Driving Status and Three-Year Mortality Among Community-Dwelling Older Adults

Jerri D. Edwards,1 Martinique Perkins,2 Lesley A. Ross,2 and Sandra L. Reynolds1

1School of Aging Studies, University of South Florida, Tampa.
2Department of Psychology, University of Alabama at Birmingham.

Background. Driving cessation can lead to myriad negative consequences for older adults. The purpose of these analyses was to examine driving status as a predictor of mortality among community-dwelling older adults.

Methods. This prospective cohort study included 660 community-dwelling adults ranging in age between 63 and 97 years. Between 2000 and 2004, participants completed performance-based assessments of vision, cognition, and physical abilities and indexes of health, depression, self-efficacy, and driving habits. Follow-up telephone interviews were completed approximately 3 years later.

Results. Among community-dwelling older adults, older age, health, poor near visual acuity, depressive symptoms, compromised cognitive status, and being a nondriver are associated with increased risk for a 3-year mortality. Nondrivers were four to six times more likely to die than drivers during the subsequent 3-year period.

Conclusions. The ability to drive represents both a sign of cherished independence and underlying health and well-being for older adults. Retaining this ability is an important health concern in the United States.

Key Words: Driving cessation—Mortality—Older drivers.

In the United States, the majority of older adults rely upon the automobile for maintaining mobility (1,2). Thus, when ceasing driving, older adults experience many adverse consequences including less access to health care, increased dependency, social isolation, and depression (3–6), and are at greater risk for subsequent nursing home placement (7).

Interestingly, many of these consequences of driving cessation are known to impact mortality. The most often cited factors increasing mortality risk include low educational attainment, non-white race (8), poor self-reported health (9), and various components of frailty (10,11). Similarly, nondrivers tend to be older; are more likely to be female (6,12,13); and have more medical conditions, poorer self-ratings of health, greater cognitive decline, and more functional difficulties (1,6,12,14,15). Jagger and colleagues (16) reported that difficulties with both basic and instrumental activities of daily living (IADL), as well as the presence of cognitive impairment, chronic conditions, and visual impairments, negatively affect years of life and disability-free years of life.

The overlap between factors linked to both driving cessation and mortality present compelling reasons to examine the effects of driving status on subsequent mortality. Considering that the negative consequences of driving cessation (3,4) are also associated with increased risk of mortality (17,18), it is of interest to examine whether driving cessation is associated with increased risk of mortality as well. This analysis examines the impact of driving status upon mortality for a 3-year period. The independent association of driving status is evaluated by simultaneously considering demographic, physical performance, comorbidity, sensory function, psychological health, and cognitive performance factors known to be associated with driving cessation or mortality, or both.

As many of these factors are in the Verbrugge and Jette (19) disablement process model, we use the model as a general guide to demonstrate how driving cessation could lead to disability and mortality. The model suggests a progression beginning with pathology (disease) and functional impairments, with dynamic internal and external forces such as lifestyle or behavioral changes, psychosocial attributes and coping, and activity accommodations as potential modifiers of the path to disability. We hypothesize that, even after controlling for these model components, driving cessation will be a strong predictor of mortality in old age.

Methods

The Staying Keen in Later Life (SKILL) (20) study was designed to examine the contributions of sensory, cognitive, and physical function as well as health and medication use to subsequent driving outcomes. Consistent with Verbrugge and Jette’s (19) disablement process, the variables included represent pathology (medical conditions), risk factors (previously related to driving cessation and mortality), and intra-individual factors (psychological, physical, and cognitive factors).

Participants

Participants included 660 individuals who completed the baseline phase of the SKILL study (20) and were either
Because the two groups did not differ in time to death, the null hypothesis of no differences between these two groups on our outcome of interest was not rejected. Mann-Whitney U test to ensure that there were no differences between these two groups on our outcome of interest. Because the two groups did not differ in time to death \( Z < 1, p = .982 \), they were not differentiated in analyses.

**Procedures**

The baseline study was conducted between 2000 and 2004 (20, 21) and involved 894 community-dwelling adults who were recruited from Alabama and Kentucky with mass mailings. Of 1,131 participants screened for participation, 894 completed the baseline phase of the study and met the inclusion criteria (age of 60 years or older, literacy level of fifth grade or better, far visual acuity 20/80 or better) to read and view study materials.

Two baseline testing visits were completed by the participants an average of 4 weeks apart. Follow-up interviews occurred within 3 years (±3 months) of each participant’s baseline assessment. Between March 2004 and March 2007, we attempted to contact 701 of the SKILL participants who had completed baseline within the past 3 years (± 3 months). Participants were readministered the mobility, health, and medication questionnaires by telephone. On average, the follow-up interviews were conducted 37 months after the participants completed their baseline visit (standard deviation = 3.36). Of the 701 participants with an active interview window during the SKILL follow-up project period, 602 were successfully reached. Of those not contacted, 58 were confirmed as deceased and 41 were not reached due to incorrect contact information.

**Measures**

**Driving status.**—Participants completed the mobility questionnaire (22). The first question ascertained whether the participants considered themselves to be current drivers, defined as, “someone who has driven a car within the last 12 months and someone who would drive a car today if they needed to.” Five percent (\( n = 32 \)) of the sample reported being nondrivers at baseline. Nondrivers included both those who had reported ceasing driving (\( n = 24 \)) and those who reported having never driven (\( n = 8 \)). Within those participants who were nondrivers, we compared those who had never driven with those who had ceased driving with the Mann-Whitney \( U \) test to ensure that there were no differences between these two groups on our outcome of interest. Because the two groups did not differ in time to death \( Z < 1, p = .982 \), they were not differentiated in analyses.

**Health.**—A health questionnaire emphasizing physical conditions that could impact driving status was administered. Participants self-reported whether a doctor or nurse had ever informed them of having any of the following conditions: arthritis, asthma, cancer, chronic skin problems, diabetes, heart disease or other heart problems, high cholesterol, hypertension, mood problems or anxiety disorders, multiple sclerosis, osteoporosis, Parkinson’s disease, or stroke (including transient ischemic attack). The number of health conditions reported was used as an indicator of health.

**Physical performance.**—Balance was assessed using the Turn 360 test (23). The number of steps required to make one complete turn was recorded, with fewer steps indicating better balance. Participants were then asked to complete a second 360° turn. The average number of steps taken for both turns was used in analyses.

**Sensory function.**—Two measures assessed visual capabilities. Far visual acuity with the participant’s available correction, if any, was tested per standard procedures with an Early Treatment Diabetic Retinopathy Study (ETDRS) chart. Scores were assigned using the Advanced Cognitive Training for Independent and Vital Elderly study method (24), which provides credit for each letter correctly identified, with possible scores ranging from 0 to 90. The Lighthouse Near Visual Acuity Modified ETDRS chart measured near vision (21), and higher scores indicated better performance. Pure-tone hearing thresholds were tested with a GSI-17 Audiometer using standard threshold procedures. The pure-tone average threshold was calculated for the better ear and used in analyses.

**Psychological health.**—The Center for Epidemiologic Studies-Depression scale (25) was used to assess depressive symptoms. The scale consists of 20 items, with higher scores indicative of more depressive symptoms.

The self-efficacy scale had a total of eight items to assess efficacy across the domains of health, transportation, relationships, finances, safety, and productivity. Each item was rated on a 4-point scale from strongly agree (1) to strongly disagree (4), with lower scores reflecting higher self-efficacy.

**Cognition.**—The Mini-Mental State Exam (MMSE) (26) was used to assess mental status. The questions assess attention, memory, language, orientation, and construction skills.

The Useful Field of View test (27) was used to measure cognitive speed of processing. The touch PC version of the test was administered per standard procedure and included four subtests, with each subtest progressively more difficult than the previous. In each subtest, the display duration threshold value for 75% correct performance was measured using the double-staircase method, with performance varying between 16 and 500 milliseconds. A composite score across subtests was used in analyses.

The road sign test was administered by computer to examine everyday speed of processing using standard...
procedures (20). Complex reaction time to a target road sign among changing displays of three or six signs was measured. During the test, one target sign (without a red slash) would suddenly appear on the screen. Reaction time in seconds was averaged across all trials.

The Trail Making Test Part B examines executive functioning (28). Participants drew lines connecting numbers and letters in alternating sequential order. The test was timed and seconds required to complete the task were recorded. Scores were capped at 480 seconds, with those unable to complete the task in the time allotted assigned the maximum time.

Wechsler Abbreviated Scales of Intelligence matrix reasoning task assessed nonverbal reasoning by providing picture puzzles with a missing piece. Based on five answer choices, the participant chose the piece that would complete the picture. Performance was indicated by T-scores (29). Wechsler Abbreviated Scales of Intelligence vocabulary subtest assessed crystallized intelligence by requiring participants to define words. T-scores were assigned (29).

**Statistical Analyses**

To examine if a significant difference existed between nondrivers and drivers on baseline health, physical performance, psychological well-being, and cognitive performance measures, multivariate analysis of variance (MANOVA) was used. As follow-up analyses for a significant overall group difference, univariate analyses of variance (ANOVA) compared the two groups on each individual measure. Baseline demographics, health, physical performance, psychological well-being, and cognitive performance were examined as predictors of mortality for a period of 3 years. Persons who survived throughout the 3-year follow-up interval were right censored. For deceased individuals, time was measured in number of months from baseline assessment to date of death. After converting continuous data to $z$-scores, Cox regression analyses were applied to the data, such that the risk of dying was estimated with adjustments for other factors thought to affect mortality or driving status.

Spearman correlations among variables were examined for multicollinearity. If variables were correlated at $r_s = .50$ or greater, the variable most strongly related to time to death was chosen for inclusion. Thus, the road sign test and near visual acuity were chosen for inclusion over Useful Field of View and far visual acuity.

**RESULTS**

Descriptives of the study sample are presented in Table 1 by survival status. MANOVA revealed significant differences between the two groups across baseline measures, $F(12, 623) = 8.28, p < .001$. Follow-up ANOVAs comparing the nondrivers to drivers for each baseline measure revealed that those who died during the 3-year period tended to be older, tended to be of lower educational attainment, reported more health conditions, did less well on the Turn360 test, had

<table>
<thead>
<tr>
<th>Demographics</th>
<th>Total</th>
<th>Deceased</th>
<th>Survived</th>
</tr>
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<tr>
<td>Age (y)</td>
<td>73.16</td>
<td>76.66</td>
<td>72.83</td>
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<tr>
<td>Gender (%)</td>
<td>55.2</td>
<td>53.4</td>
<td>55.3</td>
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<tr>
<td>Race (%)</td>
<td>85.8</td>
<td>84.5</td>
<td>85.9</td>
</tr>
<tr>
<td>Education (y)</td>
<td>13.98</td>
<td>13.57</td>
<td>14.02</td>
</tr>
<tr>
<td>Driving status (%) drivers</td>
<td>95.2</td>
<td>79.3</td>
<td>96.7</td>
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<th>Physical function and health</th>
<th>Total</th>
<th>Deceased</th>
<th>Survived</th>
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</thead>
<tbody>
<tr>
<td>Number of health conditions</td>
<td>2.76</td>
<td>3.64</td>
<td>2.68</td>
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<tr>
<td>Balance Turn360 (no. of steps)</td>
<td>7.05</td>
<td>8.3</td>
<td>6.92</td>
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<td>Near visual acuity (logMAR)</td>
<td>0.06</td>
<td>0.15</td>
<td>0.05</td>
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<tr>
<td>Hearing (dB)</td>
<td>23.60</td>
<td>29.02</td>
<td>23.06</td>
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<th>Survived</th>
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</thead>
<tbody>
<tr>
<td>CES-D (score/60)</td>
<td>8.25</td>
<td>11.96</td>
<td>7.90</td>
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<td>Self-efficacy (score/32)</td>
<td>15.24</td>
<td>16.53</td>
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<table>
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<th>Deceased</th>
<th>Survived</th>
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</thead>
<tbody>
<tr>
<td>MMSE (score/30)</td>
<td>28.05</td>
<td>26.83</td>
<td>28.17</td>
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<tr>
<td>Road sign test (s)</td>
<td>2.01</td>
<td>2.66</td>
<td>1.94</td>
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<tr>
<td>Trails B (s)</td>
<td>144.60</td>
<td>207.53</td>
<td>138.54</td>
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<tr>
<td>Vocabulary (score)</td>
<td>55.34</td>
<td>53.97</td>
<td>55.48</td>
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<tr>
<td>Matrix reasoning (T-score)</td>
<td>51.76</td>
<td>51.57</td>
<td>51.78</td>
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**Notes**: CES-D = Center for Epidemiologic Studies-Depression scale; MMSE = Mini-Mental State Exam.

*a* Group differences significant, $p < .05$.

*b* Smaller scores reflect better performance.
whether driving status remains a significant indicator of mortality risk, further models examine other indicators of functional ability and therefore mortality. In this final model, the variables from models 2–5 that were significant predictors of 3-year mortality, including comorbidity, near visual acuity, depression, and performance on the MMSE, were added to the base model of demographic predictors. The inclusion of all of these factors still results in a significant effect of nondriving status, with nondrivers being 4.86 times more likely to die during the 3-year period than drivers.

### Table 2. Three-Year Mortality Risk for Nondrivers Compared With Drivers; Hazard Ratios and 95% Confidence Intervals: Adults 60 Years or Older (N = 660)

<table>
<thead>
<tr>
<th>Model</th>
<th>Hazard Ratio</th>
<th>Confidence Interval</th>
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<tr>
<td>Model 1a</td>
<td>6.11</td>
<td>3.060–12.214</td>
<td>584.120</td>
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<tr>
<td>Model 2b</td>
<td>4.15</td>
<td>1.973–8.747</td>
<td>575.043</td>
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<tr>
<td>Model 3c</td>
<td>4.79</td>
<td>2.394–9.581</td>
<td>569.167</td>
</tr>
<tr>
<td>Model 4d</td>
<td>6.51</td>
<td>3.176–13.336</td>
<td>566.583</td>
</tr>
<tr>
<td>Model 5e</td>
<td>5.72</td>
<td>2.744–11.879</td>
<td>572.124</td>
</tr>
<tr>
<td>Full modelf</td>
<td>4.86</td>
<td>2.368–9.962</td>
<td>550.988</td>
</tr>
</tbody>
</table>

Notes: LL = log likelihood.

a Adjusted for age, male gender, race, and education.
b Adjusted for age, male gender, race, education, health conditions, and balance.
c Adjusted for age, male gender, race, education, near visual acuity, and hearing.
d Adjusted for age, male gender, race, education, performance on the MMSE, and cognitive speed of processing (ps ≤ .001). The two groups did not differ in crystallized intelligence (p = .87) or nonverbal reasoning abilities (p = .44).

The results of the Cox regressions are presented in Table 2. In the base model, we estimate the hazard ratios of mortality for nondrivers, adjusting only for demographic characteristics at baseline (age, male gender, Caucasian race, and education). In this base model (model 1), the risk of dying for nondrivers was 6.11 times the risk of dying for drivers.

Considering that many factors associated with driving cessation (ie, sensory and cognitive decline, poor health, physical function, and psychological well-being) may also be indicative of mortality risk, further models examine whether driving status remains a significant indicator of 3-year mortality while simultaneously adjusting for predictors from each of these domains and demographic factors.

In model 2, we add physical health factors. Results indicate that after adjusting for physical health and demographics, the risk of dying for nondrivers is still 4.15 times the risk for drivers. In model 3, instead, we adjust for sensory functioning (near visual acuity and hearing); in this case, compared with the risk for drivers, nondrivers were 4.79 times more likely to die during the subsequent 3 years. Model 4 adjusts for psychological health factors, including depressive symptoms and self-efficacy, in addition to demographic factors. In this case, nondrivers are 6.51 times more likely to die than drivers. Model 5 adjusts for cognitive performance (including MMSE, road sign test, Trails B, vocabulary, and matrix reasoning) in addition to demographic risk factors and reveals that nondrivers are at 5.72 times the risk of dying as compared with drivers.

The present study examined multidimensional risk factors for mortality for a period of 3 years among older adults. Consistent with the Verbrugge-Jette disablement process (1994), measures of pathology (number of health conditions) and functional impairments (visual acuity) were significant predictors of 3-year mortality (not shown). As our results show, however, none exerted enough influence on 3-year mortality to significantly reduce the effect of baseline driving status. Although hazard ratios for the significant demographic, sensory, health, and cognitive risk indicators ranged from 1.06 to 1.42, nondrivers were 4–6 times more likely to die during the subsequent 3 years as compared with drivers.

These findings highlight the importance of driving to older adults’ health and well-being in the United States. Prior research has indicated that driving cessation leads to myriad negative health outcomes such as depression, isolation, and even nursing home placement (4,5,7,30). The present study indicates, moreover, that driving status is a strong predictor of 3-year mortality risk. Although one could argue that driving status may serve as a marker for other indicators of functional ability and therefore mortality, the relationship of driving status and time to death remained significant even while considering baseline sensory and physical function, health, psychological well-being, and cognitive abilities. These results are very important for physicians and other health care professionals as well as family members of older drivers who are in a position to evaluate whether or not a person should continue driving. Considering the potential negative ramifications of driving cessation for the older adults’ psychological and physical well-being, along with this evidence that ceasing driving may even shorten their life span, driving cessation should be the last option.

The question remains as to why driving status may impact mortality risk and what may potentially mediate this relationship. Several possibilities should be explored in future research. Driving cessation is known to result in many negative psychological consequences, including increased social isolation, increased depression, and
decreased sense of control, which could, in turn, increase risk for mortality (5,30,31). Driving cessation is also known to result in decreased activity as well as less access to health care (5,30), which could result in further health declines and hasten death. Mediation analyses with a larger sample are necessary to clarify these relationships.

We acknowledge some limitations of the present study. Because the sample size was relatively small, the magnitude of the relationship between driving status and mortality may not be observed in a larger cohort. We examine mortality for a period of only 3 years. It is not known if this relationship would hold for longer time periods. Furthermore, our data do not allow us to examine whether driving cessation is more likely to be associated with particular causes of death. The present results are most generalizable to community-dwelling older adults residing in the south central region of the United States. Older adults who are nondrivers in Kentucky, Tennessee, Alabama, and Mississippi are among the most isolated across the United States (32). Thus, it would be of interest to see if the same relationships between driving status and mortality are observed among older adults in other regions where public transportation is more accessible.

As our measures of health and functioning were limited, the relationship between driving and mortality deserves further inquiry with more precise measures. Another limitation of the study is that we do not have information regarding the trajectory of health nor any functional performance data at the follow-up period. Such health changes over time and functional performance at follow-up may explain the increased risk of mortality in nondrivers rather than driving cessation per se. Multilevel modeling approaches could be used with longitudinal data to clarify the nature of the relationships among health, driving cessation, and mortality. It may be that older adults are so reluctant to relinquish driving that cessation is a last resort when health has declined significantly.

Considering prior research findings as well as the fact that participants of this study at baseline were community-dwelling, relatively healthy, and mobile enough to participate in the study, we argue that driving cessation may result in precipitous decline over time especially for older adults residing in areas of the United States where alternative modes of transportation are not available or easily accessible. According to the model of disablement, disability leads to impaired IADL functioning, which hampers social functioning and eventually leads to increased risk for mortality. Driving is an important IADL and losing this functional ability may hasten further decline. However, further research is necessary to replicate the present findings in a larger cohort and to further examine the extent to which health and functional performance over time may mediate the strong association of driving status and mortality.

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**Conflict of interest**

J.D.E has worked as a consultant to Visual Awareness, Inc. which holds the license and patent to the Useful Field of View testing software.

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**Correspondence**

Address correspondence to Jerri D. Edwards, PhD, School of Aging Studies, University of South Florida, 4202 E Fowler Ave, MHC 1326, Tampa, FL 33620. Email: jedwards1@cas.usf.edu

**References**


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