Journal of Transport & Health 24 (2022) 101310

Contents lists available at ScienceDirect

Journal of Transport & Health

journal homepage: www.elsevier.com/locate/jth

All are not created equal: Assessing initial driving self-regulation behaviors among older adults

Jonathon M. Vivoda[a,*], Lisa J. Molnar[b,c], David W. Eby[b,c], Carolyn DiGuiseppi[d], Vanya Jones[e], Guohua Li[f,g], David Strogatz[h], Raymond Yung[i], Linda Nyquist[i], Jacqui Smith[j], Jennifer S. Zakrajsek[b,c], Renée M. St Louis[b,c,k], Nicole Zanier[b,c]

[a] Department of Sociology and Gerontology, Miami University, Oxford, OH, USA
[b] University of Michigan Transportation Research Institute, Ann Arbor, MI, USA
[c] Center for Advancing Transportation Leadership and Safety (ATLAS Center), Ann Arbor, MI, USA
[d] Department of Epidemiology, Colorado School of Public Health, University of Colorado Anschutz Medical Campus, Aurora, CO, USA
[e] Department of Health, Behavior and Society, Bloomberg School of Public Health, Johns Hopkins University, Baltimore, MD, USA
[f] Department of Anesthesiology, Columbia University Vagelos College of Physicians and Surgeons, New York, NY, USA
[g] Department of Epidemiology, Mailman School of Public Health, Columbia University, New York, NY, USA
[h] Bassett Research Institute, Bassett Healthcare Network, Cooperstown, NY, USA
[i] Institute of Gerontology, Division of Geriatric and Palliative Medicine, University of Michigan, Ann Arbor, MI, USA
[j] Institute for Social Research, University of Michigan, Ann Arbor, MI, USA
[k] Monash University Accident Research Centre, Clayton, Victoria, Australia

A R T I C L E I N F O

Keywords:
Driving avoidance
Driving reduction
Driving comfort
Driving ability
Self-regulation

A B S T R A C T

Introduction: Mobility is closely tied to the ability to safely drive. In older adulthood, many people begin to avoid difficult driving situations, such as driving at night, during rush hour, on freeways, or in unfamiliar areas. Reasons for such avoidance include driving self-regulation (SR; an intentional response to perceived difficulty), lifestyle changes, or preference. Most previous research has not made distinctions between these reasons, has not compared driving avoidance situations, and has not differentiated between those early in the SR process from those farther along. This study addressed those issues by comparing each of the aforementioned driving avoidance behaviors as one's initial SR behavior.

Methods: A total of 1554 older drivers from the AAA Longitudinal Research on Aging Drivers study were analyzed. Multinomial regression was used to determine how demographics, function, and driving-related factors were related to a difference in the odds of reporting one initial SR behavior compared to each of the others.

Results: The most common initial SR behavior was avoidance of nighttime driving (57.59%), followed by avoidance of rush hour driving (26.96%), driving in unfamiliar areas (10.81%), and driving on freeways (4.63%). A variety of demographic and function variables were associated with a difference in the odds of the initial SR behaviors, including gender, race, income, anxiety, driving responsibility, having rides available, driving abilities, and driving comfort.

Conclusions: Nighttime avoidance is the most common initial SR behavior. Variables specifically related to situational driving comfort and driving ability were the best predictors of differences in driving SR.

* Corresponding author. Department of Sociology & Gerontology, Miami University, 375 Upham Hall, Oxford, OH, 45056, USA.
E-mail address: vivodajm@miamioh.edu (J.M. Vivoda).

https://doi.org/10.1016/j.jth.2021.101310
Received 29 June 2021; Received in revised form 18 October 2021; Accepted 29 November 2021
Available online 10 December 2021
2214-1405/

1. Introduction

Mobility for older Americans is closely tied to maintaining the ability to safely drive (Dickerson et al., 2019). Loss of that ability can be detrimental for older adults, as driving cessation has been linked to a variety of negative outcomes, including fewer social activities, declines in physical and cognitive health, increased depressive symptoms, and a greater risk of admission to long-term care (see Chihuri et al., 2016; Dickerson et al., 2019). Driving cessation is related to loss of independence, and even feelings of loss related to one's identity (Adler and Rottunda, 2006; Sanford et al., 2020).

Most adults progress from driving without limitation, to situational driving avoidance and reduced driving, to eventual driving cessation, a process conceptualized as the transportation continuum (Eby et al., 2009). Those at the beginning of the continuum are independent, while those at the end become dependent on others to meet their mobility needs (Gardezi et al., 2006; Mullen et al., 2017). Factors that lead to driving cessation and its consequences have been frequently studied in previous research (see Dickerson et al., 2019 for an overview). Less research has focused on the middle of the transportation continuum, when drivers limit or reduce their driving.

Research on the process of driving reduction has identified numerous situations that older adults often avoid, including driving at night, during rush hour, on freeways, in unfamiliar areas, and in bad weather (Bergen et al., 2017; Davis and Conlon, 2017). Such avoidance behavior may be due to driving self-regulation (SR; an intentional response to perceived difficulty), lifestyle changes, or preference differences (Molnar et al., 2013). However, previous research has often considered any avoidance behavior to be due to SR, without specifically assessing the underlying reason for the avoidance (Molnar et al., 2013).

Research on driving avoidance has frequently divided people into three categories, those who drive without restriction, those who avoid challenging situations/reduce their driving, and those who no longer drive at all (see e.g., Vivoda et al., 2020). That approach is useful for comparing people in the broad stages of the transportation continuum, but it does not account for differences between those who may be just beginning to reduce their driving, those who may be about to give up driving altogether, and those somewhere in the middle.

Another approach has involved adding up the number of driving avoidance behaviors in which an individual engages (Braitman and Williams, 2011; Molnar et al., 2018). That technique provides additional distinctions among those in the middle of the continuum, but can only assess driving avoidance at a single point for an individual, without regard to which behaviors were an initial response to a perceived decline, and which came later in one's driving reduction process. In addition, that approach does not distinguish between different types of avoidance behaviors, but considers only the total number. Research has recently begun to assess differences in the prevalence of individual driving avoidance behaviors, and what factors might be related to one behavior versus another (Vivoda et al., 2021).

The overall goal of this study was to assess driving SR behaviors, with a particular focus on addressing these gaps in knowledge. The study involved four key objectives. The first objective was to use SR measures to identify intentional avoidance decisions resulting from driving difficulties (i.e., self-regulation), rather than general driving avoidance. The second objective was to assess older adults early in the self-regulatory process; only those with one reported SR behavior were included. This approach is important because it allows for the identification of driving behaviors that may be seen as most challenging to those beginning to experience a decline, or behaviors that may be most practical to avoid. It also begins to identify a process for SR. Understanding more about the SR process could allow for more targeted interventions that could help older adults to maintain their mobility.

The third objective was to determine the most common SR behaviors between those compared in this study: driving at night, driving on freeways, driving in unfamiliar areas, and driving during rush hour. These behaviors were selected based on previous research that identified them as some of the most commonly avoided (night: 80%; rush hour: 87%, unfamiliar areas: 74%, freeways: 64%; Moták et al., 2014) and studied (Betz and Lowenstein, 2010; Molnar et al., 2013; Sullivan et al., 2011), and based on the availability of measures in the dataset. The final objective was to assess the influence of different factors on the odds of engaging in a given self-regulatory behavior versus the others.

Two specific hypotheses (Hs) were assessed in this study. H1) Nighttime and freeway avoidance will be the two most common initial self-regulatory behaviors, given that avoidance of rush hour and unfamiliar areas may be more likely to result from factors unrelated to SR (e.g., preference, lack of need). H2) Predictors will have a differential influence on the odds of some self-regulatory behaviors compared to others. Previous research has suggested that driving ability can be predicted by cognition, sensory function, and physical function (Anstey et al., 2005), and recognition of these declines is likely to increase SR. For example, poor vision (acuity and contrast sensitivity) may increase the odds of nighttime avoidance as one's initial self-regulatory behavior, compared to the other behaviors; and poor cognition may increase the odds of freeway SR compared to the other behaviors, given the limited reaction time available to make decisions while driving at freeway speeds.

2. Methods

2.1. Data source

Questionnaire and in-person assessment data from the AAA Longitudinal Research on Aging Drivers (LongROAD) study were used in this analysis. LongROAD is a large prospective cohort study with data collection sites in Ann Arbor, MI; Baltimore, MD; Cooperstown, NY; Denver, CO; and San Diego, CA; as well as a data coordination center at Columbia University (New York, NY). Data collection began in July 2015, and four waves of annual questionnaire data were assessed, resulting in a final analytical sample of 1554 older adults. Inclusion criteria required participants to be between 65 and 79 years of age at study initiation. The LongROAD study design and methods are described in detail elsewhere (Li et al., 2017). The institutional review board at each site reviewed and approved all study protocols (Columbia University: #AAAN9950; Johns Hopkins University: #00006200; Mary Imogene Bassett Hospital: #1092; University of California, San Diego: #141800; University of Colorado: #14-0528; University of Michigan: HUM00094031).

2.2. Data management and analysis

Four waves of questionnaire data (baseline through wave 3) and two waves of in-person assessments (baseline and wave 2) were available for analysis, with data collection for wave 3 completed in April 2020. Data from all available waves were pooled to identify each participant's first SR behavior. Pooling allowed for data from more participants to be used, as any given wave only represented a respondent's SR behavior at one point in time. Pooling data across waves also allowed for the wave to be used in which only one SR behavior was reported. Participants with exactly one SR behavior represented about 38% of the total, with another 31% reporting none of the four behaviors, 19% reporting two, 9% reporting three, and 3% reporting four. If a respondent reported only one SR behavior in multiple waves, their first wave of data was used to represent their earliest state in the driving self-regulation continuum. Once a wave with an initial SR was identified for a given individual, predictor variables (demographics, function, and driving variables) from the identified wave were used. If missing data were observed for the included wave (e.g., because in-person assessment data were only available for baseline and wave 2), the same variables from the wave that most closely preceded the included wave were assessed and included when available; if those data were missing, data from subsequent waves were then used. As such, only one record per participant was included.

Following that process, univariate analyses were used to assess individual variables, check for errors and variable distributions, and compare the frequency of initial SR behaviors. Bivariate analyses facilitated regression model building, and assessed initial relationships between the predictors and the outcome. Multinomial regression techniques were used to assess the independent effect of each predictor on the outcome, after controlling for other variables in the model. Specifically, this approach allowed for the examination of the effect of each predictor on the odds of reporting each of the four situations (nighttime, freeways, unfamiliar areas, and rush hour) as one's initial SR behavior, compared to every other situation. A significance level threshold of $p<0.05$ was used to determine statistical significance in the study. The regression model initially included all variables of interest (see next section for details). The model building process involved assessing the contribution of each predictor to the model (e.g., assessing *p*-values), and removing those that did not contribute. Because removing any variable changes parameter estimates for those that remain in the model, variables with the highest *p*-values were removed first, and the model was re-assessed. This process was repeated until only those meeting the statistical threshold were retained.

2.3. Measures

2.3.1. Outcome variable

Initial self-regulation was created using several separate items. Participants were asked about various avoidance behaviors with questions using the following stem: *Do you try to avoid driving* … followed by the specific behavior: … *at night?* … *in rush hour traffic?* … *on the freeway?* and … *in unfamiliar areas?* Response choices included *yes* and *no* for each item. Follow-up questions determined whether each avoidance behavior was due to SR or some other reason, and only behaviors determined to be self-regulatory were included. The focus of this analysis was on initial SR, so only those who reported exactly one SR behavior were included. The behaviors were confined to the four noted earlier to limit the focus to major avoidance behaviors. A new outcome variable was created with mutually exclusive categories representing each of the four behaviors as the participant's initial SR behavior.

2.3.2. Predictor variables

As noted earlier, each predictor was drawn from the same wave as the initial SR behavior, or the preceding wave if those data were unavailable. Demographic variables included age, gender, race, relationship status, income, and education. ***Age*** was divided into four categories: *65–69*, *70–74*, *75–79*, and *80+*. ***Gender*** was recorded by the interviewer with the choices of *male* or *female*. ***Race/ethnicity*** categories were collapsed due to few respondents in some groups, with final categories including: *Non-Hispanic White*, *Non-Hispanic Black*, and *Other*. Categories of ***relationship status*** were also combined, with *married/partnered*, *separated/divorced*, *widowed*, and *never married* representing the final groupings. Total household ***income*** was measured using five categories: *less than $20,000*; *$20,000 to $49,999*; *$50,000 to $79,999*; *$80,000 to $99,999*; and *$100,000 or more*. Final groupings of ***education*** included *high school or less, some college, bachelor's degree,* and *graduate degree*.

Function and health-related variables included working for pay, volunteering, visual acuity, contrast sensitivity, hearing, depressive symptoms, anxiety, satisfaction with health, and cognition. ***Working for pay*** and ***volunteering*** were each assessed with items that asked whether in the last month, respondents worked for pay or did volunteer work. Response options were *yes* and *no*. ***Visual acuity*** was measured using Tumbling E charts. Scores were converted to Logarithm of the Minimum Angle of Resolution (LogMAR) scores, and then categorized into three groups: better than or average vision (LogMAR ≤ 0), worse than average but not impaired vision (LogMAR>0 and < 0.3), and impaired vision (LogMAR ≥ 0.3). ***Contrast sensitivity*** was assessed using Pelli-Robson charts, with a higher value representing worse vision. ***Hearing*** was assessed using the Whisper Test (Pirozzo et al., 2003), and was performed in both ears. Possible outcomes included passing in both ears, failing/passing in one, and failing in both. ***Depressive symptoms*** were measured with four items, which all began with the stem: *In the past 7 days, I felt* … followed by *worthless*, *helpless*, *depressed*, and *hopeless*. Five possible response choices ranged from *never* to *always*. This variable was dichotomized to represent *never* for all four items versus any other response, because more than three-quarters of the sample reported never for all items. ***Anxiety*** was also operationalized with four items. Participants were asked to identify how frequently, during the past 7 days, they felt … *fearful*, that they *found it hard to focus on anything other than my anxiety*, that *worries overwhelmed me*, and that they *felt uneasy*. Responses ranged from *never* to *always* on a five-point scale, and the values were summed across the four items, and then dichotomized following the same rationale described for depressive symptoms. Satisfaction with ***health*** was operationalized with the question: *How satisfied are you with your health?* and responses ranged from *not at all satisfied* to *completely satisfied* on a five-point scale. ***Cognition*** was assessed using the Trail Making Test – Part B, with higher values representing longer time to complete the test (worse cognition).

Driving responsibility was assessed by asking whether anyone depended on the respondent to drive them. Participants were also asked whether others were available to provide ***rides*** when needed. Both items allowed for *yes* or *no* responses. Several individual items related to respondents' ***driving abilities*** were also assessed, including their *ability to see during the day*; *to see at night;* and their *strength, flexibility, or general mobility*. A seven-point scale anchored by *poor* (1) and *excellent* (7) was used for each item. Self-reported ***driving comfort*** in relevant situations was assessed by asking respondents to rate their comfort, using a seven-point scale anchored by *not at all* (1) and *completely* (7), with driving *at night*, *in rush hour traffic*, *on the freeway*, and *in unfamiliar areas*.

3. Results

3.1. Descriptive findings

Nighttime avoidance was the most commonly reported initial self-regulatory behavior (57.59%, $n = 895$), followed by avoidance of rush hour (26.96%, $n = 419$), unfamiliar areas (10.81%, $n = 168$), and freeways (4.63%, $n = 72$). Table 1 shows univariate results for the sample overall, and for driving-related predictors by the four SR behaviors. More than one-quarter (28%) of the sample reported that someone else relies on them for driving, while 95% reported that others are available to give them rides. Scores for driving abilities and driving comfort ranged from a low of 5.06 out of 7 for comfort driving at night and ability to see at night, to 6.56 out of 7 for ability to see during the day.

Table 2 shows demographic statistics overall and by each initial SR behavior. The largest age group was 70–74 (about 37%), followed by 65–69 (33%). About 56% were female, a large majority identified their race and ethnicity as non-Hispanic White (85.5%), and most were married/partnered (66%). The three largest income groups were between $20-50k, $50-80k, and over $100k. Participants were generally well educated, with 25% reporting a bachelor's degree, and 40% a graduate degree.

Univariate results for function variables overall and by each initial SR behavior are shown in Table 3. Most participants did not work for pay (72%) or volunteer (55%). More than half (55%) had worse than average but not impaired vision. The mean contrast sensitivity score was 1.68 which is within the range of age-based norms reported in previous research (Mäntyjärvi and Laitinen, 2001). About three quarters of the sample passed the Whisper Test in both ears, 71% of respondents did not report any depressive symptoms, and 61% did not report symptoms of anxiety. Satisfaction with health was 3.70, which was between *somewhat* and *very satisfied*. The average time to complete the Trail Making Test – Part B was about 93 s, which is similar to the normative age and education-specific data reported by Tombaugh (2004).

3.2. Multinomial regression findings

Tables 4a and 4b present multinomial regression results, including beta coefficients, odds ratios (ORs), and significance levels for each predictor on every possible comparison of initial SR behaviors. In addition to the variables shown in the tables, several other

Table 1
Descriptive statistics for driving-related predictors overall and by type of initial driving self-regulation.

	N (%) or Mean (SD)				
Characteristic	Total	Night SR	Freeway SR	Unfamiliar SR	Rush hour SR
Driving responsibility					
Yes	435 (27.99%)	235 (26.26%)	32 (44.44%)	48 (28.57%)	120 (28.64%)
No	1119 (72.01%)	660 (73.74%)	40 (55.56%)	120 (71.43%)	299 (71.36%)
Rides available					
Yes	1478 (95.11%)	848 (94.75%)	66 (91.67%)	159 (94.64%)	405 (96.66%)
No	76 (4.89%)	47 (5.25%)	6 (8.33%)	9 (5.36%)	14 (3.34%)
Driving abilities					
See during day	6.56 (0.66)	6.54 (0.68)	6.53 (0.75)	6.50 (0.73)	6.65 (0.59)
See at night	5.06 (1.14)	4.65 (1.09)	5.33 (1.16)	5.61 (0.86)	5.65 (0.95)
Strength, flex, mobility	5.75 (1.06)	5.76 (1.07)	5.85 (0.93)	5.78 (1.02)	5.70 (1.09)
Driving comfort					
Night	5.06 (1.31)	4.52 (1.28)	5.44 (1.05)	5.82 (0.91)	5.84 (0.92)
Freeways	6.24 (1.01)	6.31 (0.96)	4.76 (1.56)	6.28 (0.87)	6.32 (0.86)
Unfamiliar areas	5.59 (1.08)	5.73 (1.10)	5.28 (1.09)	5.00 (0.90)	5.58 (1.04)
Rush hour	5.45 (1.25)	5.63 (1.25)	5.13 (1.31)	5.49 (1.15)	5.12 (1.23)

Notes: SD = standard deviation; N = number; SR = self-regulation.

Table 2
Descriptive statistics for demographics overall and by type of initial driving self-regulation.

	N (%) or Mean (SD)				
Characteristic	Total	Night SR	Freeway SR	Unfamiliar SR	Rush hour SR
Age					
65–69	513 (33.01%)	310 (34.64%)	22 (30.56%)	55 (32.74%)	126 (30.07%)
70–74	569 (36.62%)	327 (36.54%)	26 (36.11%)	54 (32.14%)	162 (38.66%)
75–79	426 (27.41%)	229 (25.59%)	23 (31.94%)	55 (32.74%)	119 (28.40%)
80+	46 (2.96%)	29 (3.24%)	1 (1.39%)	4 (2.38%)	12 (2.86%)
Gender					
Male	690 (44.40%)	335 (37.43%)	27 (37.50%)	75 (44.64%)	253 (60.38%)
Female	864 (55.60%)	560 (62.57%)	45 (62.50%)	93 (55.36%)	166 (39.62%)
Race					
White	1328 (85.46%)	758 (84.69%)	65 (90.28%)	134 (79.76%)	371 (88.54%)
Black	100 (6.44%)	62 (6.93%)	5 (6.94%)	16 (9.52%)	17 (4.06%)
Other	126 (8.11%)	75 (8.38%)	2 (2.78%)	18 (10.71%)	31 (7.40%)
Relationship status					
Married/partnered	1025 (66.13%)	570 (63.90%)	49 (68.06%)	105 (62.50%)	301 (72.01%)
Divorced/separated	257 (16.58%)	158 (17.71%)	15 (20.83%)	26 (15.48%)	58 (13.88%)
Widowed	205 (13.23%)	128 (14.35%)	8 (11.11%)	27 (16.07%)	42 (10.05%)
Never married	63 (4.06%)	63 (4.04%)	0 (0.00%)	10 (5.95%)	17 (4.07%)
Income					
<$20,000	67 (4.31%)	42 (4.69%)	6 (8.33%)	10 (5.95%)	9 (2.15%)
$20,000 - $49,999	382 (24.58%)	202 (22.57%)	23 (31.94%)	50 (29.76%)	107 (25.54%)
$50,000 - $79,999	404 (26.00%)	239 (26.70%)	18 (25.00%)	43 (25.60%)	104 (24.82%)
$80,000 - $99,999	241 (15.51%)	142 (15.87%)	8 (11.11%)	22 (13.10%)	69 (16.47%)
≥$100,000	460 (29.60%)	270 (30.17%)	17 (23.61%)	43 (25.60%)	130 (31.03%)
Education					
<=HS	164 (10.59%)	96 (10.76%)	8 (11.11%)	24 (14.29%)	36 (8.63%)
Some college	393 (25.37%)	232 (26.01%)	22 (30.56%)	47 (27.98%)	92 (22.06%)
Bachelor's degree	371 (23.95%)	204 (22.87%)	19 (26.39%)	38 (22.62%)	110 (26.38%)
Graduate degree	621 (40.09%)	360 (40.36%)	23 (31.94%)	59 (35.12%)	179 (42.93%)

Notes: SD = standard deviation; N = number; SR = self-regulation; HS = high school.

Table 3
Descriptive statistics for function variables overall and by type of initial driving self-regulation.

	N (%) or Mean (SD)				
Characteristic	Total	Night SR	Freeway SR	Unfamiliar SR	Rush hour SR
Work for pay					
Yes	428 (27.54%)	228 (25.47%)	20 (27.78%)	50 (29.76%)	130 (31.03%)
No	1126 (72.46%)	667 (74.53%)	52 (72.22%)	118 (70.24%)	289 (68.97%)
Volunteer					
Yes	700 (45.10%)	394 (44.07%)	28 (38.89%)	79 (47.02%)	199 (47.61%)
No	852 (54.90%)	500 (55.93%)	44 (61.11%)	89 (52.98%)	219 (52.39%)
Visual acuity					
>=avg	473 (30.44%)	248 (27.71%)	25 (34.72%)	51 (30.36%)	149 (35.56%)
<avg, not impaired	847 (54.50%)	495 (55.31%)	36 (50.00%)	97 (57.74%)	219 (52.27%)
Impaired	234 (15.06%)	152 (16.98%)	11 (15.28%)	20 (11.90%)	51 (12.17%)
Contrast sensitivity	1.68 (0.16)	1.67 (0.16)	1.68 (0.14)	1.69 (0.15)	1.70 (0.15)
Hearing (Whisper Test)					
Pass both ears	1155 (74.56%)	687 (77.19%)	54 (75.00%)	119 (70.83%)	295 (70.41%)
Fail one ear	182 (11.75%)	92 (10.34%)	8 (11.11%)	20 (11.90%)	62 (14.80%)
Fail both ears	212 (13.69%)	111 (12.47%)	10 (13.89%)	29 (17.26%)	62 (14.80%)
Depressive symptoms					
Never	1108 (71.30%)	658 (73.52%)	50 (69.44%)	114 (67.86%)	286 (68.26%)
>never	446 (28.70%)	237 (26.48%)	22 (30.56%)	54 (32.14%)	133 (31.74%)
Anxiety					
Never	944 (60.75%)	569 (63.58%)	42 (58.33%)	90 (53.57%)	243 (58.00%)
>never	610 (39.25%)	326 (36.42%)	30 (41.67%)	78 (46.43%)	176 (42.00%)
Health	3.70 (0.84)	3.69 (0.85)	3.72 (0.68)	3.70 (0.89)	3.72 (0.82)
Cognition	93.47 (41.15)	92.69 (39.65)	100.48 (43.96)	98.89 (45.72)	91.76 (41.71)

Notes: SD = standard deviation; N = number; SR = self-regulation.

variables were included in early models, but not retained in the final model due to lack of statistical significance. Those variables included age, relationship status, education, work and volunteer status, visual acuity, contrast sensitivity, hearing, cognition, depressive symptoms, and satisfaction with health. Their lack of statistical significance in the regression model may be explained by

Table 4a
Multinomial regression results for initial driving self-regulation behavior comparisons.

	1. Night SR vs. Rush Hour SR		2. Night SR vs. Unfamiliar SR		3. Night SR vs. Freeway SR	
Variable	β	OR	β	OR	β	OR
Gender (ref: male)	0.692***	1.997	0.090	1.094	0.144	1.155
Race (ref: White)						
Black	0.520	1.683	−0.412	0.663	0.973	2.646
Other	0.489	1.630	0.012	1.012	1.705*	5.503
Income (ref: $100k+)						
<$20,000	0.928*	2.530	−0.388	0.678	−0.525	0.591
$20,000 - $49,999	−0.351	0.704	−0.729**	0.483	−0.278	0.757
$50,000 - $79,999	−0.039	0.962	−0.133	0.875	0.011	1.011
$80,000 - $99,999	−0.096	0.908	−0.141	0.869	−0.009	0.991
Anxiety (ref: never)						
>never	−0.378*	0.685	−0.522*	0.594	−0.123	0.885
Driving responsibility (ref: no)	−0.286	0.752	−0.156	0.856	−0.940**	0.391
Rides available (ref: no)	−0.985**	0.373	−0.383	0.682	0.239	1.270
Driving abilities						
See during day	0.356*	1.428	0.793***	2.209	0.509	1.663
See at night	−0.749***	0.473	−0.838***	0.432	−0.450*	0.638
Strength, flex, mobility	0.139	1.149	0.078	1.081	−0.220	0.802
Driving comfort						
Night	−1.346***	0.260	−1.470***	0.230	−1.170***	0.310
Freeways	−0.236*	0.790	−0.175	0.840	1.213***	3.363
Unfamiliar areas	0.355***	1.426	1.362***	3.903	0.350*	1.419
Rush hour	0.839***	2.314	0.046	1.047	−0.083	0.920

Notes: SR=self-regulation; β=beta coefficient; OR=odds ratio; *$p<0.05$; **$p<0.01$; ***$p<0.001$.

Table 4b
Multinomial regression results for initial driving self-regulation behavior comparisons.

	4. Rush Hour SR vs. Unfamiliar SR		5. Rush Hour SR vs. Freeway SR		6. Unfamiliar SR vs. Freeway SR	
Variable	β	OR	β	OR	β	OR
Gender (ref: male)	−0.602**	0.548	−0.548	0.578	0.054	1.055
Race (ref: White)						
Black	−0.932*	0.394	0.453	1.572	1.385	3.994
Other	−0.477	0.621	1.217	3.376	1.694*	5.439
Income (ref: $100k+)						
<$20,000	−1.317*	0.268	−1.453*	0.234	−0.137	0.872
$20,000 - $49,999	−0.378	0.685	0.072	1.075	0.450	1.569
$50,000 - $79,999	−0.094	0.910	0.050	1.051	0.144	1.155
$80,000 - $99,999	−0.044	0.957	0.087	1.091	0.131	1.140
Anxiety (ref: never)						
>never	−0.144	0.866	0.255	1.291	0.399	1.490
Driving responsibility (ref: no)	0.130	1.139	−0.655*	0.520	−0.785*	0.456
Rides available (ref: no)	0.602	1.826	1.224*	3.401	0.622	1.863
Driving abilities						
See during day	0.436*	1.547	0.152	1.165	−0.284	0.753
See at night	−0.089	0.915	0.299*	1.349	0.389	1.457
Strength, flex, mobility	−0.061	0.941	−0.359*	0.698	−0.298	0.742
Driving comfort						
Night	−0.124	0.883	0.176	1.192	0.300	1.350
Freeways	0.061	1.063	1.449***	4.258	1.388***	4.006
Unfamiliar areas	1.007***	2.738	−0.004	0.996	−1.012***	0.364
Rush hour	−0.793***	0.452	−0.922***	0.398	−0.129	0.879

Notes: SR=self-regulation; β=beta coefficient; OR=odds ratio; *$p<0.05$; **$p<0.01$; ***$p<0.001$.

the similarity of these predictors across initial SR behaviors (e.g., age and education; see Table 2 for more context).

Comparison 1 in Table 4a shows how each predictor affected the odds of nighttime vs. rush hour as the initial SR behavior. Higher odds of reporting nighttime vs. rush hour SR were related to female gender, income below $20,000 compared to ≥$100,000 (OR = 2.530), reporting no anxiety during the past week, and stating that rides were unavailable from others. Among the self-rated driving ability and comfort variables, better ability to see during the day, worse ability to see at night, less comfort driving at night and on freeways, and more comfort driving in unfamiliar areas and during rush hour were all related to higher odds of nighttime vs. rush hour as one's initial SR behavior.

Results for nighttime vs. unfamiliar area as the initial SR behavior are shown in comparison 2 of Table 4a. An income of $20-50k (compared to $100k+) and reporting at least some anxiety during the past week were related to lower odds of nighttime vs. unfamiliar area avoidance as initial SR. Higher odds of nighttime SR were related to better ability to see during the day, worse ability to see at night, less comfort driving at night; and more comfort driving in unfamiliar areas.

The final nighttime SR comparison (3) was with freeway SR. Participants who identified as a racial group other than White or Black had significantly higher odds (OR = 5.503) of nighttime vs. freeway avoidance as their initial SR behavior. Being responsible for driving someone else was related to lower odds of nighttime SR (compared to freeway). Driving abilities and comfort also played a key role, with better ability to see at night and greater comfort driving at night associated with lower odds of nighttime (vs. freeway) SR, and greater comfort driving on freeways and in unfamiliar areas associated with lower odds of freeway (vs. nighttime) SR.

Table 4b shows the remaining comparisons. When rush hour SR was compared with SR in unfamiliar areas (comparison 4), female gender was related to lower odds of rush hour SR (OR = 0.548). That is consistent with results shown in Table 2, which suggests women account for a much smaller percentage of rush hour SR, compared to the other behaviors. Participants who identified as Black and those with the lowest incomes had lower odds of rush hour (vs. unfamiliar area) as their initial SR behavior, while better ability to see during the day was associated with higher odds of rush hour vs. unfamiliar area SR. As with earlier comparisons, greater comfort driving in each situation predicted less SR.

Comparison 5 shows how each factor was related to rush hour compared to freeway SR. As with the comparison of rush hour to unfamiliar area SR (4), reporting the lowest income was also associated with lower odds of rush hour vs. freeway avoidance. Reporting that others rely on the participant to drive them was related to lower odds of rush hour avoidance (OR = 0.520), while reporting that rides are available when needed showed the opposite effect (OR = 3.401). Better ability to see at night was associated with higher odds of rush hour SR, and higher odds freeway (compared to rush hour) SR was related to better strength, flexibility, and mobility. Comfort with driving during rush hour and on freeways was related to SR in each situation in the expected direction.

Finally, unfamiliar area vs. freeway avoidance as one's initial SR behavior is shown in comparison 6. Those identified as Other race had higher odds of unfamiliar area SR, while driving responsibility was related to lower odds in this comparison. More comfort driving on freeways was associated with lower odds of freeway SR, while more comfort driving in unfamiliar areas was related to lower odds of unfamiliar area SR.

Given the statistical strength of the situational comfort and subjective vision-related variables across all comparisons, models excluding those variables were also explored to assess whether different factors (e.g., objectively-measured visual acuity, contrast sensitivity, cognition) might play a role without those variables included. In models without those groups of variables (data not shown in tables), only contrast sensitivity became statistically significant. Worse contrast sensitivity was related to higher odds of nighttime vs. rush hour as one's initial SR behavior (OR = 2.897, $p<0.01$ without comfort variables; OR = 4.648, $p<0.001$ without comfort and self-reported vision variables). As noted earlier, however, this effect disappeared in the final models.

4. Discussion

This study tested two hypotheses; H1 suggested that nighttime and freeway avoidance would be the most common initial self-regulatory behaviors, and H2 suggested that certain predictors would have differential effects on the odds of some initial SR behaviors compared to others. More specifically, H2 posited that visual problems would be more related to nighttime SR, while lower cognition would be more likely to increase the odds of freeway SR. Both hypotheses were partially supported.

In support of H1, nighttime SR was by far the most common, with about 58% of the sample reporting this as their initial SR behavior. This may result from visual declines, which are common in older adulthood, and have consistently been associated with nighttime avoidance (e.g., Bergen et al., 2017) and driving problems (Anstey et al., 2017; Edwards et al., 2008; Freeman et al., 2005). Contrary to H1, however, freeway SR was the least common initial self-regulatory behavior at less than 5%. Given that most locations can be accessed via surface streets instead of freeways, albeit with longer travel times, we hypothesized that giving up freeway travel would be a relatively easy compromise, which would not result in much mobility loss. As such, it was surprising that so few people reported this as their initial self-regulatory behavior. Previous research suggests that freeway driving is a commonly avoided driving behavior, reported by up to 64% of older adults (Moták et al., 2014). However, that research has generally not assessed SR, and typically asks older adults to identify all avoidance behaviors, so categories are not mutually exclusive. Future research should compare initial avoidance behaviors and assess what percentage of each is specifically due to SR.

Rush hour SR (27%) was the second most common, followed by unfamiliar areas (11%). The rationale for H1 was based on the idea that avoiding rush hour or unfamiliar areas was more likely to be due to factors other than SR of driving. Many people, regardless of age or health status, would likely prefer to avoid the congestion of rush hour traffic, and could meet most daily mobility needs without traveling to unfamiliar areas. The quarter of the sample who reported avoiding rush hour as their initial self-regulatory behavior, however, may reflect the additional physical and cognitive challenges associated with driving in congestion. Indeed, older drivers who live in more congested areas have a higher likelihood of driving reduction and cessation (Vivoda et al., 2017). Previous research has also noted that older drivers are overrepresented in intersection crashes (Braitman et al., 2007; Lombardi et al., 2017), a situation where greater congestion is common.

In terms of the second hypothesis, many predictors differentially affected the odds of the initial SR behaviors, including gender, race, income, anxiety, driving responsibility, having rides available from others, driving abilities, and driving comfort. H2 specifically focused on the effect of vision on nighttime SR and cognition on freeway SR. The objective vision measures were not significantly associated with a difference in any initial SR behaviors in the final model, but the self-rated vision variables were associated with several nighttime SR differences. Better self-rated nighttime vision was related to lower odds of nighttime SR compared to all other types. Better self-rated daytime vision was related to higher odds of night vs. rush hour and unfamiliar area SR. The relationships observed for nighttime SR and ability to see at night were as predicted in H2. It is unclear, however, why ability to see during the day would be associated with higher odds of reporting nighttime SR as one's initial self-regulatory behavior (compared to rush hour and unfamiliar areas). That result may be driven more by the other SR behaviors than by nighttime SR, as each comparison can also be reversed. In other words, worse ability to see during the day is associated with higher odds of rush hour or unfamiliar area SR, compared to nighttime SR. Asking participants separately about daytime versus nighttime vision seems to be an important distinction future research should continue to assess.

Contrary to H2, cognition was not statistically associated with a difference in any of the initial SR behaviors. That aspect of H2 was based on the idea that at freeway speeds, drivers have less time to make decisions, and cognition is related to reaction time (Anstey et al., 2005; Miller et al., 2016); also, cognition is related to driving avoidance (Meng and Siren, 2012; Vivoda et al., 2021). This lack of significance may be related to low variability, in that few participants identified freeway avoidance as their initial SR behavior overall.

Aside from variables included in the hypotheses, several others were also significantly related to a difference in initial SR behavior. The most consistently observed pattern was related to driving comfort. Reporting more comfort in a given situation was related to lower odds of avoiding that situation as one's initial SR behavior. Given that driving self-regulation is an intentional response to a perceived driving difficulty, this relationship was expected. This finding is also consistent with previous research that assessed how driving comfort related to general driving avoidance (Blanchard and Myers, 2010; Jouk et al., 2014).

Female gender was associated with lower odds of rush hour SR, compared to both nighttime and unfamiliar areas. Previous research has established that women are more likely to reduce and self-regulate their driving (Bauer et al., 2003; Gwyther and Holland, 2012). The current results suggest that SR by women may be most commonly observed at night or when driving farther from home. In terms of race, participants categorized as Other were less likely than those who identified as White to SR on freeways compared to both nighttime and unfamiliar areas. Those who identified as Black were less likely than White participants to SR during rush hour compared to unfamiliar areas. Previous research comparing different driving avoidance behaviors by race could not be identified, but studies have identified race as a factor that separately affects engagement in different driving avoidance behaviors (Vivoda et al., 2021).

Income also affected several SR comparisons, including rush hour versus all other SR behaviors, and nighttime versus unfamiliar areas. These results were mixed with most differences associated with only the lowest compared to the highest incomes. The percentages of initial SR behavior by income (Table 2) suggests that rush hour SR may be underrepresented among those with the lowest income, and overrepresented among those with the highest incomes. The reason for these differences is unclear and should be explored in future research. In addition, wealth may be a better representation of socioeconomic status among older adults than income (Vivoda et al., 2020), and should be considered in future studies.

Anxiety was associated with lower odds of nighttime SR compared to both rush hour and unfamiliar areas. This result could be explained if driving during rush hour or in unfamiliar areas is considered more anxiety-provoking than nighttime driving. Nighttime driving may produce anxiety only for those who have vision problems, and ability to see was controlled for in the models. In addition, most previous driving-related research has focused on driving anxiety, rather than general anxiety (see e.g., Choi et al., 2012; Hempel et al., 2017), so this finding deserves additional attention in future research.

Reporting that someone else depends on the participant to drive them was significantly related to three comparisons: lower odds of SR at night, during rush hour, and in unfamiliar areas versus freeway SR. Having responsibility to drive another may require on-demand driving, limiting one's SR options. As noted earlier, most trips can be accomplished without freeway driving, just using longer routes. It may be more difficult to avoid driving at night, during rush hour, or to an unfamiliar area when meeting the mobility needs of another.

Finally, reporting that others are available to provide rides when you need them was related to lower odds of nighttime and freeway versus rush hour SR. Although this factor suggests that the older adult can rely on others for rides, requesting a ride at night or on a freeway (suggesting a longer trip), may be perceived as a greater imposition than a ride during/near business hours.

4.1. Additional future research

This study represents an early step in understanding some of the nuance involved in older adults' driving patterns and self-regulatory changes. To continue this work, researchers could explore SR behaviors not included in this study, and determine which are the most common overall, not just as an initial behavior. Future research could also assess whether certain SR behaviors immediately precede driving cessation. If such a behavior is identified, it could be used as an early marker to initiate driving retirement planning.

4.2. Limitations and strengths

This study is not without limitations. It was cross-sectional, which only allows for associations to be assessed, not causation. Participants in the sample had more education and income and less racial/ethnic diversity than the general population, which may limit generalizability. Only four SR behaviors were assessed; including more or different behaviors could yield different results and should be explored in the future. It is also possible that some people go from driving without restriction, to more than one SR behavior, without ever reporting only one. Those individuals would not have been included in this study. Some of the study's strengths include the large cohort of older drivers from geographically diverse sites, the multi-site data collection approach, the nuanced assessment allowed by multinomial regression, and the focus on comparing initial SR behaviors.

5. Conclusions

Avoidance of driving at night was the most common initial self-regulatory behavior among older drivers, followed by avoidance of rush hour, unfamiliar areas, and freeways. Self-rated driving comfort with each type of avoidance was the best predictor of situational SR. Demographics, function, and other variables were also related to differences in the odds of a given driving situation as one's initial SR behavior. Given the established connections among of driving reduction, health, and well-being, continuing to study the nuance of this issue is vital. Future research should begin to specifically assess the point within the transportation continuum where driving reduction behaviors begin to affect one's well-being, and the extent to which SR maintains driving safety. Understanding differences between people in the middle of the transportation continuum (i.e., at different points in the driving reduction process) will provide additional information for policy-makers, practitioners, family members, and older individuals to assess their current status, better understand their potential driving risk, and plan for future changes.

Financial disclosure

The Longitudinal Research on Aging Drivers (LongROAD) Study Phase II is supported in part by the AAA Foundation for Traffic Safety (AAAFTS) through contract #AAAFTS 51178A awarded to the Regents of the University of Michigan (D. W. Eby, PI).

The sponsor did not have a role in the study design, data collection or analysis, report writing, or decision to submit the article to this journal.

Author statement

Jonathon M. Vivoda: conceptualization, methodology, formal analysis, writing-original draft preparation, writing-review & editing; Lisa J. Molnar: conceptualization, investigation, writing-review & editing, project administration, funding acquisition; David W. Eby: conceptualization, investigation, writing-review & editing, project administration, funding acquisition; Carolyn DiGuiseppi: investigation, writing-review & editing, project administration, funding acquisition; Vanya Jones: investigation, writing-review & editing, project administration, funding acquisition; Guohua Li: investigation, writing-review & editing, project administration, funding acquisition; David Strogatz: investigation, writing-review & editing, project administration, funding acquisition; Raymond Yung: writing-review & editing, project administration; Linda Nyquist: writing-review & editing, project administration; Jacqui Smith: writing-review & editing, project administration; Jennifer S. Zakrajsek: investigation, data curation, writing-review & editing, project administration; Renée M. St. Louis: investigation, writing-review & editing, project administration; Nicole Zanier: investigation, writing-review & editing, project administration.

IRB approval

Columbia University: #AAAN9950; Johns Hopkins University: #00006200; Mary Imogene Bassett Hospital: #1092; University of California, San Diego: #141800; University of Colorado: #14–0528; University of Michigan: HUM00094031.

Funder

The Longitudinal Research on Aging Drivers (LongROAD) Study Phase II is supported in part by the AAA Foundation for Traffic Safety (AAAFTS) through contract #AAAFTS 51178A awarded to the Regents of the University of Michigan (D. W. Eby, PI).

Declaration of competing interest

The authors declare that there is no conflict of interest.

References

Adler, G., Rottunda, S., 2006. Older adults' perspectives on driving cessation. J. Aging Stud. 20 (3), 227–235. https://doi.org/10.1016/j.jaging.2005.09.003.

Anstey, K.J., Li, X., Hosking, D.E., Eramudugolla, R., 2017. The epidemiology of driving in later life: sociodemographic, health and functional characteristics, predictors of incident cessation, and driving expectations. Accid. Anal. Prev. 107, 110–116. https://doi.org/10.1016/j.aap.2017.07.026.

Anstey, K.J., Wood, J., Lord, S., Walker, J.G., 2005. Cognitive, sensory and physical factors enabling driving safety in older adults. Clin. Psychol. Rev. 25 (1), 45–65. https://doi.org/10.1016/j.cpr.2004.07.008.

Bauer, M.J., Adler, G., Kuskowski, M.A., Rottunda, S., 2003. The influence of age and gender on the driving patterns of older adults. J. Women Aging 15 (4), 3–16. https://doi.org/10.1300/J074v15n04_02.

Bergen, G., West, B.A., Luo, F., Bird, D.C., Freund, K., Fortinsky, R.H., Staplin, L., 2017. How do older adult drivers self-regulate? Characteristics of self-regulation classes defined by latent class analysis. J. Saf. Res. 61, 205–210. https://doi.org/10.1016/j.jsr.2017.01.002.

Betz, M.E., Lowenstein, S.R., 2010. Driving patterns of older adults: results from the second injury control and risk survey. J. Am. Geriatr. Soc. 58 (10), 1931–1935. https://doi.org/10.1111/j.1532-5415.2010.03010.x.

Blanchard, R.A., Myers, A.M., 2010. Examination of driving comfort and self-regulatory practices in older adults using in-vehicle devices to assess natural driving patterns. Accid. Anal. Prev. 42 (4), 1213–1219. https://doi.org/10.1016/j.aap.2010.01.013.

Braitman, K.A., Kirley, B.B., Ferguson, S., Chaudhary, N.K., 2007. Factors leading to older drivers' intersection crashes. Traffic Inj. Prev. 8 (3), 267–274. https://doi.org/10.1080/15389580701272346.

Braitman, K.A., Williams, A.F., 2011. Changes in self-regulatory driving among older drivers over time. Traffic Inj. Prev. 12 (6), 568–575. https://doi.org/10.1080/15389588.2011.616249.

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. J. Am. Geriatr. Soc. 64 (2), 332–341. https://doi.org/10.1111/jgs.13931.

Choi, M., Mezuk, B., Rebok, G.W., 2012. Voluntary and involuntary driving cessation in later life. J. Gerontol. Soc. Work 55 (4), 367–376. https://doi.org/10.1080/01634372.2011.642473.

Davis, J.J., Conlon, E.G., 2017. Identifying compensatory driving behavior among older adults using the situational avoidance questionnaire. J. Saf. Res. 63, 47–55. https://doi.org/10.1016/j.jsr.2017.08.009.

Dickerson, A.E., Molnar, L.J., Bédard, M., Eby, D.W., Berg-Weger, M., Choi, M., Grigg, J., Horowitz, A., Meuser, T., Myers, A., O'Connor, M., Silverstein, N.M., 2019. Transportation and aging: an updated research agenda to advance safe mobility among older adults transitioning from driving to non-driving. Gerontol. 59 (2), 215–221. https://doi.org/10.1093/geront/gnx120.

Eby, D.W., Molnar, L.J., Kartje, P.S., 2009. Maintaining Safe Mobility in an Aging Society. CRC Press. https://doi.org/10.1201/9781420064544.

Edwards, J.D., Ross, L.A., Ackerman, M.L., Small, B.J., Ball, K.K., Bradley, S., Dodson, J.E., 2008. Longitudinal predictors of driving cessation among older adults from the ACTIVE clinical trial. J. Gerontol. B Psychol. Sci. Soc. Sci. 63 (1), P6–P12.

Freeman, E., Muñoz, B., Turano, K., West, S., 2005. Measures of visual function and time to driving cessation in older adults. Optom. Vis. Sci. 83 (8), 765–773.

Gardezi, F., Wilson, K.G., Man-Son-Hing, M., Marshall, S.C., Molnar, F.J., Dobbs, B.M., Tuokko, H.A., 2006. Qualitative research on older drivers. Clin. Gerontol. 30 (1), 5–22.

Gwyther, H., Holland, C., 2012. The effect of age, gender and attitudes on self-regulation in driving. Accid. Anal. Prev. 45, 19–28. https://doi.org/10.1016/j.aap.2011.11.022.

Hempel, M.E., Taylor, J.E., Connolly, M.J., Alpass, F.M., Stephens, C.V., 2017. Scared behind the wheel: what impact does driving anxiety have on the health and well-being of young older adults? Int. Psychogeriatr. 29 (6), 1027–1034. https://doi.org/10.1017/S1041610216002271.

Jouk, A., Tuokko, H., Myers, A., Marshall, S., Man-Son-Hing, M., Porter, M.M., Bédard, M., Gélinas, I., Mazer, B., Naglie, G., Rapoport, M., Vrkljan, B., 2014. Psychosocial constructs and self-reported driving restriction in the Candrive II older adult baseline cohort. Transport. Res. F Traffic Psychol. Behav. 27, 1–10. https://doi.org/10.1016/j.trf.2014.09.001.

Li, G., Eby, D.W., Santos, R., Mielenz, T.J., Molnar, L.J., Strogatz, D., Betz, M.E., DiGuiseppi, C., Ryan, L.H., Jones, V., Pitts, S.I., Hill, L.L., DiMaggio, C.J., LeBlanc, D., Andrews, H.F., Bogard, S., Chihuri, S., Engler, A.-M., Feng, M., the LongROAD Research Team, 2017. Longitudinal research on aging drivers (LongROAD): Study design and methods. Injury Epidemiol. 4 (1), 22. https://doi.org/10.1186/s40621-017-0121-z.

Lombardi, D.A., Horrey, W.J., Courtney, T.K., 2017. Age-related differences in fatal intersection crashes in the United States. Accid. Anal. Prev. 99, 20–29. https://doi.org/10.1016/j.aap.2016.10.030.

Mäntyjärvi, M., Laitinen, T., 2001. Normal values for the Pelli-Robson contrast sensitivity test. J. Cataract Refract. Surg. 27 (2), 261–266. https://doi.org/10.1016/S0886-3350(00)00562-9.

Meng, A., Siren, A., 2012. Cognitive problems, self-rated changes in driving skills, driving-related discomfort and self-regulation of driving in old drivers. Accid. Anal. Prev. 49, 322–329. https://doi.org/10.1016/j.aap.2012.01.023.

Miller, S.M., Taylor-Piliae, R.E., Insel, K.C., 2016. The association of physical activity, cognitive processes and automobile driving ability in older adults: a review of the literature. Geriatr. Nurs. 37 (4), 313–320. https://doi.org/10.1016/j.gerinurse.2016.05.004.

Molnar, L.J., Eby, D.W., Charlton, J.L., Langford, J., Koppel, S., Marshall, S., Man-Son-Hing, M., 2013. Driving avoidance by older adults: is it always self-regulation? Accid. Anal. Prev. 57, 96–104. https://doi.org/10.1016/j.aap.2013.04.010.

Molnar, L.J., Eby, D.W., Vivoda, J.M., Bogard, S.E., Zakraksek, J.S., Louis, St, M, R., Zanier, N., Ryan, L.H., LeBlanc, D., Smith, J., Yung, R., Nyquist, L., DiGuiseppi, C., Li, G., Mielenz, T.J., Strogatz, D., 2018. The effects of demographics, functioning, and perceptions on the relationship between self-reported and objective measures of driving exposure and patterns among older adults. Transport. Res. F Traffic Psychol. Behav. 54, 367–377. https://doi.org/10.1016/j.trf.2018.02.026.

Moták, L., Gabaude, C., Bougeant, J.-C., Huet, N., 2014. Comparison of driving avoidance and self-regulatory patterns in younger and older drivers. Transport. Res. F Traffic Psychol. Behav. 26, 18–27. https://doi.org/10.1016/j.trf.2014.06.007.

Mullen, N.W., Parker, B., Wiersma, E., Stinchcombe, A., Bédard, M., 2017. Looking forward and looking back: older adults' views of the impacts of stopping driving. Occup. Ther. Health Care 31 (3), 188–204.

Pirozzo, S., Papinczak, T., Glasziou, P., 2003. Whispered voice test for screening for hearing impairment in adults and children: systematic review. BMJ 327 (7421), 967. https://doi.org/10.1136/bmj.327.7421.967.

Sanford, S., Naglie, G., Cameron, D.H., Rapoport, M.J., Driving, C., on N, C., A, Team, D., 2020. Subjective experiences of driving cessation and dementia: a meta-synthesis of qualitative literature. Clin. Gerontol. 43 (2), 135–154.

Sullivan, K.A., Smith, S.S., Horswill, M.S., Lurie-Beck, J.K., 2011. Older adults' safety perceptions of driving situations: towards a new driving self-regulation scale. Accid. Anal. Prev. 43 (3), 1003–1009. https://doi.org/10.1016/j.aap.2010.11.031.

Tombaugh, T.N., 2004. Trail Making Test A and B: normative data stratified by age and education. Arch. Clin. Neuropsychol. 19 (2), 203–214. https://doi.org/10.1016/S0887-6177(03)00039-8.

Vivoda, J.M., Heeringa, S.G., Schulz, A.J., Grengs, J., Connell, C.M., 2017. The influence of the transportation environment on driving reduction and cessation. Gerontol. 57 (5), 824–832. https://doi.org/10.1093/geront/gnw088.

Vivoda, J.M., Molnar, L.J., Eby, D.W., Bogard, S., Zakrajsek, J.S., Kostyniuk, L.P., Louis, St, M, R., Zanier, N., LeBlanc, D., Smith, J., Yung, R., Nyquist, L., DiGuiseppi, C., Li, G., Strogatz, D., 2021. The influence of hearing impairment on driving avoidance among a large cohort of older drivers. J. Appl. Gerontol. https://doi.org/10.1177/0733464821999223, 0733464821999223.

Vivoda, J.M., Walker, R.M., Cao, J., Koumoutzis, A., 2020. How accumulated wealth affects driving reduction and cessation. Gerontol. 60 (7), 1273–1281. https://doi.org/10.1093/geront/gnaa039.