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Frailty phenotype and self-reported crashes and driving space: Baseline AAA LongROAD

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ABSTRACT

Introduction: The present study uses data from the American Automobile Association (AAA) Longitudinal Research on Aging Drivers (LongROAD) study to assess the association of the frailty phenotype with reduced driving space and involvement in motor vehicle crashes.
Methods: The LongROAD study is a multisite prospective cohort study of participants aged 65–79 years. Fried's frailty phenotype status at baseline and self-reported restricted driving space in the past three months and at least one self-reported crash in the recent year are examined. Multivariable logistic regression was used to obtain odds ratios, adjusting for covariates and clustering by site.
Results: Pre-frail (i.e. only 1–2 indicators of frailty) participants had 30% higher odds (adjusted OR = 1.3, 95% CI:1.0–1.8) of reporting involvement in a crash in the prior year than non-frail participants after adjusting for sex, age, depression, word recall, average miles driven per week, and site. No association for reduced driving space for frail older drivers was found.
Conclusions: The frailty phenotype is associated with motor vehicle crashes, but not reduced driving space. Our findings suggest that future research should be focused on the identification of pre-frail older adult drivers to improve the health and quality of life of older adult drivers.

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1. Introduction

As an increasing proportion of the United States population shifts towards late-adulthood, so does the ratio of older drivers on the road. According to the United States Department of Transportation, the population of people 65 and older has increased by 29% and the number of older licensed drivers has increased by 33% from 2006 to 2015 (National Highway Traffic Safety Administration, 2017). Many older adults limit their driving in specific contexts and circumstances due to declines in physical and cognitive skills (Albert et al., 2017; Chihuri et al., 2016; Durbin et al., 2017; Vance et al., 2006). However, a majority of older adults still rely on their personal automobile as a primary form of transportation (Webber et al., 2010). Driving cessation has not only been shown to accelerate depression and deterioration of physical and social functioning, but also has an impact on life-space restriction (mobility within and beyond one's home) (Albert et al., 2017; Chihuri et al., 2016; Huisingh et al., 2016; Marottoli et al., 1997b; Stalvey et al., 1999; Peel et al., 2005). With the aging population, safe mobility and independence are both important in maintaining and continuing their quality of life in these later years (Albert et al., 2017; Anstey et al., 2005; Bond et al., 2017; Boot et al., 2014; Chihuri et al., 2016; Choi, Betts Adams and Mezuk, 2012; Oxley and Whelan, 2008; Vance et al., 2006). Understanding the degree to which the frailty phenotype affects driving experiences can improve interventions that could have a positive impact on the aging population of drivers.

Previous research has shown that constriction of life space is positively correlated with fewer miles driven, fewer destinations per week, and fewer trips per week (Peel et al., 2005; Stalvey et al., 1999). Restriction of life space can further lead to decreased physical activity and social engagement and accelerated deconditioning in physiologic reserve, contributing to the development of frailty (Portegijs et al., 2016; Xue et al., 2008a, 2008b). In addition, quality of life is a concept that is closely linked with mobility, and transportation plays a major role, since it influences the ability to engage in social activities, to interact in a neighborhood with good facilities, and to feel safe in one's neighborhood (Banister and Bowling, 2004; Oxley and Whelan, 2008).

Mobility impairment among older adults is associated with crash involvement (Mielenz et al., 2017). Crash outcomes are more often deadly for older adults than for their younger counterparts, and older drivers pose more of a risk to themselves and their aging passengers than to other drivers on the road (Eberhard, 2008; Lyman et al., 2002; Tefft, 2008). Older drivers also have higher mileage-based crash rates than all but the youngest group of drivers (Boot et al., 2014; Dellinger et al., 2002; Dickerson et al., 2007; Koppel et al., 2011; Tefft, 2017). Older adults with physical disabilities or frailty have been identified to be at greater risk for a motor vehicle crash, and are also more vulnerable to injury (Cicchino and McCartt, 2014; Koppel et al., 2011; Kent et al., 2009; Marottoli et al., 1994).

Frailty is a common clinical syndrome in older adults that develops as a consequence of collective decline in many physiological systems and of decreased resistance to stressors resulting in vulnerability to adverse outcomes (Bond et al., 2017; Buckinx et al., 2015; Clegg et al., 2013; Fried et al., 2001; Walston and Bandeen-Roche, 2015; Xue, 2011). Frailty is associated with aging and negative effects on safety (Albert et al., 2017; Buckinx et al., 2015). The increased risks of adverse health outcomes from the frailty syndrome include comorbidity, disability, falls, hospitalization, and mortality (Bandeen-Roche et al., 2015; Bond et al., 2017; Bouillon et al., 2013; Buckinx et al., 2015; Clegg et al., 2013; Fried et al., 2001; Xue, 2011). Specifically, our focus is on the frailty phenotype proposed and validated by fried and colleagues consisting of five criteria: unintentional weight loss, weakness, exhaustion, slowness, and low physical activity (Fried et al., 2001). Frailty is considered present if at least three indicators are positive and pre-frailty status is defined with one or two positive indicators.

Driving habits and characteristics have been reported in this particular population of frail older adults; however, studies have yet to evaluate the relationship between the frailty phenotype and its influence on driving space or risk of negative driving outcomes, such as motor vehicle crashes (Bond et al., 2017; Carr et al., 2006; Owsley et al., 1999). Previous research has examined the relationship between frailty and the likelihood of sustaining injury, using an adapted marker of frailty, validated by Woods et al. (2005) or defined as the susceptibility to injury (Cicchino and McCartt, 2014; Kent et al., 2009; Ryb et al., 2012). The LongROAD study is the first large cohort study of older drivers in the United States specifically designed to examine the issues of driving safety during the process of aging (Li et al., 2017). The aim of this analysis was to determine the association of Fried's frailty phenotype in the LongROAD sample on the role of self-reported driving space (prior 3 months; distance typically drive into their environment away from their home base) and self-reported motor vehicle crashes (prior 12 months). Specifically, it was hypothesized that pre-frailty and frailty defined by the frailty phenotype will be associated with restricted driving space and increased motor vehicle crashes, adjusting for lifestyle and clinical conditions associated with driving.

2. Design and methods

2.1. Participants

This analysis used cross-sectional, baseline data from the AAA Longitudinal Research on Aging Drivers (LongROAD) study, a multisite prospective cohort study in which 2990 participants were recruited from five sites: Ann Arbor, MI; Baltimore, MD; Cooperstown, NY; Denver, CO; and San Diego, CA (Li et al., 2017). Eligibility criteria included: being 65–79 years of age with a valid driver license, driving on average at least once a week, living in the catchment area of the study site for at least 10 months a year, having no plans to move outside of the catchment area within the next 5 years, having access to a motor vehicle of model year 1996 or newer 80% or more of the time, being fluent in English, and having no significant cognitive impairment (Li et al., 2017). Recruitment of study participants and baseline data collection occurred between July 2015 and March 2017 (Li et al., 2017).

2.2. Frailty phenotype

Frailty was assessed using the Fried frailty phenotype, which is based on five indicators: weakness (grip strength in the lowest 20% of the population at baseline, adjusted for sex and BMI), slowness (walking speed in slowest 20% at baseline, based on time to walk 15 feet, adjusting for sex and standing height), exhaustion (reporting having lower energy or being easily exhausted), low physical activity (not having recently walked for exercise or engaged in vigorous physical activity) and shrinking (unintentionally losing $\geq$ 10 pounds in the past year or being underweight according to BMI of $\leq 18.5\,kg/m^2$) (Fried et al., 2001). Frailty categories were measured on a pass or fail basis, where a participant was considered to be frail if he/she failed in three or more of the five categories, pre-frail in one or two categories, and not frail in none of the categories (Fried et al., 2001). Frailty scores were calculated for 2965 of the 2990 participants in the LongROAD study.

2.3. Driving space

Self-reported driving space was measured as a scored response (0–6) using six dichotomous questions from the Driving Habits Questionnaire (DHQ) as originally used by Owsley and colleagues in 1999 (Owsley et al., 1999). The DHQ has been reported to be an acceptable and reliable measure of self-reported, interview-based driving behavior in the community-dwelling elderly (Song et al., 2015). The DHQ asked participants if they had driven to designated regions in the past 3 months (immediate neighborhood, beyond neighborhood, neighboring towns, distant towns, outside of state, and outside of the country). The composite driving space score was used to create a dichotomized variable with lower scores indicating restricted driving space (0–3) (not driving beyond neighboring towns) and higher scores indicating unrestricted driving space (4–6; Owsley et al., 1999).

2.4. Crashes

Self-reported crashes were measured using a range of 0–3 based on responses from the DHQ asking “How many crashes have you been involved in over the past year when you were the driver?” (see Owsley et al., 1999). Self-reported crash involvement has shown to be in agreement with state crash records; this is also consistent with other studies of self-report and state records for identifying crashes among older drivers (Anstey et al., 2009; McGwin et al., 1998; Owsley et al., 1999; Singletary et al., 2017). This measure was dichotomized as none versus one or more crashes due to few participants reporting more than one crash.

2.5. Covariates

Covariates as potential confounders were chosen *a priori* (sex, age, education, marital status, self-reported vision, driving importance, cognitive health, depression, and average miles driven per week). Due to sex and age differences in level of frailty, driving exposure and driving mobility, both were considered as potential effect modifiers of the association between the frailty phenotype and both outcomes (Bandeen-Roche et al., 2015; Turano et al., 2009; Woods et al., 2005).

Participants' reported sex defined as male or female, age categorized as 65–69, 70–74, and 75–79 years old, and race/ethnicity defined as non-Hispanic White, non-Hispanic Black, Hispanic, Asian, and Other (included American Indian, Alaska Native, Native Hawaiian and Pacific Islander). Highest level of education was categorized into four groups: high school or less (including 1st-8th grade and 9th-12th grade), some college (including vocational, technical, business or trade school beyond high school level), Bachelor's degree, and advanced degree (including Master's, professional or doctoral). Marital status was categorized into married or living with a partner, divorced/separated/never married, and widowed.

With age-related medical concerns such as vision impairment and cognitive decline impacting driving performance and contributing to crash risk among older adults, both were considered covariates and included in the analysis (Carr et al., 2006; Owsley and McGwin, 1999). Self-reported vision was reported on a 5-point Likert scale: “poor,” “fair,” “good,” “very good,” and “excellent,” but was ultimately dichotomized into “poor to good” and “very good to excellent” due to the skewed distribution of responses. Correct immediate and delayed word recall was used as a marker of cognitive health, more specifically episodic and working memory, and was scored from 0 to 20 (Wallace and Herzog, 1995). Word recall was dichotomized at the median: 0–10 and 11–20 with a higher score indicating better performance (Wallace and Herzog, 1995). Cognitive impairment is consistently reported to be a strong predictor of crash involvement and driving cessation in older adults (Edwards et al., 2010; Li et al., 2017). According to a previous study looking at trends in prevalence and mortality of cognitive impairment in the United States, the mean word recall score among a cohort of American adults age 70 years and older was 7.6 with 13% scoring above 10 (Langa et al., 2008). Depression has been shown to be prevalent in older adults and associated with disability and increased mortality; this excess mortality is strongly associated with frailty (Almeida et al., 2015; Brown et al., 2014). Depression and anger were both measured using the Patient-Reported Outcomes Measurement Information System instruments (PROMIS T-Score), with scores ranging from 41.0 to 79.4 and 32.9 to 64.9, respectively (HealthMeasures, 2017). Depression and anger were correlated with each other (Pearson's coefficient = 0.42), so only depression was included in the analysis. Self-reported miles driven per week was reported by asking participants “How many miles do you drive in a normal week?” and were broken down into quartiles: 0–49, 50–99, 100–150, 151–800. Driving importance was measured by asking respondents “How important is driving to you?” on a scale from 1 (Not at all) to 7 (Completely) and collapsed into 3 groups: 1–5, 6, and 7 due to the small cell sizes in categories 1–5. Covariates known to affect driving outcomes were kept in the model and the remaining variables were evaluated for confounding, using a change-in-estimate method looking at the relative change in the frailty status estimates (Anstey et al., 2005; Bandeen-Roche et al., 2015; Brown et al., 2014; Carr et al., 2006; Greenland, 1989;

Table 1
Baseline participant characteristics, AAA LongROAD Study, 2015–2017 (N = 2965).

Characteristic	N (%)	Characteristic	N (%)
Frailty Phenotype		**Correct Word Recall Score (0–20)**	
Not frail	1222 (41.2)	0–10	1505 (50.33)
Pre-frail	1656 (55.9)	11–20	1401 (46.86)
Frail	87 (2.9)	Unknown	84 (2.81)
Sex		**Self-reported Vision**	
Male	1397 (47.1)	Poor - Good	973 (32.8)
Female	1568 (52.9)	Very Good - Excellent	1990 (67.2)
Age		Unknown	2 (0.07)
65–69	1233 (41.6)	**Average miles driven per week**	
70–74	1027 (34.6)	0–49	694 (23.4)
75–79	705 (23.8)	50–99	694 (23.4)
Education		100–150	787 (26.5)
High School or less	335 (11.3)	151–800	719 (24.3)
Some College	721 (24.3)	Unknown	71 (2.4)
Bachelor's Degree	691 (23.3)	**Driving Importance (1–7)**	
Advanced Degree	1209 (40.8)	1–5	198 (6.7)
Unknown	9 (0.3)	6	454 (15.3)
Marital Status		7 (Completely)	2311 (77.9)
Married/Living with Partner	1965 (66.3)	Unknown	2 (0.07)
		Driving Space in Past 3 Months (0–6)	
Divorced/Separated/ Never Married	595 (20.1)	0–3 (Restricted)	671 (22.6)
		4–6 (Unrestricted)	2294 (77.4)
Widowed	375 (12.7)	**Crashes in Past Year**	
Unknown	30 (1.0)	None	2623 (88.5)
Depression (PROMIS[a] T-Score), mean (SD)	43.8 (5.3)	One or more	333 (11.2)
		Unknown	9 (0.3)

[a] PROMIS (Patient-Reported Outcomes Measurement Information System).

Turano et al., 2009).

Due to a higher frailty prevalence among older persons and women in the general population, and women restricting their driving space to a greater extent than men do, sex and age were considered as potential effect modifiers (Bandeen-Roche et al., 2015; Turano et al., 2009; Woods et al., 2005). Interaction terms were entered into the final multivariable model. Significance was assessed using the likelihood ratio test and associated p-value of the interaction term with the cut-off = 0.05. A conservative criterion ($p < 0.05$) was used to test for the interaction between sex, age and frailty status recognizing that interaction tests have low power (Frongillo, 2004; Greenland, 1983).

2.6. Statistical analysis

Descriptive statistics for all categorical baseline covariates by frailty status were examined using Chi-squared tests. Significance was defined as p-values ≤ 0.05. Linearity between covariates and the log odds of outcomes and bivariate associations and collinearity of independent variables were evaluated. Multivariate logistic regression was used to examine the association between frailty phenotype and the two outcomes – restricted driving space and involvement in motor vehicle crashes in the past year – generating odds ratios and confidence intervals. In all of the models, the standard errors were adjusted for potential intraclass correlation due to the cluster sampling design, with the study sites being the clusters, using STATA. Participants with missing data on frailty phenotype were excluded from the models (N = 25). All analyses were conducted using SAS 9.4 and STATA v14.0 (SAS 9.4 software, 2017; StataCorp, 2015).

3. Results

The baseline characteristics of the study cohort of 2965 AAA LongROAD participants are listed in Table 1. About 41% of this population were categorized as not frail, 55.9% were pre-frail and 2.9% were frail. Almost 23% of participants reported restricted driving space (0–3) and approximately 11.2% of participants reported having been involved in one or more motor vehicle crash in the past year. The study population was 52.9% female, 41.6% were between the ages of 65 and 69 years, highly educated with 40.8% having an Advanced Degree and two-thirds (66.3%) married or living with a partner. An even 86.0% of the population had depression scores lower than the national average of 50 with a mean of 43.8.

More than 46% of participants reported better performance (11–20) in episodic and working memory as a function of cognitive health. The mean average miles driven per week of this cohort was 120.1 miles, with driving “100–150 miles” being the most common category. About four-fifths (77.9%) of the cohort reported driving being completely important to them. With the entire cohort reporting 86.2% non-Hispanic White, race/ethnicity was dropped from the final analysis due to the limited variation in the frail category. Table 2 shows the prevalence of frailty by the baseline characteristics. Only differences in age, depression, self-reported

Table 2
Prevalence of frailty by baseline characteristics, AAA LongROAD Study, 2015–2017 (N = 2965).

Characteristic	Not Frail %	Pre-Frail %	Frail %	P-value
Sex				0.91
Female	52.7	52.9	55.2	
Age				0.01[b]
65–69	42.8	40.6	43.7	
70–74	36.2	34.1	24.1	
75–79	21.0	25.4	32.2	
Education (N = 2956)				0.20
High School or less	10.7	11.6	16.3	
Some College	25.4	23.8	22.1	
Bachelor's	23.4	23.0	31.4	
Advanced	40.6	41.7	30.2	
Marital status (N = 2935)				0.42
Married/Living with Partner	68.2	66.4	60.5	
Divorced/Separated/Never Married	20.1	20.1	25.6	
Widowed	11.7	13.5	14.0	
Depression (PROMIS[a] T-Score) (N = 2961)				< .0001[b]
Mean (SD)	43.3 (4.8)	44.0 (5.5)	46.0 (7.4)	
Word recall score (0–20) (N = 2884)				0.29
Worse immediate and delayed correct word recall (0–10)	50.1	53.1	51.9	
Self-reported vision (N = 2963)				0.05[b]
Very Good - Excellent	69.2	66.1	58.6	
Average miles driven per week (N = 2894)				0.0002[b]
0–49	22.0	24.4	43.9	
50–99	23.8	24.3	20.7	
100–150	30.0	25.6	17.1	
151–800	24.2	25.7	18.3	
Driving importance (1–7) (N = 2963)				0.06
1–5	7.0	6.2	10.3	
6	15.2	15.0	24.1	
7 (Completely)	77.8	78.8	65.5	

[a] PROMIS (Patient-Reported Outcomes Measurement Information System).
[b] $p < 0.05$.

vision, and miles driven per week were statistically significant across categories of frailty phenotype status. The results for the multivariable analyses of the association between frailty and the driving outcomes (driving space and crashes) and percentages of participants reporting restricted driving space and at least one crash categorized by frailty phenotype status are provided in Table 3. The interaction between baseline frailty status and sex and age were non-significant for either reduced driving space (0–3) or reporting at least one crash ($p > 0.10$).

After adjusting for sex, age, depression, word recall, average miles driven per week, and clustering by site, older drivers who were pre-frail had 1.2 times the odds (OR = 1.2, 95% CI:0.8–1.8) and those who were frail had 1.5 times the odds (OR = 1.5, 95% CI:0.7–3.2) of reporting restricted driving space (0–3) compared to those who were not frail participants, however, this association was no longer significant.

Pre-frail participants had 1.3 times the odds of at least one crash in the past year compared to those who were not frail (OR = 1.3, 95% CI:1.0–1.8) after adjusting for sex, age, depression, word recall, average miles driven per week, and site. Frail older drivers had increased odds of becoming involved in a crash compared to those who were not frail (OR = 1.7, 95% CI:0.9–3.2) after adjustment of the same covariates, however, this association was not significant.

4. Discussion

In the AAA LongROAD cohort, we found that pre-frail older adults had a higher odds of self-reporting involvement in motor

Table 3
Odds ratios (OR) and 95% confidence intervals (CI) for association between frailty phenotype and restricted driving space and crashes.

Frailty Phenotype Status	Driving Space			Crashes		
	%	Unadjusted OR (95% CI)	Adjusted OR[a] (95% CI)	%	Unadjusted OR (95% CI)	Adjusted OR[a] (95% CI)
Not Frail	8.1	1.00 (Ref)	1.00 (Ref)	4.0	1.00 (Ref)	1.00 (Ref)
Pre-Frail	13.6	1.4 (1.2, 1.6)	1.2 (0.8, 1.6)[a]	6.8	1.3 (1.0, 1.6)	1.3 (1.0, 1.8)[a]
Frail	1.0	1.9 (1.4, 2.6)	1.5 (0.7, 3.2)[a]	0.4	1.6 (1.1, 2.5)	1.7 (0.9, 3.2)a

[a] Adjusted for sex, age, depression, word recall, average miles driven per week, and site.

vehicle crashes in the prior year compared to those who were not frail. Pre-frail older drivers had an increased odds of crashes in which they were the driver in the past year after the adjustment for sex, age, depression, correct word recall, average miles driven per week, and site.

The association between frailty and crashes reported here is generally consistent with the findings of previous studies on frailty among older adults and motor vehicle crashes, despite different methodological approaches (Cicchino and McCartt, 2014; Kent et al., 2009; Ryb et al., 2012). While not directly assessing Fried's frailty phenotype among crash involved seniors, prior studies are supportive of the crash relation: Ryb and associates observed a link between frailty and injury causation (2012). This study used an adapted marker of frailty to assess the weakness, slowness, and exhaustion metrics identified by Fried and was validated by Woods and colleagues (Woods et al., 2005).

The adjusted association between the frail group and crashes was likely not statistically significant because of the low prevalence of frailty in this population of drivers. These self-reported crash data may also be subject to bias, particularly in an age group with increasing levels of memory difficulties and cognitive impairment (Anstey et al., 2009; Marottoli et al., 1997a,b; McGwin et al., 1998). It is possible that older adults are afraid or hesitant to report crashes due to fears about losing their right to drive. It is possible that these older drivers have neither fully recognized nor accepted the decline of their driving skills and were underreporting their physical restrictions (Albert et al., 2017). Future work should look at objectively reported crash records.

As people age, they make fewer journeys, the average length of all journeys consistently decreases, trips tend to be closer to home, and the types and frequency of recreation and social trips change (Oxley and Whelan, 2008). Our findings suggest that public health interventions that are aimed toward targeting older drivers who are beginning to experience frailty symptoms can lead to an improvement on their safety, mobility and quality of life. Opportunities to optimize and maximize the maintenance of their independence among older adults should be explored instead of limited, since age-based driver license renewal policies have the potential disadvantage of reducing mobility of older drivers (Oxley and Whelan, 2008; Shah et al., 2012). In addition, a 2016 Japan study carried out a 10-year community intervention for frailty prevention and examined the impact on healthy aging among older adults (Shinkai et al., 2016). Physical activity, nutrition, and social participation were promoted by a health education program and a geriatric assessment was added to routine annual check-ups, which helped older participants improve their functional health (Shinkai et al., 2016). Brown and Flood (2013) found that identification of older adults at risk for mobility limitation can be accomplished through routine screening and addressing functional deficits and environmental barriers with exercise and mobility devices can lead to improved safety.

The strengths of this study include the large sample size, comprehensive covariate-related questions provided by the LongROAD study and the frailty phenotype itself consisting of performance-based measures. In addition, the DHQ has been demonstrated to have good test-retest reliability in older adults in the domains of driving space and crashes (Song et al., 2015; Owsley et al., 1999). However, several limitations need to be considered when interpreting the results. First, due to the cross-sectional design of the study, we were unable to identify the causal effects of the frailty phenotype and the two driving outcomes assessed. A large portion of this relatively young cohort was categorized as pre-frail. This may be due to cut points used to define the five criteria, in which frailty may vary appreciably when percentile-based cut points are derived from different sample populations (Xue et al., 2016). The frail people in this study are not representative of all frail older people, but only those who continue to drive. In addition, compared to the general older adult driver population, the study sample is overrepresented by those who are well educated and underrepresented by racial/ethnic minorities. Although the participants enrolled in the LongROAD study come from five sites around the United States, they are not a nationally representative sample. Therefore, results from this study may not be completely generalizable to other areas of the United States. In addition, the scope of the LongROAD driving questions did not include a living arrangement status. Information about participants either living with family members or a caretaker is important in understanding the impact of the frailty phenotype and driving outcomes. The three month time sample measured by self-reported driving space may have been too short to capture long-distance trips. In addition, previous crashes before old age were not assessed. Previous research has shown that prior crash involvement predisposes affected subjects to future crashes (Sims et al., 2000). The use of self-reported data (crashes, driving space, and driving exposure (average miles driven per week) may have affected the validity of these measures and lead to biased measures of association (Anstey et al., 2009; Marottoli et al., 1997a,b; McGwin et al., 1998). Recall bias may limit self-reported driving behavior data, since respondents may have difficulty remembering trips and estimating travel times and distances (Blanchard et al., 2010). The DHQ also does not distinguish between at fault and not at fault crashes or whether unsafe driving was the cause of the crash. There was also a very small number of pre-frail and frail drivers in this study – for both outcomes; the adjusted odds ratio of the frailty group was higher than in the pre-frail group. It did not meet statistical significance most likely due to the small numbers in the frail groups given the wide confidence intervals. Comorbidities were not included as a potential confounder as in other studies given that the baseline LongROAD data only captured the lifetime prevalence of self-reported medical conditions (Durbin et al., 2017; Vance et al., 2006). Finally, the odds ratios for driving space described in this analysis may overestimate of the relative risk due to reduced driving space being common in this AAA LongROAD cohort.

Our study found that pre-frail older adults have a higher odds of crashes in the prior year. The frailty phenotype may be useful in identifying those who are at risk for negative driving outcomes and associated driving behaviors. For future research, we suggest a larger longitudinal study to assess the causality between the frailty phenotype and both outcomes, possibly involving an objective measure of driving exposure data and crash data, as well as, previous crash involvement. With the aging United States population, more focus should be directed on future research to mitigate crashes and injuries that will be more likely to occur among the growing number of frail older drivers. Such proposed research has the potential to maintain and prolong independence and quality of life of older drivers.

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