RESEARCH BRIEF

The Association of Frailty With Driving Habits Among Older Adults:

AAA LongROAD Study

May 2019

Quality of life among older adults is dependent upon safe mobility and independence (Albert *et al.,* 2017; Bond *et al.,* 2017; Boot *et al.,* 2014; Chihuri *et al.,* 2016). Crashes and driving space (i.e., how close to home a driver stays) provide objective measures of safe driving, and research shows that older adult drivers who accrue fewer than 3,000 miles per year have higher crash rates per mile driven (Antin *et al.,* 2017). If frailty is associated with these outcomes, interventions targeted at preventing or reducing the symptoms of frailty may lead to improved mobility among older adults (Davis *et al.,* 2011; Gill *et al.,* 2012; Mielenz *et al.,* 2017; Durbin *et al.,* 2017). The present study uses data from the AAA Longitudinal Research on Aging Drivers (LongROAD) study to describe the association of frailty status with driving habits (crashes, driving space and annual mileage). This study found that the frailty phenotype is associated with objectively measured low-mileage driver status, but it is not associated with self-reported crashes and driving space.

METHODS

The AAA LongROAD study is a multisite prospective cohort study of 2,990 drivers recruited from five study sites: Ann Arbor, Michigan; Baltimore, Maryland; Cooperstown, New York; Denver, Colorado; and San Diego, California. Inclusion in the study required participants to be between 65 and 79 years of age, hold a valid driver's license and drive at least once a week. Details on the study methods are outlined elsewhere (Li *et al.,* 2017). The analyses of the present study were conducted using baseline demographics and frailty data collected through questionnaires and in-person functional assessments, and up to almost three years of objective driving behavior data collected by in-vehicle devices.

Frailty status was measured using the frailty phenotype that was developed and validated by Fried and colleagues (Fried *et al.,* 2001). Frailty status was measured on a scale from 0 to 5, with one point given for each of the following criteria the participant exhibited: shrinking (unintentional loss of ≥10 pounds in the past year or underweight according to a BMI of ≤18.5 kg/m^2), weakness (grip strength in the lowest 20% of the population, adjusted for gender and BMI), exhaustion (self-report of having poor endurance and energy), slowness (slowest 20% of the population based on time to walk 15 feet, adjusted for gender and standing height), and low physical activity (not having recently walked for exercise or engaged in vigorous physical activity). Participants were classified as frail (3-5), pre-frail (1-2), or not frail (0). "DataLogger" devices (Danlaw, Inc., Novi, Michigan) were installed in participants' vehicles after researchers received informed consent to monitor and record objective data on driving behaviors, such as distance traveled and vehicle speed. The present study makes use of 62,738 person-months of driving data. A pro-rated miles per year variable was derived for each participant by dividing total miles driven by months of recording and multiplying by 12. This variable was used to categorize subjects as either a low-mileage driver or a non-low-mileage driver according to findings from Antin et al. (2017) that define a low-mileage driver as one who drives fewer than 3,000 miles per year.

Self-reported crashes were measured based on responses to the Driving Habits Questionnaire (DHQ) question: "How many crashes have you been involved in over the past year when you were the driver?" (Owsley, Stalvey, Wells, & Sloane, 1999). This measure was dichotomized as none, or one or more crashes.

Self-reported driving space was defined as the distance a participant drove from their immediate neighborhood in the past three months. It was measured as a scored response (0-6) based on answers to six dichotomous questions from the DHQ (Owsley *et al.,* 1999). The composite driving space score was dichotomized so that scores from 0 to 3 correspond to restricted driving space (not driving beyond neighboring towns) and scores from 4 to 6 correspond to unrestricted driving space.

Important control variables were selected *a priori* and included sex, age, highest level of education attained, marital status, self-reported vision, depression and performance-based cognitive health. Models for the outcomes of crashes and driving space additionally controlled for self-reported miles per week and driving importance. Depressive symptoms were measured using the Patient-Reported Outcomes Measurement Information System (PROMIS) instruments, with higher scores indicative of more depressive symptoms. Cognitive health was measured by performance on immediate and delayed word recall tasks, which are designed to test episodic and working memory.

Three separate multivariable logistic regression models were used to examine the association between frailty and the three outcomes of interest. PROMIS Depression and word recall were included in the model as binary variables (Clover *et al.,* 2018). The final model for low-mileage driver status was created using log-binomial regression, allowing for estimates of the risk of being a low-mileage driver among those classified as frail or pre-frail compared with the risk among those classified as not frail and the corresponding 95% confidence intervals. In all models, standard errors were adjusted for any potential intraclass correlation due to the cluster sampling design with each of the five study sites representing a cluster.

RESULTS

Of the 2,965 drivers in the AAA LongROAD cohort who had frailty status data, more than half (55.85%) were classified as pre-frail. Only 87 participants (2.93%) were classified as frail. Almost 7% (6.75%) of the population were classified as low-mileage drivers, 11.23% reported involvement in a motor vehicle crash in the past year and 22.63% reported restricted driving space (0-3).

Frailty status was significantly associated with low-mileage driver status at only one level of frailty (Table 1). After adjusting for covariates, older drivers who are frail have 2.30 (95% CI:1.40-3.78) times the risk of being low-mileage drivers compared with those who are not frail. While those who are pre-frail are estimated to have 1.27 (95% CI: 0.96-1.67) times the risk of being low-mileage drivers compared with those who are not frail, this association is nonsignificant.

Table 1. Association between frailty status and low-mileage driver status

Frailty Status	Unadjusted RR (95% CI)	Adjusted RR (95% CI)*
Frail	2.47 (1.53, 4.00)	2.30 (1.40, 3.78)
Pre-frail	1.30 (0.94, 1.79)	1.27 (0.96, 1.67)
Not frail	Reference	Reference

* Adjusted for gender, age, education, marital status, vision, PROMIS Depression, cognitive health and correlation within each site. Total N = 2,827.

Frailty status was not significantly associated with self-reported crashes. After adjusting for covariates, older drivers who are frail have 1.72 (95% CI: 0.92-3.21) times and those who are pre-frail have 1.31 (95% CI: 0.96-1.80) times the odds of reporting involvement in one or more crashes in the previous year compared with those who are not frail.

Table 2. Association between frailty status and self-reported crashes

Frailty Status	Unadjusted OR (95% CI)	Adjusted OR (95% CI)*
Frail	1.63 (1.07, 2.48)	1.72 (0.92, 3.21)
Pre-frail	1.28 (1.04, 1.58)	1.31 (0.96, 1.80)
Not frail	Reference	Reference

* Adjusted for gender, age, PROMIS Depression, cognitive health, average miles driven per week and correlation within each site. Total N = 2,956.

Frailty status was not significantly associated with self-reported driving space. After adjusting for covariates, older drivers who are frail have 1.52 (95% CI: 0.71-3.22) times and those who are pre-frail have 1.23 (95% CI: 0.85-1.80) times the odds of reporting restricted driving space compared with those who are not frail.

Table 3. Association between frailty status and self-reported driving space

Frailty Status	Unadjusted OR (95% CI)	Adjusted OR (95% CI)*
Frail	1.87 (1.36, 2.57)	1.52 (0.71, 3.22)
Pre-frail	1.37 (1.17, 1.60)	1.23 (0.85, 1.80)
Not frail	Reference	Reference

* Adjusted for gender, age, PROMIS Depression, cognitive health, average miles driven per week and correlation within each site. Total N = 2,965.

DISCUSSION

Based on objectively measured driving data, frailty status is significantly associated with being a low-mileage driver. This finding aligns with previous research. Specifically, given the finding from Bond *et al.* (2017) that frail drivers have increased rates of becoming nondrivers, it intuitively follows that among those who still drive, those who are frail are more likely to drive less than who are not frail. The nonsignificant association between classification as pre-frail and status as a low-mileage driver may be a result of the fact that those who exhibit only a few signs of frailty do not yet feel the need to begin self-regulating their behaviors by driving less.

The crash rate per mile driven among older adult drivers is substantially higher than it is among all but the youngest, least experienced drivers. However, research by Antin *et al.* (2017) found that this increase is not due to increased rates among all older adult drivers. Instead, their research found evidence that the increased crash rate in this demographic is primarily attributed to an increased crash rate specifically among those who accrue the lowest annual mileage. Therefore, the association found in the present study that those who are frail are at a higher risk of being low-mileage drivers implies that they are also at risk for increased crash rates. If this is true, interventions aimed at reducing the prevalence of frailty among older adult drivers may help them increase their driving exposure and decrease the overall crash rate for their age group.

While this study found that frailty status was not significantly associated with the self-reported outcomes of crashes and restricted driving space, this may be a result of the low prevalence of frailty in the AAA LongROAD population at baseline. Additionally, self-reported data may be subject to bias, particularly in an age group with increasing levels of memory difficulties and cognitive impairment (Anstey, Wood, Caldwell, Kerr, & Lord, 2009; Marattoli, Cooney, & Tinetti, 1997; McGwin *et al.,* 1998).

This study benefited from the use of objective measures of driving exposure as well as performance-based measures of frailty status. However, this study was limited to the use of baseline data for frailty status, so time-varying relationships could not be assessed (Phillips *et al.,* 2016).

Future studies conducted on the AAA LongROAD cohort should use objectively measured crash rates and driving space to further understand the implications of being a driver who is frail.

REFERENCES

Albert, G., Lotan, T., Weiss, P., & Shiftan, Y. (2017). The challenge of safe driving among elderly drivers. Healthcare Technology Letters, 5(1), 45-58. doi:10.1049/htl.2017.0002.

Anstey, K. J., Wood, J., Caldwell, H., Kerr, G., & Lord, S. R. (2009). Comparison of self-reported crashes, state crash records and an on-road driving assessment in a population-based sample of drivers aged 69-95 years. Traffic Injury Prevention, 10(1), 84-90. doi:10.1080/15389580802486399

Antin, J.F., Guo, F., Fang, Y., Dingus, T.A., Perez, M.A., & Hankey, J.M. (2017). A validation of the low mileage bias using naturalistic driving study data. *Journal of Safety Research*, 63(2017), 115-120.

Bond, E.G., Durbin, L.L., Cisewski, J.A., Qian, M., Guralnik, J.M., Kasper, J.D., & Mielenz, T.J. (2017). Association between baseline frailty and driving status over time: a secondary analysis of The National Health and Aging Trends Study. *Injury Epidemiology*, 4:9.

Boot, W. R., Stothart, C. & Charness, N. (2014). Improving the safety of aging road users – A mini-review. Gerontology, 60(1), 90-96. doi:10.1159/000354212.

Chihuri, S., Mielenz, T. J., DiMaggio, C. J., Betz, M. E., DiGuiseppi, C., Jones, V. C., & Li, G. (2016). Driving cessation and health outcomes in older adults. Journal of the American Geriatrics Society, 64, 332–341. doi:10.1111/jgs.13931

Clover, K., Lambert, S.D., Oldmeadow, C., Britton, B., King, M.T., Mitchell, A.J., Carter, G. (2018). PROMIS depression measures perform similarly to legacy measures relative to a structured diagnostic interview for depression in cancer patients. *Quality of Life Research*, 27:1357-1367.

Davis, M.G., Fox, K.R., Hillsdon, M., Coulson, J.C., Sharp, D.J., Stathi, A., & Thompson, J.L. (2011). Getting out and about in older adults: the nature of daily trips and their association with objectively assessed physical activity. *The International Journal of Behavioral Nutrition and Physical Activity*, 8, 116.

Durbin, L.L., Bond, E.G., Cisewski, J.A., Qian, M., Guralnik, J.M., Kasper, J.D., & Mielenz, T.J. (2017). Frailty Phenotype, Physical Function, and Driving Status in Older Adults: LongROAD Analysis of the National Health and Aging Trends Study. (Research Brief.) Washington, D.C.: AAA Foundation for Traffic Safety.

Fried, L.P., Tangen, C.M., Walston, J., Newman, A.B., Hirsch, C., Gottdiener, J., Seeman, T., Tracy, R., Kop, W.J., Burke, G., & McBurnie, M. (2001). Frailty in older adults: evidence for a phenotype. *J Gerontol A Biol Sci Med Sci*, 56(3), M146-M156.

Gill, T.M., Gahbauer, E.A., Murphy, T.E., Han, L., & Allore, H.G. (2012). Risk factors and precipitants of long-term disability in community mobility: A cohort study of older persons. *Annals of Internal Medicine*, 156(2), 131-140.

Li, G., Eby, D.W., Santos, R., Mielenz, T.J., Molnar, L.J., Strogatz, D., Betz, M., DiGuiseppi, C., Ryan, L.H., Jones, V., Pitts, S.I., Hill, L.L., DiMaggio, C., LeBlanc, D., & Andrews, H.F. for the LongROAD Research Team. (2017). Longitudinal Research on Aging Drivers (LongROAD): Study design and methods. *Injury Epidemiology*, 4(1), 22.

Marattoli, R. A., Cooney, L. M., Jr., & Tinetti, M. E. (1997). Self-report versus state records for identifying crashes among older drivers. The journals of gerontology. Series A, Biological sciences and medical sciences, 52A(3), M184-M187.

McGwin, G., Jr., Owsley, C. & Ball, K. (1998). Identifying crash involvement among older drivers: Agreement between self-report and state records. Accident Analysis & Prevention, 30(6), 781-791.

Mielenz, T.J., Durbin, L.L., Cisewiski J.A., Guralnik, J.M., & Li, G. (2017). Select Physical Performance Measures and Driving Outcomes in Older Adults. *Injury Epidemiology*, 4(1), 14.

Owsley, C., Stalvey, B., Wells, J., & Sloane, M. E. (1999). Older drivers and cataract: Driving habits and crash risk. The journals of gerontology. Series A, Biological sciences and medical sciences, 54(4), M203-M211.

Phillips, C.B., Sprague, B.N., Freed S.A., & Ross, L.A. (2016). Longitudinal associations between changes in physical function and driving mobility behaviors in older adults. *Transportation Research Record*, 2584, 70-76.

ACKNOWLEDGEMENTS

The researched described in this research brief was performed by Columbia University, Department of Epidemiology, Mailman School of Public Health with support from the AAA Foundation for Traffic Safety.

SUGGESTED CITATION

Crowe, C. L., Man. C., Ng, L. S., Molnar, L. J., Eby, D. W., Andrews, H., Ryan, L. H., DiGuiseppi, C., Strogatz, D., Betz, M. E., Hill, L., Guralnik, J., Li, G., & Mielenz, T. J. (Senior and Corresponding). (2019, May). *The Association of Frailty with Driving Habits Among Older Adults: AAA LongROAD Study* (Research Brief.) Washington, D.C.: AAA Foundation for Traffic Safety.