AGING AND FEMINIZATION:
IMPLICATIONS FOR FUTURE TRAVEL DEMANDS OF THE ELDERLY

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Abstract. An increasing proportion of the oldest-old (85+) population, combined with a pronounced abundance of older women relative to older men, characterize the demographic development of industrialized countries. Both, aging and feminization, strongly influence the transportation demands of the future. As people age, their driving abilities diminish, leading to driving reduction and ultimately driving cessation. Moreover, the literature suggests that the driving adjustments operate differently for men and women. Especially, women are prone to cease driving at an earlier age than men, and thus are in need of travel modes other than driving at an earlier age. This paper therefore aims at estimating the demand for non-automobile based mobility of the elderly. Towards that end, it develops a survival model that links the demographic shifts towards a growing elderly population and towards the feminization of the older population with driving cessations rates. The model is used to simulate the future demand for non-automobile based mobility of the elderly, as well as estimates of older men's and women's 'driving life expectancy'. Results for The Netherlands and the U.S. suggest that, while women's life expectancies are substantially higher than those of men, there is substantially less difference between men's and women's driving life expectancy. Moreover, in the Netherlands, demand growth rates will exceed the growth rates of the elderly population over the next 15 years. In the U.S., in contrast, excessive demand growth rates will occur substantially later, when the huge baby boom has reached the oldest age cohorts. The paper concludes with a discussion of policies and planning strategies needed to respond to the mobility needs of the elderly following driving reduction and driving cessation.

KEYWORDS: Demographic Shifts, Elderly, Non-Automobile Travel

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1. INTRODUCTION

European countries as well as the U.S. are automobile societies, where large percentages of daily trips are made by car (Waldorf 2003). In fact, driving has become an integral part of life in industrialized societies, providing and allowing spatial mobility and independence. Over the last century, several factors have contributed to and reinforced the reliance on the automobile for all segments of the population. Most notable among these factors are the dispersion of urban development and growth, and the absence or inadequacy of public transportation. The culture surrounding the automobile with its suggestions of freedom, autonomy and heightened self-esteem fostered the psycho-social car dependence even further (Gorham 2002).

Automobile reliance is pervasive among all segments of the population, including the elderly. For example in the UK, 53 percent of all trips by men over 70 were by car.[1] In the U.S., automobile reliance among the elderly is even stronger: in 1995, the elderly made over 90 percent of their trips by car, and for three quarters of all car trips the elderly were drivers rather than passengers (NPTS 1995). Even among the oldest-old (85+), the car is the dominant mode of transportation: 84.8 percent of all trips by persons age 85 or older are made by car and in 60 percent of these car-trips, the elderly is a driver rather than a passenger (Rosenbloom and Waldorf 1999).

Whereas the automobile can facilitate spatial mobility and independence even as people get older, it no longer provides these advantages if aging is associated with constraints on driving and eventually even with complete driving cessation. In this case, alternative transportation modes and/or adjustments in activity patterns are necessary to ensure spatial mobility and independence of the elderly. In order for society to plan adequately for the (future) mobility needs of the elderly, it is thus paramount to get a better understanding of the future demand for automobile alternatives.

This paper addresses the future demand for automobile alternatives by linking demographic shifts towards a growing elderly population with driving cessations rates in a life table framework. The model allows the future demand for non-automobile based mobility of the elderly to be derived, as well as estimates of the expected number of years driving a car, the 'driving life expectancy'. The paper also draws attention to gender differences in travel behavior and the resulting gender differences in non-automobile demand – an issue that gains pivotal importance given the feminization of the elderly population. In addition, the paper also argues that driving-cessation induced demand for automobile alternatives is modified by driving reductions which often precedes driving cessation.

The paper is organized in four sections. Following this introduction, Section 2 outlines the demographic shifts in the populations of Europe and the US, and discusses the implications for older person's travel adjustments in light of reduced/ceased driving. Section 3 develops a

[1] http://www.transtat.detr.gov.uk/tables/2001/tt/contents/index/datatabs/s1tabs/tt106.htm

method to derive older persons' future demand for automobile alternatives based on observed / projected demographic shifts and driving cessation rates. The last section discusses implications for policies in the fields of traffic management, public transport, locational planning and the built environment.

2. DEMOGRAPHIC SHIFTS AND FUTURE DEMAND FOR AUTOMOBILE ALTERNATIVES

All European countries as well as the United States are experiencing major demographic shifts towards an aging of their populations. Moreover, the composition of the growing elderly population is not a mirror image of the population at-large but is –in all industrialized countries– characterized by imbalances in the sex ratio with an increasing proportion of women with increasing age. Both trends, the aging of the population as well as the feminization of the elderly population, have implications for future transportation demands:

- the older population, especially the fast growing segment of the oldest-old, will be in need of transportation services other than the automobile;
- women's and men's travel behavior differ and those differences, combined with gender variations in living arrangements, are important in fine-tuning estimates for future non-automobile transportation services.

While aging and feminization are common characteristics of the population dynamics in European countries and the U.S., there are also distinct differences in these processes across countries. From a transportation planning and policy perspective, these differences potentially have important implications for the magnitude and timing of future non-automobile demand. This section, therefore, takes a comparative look at population aging and the compositional changes of the older population in Europe and the United States.

2.1 Aging Populations

In industrialized countries, the proportion of the elderly is increasing towards unprecedented highs. For all countries represented in Figure 1, the elderly already make up over 12 percent of the total population, and this percentage is projected to increase substantially by 2010. In the international comparison for the year 2001, Italy is the leader with 18.3 percent of its population being 65 or older, whereas the U.S. has a comparatively young population, with only 12.6 percent of its people belonging to the 65+ cohort. The projected age structure for 2010 reinforces the dominance of the elderly, but also exacerbates the differences in age structure between European countries and the U.S. The projected changes in the share of the elderly population are, with 3.5 percentage points, most drastic for Germany. In 2010, Germany will thus join Italy with about one out of five persons being of age 65 or older. The second largest increase will be experienced in the Netherlands that, as of now, still has a comparatively young population. In the U.S., the increase in the share of the older population is below average. Consequently, in 2010, the population of the United States will still be substantially younger than its European counterparts.

There are two main factors contributing to the overall aging of the population in industrialized countries: declines in mortality and prolonged periods of low fertility. Mortality declines at all ages and increasing life expectancies occurred universally in the U.S. and all European countries. For example, in the U.S., life expectancy at birth increased from 70.8 years in 1970 to 77 years in 1999; during that same time period, the conditional life expectancy at age 65 increased by .8 years for women and 1.8 years for men (U.S. Census Bureau 2001). As shown in Figure 2, similar advances in life expectancies are characteristic for all European countries.

Very low fertility – often far below replacement level[2] – characterizes many European countries. Following a post World-War II baby boom, European and U.S. fertility levels dropped substantially. However, the U.S. differs from many European countries in that its baby boom was particularly strong, whereas the subsequent fertility decline never reached the low levels that we have seen in European countries. Figure 3 shows the comparison with the decline in Italian fertility that has now been below replacement level for about a quarter of a century (ISTAT: Istituto Nazionale di Statistica) and has reached one of the lowest levels in Europe.

Differences in the level and speed of aging across the industrialized countries are also due to the impact of immigration. Immigration is age-selective, favoring younger rather than older immigrants. Moreover, immigrants often have higher fertility (Waldorf 1997) and thus also contribute indirectly to a decelerated aging process. Consequently, immigration countries like the United States have a younger population than European countries, especially those that experienced emigration up to the 1970s (such as Italy, Spain and Greece).

Projecting the population age structure into the future, it becomes obvious that the overall trend towards aging will be even more pronounced in the decades ahead, when the baby-boomers reach retirement age. Since the post-WW II baby boom was particularly strong in the U.S., the aging of the baby boomers will create a rapid rise in the absolute size of the U.S. elderly population between 2010 and 2030. If U.S. fertility and mortality stay at their current levels, the aging of the baby boomers will also imply an increase in the relative contribution of the older population to the total population. As Figures 4 and 5 show, the aging of the baby-boomers causes the U.S. elderly population to double in size in only 28 years, implying an average annual growth rate of over 2.4 percent.[3] In comparison, the current annual growth rate for the total U.S.

[2] The replacement level is defined as a total fertility rate of 2.1; the total fertility rate is the number of children a woman is expected to have by the end of her reproductive span, given the prevailing age-specific fertility rates.

[3] Such high population growth rates are currently observed for the total population of lesser developed countries such as Ethiopia and Libya.

population is only 0.9 percent. In European countries, where the baby-boom was less pronounced, the increase in the absolute size of the elderly population is projected to be slightly less dramatic. For example, in the Netherlands the elderly population is projected to double in size in 35 years with an average annual growth rate of 2 percent. However, given the low growth rate of only 0.4 percent for the Dutch population overall, the proportional shift in the Dutch age structure will be as dramatic as in the U.S.

Not only the population as a whole will age, but also the older population itself (Himes 2001). Of particular interest are the oldest-old, i.e., persons of age 85 or older. Since driving reduction and driving cessation rates increase with age, the oldest-old are particularly in need of automobile alternatives if they wish to maintain an active life. In the U.S. and all European countries, the oldest-old currently make up more than 10 percent of the older population. Unlike the European countries, the U.S. will eventually face a drastic increase in the population of the oldest-old when the baby-boom will reach the highest age cohorts, boosting the share of the oldest-old. For example, in the U.S., the share of the oldest-old among the older population is predicted to rise from about 12 percent in 2000 to 20 percent in 2050 (Himes 2001).

In summary, while European countries as well as the U.S. will be confronted with an aging of their populations, the situations in European countries are different than the situation in the United States. European countries already have a much higher share of older people than the U.S. and, in the short run, the share will rapidly increase. In the U.S., in contrast, immigration and higher fertility levels have kept the population relatively young, and the drastic increases in the share of the older population will be experienced with a time delay once the baby boomers reach retirement age. However, it should also not be overlooked that, in absolute terms, the U.S. will –even in the short run– be faced with a drastically increasing elderly population that will require special consideration of its transportation needs.

2.2 Feminization of the Elderly Population

The composition of the elderly population is heavily biased towards women. At all ages over 65, women outnumber men and this imbalance becomes stronger with increasing age (see Figure 6). This general trend towards a feminization of the older population is characteristic for the U.S. as well as all European countries. It can primarily be attributed to greater advances in women's compared to men's life expectancies over the last century.

However, the degree of feminization is not uniform across all countries. In the U.S., the imbalance in favor of women starts at a very early age because –at young ages– gender gaps in mortality rates are substantially wider than in many European countries. For example, the gender gap in 5-year survival probabilities of the 34-39 cohort is nearly five times bigger in the U.S. than in the Netherlands. Interestingly, starting at age 65, the gender gap in survival rates becomes bigger in the Netherlands than in the U.S., resulting in a stronger sex imbalance among the old –

especially the very old – in the Netherlands compared to the U.S. As a result, the sex ratio in the U.S. exceeds that of the Netherlands starting at age 70 and the feminization of the older population is less pronounced in the U.S. than in the Netherlands.

However, at older ages the female advantage in mortality rates diminishes (Kohler and Kohler 2000) and, more recently, we have witnessed a more rapid decline in male mortality than in female mortality – a trend which, if persistent, will eventually result in an increase in the sex ratio and thus a more balanced gender composition in the older population in the years ahead (see Figure 7). But even then, chances are that women continue to outlive men by a substantial number of years so that the older population will continue to be predominantly female.

The feminization of the older population gains added significance since living arrangements and marital status differ along gender lines. In general, older men are more likely to be married than older women. Moreover, they are substantially less likely to live alone. As shown in Figure 8, only 17 percent of American men aged 65 or older (excluding those in nursing homes or other institutions) live alone, compared to 39.9 percent of women. In the Netherlands, the percentages of older people living alone are even higher, especially for women. Moreover, the percentage of older people living alone, as well as the percentage of elderly living in nursing homes, increases with age. For the Netherlands, Figure 9 shows the distribution of elderly across different living arrangements. In particular for women at older ages, living alone or living in a nursing home are dominant forms of living.

2.3 Implications for Travel Behavior

The literature suggests that there are substantial limitations in activities of daily living (ADL) as people age. For the U.S., Himes (2001) notes that "[I]n the 1990s, about 17 percent of persons age 65 or older had some limitation in at least one ADL or were living in an institution" (p. 19). This percentage increases sharply with age but the literature yields mixed results on the question whether functioning improvement among the older population occurs over time. Crimmins and Saito (2000) conclude that functioning indicators did not differ between healthy women 70+ in 1984 and 1994, improved for comparable women with disease, but deteriorated for men with disease.

Although driving a car is typically not included in the list of ADLs[4], the transportation literature similarly suggests growing health problems that might impair driving as people age. That is, the abilities needed to drive an automobile safely and effectively deteriorate due to changes in vision, hearing, reaction time, motor ability, and the indirect effects of diseases and medications taken by the elderly (Owsley 1997). These problems may lead to older people having to reduce or eventually even cease driving (Parker et al. 2000).

[4] Typically, ADLs include "eating, dressing, walking, bathing, going outside, using the toilet, and transferring from a bed to a chair." (Himes 2002, p.17)

For the current generation of older people, for whom the automobile is the dominant mode of transportation, such anticipated limitations may reduce their mobility that is so necessary for their social and emotional well being (Carp 1988, Parker et al. 2000; Owsley 1997, Smith and Sylvestre 2001). Moreover, the fact that many older people relied on the automobile for their entire lives may make it harder to cope in old age as people may have difficulties learning about alternative modes (Burkhardt et al. 1999; Oxley 2000). Whereas older persons who never drove, are likely to have arranged their life-style accordingly, those who reduce or stop driving will need to adjust and are more likely to perceive this adjustment as a lessening of their quality of life.

In light of expected universal licensing and increasing reliance on driving in the future[5], a substantial portion of 'non-driving' among the elderly will be due to driving cessation as opposed to never having been a driver (Waldorf 2001), and reduced mobility at old age might be faced by an even larger proportion of the elderly. From a societal point of view, serving the mobility needs of the elderly becomes even more challenging since it is not only a greater proportion of the elderly who are in search of automobile alternatives but, due to the rapid growth of the elderly population, especially the oldest-old, it is also a substantially greater absolute number of older people who need to find alternatives to driving a car.

In light of the feminization of the older population, assessing the future demand for non-automobile transport becomes an even more difficult task, if age-induced changes in travel behavior differ between men and women. The current travel behavior of older men and older women suggests that there are indeed profound differences. For example:

- Compared to older men, older women are less likely to have a driving license and/or having access to a car (Root et al. 2002).
- Compared to older men, elderly women rely more heavily on getting a ride rather than driving themselves (Waldorf 2003).
- Older men drive more frequently than older women (Waldorf 2003, Rudinger 2002). They also drive substantially more miles than older women, and show the biggest percentage increase in annual driving between 1990 and 1995. (Rosenbloom and Waldorf 1999).
- With increasing age, the frequency of women's trip-making drops much faster than men's (Waldorf and Rosenbloom 2002).
- Older women give up their driver licenses at an earlier age than men (Burkhardt et al. 1999). However, older men frequently hold on to their license even though they no longer drive.

[5] Universal licensing and 'total car domination' (Sandqvist 2002) seem to be the overall trend in the U.S. However, in European countries, the trend has not yet progressed as far as in the U.S. For example, in Britain, the proportion of the population aged 70 or older holding full driving licenses has increased from 15% in 1975/6 to 41% in 1998/00 (http://www.transtat.detr.gov.uk/tables/tsgb01/3/31501.htm). Moreover, for West Europe, Sandqvist (2002) speculates that "[t]otal car dominance may not be inevitable" (p.123).

- Compared to older men, older women are more likely to express uncertainty about how to get to their destinations should they be forced to stop driving. This effect may be further enhanced by older women often living alone, thus not being able to rely on drivers within their household and / or share transportation tasks with their spouse (Waldorf and Rosenbloom 2002).
- Older female drivers are less likely to anticipate that their number of trips will be curtailed should they stop driving altogether (Waldorf and Rosenbloom 2002).

However, while we see pronounced gender differences in the travel behavior of older people today, the trends point towards a lessening of the gender gaps (Root et al. 2002). In particular, automobile ownership and licensing has increased substantially for women (Root 2002, Sandqvist 2002). In the Netherlands, for example, women (of all ages) were the main users of only 27 percent of the privately owned cars in 1988. By 1999, this percentage had increased by more than one third to 37 percent (Centraal Bureau voor de Statistiek 1990, 2002). Given these trends, Spain (1999) speculates that –in the future– older women's mobility will be substantially less constrained than the mobility of today's older women. Similarly, Rosenbloom (1999) suggests that "[a]s women over the next three decades come to more resemble men at the point they retire–in terms of years of driving experience, education, professional accomplishments, etc--they may display the same *demand* for additional travel as now seen among older men. As more women enter their retirement years with better incomes they may have the *means* to travel as often and as long as comparable men. Overall we may well see substantially more travel among older women–and even less of a gap in trip-making between all of those over and under 65 than [current data] suggest." (Rosenbloom 1999).

3. Assessing the Future Demand of Non-Automobile Transportation

This section uses a life table design to provide a framework for estimating the future demand for non-automobile transportation among the elderly. The life tables will yield estimates of life expectancies and 'driving life expectancies' as well as estimates of the proportion of people alive at age x and the proportion of people alive *and* still driving at age x. The difference of the latter will be used as an indicator for non-automobile demand and – when combined with projected population figures – will yield a valuable indicator for the potential future demand for automobile alternatives.

Conceptually, the older population may – at any point in time – be stratified according to their occupancy of various states. Of relevance here are not only the two states 'alive/dead' (which are the focus of classical demographic models) but also various states describing people's driving status. From the previous discussion, we can at least distinguish three states, namely: (1) driving; (2) reduced driving; (3) stopped driving.

Over time people not only age but their state occupancy may change as well. With respect to the driving status states, it is important to note that the transition between states is not unidirectional but may involve a continuous in- and outflow between transient states. For example, people may temporarily reduce driving due to severe medication, but resume driving as the treatment stops. Even driving cessation may be a state that people can enter but also exit – a situation that may occur, for example, when people temporarily stop driving following surgery.

Methodologically, such a situation can be captured in a multistate life table (Rogers 1975, Schoen 1988, Willekens 2003). The multistate life table starts with a synthetic cohort and describes, via age-specific transition probabilities, the changing size and composition of the (synthetic) cohort over time. As such, the multistate life table allows us to derive, for example, the proportion of older people in each driving status state at each age and the expected time to be spent in each state –in particular the 'driving life expectancy'. The age-specific transition probabilities may also be used as input into a multistate projection model, thereby assessing the future population structure based on its initial size and composition and the flows between states over time.

Unfortunately, the data necessary to estimate the transition probabilities do not exist. Ideally, longitudinal data are required that allow the dynamic process of driving status transitions within small units of time – such as a month or a week – to be described. Longer time units may very well miss temporary transitions such as short-term driving cessation following surgery. However, even for longer time units such as a year, the data have not yet been collected. Even reliable information on the prevalence of driving cessation does not exist. Waldorf (2001) makes a first attempt at estimating driving cessation rates for two broad age groups of older men and women, yet there is a wide variation in estimates depending on the assumptions about licensing rates. Nevertheless, the estimates show that – not surprisingly – driving cessation rates increase by age and are higher for women than for men.

In light of the data paucity, the following analysis focuses primarily on estimating the effect of the (projected) population structure (size and composition by five year age-sex cohorts) on future demand for automobile alternatives given currently observed five-year mortality probabilities and assumed five-year transition probabilities between driver status states. That is, given assumed flows between driver status states, the future distribution of older people across driver status states (stock) will be derived. Since the flow data across driver status states are not observed, the future stock of people in need of automobile alternatives can only be analyzed comparatively, for example, across populations with different age-sex structures.

Several simplifying assumptions enter the derivations. The 'driving' and 'reduced driving' states are collapsed into two states: (1) driving and reduced driving; and (2) stopped driving. Moreover, it is assumed that: (1) every person is a driver at age 65; (2) the probability of a transition from 'stopped driving' to 'driving' is zero for all ages and for both men and women; (3) the transition probabilities from 'driving' to 'stopped driving' increase by age, are higher for women than for men, and are time-invariant.

In the assumed absence of multi-directional transitions, the multistate life table design can be simplified to separately estimating two life tables. The first captures the traditional alive / dead history of a synthetic cohort and yields the traditional life expectancy as well as the proportion of persons alive until at least age x, S_x; the second captures the transitions from 'alive and driving' to 'stopped driving or dead' and yields the 'driving life expectancy' as well as the proportion of people alive and driving until at least age x, S_x*.

Note that $S_x^* \leq S_x, \ \forall x$, and the area between the two survivor curves, i.e.,

$$\int_{65}^{\omega} S_x - S_x * dx$$

is an indication of the demand for non-automobile transportation among the elderly. The wider the gap between S_x and S_x*, the greater the demand. Increasing survivor probabilities given unchanged transition probabilities into the driving cessation state will widen the gap, whereas decreasing cessation probabilities given unchanged survival probabilities will compress the area and thus lower the demand.

In the following, this life-table design is applied to synthetic cohorts of 100,000 male and female drivers age 65. Age-sex-specific five-year survival probabilities are derived from 1998 Dutch mortality rates. The assumed age-sex-specific five-year cessation probabilities are shown in Table 1. For example, it is assumed that the probability that a 70-year old will stop driving prior to the 75^{th} birthday is 5 percent for men and 10 percent for women.

Figure 10 shows the resulting survival curves, S_x and S_x*, for men and women. For men, the gap between the two survival curves is small, but non-negligible. For example, for male drivers alive at age 65, the median age of survival is 81, whereas the median age of surviving *and* still driving is only 78. For women, the area between the curves is substantially bigger due to women's lower mortality rates and assumed higher cessation rates. Fifty percent of the female drivers alive at age 65 will survive until at least age 86, but only 20 percent will survive *and* still drive until that same age.

If men's mortality rates continue to decline at a faster rate than women's mortality rates and assuming that there are no changes in cessation probabilities, the gap between S(x) and S*(x) will widen more rapidly for men than for women. Should gender differences in older person's travel behavior diminish and women's cessation rates decline towards those of men then, for women, S_x* will move closer to S_x, signaling lessened demand for non-automobile transportation. In general, this graph also suggests that decreases in mortality without an accompanying reduction in driving cessation rates will extend old age life expectancies but not necessarily improve the quality of life.

The life table design also provides life expectancies at age x, e_x, as well as driving life expectancies at age x, e_x^*. The difference is the expected number of years during which a person is in need of non-automobile transportation. Table 2 shows these differences for men and women. Women's life expectancy is longer than men's but – due to assumed higher female cessation probabilities – there is barely any gender gap in the driving life expectancy. In fact, despite their longer life expectancy, women cannot expect to live *and* drive substantially longer than men. If we assume that women's driving cessation probabilities drop to the lower levels for men, the driving life expectancy will increase. However, due to women's higher survival probabilities at all ages, the expected number of years in which non-automobile transportation is needed continues to be higher than for men.

In order to determine future non-automobile demand of the elderly, we multiply the non drivers, expressed as a proportion of those alive, with the size of the respective age cohort at time t, i.e.,

$$ {}_nN_x(t) = \frac{S_x - S_x^*}{S_x} \, {}_nP_x(t), $$

where ${}_nP_x(t)$ is the size of the age cohort that starts at age x and lasts for n years and ${}_nN_x(t)$ denotes the number of people who enter the cohort in need of non-automobile transportation. The results of two scenarios presented here. The first assumes a population age structure as observed in the Netherlands, the second assumes the U.S. population age-sex structure. The results for 1998, 2018 and 2033 are shown in Table 3.

Not surprisingly given the higher driving cessation probabilities for women, the demand for automobile alternatives will be substantially larger for women than for men, independent of the particular age structure. Differences in the age structure of the Netherlands and the U.S. do however yield a different time trend in the proportions of older people in need of non-automobile transportation. The Netherlands will see a steady increase in the proportion of elderly in need of non-automobile transportation from 13 percent in 1998 to 15 percent in the year 2033. In contrast, in the U.S. the overall proportion will decrease between 1998 and 2018, before increasing again. This non-monotonic trend is primarily due to the baby boomers having entered the young-old age cohorts by 2018, but it will take until 2033 before they reach older age cohorts that are more heavily dependent on non-automobile transportation services.

These age structure induced differences become even more obvious when comparing annual average growth rates for the older population as a whole to average annual growth rates for the older population in need of automobile alternatives. For the Dutch age structure, the number of persons in need of automobile alternatives will grow faster than the elderly population as a whole and the discrepancy between the growth rates is stronger for men than for women. Moreover, the Dutch age structure gives rise to very rapid growth for the population age 65+ during 1998 to 2018 whereas during the second time period from 2018 to 2033, the average annual growth rate falls from 2.3 percent to 1.6 percent. Since much of the growth occurs in the oldest age cohorts that also have the highest cessation probabilities, the average annual growth rates for non-automobile demand exceed those for the old population but show a similar declining trend when comparing the two time periods.

A quite different picture emerges for the annual growth rates of both the older population and the non-automobile demand when assuming the U.S. age structure. Until 2018, there will be a modest growth in the elderly population, with average annual growth rates of about 1.6 percent, and the annual increase in non-automobile demand is even smaller at only .5 percent. This situation changes drastically between 2018 and 2033, when the average annual growth rates in the number of people in need of automobile alternatives becomes substantially (43 percent) larger than the average annual growth rates for the older population as a whole.

Comparing the two age-structure situations thus shows that the urgency of providing transportation services may well be greater in certain European countries, in particular, the Netherlands, than in the United States. The U.S. has a comparative advantage, but only in the short-run. Moreover, when assessing the future demand, it must also be taken into account that declining old-age mortality rates without lowering driving cessation probabilities will further increase the demand. As of now, persons of age 65 can expect to live an additional 15 (men) or 20 (women) years, but only a portion of those additional years will be years in which they can rely on driving an automobile. Especially for women, the expected number of years in which they are dependent on other forms of transportation is quite high. Given that many women live alone in old age, ride-sharing becomes more difficult and the need for transportation services must be met outside the own household. For men the number of years without driving is expected to rise if male old-age mortality rates continue to decline at a fast pace. Moreover, when considering that many older persons will reduce driving prior to driving cessation, the demand for non-automobile transportation is likely to be higher and occur earlier than suggested by the two scenarios above.

4. Policy Implications

If we distinguish between those who modify their driving behavior due to impairments that come with aging and those who stop driving then we can similarly suggest policy areas for enquiry that may assist those affected to maintain life-enhancing and life-maintaining derived demands that are pertinent to each group.

To improve the ability of those who modify their driving behavior and to prolong others as unimpeded road users, a variety of strategies can be adopted in the field of traffic management.[6] Changes in roadway geometry and signage and technological advances in driver/roadway interaction can improve the safety of road use for older drivers (Hatch, 1999). Bigger, brighter and better maintained signs with reflectivity as well as wider roadway markings and simplified

[6] In the UK, only one in twenty of those over 65 lives in hospital or in an institution and among those over 75, two thirds have no physical difficulties with ordinary daily activities, P.Thompson of the University of Essex reported in The Times, 3rd December 2002. Driving confidence has been specifically addressed by Parker et al (2001).

intersections can also assist (Guerrier and Fu 2002; American Road and Transportation Builders Assn, 1990). HOV lanes may also be utilized to segregate disabled drivers from the general traffic stream (Pitfield and Watson 2001) and changes in vehicle design and infrastructure adaptations can minimize the driving related effects of impairments (Shaheen and Niemeier 2001) albeit perhaps at considerable cost.

Location Planning may be utilized to reduce the demands on older drivers and maintaining their use of cars at a less demanding level. Simplistically, this can involve moving residences closer to the source of derived transport demand or moving these sources closer to residents. It is clear that some elderly adopt the first strategy in a free market and perhaps incentives could be provided to ease and encourage this transition and prevent social exclusion.[7] Apart from the specialist sources of derived demand, such as specialist health care, it is difficult to imagine an incentive on other sources to relocate to a more adjacent location to attract elderly patronage when their market is broader. The exception, which could be argued to be ageist, is when the elderly are concentrated in retirement communities in sufficient numbers to provide a viable market. Literature on such communities includes Persson (1993), Pollak (1994), Townsend (2002), Witkowski (1985) and Kaplan (1985).

Virtual mobility may also be used to reduce the need for travel, for example, through meeting demands through the internet, including internet shopping (Kenyon et al. 2002). In the UK recently rapid growth has led to monthly online sales exceeding $1 billion for the first time in November 2002[8].

If local transport plans are concerned with land uses, social exclusion and sustainability then these issues need to be addressed as does the possibility of encouraging car sharing to alleviate these problems. It seems those affected by impairments have an obvious recourse to ridesharing (Waldorf 2001) with friends, neighbors or relations. Moreover, work by Cvitkovich (2001) suggests well-being can be maintained by prioritization of needs among the elderly despite experiencing functional limitations or being dependent on transportation services.

Turning to the needs of those who have ceased driving, although the traffic management measures discussed are irrelevant, the location planning factors already described are relevant. In addition, it is here that public transport can provide a substitute for the use of a private car and there are many ways in which the conventional and specialized transit modes can serve the elderly.

Often, the *existing* transit systems are not sufficient as an alternative. Evans (1999) who analyzes mobility among the non-driving 75+ population in the U.S., suggests that “[t]ransit availability does not seem to bear a discernible role in mobility among this group” (p. 165).

[7] Alternatively, non-conventional transport might need to beencouraged in sparsely populated and served areas such as post buses and community buses.

[8] See BBC web page report at http://news.bbc.co.uk/1/hi/business/2574627.stm

Similarly, Waldorf (2003) finds that "while public transit availability significantly lowers the probability of driving […], it has no effect on elderly automobile reliance in general (being a driver or passenger […]). Thus, it seems that older persons choose ride-sharing if they do not wish or can no longer drive, independent of transit availability. This strategy is particularly important for women […] who currently rely so strongly on getting a ride and thus depend on others being able to drive them. But it is also a 'strategy' that may prove problematic given the longer life expectancy for women and given that adult children often live and work in far-away places."

However, Evans (1999) also suggests that "transit use [among the non-driving 75+ population] seems to be positively influenced to some degree by characteristics that may be associated with both transit quality and safety" (p. 165). For example, in conventional buses, financial incentives can be given and seats can be reserved for the elderly and infirm (as already happens in many countries). However, it may be that the chief concerns are to do with information, signage, the built environment of terminals and stops and access to public transport rather than cost. Previously habitual car drivers may find it difficult to adjust to public transport use. Low floor buses that may give wheelchair access and bus stop design are discussed in Dejeammes et al (1999). Light rail transit and accessibility is discussed in Kershaw (1989) and pedestrian access to public transport is dealt with in Cervero (2001). Frye (1990) discusses how, amongst others, the elderly's problems with transport can be alleviated through low floor buses; improved access to long-distance coaches and trains; the creation of a continuous transport chain through improving access to taxis and improving pedestrian facilities. However, it is argued by Schwanen (2001) that public transport does not offer the elderly a real alternative to the car but is best seen as a substitute for walking and cycling which is of little use to those prevented from undertaking these activities by impairments. That is, walking and cycling as activities are likely to disappear as options before driving, as impairments set in.

Non-conventional or specialized public transport such as jitneys, demand-responsive services such as dial-a-ride and community bus schemes can be of particular assistance to the elderly, especially in relatively remote areas as can organized group shopping trips and more personal pick up and drop off shopping services. An overview of specialized transport is given by Gillingwater and Tyler (2001) and Stern (1993) shows how paratransit is especially valued by transportation-handicapped people.

For those who are most impaired and so most immobile, it may be that changes to the built environment are required to ease their lives. The topics that need addressing here include principally dealing with changes of level through ramps, lifts, corridor widths as well as by lighting and signage. In addition, the area of special vehicle provision may need reviewing. For example, motorized scooters for disabled use may need to be available for hire and may need an extension of their range facilitated by battery swaps or the provision of charging stations.

In its totality, the policies suggested above promise to be of substantial assistance to ensure that the mobility needs of the elderly will be met. However, following Waldorf (2003), it should be emphasized that some of the measures, such as provision of specialized transit system, need to be complemented with programs ensuring that the elderly will actually use such alternatives rather than choose immobility. “It seems necessary that such programs reach the elderly early, well before they are forced to stop driving, so that there is sufficient time to learn about these alternatives, appreciate them as alternatives that can ensure an active life if driving has (temporarily) become impossible, and learn how to use these alternatives. Acquiring knowledge about alternatives, formation of positive attitudes towards transportation alternatives, and learning how to use these alternatives so as to get from A to B, are not necessarily straightforward tasks for elderly people who have relied on the automobile for their entire lives. Thus, it will be a prime responsibility for policy makers to provide safe and high quality alternatives as well as develop programs that facilitate mobility-ensuring adjustment to non-driving. More research is needed to develop such programs and evaluate their effectiveness for the high-risk groups” (Waldorf 2003).

References

American Road and Transportation Builders Association 1990. As Drivers Age ... Visual Cues Must Change, *Transportation Builder* 2: 12-13.

Burckhardt, J., A. Berger, M. Creedon and Adam T. McGavock 1999. Mobility changes for elders who reduce or cease driving. Paper presented at the 78th Annual Meeting of the Transportation Research Board. Washington D.C.

Carp, F.M. 1988. Significance of Mobility for the Well-being of the Elderly. In: *Transportation in an Aging Society: Improving Mobility for Older Persons. Volume 2 – Technical Papers.* Special Report 218. Transportation Research Board, Washington, DC, pp. 1-20.

Centraal Bureau voor de Statistiek (various years). Statistisch Jaarboek. Voorburg/Heerlen, The Netherlands.

Cervero, R. 2001. Walk-and-Ride: Factors Influencing Pedestrian Access to Transit. *Journal of Public Transportation* 7: 1-23.

Crimmins, E. M.and Y. Saito 2000. Change in the Prevalence of Diseases among older Americans: 1984-1994. *Demographic Research* 9(3).

Cvitkovich, Y. 2001. The Importance of Transportation and Prioritization of Environmental Needs to Sustain Well-Being among Older Adults, *Environment and Behavior* 33: 809-829.

Dejeammes, M., F. Coffin, T. Ladreyt, M.-F. Dessaigne, V. Fouet, C. Dolivet and R. Zac1999. Bus Stop Design and Automated Guidance for Low-Floor Buses: Evaluation of Prototypes with Investigation of Human Factors*. Transportation Research Record* 1666: 85-91.

Evans, E.L. 1999. Influences on Mobility among Non-driving Older Americans. In: *Personal Travel: The Long and Short of It.* Proceedings of the Transportation Research Conference. TRB Transportation Research Circular E-C026, pp. 151-168.

Frye, A. 1990. Transport for the Disabled - Whose handicap? *Transport* 11: 133-136.

Gillingwater, D. and N. Tyler 2001. Specialized Transport. In: K.J.Button and D.Hensher (eds). *Handbooks in Transport, Handbook 3: Transport Systems and Traffic Control*. Amsterdam: Elsevier.

Gorham, R. 2002. Car Dependence as a Social Problem: A Critical Essay on the Existing Literature and Future Needs. In: W. B. Black and P. Nijkamp (eds). *Social Change and Sustainable Transport*. Bloomington, IN: Indiana University Press, pp. 107-115.

Guerrier, J.H. and S. H. Fu 2002. *Elder Roadway User Program Test Sections an Effectiveness Study*, Report UM Project No. 669535, Department of Psychiatry and Behavioral Sciences, University of Miami, USA.

Himes, C.L. 2001. *Elderly Americans.* Population Bulletin, Vol. 56 (4). Washington DC: Population Reference Bureau.

Hatch, S. 1999. An Eye on Older Drivers. *Roads and Bridges* 37: 44-47.

Kaplan, E.W. (ed.) 1985. *Transportation for Elderly and Handicapped Persons, Paratransit and Ridesharing*, Transportation Research Record Report HS-039 547, 1018, Washington DC, USA.

Kenyon, S., G. D. Lyons and J. Rafferty 2002. Transport and Social Exclusion: Investigating the Possibility of Promoting Inclusion through Virtual Mobility. *Journal of Transport Geography* 10: 207-212.

Kershaw, R.E. and J. A. Boda 1989. *Elderly and Handicapped Accessibility: The California Ways*, Transportation Research Board Special Report 221: 147-162.

Kohler, H.-P. and I. Kohler 2000. Frailty Modelling for Adult and Old Age Mortality: The Application of a Modified DeMoivre Hazard Function to Sex Differentials in Mortality. *Demographic Research* 3(8).

Owsley, C. 1997. Clinical and Research issues in Older Drivers: Future Directions. *Alzheimer Disease and Associated Disorders* 11: 3-7.

Oxley, P. 2000. The Travel of Older People in the United Kingdom. In: *Transport and Ageing of the Population*, Roundtable 112, European Conference of Ministers of Transport, Paris.

Parker, D., L. Macdonald, P. Sutcliffe and P. Rabbit 2001. Confidence and the Older Driver. *Ageing and Society* 21: 169-182.

Persson, D. .1993. The Elderly Driver: Deciding when to Stop. *Gerontologist* 33, 88-91.

Pollak, P.B. 1994. Rethinking Zoning to Accommodate the Elderly in Single Family Housing. *Journal of American Planning Association* 60: 521-531.

Pitfield, D.E. and R. P. Watson 2001. HOV Routes and Truck Lanes. In: K.J.Button and D.Hensher (eds). *Handbooks in Transport, Handbook 3: Transport Systems and Traffic Control*. Amsterdam: Elsevier.

Rogers, A. 1975. *Introduction to Multiregional Mathematical Demography*. New York: Wiley.

Root, A., L. Schintler and K. Button 2002. Women and Travel: The Sustainability Implications of Changing Roles. In: W. B. Black and P. Nijkamp (eds). *Social Change and Sustainable Transport.* Bloomington, IN: Indiana University Press, pp. 149-155.

Rosenbloom, Sandra. 1999. The Mobility of the Elderly; There's Good News and Bad News. In: *Transportation in an Aging Society; A Decade of Experience*. National Research Council Conference, November 1999, Washington, DC.

Rosenbloom, S. and B. Waldorf. 1999. Older Travelers: Does Place or Race Make a Difference? In: *Personal travel: The Long and Short of It.* Proceedings of the Transportation Research Conference. TRB Transportation Research Circular E-C026, pp. 103-120.

Rudinger, G. 2002. Mobility Behavior of the Elderly: Its Impact on the Future Road Traffic System. In: W. B. Black and P. Nijkamp (eds). *Social Change and Sustainable Transport*. Bloomington, IN: Indiana University Press, pp. 157-154.

Sandqvist, K. 2002. Growing Up with and without a Family Car. In: W. B. Black and P. Nijkamp (eds). *Social Change and Sustainable Transport*. Bloomington, IN: Indiana University Press, pp. 117-124.

Schoen, R. 1988. *Modeling Multigroup Populations*. New York: Plenum Press.

Schwanen, T. 2001. Leisure Trips of Senior Citizens: Determinants of Modal Choice. *Tijdschrift voor Economische en Sociale Geografie* 92: 347-360.

Shaheen, S.A. and Niemeier, D.A. 2001. Integrating Vehicle Design and Human Factors: Minimizing Elderly Driving Constraints. *Transportation Research C: Emerging Technologies* 9: 155-174.

Smith, G. C. and G. M. Sylvestre 2001. Determinants of the Travel Behavior of the Suburban Elderly. *Growth and Change* 32: 395-412.

Stern, S. 1993. A Disaggregate Discrete Choice Model of Transportation Demand by Elderly and Disabled People in Rural Virginia, *Transportation Research A: Policy and Practice* 27: 315-327.

Townsend , I.J.2002. Age-Segregated and Gated Retirement Communities in the Third Age: The Differential Contribution of Place-community to Self-actualization, *Environment and Planning B: Planning and Design* 29: 371-396.

U.S. Bureau of the Census 2002. Statistical Abstract of the United States. http://www.cenus.gov/

Waldorf, B. 1997. Fertility Trends of Immigrant Women in Germany. Discussion Paper 97-3. Department of Geography and Regional Development, University of Arizona.

Waldorf, B. 2001. Anticipated Mode Choice Following Driving Cessation. *European Research in Regional Science* 11: 22-40.

Waldorf, B. 2003. Automobile Reliance among the Elderly: Race and Spatial Context Effects. *Growth and Change* 35 (forthcoming).

Waldorf, B. and S. Rosenbloom 2002. Driving Cessation among the Elderly: Uncertainty and Anticipated Constraints. Working Paper. University of Arizona: Drachman Institute.

Weeks, J. R. 2002. *Population: An Introduction to Concepts and Issues.* Belmont, CA: Wadsworth.

Willekens, F. 2003 (forthcoming). Multistate Demography. In: P. Demeny and G. McNicoll (eds). *Encyclopedia of Population*. New York: Macmillan.

Witkowski, J.M. and T. R. Buick 1985. Travel Behavior of Residents of Retirement communities. *Transportation Research Record* 1018: 13-22.

Table 1. Five-year (Assumed) Cessation Probabilities for Older Men and Women

Age Cohort	Men	Women
65-69	.05	.05
70-74	.05	.1
75-79	.1	.2
80-84	.1	.2
85-89	.4	.8
90-94	.5	.99
95+	1	1

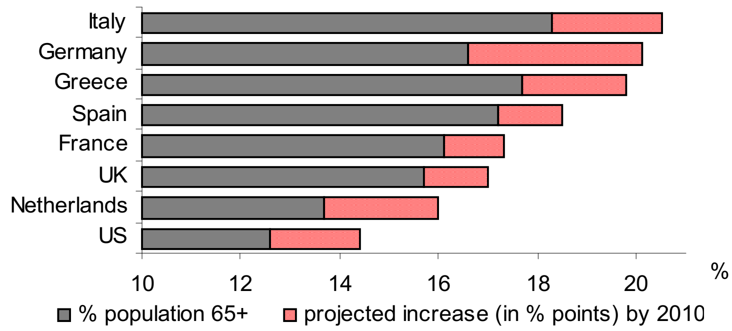
Table 2. Life Expectancy, e_x, and Driving Life Expectancy, e^*_x (in years)

	Men			Women				
		Male cessation probabilities; male survival probabilities			Female cessation probabilities; female survival probabilities		Male cessation probabilities; female survival probabilities	
Age x	**e_x**	**e^*_x**	**e_x - e^*_x**	**e_x**	**e^*_x**	**e_x - e^*_x**	**e^*_x**	**e_x - e^*_x**
65	15.4	13.5	1.9	19.6	14.7	4.9	16.4	3.2
70	12.1	10.6	1.5	15.7	11.1	4.6	13.0	2.7
75	9.2	7.9	1.3	12.0	8.0	4.0	9.7	2.3
80	6.7	5.7	1.0	8.8	5.7	3.1	7.0	1.8
85	4.9	3.8	1.1	6.2	3.0	3.2	4.3	1.8
90	3.5	2.9	.6	4.2	2.5	1.7	3.1	1.1

Table 3. Projected Population Size and Non-Automobile Demand

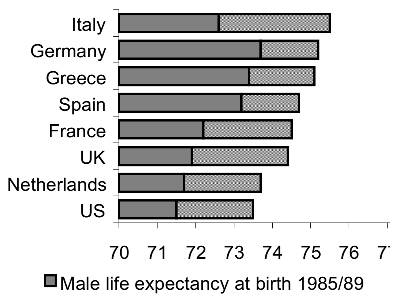
Age Cohort	Population Size 1998	Population Size 2018	Population Size 2033	Non-Automobile Demand 1998	Non-Automobile Demand 2018	Non-Automobile Demand 2033
			Male Population – Dutch Age Structure			
65-69	302	499	573	0	0	0
70-74	240	443	501	12	22	25
75-79	175	276	379	17	27	37
80-84	93	172	263	17	32	49
85-89	42	91	150	11	24	40
90-94	12	33	46	7	18	26
95+	2	6	8	2	4	6
Total	**866**	**1519**	**1920**	**66**	**129**	**184**
% of Total				*7.6%*	*8.5%*	*9.6%*
			Female Population – Dutch Age Structure			
65-69	339	511	581	0	0	0
70-74	309	478	546	15	24	27
75-79	269	330	459	39	48	67
80-84	183	250	369	58	79	117
85-89	111	177	265	50	80	120
90-94	43	93	110	38	83	98
95+	10	29	32	10	29	32
Total	**1264**	**1868**	**2363**	**211**	**343**	**460**
% of Total				*16.7%*	*18.4%*	*19.5%*
Male/Female Combined	**2130**	**3387**	**4283**	**277** *13.0%*	**472** *13.9%*	**644** *15.0%*
			Male Population – U.S. Structure			
65-69	4393	7666	8013	0	0	0
70-74	3857	5716	8014	193	286	401
75-79	2997	3789	6429	292	369	627
80-84	1764	2434	4175	331	457	784
85-89	891	748	1655	240	201	445
90-94	249	314	464	140	176	260
95+	48	60	88	37	47	69
Total	**14198**	**20726**	**28838**	**1233**	**1536**	**2586**
% of Total				*8.7%*	*7.4%*	*9.0%*
			Female Population – U.S. Age Structure			
65-69	5201	8589	8937	0	0	0
70-74	4945	6773	9283	247	339	464
75-79	4221	4882	8036	612	708	1165
80-84	2970	3506	5839	938	1108	1845
85-89	1949	1742	2451	883	789	1110
90-94	745	666	937	663	593	834
95+	172	154	216	172	154	216
Total	**20202**	**26312**	**35699**	**3516**	**3690**	**5635**
% of Total				*17.4%*	*14.0%*	*15.8%*
Male/Female Combined	**34400**	**47038**	**64537**	**4749** *13.8%*	**5226** *11.1%*	**8221** *12.7%*
Average Annual Increase	**1998-2018**	**2018-2033**		**1998-2018**	**2018-2033**	
Dutch Age Structure	2.3%	1.6%		2.6%	2.1%	
US Age Structure	1.6%	2.1%		0.5%	3.0%	

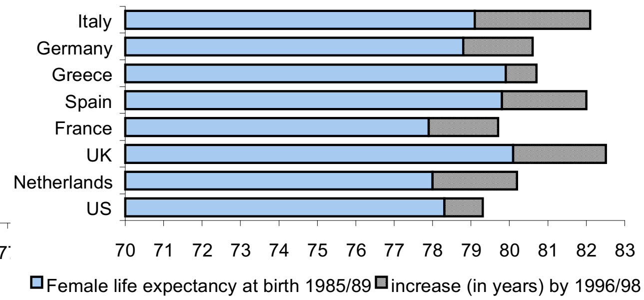
Figure 1. The elderly population (65+) in the U.S. and selected European countries in the year 2001, and projected increases by the year 2010



Data Source: U.S. Census Bureau, Statistical Abstract for the United States 2001

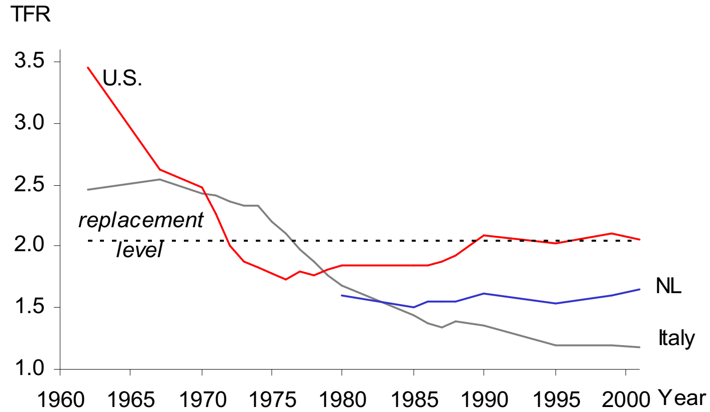
Figure 2. Life expectancies at birth in the U.S. and selected European countries in the year 1985/1989, and projected increases by 1996/98





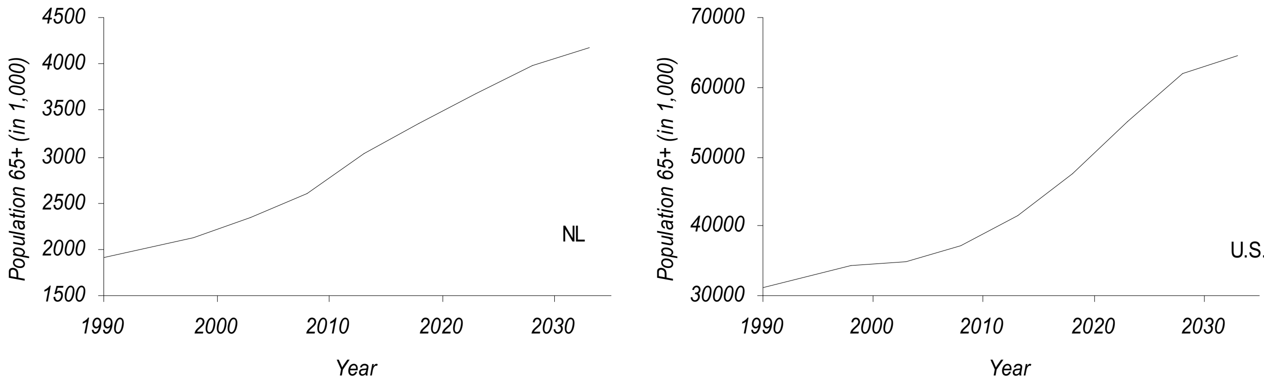
Data Source: Centraal Bureau voor de Statistiek: Statistisch Jaarboek 2001

Figure 3. Post World-War II Total Fertility Rates in Selected Countries



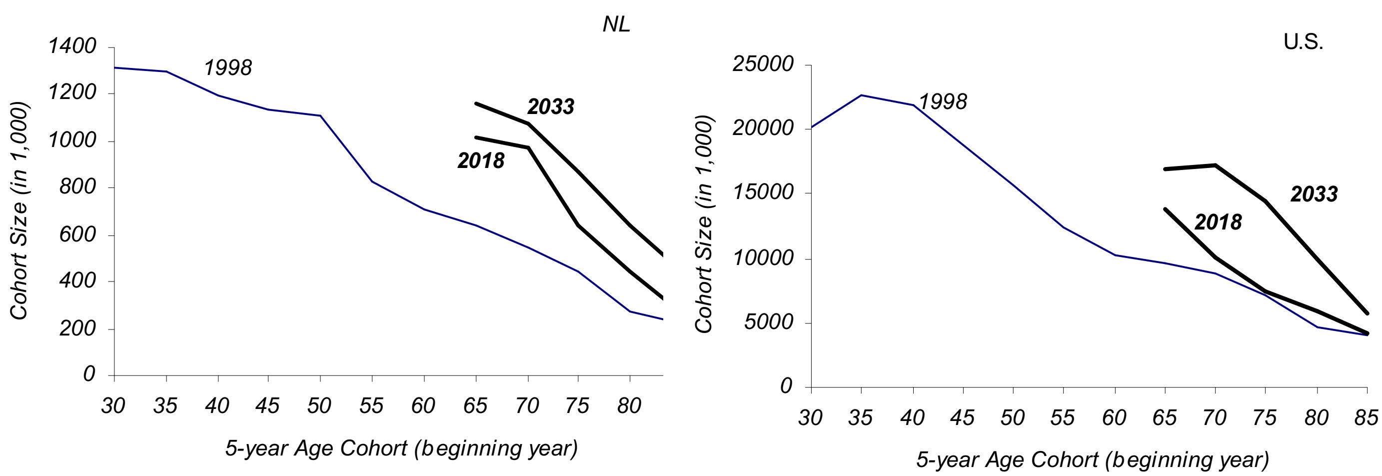
Data Sources: ISTAT(Istituto Nazionale di Statistica), U.S. Census Bureau, Statistical Abstract for the United States 2001, Centraal Bureau voor de Statistiek: Statistisch Jaarboek 1990, 2003

Figure 4: Projected[*)] increase in elderly population sizes in the Netherlands and the U.S.



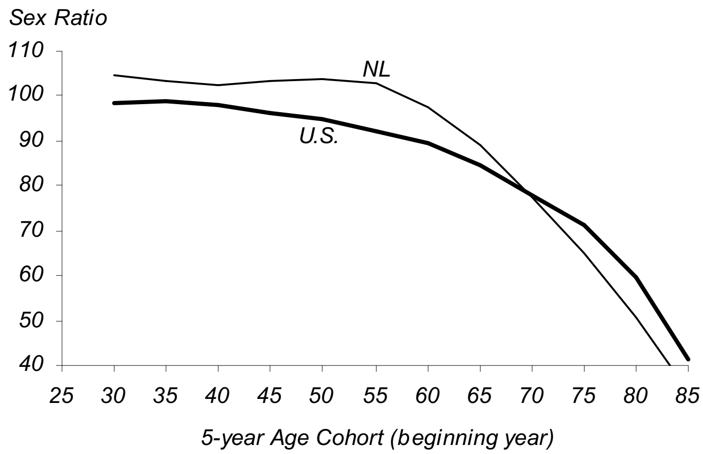
*) The 1990 and 1998 population figures and the projections for the Netherlands are based on data provided in the Statistisch Jaarboek (several years). The 1990 U.S. population size is taken from the Statistical Yearbook of the United States (2001). The projections for the U.S. are based on population estimates and survival rates taken from Weeks (2002). For both countries, the projections start with base-year population data for 1998 and assume that age-specific international net migration rates are zero and that age-specific mortality rates as observed in 1998 remain constant in the future.

Figure 5: Projected[*)] age composition of the elderly population in The Netherlands and the U.S.



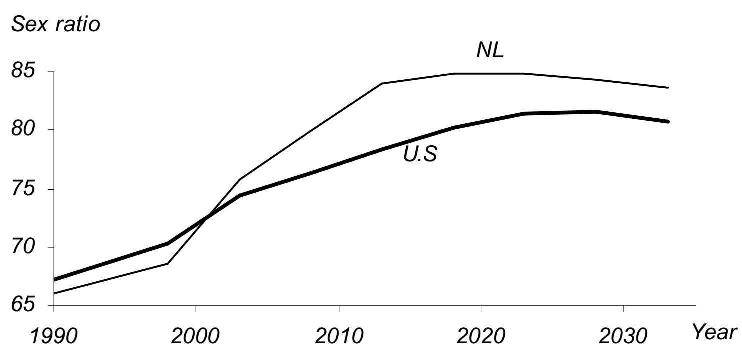
* see footnote to Figure 4.

Figure 6. Age-specific sex ratio 1998, The Netherlands and U.S.



Data Source: for the Netherlands: Statistisch Jaarboek (2001); for the U.S.: Weeks (2002).

Figure 7. Projected sex ratio for the elderly (65+), The Netherlands and U.S



*) see footnote to Figure 4.

Figure 8. Percentage of older persons living alone, The Netherlands 2000 and USA 1999

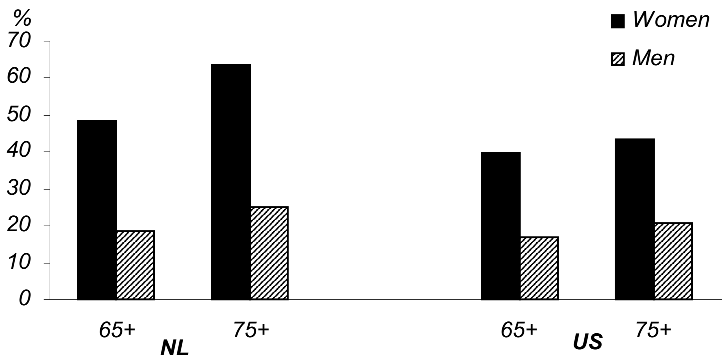
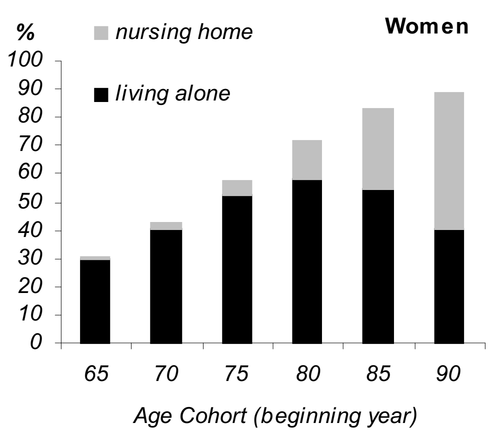


Figure 9. Living arrangements by gender and age, The Netherlands 2000



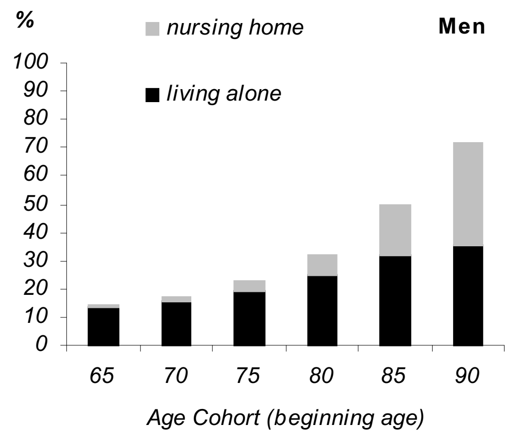


Figure 10. Survivor Curves, S(x) and S*(x), for Women and Men