TRAVEL PATTERNS OF THE ELDERLY: THE ROLE OF LAND USE

FINAL REPORT

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DISCLAIMER

ABSTRACT

This report examines relationships between residential location and travel patterns of the elderly. Using the 1995 Nationwide Personal Transportation Survey, we describe travel patterns of the elderly and estimate models of trip making, daily travel and transit use. Travel tends to shift to the middle part of the day with age, and trip making declines after age 75. We find that land use and travel relationships are largely the same for the elderly as for the non-elderly, though there is some evidence that the oldest elderly are more sensitive to local accessibility. Based on our findings, we consider the potential effectiveness of various land use strategies. Promoting more transit-friendly, mixed-use communities will increase local accessibility, but current preferences for automobile travel, low-density living environments, and the benefits of aging in place suggest that such strategies will play a limited role in addressing mobility problems of the elderly. Safer cars and transportation facilities, behavioral adjustments, and development of paratransit options more competitive with the private vehicle may be effective strategies for addressing mobility of the elderly.

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CHAPTER ONE
INTRODUCTION

The rapid growth of the elderly population may be creating special transportation challenges. People who are reaching retirement age have been drivers throughout their adult lives. The elderly are likely to become transportation disadvantaged as the aging process takes its toll. Aging often leads to physical disabilities that make driving difficult, hazardous, or impossible. Elderly drivers are more likely to be involved in crashes (based on exposure rates), and are more likely to suffer serious or fatal injury in crashes. Available evidence suggests that the elderly hold on to their cars as long as possible in order to retain their mobility (Rosenbloom, 2001). They do not rely more heavily on public transit. Indeed, the elderly use public transit less than the non-elderly. When the elderly can no longer drive, mobility may be seriously compromised, especially in areas where there is no suitable alternative to the car. Since mobility is critical to quality of life, those without mobility may suffer isolation, depression, and other ills.

At the time this project was funded, the intent of the research was to determine whether public transportation might play a larger role in serving the demands of the elderly in the future. The research had the following objectives:

1. Document and describe travel patterns of the elderly.
2. Explain travel patterns as a function of age, household and individual characteristics, residential location, and attitudes.
3. Explore public transportation service alternatives that better address the travel patterns of the elderly.

Shortly after the project was funded, three new studies appeared. The European Conference of Ministers of Transport (ECMT) issued a Round Table Report, *Transport and Ageing of the Population* (2000). Included in the report was a comparative discussion of travel patterns of the elderly in the US and in Europe. The Transportation Research Board was finishing a report on mobility issues of the elderly (2002, forthcoming). This report includes a chapter on elderly travel patterns and another on public transit. Finally, the Transit Cooperative Research Program had funded Project B-19, Improving Public Transit Options for Older Persons (WESTAT, 2000).

In order to avoid duplicating these studies, this research was restructured to emphasize the role of land use and residential location in elderly travel. We therefore briefly summarize travel patterns of the elderly, and examine travel patterns and their relationship to socioeconomic, demographic, and geographic factors. However, the focus of the report is on the role of land use. Our assessment of ways to better address the travel patterns of the elderly considers both transit and land use policy.

Land use planning is increasingly seen as an important strategy for solving transportation problems. It is argued that low-density, dispersed land use patterns foster automobile dependence. Decades of such development in US metropolitan areas is both the cause and result of the dominance of auto travel and the consequent decline of both public transport and the use of non-motorized modes. Many problems are associated with auto dependence, among them the mobility of the transportation disadvantaged—those who do not have access to a car, or who are either unwilling or unable to drive a car. Transportation disadvantage has become more critical, as an increasing share of the US population resides in suburban, lower-density areas, and as alternative modes become ever less competitive with the private auto.

Is land use policy a viable strategy for addressing the mobility needs of the elderly? Will policies that promote higher density, mixed-used environments provide increased levels of accessibility, and hence reduce reliance on the auto? Will such environments be sufficiently attractive to the elderly that they will relocate, rather than aging in place? Will the elderly be more likely to walk or use public transit when walking is convenient and transit is available?

This report presents the results of our research. We find that land use and travel relationships are largely the same for the elderly as for the non-elderly, though there is some evidence that the oldest elderly are more sensitive to local accessibility. Based on our findings, we consider the potential effectiveness of various land use strategies. Promoting more transit-friendly, mixed-use communities will increase local accessibility, but current preferences for automobile travel, low-density living environments and the benefits of aging in place suggest that such strategies will play a limited role in addressing mobility problems of the elderly. Moreover, most elderly are expected to "age in place," which implies remaining in suburban residential areas. Hence transit options must address such environments. Policies to encourage the elderly to move to more transit-friendly environments must consider the consequences of leaving strong social networks and familiar surroundings.

The remainder of this report is organized as follows. Chapter Two presents a literature review. The first part deals with the concept of elderly mobility. Then we summarize the existing literature on land use and travel patterns and provide some context by describing larger urban development trends. Chapter Three and Chapter Four present some descriptive statistics of socio-economic, location, and travel characteristics across age cohorts of the elderly. Chapter Five presents results of models of total daily travel as a function of land use characteristics. Since public transit use is such an important aspect of land use policy discussions, we model transit use in a similar manner. Chapter Six summarizes results and discusses the potential of land use policy to promote accessibility and reduce reliance on the private automobile.

CHAPTER TWO
LITERATURE REVIEW

The Bureau of the Census defines the elderly as those who are 65 or over. According to the Bureau of Census (2000), about 20 percent of the total population will be over 65 in 2030, compared to 12.4 percent as of 2000. The rapid growth of the older population is creating special transportation challenges. With increasing age, the elderly have more difficulties with driving. Research indicates that many older drivers experience delayed reactions and various vision problems (USDOT, 1997; Fozard, 1990; Goggin, et al., 1989). In a society where the automobile provides a level of mobility unparalleled by any other travel modes, the loss of driving ability dramatically impacts the lifestyle of the elderly. It reduces personal independence and accessibility to activities, and eventually may result in isolation from the rest of the society (Carp, 1988). Many seniors identify mobility as a critical element of overall life satisfaction (Coughlin, 2001).

MOBILITY AND THE ELDERLY

Travel is fundamental to conducting everyday activities—work, shopping, visiting friends, school. Mobility, or the ability to travel depends on individual resources: time, money, car availability, and physical capacity. Mobility also depends on the supply of transportation services and the spatial distribution of activity destinations. Accessibility refers to the ease of movement between places, and hence is a function of spatial structure and transportation supply. As movement between any two places becomes less costly, accessibility increases. Accessibility also includes the concept of attractiveness: the opportunities that are located within a given place. All else equal, as land-use pattern become more dispersed, individuals require more resources (cars, money) to maintain mobility. Similarly, for any given land-use distribution, an individual's mobility increases with the supply of transportation services available and the ability to use or purchase these services. Accessibility may become increasingly important with age as mobility declines.

Mobility contributes to well-being by allowing people to meet their own needs. Well-being, defined as the presence of self-esteem, feelings of usefulness, and happiness, depends on an individual's success in meeting his or her own needs (Lazarus, 1966; Lewin, 1951; Maslow, 1964). Transportation enables people to maintain their needs for daily life maintenance and social contact. According to Rosow (1967), the key problem of later life is not health care or economic well-being, but social integration. Generally, there are two indicators of social integration: one is participation in social roles, such as club member, volunteer, and religious service; the other is interaction with social networks or social support, for example, visiting friends, neighbors, and relatives (Glasgow, 2000). Past research has shown that participation as club members or volunteers and in church is positively associated with health and longevity (Moen et al.,1989; Young & Glasgow, 1998). According to Glasgow (2000), non-metropolitan elderly with higher mobility (drivers) are associated with higher levels of participation in social roles and interaction with social networks than non-drivers. Ability to travel promotes older individuals' social integration, and greater social integration leads to physical and psychological well-being (Pillemer & Glasgow, 2000; Wentowski, 1981).

Survey research indicates that many seniors identify mobility as a critical element in life satisfaction (Coughlin, 2001). Reduced mobility among older persons is accompanied by lower self-esteem, feelings of uselessness, loneliness, unhappiness, and depression (Butler, 1977). Older drivers facing the reduction of cessation of driving expect substantially reduced mobility and undesirable consequences, including loss of personal independence, social isolation, and reduced (or even eliminated) access to essential services (Burhardt, et al., 1998). Mobility is therefore very important for quality of life of the elderly.

As will be shown in the next section, travel does not decrease with age until after about age 75. Among the "younger" elderly, non-work trips are substituted for work trips, and among all elderly, about 90 percent of all trips are made by car. It appears that physical capacity limits travel after age 75; vision and hearing problems, physical movement problems, and reduced energy may explain observed lower rates of travel among the oldest old.

Social and demographic trends show that the elderly are better educated, wealthier, and healthier than ever before. Life expectancy has increased dramatically: The average expectancy of additional years of life at age 65 increased from 14.3 years in 1960 to 17.4 years in 1991. As a result, the over 85 cohort is the fastest growing cohort in the US population. Although the disability and institutionalization rates of the elderly continue to decline, it is also the case that about half of those over 85 required some personal assistance in performing basic activities in 1990-91 (US Census, 1996). Rosenbloom (2001) points out that care-giving may be a big problem in the future, given the low birth rates of "baby boomers". In sum, mobility is critical for quality of life of the elderly, but when physical frailty starts to take its toll and driving becomes difficult or impossible, mobility may be severely constrained.

TRAVEL PATTERNS AMONG THE ELDERLY

Mobility issues associated with the elderly have been of great interest to researchers and transportation planners in the recent past. Rosenbloom (2000) found that average daily trips and travel distance decline significantly for the elderly. It is no surprise that the elderly travel less than the non-elderly, since most of the elderly are not employed. For non-work travel, Rosenbloom (2001) found that older men under 85 take more non-work trips than the younger men, while older women take fewer trips than younger women, but the drop is not large. She concludes that the elderly are very active and mobile after they reach 65 and even 75. However, the very old have dramatically lower mobility levels than younger elderly (Rosenbloom, 1995, 2000; Tacken, 1998; Burkhardt, et al., 1999). According to the 1995 NPTS data, an average elderly person (over 65) makes 3.4 trips and travel 24.4 miles per day, compared to only 1.5 trips and 9.1 miles for those above 85 (Rosenbloom, 2000).

For many older people, especially men, driving has been a large part of their adult lives and is closely identified with their self-perceived roles in family and society. The ability to drive is closely linked with overall mobility. Those with a driver's license make significantly more trips and travel longer distances than those without a license (Rosenbloom, 2000). The share of trips made by car is similar for the elderly and non-elderly (Rosenbloom, 2000).

Rosenbloom also examined mode choice among the elderly. The share of automobile is 90 percent for those between 65 and 84, and dramatically drops to 80 percent for those above 85. The elderly are more likely to travel as a car passenger than the non-elderly. The transit share between the elderly and non-elderly is about the same (2%). The elderly have a somewhat larger share of walking trips (5.5%) than the non-elderly (4.6%). For those who are above 85, transit use accounts for 2.3 percent of total travel, while walking accounts for 11.2 percent. The difficulty of getting on a bus and the problems associated with standing in moving vehicles likely deter the elderly from taking transit. Safety issues, such as fear of crime and possibility of suffering personal injury during a ride, may also be important considerations.

Little research has been conducted on the relationship between travel patterns and residential location among the elderly. Rosenbloom (2001) examined travel characteristics of the elderly by residential location based on 1995 NPTS data. She found that the elderly living in suburban or rural areas made more trips and travel longer distances than those living in urban areas. In addition, older people living outside urban cores make more of their trips in a car than those who live in central cities.

PRIOR RESEARCH ON RESIDENTIAL LOCATION AND TRAVEL[1]

The relationship between land use and transportation has been subject to extensive research by geographers, planners, urban economists and others.[2] The history of the Twentieth Century is one of growing car ownership and use, declining use of transit and other modes, and the decentralization of both population and employment. Trends in travel and land use have complimented and re-enforced one another: growing car ownership generated demand for highways, development of the highway system changed accessibility patterns, and population and jobs responded to these new patterns of accessibility (Jackson, 1986; Muller, 1981, 1995). By 1990, the suburbs of US metropolitan areas were home to about 62 percent of the metropolitan population and 52 percent of the jobs. At the same time, per capita car ownership and travel have reached all-time highs (Pisarksy, 1996).

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[1] This section is drawn from Giuliano, 2000.
[2] See reviews by Giuliano, 1995; Anas, Arnott, and Small, 1998; Pickrell, 1999.

There is no question that from a broad perspective, land use and transportation trends are closely related. However, the historical record does not necessarily provide useful evidence for understanding land use and transportation at a single point in time, and the empirical research on relationships between daily travel and land use characteristics is far less clear.

Metropolitan Size and Density

Extensive research has been conducted on the relationship between metropolitan density and modal split, commute trip length and total automobile travel. Newman and Kenworthy (1989a, 1989b, 1998) conducted comparative studies of per capita gasoline consumption and metropolitan densities. A comparison of cities around the world yielded a non-linear relationship of increasing per capita gasoline consumption with declining density. Their work has been extensively criticized, primarily because per capita fuel consumption is an indirect measure of auto travel and because they fail to account for many other factors which affect automobile use, such as the employment rate or household size (Gordon and Richardson, 1989; Gomez-Ibañez, 1991).

Pushkarev and Zupan (1977) documented a positive relationship between population density and transit use, using data from 105 urbanized areas for 1960 and 1970. Gordon, Richardson, and Jun (1991) found that cities with higher average densities have longer automobile commute times than those with lower average densities. Noting that density is a measure of concentration, the authors conclude that shorter commutes indicate greater efficiency of low density urban form: decentralization of both population and jobs allows people to economize to a greater extent in selecting their job and housing locations. However, city size is correlated with density, so the most dense cities are also the largest cities, and longer commutes are an expected characteristics of large cities.

Pushkarev and Zupan (1977) also found a significant but small relationship between residential density and car ownership: a large increase in residential density is associated with a small decrease in car ownership. Schimek (1996) found a modest relationship between the two variables, and concluded that the primary determinants of household car ownership were household income, household size, and the number of workers per household. Transit availability was also found to be significant. Schimek also examined relationship between residential density, vehicle miles traveled (VMT) and the number of vehicle trips. Results showed that both VMT and vehicle trips have a significant but small relationship with density: a 10 percent increase in density is associated with a 0.7 percent decrease in VMT. Downs (1992) used simple simulation studies to demonstrate the same result for commuting distance: very large increases in metropolitan density are required to achieve rather modest reductions in average commute length.

Niemeier and Rutherford (1994) examined non-motorized travel. Higher density is associated with fewer daily VMT and fewer daily trips by all modes. The daily walking trip rate increases at an increasing rate with population density greater than 5,000 persons per square mile. Walking trips are also most frequent in urban areas with population of 1 million or more and presence of rail transit. However, the observed relationships do not control for demographic factors that are also related to urban density (e.g., age, family size, household income), and therefore likely overstate the actual relationship of density to trip rates and VMT. Residents of high-density areas are more likely to be elderly, have low income, and live in single-person households—all factors associated with less travel.

Neighborhood Characteristics

The New Urbanism movement has generated great interest in the relationship between travel and the spatial characteristics of the local environment. Although widely embraced by urban planners, the movement was the creation of architects, and its claims regarding transportation-related environmental benefits remain largely unproven[3]. New Urbanism focuses on the neighborhood environment and emphasizes mixed use around a defined center, a fine network of streets and convenient pedestrian and transit access (Duany and Plater-Zybeck, 1994). These accessible neighborhood designs are expected to reduce automobile travel and increase transit and non-motorized travel.

Several studies have compared automobile travel in "new urbanist-type" communities with traditional suburban communities. Simple comparisons show substantially less VMT in the new urbanist type communities, but when household and

[3] See recent reviews by Pickrell (1999); Boarnet and Crane (2001),

other characteristics are considered, differences in travel are much smaller and in some cases not significant (Kulash, Anglin, and Marks, 1990; Gordon and Peers, 1991; Cervero and Gorham, 1995). Hanson and Schwab (1987) used data from Uppsala Sweden, and found that people living in areas with convenient access to local services made a higher proportion of non-work trips by non-motorized modes than people living in areas with low access to local services.

Handy conducted a series of studies of local travel and neighborhood characteristics (1992, 1993, 1996). She found that shopping trips increase with accessibility, but walking trips are not necessarily substitutes for car trips. That is, the walk trips may be additional trips taken in response to high accessibility. In contrast, shopping and other discretionary travel becomes more efficient when accessibility is low (Ewing, Haliyur, and Page, 1994).

Kitamura, Mokhtarian, and Laidet (1997) analyzed total daily travel across five San Francisco metropolitan area neighborhoods of widely divergent spatial form and transit access. They found significant relationships between person trips and transit trips and the following geographic factors: location within the region, BART access and high density. Also included in the model were general attitudinal measures (e.g., indicators of whether the person was "pro-transit," preferred a suburban lifestyle, etc.). The attitudinal factors had the strongest explanatory powers of all groups of factors examined.

TRENDS IN URBAN DEVELOPMENT PATTERNS

The major trend in urban spatial patterns for several decades has been decentralization. Suburbanization of population and employment has been evident in the US throughout the twentieth century. Large-scale population suburbanization was followed by large-scale employment decentralization and by the emergence of major agglomerations outside the traditional downtown (e.g., Muller, 1995). More recently, decentralization has been accompanied by dispersion, with most growth occurring outside major centers. The recently released 2000 US Census figures indicate that these trends have continued in the 1990s. Although population increases have occurred for the first time in several decades in some of the nation's largest cities (e.g., New York, Chicago), much larger increases were documented in the suburbs of these cities, and in the smaller metropolitan areas.

Population decentralization has been accompanied by employment decentralization. Empirical evidence of this trend is extensive. Giuliano and Gillespie (2002) used annual county level employment data 1969 through 1997 to compare growth rates across metropolitan areas. They found that core counties (those including the central city) of the largest metropolitan areas had the slowest growth rates throughout the series, relative to non-core counties and smaller metropolitan areas. Using the same county level private employment data, Gordon, Richardson, and Yu (1998) compared growth rates of metropolitan areas with non-metropolitan areas. They found higher rates for non-metro areas for 1969-77 and 1988-1994, but not for 1977-1988. The authors conclude that while the trend away from core counties is clear, whether job growth will shift more to smaller metro areas or to non-metro areas remains to be determined.

US patterns of retailing have also changed. The suburban shopping mall is now in competition with "Big Box" retail centers, grocery chains are competing with large discount "club" stores, and WalMart has all but eliminated small-scale retailers in rural and exurban areas. These new forms of large-scale retailing have given consumers more variety and lower prices, and their success attests to consumer preferences. Small shops have been relegated to niche markets: high-end specialty stores serving the boutique consumer, and low-end independents serving poor inner-city neighborhoods avoided by the national chains. There is a clear connection between retailing trends and development patterns; the increasing scale of retailing is built around the private vehicle and plentiful home storage capacity.

There is little evidence to suggest that these trends will turn around. Major explanatory factors include rising real household income, social change (e.g., decline of nuclear family, increased population diversity), and a shift to an information-based economy, which has led to increased location mobility of economic activity and a corresponding decline in agglomeration benefits.

Preferences among households for low-density living continue to be strong, and rising incomes allow more consumption of single-family housing. Annual housing surveys conducted by Fannie Mae consistently show that people prefer suburbs to cities and small cities to large cities. For example, the 1997 survey asked, where would you prefer to live? As shown in Table 2.1, over 2/3 of respondents preferred rural, a small town not near a city, or a small to medium city. When asked whether they would consider buying a home in the central city closest to where they currently live, nearly 2/3 responded negatively. It would appear that when households reach retirement, those with strong preferences will relocate to lower-density, more remote areas. Others will be drawn to centers of smaller metro areas that offer attractive cultural or natural environments (e.g., Boise, Charlotte NC, Santa Fe, NM). Only a small portion of the elderly will likely be drawn back to the central parts of larger cities, and these will be the cities that remain attractive as centers of culture or diversity.

Table 2.1
Where Would You Prefer to Live?

Type of Area	Percent
Rural area	22
Small town not near a city	24
Small or medium size city	22
Suburb near large city	23
Large city	9

Source: 1997 Fannie May Survey

Location Patterns of the Elderly

The distribution of the elderly population is consistent with the general population distribution. The most rapid growth of the elderly population is occurring in the high-growth regions of the country (south and west), and in the high-growth metropolitan areas, including those traditionally known as retirement destinations (e.g., Florida, Arizona).

There is extensive evidence that the elderly prefer to “age in place”, e.g. live independently and remain in residences selected in earlier stages of life (Howell, Lane and Friedman, 1982; Boersch-Supan, 1989; Frey, 1999). According to the American Housing Survey of 2001 (U.S. Department of Commerce, 2001), the elderly are far less likely to have moved in the past year than the non-elderly: 4.6% of the elderly vs. 18.5% for the non-elderly. A high home ownership rate among the elderly is one important explanatory factor. The 2001 American Housing Survey also showed that 80 percent of elder householders own their homes, and most of them are mortgage free. According to a 1996 survey conducted by the American Association of Retired Persons (AARP), over 90 percent of households at least 65 years old preferred to remain in their own home. For the elderly, the home is not only an economic asset, but also a sourse of emotional attachment (Fogel, 1993). Psychological benefits are derived from remaining in the home (Fogel, 1993), feelings of independence, familiarity of the home environment, and a social network of friends and neighbors (Antonucci & Akiyama, 1991). Home is also a locus of meaning – the site of memorable life events. The reduced residential mobility of the elderly is borne out in U. S. Census data. For 2000, the share of population of all ages reporting a move in the previous year was 6.1%, compared to 4.7% for those 60 or older.

The elderly population is concentrated in metropolitan areas, especially in suburbs. The 2001 American Household Survey indicates that 76 percent of the dwellings in which the elderly reside are within metropolitan areas (in MSAs): 48 percent in the suburbs and 28 percent in central cities. The share of elderly households living in the suburbs is increasing: between 1989 and 2001 the share of suburban elderly increased by 6 percent, while the share residing in central cities decreased by three percent.

The suburban concentration of the elderly has made aging in place “a less than satisfactory situation for many elders by isolating them through lack of transportation” (Callahan, 1993). According to the 2001 American Housing Survey, just 51 percent of elderly in suburbs state that their neighborhood has public transportation services, compared to 80 percent in central cities. For the 24 percent of elderly households who live outside metropolitan areas, over ¾ report no transit services available in their neighborhood. Even where public transportation service is available, the survey indicates that about three quarter of suburban elderly have never used it.

When the elderly move, where do they go? Table 2.2 shows some differences in migration patterns of the elderly and non-elderly based on the 2000 US Census. In this case, the elderly are those 60 years or older. The elderly make fewer moves within

MSAs, more moves between MSAs, and more moves from MSAs to non-metropolitan areas. This suggests relatively more long distance moves for the elderly. Comparing moving within the MSA groups, there are no differences between the elderly and total population. That is, the elderly are no more likely to move from suburb to city, or from city to suburb, than the general population (data not shown). If we examine the same data by county, we find that the elderly are less likely to move within the same county and more likely to move to a different county (or even different state) than the general population. This makes sense. If the elderly do move, they may be seeking lower cost areas.

Table 2.2
Migration Patterns, Total Population and Elderly, Percent Shares

Move	Total Population	Elderly (60 or older)
Within same MSA	54	47
Between MSAs	21	25
From MSA to non-metro area	4	7
From non-metro area to MSA	5	6
Within/between non-metro area	12	11
From abroad	4	3

CHAPTER THREE
BASIC DESCRIPTIVE STATISTICS

This chapter describes socioeconomic characteristics of the elderly and presents basic information on elderly travel patterns. Much of this information is presented in Rosenbloom (2001) and ECMT (2000). This chapter provides essential background information for the analyses in Chapter Four. It is well known that travel behavior is a function of socioeconomic and demographic characteristics. It is therefore useful to begin with a brief description of these factors.

DATA

We use the 1995 NPTS survey for this research. The NPTS is a household-based travel survey conducted periodically by the Federal Highway Administration (FHWA). The 1995 survey included 42,000 households and 95,360 persons. The sample was drawn from a stratified random digit dial telephone sample. In addition, several metropolitan areas paid FHWA to over-sample their areas. The survey includes household, individual, and vehicle information, as well as a one-day travel diary for each person 5 years old or older. The travel data were collected in a two-stage process. Households were given one-day travel diaries to complete for each eligible member of the household. The diaries were reported to the interviewer via telephone. The travel diary data includes a total of 409,025 trips. The data files also include basic geographic and demographic data drawn from the US Census and updated for 1995, provided at both block group and census-tract level and linked to each household record. In addition to the actual one-day travel information, the survey includes information on the journey to work, transit use, and a variety of attitudinal information. NPTS is therefore an exceptionally rich dataset.

A complex weighting procedure was developed for the NPTS data, as the weights must adjust for various types of response bias as well as the over-sampling of large metropolitan areas with rail transit and of areas which contracted with NPTS for larger samples.[4] The weights also expand the sample to estimates for the US population. In order to conduct statistical tests, we adjusted the person weights to scale the sample down to its original size. This is a second-best procedure, as the weighting scheme in theory requires statistical calculations, which are not available in most statistics software packages. The effect of using conventional statistics is to bias downward estimates of variance, and therefore increase the probability of Type I errors (reject the null hypothesis when it should be accepted). Increasing the stringency of statistical significance tests compensates for this problem.

A daily travel data file was constructed by aggregating all travel day trips and their characteristics for each person, using the 95,360 observation of NPTS person file as the working file. Trips longer than 75 miles were excluded from the analysis. Most of the results reported here are based on the person file, and all are based on the adjusted weights described above. Because of missing data on key variables, actual sample size varies by type of analysis.

SOCIO-ECONOMIC CHARACTERISTICS OF THE ELDERLY

The elderly are obviously not homogeneous. The "younger" elderly are more likely to be employed, living with others, and in good physical health. This group is also more likely to be "actively retired" and therefore to engage in substantial leisure or recreational travel. The "older" elderly are more likely to be living alone and poor. Prior research has shown that socioeconomic factors are related to travel behavior. We compare socio-economic characteristics by elderly (65+) vs. not elderly (16-64), and by three age groups: "pre-elderly" (55-64), "younger elderly" (65-74), and "older elderly" (75 or over). We do not break out an oldest category of 85 or older due to small sample size. The NPTS data are weighted to the US population, so sample shares by age are consistent with actual population shares. The age shares for our three groups are: pre-elderly, 8 percent; younger elderly, 8 percent; older elderly, 5 percent.

Table 3-1 gives gender distribution by age cohort for the elderly. For the non-elderly, the male and female shares are approximately equal. Among the elderly, the female share increases with age, consistent with women's longer life expectancy.

[4] See Chapter 3 of the 1995 NPTS User's Guide for details on the NPTS weighting procedure.

Table 3-1
Gender Distribution by Age Cohort

Age Cohort	Male	Female
16-64	49.4%	50.6%
>= 65	41.6%	58.4%
55-64	47.7%	52.3%
65-74	44.7%	55.3%
>= 75	36.4%	63.6%

Household income is the best predictor of resource availability for travel. As household income decreases, so does consumption of goods and services, including private vehicles. Less consumption leads to less demand for travel and trip making. The elderly are more likely to be members of low-income households, since most elderly are not employed. We use a measure of household income that controls for both household size and regional housing market. It is based on the Department of Housing and Urban Development's (HUD) definition. HUD defines "low income" in order to determine eligibility for housing subsidies. The "low income" definition is approximately 80 percent of the region's median household income, adjusted for regional housing costs.

Table 3-2 shows that significant disparity can be observed between the elderly and non-elderly. Note that these tables are based on persons rather than households. Thus the percentages show the share of persons in low-income households. About half of the elderly are members of low-income households, compared to about 30 percent of the non-elderly. Table 3-2 also gives distribution of low-income households by age cohort. As expected, the low income share increases with age.

Table 3-2
Low-Income Status by Age Cohort

Age Cohort	Not Low Income	Low Income
16-64	71.4%	28.6%
>= 65	46.7%	53.3%
55-64	71.2%	28.8%
65-74	51.1%	48.9%
>= 75	38.7%	61.3%

Many elderly live alone. Table 3-3 gives life cycle status. Again, these tables are based on persons rather than households. The percentages show the share of persons in each life cycle category. The share of people living in single-person households is significantly higher for the elderly than the non-elderly. The share of people in single-person households increases from 13 percent for the pre-elderly to 35 percent for the older elderly.

Table 3-3
Life Cycle Status by Age Cohort

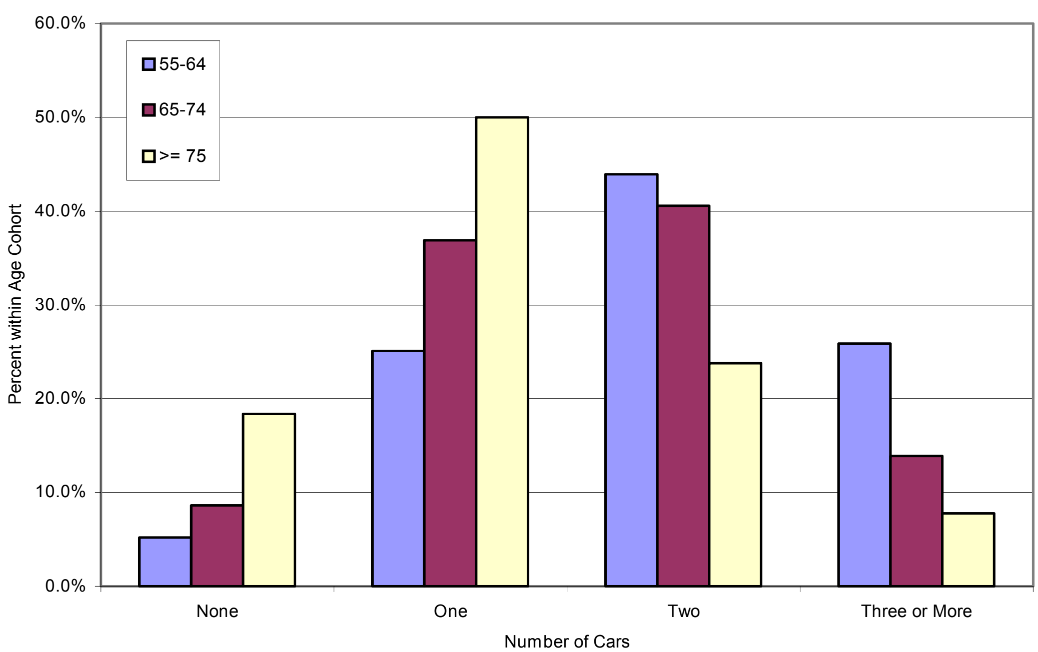
Age Cohort	1adult, not retired	>1adult, not retired	1 adult, retired	>1 adults, retired
16-64	11.7%	80.6%	0.5%	7.3%
>= 65	6.8%	15.8%	18.9%	58.4%
55-64	9.9%	56.0%	3.1%	31.0%
65-74	6.9%	19.1%	13.4%	60.5%
>= 75	6.6%	10.2%	28.3%	54.9%

Car availability is a key indicator of mobility, since most trips are made by car. Table 3-4 shows the distribution of persons in households by the number of cars in the household. For the elderly, about 12 percent belong to households with no cars, while only 5 percent of the non-elderly belong to households without cars. Figure 3-1 shows that most people have at least one car available, even for the older elderly. For the older elderly, 18 percent have no cars in the household, double that of the younger elderly.

Table 3-4
Cars in Household of the Elderly and Non-Elderly

Age Cohort	None	One	Two	Three or More
16-64	5.0%	21.7%	44.5%	28.7%
>= 65	12.3%	41.8%	34.3%	11.6%

FIGURE 3-1
CARS IN HOUSEHOLD BY AGE COHORT



A better way of measuring car availability is to compare the number of cars with the number of drivers in a household. Table 3-5 and Figure 3-2 show car availability by age cohorts. Most people live in households with equal number of cars and drivers, and about 87 percent of the elderly reside in households with at least one car. The elderly are more likely than the non-elderly to live in households without cars. Car availability also declines with elderly age cohorts.

Table 3-5
Car Availability of the Elderly and Non-Elderly

Age Cohort	No Cars	Cars < Drivers	Cars = Drivers	Cars > Drivers
16-64	5.1%	17.1%	61.5%	16.3%
>= 65	12.4%	13.8%	60.5%	13.3%

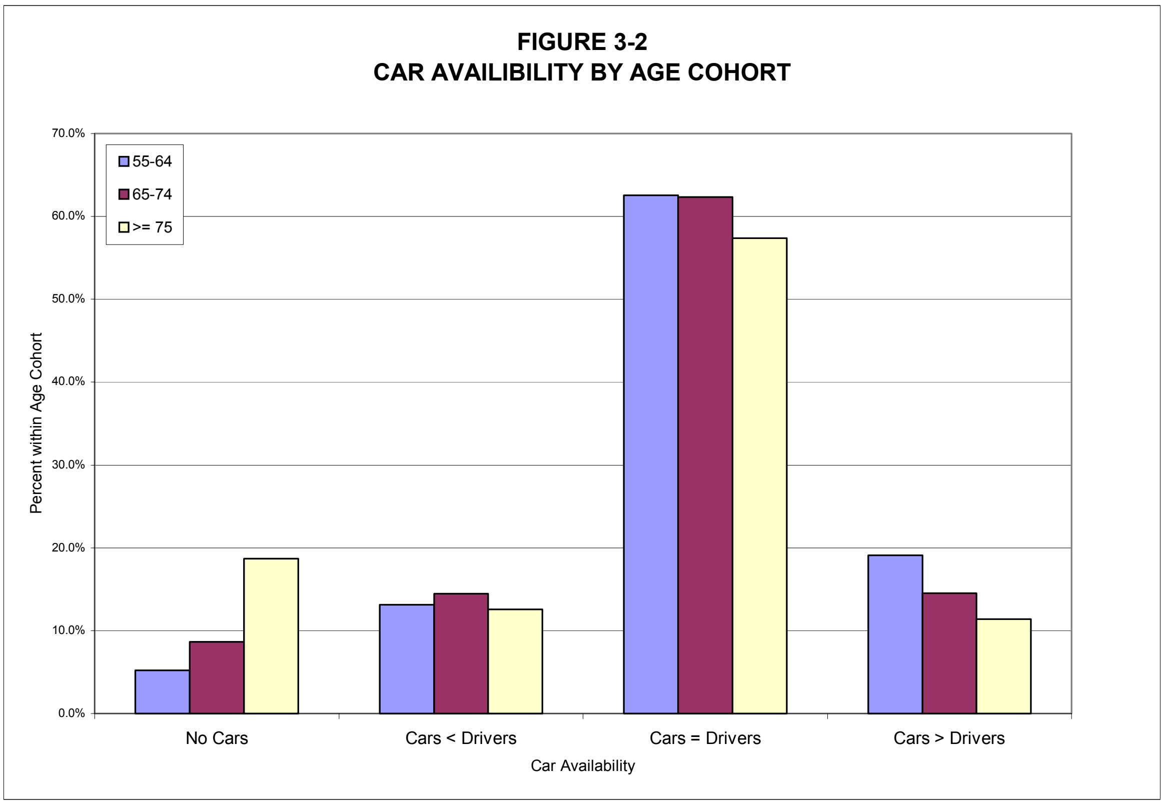


Table 3-6 gives the share of people holding a driver's license. Driver's license holding is somewhat lower for the elderly. The difference among age cohorts for women is significant: the share of older females with a driver's license is 20 percent lower than non-elderly females, compared to a 3 percent difference for males. Table 3-7 shows driver's license status by three age cohorts. The share of licensed drivers decreases dramatically for the older elderly (66 percent). Again, the share of female drivers decreases significantly over age. The automobile is still a major transportation mode for the oldest men, but about 45 percent of the oldest women do not have a driver's license.

The difference between the oldest men and women is likely explained by the effects of cohort differences; the current generation of elderly women were pre-WWII young adults, an era when gender differences in license holding were still significant. It is also possible that women are more willing to give up driving than men.

Table 3-6
Driver's License Holding, Elderly and Non-Elderly

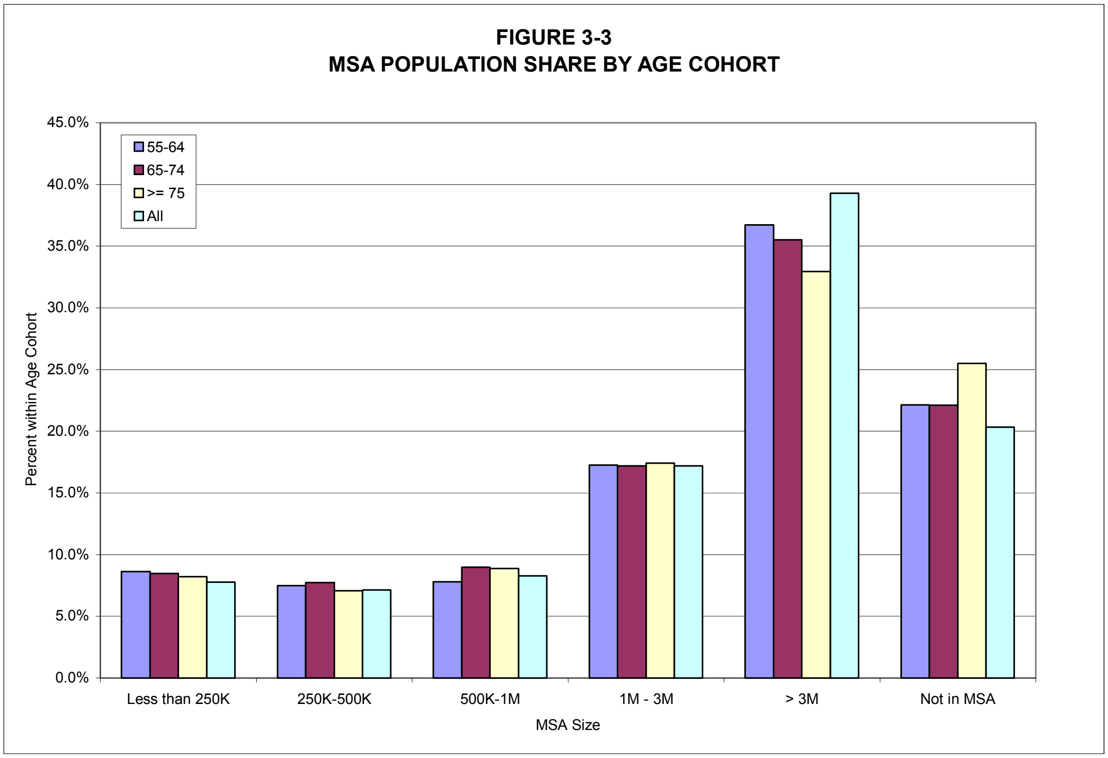
Age Cohort	Male	Female	Total
16-64	93.0%	88.9%	90.9%
>= 65	89.9%	68.7%	77.5%

Table 3-7
Driver's License Holding by Age Cohort

Age Cohort	Male	Female	Total
55-64	94.9%	85.7%	90.1%
65-74	92.7%	78.2%	84.7%
>= 75	83.8%	55.0%	65.5%

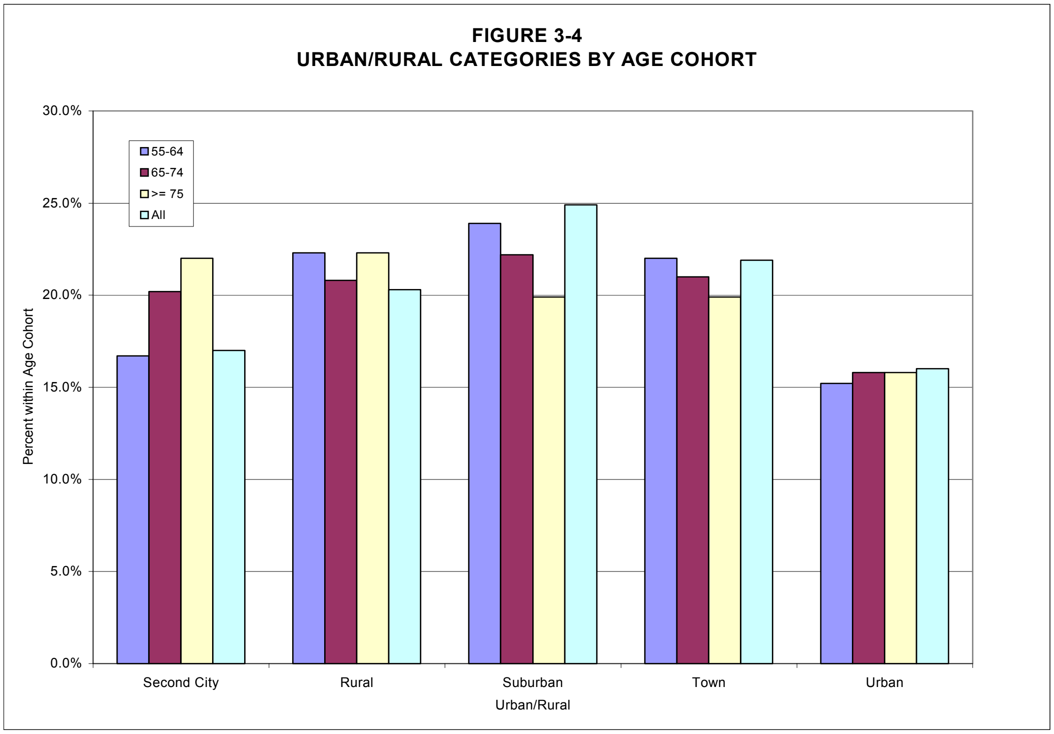
RESIDENTIAL LOCATION CHARACTERISTICS OF THE ELDERLY

The literature review indicated that travel patterns differ across residential location. Differences in location patterns across age groups may explain observed travel patterns. About one-third of the elderly reside in the largest MSAs, while one-fourth of the elderly reside outside MSAs. Figure 3-3 gives the distribution of the NPTS sample across MSAs by size for each age cohort and total population. The older elderly have the lowest share for the largest MSA, and the largest share for not residing in an MSA. However, the shares do not differentiate significantly among age cohorts. This is consistent with aging in place.



The NPTS provides an "urban/rural" variable that was developed as an indicator of both population density and the spatial relationship of each block group to population centers.[5] Rural areas have the lowest density, followed by "towns." "Second cities" have a higher density than towns, and "urban" has the highest density. Suburban areas have lower density than urban areas, but are physically proximate to urban areas. Figure 3-4 shows that the older elderly are somewhat more concentrated in second cities, and somewhat less concentrated in suburban areas, suggesting slightly more likelihood of living in smaller, less urban communities.

[5] Prepared by Claritas, Inc. See Appendix L of the 1995 NPTS User's Guide, and Miller and Hodges, 1994.



The NPTS provides place of residence zip code information. We developed a central city residence location variable for each person based on the zip code information and Census definition. According to Table 3-8, there are slight differences in the distribution for each age cohort. Nearly 30 percent of those living in MSAs reside in the central city, and the proportion is similar across elderly age cohorts.

Table 3-8
Percent Residing in Central City by Age Cohort

Age Cohort	Not in Central City	Central City
55-64	71.9%	28.1%
65-74	70.5%	29.5%
>= 75	72.0%	28.0%
Total Population	70.3%	29.7%

NPTS provides place of residence population density by census tract. The variable has eight categories ranging from "0 to 100" to "25k or more." We use four levels of population density: low (less than 500 persons per square mile), medium (500 to

2,000), high (2,000 to 10,000), and very high (more than 10,000). Table 3-9 shows that there are no significant differences in the distribution of age cohorts across density categories.

Table 3-9
Population Density, Elderly and Non-Elderly

Age Cohort	less than 500	500 - 2k	2k - 10k	10k or more
55-64	34.5%	19.0%	37.6%	8.9%
65-74	32.5%	19.9%	38.5%	9.0%
>= 75	33.0%	19.2%	39.1%	8.8%

TRAVEL PATTERNS OF THE ELDERLY

The descriptive statistics of travel patterns to be examined in this section include mobility measures—daily trips, travel distance and travel time—as well as mode share, trip purpose, and temporal patterns of non-work activity.

Total Daily Travel Distance, Time, and Trips

Table 3-10 gives group mean and median for total daily trips, total travel distance (person-miles) and total travel time (person-minutes). We also include the share of people who traveled on the survey day. There are significant differences among age cohorts for all travel measures. The trend of decreased travel with age is evident. Means are skewed by a long tail of high values; median values are much lower than means. The oldest cohort has the lowest trip rates, and the largest share of people who did not travel on the travel survey day. Significant reduction of travel distance for the 75+ cohort is also evident: average travel distance for the 75+ cohort is nine miles shorter than that of 65-74 cohort. There is little difference between 55-64 and 65-74 cohorts. It bears noting that the decline in work travel occurs between the pre-elderly and younger elderly.

Table 3-10
Total Daily Trips, Distance and Time by Age Cohort, All Trips

Age Cohort	Trips		Distance		Time		Persons Made Trip
	Mean	Median	Mean	Median	Mean	Median	
16-64	4.17	4.00	33.42	22.00	64.79	53.00	87%
>= 65	3.07	3.00	19.05	9.00	46.74	34.00	72%
55-64	3.74	4.00	27.62	18.00	59.03	47.00	83%
65-74	3.49	3.00	22.34	12.00	52.98	40.00	77%
>= 75	2.37	2.00	13.56	4.00	36.32	22.00	62%

In order to separate out the effect of being employed, we calculate the same measures for non-work travel only (see Table 3-11).[6] The 65-74 cohort make more non-work trips than 55-64 cohort; 3.2 trips per day vs. 2.9. Travel distance is about the same between the two groups, suggesting that non-work trips are substituted for work trips among the younger elderly. A significant decline in travel does not take place until after age 75. The older elderly travel much less by all measures. Only 60 percent of the older elderly traveled on the survey day. Of those who traveled, half of them traveled 4 miles or less a day.

Table 3-11
Total Daily, Non-Work Trips, Distance and Time by Age Cohort

Age Cohort	Trips		Distance		Time		Persons Made Trip
	Mean	Median	Mean	Median	Mean	Median	
16-64	2.91	2.00	20.84	8.00	41.43	23.00	68%
>= 65	2.93	2.00	17.47	7.23	43.04	30.00	68%
55-64	2.89	2.00	20.02	8.00	43.32	27.00	68%
65-74	3.17	3.00	20.24	10.00	48.15	34.00	73%
>= 75	2.27	2.00	12.85	4.00	34.54	20.00	60%

[6] Non-work travel is obtained by removing all trips taken from home to work and from work to home, including intermediate stops.

Mode Share

Mode share is calculated for all recorded person trips. Results are the same for total trips and non-work trips, hence only total trips are shown here (see Table 3-12). The private vehicle (POV) is the dominant mode for everyone, accounting for about 90 percent of all person trips. The use of POV is segmented into two categories: as a driver and as a passenger. For all age cohorts, the share of POV driver is much higher than the share of POV passenger, although the share declines with age. Even for the older elderly, the share of POV driver is double that of POV passenger. Walking accounts for about 5 to 7 percent of all person trips, followed by transit use, which is about 2 percent. The share of transit use does not increase as people age. Apparently people do not shift to transit when they are no longer drivers.

Table 3-12
Mode Share by Age Cohort, All Trips

Age Group	POV Driver	POV Pass.	Bus/Rail	Walk
16 – 64	74.9%	17.4%	1.7%	4.8%
65 or over	69.0%	22.8%	1.6%	5.9%
16 – 54	74.8%	17.3%	1.7%	4.9%
55 – 64	75.7%	18.2%	1.3%	4.2%
65 – 74	71.8%	20.5%	1.5%	5.4%
75 or over	62.2%	28.2%	1.9%	7.0%

Trip Purpose

NPTS provides a destination information for each trip. We categorize seventeen NPTS trip destinations into six trip purposes: home; work; shopping; personal business; social and recreational; and others. “Home” represents a trip from another location to home. “Work” includes trips to the work place and trips related to work. “Shopping” includes trips for purchasing commodities and window-shopping. “Personal business” includes trips to see doctors or dentists, or trips for purchasing services, such as dry cleaning, banking, haircuts, etc. “Social and recreational” includes trips made to visit friends or relatives, religious places, restaurants or coffee shops, vacation, and other social activities such as parties, movies, and sightseeing. "Other" includes trips to take someone somewhere, pick up someone, and to school. Table 3-13 gives the share of non-work trip purposes by age cohort. Non-work trip purpose does not change much by age cohort; the pre-elderly make fewer personal business and social and recreational trips, presumably because many are still employed.

Table 3-13
Share of Non-Work Trips by Purpose, Age Cohorts

Age	Shopping	Personal Business	Social & Recreational	Other
55-64	31.4%	25.5%	31.7%	11.4%
65-74	32.2%	28.2%	32.0%	7.6%
75 +	31.8%	27.4%	34.4%	6.5%

Tables 3-14 and 3-15 give average trip length and trip time across non-work purposes by age cohort. Social and recreational trips tend to be the longest, and shopping trips tend to be shortest. There is a decline in average trip distance with age across all trip purposes, suggesting an increasing propensity to engage in activities closer to home. We calculate average speed based on the above tables: social and recreational trip is 23 mph for the older elderly, 27 mph for the younger elderly, and 29 mph for the pre-elderly, while average speed for shopping and personal business is about 2-3 mph less. Given the stability in mode shares across age cohorts, these differences may be a function of shorter trips (e.g., less travel on high-speed facilities).

Table 3-14
Average Trip Length (Miles) by Purpose, Age Cohort

Age	Shopping	Personal Business	Social & Recreational
55-64	5.4	6.3	7.9
65-74	4.8	5.8	7.6
75 +	4.7	5.4	6.3

Table 3-15
Average Trip Time (Minutes) by Purpose, Age Cohort

Age	Shopping	Personal Business	Social & Recreational
55-64	12.6	14.0	16.4
65-74	12.4	14.0	17.2
75 +	13.5	14.5	16.4

Activity Patterns and Travel

Travel is a derived demand. People must travel to work, to obtain services and participate in a variety of day-to-day activities. People choose a daily schedule of activities based on their demand for activities and their travel resources. Travel is an outcome of daily activity choices. Consequently, understanding travel behavior requires understanding the underlying patterns of people's daily activities. In this section we compare daily activity patterns across elderly cohorts. Three types of non-work activities are discussed: shopping; personal business; and social and recreational.

The trip file data of 1995 NPTS includes the start time and total travel time of each trip. We use this information to calculate the time each person spends in each out-of-home activity or destination. This provides interesting information on the temporal distribution of daily travel by age cohorts. Figures 3-5 to 3-8 show the distribution of out-of-home activities by purpose over the whole day for four age groups: 16-54, 55-64, 65-74, and 75 or over. The x axis of each figure represents time of day: from 12 a.m. to 11:50 p.m., and y axis represents the percentage of total population of the age group engaged in a given activity at a given time. For example, Figure 3-5 shows that about 40 percent of the 16-54 population are at home at 12 noon, and 60 percent are engaging in some out-of-home activity: 34 percent for work, 5 percent for shopping, 5 percent for personal business, and 12 percent for social and recreational. The profile of activities shows that most out-of-home activity takes place during the day (from about 7 AM to 5 PM). Comparing activities by purpose, we see that social and recreational activities are most frequent in the evening, while shopping and personal business activities are spread through the day and early evening.

Figure 3-6 gives out of home activities for the 55–64 cohort. Comparing Figures 3-5 and 3-6 reveals that the pre-elderly spend far less time out of home than their younger cohorts. Most of the difference is attributable to less time spent working (either fewer people employed, or fewer people working a full day). The trend of declining out-of-home activity with age is strongly apparent in Figures 3-7 and 3-8 (younger elderly, older elderly). The share of social and recreational activity time as a proportion of all out of home activity increases with age. For the younger elderly, there is more shopping and personal business activity and far less work activity relative to the pre-elderly. Time spent on all out of home activities decreases for the older elderly.

Out-of-home time also becomes increasingly concentrated in the daytime hours. If we look at the time when the largest share of people are not at home, we note that the peak time shifts to an earlier hour with age, and a smaller share of people are not at home at any given hour. For the older elderly, just 30 percent of people are away from home even at the "peak" hour (about 11 AM). Figures 3-6 to 3-8 provide graphical evidence of the decline in out-of-home activities that occurs with age. Figure 3-9 gives the shares of people by age cohort engaged in out-of-home activity, for all activities. This figure combines the four previous graphs and provides a clear picture of declining out-of-home time by age cohort. Finally, the concentration of activities in time is illustrated in Figure 3-10 for shopping. The non-elderly spread shopping trips throughout the day and early evening, while elderly shopping trips are highly concentrated between 9 AM and 3 PM. The shape of the pattern is similar for younger elderly and older elderly, but much lower overall and with a steeper decline in the evening hours for the older elderly.

Table 3-16 gives average total activity time spent in each type of activity. For all age cohorts, people spend much more time on social and recreational activities than on shopping or personal business activities. In addition, the older elderly spend approximately the same time in any given activity as the younger groups do. However, the data in Table 3-16 counts only those who conducted such an activity on the travel day. The difference in overall levels of activity is explained by fewer activities, rather than less time spent on a given activity. For example, the average daily trip rate for all non-work travel is 2.9 for the pre-elderly, 3.2 for the younger elderly, and 2.3 for the older elderly.

Table 3-16
Average Activity Time by Trip Purpose, Age Cohort

Age	Shopping	Personal Business	Social & Recreational
55-64	49.67	74.50	115.24
65-74	47.97	66.25	116.37
75 +	51.07	72.28	122.35

A key question is whether the decline in out-of-home activities and their concentration in the middle of the day is a result of declining physical strength and energy that reduces the demand for activities, or less ability to travel (particularly drive), or some combination of both. These shifts in activity patterns are consistent with the elderly trying to avoid nighttime or rush hour travel. According to a recent Association of American Retired Persons (AARP), 63 percent of drivers 75+ said they avoid traveling at night, and over a half of them said they avoid driving during rush hour (Straight, 1997).

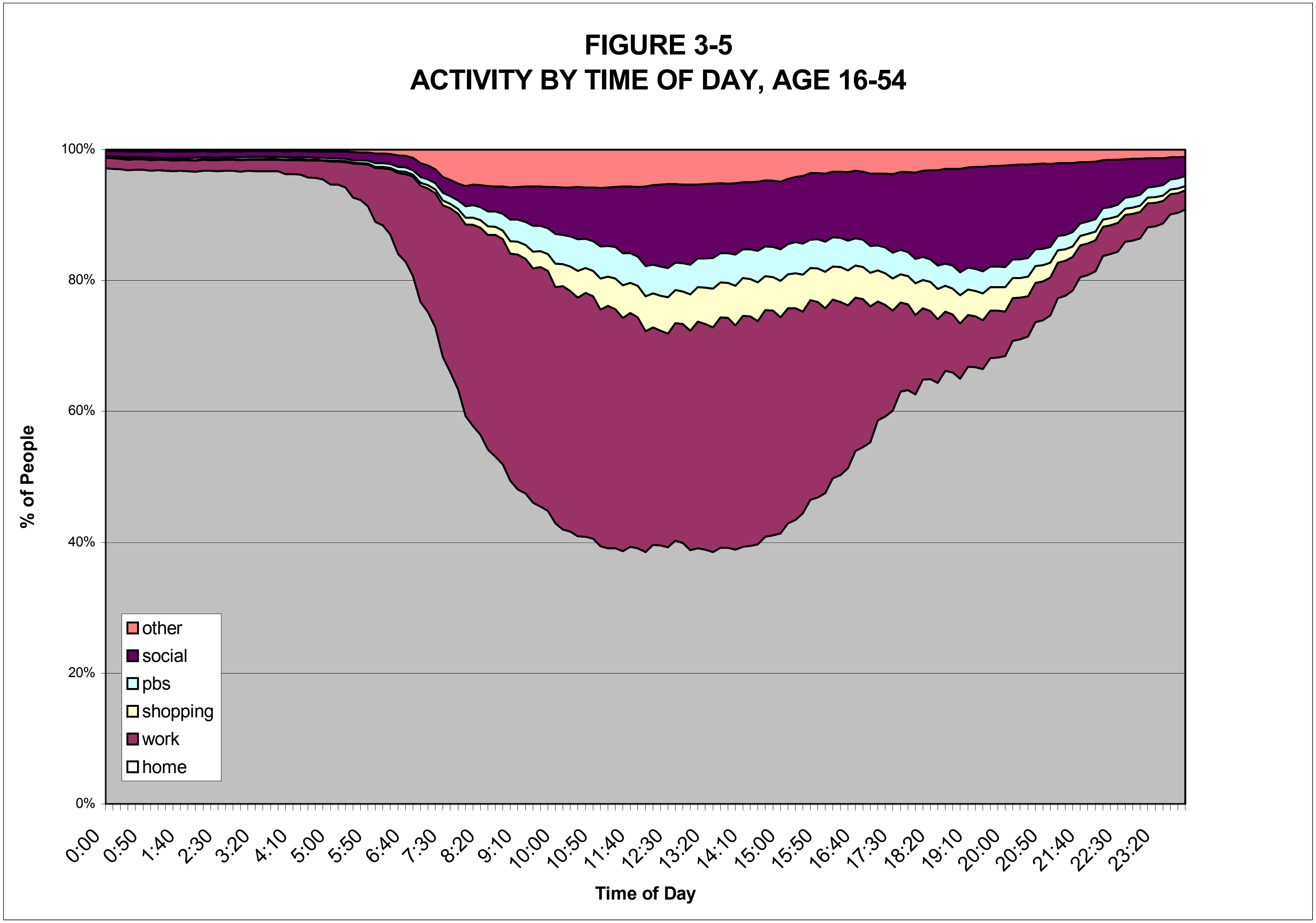


FIGURE 3-5
ACTIVITY BY TIME OF DAY, AGE 16-54
100%
80%
60%
40%
20%
0%
% of People
other
social
pbs
shopping
work
home
0:00
0:50
1:40
2:30
3:20
4:10
5:00
5:50
6:40
7:30
8:20
9:10
10:00
10:50
11:40
12:30
13:20
14:10
15:00
15:50
16:40
17:30
18:20
19:10
20:00
20:50
21:40
22:30
23:20
Time of Day

FIGURE 3-6
ACTIVITY BY TIME OF DAY, AGE 55-64

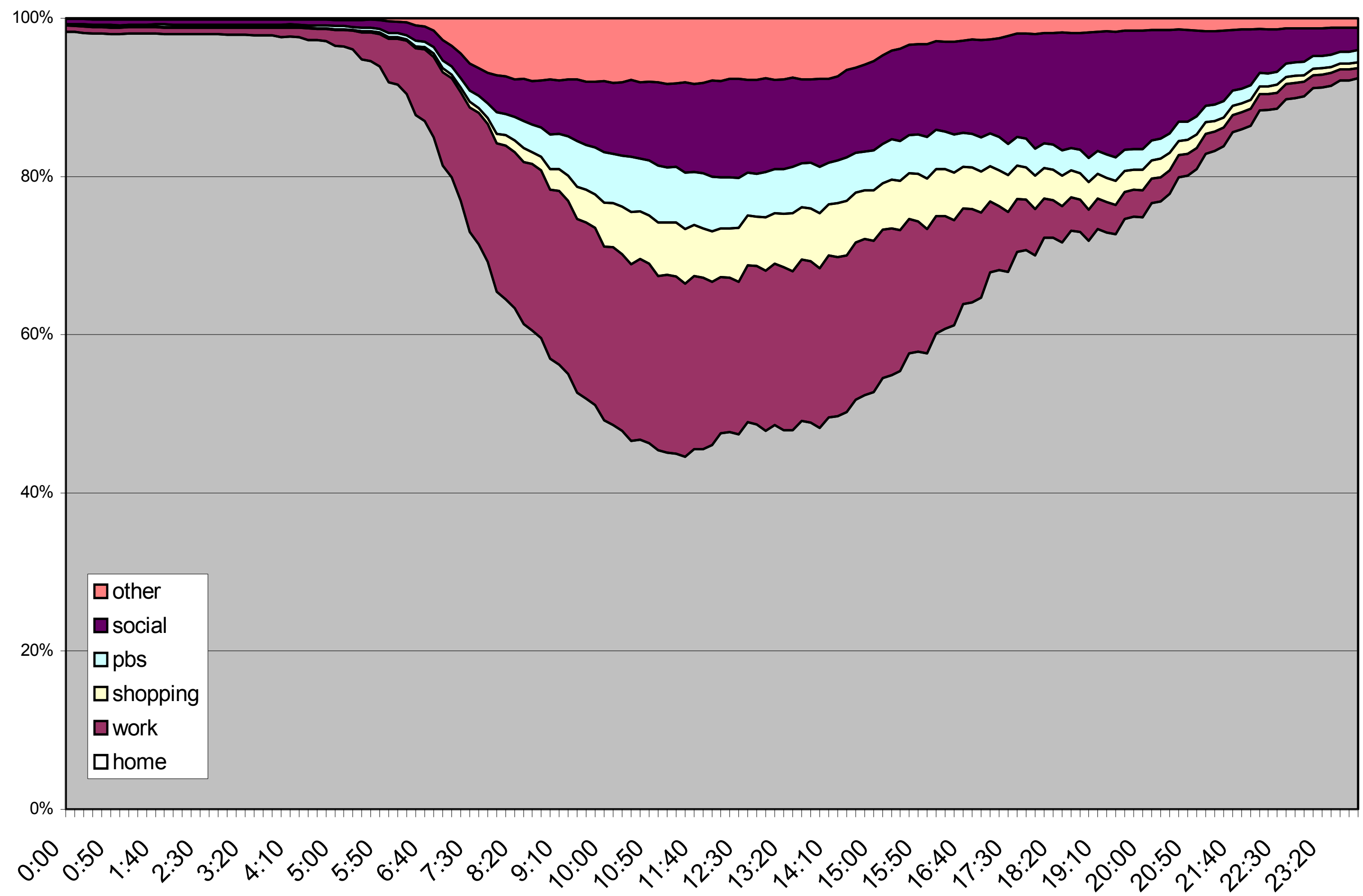
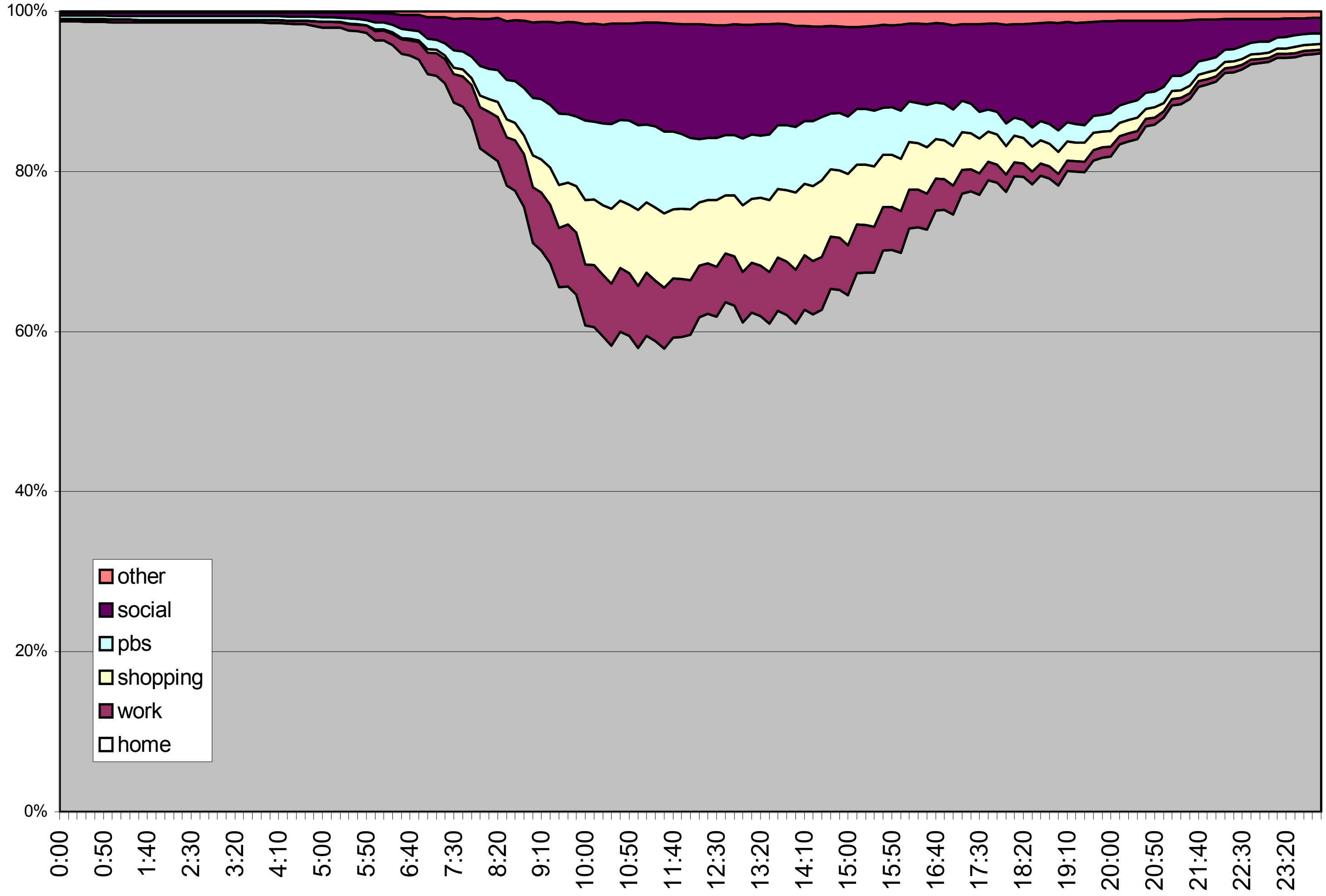


FIGURE 3-7
ACTIVITY BY TIME OF DAY, AGE 65-74



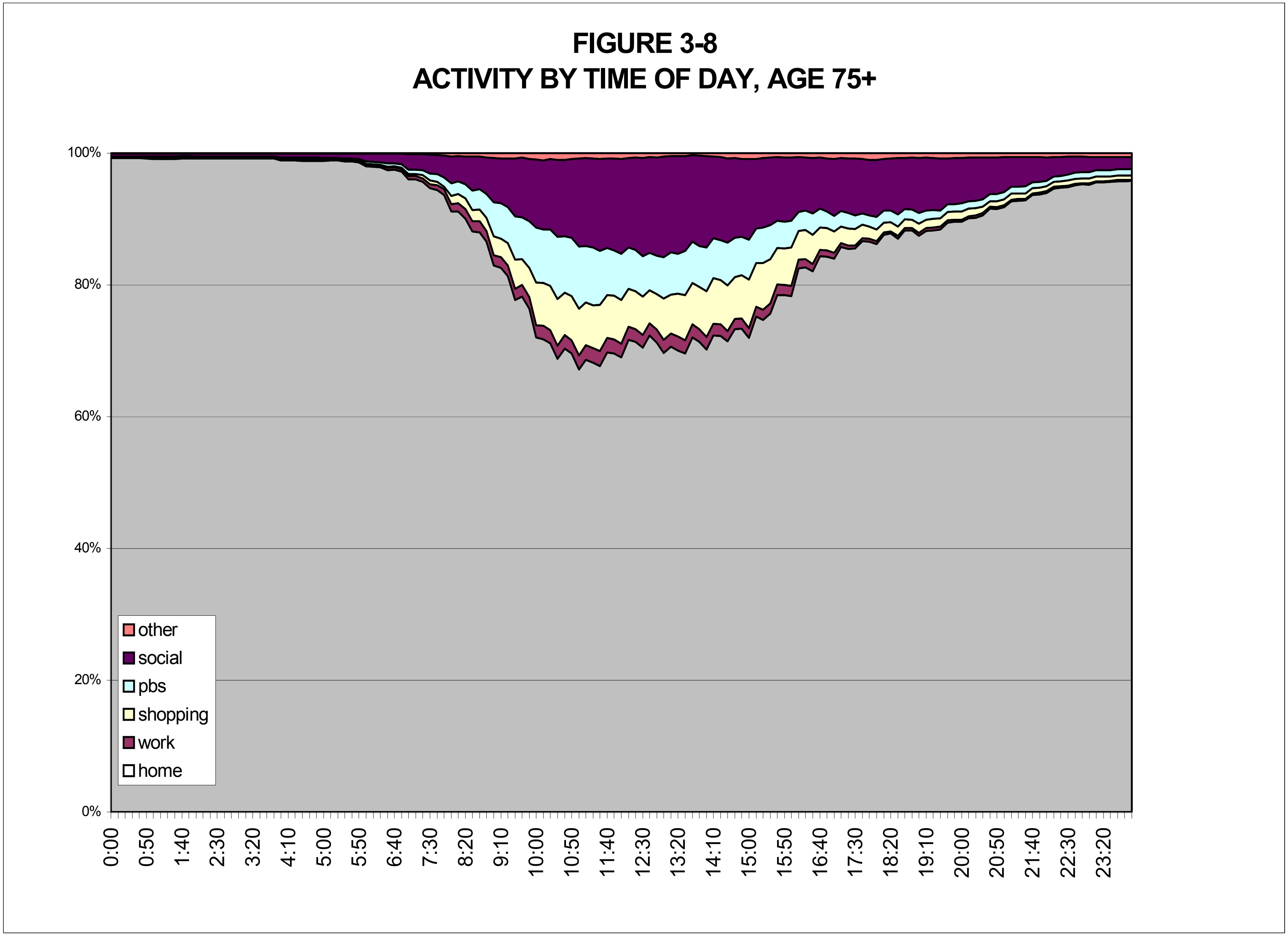


FIGURE 3-8
ACTIVITY BY TIME OF DAY, AGE 75+
100%
80%
60%
40%
20%
0%
other
social
pbs
shopping
work
home
0:00
0:50
1:40
2:30
3:20
4:10
5:00
5:50
6:40
7:30
8:20
9:10
10:00
10:50
11:40
12:30
13:20
14:10
15:00
15:50
16:40
17:30
18:20
19:10
20:00
20:50
21:40
22:30
23:20

FIGURE 3-9
ACTIVITY BY TIME OF DAY, TOTAL ACTIVITY

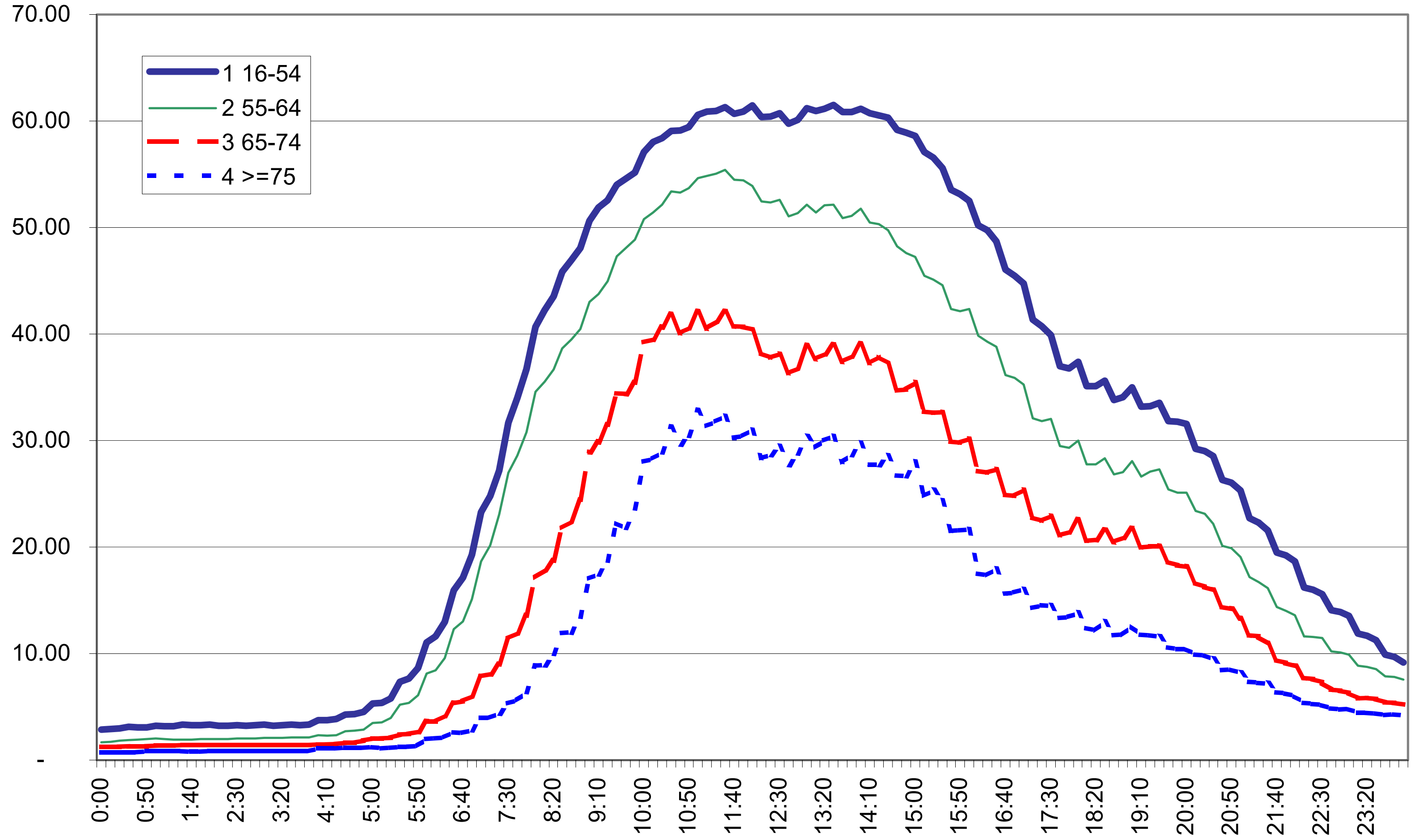
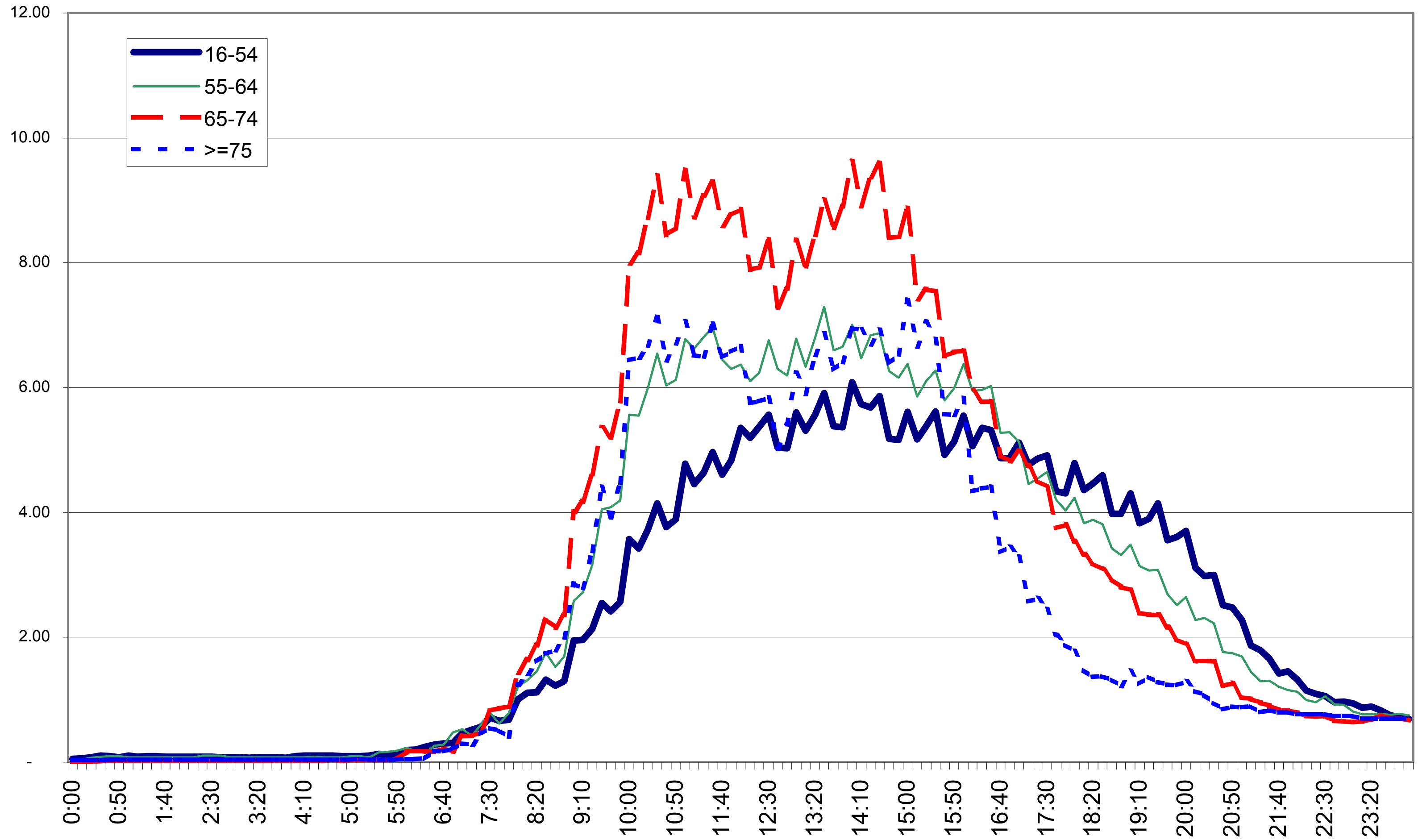


FIGURE 3-10
ACTIVITY BY TIME OF DAY, SHOPPING ACTIVITY



CHAPTER FOUR
LAND USE AND TRAVEL PATTERNS OF THE ELDERLY

The previous chapter provides a comprehensive picture of travel patterns of the elderly. We focus here on comparing travel patterns across different land use environments. The 1995 NPTS provides relatively rich land use data. All households are located to US census block, and information on urban area location, as well as census tract and block level population, housing and employment characteristics are appended to each household record. Neighborhood characteristic variables are 1995 estimates from a proprietary database based largely on 1990 US Census data.[7]

TOTAL DAILY TRAVEL AND LAND USE

Table 4-1 gives total daily trips, travel distance (person-miles) and travel time (person-minutes) by metropolitan area size for three age cohorts. These measures of travel include all modes, but exclude long distance trips over 75 miles long. We also include the share of people who made at least one trip on the survey day. Table 4-1 shows that differences between age cohorts are greater than differences within age cohorts across all travel measures. The trend of decreased trip making with age is evident, with the drop-off particularly marked for the oldest cohort. The oldest cohort has the lowest trip rate as well as the largest share of people who did not travel on the travel diary day. It bears noting that the decline in work travel occurs between the 55-64 and 65-74 cohorts, but the big reduction in travel occurs in the 75+ year cohort. Looking within each age cohort, travel distance varies more than travel time, reflecting use of slower modes in the largest MSAs. As expected, those living outside metro areas travel the most miles in all cases. Finally, note that those living in the smallest MSAs have the highest average trip rate.

[7]The proprietary data were prepared by Claritas. See Appendix L of the 1995 NPTS User's Guide.

Table 4-1
Daily Trips, Distance, Time and Share Who Traveled, All Trips, by MSA Size[a]

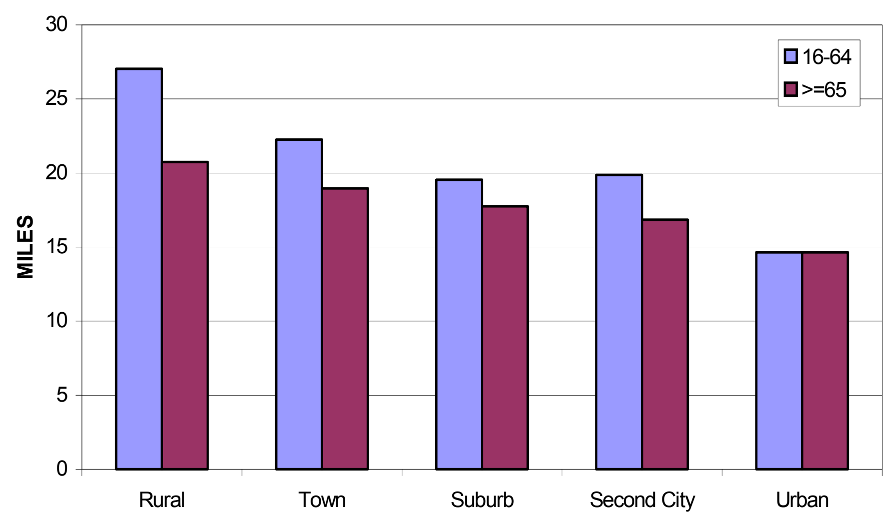
Age Group	MSA size	Trips	Distance	Time	% Traveled
55-64	Not in MSA	3.6	29.5	55.4	81
	< 250K	4.1	27.7	59.0	85
	250K - 500K	3.8	26.2	56.4	84
	500K – 1M	3.8	24.6	55.6	85
	1M - 3M	3.8	26.6	57.2	83
	>3M	3.5	23.9	57.8	83
65-74	Not in MSA	3.6	26.4	54.9	77
	< 250K	3.7	22.6	52.5	79
	250K - 500K	3.7	20.7	49.3	78
	500K – 1M	3.4	23.1	54.1	76
	1M - 3M	3.5	20.5	50.5	77
	>3M	3.4	20.8	53.7	77
75+	Not in MSA	2.4	15.1	37.2	59
	< 250K	2.8	14.7	38.4	66
	250K - 500K	2.2	13.4	32.5	61
	500K – 1M	2.5	14.4	37.6	62
	1M - 3M	2.4	12.8	36.2	65
	>3M	2.3	12.3	35.7	61

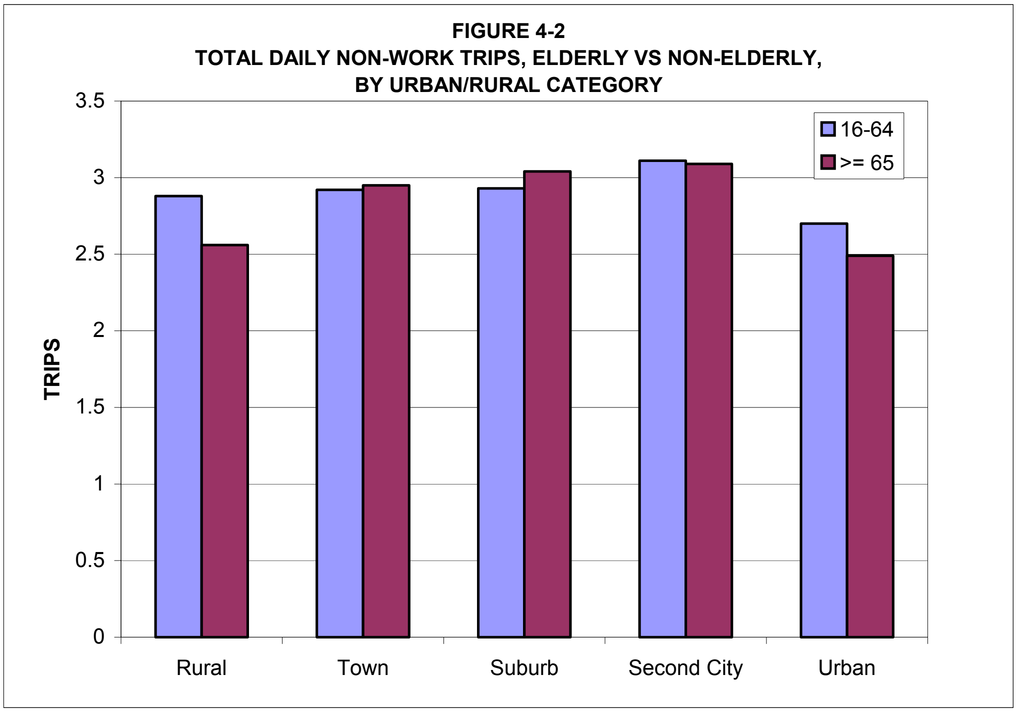
[a] Distance in person-miles, time in person-minutes

We also compared the same measures of travel for people living inside and outside the central city. As expected, those residing inside the central city travel less than those residing outside the central city, but this difference declines with age. For example, total travel distance is 28 and 22 miles respectively for the 55-64 cohort, and 14 and 13 miles for the 75 and over cohort. Apparently the wealth and household composition effects represented by central city residence disappear or are offset by the general decline in travel demand among the oldest travelers.

The NPTS also provides an "urban/rural" variable, as described earlier, that categorizes census tracts on the basis of contextual density. Rural areas have the lowest density, followed by "towns." "Second cities" are higher-density than towns, and "urban" has the highest density. Suburban areas have lower density than urban areas, but are physically proximate to urban areas. We use the urban/rural categorization to compare travel measures across age cohorts, using both total travel and non-work travel. Findings are similar to those for MSA size: differences between elderly and the non-elderly decline as size/density increases. For example, Figure 4-1 shows total non-work travel distance by urban/rural category, for elderly and non-elderly. In urban areas, non-work travel distance is virtually the same for both groups. Figure 4-2 gives non-work trip rates by urban/rural category. The pattern is similar for both groups, but the elderly have somewhat lower trip rates in rural areas and urban areas. In the case of rural areas, this may suggest that the elderly tend to compensate for less access by making fewer trips. On the other hand, this may simply reflect household income differences associated with residential location.

FIGURE 4-1
TOTAL DAILY NON-WORK TRAVEL DISTANCE, ELDERLY VS NON-ELDERLY, BY URBAN/RURAL CATEGORY





TOTAL DAILY TRAVEL AND LOCAL DENSITY

We use local density (persons per square mile in census tract place of residence) as a general measure of neighborhood form. We use a four-category density measure based on prior research: low (less than 500 persons/mile^2); medium (500 to 2,000 persons/mile^2); high (2,000 to 10,000 persons/mile^2); and very high (over 10,000 persons/mile^2). As before, we compare both total trips and non-work trips, and use trips, miles, and time as measures of travel. Table 4-2 gives information for total trips. Again we see the effect of lower trip rates for the elderly reflected in lower average total travel time and distance across density categories. For both the elderly and non-elderly, travel distance declines with density.

Table 4-2
Trips, Distance, Time by Density, All Trips, Elderly and Not Elderly

Age Group	Density	Trips	Distance	Time
Not Elderly	Low (< 500/mi^2)	4.1	39.8	65.9
	Med (500 - 2K/mi^2)	4.3	35.0	64.4
	High (2K - 10K/mi^2)	4.4	30.4	63.9
	Very High (>10K/mi^2)	3.7	21.9	65.4
Elderly	Low (< 500/mi^2)	2.9	22.3	46.4
	Med (500 - 2K/mi^2)	3.3	20.7	49.5
	High (2K - 10K/mi^2)	3.2	16.9	45.9
	Very High (>10K/mi^2)	2.7	13.3	46.6

If we remove home-work tours and do the same comparison, there is far less difference between the elderly and non-elderly, as shown in Table 4-3. Trip rates are quite comparable, as are travel times. Trip distance is higher in each density category for the non-elderly, but the pattern of declining distance with increasing density is similar.

Table 4-3
Non-Work Trips, Distance, Time by Density, Elderly vs. Not Elderly

Age Group	Density	Trips	Distance	Time
Not Elderly	Low (< 500/mi^2)	2.9	25.2	42.9
	Med (500 - 2K/ mi^2)	3.0	21.9	41.5
	High (2K - 10K/ mi^2)	3.0	18.7	40.4
	Very High (>10K/ mi^2)	2.6	13.3	41.1
Elderly	Low (< 500/mi^2)	2.7	20.6	42.9
	Med (500 - 2K/ mi^2)	3.0	18.9	45.5
	High (2K - 10K/ mi^2)	3.0	15.5	42.3
	Very High (>10K/ mi^2)	2.5	12.0	42.2

When we segment the elderly, we again find that the pre-elderly and younger elderly behave very much the same, although there appears to be some substitution of non-work trips for work trips among the younger elderly, while the older elderly travel less distance more because of fewer trips than responses to density. As was evident in the urban/rural comparisons, it appears that the elderly in low-density areas (e.g., less accessible areas) travel fewer miles because they make fewer trips. See Figures 4-3 and 4-4. The older elderly make fewer and shorter trips in low-density areas relative to the other age cohorts. Comparing across density categories, the older elderly make the shortest trips in high-density areas, but make the most trips in high-density areas. Note that the relationships between trips and density and between distance traveled and density are quite similar across age cohorts. Taken together, it is unclear whether the older elderly are more sensitive to density (and the accessibility it represents) than others, or whether these patterns simply reflect different demographics that may be correlated with residential density.

FIGURE 4-3

TOTAL DAILY NON-WORK DISTANCE, ELDERLY AGE COHORTS, BY RESIDENTIAL DENSITY

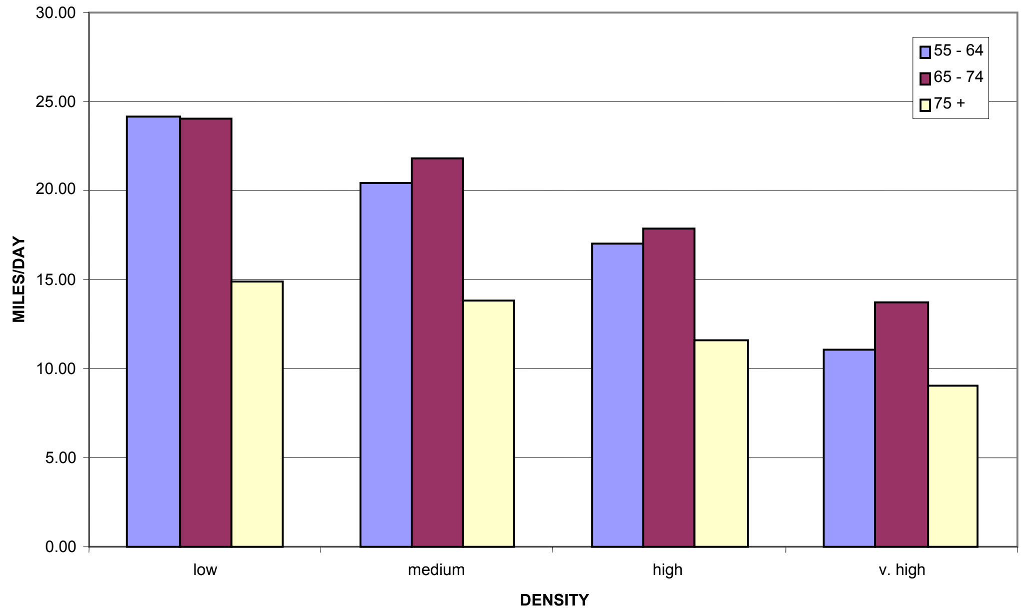
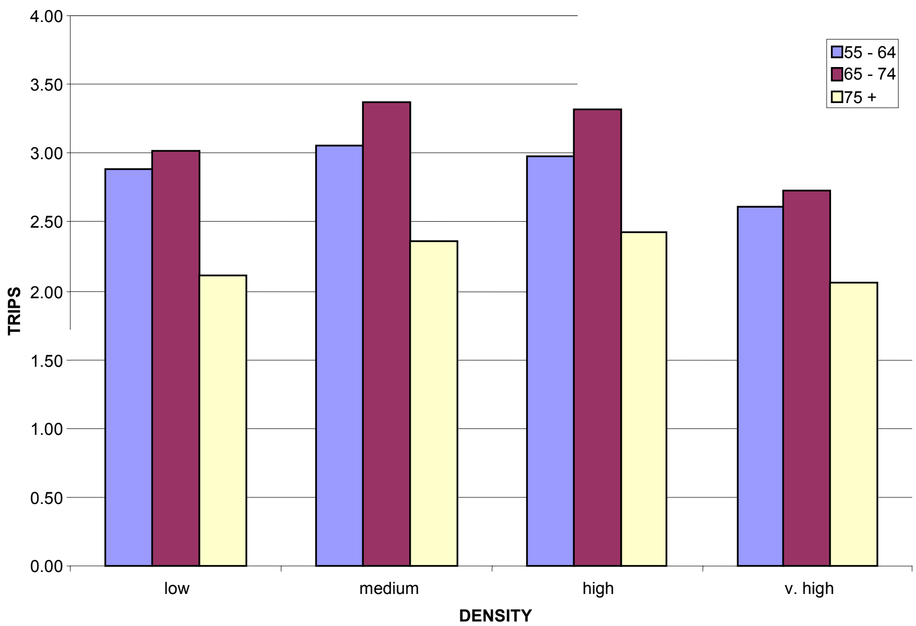


FIGURE 4-4

TOTAL DAILY NON-WORK TRIPS, ELDERLY COHORTS, BY RESIDENTIAL DENSITY



LAND USE AND MODAL SHARES

The emphasis on land use planning stems in part from the assumption that higher-density, mixed-use environments promote the use of alternative modes, namely public transit and walking. We compare mode shares for all trips across metropolitan size categories, for non-elderly and elderly age cohorts. Table 4-4 shows that the privately owned vehicle (POV) share is over 90 percent for all MSA categories except those of more than 3 million, and across all age cohorts ("other" mode category not shown in table). In the largest metropolitan areas, the POV share drops below 90 percent, and the combined total of transit and walk is in the range of 11–12 percent. There is little difference in this pattern across age cohorts. The transit share ranges from 3.6 in the youngest group to 2.7 in the eldest group. It is only in the eldest group that transit mode share is greater than 2 percent for MSAs in the lower size categories. Similarly, the walk share in the largest MSAs ranges from 7.7 percent in the youngest group to 8.7 in the eldest.[8] These patterns suggest that MSA size has the same effect for all age groups. There are also rather large differences in the relative shares of driver and passenger trips across age cohorts; these may be indicative of household size and lifestyle differences. If we look only at non-work trips, the same patterns are evident, except that non-work trips in general are more likely to have higher vehicle occupancy, hence the share of POV passenger trips is higher (data not shown).

[8] The NPTS Survey likely understates short walk trips, because short trips are most likely to be omitted from travel diaries. If the central portion of large MSAs is more amenable to short walk trips, the observed walk shares may be biased across MSA size categories.

Table 4-4
Mode Share (Percent), All Trips, by MSA Size[a]

Age Group	MSA	POV Driver	POV Pass.	Bus/Rail	Walk
Under 55	Not in MSA	78.7	17.4	0.1	2.7
	< 250K	76.5	18.3	0.5	3.2
	250K - 500K	76.4	18.3	0.3	3.4
	500K - 1M	77.3	18.4	0.7	2.8
	1M - 3M	76.3	17.9	0.9	3.6
	> 3M	71.0	16.3	3.6	7.7
55-64	Not in MSA	77.6	19.3	0.1	2.5
	< 250K	70.7	24.4	0.5	3.5
	250K - 500K	79.2	16.6	1.2	3.0
	500K - 1M	78.5	17.9	0.6	2.7
	1M - 3M	77.6	18.2	1.0	2.6
	> 3M	73.6	16.3	2.6	6.8
65-74	Not in MSA	75.5	20.5	0.4	3.3
	< 250K	78.5	18.2	0.6	2.4
	250K - 500K	72.6	22.5	0.3	4.3
	500K - 1M	74.1	19.4	0.4	4.3
	1M – 3M	72.0	21.2	0.6	5.4
	> 3M	67.0	20.5	3.6	8.1
75 or over	Not in MSA	60.4	29.6	1.0	8.6
	< 250K	67.6	28.4	0.7	3.1
	250K - 500K	67.5	26.9	0.4	4.8
	500K - 1M	66.7	27.4	2.4	2.5
	1M – 3M	63.4	26.6	2.6	7.1
	> 3M	59.0	28.5	2.7	8.7

[a] "Other" mode category omitted

Population density is a standard measure of urban form, and the one most frequently used as a measure of "transit friendly" environments. Tables 4-5 and 4-6 below give mode shares by population density categories, again by age cohorts. We chose our categories based on previous work, which indicates that only very high densities (by US standards) are supportive of transit. Transit use within the first two density categories is almost non-existent, and the walk share varies between 2 and 3 percent for all but the older elderly. Transit use ranges from 8.5 to 11.6 percent in the very high density category, and the walk share ranges from 18 to 22 percent. The POV share is lower in all density categories for the older elderly, as more persons become unable or unwilling to drive. If we look only at non-work trips, the transit share is lower and the walk share is higher. Public transit is oriented to commuting: transit routes are usually oriented to serve downtown job centers, and service frequency is highest during peak commuting periods. Hence transit is less likely to be used for non-work travel. Tables 4-5 and 4-6 suggests that transit may be used more frequently by those 65–74 years, but as travel becomes more physically difficult, the older elderly shift to walking and traveling as POV passengers.

Table 4-5
Mode Share, Percent of All Trips, by Density, Elderly Age Cohorts[a]

Age Group	Density	POV Driver	POV Pass.	Bus/Rail	Walk
Under 55	Low (< 500/mi^2)	79.0	17.5	0.2	2.2
	Med (500 - 2K/mi^2)	78.4	17.3	0.5	2.5
	High (2K – 10K/mi^2)	75.3	17.5	1.4	4.7
	Very High (> 10K/mi^2)	50.5	15.7	10.8	20.0
55-64	Low (< 500/mi^2)	77.8	19.3	0.1	2.2
	Med (500 - 2K/mi^2)	78.2	18.8	0.6	1.9
	High (2K – 10K/mi^2)	76.8	17.2	1.1	4.2
	Very High (> 10K/mi^2)	56.3	16.5	8.5	17.9
65-74	Low (< 500/mi^2)	74.8	21.6	0.2	3.0
	Med (500 – 2K/mi^2)	75.4	19.9	0.4	3.3
	High (2K – 10K/mi^2)	72.4	19.9	1.2	6.0
	Very High (> 10K/mi^2)	48.4	21.1	11.7	17.9
75 or over	Low (< 500/mi^2)	60.7	32.0	0.9	6.0
	Med (500 – 2K/mi^2)	64.8	29.1	0.7	4.6
	High (2K – 10K/mi^2)	65.7	25.9	1.9	6.2
	Very High (> 10K/mi^2)	42.2	24.8	9.0	22.1

[a] "Other" mode not included

Table 4-6
Mode Share, Non-Work Trips, by Density, Elderly Age Cohorts[a]

Age Group	Density	POV Driver	POV Pass.	Bus/Rail	Walk
Under 55	Low (< 500/mi^2)	74.1	21.8	0.2	2.6
	Med (500 - 2K/mi^2)	73.8	21.3	0.4	3.1
	High (2K - 10K/mi^2)	70.6	21.2	1.0	5.8
	Very High (> 10K/mi^2)	46.9	18.4	7.6	24.0
55-64	Low (< 500/mi^2)	74.1	23.0	0.1	2.4
	Med (500 - 2K/mi^2)	75.1	22.0	0.6	1.8
	High (2K - 10K/mi^2)	73.2	20.1	0.9	5.1
	Very High (> 10K/mi^2)	54.0	18.2	6.2	20.5
65-74	Low (< 500/mi^2)	73.2	23.2	0.2	3.1
	Med (500 - 2K/mi^2)	73.9	21.4	0.4	3.3
	High (2K - 10K/mi^2)	71.2	21.0	1.0	6.1
	Very High (> 10K/mi^2)	47.0	22.7	10.7	18.5
75 or over	Low (< 500/mi^2)	60.3	32.1	0.9	6.2
	Med (500 - 2K/mi^2)	64.3	29.6	0.7	4.5
	High (2K – 10K/mi^2)	65.1	26.3	1.8	6.4
	Very High (> 10K/mi^2)	42.0	25.5	8.4	22.3

[a] "Other" mode not included

In order to further examine the role of transit for the elderly, we examined frequency of transit use and transit access, as measured by distance to the nearest transit stop. For the entire NPTS sample, about 38 percent of all persons reported that there was no transit available in their community, and for the elderly the percentage is 40. As would be expected, the likelihood of living near a transit stop increases with metropolitan size and location within the metro area. Interestingly, when controlling for metropolitan size, we find that the elderly are more likely to live within ½ mile of a transit stop than the non-elderly, within every metro size category.[9] (See Table 4-7) It would appear that

[9] It might be argued that ½ mile is too great a distance to use in measuring access to a transit stop; the rule of thumb used by transit agencies is ¼ mile. We experimented with 0.2 and 0.3 miles and found that results are unaffected. We therefore chose to use the more generous measure.

this is more a function of aging in place (older people are more likely to be living in older neighborhoods) than of locating to take advantage of transit access.

Table 4-7
Percent Share Within ½ Mile of Transit Stop, Elderly vs. Not Elderly, by MSA Size, for Those Who Reported Transit Available in Their Community

	Not in MSA	< 1 M	1 M – 3 M	> 3 M
Not elderly	52.6	64.5	63.3	74.9
Elderly	60.7	73.9	68.8	79.1

It might be argued that since transit trips are not likely to be taken every day, and since many elderly did not make any trips on the travel day, the mode share data provides only a limited picture of transit use among the elderly. We therefore examined stated frequency of transit use. We define "regular user" as a person who uses transit at least once per week, and "occasional user" as using transit at least once in two months. Again controlling for metropolitan size, we find that the elderly are more likely *not* to use transit than the non-elderly. See Table 4-8. Part of the difference is explained by the absence of work trips among the elderly, but this should be offset somewhat by lower levels of household income and car ownership among the elderly.

Table 4-8
Transit Use (Percent), Elderly vs. Not Elderly, by MSA Size

		Not in MSA	< 1 M	1 M – 3 M	> 3 M
Not elderly	Regular	8.7	5.6	6.1	23.2
	Occasional	6.9	6.5	6.2	14.3
	Never	84.4	87.9	87.7	62.6
Elderly	Regular	4.2	4.1	3.9	14.2
	Occasional	6.8	4.8	5.0	11.8
	Never	89.0	91.1	91.0	74.0

CHAPTER FIVE
MODEL ANALYSIS

This chapter focuses on the role of land use in travel patterns of the elderly. We estimate a series of models to determine whether land use characteristics explain travel patterns of the elderly, and whether these characteristics operate differently for the elderly than the non-elderly. We estimate 3 sets of models: one for making any trip on the travel day, one for total daily travel distance, and one for using transit.

TOTAL TRIPS ON THE TRAVEL DAY

We noted earlier that the elderly have lower rates of travel overall, and that they are more likely not to have made any trips on the travel day. Does metropolitan location or local land use patterns have any relationship to traveling? Rosenbloom (2001) noted that the observed decline in trip making with age may be due to physical or other difficulties. If walking is more feasible, or if better transit service is available, will the elderly be more likely to travel? On the other hand, we might argue that the decision to travel is more a function of overall life circumstances, and land use factors are more relevant to how and where one travels.

Many factors are known to affect travel behavior across age cohorts. Hence a multivariate approach is required for testing hypothesis regarding these differences. The general model is:

$$\boldsymbol{Y = f\,(X, T, L)} \tag{1}$$

where ***Y*** = travel measure

X = vector of attributes of individual

T = vector of travel resources of individual

L = vector of residential location attributes

The **X** variables include gender, low-income household, and employment status. Men travel more than women, and travel increases with household income. Workers are more likely to travel on any given day than those who are not employed. The ***T*** vector includes measures of transportation resources. Car availability is measured as a person in a household with or without cars. Transit access is measured as whether the household lives in a community where transit service is available, or in terms of whether the household is located within ½ mile of a transit stop. Limitations in the NPTS data prevent finer measures of transit access.

The ***L*** vector includes two sets of variables, one set for metropolitan location, and the other set for neighborhood characteristics. The metropolitan location variables include: MSA by size category (<250K, 250K-500K, 500K-1M, 1M-3M, >3M), live outside an MSA, and live in the central city. The relationship of travel with metropolitan size could be positive or negative. As MSA size increases, there are more distant total destination opportunities; therefore trips may decrease, especially for those with limited mobility. On the other hand, density increases with metropolitan size, so there are more nearby destination opportunities, therefore trip making may increase. The effect of location inside or outside an MSA is also uncertain. Lack of available opportunities may suppress travel, while dispersed land use patterns may increase travel. Location within the central city implies a higher level of accessibility and transit access.

The second set of location factors to be examined is local neighborhood characteristics. The NPTS data provide a wide variety of neighborhood variables based on census tract or block group levels, and matched to each survey household. We use census tract level, since it provides a better indication of the general surroundings of the respondent's residence. We use three measures of neighborhood characteristics from NPTS: population density, the share of owner occupied housing, and the share of housing units less than 10 years old. We also create a local service density variable based on zip code level drawn from 1992 Economic Census data, which is measured as the number of service and retail establishments per square mile.

Population density is categorized in four levels: low (less than 500 persons/square miles), medium (500 to 1,999 persons/square miles), high (2000 to 9,999 persons/square miles), and very high (10,000 or more persons/square miles). Higher population density level is expected to have a positive relationship to trip making since there are more activity destinations in the neighborhood. The share of owner occupied housing is related to household income, but also represents lower residential densities, and therefore is expected to have a negative relationship with trip making. The share of housing units less than 10 years is an indicator of more recently developed neighborhoods that presumably have a more dispersed and segmented land use pattern. Again, a negative relationship is expected. Service density is related to access to local stores or services, and therefore a positive relationship to trip making is expected. Variable description and definitions are given in Appendix 1. Descriptive statistics of variables are given in Appendix 2.

There are three possibilities for including age cohort effects in our models. The first is simply to add dummy variables, which tests whether elderly age cohort has an independent effect on travel. A second approach is to estimate models for each age group separately. Whether age affects the relationship between a given independent variable and travel is determined by testing for differences between estimated coefficient values across the age group models. The third possibility is to estimate a model that includes interaction dummies for each independent variable,

$$\boldsymbol{Y = f\,(X, T, L, XA, TA, LA, A)} \tag{2}$$

where $\boldsymbol{A}$ is the vector of age cohort dummies, with 16–64 the omitted category.

Finally, the appropriate measure of travel must be defined. Some researchers argue that we should examine non-work travel (e.g., Rosenbloom, 2001). Since the elderly are not likely to be employed, comparing total travel will overestimate true differences in behavior. On the other hand, one could argue that work becomes increasingly discretionary with advancing age (except for those with very low incomes), and the ability to work is itself an indicator of physical well being. We have chosen to use total travel, including work trips for our analysis.

Binary Logistic Regression Model

We estimate a simple binary probability choice model on whether the person took at least one trip on the survey day for any purpose. The binary model estimates the probability that an individual make at least one trip on the survey day as a function of those factors discussed above. It has the following form:

$$P_1 = \frac{\exp(\beta_0 + \sum_j \beta_j x_j)}{1 + \exp(\beta_0 + \sum_j \beta_j x_j)} \quad (3)$$

or equivalently

$$P_1 = \frac{1}{1 + \exp(-\beta_0 - \sum_j \beta_j x_j)} \quad (4)$$

where $P_1 =$ estimated probability of an individual who travels

$x_j =$ independent variables

$\beta_j =$ estimated coefficients

The functional form assumes independence among the observations and extreme value distributed error terms. The logistic model is estimated via maximum likelihood, and model significance is tested via the likelihood ratio test.

As discussed above, three types of variables are included in this model: individual socio-economic characteristics, individual travel sources, and characteristics of residential location. If the elderly are more sensitive to land use characteristics, the interaction dummy variables should be significant.

Analysis

Results for the binary trip model are shown in Table 5-1. For ease of interpretation, values are given only for coefficients significant at $p < 0.1$. The first column of coefficient values corresponds to the total sample; the remaining column coefficient values are relative to the total sample values.

The age dummy coefficients indicate decreased likelihood of taking at least one trip with advancing age, consistent with the descriptive data. Turning to the socio-economic variables, signs for male sex, low income, and employment status are as expected. Note that the coefficient of male sex is larger for the older age categories; this is consistent with more traditional gender roles (e.g., men conduct more out-of-home activities), and the greater likelihood that men have a driver's license among the older elderly. Having no car in the household has a negative effect on trip making, while living in an area where transit service is available has a positive effect, and these effects are consistent across age groups. Note that the magnitude of the transit access coefficient is much smaller than that of the car availability coefficient.

For non-elderly adults, living in any MSA of over 250,000, or living outside an MSA, has a negative effect. The coefficient values are similar, indicating no relationship with MSA size. The positive coefficients on the elderly group interaction terms indicate no relationship between trip making and MSA size for the elderly. Living in the central city is not significant for any group. The service density variable coefficient is positive for the elderly, suggesting that greater access to service does matter for the elderly. Other measures of local geography are not significant. Results for the density variables are mixed and difficult to interpret.

We may summarize our results as follows. First, differences between the elderly and non-elderly are explained primarily by age itself, and by differences in socio-economic and demographic characteristics. Second, metropolitan form variables are not significant for the elderly groups. Third, neighborhood form variables have little effect on trip making across all age groups.

Table 5-1
Trip Model Results

Variable	All	65-74	75+
Constant	1.805		-1.490
Age Dummy		-0.453*	
Male	0.108	0.342	0.412
Low income household	-0.246	-0.217	NS
Employed	0.930		
Zero-car household	-0.462	NS	NS
Transit access	0.065*	NS	NS
Live in central city	NS	NS	NS
MSASIZE = 2 (250K-500K)	-0.246	0.344	NS
MSASIZE = 3 (500K -1M)	-0.378	NS	0.527
MSASIZE = 4 (1-3M)	-0.281	0.397	NS
MSASIZE = 5 (> 3M)	-0.351	0.439	NS
Outside MSA	-0.265	0.448	0.549
Log of service density	NS	0.058	0.096
Share of new housing	NS	NS	NS
Share of owner-occ. Units	NS	NS	NS
Low density (<500)	-0.135	NS	0.411
High density (2k-10k)	NS	NS	0.286
Very high density (>10k)	NS	-0.428	NS
N	62020		
-2 Log Likelihood	46386		
C&S R^2	0.055		

* Significant at $p < 0.1$; all other values significant at $p < 0.05$.

TOTAL DAILY TRAVEL DISTANCE

We estimate a regression model to examine the effects of land use characteristics on total daily travel distance. As with trips, we include travel for all purposes. We include only those who traveled on the survey day. If travel becomes more onerous as people age, we would expect the elderly to be more sensitive than the non-elderly to geographic characteristics, and hence economize on travel in environments where shorter trips are possible.

Multiple Regression Model

The multiple regression model includes socio-economic, transportation resource, and land use variables, together with a full set of interaction terms as in equation (3) above. Because the distribution of the dependent variable is non-linear, we use the natural log of total daily travel distance. We include only those who traveled on the survey day.

The **X** variables include gender, low-income household, and employment status. Men travel more than women, and travel increases with household income. Workers travel more than the unemployed due to the needs for work during the day. The ***T*** variables include car availability, whether a person has a driver's license, and the total number of trips taken. Car availability is measured as a person in a household with or without cars. It is expected that a person with a driver's license travels more than one without a license. Whether trips should be entered as an independent variable is a matter of judgment. In this case, it is used as a scaling factor, e.g., to determine whether distance is affected by factors other than the number of trips made.

The ***L*** vector is as described in the previous section. The relationship of total travel distance with metropolitan size could be positive or negative. As MSA size increases, there are more distant total destination opportunities; therefore travel may increase. On the other hand, density increases with metropolitan size, so there are more nearby destination opportunities, therefore travel may decrease. The effect of location inside or outside an MSA is also uncertain. Lack of available opportunities may suppress travel, while dispersed land use patterns may increase travel. Location within the central city implies a higher level of accessibility; hence less total travel is expected.

Regarding local land use variables, higher population density level is expected to have a negative relationship to travel distance since there are more activity destinations in the neighborhood and distance for each trip is relatively short. The share of owner-occupied housing, as well as the share of housing units less than 10 years, is expected to have a positive relationship with travel distance. Service density is expected to have a negative relationship to travel distance.

Analysis

The regression model results are shown in Table 5-2. As before, coefficient values are shown only for those significant at $p < 0.05$. In contrast to the previous model, age has no independent effect on total daily travel distance. The variables for individual socio-economic characteristics and travel resources show expected effects: travel distance is positively associated with male sex, being employed, and having a driver's license. It is negatively associated with low income, and without car access. Since most of the elderly are not employed, we do not include interaction terms for this variable.

The low-income household variable becomes insignificant for the older elderly. According to Table 3-2, 61 percent of the older elderly are in a household with low income status, implying that this low income standard is not appropriate for the older elderly. As noted earlier, income measures do not incorporate savings or other sources of income. The effect of car availability is more pronounced for the older elderly. The driver's license status variable coefficient becomes insignificant for the older elderly due to its high correlation with zero-car household variable. The effect of trips is slightly greater for the elderly, suggesting less variability in trip distance.

Turning to metropolitan form, travel distance increases with MSA size, and decreases for those living inside the central city or outside an MSA for the total sample. MSA size is not significant in most cases for the elderly groups. These MSA variables may reflect other demographic characteristics that become less important with age.

Total sample results are as expected also for the neighborhood form variables. Access to services does not have the negative effect on travel distance for the elderly; this may be the result of the elderly making more non-work trips (and fewer chained non-work trips), rather than not economizing on non-work travel. The remaining neighborhood form variable coefficients are as expected, with measures of dispersed urban form associated with more travel distance, and high density associated with less travel distance. The more negative value of the density coefficients for the elderly age groups suggests the older elderly are more likely to economize on travel when it is convenient to do so.

It is important to note that the land use variables as a group explain very little of the variation in non-work travel distance. Most of the explanatory power of this model is from the overall trip rate (lower for the elderly) and socio-economic characteristics of the individual. As with trips, using total daily travel distance (e.g., including work and work-related travel) gives similar results, and the results are not presented here.

Taken together, the results of Tables 5-1 and 5-2 suggest that there is a significant difference in the propensity to travel between the elderly and non-elderly, and this difference increases with age. Having no car in the household decreases the likelihood of traveling as well as travel distance. Metropolitan form variables have little effect on elderly travel, while neighborhood form variables do suggest less travel distance in more accessible neighborhoods, all else equal. With one significant exception (high density for the older elderly), there is no evidence that the elderly are any more likely to take advantage of nearby travel opportunities than the non-elderly. Finally, as a group, the spatial form variables explain little of the variation in either trip making or travel distance.

Table 5-2
Total Travel Distance Model Results

	All	65-74	75+
Constant	1.407		
Age Dummy		NS	NS
Gender	0.153	-0.067	NS
Low income household	-0.121	NS	0.132
Employed	0.232		
Total number of trips	0.174	0.027	0.062
Has driver's license	0.409	NS	-0.325
Zero-car household	-0.334	NS	-0.225
Live in central city	-0.059	NS	NS
MSASIZE = 2 (250K-500K)	0.083	NS	NS
MSASIZE = 3 (500K -1M)	0.180	NS	-0.215
MSASIZE = 4 (1-3M)	0.260	-0.185	-0.328
MSASIZE = 5 (> 3M)	0.300	-0.178	-0.436
Outside MSA	-0.064	NS	-0.268
Log of service density	-0.053	0.024*	0.089
Share of new housing	0.325	0.228*	NS
Share of owner-occ. Units	0.273	NS	NS
Low density (<500)	0.215	NS	NS
High density (2k-10k)	-0.041	NS	-0.279
Very high density (>10k)	-0.088	NS	-0.278
N	53331		
F	396		
Adj. R^2	0.286		

Significant at $p < 0.1$; all other values significant at $p < 0.05$.

TRANSIT USE

Public transit is a key aspect of proposed land use strategies that promote higher density, mixed-use patterns. It is therefore important to examine whether the elderly are more likely to use transit when it is accessible and when land use patterns support it. Similar to the trip-making model, we propose a binary logistic model to test the relationship between transit use and residential location for the elderly.

Binary Logistic Regression Model

We estimate a simple binary probability choice model on persons use transit at least once vs. persons never use transit during the past two months on the survey day. The binary model estimates the probability that an individual make at least one transit trip in two months as a function of a set of factors discussed below.

The data for this model were drawn from the original sample of 95,360 persons. This sample yielded 48,546 valid cases for the transit use analysis. The data was filtered based on two NPTS survey questions. The first filter was based on household survey question, "is transit available in your town or city?" The second filter is based on the question regarding usual behavior. The question was asked only of persons 16 years old or older, and only of persons completing their own questionnaire. This left a sample of 50,035 observations. Additional missing data on key variables further reduced the sample, ultimately yielding 48,546 observations distributed to transit users and non-transit users.

Note from Chapter Four that the elderly are less likely to be transit users than the non-elderly. The question here is whether this is the case when other factors are controlled. Three types of variables are included in this model: individual socio-economic characteristics, individual travel sources, and characteristics of residential location. Individual characteristic variables include gender, low-income household, and employment status. Women are more likely to use transit than men, because women have fewer travel resources. It is well known that low income is associated with transit use. Employment status is related to income level. A negative association between an employed person and transit use is expected. As mentioned, most of the elderly are not employed. This variable is not applicable for the elderly.

Many travel behavior theorists argue that travel choices are joint choices made at the household level. Household members decide who gets the car, who takes the children to school, etc., and allocate travel resources and responsibilities accordingly. The composition of the household therefore may affect transit use. However, household composition measures are highly correlated with age (most elderly households have no kids), and therefore are not included in the model.

Individual travel sources used in the model include car ownership and transit access. Car ownership is measured as whether a person in a household with cars or not. If there is no car in a household, there is more likelihood of using transit. Access to transit service is of course a necessary condition for using transit. Distance to stops and transit headways are typical measures of transit availability. Since we have no information on headways, we consider only distance to the nearest transit stop. Transit access was measured as a transit stop located within ½ mile of the residence.

It was noted earlier that the largest US metropolitan areas account for most US transit ridership. This is due to the higher cost of using private vehicles (congested roads, limited and costly parking), particularly in downtown areas. Prior research also show that transit use is highest in the central parts of the largest metropolitan areas, and among low-income households (e.g., Pucher, Evans, and Wenger,1998). We therefore limited our land use measures to large metropolitan size (1-3M and >3M), living in the central city and high local density (high density and very high density).

It is expected that the likelihood of using transit is positively associated with the two large metropolitan variables. In addition, the central parts of the largest MSAs have relatively high development densities and more extensive transit service, making transit more competitive with the private auto. Hence, the central city variable is expected to have positive association with transit use. In addition, it is assumed that transit use increases with higher neighborhood density.

Attitudes are important predictors of travel behavior. Fear of crime or other negative perceptions of transit may prevent transit use. It is unfortunate that the NPTS data preclude our consideration of attitudes.

Analysis

Model results are shown in Table 5-3. Our results show that for non-elderly adults (16–64 years), the likelihood of being a transit user is negatively related to male gender, positively related to low income, having no car, and having a transit stop nearby.

Transit use is also positively related to all the land use variables (e.g., living in large metropolitan areas and in places of high population density).

The independent age dummy results indicate a slightly more negative effect for the older elderly. Results for the elderly cohorts show that low income is negatively related to likelihood of transit use, and the effect of having no car is less positive, with both effects greater for the older elderly. We surmise that low income is not as good a measure of overall resources for retired people (savings or wealth not included). It is possible that the effect of having no car for the elderly is less strong because the elderly travel less overall, and because lack of car may be related to physical limitations. Results for the 75 and older cohort are similar to those for the younger elderly, but suggest more sensitivity of this group to travel convenience, and less likelihood overall of being a transit user.

Access to a transit stop is quite significant. We tested models using ½ mile distance and 1/10 mile distance, and short distance to a transit stop is quite significant. In addition, high local density has a strong effect. Taken together, these results suggest that land use and access factors work similarly for all age groups, but the elderly are nevertheless less likely to be transit users.

These results are quite consistent with the descriptive information presented previously. They are "good news and bad news" with respect to the potential role of transit in serving the mobility needs of the elderly. The elderly are less likely to be regular transit users, even when transit is accessible (at least as measured here) and when land use patterns are more favorable to transit. In addition, the older elderly are more likely to be transit users when transit stops are close to home and when local access to goods and services is likely to be high. This is not surprising; transit is less convenient than the private auto under most circumstances; it is also a more physically challenging mode of travel. Walking to and from the bus stop or train station, waiting and transferring, boarding and alighting vehicles all make transit use more difficult for those with limited physical stamina. It therefore seems quite reasonable that the elderly will prefer auto travel, and will compensate for physical limitations by traveling less, rather than shifting modes. These results suggest caution in considering more transit-oriented environments as a transit mobility strategy for the elderly. A very high level of access and service quality would be required to attract the older elderly to transit.[10]

Table 5-3
Transit Use Model

Variable	All	65-74	75+
Constant	-2.886		
Age Dummy		NS	-0.582*
Male	-0.089	NS	NS
Employed	-0.090		
Low income household	0.252	-0.548	-0.949
Zero-car household	2.581	-1.122	-0.952
Dist. to stop < 0.5 mile	0.489	-0.289*	NS
Live in central city	0.399	NS	NS
MSA population 1 - 3M	0.356	0.483	NS
MSA population > 3M	0.978	NS	-0.818
High density (2k-10k/mi^2)	0.364	-0.302*	NS
Very high density (>10k/mi^2)	1.326	NS	NS
N	28,183		
-2 Log Likelihood	25,569		
C&S R^2	0.159		

* Significant at $p < 0.1$; all other values significant at $p < 0.05$.

5.4 A BRIEF COMPARISON: LAND USE AND TRANSIT USE IN GREAT BRITAIN

Another way of considering the issue of public transit is to compare the US with other countries where transit access is much greater overall, and the transit mode share is greater. Data from Great Britain is illustrative.[11] Figure 5-1 gives total annual journeys per year by metropolitan location for persons 70 years or older. London includes the 33

[10] Another key argument for higher density, mixed-use land use is to facilitate walk trips. Analysis of walk trips is beyond the scope of this report.

boroughs of London; "metro areas" include seven provincial conurbations.[12] The remaining location categories are in descending order of population. Figure 5-1 shows that walking is a major mode (walk share averages about 30 percent in Great Britain, compared to about 7 percent in the US) in all categories. Transit use is higher in the largest metro areas, and car use, either as passenger or driver is lower in the largest metro areas. These differences across metro areas are much greater than is the case for the US (Table 5-4). Data based on all age groups show a similar pattern, but with far higher shares for car modes across all areas and smaller differences in modal distribution across all areas. It would appear that the greater availability of public transit in London and other large metro areas makes it possible for the elderly to use transit more extensively in the these areas.

Figure 5-2 gives mode shares for all trips by age. It clearly shows that car use starts to decline with the 60–69 year cohort, and for those over 70, the car share (driver plus passenger) drops below 50 percent. Conversely, walking and transit use greatly increase after age 60. One might conclude from these figures that the availability of transit alternatives makes it possible for the elderly to shift away from cars as driving becomes more difficult, but this is not the whole story. First, the British came later to car ownership and driver's license holding, hence people over 60 have much lower rates of license holding than younger people. As younger cohorts age, we will likely see far less transit use among the British elderly. Second, per capita income is much lower in Britain: comparable figures for 1999 median household income are $33,900 for the US and $21,800 for Great Britain. Third, the cost of owning and operating a private vehicle is much greater in Britain: the 1995 fuel price per liter was $.30 for the US and $.90 for Great Britain (Giuliano and Narayan, 2003). Thus the price of travel as a proportion of income is much higher in Great Britain than in the US, and the rate of car ownership is much lower. The outcome is much lower rates of mobility overall as measured in daily trips or miles traveled, as shown in Table 5-4. The difference in total time spent traveling is small, due to greater use of slower modes in Great Britain.

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[11] A portion of the data discussed in this section was provided to the authors by Mr. C.G.B. (Kit) Mitchell. The remainder was drawn from National Transport Survey data prepared by the authors.

[12] Provincial conurbations: West Midlands, Greater Manchester, Merseyside, South Yorkshire, Tyne and Wear, Glasgow.

Table 5-4
Average Daily Person Trips, Travel Distance, Time

	US		GB	
	Mean	Median	Mean	Median
Trips/day	3.8	4.0	2.9	2.0
Miles/day	28.7	17.0	14.0	6.0
Minutes/day	58.4	46.0	54.4	40.0
Share no trip days		16.0		21.0
N		95360		23167

Source: Giuliano, 2001

This brief comparison illustrates the complexity of the issue of land use and transit. It is certainly the case that transit access and service availability is greater in Britain than in the US, and consequently it provides a more competitive alternative to the car than in the US. It is also the case that limited car ownership (mostly a function of low per capita income and high prices) makes possible a much greater demand for transit, making its more extensive supply more economically viable. These conditions are not replicable in the US, and indeed are changing in Britain and throughout the developed world, as per capita income and car ownership continue to rise (Giuliano, 1999; Orfeuil and Salomon, 1993; Pucher and Lefevre, 1996).

FIGURE 5-1

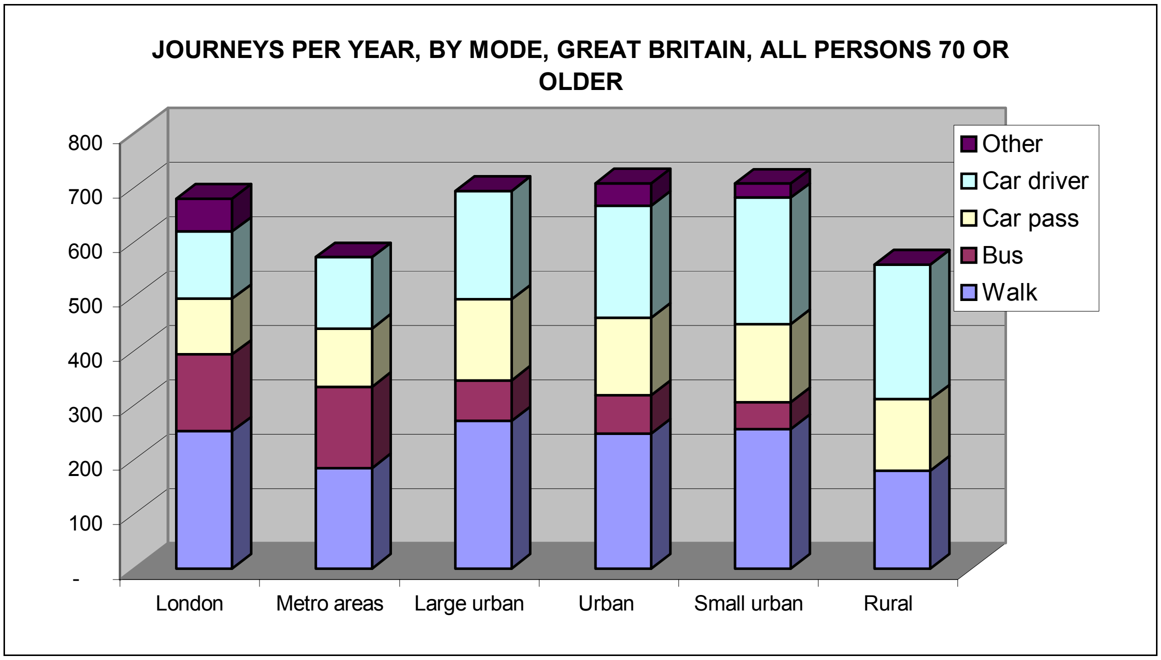
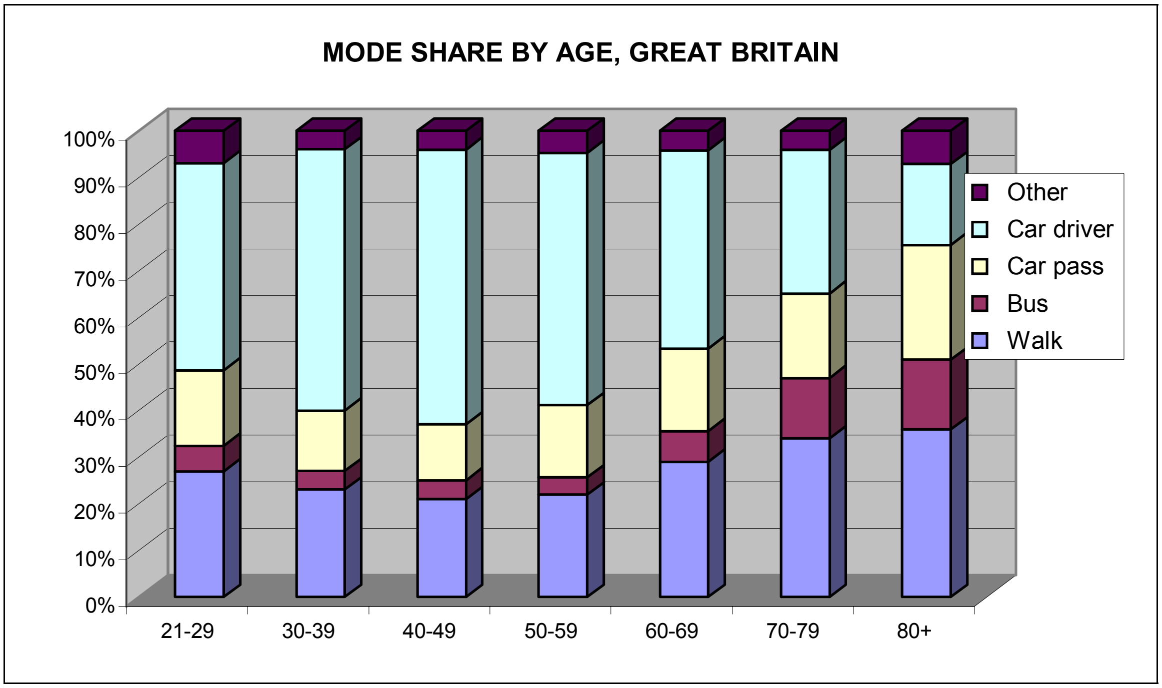


FIGURE 5-2



CHAPTER SIX
CONCLUSIONS AND POLICY IMPLICATIONS

Although promoting the use of public transit is an important objective of land use strategies, it is not the only objective. Higher density, mixed-use land use patterns improves accessibility for all modes, including walking and driving. Our results showed that total daily travel distance declines in places where such land use patterns exist. If we assume that travel behavior is indeed influenced by land use patterns (as opposed to land use patterns acting as surrogates for unobserved preferences that lead some people to seek out such neighborhoods because they prefer to travel less), then the more pedestrian friendly, mixed-use development expands, the more travel distances will be reduced. However, with a few notable exceptions, the elderly are no more likely to take advantage of these potential economies than the non-elderly; the older elderly travel less wherever they live. What then can be said about the potential of land use policy to address mobility problems of the elderly, especially the oldest old?

LAND USE POLICY ISSUES

Most elderly age in place, preferring to remain in the homes or apartments selected in earlier stages of the life cycle. Since population shifts of the last several decades have been towards decentralization, aging in place means aging in the suburbs for the majority of the elderly (Frey, 1999). In addition, as noted in Chapter 2, there is substantial evidence that aging in place promotes well-being and quality of life. Aging in place allows people to maintain local friendships and ties in the community, shop and obtain medical care in familiar places, rely on neighbors for emergency support, etc. As the geographically proximate extended family becomes increasingly rare, these neighborhood relationships may become more important: for many elderly, friends and neighbors are more readily accessible than children or siblings (Wethington and Kavey, 2000). Therefore any policy proposal to encourage the elderly to relocate to more accessible places must consider whether the marginal increase in travel opportunities is worth the loss of an established social network and the comfort and familiarity of one's long-established neighborhood. Rather, the challenge is to improve accessability in the suburbs and the exurbs.

Another way of looking at this issue is to observe what choices the elderly are making now. We noted in Chapter Two that the elderly are less likely to move than the non-elderly. When the elderly do move, there is a slightly greater likelihood for a long distance move, but the elderly are no more likely to move from suburb to city, or from city to suburb, than the general population.

Taken together, the migration data is consistent with expectations for continued decentralization of the elderly population, and continued movement to smaller urban areas. These areas not only offer lower housing and living costs, but less congestion and traffic and "a slower pace of life." Driving is no doubt much easier in such areas; people can avoid high-speed freeway travel, and there is less "rush hour" to avoid in scheduling trips. Such places allow the elderly to maintain their auto-mobility and the lifestyle that goes along with it.

Therefore land use policy must address improving the accessibility of suburban and smaller urban areas. Such policies must of necessity be highly context specific. A few examples may be instructive. Pasadena, CA is located about 15 miles north of Los Angeles. Once an affluent suburb of Los Angeles, it is now a very diverse city of about 130,000 population. For over 20 years the city has pursued an aggressive redevelopment policy to revitalize the downtown. Pasadena uses a variety of incentives to attract elderly housing to the downtown core area. Senior housing projects are given density bonuses of up to 50 percent, and have reduced parking requirement down to a minimum of 0.5 spaces per unit. In return, such developments are expected to offer subsidized transit passes to residents. Pasadena's General Plan has an explicit policy of promoting accessible location of public and private services and of considering transit accessibility in the location of housing. As a result the downtown area is quite pedestrian-friendly, and the mix of housing, retail, commercial, and medical services makes it very accessible.

Irvine, CA is a much newer city, having been established in the 1960s as the largest planned community in the US. Unlike Pasadena, Irvine has no "center" (despite a population of over 140,000), but rather was designed as a collection of "villages", each with its own commercial center, connected to one another by "activity corridors" (major arterials). Irvine typifies suburban land use—segmented land use, walled residential communities, and circulation oriented around the car. Irvine has several senior housing developments, and they are located in activity corridors and adjacent to neighborhood shopping centers. Consequently, basic goods and services are within walking distance of each development, and each development has transit access, though transit access is quite limited (e.g., few routes, long headways). Essentially, in a transit and pedestrian unfriendly environment, the senior housing has been placed in the best possible locations. The challenge for land use planning is how to further improve accessibility of such locations.

We must close this section by cautioning that we have little evidence regarding how such policies actually affect travel patterns or well-being of the elderly. Although intuitively we would expect benefits, whether Pasadena or Irvine senior housing residents are relatively more mobile, or are enjoying significantly better quality of life as a result of having greater accessibility remains to be demonstrated. This is clearly a question that merits further research.

IMPLICATIONS FOR TRANSPORTATION POLICY

What does this imply for transportation policy? It seems clear that the elderly both now and in the future will want to retain the ability to drive for as long as possible. This is quite rational, since the comfort, convenience, and flexibility of the automobile is surely even more valued by the elderly than the non-elderly. It seems that we should be thinking about "driver-friendly" as well as pedestrian and transit-friendly urban design alternatives: streets not so narrow as to be a hazard for pedestrians, more and better signage and traffic control, easily negotiated parking facilities, etc. None of this is inconsistent with promoting safe and pleasant environments for pedestrians or transit.

Efforts to improve the safety of older drivers and their vehicles should continue. New technology such as collision avoidance, enhanced night vision, lateral guidance, and eventually automated vehicles will provide enormous benefits to the elderly. We might also be thinking about a further differentiated private vehicle fleet, with smaller (but safer) "town cars" that would suffice for everyday errands and other activities.

Trends in travel patterns suggest that conventional transit's potential for offering an acceptable substitute to the private vehicle is quite limited. Most elderly will not be living in places where fixed route transit is efficient or effective. Hence transit alternatives of the future must mimic the car. This is of course an old notion; efforts to develop viable forms of paratransit have been in progress for over 25 years. There have been two main barriers to paratransit. First, there is the problem of serving sparse, dispersed travel demand patterns in a cost-efficient manner. New technology gives the potential for developing more efficient dispatching and routing and accommodating real-time, "on-the-fly" trip requests. Combined with private contracting or other strategies that reduce costs, new technology may generate cost-effective paratransit options. Second, there is the array of regulatory and institutional barriers that prevent jitneys, shared-ride taxis, or other privately provided paratransit services from operating within the service areas of conventional transit operators, or in competition with local taxi services. These institutional barriers will have to be reduced if innovative auto-like modes are to emerge.

Again, what people are doing now provide some insights. A recent case study of a low-income area in Los Angeles revealed that private organizations—churches, senior centers, etc.—provide rides for members, but generally only for specific purposes (Giuliano and Moore, 2000). Interestingly, many churches reported having to abandon these services in response to rising insurance and liability costs. Again, legal and institutional barriers will have to be reduced if these more informal forms of transit are to expand. The Los Angeles study also revealed that many trips are accomplished via informal carpools—people providing rides to neighbors and relatives for a fee. In less-poor neighborhoods, we surmise that such ridesharing less frequently involves cash payments. These informal arrangements emphasize the importance of social networks (and by implication, aging in place) in retaining mobility.

We might consider how these more informal forms of transport might be extended. For example, many suburban communities today have some type of governance structure (e.g., homeowners associations). There may be possibilities of enlisting such organizations as centers for neighborhood ridesharing. Some markets in high-poverty areas offer rides to customers; why not expand this concept to markets in places with high concentrations of elderly population? An area that may provide insights on such services is Los Angeles County. Cities in the county receive a portion of a local sales tax earmarked for transportation, and this funding may be used for any transportation purpose. As a result, the cities provide a wide variety of local transit services. It may be worthwhile to examine these services and determine their applicability in other metropolitan areas.

FURTHER RESEARCH

Our understanding of the relationship between land use and transportation among the elderly is very limited. Our literature review revealed that almost no empirical research on this topic exists. The results presented here are based on a single (but comprehensive and representative) cross section, and land use characteristics were represented in rather approximate ways. There are many questions yet to be answered. Here are some examples:

- How do the elderly adapt to declining driving skills in low accessibility areas? Are the elderly residing in such areas significantly more mobility disadvantaged than those who live in neighborhoods with higher accessibility?
- When elderly move, how much consideration is given to future mobility needs?
- How sensitive are the developers of senior communities to mobility and accessibility? And what are cities doing to encourage location of such communities in appropriate places?
- How much does land use really matter, relative to social networks and support systems?

Given the state of knowledge on this topic, further research is in order. Some possibilities include:

- Longitudinal case studies of residents in different types of neighborhoods to trace shifts in travel behavior over time and how these may vary across neighborhood/community type.

- Cross-sectional studies of senior community residents in various locations to determine how different levels of accessibility may affect travel patterns and car use.
- Studies of urban planning practice related to senior housing development.
- Studies of mixed-use development that examine who locates in such developments and why.

This report has summarized the existing literature and presented a brief analysis of land use and transportation relationships among the elderly. Our results suggest that land use effects are small and largely consistent across age groups. There is much we do not know, yet many planners and policy makers assume that land use policy is an effective tool for addressing the mobility problems of the elderly. Further research is clearly in order.

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APPENDIX 1: VARIABLE DESCRIPTIONS FOR TABLES

Variable	Description
Gender	1 = male
Low income household	1 = low income household member
Employed	1 = worker
Total number of non-work trips	
Has driver's license	1 = person has a driver's license
Zero-car household	1 = household without cars
Live in central city	1 = live in central city
Live MSA 250K-500K	1 = person residing in a MSA with 250K-500K population
Live MSA 500K -1M	1 = person residing in a MSA with 500K-1 million population
Live MSA 1-3M	1 = person residing in a MSA with 1 - 3 million population
Live MSA > 3M	1 = person residing in a MSA with more than 3 million population
Live Outside MSA	1 = person residing out of a MSA
Local access	number or service & retail establishments per square mile, zip code
Share of new housing	percent of housing units built in last 10 years, census tract
Share of owner-occ. Units	percent of owner-occupied housing, census tract
Low density	1 = person residing in low-density neighborhood (<500 persons/sq. mile)
High density	1 = person residing in high-density neighborhood (500-1999 persons/sq. mile)
Very high density	1 = person residing in very high-density neighborhood (2000-9999 persons/sq. mile)
Dist. to stop < 0.5 mile	1 = a transit stop located within ½ mile of the residence

APPENDIX 2: VARIABLE DESCRIPTIVE STATISTICS

Variable [a]	N	Mean	Std Dev	Minimum	Maximum
Gender	75797	0.482	0.498	0	1
Low income household	62280	0.346	0.476	0	1
Employed	75797	0.664	0.471	0	1
Total number of trips	75797	2.903	2.886	0	25
Has driver's license	75797	0.887	0.315	0	1
Zero-car household	75797	0.062	0.241	0	1
Live in central city	75797	0.304	0.459	0	1
Live MSA 250K-500K	75797	0.072	0.258	0	1
Live MSA 500K -1M	75797	0.083	0.275	0	1
Live MSA 1-3M	75797	0.174	0.378	0	1
Live MSA > 3M	75797	0.396	0.488	0	1
Live Outside MSA	75797	0.197	0.397	0	1
Local access	75797	55.78	264.92	0.0015	8850.73
Share of new housing	75487	0.123	0.144	0	0.95
Share of owner-occupied units	75487	0.672	0.211	0	0.95
Low density	75797	0.305	0.459	0	1
High density	75797	0.387	0.486	0	1
Very high density	75797	0.103	0.303	0	1
Dist. to stop < 0.5 mile	38739	0.720	0.427	0	1

[a] age < 16 are not included