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RESEARCH REPORT

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Transportation, Quality of Life, and Older Adults

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16. Abstract

Driving rates decline with age as vision, health, and cognitive ability cause some older adults to give up driving. Many older adults first gradually limit their driving as they age and later cease driving. Using data from the Health and Retirement Study (HRS), which surveys 22,000 older Americans every two years, we modeled the extent to which older drivers limit and stop driving. The data are longitudinal, allowing analysis of changes in driving and residential location as well as cohort effects that could not be studied using standard, cross-sectional survey data that only allow comparisons of different people at one point in time. The analysis shows that decisions to limit and eventually stop driving vary in statistically significant ways with sex, age, and health conditions. These relationships also differ by birth cohort. More recent cohorts are less likely to stop and limit driving than older ones. To analyze the relationship between residential location and driving behavior, we linked the HRS data to census-tract level data from the US Census and a categorization of community types. We found that residential density and other urban built environment features are associated with changes in driving and vehicle ownership. HRS survey participants showed a greater propensity to reduce or give up driving if they resided in denser, more diverse, transit-oriented neighborhoods. People who prefer non-automotive modes of transportation may have been more likely than others to self-select into walkable and transit-rich areas. The findings should inform California's strategic planning for aging and its community development policies. In addition to informing planning for the next generation of older Californians, this study demonstrated the utility of longitudinal information and models for the understanding of older populations and their travel.

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Executive Summary

Executive Summary

The population of the United States is aging rapidly and by 2060 almost a quarter of the U.S. population is predicted to be older than 65. California is aging particularly quickly; according to state projections more than 20% of the state's residents will be seniors by 2030 when more than 9 million Californians will be over the age of 65, some 3 million more than today. The ability to continue driving as one ages is a fundamental determinant of the quality of life among older adults. Data from the 2017 National Household Travel Survey reveal that most people over the age of 65—82 percent of them—drive. Older adults made 86 percent of their trips by automobile, 66 percent as drivers and 20 percent as passengers.

Data on the driving behavior of older adults reveal two trends. Older Americans today are driving more than past generations of the elderly, while driving less than younger population groups. On average, a higher percentage of older adults are drivers and are driving more miles over time. Older people both keep their licenses longer and make up a bigger proportion of the population than in past decades. The number of licensed drivers 70 and older increased 65 percent between 1997 and 2018. The proportion of the 70-and-older population with licenses went from 73 percent in 1997 to 83 percent in 2018. Compared with Americans between the ages 20 and 69, however, fewer people 70 and older are licensed to drive, and, based on data from the National Household Travel Survey, they drive fewer miles (Federal Highway Administration, 2020).

Though older Americans drive more than in the past, driving rates decline significantly with age as health, cognitive ability, and other factors necessitate that some older adults give up driving. Driving cessation is a complex process. Many older adults first gradually limit their driving as they age to daylight hours, familiar routes, and essential trip purposes. With the involvement of family members, friends, doctors, and licensing authorities, eventually some older adults stop driving entirely.

A growing body of research has addressed the causes of driving cessation among older Americans Most of these used cross sectional datasets, such as national travel surveys, which allow comparisons across different age groups and different places at one point in time. Though these data include many different people at one point in time, cross sectional studies do not allow analysis of members of the sample as each one ages. Cross sectional data also do not permit exploration of changes in the behavior of individuals as they age and their circumstances change, such as the association between aging, changes in residential location, and driving cessation. Driving patterns, especially, differed among Americans born sixty years ago and those born thirty years ago.

This study examined the contribution of two factors to explaining driving limitation and cessation: birth cohorts and residential location. To do this, we used a unique national longitudinal data base—the Health and Retirement Survey (HRS)—that has rarely before been used by transportation researchers. The data enabled us to assess changes in behavior among individuals as they aged and across different birth cohorts.

The University of Michigan Health and Retirement Study (HRS) was founded in 1992 and surveys more than 22,000 Americans over the age of 50 every two years. The study includes questions of panel members that address aging participants' physical and mental health, insurance coverage, financial status, family support systems, labor market status, and retirement planning. The data include information on mobility and travel, though not detailed trip diaries. We used the confidential version of the data, which included the census tract of each respondent in each survey wave. We linked the HRS data to residential density data from the U.S. Census. We also placed each participant into the type of neighborhood in which he or she resided in each survey wave using a categorization of seven neighborhood types developed in a previous study. Based on their locations we also identified respondents' transit accessibility to jobs using a metric developed by the Accessibility Observatory at the University of Minnesota. Though most elderly persons are not employed, the number of jobs that can be reached via transit from a given census tract within 30 minutes was used as a proxy for access to a range of activities.

Responses to two survey items in the HRS—whether or not an individual is able to drive and whether or not that person limits his or her driving— were examined using statistical models. We specified a series of discrete-time logistic regression models to explore whether driving cessation and driving limitation are correlated with key dependent variables such as age, sex, and birth cohort. We also tested relationships between driving limitation and driving cessation and the types of communities in which survey participants resided and their accessibility to activities to which older people might travel. We used some models in which all survey respondents were pooled, and we developed other models that compared cohorts with one another.

We found, like many previous studies, that personal decisions to limit and eventually stop driving vary in statistically significant ways with sex, age, and health conditions. In addition, unlike most previous studies, we also found that those relationships differ by birth cohort. More recent cohorts are less likely to stop and limit their driving than their older counterparts.

We also found that residential density and other urban built environment features are associated with less driving and lower levels of vehicle ownership. Older adults who participated in the HRS interviews showed a greater propensity to reduce or give up driving if they resided in transit-accessible, denser, and more diverse types of neighborhoods. This raises quality-of-life questions about older adults who give up driving in dense urban neighborhoods versus those who give up driving in suburban and rural locations. Planning for the increasing number of older Californians must consider the negative effects associated with driving cessation which appear to be somewhat less acute for those who stop driving in areas where desired destinations are more accessible.

As they age, older adults will need access to destinations (e.g. jobs, health care, friends and family) that allow them to maintain high-quality lifestyles. Policymakers must address the safety needs of the growing population of older adult drivers. Safety may require lessening access of some older people to automobiles. At the same time, interventions may be needed to enhance accessibility of older adults with limited mobility who may experience poorer quality of life than older adults who drive and/or live in neighborhoods in which transit and other destinations are proximate.

The findings reported in this study about relationships between aging, driving, and residential location should inform California's strategic planning for aging and its community development policies. For example, older people in the past were less likely to be licensed drivers than are members of younger cohorts who grew up with the auto. During earlier times men were more likely to be drivers than women. Today a very large proportion of people entering old age have driven throughout most of their adult lives and women are as likely to be drivers as men. Cohort differences in driving cessation and the association between those differences and residential location are important in long-term comprehensive planning for our aging population because they show that communities in which older people will live in future decades will have to fulfill different needs and support different preferences than did communities in the past. For example, older Americans today are more likely to reside in suburban communities than at any point in the past and people tend to grow old in place rather than to relocate to new communities after they enter old age. In addition to informing planning for the mobility of the next generation of older Californians, this study demonstrated the utility of longitudinal information and models for the understanding of older populations and their travel.

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Introduction

The population of the United States is aging rapidly and by 2060 almost a quarter of the U.S. population is predicted to be older than 65, the chronological age most often used to identify older adults. The ability to continue driving as one ages is, consequently, a fundamental determinant of the quality of life among older adults (Coughlin, 2009). Data from the 2017 National Household Travel Survey (NHTS) reveal that most people over the age of 65—82 percent of them—drive. Older adults made 86 percent of their trips by automobile; 66 percent as drivers and 20 percent as passengers (Federal Highway Administration, 2018).

Automobiles are central to participation in economic, social, and cultural activities in America. Data on the driving behavior of older adults reveal two trends, both important to understanding how mobility in old age is changing over time. Older Americans drive more today than at any time in the past; yet they drive less than younger Americans do. Clearly, driving declines as we age. Data from the National Household Travel Survey show an increase in the percentage of older drivers over time. Compared with Americans between the ages 20 and 69, fewer people 70 and older are licensed to drive, and, based on data from the National Household Travel Survey, they drive fewer miles. However, older people both keep their licenses longer and make up a bigger proportion of the population than they did in past decades. The number of licensed drivers 70 and older increased 65 percent between 1997 and 2018. The proportion of the 70-and-older population with licenses went from 73 percent in 1997 to 83 percent in 2018 (Federal Highway Administration, 2019). Additionally, the annual miles per licensed driver 65 years and older increased by 16 percent from 1990 to 2017 (McGuckin and Fucci, 2018). At the same time, studies show that driving rates decline significantly with age as health, cognitive ability, and other factors necessitate that some older adults give up driving (Federal Highway Administration, 2018). Driving cessation is a complex process. Many older adults first gradually limit their driving as they age to daylight hours, familiar routes, and essential trip purposes. With the involvement of family members, friends, doctors, and licensing authorities, eventually some older adults stop driving entirely (Chipman et al., 1998).

A growing body of research has addressed the causes of driving cessation among older Americans, a literature that we review in this report. However, there has been relatively little study of the role of birth cohorts and residential location in explaining driving behavior, the focus of this study. To analyze these factors, we drew on a unique national longitudinal data base – the Health and Retirement Survey (HRS) – that has rarely before been used by transportation researchers.

We took advantage of this dataset to explore differences among several cohorts that comprise the aging population. A cohort consists of the group of people who were born in the same decade, and the longitudinal data base allows us to identify cohorts and compare them with one another. Women in the oldest cohorts became licensed to drive when they reached adulthood at much lower rates than men, but more recently men and women were equally likely to become licensed to drive. Do these cohort differences influence relationships between aging and driving? Similarly, people born in the forties may relate to the internet differently than people born in the sixties. We explored cohort influences using the HRS data and a set of multivariate statistical models that have rarely been applied to understand relationships between aging and travel.

In addition to using the HRS data to study the role of birth cohorts in helping to explain driving behavior, we examined associations between driving transitions and the characteristics of the neighborhoods in which people live or to which they move. Many studies show that most older Americans "age in place," and while some relocate in their later years, the association between residential location, aging in place, and access to automobiles is not well understood. The relationship is changing over time in part because of the rise of the internet and increasing connections between physical mobility and electronic connectivity (Pangbourne, 2018; Peek et al., 2014).

The report is organized as follows. In Chapter 1 we describe relationships between driving limitation and cessation and a variety of social, demographic, and environmental characteristics and factors as revealed in research in the fields of transportation and aging. In Chapter 2 we describe the data and analytical strategy used in this study.

Chapter 3 reports on the cohort models. The analysis shows that older adults cease or limit driving as they age in predictable ways, with age, gender, and health explaining a great deal of the variation in cessation and limitation of driving. The statistical models also show that after taking age, gender, and health variables into account, cohort membership also helps to explain differences in the rates with which people cease or limit their driving in their older years. More recent cohorts are less likely to stop and limit their driving than their older counterparts.

Chapter 4 extends the cohort analysis to include characteristics of the built environment. With regard to residential location, the models show that all else equal, older adults are more likely to reduce or give up driving if they reside in denser, urban, transit-oriented neighborhoods. The results of models incorporating only those who had relocated between panel waves are surprising. Older adults who moved to denser and more urban neighborhoods showed no increased likelihood of reducing or stopping driving, while driving cessation was more common among those who relocated to more suburban settings.

We conclude in Chapter 5 by summarizing our findings and discussing their implications for policy and research generally as well as their application to California. The findings of this report should inform policymakers in the state's Department of Transportation and Department of Aging, The Governor's Office of Planning and Research, the Department of Housing and Community Development, as well as scholars interested in the dynamic changes underway related to our aging population and its mobility. As they age, older adults will need access to destinations (e.g. jobs, services, friends and family) that allow them to maintain high-quality lifestyles. The findings of this study will enable policymakers to better plan for the state's increasing population of older adults, many of whom will continue to drive longer than previous generations of older adults. Our findings suggest that these trends may be partially offset among older adults who age in place in dense urban neighborhoods where destinations are more easily accessed by modes other than the automobile.

The study relied on national data that included California respondents, but because the sample size would have been too small, we did not isolate and study older adults in California alone. We believe that conclusions drawn from a national study are relevant to California, but additional studies of older Californians would be required to verify that this is so.

Chapter 1. Understanding Driving Reduction and Cessation and Quality of Life

Older adults primarily travel by car both as passengers and drivers (Buehler & Nobis, 2010; Collia et al., 2003; Rosenbloom, 2009, 2012; Rosenbloom & Herbel, 2009; Yang et al., 2018). Over time, the percentage of the population comprised of older drivers has grown due to improved health and growing life expectancies among older adults, increasing disposable income, the continuation of patterns, including suburban lifestyles, established in their younger years, and, related to all of these factors, the increase in the proportion of older adults who are licensed to drive (Coughlin, 2009).

Despite the prevalence and growth of automobile travel among older adults in comparison with earlier generations, driving rates still do decline with age. **Error! Reference source not found.** shows that travel by automobile remains high for all older age groups, but the percentage who travel as passengers increases in parallel with the percentage of older adults who are non-drivers.

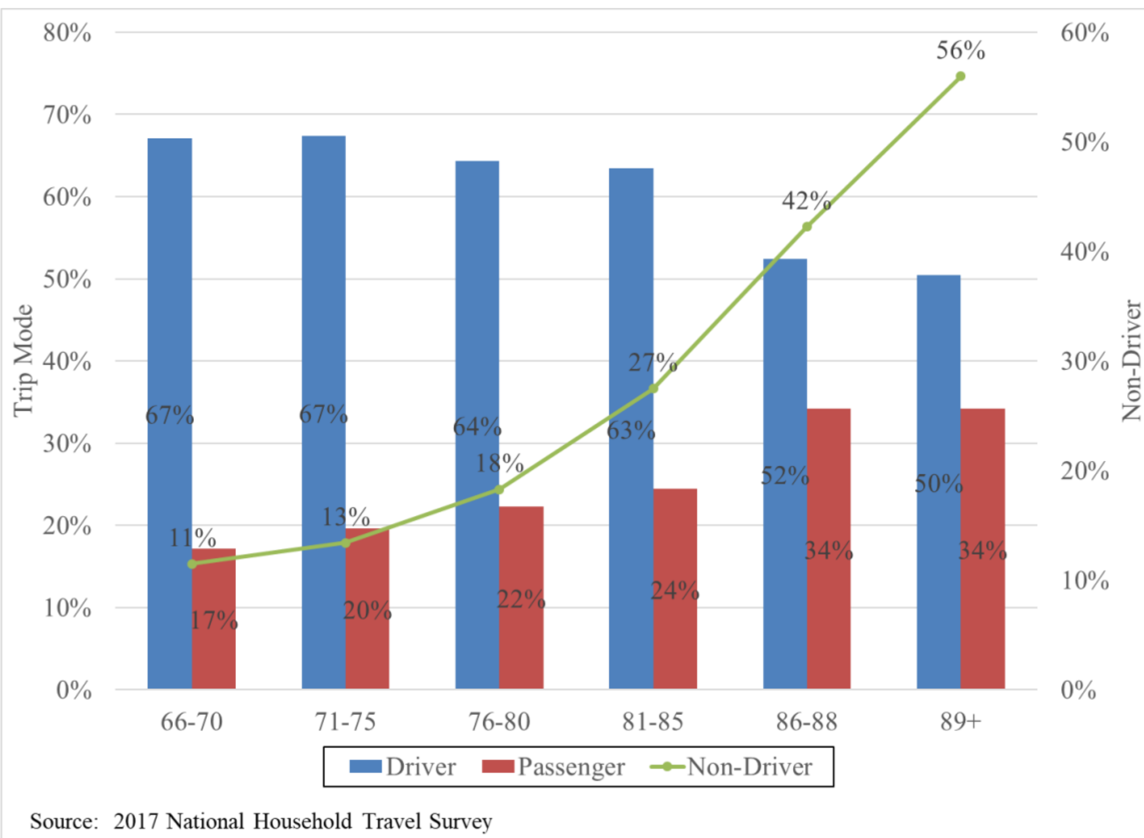


Figure 1.Trips by Mode and Age

Many studies address the determinants of self-regulation or limitation of driving leading eventually to driving cessation, pointing to five sets of factors that help to explain this process. These are shown schematically in Figure 2. They include individual characteristics, household characteristics, social networks, environmental conditions, and characteristics of the residential area in which someone lives. With respect to individual characteristics, driving limitation is strongly associated with declining vision (Edwards et al., 2009; Ragland et al., 2004) and also is strongly and positively associated with stroke, dementia, heart failure, cognitive decline, and the medications used to treat these conditions (Dickerson et al., 2019; Edwards et al., 2010; Ray et al., 1993). Sex and race also influence the likelihood of giving up driving; women and non-white older adults have higher rates of driving cessation at every age, controlling for other factors (Babulal et al., 2018; Bauer et al., 2003; Choi, Mezuk, et al., 2012; Rosenbloom, 2001). Finally, driving cessation is influenced by previous driving experience—the length and level of driving activity (Hakamies-Blomqvist & Siren, 2003)—a characteristic that is shaped by many other factors.

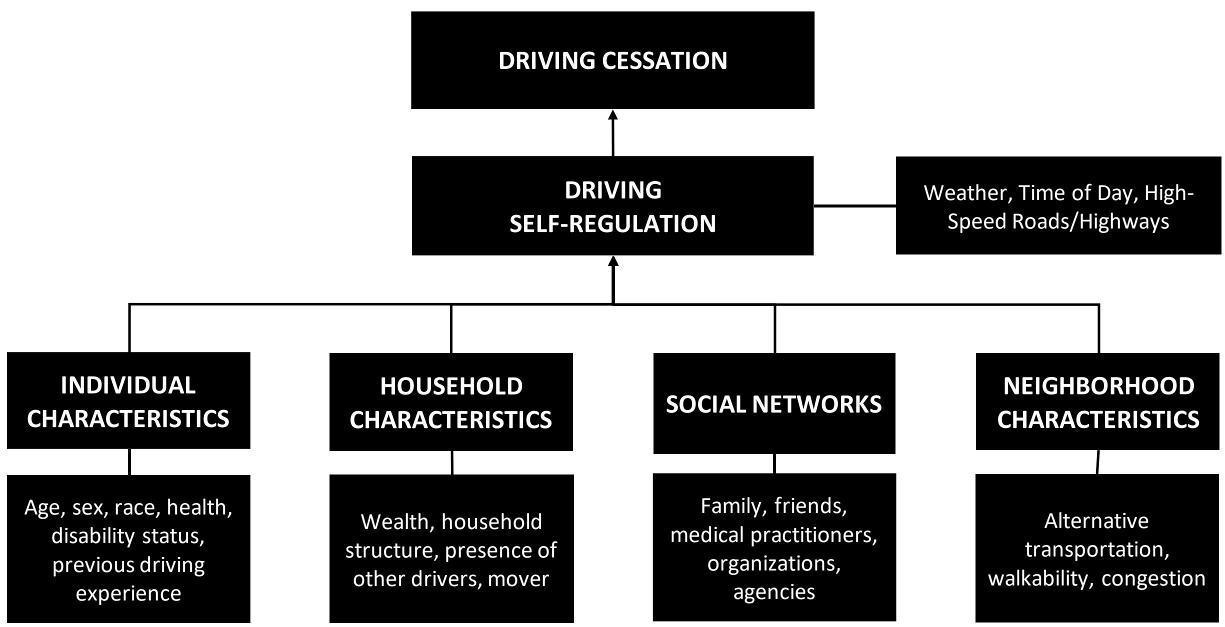


Figure 2. Conceptual Model of Driving Limitation and Cessation

The household situation in which a person lives also plays a role in driving limitation and cessation decision making. Transitions away from driving may be easier if the household includes other drivers who are available to provide rides (Choi, Adams, et al., 2012). Income is negatively associated with the decision to give up driving among older drivers just as it is for working-age adults. Many older adults live on fixed incomes and, therefore, may not have the resources to own and maintain private vehicles (Choi, Mezuk, et al., 2012; Vivoda et al., 2020). Social relationships beyond the household influence driving decisions. For example, pressure from friends and/or doctors can persuade older adults to reduce and eventually give up driving (Adler & Rottunda, 2006). So too can receiving at least some transportation support from friends, neighbors, organizations, and agencies (Choi, Adams, et al., 2012).

Environmental conditions can prompt drivers to reduce their travel. The most common conditions include driving in bad weather, at night, or on high-speed roads and highways (Naumann et al., 2011). The geographic concentration of these conditions helps to explain the relationship between driving status and neighborhood characteristics. For example, Vivoda et al. (2017) found a positive relationship between both driving cessation and driving reduction and roadway density and congestion. These findings are consistent with those of other studies showing that older adults experience increased anxiety when driving in heavy or speeding traffic (Hakamies-Blomqvist & Wahlström, 1998). Congestion tends to be highest in dense urban areas where activities are geographically concentrated. These same neighborhoods are ones in which alternative transportation services (e.g. public transit, taxis, paratransit, ridehail) are most available and access to destinations by foot is greatest, potentially influencing the willingness of older adults to give up driving. Hwang and Hong (2018) found that living in an urban area has the strongest association with driving cessation in Korea.

Among older adults who no longer have driver's licenses, those who live in urban areas and areas where destinations are in walking distance are more likely than other older adults to use transit and to walk, controlling for other factors including health status (Kim, 2011). Older adults who use transit or walk may self-select into high-access neighborhoods. Schwanen and Mohkarian (2005) suggested that people's travel behavior is based on their attitudes toward urban environments. People with "urban attitudes" drive less both in urban and suburban environments than those having "suburban attitudes." Perhaps the people who move later are more likely to have suburban attitudes, or do not consider the built environment of the place they live as self-consciously as those preferring urban lifestyles. Individuals and couples who plan ahead for aging may move earlier than those who only do so when they have few other choices. Earlier movers may consciously choose places in which they know they can get around after they stop driving.

It is often said that older Americans tend to "age in place." For some, aging in place could mean staying in their long-time residences or it could include moving to a new dwelling in a community in which they have long resided. Some age in place in urban neighborhoods, while others move into them from outlying suburban neighborhoods (Nordbakke, 2013). In any given year about six percent of older adult movers relocate from outlying areas into the central city (U.S. Census Bureau, 2019). Despite this modest percentage, stated interest in moving to neighborhoods with better public transit is high. A survey of older adults in Michigan found that more than a third of respondents who anticipated losing their licenses in the next five years reported that they had contemplated moving somewhere with better public transportation services (Kostyniuk et al., 2000). Finally, driving cessation for some older adults is associated with moves into senior apartments or residential facilities that provide transportation (Adler & Rottunda, 2006).

Yet reliance on automobiles remains important as almost three-quarters of older Americans live in low-density suburban or rural areas (Kostyniuk et al., 2000) where alternative transportation options are limited (Glasgow & Blakely, 2000). Gradually, and in recent years, the availability of ridehailing services, better known to many by the trade names of Uber and Lyft, is increasingly influencing driving and locational decisions by older Americans who have access to smart phones and the internet. The proportion of older adults who use these services is climbing rapidly as cohorts who grew older having internet access enter the post-retirement years (Shirgaokar et al., under review).

Driving means retaining functional independence and personal autonomy, but that must be balanced against the fact that older drivers incur increasing risk of injury and mortality from vehicular crashes compared to other age groups (Dickerson et al., 2007). Cessation, while it reduces crash risk, has been associated with a host of negative consequences for psychosocial and physical well-being, including increased depressive symptoms (Fonda et al., 2001; Marottoli et al., 1997); decreased out-of-home activity levels (Marottoli et al., 2000), reduced networks of friends (Mezuk & Rebok, 2008), and accelerated health decline (Edwards et al., 2009).

Many studies have explored the travel of older adults. Most of these used cross sectional datasets, such as national travel surveys, which allow comparisons across different age groups and different places at one point in time (Rosenbloom, 2012; Siren & Haustein, 2016). Though they interview many different people at one point in time, cross sectional studies do not compare what happens to any member of the sample as he or she ages. Most studies, therefore, were unable to compare different generational cohorts to one another when examining the effects of aging because they did not identify people in cohorts – groups of respondents who were similar to one another in terms of the decade in which they were born. Moreover, cross sectional data do not permit exploration of changes in the situations of individuals as they age and their circumstances change, such as the association between aging, changes in residential location, and driving cessation. While there is a substantial body of research on relationship between the built environment and the unmet travel needs of older adults (Luiu et al., 2017), very few of these studies center on driving cessation. The HRS enabled us to make both of these types of comparisons, previously rarely done in studies of aging and travel.

Studies of cohorts as they age can reveal the long-term influence of shared generational experiences that are not discoverable using cross-sectional data. The benefits of longitudinal analysis—following older adults over time—is the basis for the Longitudinal Research on Aging Drivers (LongROAD) project, a prospective cohort study designed to understand the factors that influence safety during the aging process (Li et al. 2017; Molnar et al. 2015). These data will provide useful findings moving forward. However, current research suggests a role for retrospective analysis, as more recent cohorts of older adults may behave in ways different from previous generations of older adults.

As we note above, health is an important determinant of driving. Studies show that more recent cohorts of older adults live longer and spend less time in worse health than older cohorts of adults (Chatterji et al. 2015; Christensen et al. 2009; Dodge et al. 2014), although some evidence suggests that these health benefits have occurred mostly among the wealthiest adults (de la Fuente et al. 2019). If recent cohorts of older adults are healthier than older cohorts, they also are likely to drive longer.

The tendency to drive longer may be increased by recent technological changes such as automobile safety improvements that increase comfort with driving at older ages (Eby et al. 2016). Advanced vehicle technology (e.g. automatic emergency braking, blind spot and lane departure warning, navigation assistance) may make older adults feel safer and, therefore, extend their automobile use. Older adults tend to have low technology adoption rates (Coughlin 2009). The effect of these new innovations on the driving behavior of older adults, therefore, will rest on their value, usability, affordability, accessibility, technical support, social support, emotion, independence, experience, and confidence (Coughlin 2009). Reliance on new technology is an example of a cohort effect. Members of the oldest cohorts are least comfortable with technological driving assists, which are more broadly accepted by younger cohorts (Chiu et al. 2016; Vogels 2019).

While safety improvements may increase driving among older adults, advances in information and communication technologies (ICTs) may enable access to opportunities without driving. Although more resistant to the use of technology than younger adults, many recent older adult cohorts have experience using computers, smart phones, and the internet while earlier cohorts do not. In fact, their use of these technologies has increased over time. Seventy-three percent of those ages 65 and older use the internet and more than half (53%) are smartphone owners (Livingston 2019). While their use of technology continues to lag that of younger adults, older adults today are more likely than older adults of previous generations to use technology (Gilleard and Higgs 2008; Hunsaker and Hargittai 2018) and, therefore, may be more likely to take advantage of technology-based alternatives to driving such as ridehailing or on-line shopping (Mitra et al. 2019). The proportion of older adults who use these services is climbing rapidly as cohorts who grew older having internet access enter post-retirement years (Shirgaokar et al. forthcoming).

Finally, shifting gender norms also may contribute to increased driving among recent older adult cohorts. Women's labor force participation has increased rapidly over time, growing from 38 percent in 1960 to 57 percent in 2018 (U.S. Bureau of Labor Statistics 2020), requiring many women to balance paid employment while shouldering primary responsibility for unpaid household labor (Sayer 2016). Juggling work and non-work responsibilities often requires women to take multiple trips on a single tour—for example traveling from home to the child care center and then to work (McGuckin and Murakami 1999), a trip pattern more easily made by automobile than by other modes (Blumenberg 2016; Hensher and Reyes 2000). Women's driver's licensing rates increased in parallel with their growing presence in the labor force. Women of every age were much less likely than men to be licensed to drive five decades ago but licensure rates today are approximately equal among men and women (Sivak 2013). Although women continue to drive fewer miles than men, the gap has narrowed over time (Sivak 2013). Consequently, more recent cohorts of older women will have had greater experience driving than older cohorts and, therefore, and can be expected to drive longer as they age. Licensing data are suggestive of this trend. From 1995 to 2010 there was a significant increase in licensing among women 55 and older as a percentage of their age group (Sivak and Schoettle 2012).

Chapter 2.
Data Describing Aging Drivers, Non-Drivers, Their Health Status, and Residential Mobility

To conduct the research described in the following chapters, we combined information from four different sources that are briefly described in this chapter. The first was the Health and Retirement Survey(HRS) of older Americans made available by the University of Michigan. We also employed data on residential densities from the US Census, and complemented these data with a typology of neighborhoods that describe the characteristics of where survey participants lived. Finally, we also used data from the University of Minnesota Accessibility Observatory to characterize the accessibility by transit of those neighborhoods to a range of opportunities to engage in activities outside of the home.

Health and Retirement Study

The analysis described in this report relied on a unique longitudinal dataset that has often been used by health researchers to study relationships between aging and wellbeing, but rarely before employed to analyze travel and residential location patterns among older Americans as they age. The University of Michigan Health and Retirement Study (HRS) was founded in 1992 and surveys more than 22,000 Americans over the age of 50 every two years. The study is managed by the University's Institute for Survey Research and includes questions of panel members that address aging America's physical and mental health, insurance coverage, financial status, family support systems, labor market status, and retirement planning. A public version of the survey results is widely available but that version does not contain locational information about the respondents. For this study, we used the confidential version of the data, which allowed us to analyze information that included the census tracts in which participants responded in each survey wave. We were required to keep the data secure and anonymous and to take care not to reveal any information about individual participants that would violate confidentiality rules. From 1991 through 1998 two separate survey panels existed, and in the latter year they were merged and continuing surveys were regularized in alternating years. Readers wishing to learn more about the participants in the survey, review the survey questions, learn more about the sampling methodology, and find research reports of results from research that employed HRS data, will find these at: https://hrs.isr.umich.edu/about.

Figure 3 describes the HRS data used in this study. Seven cohorts were available for comparison with one another. To investigate some research questions data from all cohorts could be combined or pooled to provide a larger sample to model trends and changes for which cohort comparisons were not being made. To the right of the figure seven cohorts are identified by their names and the years of birth of their members. The figure shows the seven older adult cohorts included in the data – those born prior to 1924 (Oldest Old), between 1924-1930 (Children of the Depression), 1931-1941 (Original Cohort), 1942-1947 (War Babies), 1948-1953 (Early Baby Boomer), 1954-1959 (Mid-Baby Boomer), 1960-1965 (Late Baby Boomer). Each cohort is identified by a unique color code, and the vertical bars in the figure show the years in which each cohort was surveyed and the age range of the members of each cohort in each survey year. The figure shows, of course, that younger cohorts, most recently added to the sample, were not interviewed in the earlier years of the survey. And, as time passes members of the oldest cohorts die or stop participating in the survey and the earlier cohorts become smaller in size as members of younger cohorts are added.

The HRS surveys participants by asking them questions about household characteristics, health, income, wealth, and activity participation. The data also include a number of questions related to driving including the respondents' ability to drive, whether the respondent had driven in the past month, whether a car was available when the respondent needed one, and whether the respondent limited their driving. The surveys do not ask questions about specific trips made, such as destinations, times at which trips were made, or travel modes used by the survey participants.

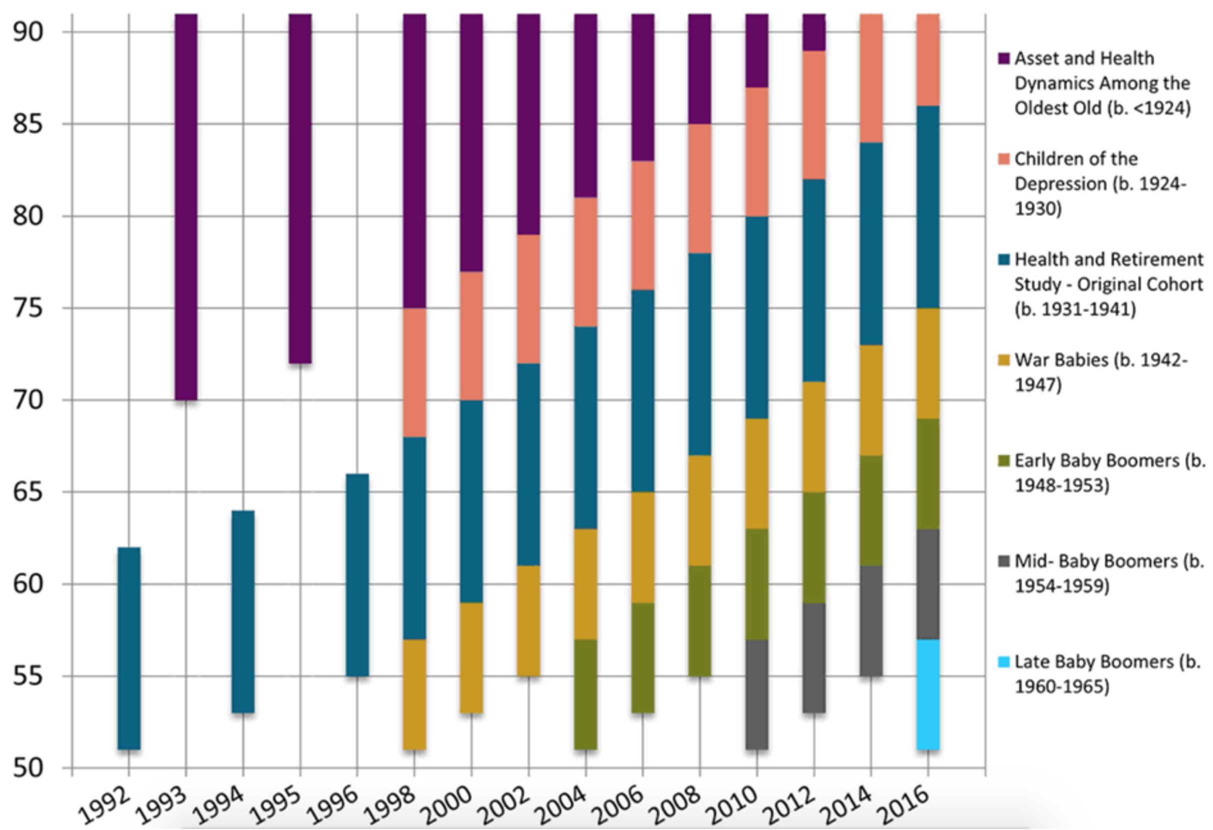


Figure 3. Age Cohorts included in the Health and Retirement Survey

Census Data and Neighborhood Typology

The HRS data are rich in information about personal and household characteristics but they include little information about the physical characteristics of neighborhoods in which respondents reside and the mobility options available in those neighborhoods. To enable us to incorporate comparisons of HRS variables with the physical characteristics of the places at which survey respondents resided and to analyze their movements over time from one community to another, we combined data from the HRS with information from other sources to explore relationships between driving cessation, driving reduction, and neighborhood characteristics. The confidential version of the HRS data include a census tract identifier which allowed us to match respondents to U.S. Census data about the characteristics of the neighborhoods in which they live. The Census data provided descriptions of the characteristics of the communities in which the respondents resided, including their residential densities.

In addition to the HRS database and information from the U.S. Census, we placed HRS participants into the types of neighborhoods in which they resided in each survey wave using a categorization of neighborhoods that was developed in a previous study by one of the authors of the current one (Blumenberg et al., 2015). The neighborhood types were developed by applying cluster analysis to a wide range of variables describing the socio-demographic and physical environments in which people live. Using first factor and then cluster analysis, seven distinct neighborhood types were defined in terms of the characteristics of their built environments and transportation systems—but not in terms of the characteristics of the people in those neighborhoods or their travel. The seven neighborhood types were labeled to reflect their most salient characteristics: Mixed Use (urban), Old Urban, Urban Residential, Established Suburbs, Patchwork (Suburban), New Development, and Rural. Virtually every census tract in the U.S. can be placed into one of these seven types. Figure 4 shows each neighborhood type, its prevalence, and basic built environment characteristics, as well as the characteristics of the people living in them. There is substantial variation in the distribution of these neighborhoods across metropolitan areas, but they tend generally to be arranged roughly in concentric rings around the central business districts or downtown areas. The rings include mixed use (urban) neighborhoods (which are also found in the central business districts of suburbs and small cities, as well as in major commercial/industrial areas) at the core, new developments at the fringe, and rural areas outside of cities and suburbs, with other neighborhood types in between. These neighborhood types were used to explore travel patterns of the HRS survey participant and to determine whether moves from one neighborhood type to another were associated with changes in their travel patterns, particularly their propensity to limit their driving or to stop driving as they aged between survey waves.

Accessibility to Activities

Based on their locations we also identified respondents' transit accessibility to jobs using a metric developed by the Accessibility Observatory at the University of Minnesota (http://access.umn.edu/). The number of jobs that can be reached via transit from a given census tract within 30 minutes was used as a proxy for access to a range of activities. A majority of older adults are retired but employment in a census tract indicates the scale of non-residential commercial, cultural, and social activity since people are employed where activities take place. The University of Minnesota accessibility data estimates the accessibility to jobs by transit and walking for each of the United States' 11 million census blocks and analyzes these data in 49 of the 50 largest (by population) metropolitan areas. Travel times by transit are calculated using detailed pedestrian networks and full transit schedules for the 7:00 – 9:00 a.m. period. The calculations include all components of a transit journey, including "last-mile" access and egress walking segments and transfers, and account for variations in service frequency within the morning peak period.

Neighborhood Type (% of Tracts)	Built Environment Characteristics	Household Characteristics
Mixed Use (6%)	*greatest land use diversity *high residential density *high share of renters and movers *iurban core & outlying bus./indus. areas	*35% non-white *median income: $42,668 *0-vehicles in household: 18%
Old Urban (4%)	*highest accessibility *highest densities *high in transience & long-term residents *high levels of transit service	*61% non-white *median income: $43,255 *0-vehicles in household: 42% *Very high walking/transit use
Urban Residential (15%)	*high residential density *mostly residential	*48% non-white *median income: $41,300 *0-vehicles in household: 13%
Established Suburbs (15%)	*older suburbs *higher densities than other suburban neighborhoods	*33% non-white *median income: $65,053 *0-vehicles in household: 8%
Patchwork Suburban (18%)	*low residential densities *scattered throughout metro areas *mix of land use types	*26% non-white *median income: $54,365 *0-vehicles in household: 8%
New Development (22%)	*mostly relatively new development *often in far-flung parts of metro areas *mostly very limited public transit service	*24% non-white *median income: $70,395 *0-vehicles in household: 3%
Rural (21%)	*low accessibility *lowest densities *no fixed-route transit service	*13% non-white *median income: $50,727 *0-vehicles in household: 5%

Figure 4. Neighborhood Types in the US and Summary of their Characteristics

Conclusion

These data were used to investigate factors that influence and explain the extent to which older Americans limit their driving and cease driving as they age. The models in Chapter 3 that investigated those relationships used the data that were described in this chapter. In Chapter 3 we ask whether there are differences in driving limitation and cessation that can be explained by the differences in cohorts that comprise the HRS data and make it unique in comparison with most travel surveys. Following that, in Chapter 4 we explore associations between driving cessation and limitation and the residential environments in which participants in the HRS reside and whether moving from one type of neighborhood to another is associated with decisions to cease or limit driving. Detailed descriptions of our methodology are included in both chapters.

Chapter 3.
Cohort Analysis of Driving Cessation and Limitation Among Older Adults

Responses to two survey items in the HRS—whether or not an individual is able to drive and whether or not that person limits his or her driving—are our outcomes of interest that were examined using models described in this chapter. To address correlations between these outcomes and the rich set of variables available in the HRS, we specified a series of discrete-time logistic regression models. Discrete-time logistic regression is a common modeling strategy for analyzing event histories (Allison, 1982). In this study, discrete-time modeling allowed us to explore whether driving cessation and driving limitation are correlated with key dependent variables such as age, sex, and birth cohort.

We specified two sets of models to address our research questions. In all models, an individual's driving behavior in consecutive survey waves was the dependent variable. In models of driving cessation, a binary outcome measure indicated whether the respondent continued driving from wave *a* to wave *b*, or stopped driving between waves *a* and *b*. The outcome measure in the driving limitation models was similar, indicating whether a driver began to limit his or her driving between waves *a* and *b*, or whether he or she continued as an "unlimited" driver over consecutive waves. In addition to the primary variables of interest (age, sex, and cohort), all models included a suite of other control variables associated with the driving behavior of older adults. These included measures of health, family structure, residential location, and demographic and socioeconomic indicators.

The first set of models, which we term "pooled models," included the entire sample of older adults. In the pooled models, the coefficient of the "cohort" variable provided a direct measure of the relationship between an individual's birth cohort and changes in his or her driving behavior. Most importantly, the magnitude of this coefficient allowed us to evaluate whether, all else equal, members of a given cohort were more or less likely to stop or limit their driving than their counterparts in previous or subsequent cohorts. In addition to these base pooled models, we developed models with interaction terms. The first of these interaction models included a "cohort * age" term that provided an understanding of whether, all else equal, the relationship between age and stopping or limiting driving differed by cohort. A second series of interaction models included a "cohort * gender" term that evaluated whether the relationship between gender and driving behavior differed by cohort.

In addition to these pooled models we also specified a second set of models which we labeled "cohort models." These models investigated associations between changes in driving behavior and several independent variables. Unlike the pooled models, the cohort models examined these relationships separately for each cohort. These models have two purposes. First, because the cohort models included a respondent's age as an independent variable, they served as a robustness test for the pooled models. Specifically, the cohort * age and the cohort * gender interaction terms in the pooled models and the age and gender variables in the cohort models both assessed the same relationship—the degree to which the driving behavior of members of a given cohort differed, either as they got older or by gender. Consequently, the coefficients of these terms should reflect a consistent association between age, gender, cohort, and changes in driving behavior across models.

Second, the cohort models also allowed us to examine associations among age, sex, and cohort in more detail than the pooled models. Of particular interest is whether the relationship between age and driving behavior differed by sex, and whether associations among age, sex, and driving behavior differed by cohort. While these relationships can be assessed using pooled data, this would require a triple interaction term (cohort * age * sex), making analysis and interpretation of the findings rather complex. To obtain more straightforward and interpretable results, we examined associations among age, sex, and cohort using the interaction of two variables (age * sex) in separate cohort models.

Table 1 contains descriptive statistics for the sample, which includes three HRS cohorts: the oldest cohort is comprised of people born in 1923 or earlier, the middle cohort includes respondents born between 1924 and 1930, and the youngest cohort contains respondents born between 1931 and 1941.

Table 1. Characteristics of the Three Cohorts

Characteristics	**COHORTS**		
	Oldest	**Middle**	**Newest**
% stopped driving (between survey waves)	15.1	6.4	3.2
% male	46.6	45.4	47.5
% in couple household	45.2	60.0	68.7
Average age	85.1	78.5	73.0
% white	92.7	89.4	85.4
% black/African American	4.0	5.8	7.6
% Hispanic	2.6	3.4	5.0
Average wealth (2016$)	465,332	506,261	602,909
% child nearby	57.6	60.7	58.9
% with major ailment	64.1	60.6	57.6
% excellent eyesight	7.6	8.2	8.5
% very good eyesight	23.7	26.6	29.2
% good eyesight	43.0	45.8	45.1
% fair eyesight	18.6	15.0	13.8
% poor eyesight	7.0	4.4	3.4
% had stroke	11.0	9.2	6.7
% health got worse between waves	35.3	28.2	25.5
% moved between waves	12.1	9.3	9.6
Population density (census tract, per sq. mi.)	3,239	3,706	3,150
n (person-years)	8,382	13,941	27,175
n (unique individuals)	2,547	2,881	6,320

Results

Pooled Models

Table 2 presents the results from the pooled models. Control variables in the base models generally have the expected relationship with both stopping and limiting driving. Not surprisingly, health-related variables are powerful predictors of driving cessation and limitation. Those reporting declining health between survey waves and those suffering from major ailments and conditions were far more likely to stop or limit driving than those without major health issues. Having had a stroke is strongly associated with an increased likelihood of stopping or limiting driving. Self-reported failing eyesight also has the expected relationship with driving; respondents' likelihood of stopping or limiting driving increased as their vision declined.

Age has the expected correlation with changes in driving behavior; respondents became more likely to stop driving as they got older. Each additional year of age is associated with an approximately ten percent increase in the likelihood of stopping driving. Put differently, aging a decade is associated with a three-fold increase in the predicted likelihood of driving cessation. The relationship between advancing age and limiting driving is similarly positive, but less pronounced; aging one year is correlated with a five percent increase in the propensity to limit driving, which translates into a 1.6 times greater likelihood of limiting driving over a ten-year period.

Sex, like age, is also strongly correlated with driving cessation and limitation. As found in many previous studies (Bauer et al. 2003; Choi et al. 2012b), men are far less likely to stop or limit their driving than women. All else equal, men are 41 percent less likely to stop driving than female respondents. Patterns are similar for limiting driving with men 50 percent less likely to limit their driving than comparable women.

Variables describing household characteristics and family structure are also associated with changes in driving behavior. Wealth, for example, has a clear negative correlation with decisions to reduce or stop driving. Living with a partner, while not predictive of stopping driving, is a determinant of limiting driving. All else equal, those who lived in a couple household were less likely to limit their driving than those who did not live with a partner. Having nearby family members also is associated with driving behavior: older adults who did not have children living within ten miles of their homes were less likely to stop or curtail their driving, perhaps reflecting their inability to rely on nearby family members to provide mobility.

Race is a consistent predictor of stopping and limiting driving. Both Black and Hispanic respondents were substantially more likely to stop and limit their driving than non-Hispanic whites. Results also show correlations between residential location characteristics and driving behavior. Population density is positively associated with driving cessation, suggesting that those who lived in denser neighborhoods—areas that tend to have more non-auto transportation options—were more likely to stop driving than residents of more car-centric communities. Black and Hispanic individuals make up just under 7 and 5 percent of the total sample, respectively, but they represent 24 and 14 percent, respectively, of those living in the high-density neighborhood tracts. The models establish that ethnicity and density independently influence driving cessation, but it is notable that they tend to intersect because of residential concentration of these populations in certain neighborhoods.

Table 2. Pooled Models

	Stopping Driving			Limiting Driving		
	No interaction	Age* cohort interaction	Gender* cohort interaction	No interaction	Age* cohort interaction	Gender* cohort interaction
Couple household	0.064	0.069	0.069	-0.168***	-0.161***	-0.168***
	1.07	1.07	1.07	0.85	0.85	0.85
	(0.045)	(0.045)	(0.045)	(0.038)	(0.038)	(0.038)
Male	-0.523***	-0.526***	-0.677***	-0.697***	-0.703***	-0.688***
	0.59	0.59	0.51	0.50	0.50	0.50
	(0.043)	(0.043)	(0.068)	(0.036)	(0.036)	(0.082)
Age	0.103***	0.119***	0.103***	0.049***	0.082***	0.049***
	1.11	1.13	1.11	1.05	1.09	1.05
	(0.004)	(0.007)	(0.004)	(0.004)	(0.009)	(0.004)
Cohort (base: oldest cohort (AHEAD)						
Middle cohort (CODA)	-0.261***	2.212*	-0.371***	-0.383***	1.890*	-0.360***
	0.77	9.13	0.69	0.68	6.62	0.70
	(0.055)	(0.861)	(0.068)	(0.054)	(0.941)	(0.079)
Youngest cohort (HRS)	-0.427***	1.449	-0.516***	-0.680***	3.528***	-0.682***
	0.65	4.26	0.60	0.51	34.06	0.51
	(0.070)	(0.873)	(0.080)	(0.063)	(0.903)	(0.081)
Race/ethnicity (base: non-Hispanic white)						
Black	0.322***	0.324***	0.328***	0.565***	0.561***	0.565***
	1.38	1.38	1.39	1.76	1.75	1.76
	(0.063)	(0.063)	(0.063)	(0.059)	(0.059)	(0.059)
Hispanic	0.567***	0.568***	0.565***	0.684***	0.682***	0.683***
	1.76	1.76	1.76	1.98	1.98	1.98
	(0.078)	(0.078)	(0.078)	(0.077)	(0.077)	(0.077)
Other	0.048	0.055	0.046	0.308*	0.305*	0.308*
	1.05	1.06	1.05	1.36	1.36	1.36
	(0.178)	(0.177)	(0.177)	(0.134)	(0.134)	(0.134)
ln(wealth)	-0.105***	-0.105***	-0.105***	-0.093***	-0.093***	-0.093***
	0.90	0.90	0.90	0.91	0.91	0.91
	(0.006)	(0.006)	(0.006)	(0.007)	(0.007)	(0.007)

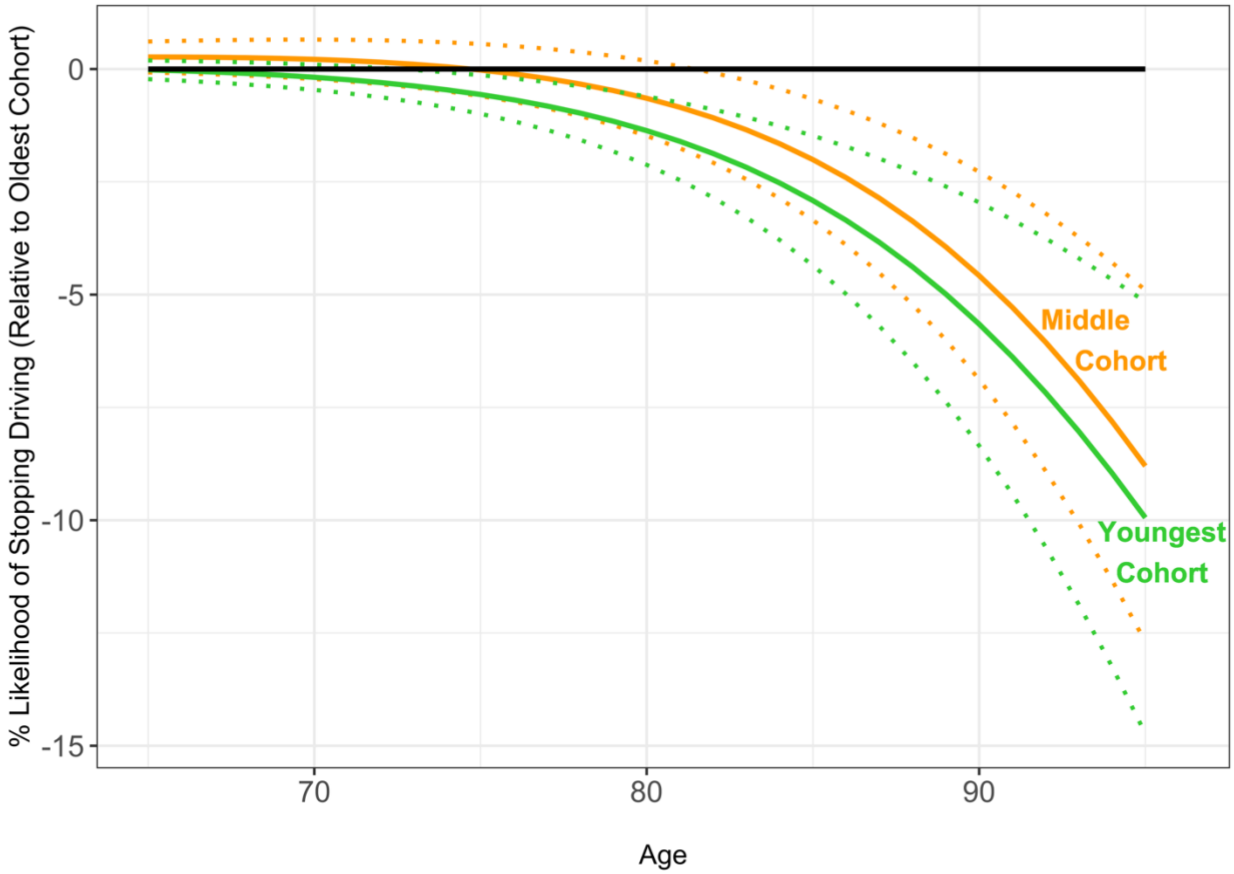
No child nearby	-0.121**	-0.123**	-0.121**	-0.271***	-0.274***	-0.271***
	0.89	0.88	0.89	0.76	0.76	0.76
	(0.040)	(0.040)	(0.040)	(0.033)	(0.033)	(0.033)
Major ailment	0.149***	0.153***	0.150***	0.130***	0.134***	0.131***
	1.16	1.17	1.16	1.14	1.14	1.14
	(0.043)	(0.043)	(0.043)	(0.035)	(0.035)	(0.035)
Has had stroke	1.044***	1.048***	1.043***	0.337***	0.341***	0.338***
	2.84	2.85	2.84	1.40	1.41	1.40
	(0.049)	(0.050)	(0.049)	(0.062)	(0.062)	(0.062)
Eyesight (base: excellent)						
very good	-0.047	-0.043	-0.050	0.184**	0.192**	0.184**
	0.95	0.96	0.95	1.20	1.21	1.20
	(0.093)	(0.093)	(0.093)	(0.069)	(0.069)	(0.069)
good	0.134	0.140	0.130	0.460***	0.472***	0.460***
	1.14	1.15	1.14	1.58	1.60	1.58
	(0.087)	(0.087)	(0.087)	(0.065)	(0.065)	(0.065)
fair	0.529***	0.532***	0.528***	0.785***	0.794***	0.785***
	1.70	1.70	1.70	2.19	2.21	2.19
	(0.091)	(0.091)	(0.091)	(0.074)	(0.074)	(0.074)
poor	1.490***	1.493***	1.488***	1.253***	1.264***	1.253***
	4.44	4.45	4.43	3.50	3.54	3.50
	(0.098)	(0.098)	(0.098)	(0.108)	(0.108)	(0.108)
Health got worse	1.006***	1.008***	1.010***	0.593***	0.593***	0.593***
	2.73	2.74	2.75	1.81	1.81	1.81
	(0.040)	(0.040)	(0.040)	(0.036)	(0.036)	(0.036)
Moved	0.789***	0.787***	0.789***	-0.114*	-0.121*	-0.114*
	2.20	2.20	2.20	0.89	0.89	0.89
	(0.050)	(0.050)	(0.050)	(0.056)	(0.056)	(0.056)
ln(density)	0.043***	0.043***	0.043***	0.014	0.015	0.014
	1.04	1.04	1.04	1.01	1.02	1.01
	(0.011)	(0.011)	(0.011)	(0.009)	(0.009)	(0.009)
Interaction (base: age*oldest cohort)						
*Age*middle cohort*		-0.030**			-0.027*	
		0.97			0.97	
		(0.010)			(0.011)	

*Age*youngest cohort*		-0.023*			-0.053***	
		0.98			0.95	
		(0.011)			(0.011)	
Interaction (base: female*oldest cohort)						
*Male*middle cohort*			0.263**			-0.043
			1.30			0.96
			(0.097)			(0.100)
*Male*youngest cohort*			0.221*			0.009
			1.25			1.01
			(0.095)			(0.092)
Constant	-10.448***	-11.867***	-10.402***	-3.864***	-6.696***	-3.871***
	(0.407)	(0.638)	(0.407)	(0.356)	(0.805)	(0.358)
Observations	49,498	49,498	49,498	29,073	29,073	29,073
Log Likelihood	-9,811.118	-9,806.622	-9,806.687	-12,207.890	-12,195.730	-12,207.640
Akaike Inf. Crit.	19,662.240	19,657.240	19,657.370	24,455.780	24,435.470	24,459.290

Note: *p < 0.05, **p < 0.01, ***p<0.001; for each variable, the top entry shows the coefficient, the middle entry the odds ratio, and the bottom entry the standard error (in parentheses)

The pooled base models show clear associations between changes in driving behavior and cohort. Younger cohorts were less likely to stop and limit their driving than their older counterparts. Relative to members of the oldest cohort, members of the middle cohort were 23 percent less likely to give up driving and 32 percent less likely to limit their driving. Members of the youngest cohort showed an even lower propensity to stop and limit their driving: they were 35 and 49 percent less likely to stop and limit their driving, respectively, than those in the oldest cohort.

The results of the interaction models reveal that, in addition to the base cohort effects described above, associations between age, gender, and driving behavior or also differ depending upon one's cohort. Models that include a "cohort * age" interaction term enabled us to evaluate how the relationship between aging and driving behavior differs between cohorts. The interaction term shows that while increased age is associated with a higher likelihood of stopping and limiting driving for members of all groups, this correlation is weaker among the younger cohorts. Compared to the oldest cohort, an additional year of age is associated with a three percent lower likelihood of stopping driving for the middle cohort and a 2.3 percent lower probability of driving cessation for the youngest cohort. Results for the driving limitation model are similar: for members of the middle cohort, an additional year of age is correlated with a 2.6 percent lower likelihood of limiting driving compared to those in the oldest cohort; for the youngest cohort, an additional year corresponds to a 5.2 percent decline in the likelihood of limiting driving, all else equal. Figure 5 illustrates the predicted likelihood that members of the middle and youngest cohorts will stop driving as they age, relative to the oldest cohort. Figure 6 shows the same relationship as it pertains to driving limitation.



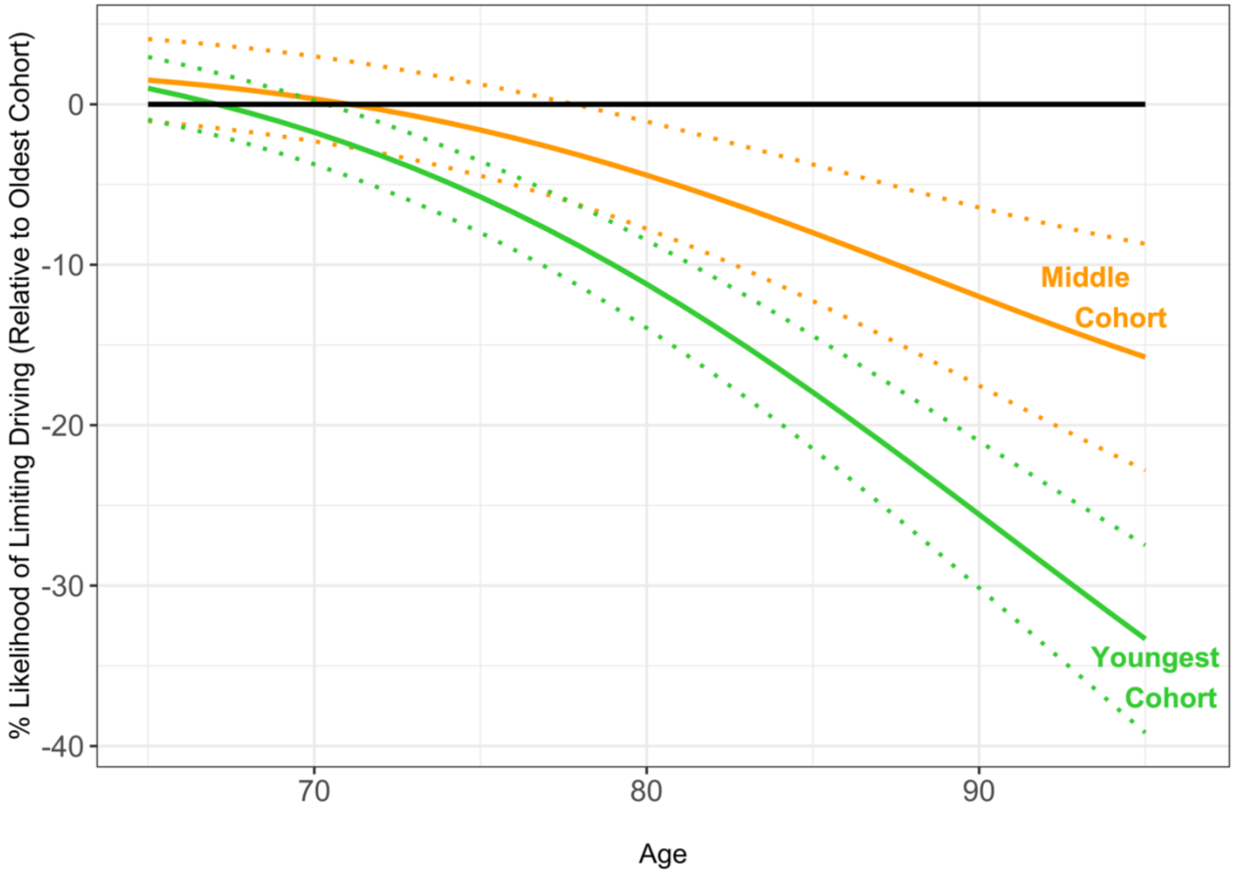
* dotted lines represent the 95% confidence interval around predicted values

Figure 5. Predicted Likelihood of Stopping Driving by Age and Cohort

Associations between gender and driving behavior are also attenuated by cohort. The results of the base model, discussed above, show that all else equal, men are far less likely to stop and limit their driving than women. However, the findings of models which contain cohort * gender interaction terms suggest that, at least with regard to driving cessation, the gender gap is less pronounced among younger cohorts.

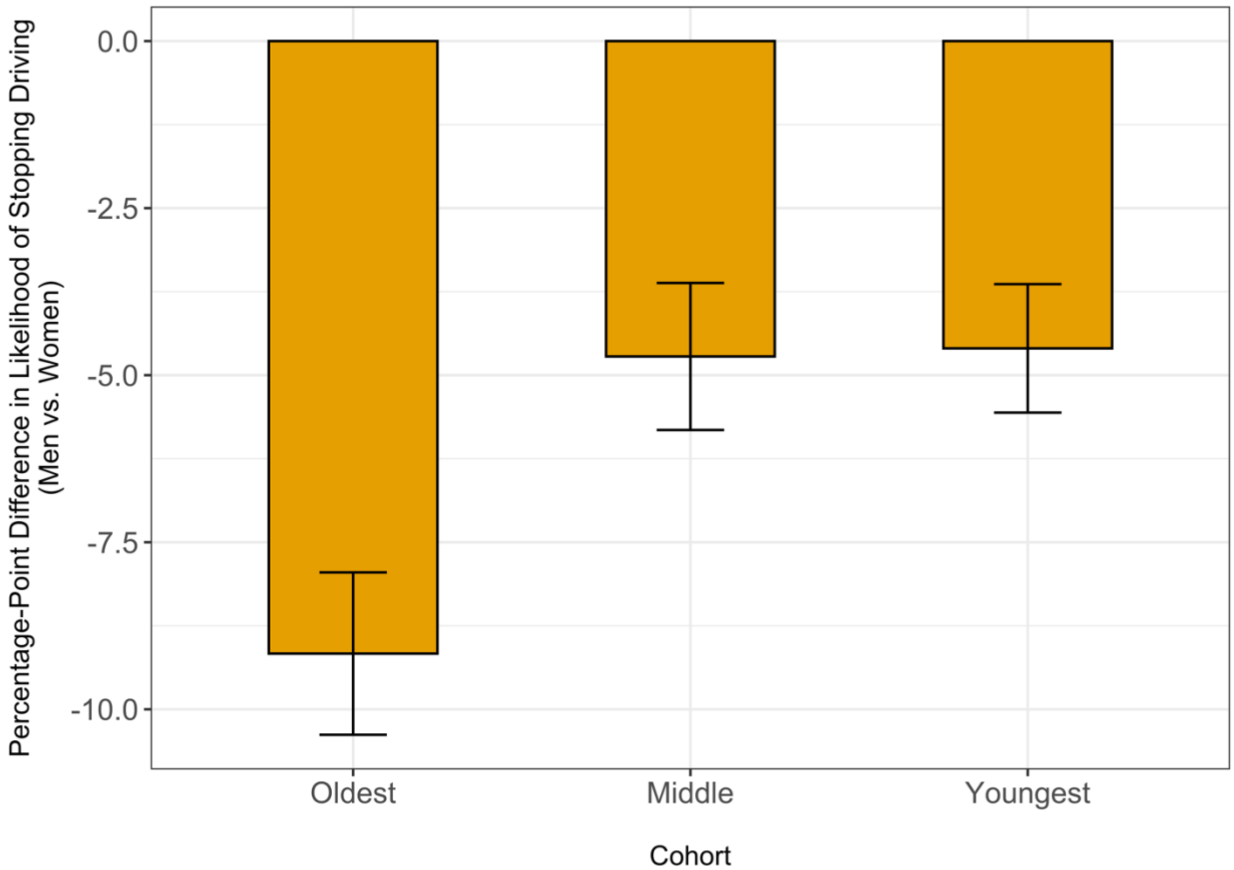
The interpretation of interactions between two categorical variables is rather complex; depending on the groups being compared, the main effects often must be considered in combination with the interaction terms. We, therefore, discuss the results of the cohort * gender interaction models using fitted values. These values, presented in Figures 7 and 8, highlight the gap in driving cessation and limitation between men and women for each cohort.

Figure 7 clearly shows that, relative to the oldest cohort, gender differences in stopping driving narrowed in the middle and youngest cohorts. All else equal, men in the oldest cohort were just over nine percentage points more likely to stop driving than women in the same cohort. Among members of the middle and youngest cohort, the male-female gap in driving cessation was substantially smaller, at 4.7 and 4.6 percentage points respectively. Figure 8 suggests that the narrowing gender gap is limited to driving cessation: with regard to limiting driving, differences between men and women are relatively consistent across cohorts, with men's predicted likelihood of limiting driving roughly 15 to 18 percentage points lower than women's.



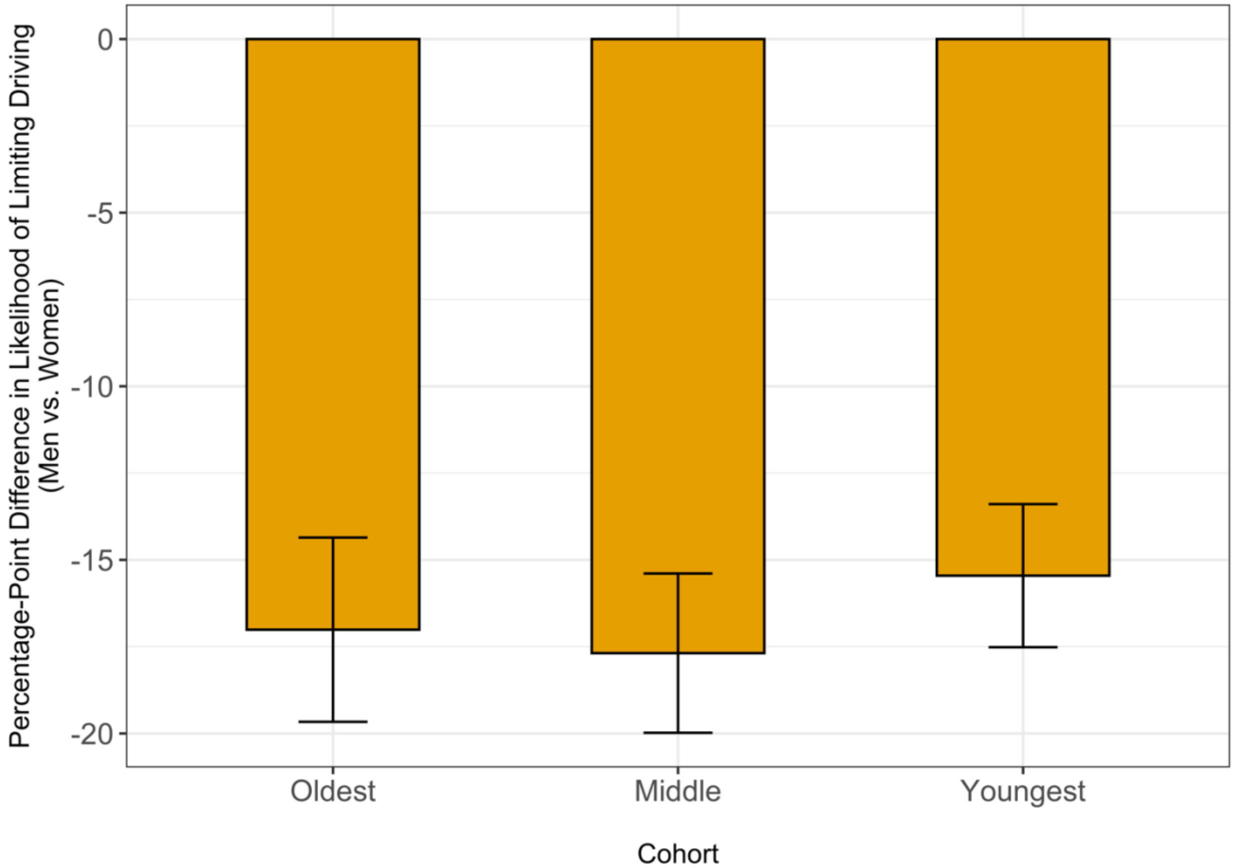
* dotted lines represent the 95% confidence interval around predicted values

Figure 6. Predicted Likelihood of Limiting Driving by Age and Cohort



* error bars represent the 95% confidence interval around predicted means for each cohort

Figure 7. Likelihood of Men Stopping Driving, Relative to Women



* error bars represent the 95% confidence interval around predicted means for each cohort

Figure 8. Likelihood of Men Limiting Driving, Relative to Women

Cohort Models

Tables 3 and 4 show the results of the cohort models. Table 3 contains the results of the driving cessation models and Table 4 provides results of the driving limitation models. The analysis of each cohort consists of a base model (Models 1, 3, and 5) and a model that includes the interaction between age and sex (Models 2, 4, and 6).

As mentioned earlier, one purpose of the cohort models is to serve as a robustness check of our pooled model results. In particular, we focus on the interaction terms in the pooled models: age and gender. While comparing coefficients from different logistic regression models poses some methodological challenges (Allison 1982; Mood 2010), we make such comparisons to validate to the findings of our pooled models and not to make firm conclusions regarding the magnitude of differences between cohorts.

With regard to age, results of the cohort models echo the pooled models, with the association between increasing age and stopping or limiting driving being somewhat weaker in the younger cohorts. The relationship between increasing age and stopping driving is strongest among the members of the oldest cohort. Members of that cohort are 13 percent more likely to stop driving each year. By contrast, individuals in the subsequent, or middle, cohort are somewhat less likely to stop driving as they age: each additional year of age is associated with a nine percent increase in the likelihood of stopping driving. Members of the youngest cohort also gave up driving later than those in the oldest cohort; however, they were slightly more likely to give up driving as they aged than those in the middle cohort. An additional year of age was associated with a ten percent increase in the likelihood of stopping driving among older adults in the youngest cohort.

The models show similar relationships for driving limitation. Respondents in the oldest of the three cohorts were the most likely to limit their driving as they aged, becoming nine percent more likely to limit their driving with each additional year. Unlike the association between age and stopping driving, however, the relationship between age and driving limitation continues to weaken with each subsequent cohort: aging one year is associated with a six percent higher likelihood of limiting driving for members of the middle cohort, while an additional year is associated with only a three percent increase in the propensity to limit driving for those in the youngest cohort. Figure 7 shows the predicted likelihood that members of the three cohorts stopped driving as they aged.

Like age, the predictive power of sex as a determinant of driving cessation is strongest among respondents in the oldest cohort. Among members of that cohort, men were 46 percent less likely to stop driving than women. In subsequent cohorts, this relationship weakens somewhat. Men in the middle cohort were 34 percent less likely to stop driving than women, while male members of the youngest cohort were 39 percent less likely to give up driving than women. Similar to the pooled models, we once again find that the weakening strength of sex as a predictor of driving behavior only applies to driving cessation; for driving limitation sex is a relatively stable predictor of limiting driving across cohorts.

Results of the cohort models confirm the findings of the pooled models and suggest that, at least to some degree, both age and sex were stronger predictors of changes in driving behavior among older cohorts: members of the oldest cohort were the earliest to give up driving as they age, and the gender gap in driving cessation was most pronounced among the oldest members of the population. However, one issue that the base cohort models did not address was how the relationship *between* age and sex changes by cohort. Are women more (or less) likely than men to give up driving sooner as they get older? And if so, does this difference change by cohort? To address these questions, we examined a series of cohort interaction models, the results of which are included in Table 4.

Almost universally, the interaction models demonstrate, regardless of cohort, that men and women stopped and limited their driving at the same rate as they aged. The lack of significance of the interaction terms suggests that both within and between cohorts, age does not have an additive (or subtractive) effect on driving behavior: neither men nor women became increasingly likely to change their driving behavior as they aged, while, all else equal, women were far more likely to stop or limit their driving than men. The sole exception to this with regard to limiting driving was found in the middle cohort. Relative to women, an additional year of age for men is associated with a modest three percent increase in the likelihood of limiting driving. While this translates into a roughly 39 percent higher likelihood of men limiting driving relative to women, the increased rate of driving limitation among middle-cohort men narrows—but does not close—the baseline gap in driving limitation between the sexes. Even among the oldest members of the middle cohort, women were substantially more likely to limit their driving than men.

Table 3. Cohort Model, Likelihood of Stopping Driving

	Oldest Base (Model 1)	**Oldest** Interaction (Model 2)	**Middle** Base (Model 3)	**Middle** Interaction (Model 4)	**Youngest** Base (Model 5)	**Youngest** Interaction (Model 6)
Couple household	0.066	0.066	0.039	0.037	0.131	0.135
	1.07	1.07	1.04	1.04	1.14	1.14
	(0.076)	(0.076)	(0.080)	(0.080)	(0.078)	(0.078)
Male	-0.623***	-0.614	-0.421***	-1.147	-0.492***	0.774
	0.54	0.54	0.66	0.32	0.61	2.17
	(0.073)	(1.219)	(0.078)	(1.224)	(0.075)	(1.281)
Age	0.118***	0.118***	0.089***	0.085***	0.095***	0.102***
	1.13	1.13	1.09	1.09	1.10	1.11
	(0.007)	(0.010)	(0.008)	(0.010)	(0.009)	(0.011)
Race/ethnicity (base: non-Hispanic white)						
Black	0.359**	0.359**	0.338**	0.338**	0.300**	0.302**
	1.43	1.43	1.40	1.40	1.35	1.35
	(0.120)	(0.120)	(0.127)	(0.127)	(0.095)	(0.095)
Hispanic	0.497**	0.497**	0.637***	0.639***	0.587***	0.587***
	1.64	1.64	1.89	1.89	1.80	1.80
	(0.157)	(0.157)	(0.152)	(0.153)	(0.115)	(0.115)
Other	0.494	0.493	0.757**	0.758**	-1.213**	-1.213**
	1.64	1.64	2.13	2.13	0.30	0.30
	(0.366)	(0.367)	(0.251)	(0.251)	(0.420)	(0.420)
ln(wealth)	-0.133***	-0.133***	-0.092***	-0.092***	-0.094***	-0.094***
	0.88	0.88	0.91	0.91	0.91	0.91
	(0.011)	(0.011)	(0.011)	(0.011)	(0.009)	(0.009)
No child nearby	-0.161*	-0.161*	-0.220**	-0.220**	0.025	0.024
	0.85	0.85	0.80	0.80	1.03	1.02
	(0.065)	(0.065)	(0.074)	(0.074)	(0.070)	(0.070)
Major ailment	0.116	0.116	0.129	0.129	0.201**	0.204**
	1.12	1.12	1.14	1.14	1.22	1.23
	(0.069)	(0.069)	(0.080)	(0.080)	(0.077)	(0.077)
Has had stroke	0.904***	0.904***	1.075***	1.076***	1.158***	1.157***
	2.47	2.47	2.93	2.93	3.18	3.18
	(0.084)	(0.084)	(0.088)	(0.088)	(0.084)	(0.084)

Eyesight (base: excellent)						
very good	-0.009	-0.009	-0.089	-0.089	-0.031	-0.028
	0.99	0.99	0.91	0.91	0.97	0.97
	(0.148)	(0.148)	(0.163)	(0.163)	(0.180)	(0.180)
good	0.190	0.190	0.006	0.007	0.233	0.235
	1.21	1.21	1.01	1.01	1.26	1.26
	(0.138)	(0.138)	(0.152)	(0.152)	(0.167)	(0.167)
fair	0.489***	0.489***	0.546***	0.546***	0.605***	0.607***
	1.63	1.63	1.73	1.73	1.83	1.83
	(0.145)	(0.145)	(0.159)	(0.159)	(0.174)	(0.174)
poor	1.416***	1.416***	1.407***	1.407***	1.674***	1.677***
	4.12	4.12	4.08	4.08	5.33	5.35
	(0.158)	(0.158)	(0.174)	(0.174)	(0.183)	(0.183)
Health got worse	0.586***	0.586***	1.152***	1.152***	1.386***	1.386***
	1.80	1.80	3.16	3.16	4.00	4.00
	(0.065)	(0.065)	(0.073)	(0.073)	(0.072)	(0.072)
Moved	0.770***	0.770***	0.877***	0.877***	0.709***	0.708***
	2.16	2.16	2.40	2.40	2.03	2.03
	(0.081)	(0.081)	(0.092)	(0.092)	(0.091)	(0.091)
ln(density)	0.032	0.032	0.061**	0.061**	0.051**	0.050**
	1.03	1.03	1.06	1.06	1.05	1.05
	(0.017)	(0.017)	(0.020)	(0.020)	(0.018)	(0.018)
Interaction (base: female*age)						
*Male*age*		-0.0001		0.009		-0.017
		1.00		1.01		0.98
		(0.014)		(0.015)		(0.017)
Constant	-11.101***	-11.106***	-9.916***	-9.592***	-10.886***	-11.382***
	(0.668)	(0.869)	(0.670)	(0.861)	(0.664)	(0.833)
Observations	8,382	8,382	13,941	13,941	27,175	27,175
Log Likelihood	-3,246.741	-3,246.741	-2,958.629	-2,958.453	-3,524.382	-3,523.891
Akaike Inf. Crit.	6,529.482	6,531.482	5,953.259	5,954.905	7,084.764	7,085.783

Note: $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p<0.001$; for each variable, the top entry shows the coefficient, the middle entry the odds ratio, and the bottom entry the standard error (in parentheses)

Figure 9 shows the results of the interaction models to illustrate the predicted likelihood of stopping driving by age, sex, and cohort. Once again, as these are cross-model comparisons, we use these predicted values to provide a general sense of trends among different combinations of cohort and gender, and not to make firm conclusions regarding the magnitude of differences between cohorts.

Figure 9 demonstrates how the age coefficients described above cumulatively effect on the members of various groups. While respondents in their late 60s, regardless of their sex or cohort, have a relatively low probability of stopping driving, the rate of driving cessation among individuals in the oldest cohort increases far more rapidly than for those in other cohorts. Figure 9 also illustrates the relationship between age and sex. As described above, neither men nor women become increasingly likely to stop driving as they age. Nevertheless, small differences in the likelihood of stopping driving grow larger with age, particularly in the oldest cohort. Thus, while the male-to-female ratio in the likelihood of stopping driving changes very little over time, gender differences in driving cessation become larger with age.

Figure 10 illustrates associations between age, sex, and cohort and limiting driving. The similarities with Figure 9 are clear, in that women and older cohorts limit their driving at much higher rates than men and younger cohorts, respectively. Figure 10 does, however, highlight some differences as well. In particular, while increases in the likelihood of driving limitation are relatively consistent in the oldest and youngest cohorts regardless of sex, trends are distinct among the middle cohort. For its members, the gender gap in limiting driving declines somewhat with age, as predicted rates of men’s driving limitation increase slightly faster than women.

Table 4. Cohort Model, Likelihood of Limiting Driving

	Oldest Base (Model 1)	**Oldest** Interaction (Model 2)	**Middle** Base (Model 3)	**Middle** Interaction (Model 4)	**Youngest** Base (Model 5)	**Youngest** Interaction (Model 6)
Couple household	-0.161	-0.160	-0.156*	-0.163*	-0.163**	-0.160**
	0.85	0.85	0.86	0.85	0.85	0.85
	(0.090)	(0.090)	(0.070)	(0.070)	(0.052)	(0.052)
Male	-0.730***	-0.183	-0.754***	-3.297**	-0.668***	0.515
	0.48	0.83	0.47	0.04	0.51	1.67
	(0.091)	(1.675)	(0.065)	(1.035)	(0.049)	(0.869)
Age	0.084***	0.088***	0.057***	0.040***	0.030***	0.037***
	1.09	1.09	1.06	1.04	1.03	1.04

	(0.010)	(0.016)	(0.007)	(0.010)	(0.006)	(0.008)
Race/ethnicity (base: non-Hispanic white)						
Black	0.451*	0.452*	0.662***	0.664***	0.561***	0.565***
	1.57	1.57	1.94	1.94	1.75	1.76
	(0.214)	(0.214)	(0.133)	(0.133)	(0.070)	(0.070)
Hispanic	0.751**	0.749**	0.978***	1.003***	0.604***	0.603***
	2.12	2.11	2.66	2.73	1.83	1.83
	(0.260)	(0.260)	(0.168)	(0.169)	(0.093)	(0.093)
Other	0.450	0.446	0.334	0.334	0.285	0.288
	1.57	1.56	1.40	1.40	1.33	1.33
	(0.586)	(0.585)	(0.251)	(0.251)	(0.165)	(0.165)
ln(wealth)	-0.120***	-0.120***	-0.102***	-0.102***	-0.089***	-0.089***
	0.89	0.89	0.90	0.90	0.91	0.91
	(0.024)	(0.024)	(0.014)	(0.014)	(0.008)	(0.008)
No child nearby	-0.224**	-0.224**	-0.293***	-0.295***	-0.285***	-0.286***
	0.80	0.80	0.75	0.74	0.75	0.75
	(0.080)	(0.080)	(0.061)	(0.061)	(0.046)	(0.046)
Major ailment	0.190*	0.190*	0.125	0.123	0.125**	0.128**
	1.21	1.21	1.13	1.13	1.13	1.14
	(0.086)	(0.086)	(0.064)	(0.064)	(0.047)	(0.047)
Has had stroke	0.612***	0.611***	0.332**	0.331**	0.245**	0.245**
	1.84	1.84	1.39	1.39	1.28	1.28
	(0.141)	(0.141)	(0.110)	(0.110)	(0.091)	(0.091)
Eyesight (base: excellent)						
very good	0.244	0.244	0.329**	0.326**	0.094	0.095
	1.28	1.28	1.39	1.39	1.10	1.10
	(0.159)	(0.159)	(0.126)	(0.126)	(0.096)	(0.096)
Good	0.573***	0.574***	0.571***	0.568***	0.381***	0.381***
	1.77	1.78	1.77	1.76	1.46	1.46
	(0.151)	(0.151)	(0.120)	(0.120)	(0.091)	(0.091)

Fair	0.880***	0.881***	0.977***	0.975***	0.664***	0.665***
	2.41	2.41	2.66	2.65	1.94	1.94
	(0.170)	(0.170)	(0.137)	(0.137)	(0.103)	(0.103)
Poor	1.147***	1.147***	1.589***	1.591***	1.124***	1.129***
	3.15	3.15	4.90	4.91	3.08	3.09
	(0.244)	(0.244)	(0.204)	(0.204)	(0.149)	(0.149)
Health got worse	0.511***	0.511***	0.572***	0.568***	0.636***	0.637***
	1.67	1.67	1.77	1.76	1.89	1.89
	(0.086)	(0.086)	(0.067)	(0.067)	(0.051)	(0.051)
Moved	-0.093	-0.093	-0.105	-0.104	-0.141	-0.141
	0.91	0.91	0.90	0.90	0.87	0.87
	(0.125)	(0.125)	(0.106)	(0.106)	(0.078)	(0.078)
ln(density)	0.051*	0.051*	0.025	0.025	0.0002	-0.0001
	1.05	1.05	1.03	1.03	1.00	1.00
	(0.022)	(0.022)	(0.016)	(0.016)	(0.012)	(0.012)
Interaction (base: female*age)						
*Male*age*		-0.007		0.033*		-0.016
		0.99		1.03		0.98
		(0.020)		(0.013)		(0.012)
Constant	-6.846***	-7.203***	-4.997***	-3.597***	-3.027***	-3.575***
	(0.895)	(1.413)	(0.565)	(0.800)	(0.458)	(0.609)
Observations	3,259	3,259	7,898	7,898	17,916	17,916
Log Likelihood	-1,879.351	-1,879.297	-3,594.139	-3,591.109	-6,708.230	-6,707.300
Akaike Inf. Crit.	3,794.702	3,796.595	7,224.278	7,220.218	13,452.460	13,452.600

Note: *p < 0.05, **p < 0.01, ***p<0.001; for each variable, the top entry shows the coefficient, the middle entry the odds ratio, and the bottom entry the standard error (in parentheses)

Conclusion

In America, where the vast majority of people drive automobiles, the transition from driver to non-driver associated with advancing age can greatly affect the quality of a person's life. Often necessitated by declining health and frequently necessary to insure personal and public safety, reduction and eventual cessation of driving can be traumatic because it reduces access to shopping, health care, social, cultural, and religious activities, and makes a person more dependent on others. Late life driving cessation has been studied because of its importance in the fields of traffic safety and gerontology. But, studies of driving cessation most often rely on cross sectional data – comparing different people and their circumstances at one point in time. While very useful, this can explain associations only at one point in time, even if those relationships are dynamic. Relationships between age and driving have steadily evolved in ways that are better understood if cohorts are studied. Fewer people drove in past decades and today older people use ridehailing services differently than younger people and use on-line apps to select routes differently than younger cohorts. Men and women have long been observed to behave differently when it comes to driving cessation, but men and women have had different propensities to drive over the decades and this association could well be changing over time as their social and cultural determinants evolve.

By taking advantage of the unique HRS longitudinal data base that followed people as they aged over more than thirty years, we were able to show that relationships among driving cessation, aging, and sex, are indeed evolving. While age and sex continue to influence driving outcomes in the ways predicted in earlier studies, we found that more recent generations of older adults are driving longer. The largest differences are between the oldest cohort and the two more recent cohorts whose maturation occurred when there was widespread use of the automobile. Many older adults from this earlier generation never drove and, therefore, were not included in our sample. But it is also likely that adults in the oldest cohort spent less of their adults lives behind a wheel compared to those in more recent cohorts. Per capita vehicle registrations grew substantially from 1930 to 1990, increasing from 0.22 to 0.75 (Federal Highway Administration 1997; Federal Highway Administration various years; Population Estimates Program various dates). More recently the growth in the number of vehicle registrations has slowed as automobile ownership has become almost universal; in 2000, 92 percent of all households in the U.S. had at least one automobile (Ruggles et al. 2020).

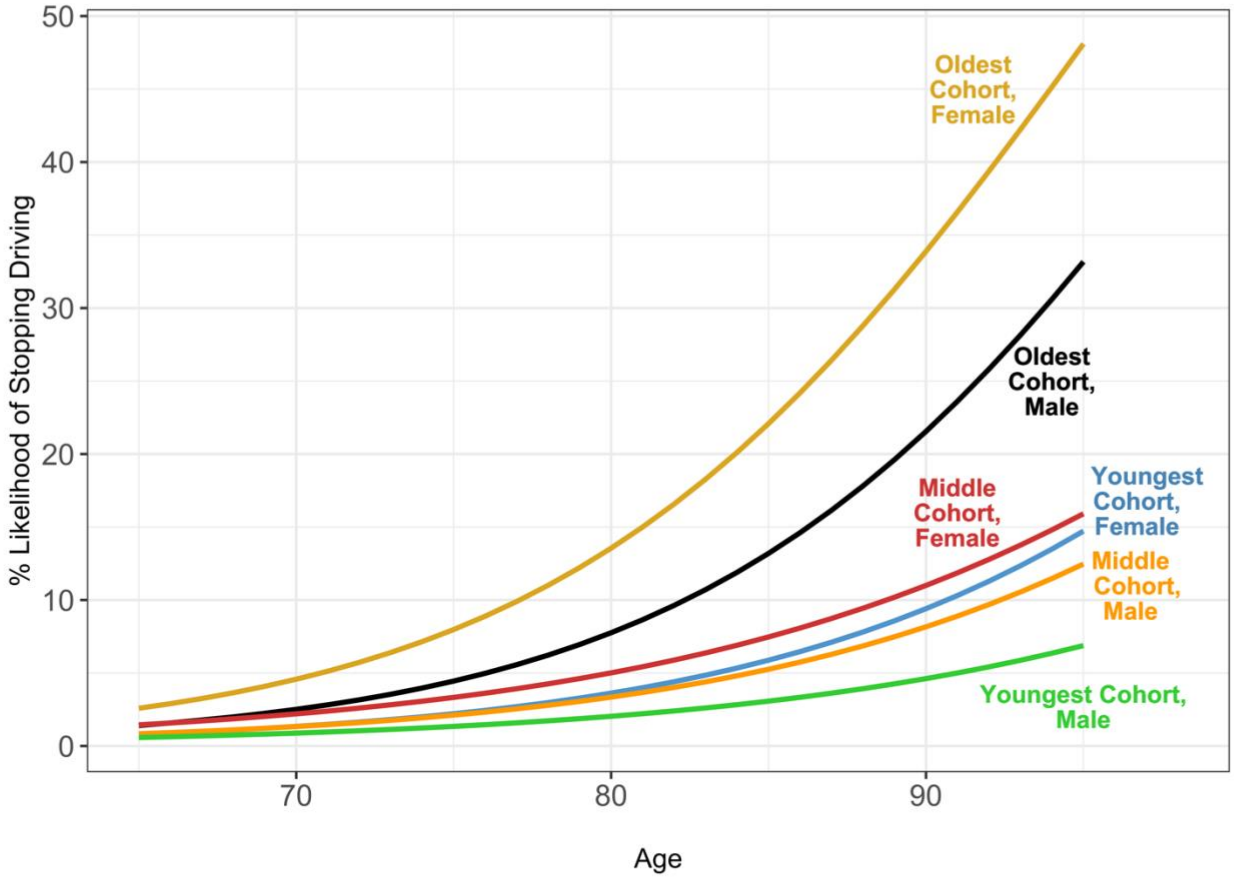


Figure 9. Predicted Likelihood of Stopping Driving by Age, Sex, and Cohort

The longitudinal data also show that, as we predicted, the gender gap in driving cessation has waned among recent cohorts of older adults. For the same reasons as men, women in recent cohorts likely had more driving experience than in earlier cohorts. Women's need for automobility was further bolstered by suburbanization and increased labor force participation, a combination which made travel for household and work next to impossible by modes other than the automobile (Walsh 2004). Gender differences in driving *limitation* remained largely the same across cohorts, perhaps due to underlying attitudinal differences between men and women (D'Ambrosio et al. 2008; Gwyther and Holland 2012) or women's greater willingness to rely on alternatives to driving (Barrett et al. 2018). Finally, the models show that regardless of cohort, men and women stopped and limited their driving at the same rate as they aged.

Driving cessation reduces crash risk, but has been associated with negative consequences for psychosocial and physical well-being, including decreased out-of-home activity levels (Marottoli et al. 2000), reduced networks of friends (Mezuk and Rebok 2008) perhaps leading to increased depression (Fonda et al. 2001; Marottoli et al. 1997) and accelerated health decline (Edwards et al. 2009).

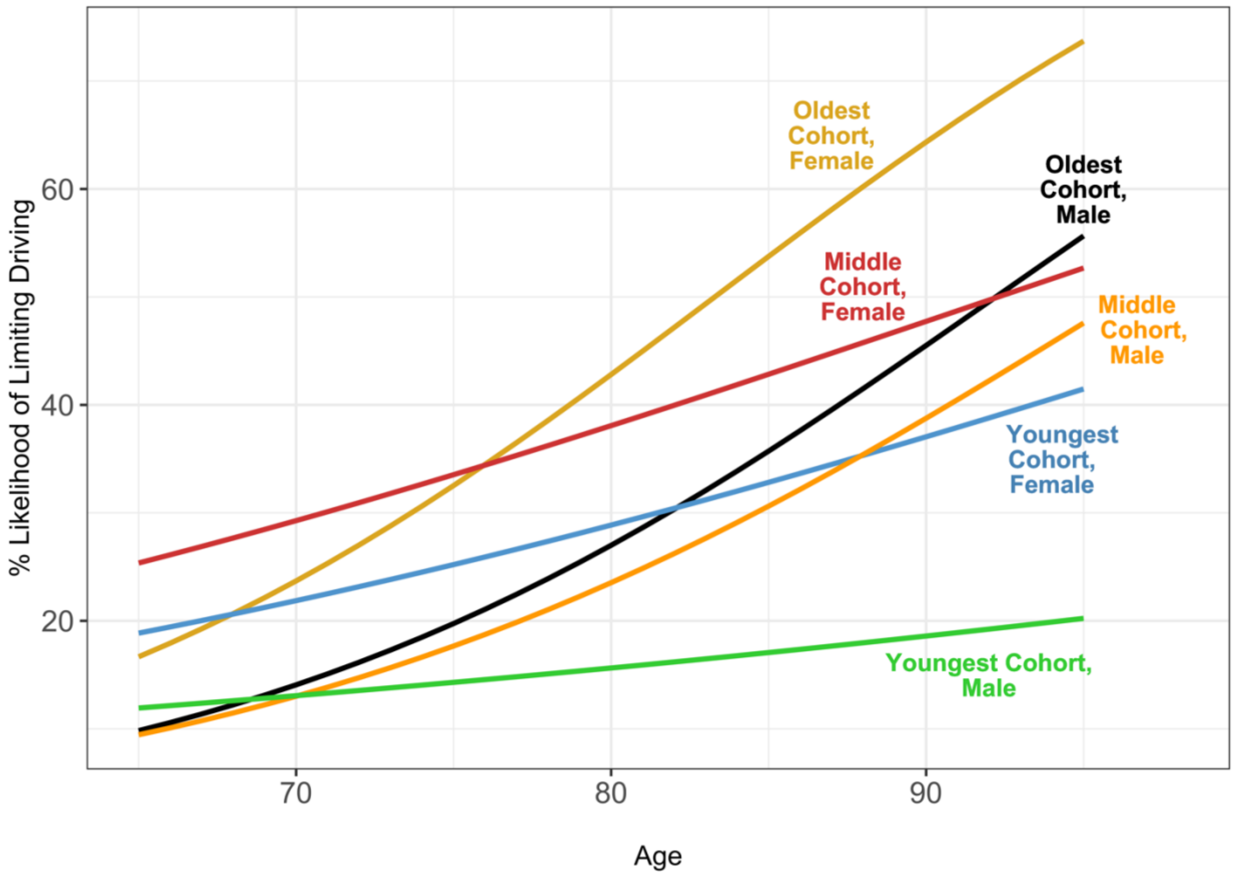


Figure 10. Predicted Likelihood of Limiting Driving by Age, Sex, and Cohort

Reliance on automobiles remains important because almost three-quarters of older Americans live in low-density suburban or rural areas (Kostyniuk et al. 2000) where alternative transportation options are limited (Glasgow and Blakely 2000). Even in dense urban areas, older adults may have difficulty walking, including walking to and from bus stops and stations and may prefer to travel by automobile. Driving means retaining functional independence and personal autonomy, but that must be balanced against the fact that older drivers incur increasing risk of injury and death from vehicular crashes compared to other age groups (Dickerson et al. 2007). To explore possible relationships between driving cessation, driving limitation, and the characteristics of the communities in which older Americans reside, we complemented the longitudinal data from the HRS with community descriptors and report on our findings in the next chapter.

Chapter 4. Driving Cessation and Residential Location among Older Adults

Because the capability to drive so directly influences the quality of life in older adults, in the previous chapter we used the HRS data to investigate the factors most associated with the limitation of driving and the decision to stop driving. We explored the health and personal characteristics that associated with driving limitation and cessation and in this chapter we explore relationships between the characteristics of neighborhoods in which older adults reside and their decisions to limit or stop driving. We also examine whether *changes* in residential location are associated with changes in older adults' driving status. In particular, we ask whether moves by older adults into dense, urban neighborhoods that are presumably more walkable and transit accessible than other neighborhood types, coincide with higher rates of driving limitation and/or cessation. To carry out this analysis, we developed several statistical models using HRS data complemented by the neighborhood typology and the accessibility measure outlined in Chapter 2.

To examine associations between driving status and residential location, we specifed another series of discrete-time logistic regression models, similar in form to those presented in the previous chapter. Like the earlier models, these also include two outcomes: the likelihood that an HRS panel member either limited or stopped driving between time t (the year of an HRS wave) and time $t + 2$ (the next HRS wave, two years later) and the HRS waves used were the same, from 1993 to 2016. The independent variables include characteristics that previous research shows are strongly associated with driving limitation and cessation such as age, sex, race, family structure, household wealth, and health.[1] Figure 2 in Chapter 2 presented a schematic of these characteristics and they were further explained in Figure 4. Table 5 shows basic descriptive data for the neighborhood types and, in particular, compares the occurrence of each neighborhood type among U.S. census tracts and among census tracts in which participants in the HRS panel reside. Table 6, shows the descriptive statistics for the model variables.

Each model also includes measures characterizing the built environment of the census tract in which a respondent resides, using census data, the neighborhood typology described above, and the accessibility indicator introduced above. These variables are used to evaluate associations between residential location, changes in residential location, and driving behavior. We test three distinct measures of the built environment. The first is a categorical measure of population density, identifying individuals who live in extremely dense census tracts (the 95th percentile or above) relative to those

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[1] The HRS data do not include information on travel behavior (e.g. trips by time of day) nor the specific environmental conditions in which older adults travel (e.g. weather). Therefore, we are unable to control for these characteristics in our models.

who do not. Transit and walking rates are highest in the densest urban communities where 2.8 percent of our sample lives. The second measure employs the job accessibility metric—the number of jobs that can be reached via transit from a given census tract in 30 minutes. We use this measure to classify individuals in the sample into two groups: those who live in census tracts having extremely high levels of accessibility by transit (the 95th percentile or above) and those who do not. About 3.1 percent of our sample live in these neighborhoods. We use a 95-percent threshold for both measures, since non-automotive modes are competitive with cars only in the most transit-rich neighborhoods (Smart & Klein, 2020). We tested alternative model specifications and found similar results when we varied some of the parameters over reasonable ranges. The third measure is the "neighborhood type" in which panel members resided or to which they had moved.

We include models for two distinct samples to address the two research questions. The first set of models examines the relationship between an individual's residential location—in particular, the built environment at this residential location—and changes in his or her driving status. This analysis includes all individuals in the panel who were drivers at time t, whose driver status was known at time $t + 2$, and for whom a full complement of independent variables was available. The models include a total of 13,803 unique respondents and 53,273 person-year observations.

The second set of models examines whether *changes* in residential relocation are associated with changes in driving status. For this analysis, we used the 3,877 individuals in the HRS panel who moved at some point during the study period, comprising 28.1 percent of the total sample. Because we are particularly interested in associations between residential relocation and changes in driving status, we focus on moves that, at least theoretically, are most likely to significantly influence travel behavior. Therefore, we measure associations between driving status and moves into and out of the following neighborhoods: extremely high density (95th percentile or above); extremely high levels of job access by transit (95th percentile or above); and the old urban neighborhood type. Roughly one percent of all relocations involve an individual moving into one of these clearly urban areas (either extremely high density, extremely high job access, or old urban) from another type of neighborhood.

Table 6 provides descriptive statistics showing relationships between residential location variables and changes in driving status. It includes data for the entire sample, including individuals who made at least one household move during the study period. In total, 24.3 percent of individuals in the sample stopped driving during the study period, while 46.8 percent of those who were able to drive started to limit their driving at some point. In a given two-year period (i.e., between two consecutive survey waves) just under six percent of drivers stopped driving while 16.5 percent of those in the sample limited their driving.

Table 5. Description of Neighborhood Types

	Description	Mean housing density[1]	Mean job accessibility[2]	Transit supply index[3]	% of tracts (all US)	% of tracts (HRS sample)
Old Urban	High-density, transit-rich areas, generally in central cities	27.5	533	4.2	4	1
Mixed Use	Urban commercial/industrial districts	5.2	181	1.1	5	3
Urban Residential	Residential neighborhoods, generally in central cities	5.9	147	0.8	14	9
Established Suburb	Older, mostly residential suburban neighborhoods	4.1	186	0.6	13	15
Patchwork	Mixture of residential and commercial land uses in suburban areas	1.7	94	0.1	18	22
New Development	Mostly new, low-density suburban neighborhoods, generally in outlying portions of metropolitan areas	1.4	68	0.0	27	25
Rural	Non-urban and non-suburban development	0.1	14	0.0	19	24

Adapted from Blumenberg et al. (2015).
[1]Housing units per acre
[2]Jobs within a 45-minute drive (in thousands)
[3]Composite index of transit supply; see Blumenberg et al. (2015) for details

Among all respondents, there is a clear relationship between residential location and driving behavior. Respondents who live in very dense neighborhoods and neighborhoods with high levels of job access via transit are much more likely to limit or stop driving than those residing in less dense areas and areas having less transit access to activities as indicated by jobs. The relationships between driving status and the seven-category neighborhood types is similar. With a few exceptions, respondents generally limit or stop driving at higher rates as their neighborhood of residence becomes more urban.

Table 6. Descriptive Statistics of Model Variables (Pooled)

Variable	**Value**		**Variable**	**Value**
Individual Characteristics			**Household Characteristics**	
Age (mean)	75.8		Wealth (mean)	$561,657
% male	46.9		% couple household	63.2
Race			% child nearby	58.1
% white	87.2		% moved	9.8
% black	6.7			
% Hispanic	4.5			
% other	1.7			
Health			**Cohort**	
% had stroke	8		% AHEAD (born pre-1924)	15.2
% major ailment	59.1		% CODA (born 1924-1930)	26.6
Eyesight			% HRS (born 1931-1941)	46
% excellent	8.5		% War Babies (born 1942-1947)	12.1
% very good	28.1			
% good	44.4			
% fair	14.8		N (individuals)	13,803
% poor/legally blind	4.1		N (person-years)	53,273

For movers, however, the association between changes in residential location and changes in driving status is less straightforward. In some cases, the behavior of movers mirrors the full sample, with moves to highly urban areas associated with a greater likelihood of limiting or stopping driving. For example, driving cessation appears to be associated with moves to neighborhoods with high access by public transit and to mixed-use development neighborhoods. However, it is not associated with moves to neighborhoods with high residential densities alone.

Of course, these descriptive findings do not reflect the range of characteristics that may be correlated with both residential location and changes in driving status, such as age, family structure, sex, race, financial status, and health. To obtain a more refined understanding of the relationship between built environment characteristics and the driving behavior of older adults, we turn to the model results.

Built Environment and Changes in Driving Status

The first set of multivariate models examines whether or not built-environment characteristics are associated with changes in driving status. Figure 11 presents the percentage change in the likelihood of limiting or stopping driving for all of the significant variables in our models including the residential location measures. The complete model results are presented in Table 7.

In all three models, coefficients of the control variables largely conform to the literature review findings. Age is strongly associated with driving cessation and limitation, with individuals being more likely to curtail and then stop driving as they grow older. Some 58% of panel members who eventually stopped driving reported that they limited their driving during the survey period prior to the one in which their driving ceased. Holding all other variables in the model constant, men are less likely to limit and stop driving than women, as are those who live near a child and those with more household wealth. Race and cohort also play roles in driving decisions. All else equal, non-whites are far more likely to limit or stop driving than whites, and younger cohorts have a lower propensity to reduce or stop driving than older cohorts.

Health-related variables are strongly correlated with driving behavior. Having at least one major ailment (arthritis, cancer, diabetes, a heart problem, or a lung problem) is correlated with limiting or stopping driving, as is having had a stroke at some point in the past. Eyesight is, not surprisingly, a powerful predictor of driving cessation, with an increase in the propensity to stop or limit driving as one's self-rated eyesight worsens.

Several of the residential location indicators—the primary variables of interest in this analysis—are also statistically significant predictors of driving behavior. The residential density and job access models show that those living in both extremely dense neighborhoods and in neighborhoods having very high levels of access to opportunities (as measured by employment concentrations) via transit show a high propensity to stop driving. All else equal, residents of census tracts having residential densities in the 95th percentile or higher are 48 percent more likely to stop driving than those who live in neighborhoods below this threshold; similarly, those residing in census tracts in which job access by transit is in the 95th percentile or higher are 70 percent more likely to stop driving than those living in areas with less transit accessibility. The built environment measures, however, are not associated with the decision to limit driving: residents of high density and high transit access neighborhoods are equally likely to limit their driving as residents of other census tracts. Research suggests that only the densest, most transit-rich neighborhoods offer competitive non-auto transportation options. However, focusing solely on census tracts with densities or job access by transit in the 95th percentile or above means that only a very small percentage of our sample live in these neighborhoods or relocate to them. Therefore, we also tested lower thresholds, specifically the 90th percentile and above as well as the 85th percentile and above. Results were consistent with the findings presented below.

The neighborhood typology model produced results similar to the findings from the density and job access models. Residents of old urban neighborhoods—the neighborhood type with by far the highest levels of residential density and transit supply—are 40 percent more likely to stop driving than those living in sprawling new development neighborhoods. Those in mixed-use neighborhoods—another urban neighborhood type—also show a high propensity to stop driving relative to new development residents (28 percent). Residents of established suburbs—older, moderately dense suburban neighborhoods with modest levels of transit supply—were 15 percent more likely to stop driving than new development residents. Finally, the urban residential neighborhood type is the only residential

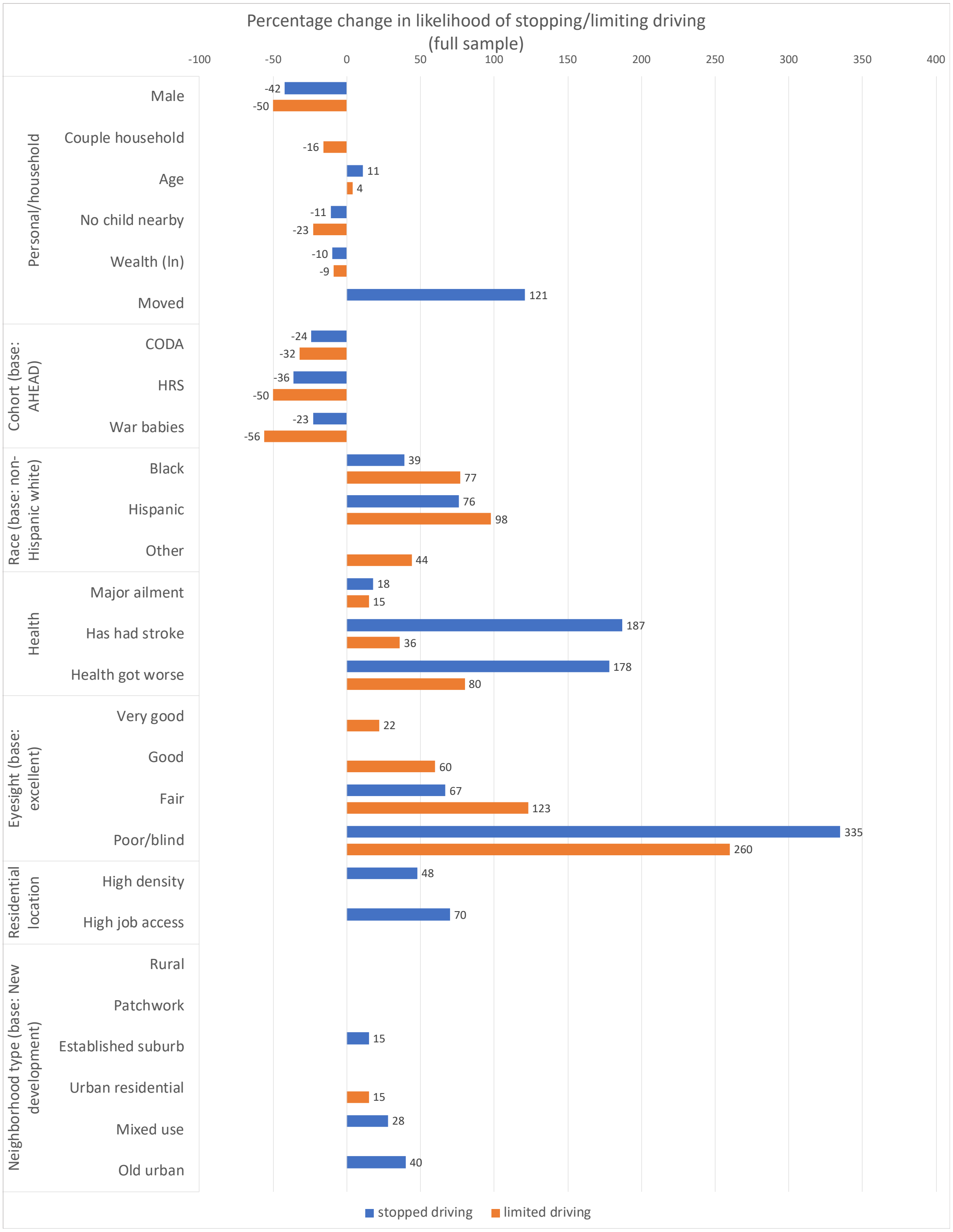

Figure 11. Percentage Change in the Likelihood of Stopping or Limiting Driving (Full Sample)

Table 7. Full Sample Model including Density Variables

Dependent variable	stop driving	limit driving	stop driving	limit driving	stop driving	limit driving
Residential location indicator	Density	Density	Job access	Job access	Neighborhood type	Neighborhood type
Male	-0.542***	-0.697***	-0.541***	-0.697***	-0.538***	-0.698***
	-0.043	-0.035	-0.043	-0.035	-0.043	-0.035
Couple household	0.068	-0.171***	0.077	-0.171***	0.077	-0.168***
	-0.044	-0.036	-0.044	-0.036	-0.044	-0.037
Age	0.103***	0.048***	0.103***	0.048***	0.103***	0.048***
	-0.004	-0.004	-0.004	-0.004	-0.004	-0.004
Cohort (base: Ahead)						
CODA	-0.270***	-0.389***	-0.267***	-0.388***	-0.264***	-0.385***
	-0.055	-0.054	-0.055	-0.054	-0.055	-0.054
HRS	-0.446***	-0.693***	-0.441***	-0.691***	-0.432***	-0.682***
	-0.07	-0.062	-0.07	-0.062	-0.07	-0.063
War Babies	-0.266*	-0.819***	-0.258	-0.817***	-0.253	-0.803***
	-0.132	-0.095	-0.132	-0.095	-0.132	-0.095
Race (base: white)						
Black/African American	0.330***	0.572***	0.308***	0.566***	0.326***	0.559***
	-0.062	-0.056	-0.062	-0.056	-0.062	-0.056
Hispanic	0.563***	0.685***	0.563***	0.684***	0.568***	0.683***
	-0.076	-0.073	-0.076	-0.072	-0.076	-0.073
Other	0.122	0.367**	0.13	0.366**	0.118	0.372**
	-0.167	-0.125	-0.167	-0.125	-0.167	-0.125
ln(household wealth)	-0.105***	-0.091***	-0.105***	-0.091***	-0.106***	-0.091***
	-0.006	-0.006	-0.006	-0.006	-0.006	-0.006
No child nearby	-0.115**	-0.254***	-0.113**	-0.254***	-0.110**	-0.249***
	-0.039	-0.032	-0.039	-0.032	-0.039	-0.032

Has major ailment	0.162***	0.144***	0.160***	0.144***	0.162***	0.146***
	-0.042	-0.033	-0.042	-0.033	-0.042	-0.033
Has had stroke	1.056***	0.310***	1.059***	0.311***	1.057***	0.310***
	-0.049	-0.06	-0.049	-0.06	-0.049	-0.06
Eyesight (base: excellent)						
Very good	-0.041	0.199**	-0.036	0.200**	-0.038	0.197**
	-0.092	-0.067	-0.092	-0.067	-0.092	-0.067
Good	0.134	0.473***	0.141	0.474***	0.139	0.469***
	-0.085	-0.063	-0.086	-0.063	-0.086	-0.063
Fair	0.512***	0.803***	0.520***	0.804***	0.521***	0.799***
	-0.089	-0.072	-0.09	-0.072	-0.09	-0.072
Poor/legally blind	1.470***	1.280***	1.480***	1.285***	1.481***	1.285***
	-0.096	-0.104	-0.096	-0.104	-0.096	-0.104
Health got worse	1.023***	0.589***	1.023***	0.590***	1.022***	0.590***
	-0.039	-0.035	-0.039	-0.035	-0.039	-0.035
Moved since last wave	0.794***	-0.101	0.795***	-0.1	0.795***	-0.09
	-0.049	-0.054	-0.05	-0.054	-0.05	-0.054
Density >= 95th percentile	0.391***	0.015				
	-0.097	-0.1				
Job access >= 95th percentile			0.530***	0.078		
			-0.087	-0.096		
Neighborhood type (base: New development)						
Rural					-0.059	0.078
					-0.06	-0.047
Patchwork					0.01	0.066
					-0.057	-0.047
Established suburb					0.143*	0.091
					-0.062	-0.052

Urban residential					-0.01	0.141*
					-0.07	-0.058
Mixed-use					0.244*	0.046
					-0.097	-0.09
Old urban					0.335*	-0.065
					-0.132	-0.146
Constant	-10.152***	-3.745***	-10.183***	-3.750***	-10.201***	-3.844***
	-0.399	-0.347	-0.399	-0.347	-0.401	-0.35
Observations	53,237	31,746	53,235	31,744	53,234	31,744
Log Likelihood	-10,203.04	-13,092.32	-10,193.24	-13,091.39	-10,198.99	-13,087.73
Akaike Inf. Crit.	20,448.08	26,226.63	20,428.48	26,224.78	20,449.98	26,227.46
Pseudo R^2	0.22	0.1	0.22	0.1	0.22	0.1

Note: $^{*}p < 0.05$ $^{**}p < 0.01$ $^{***}p<0.001$

location type to show an association with limiting driving. Those living in these neighborhoods are 15 percent more likely to limit their driving than their new development counterparts.

The foregoing analysis reveals that people living in densely-populated, transit-rich, urban locations, all else equal, are more likely to stop driving during a given time period than those residing in other types of neighborhoods. The second question is whether a change in driving status is associated with a move into or out of these types of communities. For example, it is possible that someone who wishes to (or must) stop or limit their driving may choose to relocate to a central-city neighborhood where alternative modes of transportation are more widely available. Similarly, an individual may relocate to an area with ample non-automotive transportation options and then decide to stop or limit their driving, either out of convenience or necessity.

To address the relationship between residential relocations and changes in driving status, the second set of models examined only those respondents who made household moves between time *t* and time *t + 2*. While we do not know whether a move preceded a change in driving behavior or *vice versa,* we are able to examine correlations between the two occurrences. The statistically significant findings are included in Figure 12 and the complete model results are in Table 8.

In these models, several of the control variables have effects similar to those from the full model in the earlier sections. Increasing age is strongly associated with a higher likelihood of limiting and stopping driving, as is having had a stroke and the presence of vision problems. Men are less likely to stop and limit driving, and higher household wealth is associated with a decreased propensity to reduce or stop driving.

There are, however, some notable differences between the models that include all panel members and those with movers only. Race is far less predictive of driving status among movers than in the larger sample, and cohort effects are also somewhat smaller among movers. The influence of one's children living nearby on driving status also differs by residential mobility. The models including all respondents show that individuals are more likely to continue driving if they did not live close to their children. For the models of movers only, the absence of nearby children in one's post-move neighborhood is not associated with driving cessation among movers, although it is associated with limiting driving.

The most notable differences between the models of all panelists and the movers-only models relate to residential location characteristics. While the models including movers and non-movers show strong associations between living in a dense, transit-rich neighborhood and driving cessation, the evidence is less convincing that residential *relocations* to such neighborhoods are correlated with driving cessation. Those moving into high-density census tracts, for example, are not more likely to stop driving than those moving between less dense census tracts. Similarly, individuals moving into old urban neighborhoods do not give up driving more readily than those moving between non-old urban neighborhoods. Only moving into a census tract with high access via transit is associated with an increase in driving cessation. These movers are almost twice as likely to give up driving than those moving between tracts with lower levels of transit access to jobs.

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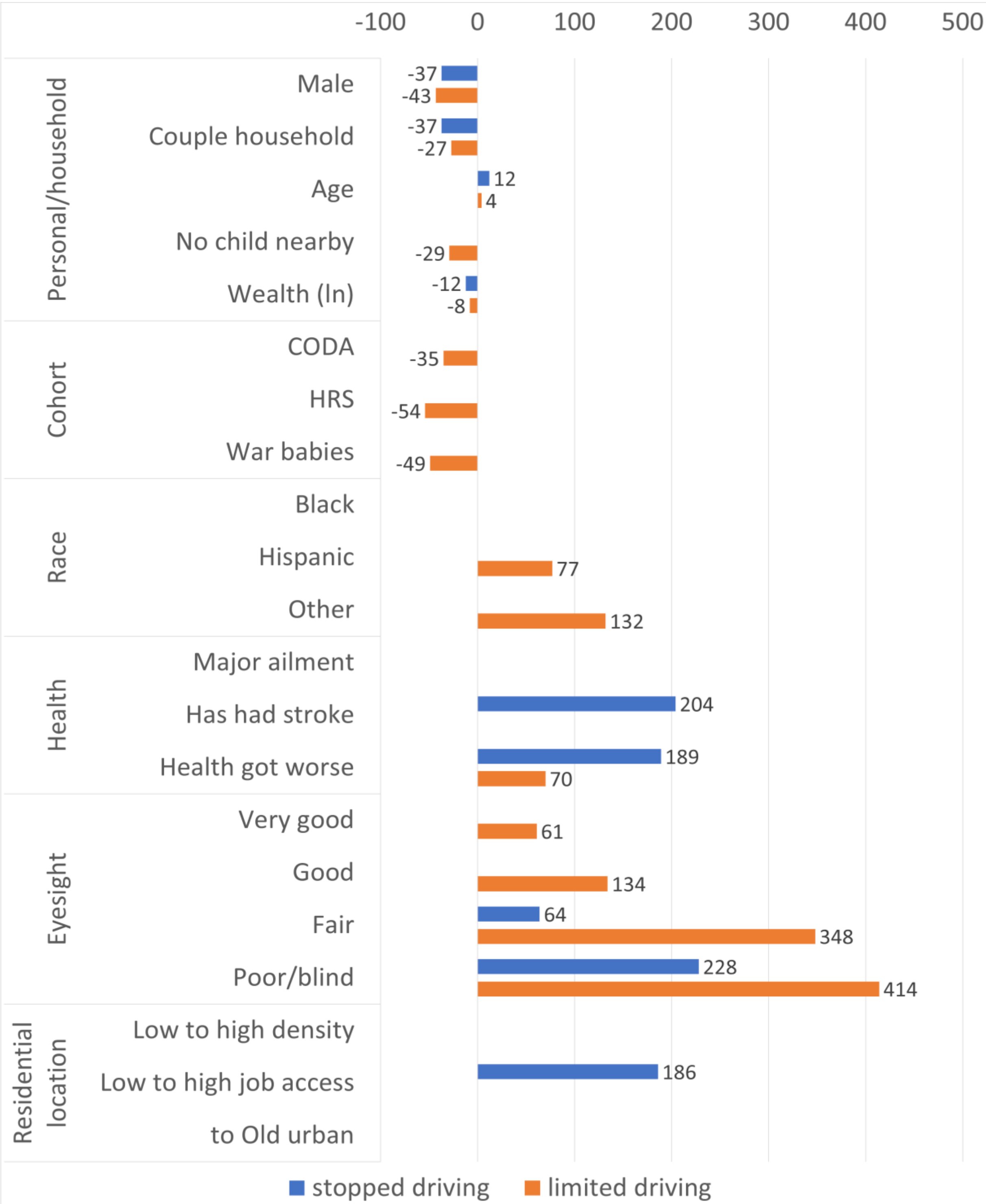

Figure 12. Percentage Change in the Likelihood of Stopping or Limiting Driving (Movers Only)

Table 8. Movers Only Model

Dependent variable	stop driving	limit driving	stop driving	limit driving	stop driving	limit driving
Residential location indicator	Density	Density	Job access	Job access	Neighborhood type	Neighborhood type
Male	-0.456***	-0.568***	-0.465***	-0.570***	-0.457***	-0.571***
	(0.101)	(0.116)	(0.101)	(0.116)	(0.101)	(0.116)
Couple household	-0.456***	-0.311**	-0.443***	-0.312**	-0.457***	-0.313**
	(0.105)	(0.117)	(0.105)	(0.117)	(0.105)	(0.117)
Age	0.114***	0.041**	0.115***	0.042**	0.114***	0.042**
	(0.011)	(0.013)	(0.011)	(0.013)	(0.011)	(0.013)
Cohort (base: Ahead)						
CODA	-0.080	-0.433*	-0.077	-0.430*	-0.082	-0.428*
	(0.130)	(0.175)	(0.131)	(0.175)	(0.130)	(0.175)
HRS	-0.298	-0.779***	-0.286	-0.768***	-0.294	-0.767***
	(0.176)	(0.206)	(0.176)	(0.206)	(0.175)	(0.206)
War babies	-0.012	-0.689*	-0.004	-0.681*	-0.010	-0.680*
	(0.315)	(0.312)	(0.316)	(0.312)	(0.315)	(0.312)
Race (base: white)						
Black/African American	-0.037	0.386	-0.055	0.386	-0.030	0.386
	(0.166)	(0.204)	(0.167)	(0.204)	(0.167)	(0.204)
Hispanic	0.036	0.573*	0.014	0.568*	0.036	0.573*
	(0.210)	(0.247)	(0.211)	(0.248)	(0.210)	(0.248)
Other	0.521	0.842*	0.514	0.847*	0.521	0.853*
	(0.359)	(0.370)	(0.358)	(0.370)	(0.359)	(0.369)
ln(household wealth)	-0.133***	-0.079***	-0.134***	-0.079***	-0.133***	-0.079***
	(0.012)	(0.016)	(0.012)	(0.016)	(0.012)	(0.016)
No child nearby	-0.164	-0.347**	-0.162	-0.346**	-0.165	-0.346**
	(0.093)	(0.106)	(0.093)	(0.106)	(0.093)	(0.106)
Has major ailment	0.046	0.135	0.037	0.133	0.043	0.133
	(0.099)	(0.111)	(0.100)	(0.111)	(0.099)	(0.111)
Has had stroke	1.112***	0.277	1.121***	0.279	1.109***	0.277
	(0.116)	(0.181)	(0.116)	(0.181)	(0.116)	(0.181)
Eyesight (base: excellent)						
Very good	-0.055	0.474*	-0.025	0.469*	-0.058	0.468*

	(0.209)	(0.232)	(0.211)	(0.232)	(0.209)	(0.232)
Good	0.186	0.851^{***}	0.207	0.848^{***}	0.184	0.847^{***}
	(0.195)	(0.221)	(0.196)	(0.221)	(0.195)	(0.221)
Fair	0.496^{*}	1.500^{***}	0.514^{*}	1.492^{***}	0.497^{*}	1.493^{***}
	(0.207)	(0.245)	(0.209)	(0.245)	(0.207)	(0.245)
Poor/legally blind	1.188^{***}	1.636^{***}	1.228^{***}	1.633^{***}	1.185^{***}	1.633^{***}
	(0.227)	(0.321)	(0.229)	(0.320)	(0.227)	(0.320)
Health got worse	1.063^{***}	0.532^{***}	1.058^{***}	0.533^{***}	1.064^{***}	0.534^{***}
	(0.093)	(0.115)	(0.093)	(0.115)	(0.093)	(0.115)
Density (base: not a low-to-high density move)						
Low to high density	0.293	0.468				
	(0.434)	(0.535)				
Job access (base: not a low-to-high job access move)						
Low to high job access			1.052^{***}	0.147		
			(0.309)	(0.509)		
Neighborhood type (base: not a move into an old urban neighborhood						
Moved into old urban					0.169	-0.057
					(0.540)	(0.722)
Constant	-9.803^{***}	-3.693^{**}	-9.862^{***}	-3.748^{**}	-9.800^{***}	-3.753^{***}
	(0.942)	(1.141)	(0.945)	(1.139)	(0.943)	(1.139)
Observations	5,391	2,970	5,391	2,970	5,389	2,970
Log Likelihood	-1,624.940	-1,194.999	-1,619.825	-1,195.321	-1,624.610	-1,195.359
Akaike Inf. Crit.	3,289.879	2,429.999	3,279.651	2,430.642	3,289.219	2,430.718
Pseudo R^2	0.27	0.12	0.28	0.12	0.27	0.12

Note: $^{*}p < 0.05$ $^{**}p < 0.01$ $^{***}p<0.001$

Discussion and Conclusion

Findings from the models with all HRS panel members are consistent with expectations based on previous research involving people of all ages. Density and other urban built environment features are associated with less driving and lower levels of vehicle ownership (Bhat & Guo, 2007; Cao et al., 2007; Chen et al., 2008). Furthermore, individuals with a preference for non-automotive modes of transportation are more likely than others to self-select into walkable and transit-rich areas. Therefore, it is not surprising that older adults show a greater propensity to reduce or give up driving if they reside in these types of neighborhoods. This raises quality-of-life questions about older adults who give up driving in dense urban neighborhoods versus those that give up driving in suburban and rural locations: are the negative effects associated with driving cessation less acute for those who stop driving in areas where desired destinations are more accessible? Do those who cease driving in less dense environments depend more upon friends and relatives for their mobility? These are topics for further study.

Given the difficulty and potential risks associated with driving as people age, it is tempting to think that older adults might find opportunity and satisfaction in neighborhoods where they are less vehicle dependent—where they can walk and potentially take transit to destinations. However, the results presented above, combined with prior research on the residential location choices of older adults, suggest that this type of move is rather rare. Despite stated interest in moving to walkable and transit-rich neighborhoods among older adults, most age in place. When older adults *do* move to densely populated neighborhoods with high levels of transit supply, their new residential location does not have a clear and consistent influence on their driving behavior. Previous research shows that dense urban neighborhoods are sometimes not conducive to walking and transit use by older Americans if they are characterized by high crime rates, littered streets, and heavy traffic flows (Loukaitou-Sideris et al., 2019).

Conversely, we speculated that moves away from dense urban neighborhoods might make older adults more automobile dependent and less likely to stop or limit driving. Model results, however, indicate that this is not the case. In fact, the opposite is true: moving away from dense, transit-rich, urban neighborhoods was associated with an *increased* likelihood of stopping driving cessation. It is difficult to explain this finding, and previous research yields few clues. One potential explanation is that some movers relocate from an independent living situation into an assisted living facility, nursing home, or some other senior care facility, or closer to friends and family members. All else equal, these movers might be more prone to stop driving than others. While the HRS asks participants about the type of residence in which they live, questions about senior care facilities are not asked of the entire sample in each survey wave. Because eliminating non-respondents to this question would dramatically reduce the sample size, we were unable to explore potential relationships between residential relocations, senior living facilities, and driving cessation.

These somewhat counterintuitive findings highlight the complexity of older adults' driving decisions. Our models show a clear relationship between residential location and the likelihood of reducing or stopping driving, but more research is necessary to fully understand how neighborhoods affect the driving habits of older adults. In particular, qualitative analyses may be well suited to untangling issues that we are unable to address in this analysis. Surveys, interviews, and focus groups would likely yield further insight into the role of neighborhood self-selection in driving-related outcomes; qualitative research could also address relationships between residential location and quality of life for those who give up driving. Similarly, reasons for changing one's driving status and changing one's residential location are both personal and diverse, and may require a qualitative approach to understand the chronology of these choices and the motivations behind them.

Driving is important to many older adults as a means of mobility which enables them to maintain independence, social connections, and peace of mind. Nevertheless, the risks associated with driving increase with age, and many older adults face difficult decisions about when to limit or stop driving. This analysis shows that, all else equal, older adults are more likely to give up driving if they live in densely populated urban areas with high levels of transit supply. However, only a small percentage of older adults live in and move to these types of neighborhoods, a percentage that, according to other sources, has declined over time (Hermann, 2019). Cities may have qualities that make them ideal places for growing old, including the ability to travel by modes other than the automobile. Our findings suggest that for older adults to take advantage of these characteristics they need to age in place – in urban neighborhoods. With respect to driving reduction and cessation, older adults, therefore, would benefit from policies to foster high-quality urban neighborhoods that not only attract younger adults (as is currently the trend) but also retain them as they age through the lifecycle.

Chapter 5. Conclusion

The relationship between driving and aging is complex, changing rapidly, and important to California policymaking in many ways. People are living longer, birth rates are declining, and migration into California has slowed. These trends taken together mean that the population of this state will continue to grow older at an accelerating rate as the generation of baby boomers enters old age. In comparison to other parts of the country, Californians are still pretty young. The median age of people in this state is among the 10 youngest among the fifty states. According to state projections, however, by 2030 more than 9 million Californians will be over the age of 65, 3 million more than today. Within a decade, more than 20% of the state's residents will be seniors — a higher proportion than the current rate in Florida, a state famous for its large population of snowbird retirees. The highest rates of growth among those over sixty-five in California are expected to take place outside the largest population centers (Levin, 2019).

The aging population is changing steadily. In the past, older people were less likely to be licensed drivers than members of younger cohorts who grew up with the auto. During earlier times men were more likely to be drivers than women. Today a very large proportion of people entering old age have driven throughout most of their adult lives and women are as likely to be drivers as men. A primary function of the state is regulating driving and licensing drivers to insure safety. This requires an understanding of the processes of driving cessation which are strongly associated with advancing age. While most older adults are safe drivers, aging eventually leads to changes in health that require driving limitation and cessation. Safety is critically important and understanding relationships between aging and driving are necessary for many reasons in addition to safety.

If as many as one in five Californians will be elderly in less than a decade, there also is a pressing need to plan today the physical communities in which they will reside and the range of services they will require. Because automobiles are the principal means by which people access medical care, grocery shopping, religious observations, and many other services, we must increase our understanding of relationships among cars and people as they age. In addition to driving there are, of course, many alternatives ways to access opportunities and those are changing rapidly. People who cannot drive themselves often depend on friends and family members for mobility via autos. Many older Californians live in dense communities in which diverse activities are located in safe and convenient walking distance. Some older people who live in those areas often choose to walk to their destinations, but others cannot do so for health reasons of for fear of crime and traffic hazards in their neighborhoods.

Public transit is an alternative to driving for many, but transit does not adequately serve areas where most older Californians reside. Because some older people cannot drive autos or use transit, many communities provide alternative services in the form of paratransit or volunteer-provided rides. Those programs are costly of public resources and fall short of satisfying most older people. Taxicabs and, in recent years, new private-sector options including ridehailing services like Lyft and Uber, provide additional alternatives to cars and transit for those who have smart phones, credit cards, sufficient funds, and are technology savvy. Looking to the future, automated driving eventually will become yet another option. The variation in mobility options for older Californians creates a very wide range of policy choices making planning complicated because conditions and services are changing rapidly.

This study extended explorations by the authors in earlier works that examined many challenging dimensions of the evolving relationships between driving, mobility, and older people. In one study we found that low income elderly people living in transit oriented neighborhoods near downtown Los Angeles were far less likely than expected to use transit and neighborhood facilities because of fears of crime, traffic hazards, and streets laden with litter and populated by drug dealers (Loukaitou-Sideris et. al., 2019). In another study we examined the propensity of older people to stay in the paid workforce past "normal" retirement age as a function of their access to automobiles and excellent public transit (Schouten, Blumenberg, Pinski, and Wachs, 2019).   While those studies shed light on relationships between aging, mobility, and the physical arrangement of communities, they led us to believe that studies of older populations, their travel, and communities at a single point in time, often called cross-sectional, were incomplete in two important ways. Most data sources allow for comparisons of different people and groups at one point in time. But relationships among variables like aging and driving are dynamic and changing over time. Relationships measured in 2020 differ from those reported twenty or forty years ago and differ from those likely to occur in the future. Cohorts— groups of people born during the same decade—differ from one another. People born in the forties had no smart phones or ridehailing options; people who will be elderly a decade from today grew older with different options, choices, and lifestyles.

In addition to comparing people at one point in time we decided that it was important to compare individuals over time as they aged and to compare generations, or cohorts, to one another. The HRS data allowed us to improve upon previous research by adding longitudinal analysis to more common cross sectional studies. The results presented in this report demonstrate that longitudinal analysis of aging and driving adds to our understanding of relationships among them. We showed that relationships among driving cessation, aging, and sex, are indeed evolving. Our models revealed, for example, that men and women limit and cease driving differently, and that the difference between the sexes is changing over time in ways that can be modeled when longitudinal data are available, though difficult to detect in cross-sectional data. Modelling travel and mode choices by older adults can become more accurate in the future by incorporating differences between cohorts as well as age, gender, and other socio-demographic variables.

We also used longitudinal models to show that density of activities and other urban built environment features are associated with less driving and lower levels of vehicle ownership (Bhat & Guo, 2007; Cao et al., 2007; Chen et al., 2008). Furthermore, individuals with a preference for non-automotive modes of transportation are more likely than others to self-select into walkable and transit-rich areas. Therefore, it is not surprising that older adults show greater propensity to reduce or give up driving if they reside in these types of neighborhoods. Longitudinal models also demonstrate that these preferences and patterns differ over time among cohorts and may change over time at least in part because the nature of residential environments has evolved over time.

The substantive findings reported in this study about cohort differences in driving cessation and the association between those differences and residential location are important in themselves to California policymakers engaged in long-term comprehensive planning for our aging population and the communities that will be occupied by our older population in future decades. Perhaps more importantly, this study demonstrated the utility of longitudinal information and models for the understanding of older populations and their travel. Future research using longitudinal panel data could extend our findings from earlier studies by, for example, studying the way changes over time in relationships between driving and transit access relate to decisions by older adults to remain in the active or paid work force and to engage in volunteer activities. Measures of quality of life in older years and self-reported life satisfaction could also be examined using longitudinal analysis as older populations experience in health, residential location, and driving. The findings also suggest but did not test the value of longitudinal studies of aging populations with respect to topics beyond mobility and travel.

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