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Mediators of the Association between Driving Cessation and Mortality among Older Adults

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Abstract

Objectives—The present study examined health and physical performance as mediators of the association between driving cessation and mortality among older residents of small and large cities.

Methods—Participants (*N*=2,793) were from the Advanced Cognitive Training for Independent and Vital Elderly (ACTIVE) study. Participants' driving status and health were measured at baseline, and mortality rates were observed across the subsequent five years.

Results—Overall, mortality risk was 1.68 times higher for nondrivers versus drivers; this relationship was significantly mediated by physical performance and social, physical, and general health. For large city residents, mediation effects for all mediators were significant and complete. For small city residents, only physical and general health were significant mediators, and these effects were partial.

Discussion—Health difficulties that accompany or follow driving cessation may explain the association between driving cessation and mortality, particularly for residents of large cities, where alternative transportation options may be more numerous.

Keywords

health; driving cessation; death; survival analysis

For the majority of older Americans, driving is important for maintaining quality of life and independence (Adler & Rottunda, 2006; Donorfio, D'Ambrosio, Coughlin, & Mohyde, 2009). This is particularly true for individuals from small cities and rural areas, where there may be fewer alternative transportation options (Johnson, 1998, 2002). Driving cessation is associated with many negative consequences, including increased social isolation,

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depression, and greater risk for long-term care placement (Fonda, Wallace, & Herzog, 2001; Freeman, Gange, Munoz, & West, 2006; Mezuk & Rebok, 2008). A recent prospective study found that driving cessation is followed by more rapid declines in overall health (Edwards, Lunsman, Perkins, Rebok, & Roth, 2009). Similarly, Edwards, Perkins, and colleagues (2009) found that driving cessation is associated with increased mortality risk. However, to what extent health and physical difficulties may mediate the relationship between driving cessation and mortality is not clear. The current study investigated relationships between being a nondriver and self-reported health, physical performance (i.e., balance), and mortality among older adults. To begin to examine if these relationships vary according to residential environment, we compared the mediation effects among older adults from small and large cities in the United States (U.S.).

Many factors are associated with driving cessation in cross-sectional studies, including older age, female sex, and lower education levels (Dellinger, Sehgal, Sleet, & Barrett-Connor, 2001; Freeman, Munoz, Turano, & West, 2005; Freund & Szinovacz, 2002). Relative to drivers, nondrivers may also demonstrate poorer physical performance, cognition, vision, and physical and mental health (Naumann, Dellinger, Anderson, Bonomi, & Rivara, 2012; Ragland, Satariano, & MacLeod, 2004; Raitanena, Törmäkangasb, Mollenkopfc, & Marcellinid, 2003; Singh-Gilhotra, Mitchell, Ivers, & Cummings, 2001). Each of the above variables has been found to predict driving cessation in prospective studies conducted in the U.S. and Europe, with physical performance and self-reported health playing key roles (Ackerman, Edwards, Ross, Ball, & Lunsman, 2008; Anstey, Windsor, Luszcz, & Andrews, 2006; Edwards et al., 2008; Freeman et al., 2005; Lafont, Laumon, Helmer, Dartigues, & Fabrigoule, 2008). Former drivers commonly cite health problems as the primary reason why they stopped driving (Adler & Rottunda, 2006; Donorfio et al., 2009; Hakamies-Blomqvist & Peters, 2000).

Interestingly, health and physical performance not only influence the decision to drive, but appear to decline further after driving cessation occurs. Edwards, Lunsman, and colleagues (2009) showed that older adults' transition to driving cessation was accompanied by declines in physical performance and self-reported physical and social health, while ratings of general health declined more rapidly following driving cessation. More than 50% of older nondrivers in the U.S. have reduced out-of-home mobility due to transportation limitations (Bailey, 2004), and limited mobility has been found to predict declines in mental and emotional health (Findlay, 2003; Sartori et al., 2012). Thus, the maintenance of driving mobility is important for older adults' health and well-being.

Driving cessation may not only be associated with health declines, but with increased mortality risk as well. Edwards, Perkins, and colleagues (2009) found that older adults who either ceased driving or never drove were four to six times more likely to die over the subsequent three years than older adults who continued driving, controlling for baseline demographics, sensory functioning, cognitive performance, self-efficacy, depressive symptoms, and number of medical conditions. Another recent study found that mortality was decreased for nondrivers who engaged in volunteer work, perhaps because volunteering increased their out-of-home mobility. Volunteering did not influence mortality risk among drivers (Lee, Steinman, & Tan, 2011).

These findings raise the question of the extent to which the relationship between driving cessation and mortality is indirect. Since health is important for sustained driving and declines after driving cessation, health and/or physical performance could completely or partially mediate the association between driving status and mortality. This question was not adequately examined in Edwards, Perkins, and colleagues (2009), which was limited to three years of follow-up, only included older adults from the south central U.S., and did not examine health indicators besides number of medical conditions. Thus, further analyses, with more follow-up and a greater representation of the U.S., are necessary to understand how driving status relates to mortality.

It is also possible that the potential mediating effects of health and physical performance are not the same for older adults residing in different residential environments. The strength of the relationship between driving cessation and mortality found in Edwards, Perkins, and colleagues (2009) could be due to geographical region, because older adults from the south central U.S. are among the most isolated when they cease driving (Bailey, 2004). Research has shown that older adults from small cities and rural areas tend to continue driving in spite of health difficulties (Hanson & Hildebrand, 2011; Johnson, 2002), because they view driving cessation as a last resort due to the limited opportunities to access the community (Hanson & Hildebrand, 2011; Johnson, 1998; Lee et al., 2011). Therefore, for older adults in less populous regions, health and physical performance may not completely mediate the association between driving cessation and mortality, indicating a direct connection between the latter two variables. However, further research is needed. The present study offered the unique opportunity to investigate differential effects of driving status in small and large cities as related to mortality.

In the current study, we examined whether or not an association between driving cessation and mortality was evident across a 5-year time period among older adults residing in six U.S. locations. Furthermore, we examined whether or not such an association was completely or partially mediated by physical performance or self-reported health, and whether these relationships varied by community size. We hypothesized that health and physical performance indicators would significantly mediate the association between driving status and mortality for the overall sample, as well as residents of large cities.

Design and Methods

Participants and Procedure

The present study utilized data from the multi-site Advanced Cognitive Training for Independent and Vital Elderly (ACTIVE) clinical trial (Jobe et al., 2001; Tennstedt et al., 2010). The ACTIVE study investigated the impact of three cognitive training interventions (memory, reasoning, and speed of processing) upon the cognitive and everyday functioning of older adults across a 5-year period. Participants were community-dwelling adults aged 65 and older with relatively-good health, no communicative difficulties, and no evidence of advanced cognitive decline (Mini-Mental State Examination score ≥ 23). These individuals were recruited from six sites: Detroit, MI; Boston, MA; Baltimore, MD; Indianapolis, IN; State College, PA, and Birmingham, AL. First, participants completed in-person screening and baseline visits, during which mobility questionnaires and tests of cognitive and functional abilities were administered. Participants were then randomly assigned to a no-contact control group or one of three cognitive training groups; a total of 2,802 individuals were randomized. Annual follow-up assessments were conducted one year, two years, three years, and five years after the baseline assessment.

Only participants who reported their driving status at baseline were included in the present analyses (N = 2,793). These participants were mostly women (75.80%) and either White (72.60%) or African American (26.00%). The average baseline age was 73.62 years (SD = 5.90), and years of education ranged from 4 to 20 (M = 13.52, SD = 2.70). A total of 695 participants were in the control group, and 2,098 participants were in one of the cognitive training groups. By the 5-year follow-up assessment, 244 participants (8.73% of the sample) were confirmed as deceased. An additional 690 participants had dropped out of the study for other reasons, including refusal or inability to return (*n* = 459), deactivation by study personnel (*n* = 208), and family not wanting the participant to continue (*n* = 23).

Measures

Driving status—Driving status was ascertained via the Driving Habits Questionnaire (DHQ), an 18-item measure of driving behaviors (Owsley, Stalvey, Wells, & Sloane, 1999; Stalvey, Owsley, Sloane, & Ball, 1999). Current drivers were defined as "someone who has driven a vehicle within the past 12 months and would do so today if needed." A total of 400 participants (14.30% of the sample) reported being nondrivers at baseline. Of these individuals, 252 were former drivers who ceased driving before the baseline assessment, and 148 reported never driving a vehicle. We used the Mann-Whitney *U* test to compare former drivers to those who never drove on our outcome of interest. The two groups did not differ in terms of time to death or time in the study, $p = 0.38$, so they were combined in all statistical analyses. This same procedure was used in Edwards, Perkins, et al. (2009).

Physical performance—The Turn 360 Test, a measure of balance, was used to assess physical performance (Steinhagen-Thiessen & Borchelt, 1999). For this task, participants were asked to turn in two complete circles. The number of steps required to complete each circle was recorded, and the average number of steps for both circles was used in the analyses. Fewer steps indicated better physical performance.

SF-36 health—Four out of the eight subscales on the Short Form Health Survey (SF-36) questionnaire were used to assess health: physical role, physical functioning, social functioning, and general health (Ware & Sherbourne, 1992). The physical role subscale indicated how often participants experienced problems with work or daily activities as a result of their physical health, whereas the physical functioning subscale measured the extent to which participants were limited in their physical activities due to their health. The effects that physical or emotional difficulties had on social activities was measured by the social functioning composite, while the general health subscale reflected participants' ratings of their general health compared to others and with regard to expectations for the future. Each of the four subscales ranged from 0 to 100, with higher scores indicating better health and functioning. These subscales were analyzed as separate variables, as they were in Edwards, Lunsman, and colleagues (2009).

Self-rated health—Participants rated their overall health status on a 5-point Likert scale ranging from excellent (1) to poor (5).

Study location—A dichotomous variable was created for study location, "large cities" (Detroit, Boston, Baltimore, and Indianapolis) and "small cities" (State College and Birmingham). In 2009, the large cities had over 600,000 inhabitants each and comprehensive public transit systems. By contrast, the small cities had less than 250,000 inhabitants each and comparably fewer alternative transportation options (American Public Transportation Association, 2011; Thomas, 2010). A total of 1,813 participants lived in or near large cities, and 980 participants lived in or near small cities.

Statistical Analyses

Data analyses were performed using SAS 9.3. For each deceased individual, time to death was calculated as the number of months from the baseline assessment to the date of death. Exact dates of death were unavailable for 34 individuals, so death dates for each of these participants were estimated as the midpoint between their last study visit and the date they were confirmed deceased by study personnel. Participants who were not confirmed deceased were right censored, and their time in the study was measured as the months between their baseline and final study visits. Continous variables were converted to z-scores.

Multivariate analysis of variance (MANOVA) and chi-square tests were used to examine whether there were baseline differences between decedents and survivors in terms of age, sex, years of education, race (dichotomized as white vs. other), study location, cognitive training group (dichotomized as no training vs. any training), SF-36 physical role, SF-36 physical functioning, SF-36 social functioning, SF-36 general health, self-rated health, and Turn 360 Test performance.

In order to test our hypotheses, we calculated coefficients for a series of models in which each indicator as measured at baseline (the four SF-36 subscales, self-rated health, and Turn 360 performance) was examined a single mediator. Baseline age, sex, years of education, race, and cognitive training participation were included in all models as covariates, comparable to what was done in Edwards, Lunsman, and colleagues (2009). Models were based on the following three equations:

$$M=i_1+aX+e. \quad 1$$

$$log\,Y=i_2+tX+e. \quad 2$$

$$log\,Y=i_3+t^{\prime}X+bM+e. \quad 3$$

In these equations, the *i* variables are intercepts, Y is the hazard function for time to death, X is the predictor, M is the mediator, *t* is the coefficient between X and Y, t' is the coefficient between X and Y adjusted for M, *b* is the coefficient between M and Y adjusted for X, *a* is the coefficient between X and M, and the *e* variables are residuals.

A Cox proportional hazard model was first conducted to examine the effect of baseline driving status on time to death, or the *t* path in equation 2. Next, ordinary least squares regression models were conducted to examine the effect of driving status as a predictor of each potential mediator; these models yielded coefficients corresponding to the *a* path in equation 1. Finally, Cox proportional hazard models were conducted that included driving status and each baseline potential mediator as predictors of time to death; these models provided estimates for the *b* and t' paths in equation 3.

To examine the appropriateness of using time-on-study as the time scale, we plotted the cumulative baseline hazard function against age for the entire sample and generated a corresponding Quantile Quantile (QQ) plot. The baseline hazard appeared to be an exponential function of age, suggesting that the time scale and adjustment for age was adequate in our models (Thiébaut & Bénichou, 2004). To test the proportional hazard assumptions underlying the Cox models, interactions between the log of survival time and all predictors and covariates were included in the models. None of the interactions were significant at $p < 0.05$, indicating that the proportionality assumption was satisfied for each variable.

For the current paper, complete and partial mediation were defined as follows. In complete mediation, the *t* coefficient is significant, but the t' coefficient is not. A strict definition of complete mediation would require t' to be zero. In partial mediation, the path from X to Y is reduced in absolute size when M is introduced, but is still significant (Baron & Kenny, 1986). The amount of mediation is traditionally tested in two ways, as the difference of coefficients ($t - t'$) or the product of coefficients (*ab)*. Previous studies have indicated that these two methods do not yield equivalent results with binary dependent variables or censored data (Fritz & MacKinnon, 2007; MacKinnon & Dwyer, 1993; MacKinnon, Lockwood, Brown, Wang, & Hoffman, 2007; MacKinnon, Warsi, & Dwyer, 1995; Sun, 2010). In such cases, the product of coefficients method with asymmetric confidence limits appears to yield the most reliable estimates (Sun, 2010).

For the current study, we tested the significance of mediation effects via a program called PRODCLIN (distribution of the PRODuct Confidence Limits for Indirect effects), which has been used in prior research on mediation in survival analysis (Fritz & MacKinnon, 2007; MacKinnon, Lockwood, & Hoffman, 1998; Sun, 2010). This program calculates the product of coefficients, along with its corresponding standard error and 95% asymmetric confidence limits. Significant mediation effects are indicated when the confidence interval does not include zero.

We ran each series of models and PRODCLIN tests separately for the entire sample, participants from large cities, and participants from small cities. Together, our analyses determined whether a significant relationship between driving status and time to death could be completely explained, or partially explained, through health status or physical performance.

Results

Descriptive Statistics

By survival status—Descriptive statistics of the study sample by survival status and location are shown in Table 1. Chi-square tests revealed that compared to survivors, decedents were more often male, $\chi^2(1) = 28.38$, $p < 0.001$, White, $\chi^2(1) = 5.60$, $p = 0.01$, and nondrivers at baseline, $\chi^2(1) = 8.30$, $p < 0.01$. A MANOVA [$F(8, 2648) = 15.73$, Wilks' $\lambda = 0.96$, $p < 0.01$] and subsequent univariate tests showed that decedents were significantly older, $F(1, 2655) = 57.82$, $p < 0.001$, and had poorer scores on all baseline health measures relative to survivors (*p*s < 0.001). Cognitive training participation, years of education, and study location did not significantly differ between groups. A specific cause of death was provided for 108 of the 244 decedents; the majority of deaths were due to cancer (40%), heart disease (38%), or another disease process (15%), as opposed to accidents (7%).

By study location—Relative to participants from large cities, participants from small cities were more often male, $\chi^2(1) = 6.32$, $p < 0.01$, White, $\chi^2(1) = 288.80$, $p < 0.01$, and drivers at baseline, $\chi^2(1) = 7.60$, $p < 0.01$. See Table 1. A MANOVA [$F(8, 2648) = 13.70$, Wilks' $\lambda = 0.96$, $p < 0.01$] and univariate tests revealed that participants from small cities were significantly younger, $F(1, 2655) = 13.53$, $p < 0.01$, and less educated, $F(1, 2655) = 46.27$, $p < 0.01$, than participants from large cities. Small city residents also reported better physical functioning, $F(1, 2655) = 11.03$, $p < 0.01$, but had worse Turn 360 performance, $F(1, 2655) = 6.82$, $p = 0.01$. The following variables did not significantly differ by study location: SF-36 general health, SF-36 social functioning, SF-36 physical role, self-rated health, or participation in cognitive training.

Outcome correlations—Table 2 displays bivariate correlations between the baseline health and physical performance indicators for the entire sample. All correlations were below 0.70, with the exception of the correlation between SF-36 general health and self-rated health, which was −0.77. Due to the multicollinearity between these two variables, the decision was made to combine them into a general health composite by scoring them in the same direction, standardizing them, and summing them. This composite score was used in subsequent analyses.

Mediation Analysis Models

Entire sample—In the base Cox proportional hazard model, driving status, age, and sex were significant predictors of time to death, while education, cognitive training group, and race were not (Table 3). Older age, male sex, and being a nondriver were associated with significantly higher odds of dying over the five-year study period (ps < 0.01). The same set of predictors was regressed on each of the five health indicators, and results pertaining to driving status are displayed in Table 4.

Driving status significantly predicted all of the health and physical performance variables, such that being a nondriver was associated with poorer scores on SF-36 physical role, SF-36 physical functioning, SF-36 social functioning, the general health composite, and Turn 360 performance (ps < 0.01). Of the covariates, only cognitive training group was not associated with any of the health variables. Thus, cognitive training group was not included in subsequent Cox models.

Table 5 presents the simultaneous effects of driving status and the health and Turn 360 variables (mediators) on time to death after adjusting for the same covariates as the base model (except cognitive training group). Each indicator significantly predicted time to death, such that participants with poorer health had higher odds of dying (ps < 0.01). Driving status remained a significant predictor in the models with the SF-36 subscales (ps < 0.05), but was no longer significant in the models with the general health composite and Turn 360 performance.

Finally, tests of the mediation effects using the product of coefficients method are presented in Table 6. Parameter estimates (a, b) and standard errors calculated from the models presented in Tables 4 and 5 were entered into the PRODCLIN program, which calculated 95% asymmetric confidence intervals for the mediation effect ab. None of the confidence intervals included zero, indicating that each of the health and physical performance variables had significant mediation effects on the relationship between driving status and mortality. The general health composite and Turn 360 performance acted as complete mediators, since including these variables rendered the path between driving status and mortality non-significant.

Large cities—When the sample was limited to participants from large cities, driving status, age, and sex were again significant predictors of driving status in the base Cox model (Table 3). Driving status was also a significant predictor of each health and physical performance indicator (Table 4). In the models that examined the simultaneous effects of driving status, health, and physical performance on time to death, each of the health indicators was significant, as was Turn 360 performance. However, driving status was no longer significant in any of the models (Table 5). PRODCLIN tests confirmed that the mediation effects for each health and physical performance variable were significant (Table 6); therefore, for this subset of participants, all mediation effects appeared to be complete.

Small cities—When only participants from small cities were examined, driving status, age, and sex remained significant in the base Cox model (Table 3). Driving status significantly predicted SF-36 physical functioning, the general health composite, and Turn 360 performance in the regression models, but did not predict SF-36 physical role or SF-36 social functioning (Table 4). In the simultaneous models, Turn 360 performance was not significantly associated with time to death, but all of the health variables were significant. The effect of driving status on time to death remained significant in each of these models

(Table 5). PRODCLIN tests revealed that only SF-36 physical functioning and the general health composite had significant mediation effects, and these effects were partial.

Discussion

The present study examined the association between driving status and mortality, as well as potential mediators of this relationship among community-dwelling older adults across five years. In the entire sample, nondrivers were 1.68 (95% CI = 1.20 – 2.34) times more likely to die during the subsequent five years relative to drivers, above and beyond demographic factors (Table 3). As hypothesized, indicators of health and physical performance significantly mediated the association between driving status and mortality. In the overall sample, mediation effects were partial for the SF-36 measures and complete for general health and physical performance. Previous research has shown that Turn 360 performance and general health decline at the transition to driving cessation, which may explain why these variables acted as complete mediators in the current study (Edwards, Lunsman, et al., 2009). The present findings suggest that, in general, the relationship between driving cessation and mortality can be attributed to declines in health and physical performance. Nondriving status may be a marker for the declining health that precedes death, and may even exacerbate such health declines.

While the current study found that nondrivers were initially 1.68 times more likely to die than drivers, Edwards, Perkins and colleagues (2009) found that drivers were 4.15 (95% CI = 2.37 – 9.96) to 6.51 (95% CI = 3.06 – 12.21) times more likely to die. These discrepancies may have been due to differences in sample characteristics. Edwards, Perkins, and colleagues (2009) utilized data from the Staying Keen in Later Life (SKILL) study in which participants were initially lower-functioning and less healthy relative to ACTIVE participants. SKILL participants also resided in the southeastern United States, where nondrivers are among the most isolated in the country due to lack of transportation options (White et al., 2010). These reasons may explain why nondrivers in the SKILL study had greater probabilities of death than the individuals observed in the present analyses. Nondrivers in the current study were 2.09 (95% CI = 1.14 – 3.84) times more likely to die than drivers if they were from small cities, but 1.51 (95% CI = 1.02 – 2.26) times more likely to die if they were from large cities (Table 3). The participants from small cities were more comparable to SKILL participants in terms of residence characteristics.

The current study was not only the first to examine mediators of the relationship between driving cessation and mortality, but also the first to examine whether that relationship differed by residential environment. As hypothesized, the mediation effects for the health variables, as well as Turn 360 performance, were significant for residents of large cities. Indeed, all of the mediation effects were complete; no significant direct path between driving status and mortality remained after the SF-36 health variables, the general health composite, and Turn 360 performance were entered into the equations. While driving status was strongly linked to health for large city residents, this was not the case for residents of small cities. For these participants, none of the mediation effects were complete, and SF-36 physical functioning and general health were the only significant partial mediators. Thus, health factors were relevant, but driving status had a direct effect on mortality that did not operate through health or physical performance.

Potential explanations for the lack of health influences on the driving-mortality association among small-city drivers include the following. First, drivers from small cities and the surrounding rural areas may continue driving even after their health declines, because it is the only way they can get access to services (Hanson & Hildebrand, 2011; Johnson, 1998, 2002). Smaller cities tend to have fewer alternative transportation options relative to larger cities, so driving cessation may be a last resort for small-city residents. Second, driving may be essential for the maintenance of health, quality of life, and social interaction among older drivers from rural areas, given the isolation experienced by rural nondrivers (Hildebrand, Myrick, & Creed, 2000; Lee et al., 2011). Thus, nondrivers from less populous areas may be particularly vulnerable to declines in their quality of life following driving cessation, which may increase their mortality risk.

Causal relationships between driving status, health, and mortality are difficult to distinguish given that the health difficulties that precipitate mortality also affect the decision to drive (Adler & Rottunda, 2006; Dellinger et al., 2001; Donorfio et al., 2009; Jette & Branch, 1992). Ideally, a large sample of older adults would be followed before and after driving cessation, and changes to their health and mortality risks would be assessed dynamically. Currently available datasets do not permit such analyses, as follow-up intervals are too short to yield sufficient numbers of individuals who cease driving and then die during the studies. In ACTIVE, just nine participants both ceased driving and died between the baseline and last annual assessments. However, the current study does support some causal inferences. Edwards, Lunsman, et al. (2009) established temporal precedence for driving cessation by showing that it accompanies and precedes declines in health. Since participants in the current study stopped driving prior to the baseline assessment, their baseline health and physical performance scores would have reflected any declines that had accompanied or followed driving cessation; the median length of time since driving cessation for nondrivers was eight years. Future studies could build upon the current study by examining time-varying relationships between driving status, health, and mortality risk as data become available for doing so.

We acknowledge other limitations of the present study as well. With the exception of physical performance, health was measured via self-report in ACTIVE. Although the SF-36 questionnaire and self-rated health item are valid and commonly used with older adults, future analyses should include more objective measures of health as well. We also lacked information regarding participants' use of alternative transportation methods and the availability of transportation support. Researchers should continue to explore the complex relationships between the need for transportation, the utilization of transportation, and the availability of transportation among older adults (Choi, Adams, & Kahana, 2012). Additionally, ACTIVE participants did not include residents of small towns with populations of less than 10,000, so current findings for small cities may represent conservative estimates of the association between driving and mortality in rural areas. The current findings may also not generalize to older adults with major functional impairments who are not community-dwelling.

Finally, the majority of data on driving cessation come from the U.S. In countries with comprehensive public transportation systems and commonly-used alternative methods of transportation, such as cycling, driving may be less important for older adults' health and well-being (Hakamies-Blomqvist & Peters, 2000). More international studies are needed, especially since the percentage of older drivers has increased in Europe and other developed countries (Sivak & Schoettle, 2012).

In conclusion, a substantial portion of the association between driving status and mortality can be accounted for by health and physical performance. The current study and prior evidence (Edwards, Lunsman, et al., 2009; Edwards, Perkins, et al., 2009) suggests that being a nondriver may increase mortality risk by exacerbating already-declining health and physical performance. For nondrivers from large cities, health and physical performance account for the relationship between driving cessation and mortality. However, for nondrivers from small cities with fewer alternative transportation options, there appears to be a direct link between driving cessation and mortality that cannot be explained by health. Therefore, we offer evidence that individuals, families, health professionals, and the larger community needs to identify ways to counteract the negative outcomes associated with driving cessation and declining health while more research is needed within small (and possibly rural) cities on the relationship between driving cessation and mortality. The present findings underscore the importance of driving in the U.S. as an instrumental activity of daily living with implications for older adults' health, well-being, and even survival.

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Table 1

Baseline Characteristics of the Total Sample, Decedents, Survivors, Residents of Small Cities, and Residents of Large Cities

	Total Sample		Decedents		Survivors		Small Cities		Large Cities	
Variable	**Mean(%)**	***SD***	**Mean(%)**	***SD***	**Mean(%)**	***SD***	**Mean(%)**	***SD***	**Mean(%)**	***SD***
Age	73.57	5.85	76.74[b]	6.73	73.26	5.67	73.04[c]	5.46	73.92	6.10
Years of Education	13.52	2.69	13.70	2.87	13.50	2.68	13.04[c]	2.49	13.79	2.78
Sex (% female)	(75.80)		(61.90)[b]		(77.20)		(73.10)[c]		(77.30)	
Race (% white)	(72.60)		(79.10)[b]		(72.00)		(92.10)[c]		(62.10)	
Cognitive Training (% any)	(75.10)		(74.20)		(75.20)		(75.10)		(75.10)	
Driving Status (% drivers)	(85.70)		(79.50)[b]		(86.30)		(88.20)[c]		(84.30)	
Location (% large cities)	(64.90)		(66.40)		(64.80)					
SF-36 Physical Role	61.18	39.18	45.90[b]	39.53	61.54	38.88	60.66	39.06	59.89	39.28
SF-36 Physical Functioning	69.47	24.26	55.89[b]	23.76	70.78	23.93	70.58[c]	23.47	67.85	24.36
SF-36 Social Functioning	86.55	19.96	81.30[b]	21.84	87.05	19.71	86.82	20.29	86.24	19.97
SF-36 General Health	68.99	19.21	60.56[b]	20.27	69.80	18.92	69.17	19.54	68.88	19.07
Self-Rated Health[a]	2.64	0.88	3.05[b]	0.88	2.60	0.87	2.62	0.89	2.65	0.88
Turn 360 Test[a]	6.91	2.02	7.67[b]	2.92	6.84	1.91	7.04[c]	1.80	6.86	2.14

Note. SF-36 = Short Form Health Survey; SD = standard deviation.

[a]Smaller scores reflect better performance.

[b]Difference between decedents and survivors significant at $p < 0.05$.

[c]Difference between small and large cities significant at $p < 0.05$.

Table 2

Correlations between Baseline Health and Physical Performance Indicators in Entire Sample

Indicator	**1**	**2**	**3**	**4**	**5**
1. SF-36 Physical Role	1.00				
2. SF-36 Physical Functioning	0.59*	1.00			
3. SF-36 Social Functioning	0.53*	0.46*	1.00		
4. General Health Composite	0.50*	0.57*	0.45*	1.00	
5. Turn 360 Test[a]	−0.24*	−0.32*	−0.17*	−0.19*	1.00

Note. SF-36 = Short Form Health Survey.

[a]Smaller scores reflect better performance.

* $p < 0.05$.

Table 3

Cox Hazard Models of the Relationship between Baseline Driving Status and Time to Death in Entire Sample and by Study Location

	Entire Sample			Small Cities			Large Cities		
Predictor	**B *(SE)***	**HR**	**95% CI**	**B *(SE)***	**HR**	**95% CI**	**B *(SE)***	**HR**	**95% CI**
Driving Status	0.52 *(0.17)*	1.68**	1.20 – 2.34	0.74 *(0.30)*	2.09**	1.14 – 3.84	0.41 *(0.20)*	1.51*	1.02 – 2.26
Baseline Age	0.49 *(0.06)*	1.63**	1.45 – 1.83	0.37 *(0.12)*	1.44**	1.15 – 1.81	0.54 *(0.07)*	1.71**	1.49 – 1.98
Education	0.02 *(0.07)*	1.02	0.89 – 1.16	0.04 *(0.13)*	1.04	0.82 – 1.33	−0.01 *(0.08)*	0.99	0.85 – 1.16
Race	−0.12 *(0.16)*	0.89	0.65 – 1.23	−0.11 *(0.47)*	0.90	0.36 – 2.25	−0.10 *(0.19)*	0.90	0.63 – 1.30
Sex	−0.75 *(0.14)*	0.47**	0.36 – 0.62	−0.85 *(0.25)*	0.43**	0.26 – 0.70	−0.70 *(0.17)*	0.50**	0.36 – 0.69
Cognitive Training	−0.01 *(0.15)*	0.99	0.74 – 1.32	−0.39 *(0.29)*	0.67	0.38 – 1.18	0.16 *(0.17)*	1.17	0.83 – 1.64

Note. SF-36 = Short Form Health Survey; SE = standard error; HR = hazard ratio; CI = confidence interval. The reference groups were drivers, males, non-whites, and trained participants. The 95% CI was for the HR.

* $p < 0.05$,

** $p < 0.01$.

Table 4

Linear Regression Coefficients for Baseline Driving Status as a Predictor of Baseline Health Indicators in the Entire Sample and by Study Location

	Driving Status					
	Entire Sample		Small Cities		Large Cities	
Health Outcomes	**B *(SE)***	***t***	**B *(SE)***	***t***	**B *(SE)***	***t***
SF-36 Physical Role	−0.17 *(0.06)*	−2.96**	−0.19 *(0.12)*	−1.66	−0.16 *(0.07)*	−2.45*
SF-36 Physical Functioning	−0.42 *(0.05)*	−7.70**	−0.25 *(0.10)*	−2.51*	−0.49 *(0.07)*	−7.61**
SF-36 Social Functioning	−0.24 *(0.06)*	−4.23**	−0.15 *(0.11)*	−1.41	−0.29 *(0.07)*	−4.27**
General Health Composite	−0.40 *(0.06)*	−7.28**	−0.36 *(0.10)*	−3.44**	−0.43 *(0.07)*	−6.59**
Turn 360 Test[a]	0.38 *(0.06)*	6.92**	0.20 *(0.09)*	2.16*	0.46 *(0.04)*	6.73**

Note. SF-36 = Short Form Health Survey; SE = standard error. Separate models were run for each health indicator, and models controlled for baseline age, years of education, race, and sex. The reference group for driving status was drivers.

[a]Smaller scores reflect better performance.

*$p < 0.05$,

**$p < 0.01$.

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Table 5

Cox Hazard Models of the Relationship between Baseline Driving Status and Time to Death, Controlling for Baseline Health

	Entire Sample			Small Cities			Large Cities		
Predictor	**B *(SE)***	**HR**	**95% CI**	**B *(SE)***	**HR**	**95% CI**	**B *(SE)***	**HR**	**95% CI**
Model 1									
Driving Status	0.48 *(0.17)*	1.62**	1.16 – 2.27	0.73 *(0.31)*	2.08*	1.13 – 3.81	0.38 *(0.21)*	1.46	0.97 – 2.19
SF-36 Physical Role	−0.30 *(0.07)*	0.74**	0.65 – 0.84	−0.36 *(0.11)*	0.70**	0.56 – 0.87	−0.28 *(0.08)*	0.76**	0.65 – 0.89
Model 2									
Driving Status	0.39 *(0.17)*	1.48*	1.05 – 2.08	0.70 *(0.31)*	2.00*	1.09 – 3.69	0.28 *(0.21)*	1.32	0.87 – 1.99
SF-36 Physical Functioning	−0.37 *(0.06)*	0.70**	0.61 – 0.78	−0.48 *(0.11)*	0.62**	0.50 – 0.76	−0.32 *(0.08)*	0.72**	0.62 – 0.85
Model 3									
Driving Status	0.48 *(0.17)*	1.62**	1.15 – 2.27	0.75 *(0.31)*	2.11*	1.15 – 3.86	0.36 *(0.21)*	1.44	0.95 – 2.16
SF-36 Social Functioning	−0.19 *(0.06)*	0.82**	0.74 – 0.92	−0.22 *(0.10)*	0.81*	0.67 – 0.97	−0.19 *(0.07)*	0.83**	0.72 – 0.95
Model 4									
Driving Status	0.33 *(0.18)*	1.39	0.99 – 1.96	0.61 *(0.31)*	1.84*	1.01 – 3.38	0.21 *(0.21)*	1.23	0.81 – 1.88
General Health Composite	−0.44 *(0.06)*	0.64**	0.57 – 0.73	−0.51 *(0.10)*	0.60**	0.49 – 0.74	−0.41 *(0.08)*	0.66**	0.56 – 0.78
Model 5									
Driving Status	0.35 *(0.19)*	1.42	0.98 – 2.04	0.69 *(0.33)*	1.98*	1.03 – 3.81	0.17 *(0.23)*	1.18	0.76 – 1.85
Turn 360 Test[a]	0.17 *(0.05)*	1.18**	1.08 – 1.29	−0.09 *(0.14)*	0.91	0.69 – 1.21	0.20 *(0.05)*	1.22**	1.12 – 1.34

Note. SF-36 = Short Form Health Survey; SE = standard error; HR = hazard ratio; CI = confidence interval. The 95% CI was for the HR. Models controlled for baseline age, years of education, sex, and race. Drivers were the reference group.

[a]Smaller scores reflect better performance.

*$p < 0.05$,

**$p < 0.01$.

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Table 6

Mediation Effects of Baseline Health Variables on the Relationship between Driving Status and Time to Death

	Entire Sample			Small Cities			Large Cities		
Mediators	**Mediation Effect (ab)**	**First Order SE**	**95% Asymmetric CI**	**Mediation Effect (ab)**	**First Order SE**	**95% Asymmetric CI**	**Mediation Effect (ab)**	**First Order SE**	**95% Asymmetric CI**
SF-36 Physical Role	0.05*	0.02	0.01 – 0.09	0.07	0.05	−0.01 – 0.18	0.04*	0.02	0.01 – 0.10
SF-36 Physical Functioning	0.16*	0.03	0.10 – 0.22	0.12*	0.06	0.03 – 0.24	0.16*	0.05	0.08 – 0.25
SF-36 Social Functioning	0.05*	0.02	0.01 – 0.09	0.03	0.03	−0.01 – 0.10	0.06*	0.02	0.01 – 0.11
General Health Composite	0.18*	0.04	0.11 – 0.25	0.18*	0.06	0.07 – 0.32	0.18*	0.04	0.10 – 0.27
Turn 360 Test[a]	0.06*	0.02	0.03 – 0.11	−0.02	0.03	−0.08 – 0.04	0.09*	0.02	0.05 – 0.14

Note. SF-36 = Short Form Health Survey; SE = standard error; CI = confidence interval.

[a]Smaller scores reflect better performance.

*Significant mediation effect at $p < 0.05$.