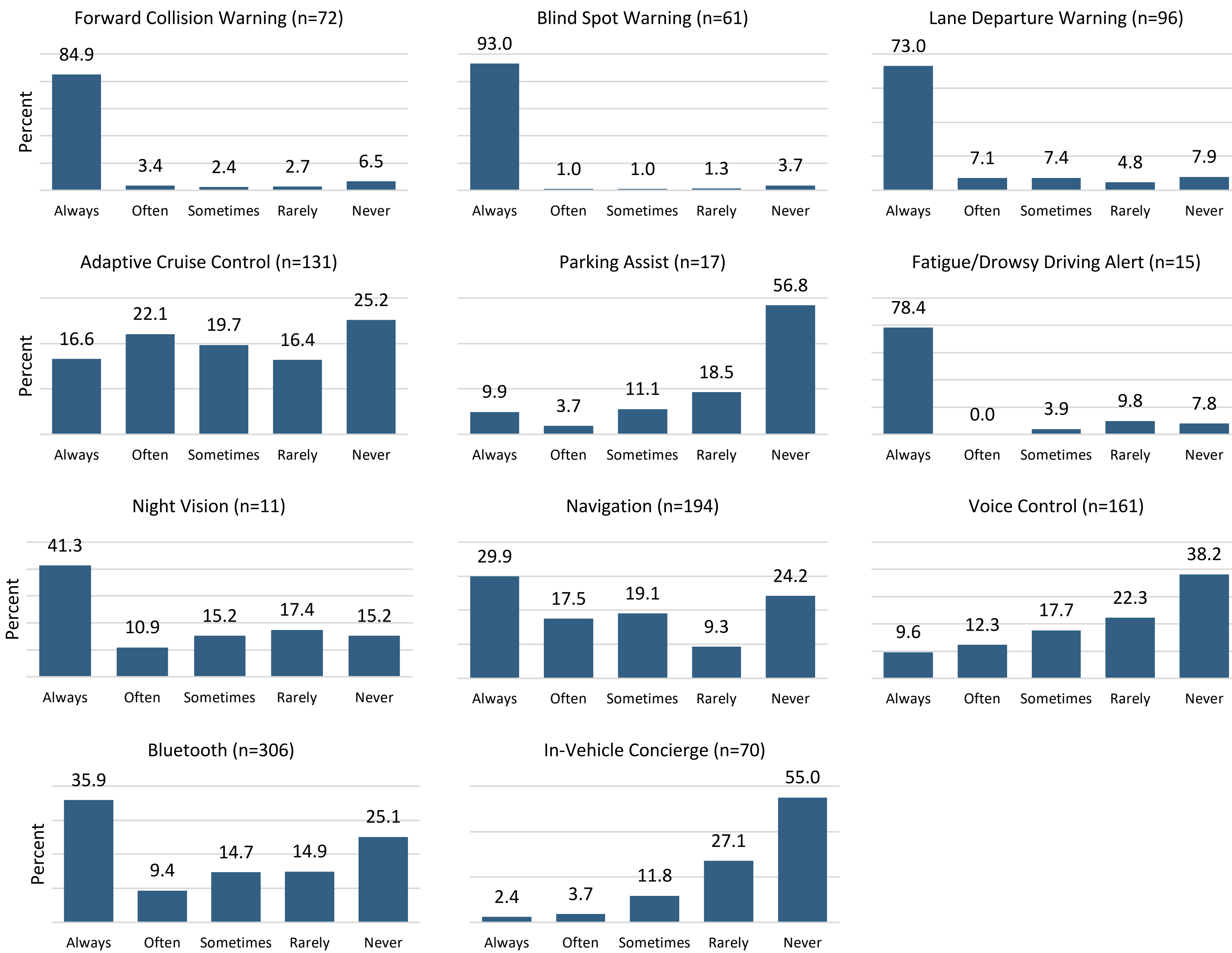

Figure 1. Distribution of use frequency of each in-vehicle technology at Year 3 (%)

Table 4. Spearman correlation (r_s) between in-vehicle technology use frequency and health and driving related measures at Year 3

	Forward Collision Warning	Blind Spot Warning	Lane Departure Warning	Adaptive Cruise Control	Semi-Autonomous Parking Assist	Night Vision Enhance-ment	Fatigue/ Drowsy Driving Alert	Navigation Assistance	Voice Control	Integrated Bluetooth Cell Phone	In-Vehicle Concierge
Cognitive concerns[a]	−0.2	0.04	−0.12	**−0.29****	**0.49***	−0.35	**−0.59***	−0.09	−0.14	**−0.16****	0.08
Physical health[b]	0.08	0.02	0	0.03	−0.24	0.47	**0.65****	**0.25*****	0.01	0.04	0.07
Crashes	−0.08	−0.04	0.02	−0.01	0.29	−0.15	0.19	−0.05	−0.13	−0.06	−0.22
Driving errors, lapses and violations	−0.17	−0.08	−0.12	−0.13	0.36	0.04	0.01	−0.08	−0.03	−0.05	0.04
Driving avoidance behaviors[c]	−0.06	0.03	0.01	**−0.18***	0.23	−0.39	0.06	−0.1	**−0.17***	**−0.18****	−0.1
Driving space	0.11	0.18	−0.05	**0.28****	−0.2	0.4	−0.06	**0.22****	−0.09	**0.14***	0.14
Perceived driving-related abilities[b]	0.1	0	0.14	**0.18***	0.08	0.59	**0.68****	**0.16***	**0.28*****	**0.25*****	0
Driving comfort	0.09	0.04	0.04	**0.24****	−0.27	0.52	0.41	**0.15***	**0.22****	**0.24*****	−0.02

Note: Significant correlations are bolded.

* for $p < 0.05$, ** for $p < 0.01$, *** for $p < 0.001$

In-vehicle technology use frequency score range from 1 (never) to 5 (always).

[a] Higher represents more concerns.

[b] Higher represents better function/ability.

[c] Higher represents more driving avoidance behaviors.