SAFE MOBILITY IN AN AGING WORLD

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January 1999

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This paper has been prepared for presentation at the Annual Meeting
of the Transportation Research Board, Washington, D.C., January 1999.

January 11, 1999

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ABSTRACT

This paper presents issues related to individual aging, a growing aging population, and the operation of *private* motor vehicles. The discussion progresses roughly from demography and social factors, to health status, aging and motor vehicle operating risk, determinants of mobility, economic status, and onto recommendations for safe mobility -- the main theme of this paper. Not discussed are issues related to aging and commercial and public operations in all transportation modes. These issues also are of great importance. However, many of the issues discussed herein with some modification are relevant to those areas.

There is a strong relationship between aging and motor vehicle operation because time can lessen human capabilities like good vision, mental agility, and physical dexterity -- all needed for safety. The demand to operate, however, remains strong because of the benefits mobility (trip making) bestows in the modern age. In many countries, a demographic transition is occurring, the result of an unprecedented, simultaneous low birth and death rate. Countries experiencing this transition will have an increasingly elderly population continuing to operate motor vehicles.

Generally, vehicle operators self regulate with compensating strategies for age-associated deficits. With age, there is increased awareness of the risks inherent in operating a motor vehicle. Such awareness allows older operators to make tactical-level adjustments. As an example, visual limitations result in a reduction or even elimination of night driving. When risks are deemed too great, many persons withdraw completely from driving. However, the self regulation mechanism is not perfect. Data suggests some males continue to operate beyond their capabilities while some female operators may withdraw from vehicle operation prematurely. In any case, the concern is for a loss of safe mobility and the decrease in social and physical well-being.

This paper stresses the need for prolonging safe operation by retraining, making individuals aware of their deficits and the resulting risks to themselves and others, making informed decisions, and to offer to older vehicle operators mobility alternatives. Suggested are ways the benefits of mobility can -- and should be -- maintained after age decrements render safe operations unreasonable. There is also a need

for more work to uncover the relationships among medical conditions, drug interactions, and changes in the risk of operating a motor vehicle. Also urged is investigation into the differences between countries, and even regions of countries, on aging and operation issues.

Because age groups have different rates, and, more importantly, different types of crashes, highway safety programs must be optimized for age composition. What is appropriate for one age cohort may not be so for another. Older drivers, in absolute numbers, have fewer crashes of all types because they drive less. However, their crash distribution shows a disproportionately high number of intersection crashes. Left turns are particularly problematic for older vehicle operators. Thus, a need exists for treating, at the operator and infrastructure level, the reasons for this difficulty. Crash worthiness is also important. If older drivers are more likely to be hit from the side, given the types of crashes they have, and the side has less protection, then adjustments are called for to the struck and striking vehicles.

Keywords: aging, motor vehicle safety, accident, mobility

ACKNOWLEDGMENTS

Some of the ideas contained in this paper are based on material gathered and discussed during the writing of the report *Improving Transportation for a Maturing Society*. The authors of this paper were part of a large team who worked on that report. We wish to acknowledge the contributions of all who participated in producing *Improving Transportation for a Maturing Society*.

Work on that report got underway in December 1995 when the then Secretary of Transportation directed the United States Department of Transportation (USDOT) to develop an overview of, and strategies for, the challenge of older operators and travelers using all modes. As a part of that effort, five expert panels were convened during March and April of 1996. The themes of those five panels were aging scenarios, medical, management of transportation systems with aging issues in mind, human factors, and alternative transportation. There were some sixty experts all together. As well, a Steering Committee, consisting of one USDOT administrator representing each mode, provided guidance and knowledge. Using the content of the panels and additional efforts, the report was prepared.

It should be noted that issues discussed at these panels involved all older operators and travelers using private, public, and commercial vehicles and all modes: air, maritime, rail, highway, and pipeline. Again, the authors wish to thank all who participated. Many of the ideas contained within this paper have the intellectual lineage of the panels. Any misinterpretations of those ideas belong to the authors of this paper.

1. INTRODUCTION

At the end of the twentieth century, the world's population is aging, particularly in countries in the industrial and post-industrial stage of development. The reasons for the growth of the older segment of population are interrelated and interacting: biomedical advances, containment of infectious disease, lifestyle changes, rising per capita income, and other factors. With an aging population comes public concern for safe, private motor-vehicle operation. For some of the increasing numbers of older people, aging leads to the accruing of physical deficits related to the skills necessary to operate motor vehicles.

Aging/mobility issues are briefly discussed below in this introductory section. The same and related issues, along with some tables, are presented in more detail in following sections.

1.1 Scope

Much of the discussion in this paper is based on the experience of the United States with aging and motor vehicle operation. This information will be valuable for other countries undergoing an aging transition. Countries such as Japan, Australia, Netherlands have had more experience in maintaining safe mobility for older citizens. In these countries, the aging issue now has risen to public and political prominence.

The discussion is limited to the operation of private motor vehicles. Hence, not discussed are issues related to aging and pedestrians, aging and commercial and public motor vehicle operations, and the significance of an aging operator population for other transportation modes. These issues are also of great importance to society. However, many of the issues discussed here for private vehicles are, with slight modification, relevant to other transportation operations.

Mobility, in this paper, is defined as a transportation specialist would use it, i.e., trip making with attributes of origin, destination, linking, etc.; and not generally as the demographer would, as settlement or residential patterns. Mobility is thought of as a derived demand for goods, services, and social interactions. This latter aspect is important in the consideration of aging issues. The trips, and characteristics of those trips, made by older persons will depend on their wants and command over goods and services, and desires for social interactions. Thus, the aging and mobility issue implies a sequence of topics to arrive at recommendations for the goal of safe mobility.

This paper discusses the following topics: population growth and structure, social characteristics such as family formation, health status, aging and motor vehicle operating risk, determinants of mobility, economic status, and recommendations for safe mobility.

1.2 Benefits of mobility

In industrial or post-industrial societies, where there is dispersed land usage, mobility grants access to goods, services, and social interactions. The benefits that mobility brings can be social, economic, physical, and, even, emotional in nature. In fact, being mobile becomes a precondition for full participation in these societies. Bringing things to people in their homes is not a sufficient solution.

1.3 Operational definition of aging

Aging is defined demographically as (1) an increase in the average, or median age, of the entire population; and/or (2) an increase in the relative proportion of older persons. The category "older" is defined by chronology, often at age sixty or sixty-five years. Many employment and income supplement programs use chronological boundaries. However, there is no chronological boundary established for the cessation of motor vehicle operation in the United States.

Aging, in biological terms, is the slow, but cumulative, buildup of physical and cognitive deficits. There is much individual variation in the aging process but no one escapes. Because motor vehicle operation requires sensory-motor skills, there must be a relationship between aging and driving. Motor vehicle operation requires the driver to make a continuous visual search for information, process that information, make decisions, and provide physical inputs. Physical decrements, such as poor eyesight or cognitive limitations due to dementias, such as Alzheimer's disease, may make safe motor vehicle operation problematic.

The variability of performance within any age category increases with the age category. The expanding range of performance differences among individuals through the course of a life span make chronologically-based policies intractable. Because chronological age is associated with variation in physical and mental capabilities, there is no chronological age when all people must curtail or cease vehicle operation. It should be noted however, that when safety is critical and there is no tolerance for error in operation, as a society, we adopt chronological age limits.

Although the "aging" population is frequently defined as counted as beginning at 65 years, the risks associated with motor vehicle operation increase exponentially at age 75 and older. For this reason it is important to examine the growth in the population age 75 and older. The crash data suggest that motor vehicle operators age 70 or 75 face a rapidly escalating crash risk . In the United States, crash involvement increases on a per mile driven basis by age 70 to 75. Because older drivers tend to avoid safer driving as on limited access roads, they may have a disproportionately higher risk of crash involvement. This is shown by their higher relative involvement in intersection crashes.

Despite age-related impairments, the probability on a per mile or capita basis, of any particular elderly operator getting into a crash is low. The cumulative increase in deficits associated with aging does not

translate proportionately into higher crash rates. Generally older people have an offsetting awareness of the risks involved in motor vehicle operation that allows them to compensate or withdraw from driving.

On average, older operators have elevated rates of crash involvement as they do for some other types of unintended injuries and diseases. But many in that age group operate vehicles and do so safely. The normative question for society is to address is what is an "unacceptable risk." How can a society get operators approaching the risk threshold to accept it? What alternatives can be offered to someone who should not operate a vehicle? If society expects older drivers (or for that matter any drivers) to make rational decisions, there must be rational alternatives. The challenge for those impaired -- and society -- is how to maintain mobility, first by allowing persons to go on driving appropriately and then by offering alternatives and substitutes for personal mobility.

1.4 Future health status of elderly

The projections of relative and absolute increases in the number of older people are certain because they are already born. However, the health, lifestyle, and social characteristics are not as firmly established. A 70-year-old person in the next century will not have the same health status as those people currently 70 years old. It is likely they will be healthier, although not without some chronic afflictions. Some will be wealthier and even more accustomed to mobility and motor vehicle operation. These lifestyle changes will have a profound effect on the propensity of older people to operate vehicles safely.

1.5 Elevated risk

The age distribution of a population has a relationship to the absolute number of crashes. When injury and fatal crashes in the United States are plotted by age, the curve has a flattened U-shape as shown in Figure 1. Drivers with the lowest accident rates are in the middle of the age range, between 35 and 55 years old. Younger and older drivers have more elevated rates.

At present, Figure 2 shows that there are more persons, in absolute numbers, in the lower-rate middle of the injury and fatality crash curve due to the age profile of the baby boomers in the United States. This distribution suggests that the actual incidence of crashes is as low as possible without improvements in vehicle operation and road design. If the age composition has more of the population concentrated at the beginning and the end of the age range, there will be more crashes for a same size population. The deduction is that the injury and fatality rate due to motor vehicle crashes is now as low as it can be. As the baby boomers age, the sheer size of this group will amplify the increased injury and fatality rate associated with older vehicle operators.

Injury and fatality rates based on age represent the collective experience of that population segment.

The individuals in any age category display variation. The range of variation in vehicle operation is particularly true for older age groups. Some older operators with identifiable health conditions have an elevated risk of operating a motor vehicle. There is a need for more research to understand how risk is distributed among members of older age groups. Older operators with a variety of health afflictions are likely to be most at risk. They also are likely to lack mobility alternatives.

1.6 Aging and human performance

Operators should be considered as essential as the technical components as vehicles become more complex. The human factors approach provides a way to understand vehicle operation as a system composed of people and technology. The use of human factors knowledge should encourage engineers to design in relation to users. The resultant products would feature ease of use and, as a result, appeal to an expanded market. The Baby Boom population, over 70 million, is now starting to have failing eyes and yet there are displays on windshields.

Human Factors has two components; "knobology," the physical part and the information load. The latter, information load, varies with stress and fatigue which can be caused by, for example, night driving, fatigue, or poor eyesight. ITS design requirements can be worrisome because users may be near-sighted, left-handed, dyslexic, presbyopic because people who can afford ITS (Intelligent Transportation Systems) options tend to be older. There is a need to design environments which allows some forgiving.

A substantial component of the human factors data used for design parameters was generated by research conducted during World War II. Most of that data measured vision and hearing. The available standards come from military research and standards developed during and after World War II. Software designers need to understand the cognitive process but there is little data available about motor performance and cognitive areas such as memory performance, reaction time, and other human performance topics. There is a need for a data infrastructure to be able to asses how parameters change with aging to support design. There are no studies which systemically explore these variables and this would be useful knowledge to update national and international standards.

1.7 Retirement trends impact mobility

The timing of retirement, the subsequent choices of residential location, and the amount of retirement income will all influence the mobility and trip-making patterns of older people. Some people will continue to work past the traditional age of retirement, full- or part-time. (As an aside, this is an issue for commercial and public drivers who want to remain in their occupations.) In the United States the land usage is dispersed and activity centers are not collocated.

There are a variety of decisions made about residential location in retirement. "Most adults remain

in their own homes or communities after retirement." (Treas, p.10). This is referred to as "aging in place." As a result older people may increasingly find themselves living in areas where shopping, entertainment, and socializing may be linked only by roads and often lacking public transportation. However there is a highly selective interstate migration of elderly people. This migration lows out of a large number of states and into a few states. The elderly who migrate tend to be the younger elderly and have higher incomes. (Treas) These residential decisions of older Americans need further study to determine the consequences for mobility.

2. DEMOGRAPHIC TRENDS

2.1 Age profiles

The size of the population depends on three factors: the fertility rate, morbidity rate, and the net of immigration and emigration. Many countries are experiencing the maturing of the baby boomers, those born after the World War II, from 1946 to 1957. Fertility rates during that period in the United States were high but precedented. The net increase was due to the reduction in death rates for children and adults. This decline in mortality rates is also occurring in many developed countries. Starting in 1958, there has been a historic decline in the birth rate in the United States.
The low birth rate should also be considered in evaluating the age profiles.

The increase in longevity due to healthier lifestyles and medical advances has not brought health without infirmity. In fact, one of the important issues for motor vehicle safety is whether there is an increased prevalence of chronic disease among the elderly. The age distribution of young, middle, and old age is shown for countries with population in 1995 greater than ten million in Figure 3. A number of countries now have at least 10, and in some cases, 15 percent of the population over sixty-five years of age.

In many countries the median age of the population is increasing. In 1995, as shown in Figure 4, in the United States there were 33.7 million people over the age of 64. The U.S. Census Bureau projects that in the year 2000 there will be 35.3 million persons older than 64 years; in 2010, 40.0 million; by 2030, 70.2 million; and by 2050, 80.1 million. In 1995 those aged 80 and older represented 11 percent of the 64 and older population; by 2010, they will represent 15 percent.

The United States is not alone in experiencing rapid growth in the numbers of elderly. By 2010, the growth rate of the older population, age 60+, will be three and one half times greater than the growth rate for the total population. Figure 5 gives life expectancies for various countries.

2.2 Gender

There is differential survival by gender which is increasingly a world-wide phenomenon. The average life expectancy of a female in some countries may be as much as five or more years longer than that of a male. Over time this difference may decline, but it will persist if the causes are genetic and not just lifestyle. This differential has implications for safe mobility. Women generally have lower crash rates by age. Women are not as likely to have funds to support mobility at the levels of males, having earned less, and likely having smaller pensions. Some women may over compensate and give up driving prematurely.

2.3 Other social factors

It is likely that the health characteristics of the older population will influence the number of motor vehicle crashes. Physical and mental capabilities influence the rate at which crashes occur. Social factors determine who drives and how much. Marital status, household and family composition, gender, and employment status all influence driving, and the risk distribution of that driving. These social factors are changing and shifts may have consequences for vehicle operations. The highway safety community needs to monitor these shifts to enhance the effectiveness of safety programs.

2.4 Age structure and entitlement

The age structure and composition have implications for social security, pension, and health insurance. Retirement income is an important determinant of mobility, especially if alternatives to operating are necessary.

3. HEALTH OF THE AGING POPULATION

3.1 Longevity

There has been a continuing decline in the death rates in many countries. Childhood and adult mortality and deaths from crashes have been reduced. In some countries, life expectancy has been extended by as much as five years. The question arises whether this increase in life expectancy is also accompanied by increased morbidity. The chronic and worsening health conditions accompanying longevity can have strong effects on motor vehicle operation.

3.2 Links from health status to driving risk

It is difficult to draw an explicit link from age, to medical condition, to functional disabilities (both physical and cognitive), and, finally, to operator performance. Vehicle operators have many ways of

compensating. There is not a path from medical conditions to a certainty of a crash. The simultaneous change in driving behavior that accompanies a physical condition makes any statistical estimation difficult. With biomedical progress, the incidence of some diseases will be lessened; but others, more chronic, will increase in prevalence. There may be a substitution of increased morbidity for deferred mortality. There is a need to inventory the prevalence of physical and cognitive conditions.

There is a changing disease mix among older persons. There is a need to understand how different impairments affect the capability to operate a motor vehicle. Such understanding presupposes the knowledge of what capabilities are needed to operate motor vehicles. We must understand what remediation is appropriate for specific impairments and what warnings should be placed on certain types of driving.

4. MOTOR VEHICLE OPERATION AND RISK

4.1 Crash experience

Older operators of motor vehicles have fewer number of absolute crashes of all types than those of other age groups, but they also drive less. Relative to their number of crashes, older operators have a higher frequency of crashes at intersections. They have trouble turning left when immersed in traffic. Traffic conflict and congestion are not going away. The rush 'hour' now is spread over longer periods. There is traffic congestion even in suburban areas during off-peak, daytime periods when the majority of older operator driving is done.

On a per capita, or license, basis, older drivers have relatively low rates of crash involvement. But on a per mile operated basis, their rates are as high as young operators. This is especially true for those operators 80 years and older who have the highest crash rates on a per-mile driven bases.

Rates of older operators appear higher because they drive most of their miles in traffic. They do not drive as often on safer, divided highways. In the case of fatal and severe injury crashes, fragility and frailness are also factors. The fatality rate per crash starts turning up around age 60 and appears almost vertical by age 80. But this may not be a good predictor for an individual because of increasing variation in capability with age. At any age, serious crash involvement is a low probability event. For example, only one out of 100 elderly die due to vehicle crashes compared with 1 out of 3 teenagers, age 16-19.

The United States is not alone in experiencing higher fatalities rate among aging operators. Figure 6 shows motor vehicle fatalities per capita by age for different countries. Portugal, Greece and Japan report a higher incidence of road accident deaths for people age 65 and older than the United States. Countries with higher road accident deaths per 100,000 for all ages than the United States include

Portugal, Greece, Belgium, Austria, New Zealand, and France.

The data in Figure 7 for the United States shows that because older operators do not drive proportionately as much at night, fatalities are less. Figure 8 also shows that the increases in older-age fatalities are occurring during the day, defined as the period 6:00 a.m. to 6:00 p.m. Recognizing the temporal distribution of these risks, it is useful to allocate highway safety efforts accordingly.

The United States is not alone in experiencing a higher fatality rate among aging operators. Figure 9 shows motor vehicle fatalities per capita by age for different countries. Portugal, Greece and Japan report a higher incidence of road accident deaths for people age 65 and older per 100,000 per licensed driver than the United States. Countries with higher road accident deaths per 100,000 for all ages than the United States include Portugal, Greece, Belgium, Austria, New Zealand, and France.

4.2 Crashworthiness and fragility

Older operators have a high relative number of crashes at intersections, merges, and other locations requiring turning maneuvers in the presence of traffic. Hence, the most vulnerable and frail operators are being hit relatively more times in the part of the vehicle where there is the least crash worthiness -- the side.

4.3 Driving times of older and younger operators overlap

Older drivers concentrate their driving in the afternoon. They have interactions with younger drivers and pedestrians at that time. The interactions among the young and older cohorts with different driving styles warrant study. Likely operating a motor vehicle is not going to get any easier where traffic congestion and conflict in driving styles are concerned.

4.4 Operating strategies and decision making

Most older operators make rational decisions about when and where to drive or whether to drive at all. They are successful in substituting good judgment for loss of physical and mental skills. Gender also plays a role in this decision making. Experts offer that some older males persist in operating too long while some older females withdraw from operating prematurely. Mobility is especially important for females who live longer and have less pension income.

Although choices exist as to when to drive, the nature of motor vehicle travel is that of a derived demand for goods, services, and social interactions. Some demands will occur at specific times as scheduled events, i.e., doctor visits, concerts. There cannot be complete flexibility in trip timing. Hence, there is some loss of utility from using conventional compensating strategies.

5. LAND USE AND DEMAND FOR MOBILITY

5.1 Mobility

The interactions among retirement patterns, medical and health advances, lifestyles past and present, pension programs and many other factors, produce a unique set of derived travel demands. The demands have origins, destinations, and linkage patterns to the goods and services older persons want to consume. 'Mobility' is used here to mean both settlement pattern and, interrelatedly, trip making. Older persons require mobility for more than just shopping for essential needs. Social interactions and maintaining friendships require travel also.

5.2 Retiring in-place

An aging population, coupled with dispersed land use, will create more demand for transportation. It is unlikely that older persons, especially those with pension income, will cluster together in cities. They most likely will want to continue their independent lifestyle built upon years of mobility while living in low density areas. People tend to remain after retirement where they have lived. There are exceptions where persons cluster in retirement communities. Some who have moved away after retirement return to be near family or medical facilities when they become dependent or ill.

5.3 New forms of private and public transportation

Because many older people will, at some time, be unable to drive in all circumstances, they need alternative transportation. Public transportation must be more 'older-user friendly'. But for places that older persons want to go, and not served by existing public services, there is a need for flexible and demand-responsive alternatives. The appearance of new transportation forms may be another manifestation of the emerging volunteer sector. There are not the population densities to support traditional public transportation forms. Volunteer-based, low-fare services are needed.

6. ECONOMIC STATUS AND IMPACT ON MOBILITY

6.1 Dependency ratio

The maturing of the baby boom in many countries has now resulted in a sizable group of people approaching retirement age. They will have an increased number of years to look forward to in retirement because of biomedical and lifestyle improvements. They have expectations for a productive retirement which will include mobility.

The decrease in fertility rates and the early retirement of some older workers, some believe, will result in a smaller work force to fund programs for the growing number of older persons. This is an increase in the dependency ratio, as shown in Figure 10. A dependency ratio of, say, 0.50 indicates that for each person 15 to 65 years old there is one-half of a person under the age of 15 or above the age of 65. However, even if so, immigration, incentives for older workers to return to the work force if only part time, and more capital investment per worker can mitigate any shortages.

What can be funded depends on the dependency ratio -- or does it? Economic mechanisms can compensate. These include immigration, increased labor force participation, increased capital intensity and other productivity gains, and job restructuring which could include older workers.

7. RECOMMENDATIONS

7.1 Recommendations

Much can be done to prevent any undue safety impacts from an increasingly older population operating private motor vehicles. The following recommendations are suggestive of directions to be explored and are not inclusive.

7.1.1 Social and political process

The social, political, and economic influence of older persons will influence policy toward development of alternative transportation systems. Licensing programs that place restrictions based on chronological age for older persons are likely to be met with strong opposition. There is a need for alternatives to age-based operating rules. However the current view is that chronology is the only objective method.

A more equitable approach would be to make driving/mobility decisions performance based. This is difficult to do because of the need to establish a quantifiable link between a performance deficit, or deficits, and performance. For example, when physical or mental declines are assessed, it is the middle, not the early or late stages, that present difficulty for evaluating performance. There are also risks due to conditions not recognized, diagnosed, or treated. By contrast, properly treated conditions may pose little risk.

There is a need to identify what are the links between physical and mental declines and performance declines. There is a need for risk assessment data because society needs to understand explicitly what level of risk it is willing to assume to ensure mobility. Part-task simulators have the potential to be a major aid in evaluation but currently their critical features have not been identified.

At present there is a lack of objective measures of safety critical performance for testing older

operators. Short tests may not reveal deficits or may actually make driver appear to be worse than he/she is. There is a need for in-situ tests which monitor driver for extended period in actual driving environment.

There is a need to re-conceptualize regulation because no one wants to be the licensing gatekeeper**.** Currently the responsibility passes between relatives to physicians, occupational specialists, and the DMVs. Liability issues influence the likelihood of health care workers to reporting people relative to motor vehicle operation. People with marginal impairments may not seek help from physician for fear of licensing forfeiture. It is possible that better training in this area could significantly enhance primary physicians' contributions. There needs to be a shift from an adversarial to supportive approach to provide ways to aid an aging operator to make the right choice.

7.1.2 The aging as a expanding travel market

Private transportation must accommodate the aging traveler because they will increasingly have the interest in and resources to continue to be mobile. Currently the accessibility of air travel and its support facilities such as restrooms can be challenging. To make travel more elderly friendly, the 'aging option' should be built into vehicles and infrastructure and fragility should be considered in design of vehicles.

7.1.3 Public transportation

Public transportation is part of the answer to aging mobility. There is a need to redefine the concept of public transportation for aging users. It should emphasize low cost technologies and calibrate occupant protection to the aging. Public transportation should emphasize security and accessibility. It should not confuse or burden aging operators. Better access, more security, rest rooms, places to sit while waiting, readable signage, and courteous employees are all necessary for elderly patronage. Existing public transportation needs to be made more elderly friendly. Yet public transportation, even with improvements cannot completely fill the need, especially in low-density areas.

At present alternative mobility services are fragmented. There is a need to inventory existing mobility services including demonstration projects and to identify their strengths, weaknesses, and gaps in services. The goal should be to foster cooperation among providers. It might be possible to retrofit existing fleets, like school buses, for use by the elderly. Better infrastructure design might encourage use of more walking. Assisted living facilities which incorporate mobility services may reduce need for mobility.

7.1.4 Human factors improvements

There is a need for human factor improvements such as vision aids and collision warning to give the vehicle operator more decision time. Advances in technology, including low tech, can help aging operators and are coming soon. Human factors improvements may extend an operator's decision time. Simple improvements such as increased brightness and larger letter size on signs, or reduced clustering of signs at intersection can help. It is important to maintain road markings and signs to original specifications. It would also be useful to foster more standardization of controls and displays in vehicles. The goal should be to design and create vehicles and infrastructure that are 'elderly friendly'. Loss of bone and muscular strength make aging more vulnerable. Occupant protection should be calibrated to the aging.

Advances in technology can help aging operators but enhanced technology should resist complexity. Performance-aiding and safety features can be commercially successful because experience with compliance with the Americans with Disability Act shows that the required features were useful to all users. Aids for aging may be beneficial to all although relief from product liability may be required to stimulate their availability.

7.1.5 Document the functional content of tasks in non-commercial vehicle operation.

There is a need for a better understanding of the driving/flying/piloting task. It is critical to understand what operators actually do. Acquisition of this knowledge would make it possible to develop performance based standards or operating tasks for all modes. It would then be possible to define impairment relative to specific task. The medical community must know what performance standard is desired if they are to act as judges of performance.

7.1.6 Transportation alternatives

There is a need for new forms of public transportation. Such transportation may actually be based on public-private cooperation. Any new forms of transportation should be demand responsive to the lifestyle of older people.

7.1.7 Understand the relationships among age, drug use, alcohol, impairments, and fatigue.

The aging may be more affected by drug use, alcohol, impairments, and fatigue. There is a need to better understand effects of medication on operating. Liability concerns may have overstated side effect descriptions. Newer drugs have fewer sedating effects. The effects of fatigue and sleep apnea are important consideration for older operators.

7.1.8 Training

People can learn at any age although rates and methods may differ. Training and, more specifically retraining and refresher courses, have the potential to make older drivers safer and more aware of their deficits and limitations. These programs exist and some wisely begin before the operator actually needs to make age-related modifications to driving. As an example, the American Association of Retired Persons (AARP) has a program, 55 Alive. Hence, the older operator can make more informed decisions about when and if to operate.

To maintain skills, they must be used or practiced continually. It is known the recentness of training and experience impacts performance the most. It is easier to train to compensate for physical deficits than for mental deficits. Similarly the trainers and the training content must be sensitive to the needs of the aging.

As people live longer, any type of training or human capital investment has increased benefits. Older operators need to be kept abreast of new traffic regulations and operating practices. Older operators should be advised, as should all drivers, to use their vehicle restraint system (lap and shoulder) and to properly position themselves as drivers or passengers in a vehicle having airbags. Older drivers should be aware of strategies to avoid difficult types of driving such as rush hour, intense sunlight, slippery conditions, and the like. Older drivers should be cautioned to keep a vehicle-following gap commensurate with their braking perception and reaction time.

7.1.9 Licensing

There is a need to create uniformity and cooperation in licensing. Currently the states vary in the procedures they use to evaluate aging. Objective criteria are very scarce and, as a result, DMVs remove relatively few from driving. Testing options have their limitations because aggressive testing can give false positives and periodic re-testing of all drivers may be too costly. Also, with episodic health declines, periodic testing is not timely or effective. On-road testing is relatively subjective. There is a need for non-adversarial procedures but performance based testing can be very costly. Health practitioners need objective descriptions of risk to make informed evaluations.

Licensing and de-licensing are based on physical and mental health. Licensing should involve eye exams that can detect conditions detrimental to driving, such as those involving night vision. There is a need to develop new instruments for testing, detecting, and tracking age-related deficiencies that impact the risk of operating.

Doctors and other medical professionals generally do not want to be gatekeepers for private operators. They see their role as advising rather than adversarial -- feeling patients will not be honest about treatable conditions if they know the doctor is required to report.

7.1.10 Crash avoidance technologies and driver aids

There are few decrements to vehicular operating that technology and ergonomics could not overcome. However, it may not be possible to overcome cognitive deficits and dementia. Development and deployment of crash avoidance technologies to aid older drivers are to be encouraged. But these technologies must be made elderly friendly and accommodate the fragility of the elderly skeletal structure. Unintended safety hazards resulting from the use of these technologies must be fully understood.

7.1.11 Infrastructure

The vehicle infrastructure can be made elderly friendly by eliminating traffic conflicts at intersections, rotaries, ramps, and other locations of confluence. These improvements would actually benefit all highway users.

7.1.12 Signing

Road signage must become more standardized. Signage should be compatible with the physiology and perception-reaction capabilities. Various levels of government, including municipal, should plan and budget for upgrading signage -- and maintaining by appropriate repainting.

7.1.13 Need for Caretakers

Volunteerism could augment changing family roles. The higher proportion of individuals in the workforce reduces the availability of volunteers. Due to the declining family size and dispersion of relatives there will be an increasing need for caretakers for the elderly. Because the 'young' old may use low wage jobs to supplement retirement income, it might be possible that they could assist the most impaired.

7.1.14 Transportation planning

People need to plan for their future transportation needs just as they do for other aspects of retirement. They should include in estimating financial needs for retirement as a line item, alternative transportation expense, for the time when they are no longer able to operate a vehicle.

7.1.15 Needed research

There is a need to collect data on older operator performance. There are few longitudinal studies. One such issue that could benefit from this type of study is the linkage between a medical condition and the

likelihood of a crash. Constant reporting, such as an older operator status report, is to be encouraged. Identification of the types of crashes of older operators should continue to detect changes and emerging trends that are remediable by technology, infrastructure, and/or training. Research is warranted on effects of various drugs, and drug interactions, on the ability to operate.

8. SUMMARY

Evidence suggests that mobility is essential and must be maintained as long as possible. Mobility is important to a persons social, physical, and mental well being. Many countries are undergoing demographic transition. The older segment of the population is growing both relatively and absolutely.

At some point, it may not be prudent to continue to operate a motor vehicle. Most older operators are aware when this time arrives. But some operators need guidance in understanding the risk they present to themselves, their families, and others. Those who do not operate should have alternatives so they gain the benefits of mobility and avoid debilitating isolation. There is a need for new concepts of demand responsive transportation systems with low cost structures and perhaps volunteer staffing. It is necessary to supplement and/or support vehicle operation and to offer mobility alternatives. The issue of aging vehicle operators is likely to increase worldwide faster than rate of population growth.

At this time technology should be viewed as a resource. Because older consumers tend to have a disproportionate share of the society's wealth, their mobility represents a market opportunity for the private sector to capture.

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[2] U.S. Bureau of the Census, Current Population Reports, "Population Projections of the United States, by Age, Sex, Race, and Hispanic Origin: 1993 to 2050," U.S. Government Printing Office, Washington, D.C., 1993, Table 2.

FIGURES

FIGURE REFERENCES

Figure 1: NHTSA Research Note, October 1995

Figure 2: U.S. Bureau of Census

Figure 3 - 5: United Nations, "World Resources 1994-1995," Tables 16.1, 16.2, and 16.3, Oxford University Press, New York, 1994. Republished: "The Population of the United States".

Figure 6: National Center for Health Statistics. Health United States .

Figure 7: Transport Statistics Report, International Comparisons of Transport Statistics. Government Statistical Service. Norwich, England, 1997.

Figure 8: Fatal Analysis Reporting System, 1982-1994.

Figure 9-10: United Nations, "World Resources 1994-1995, Oxford University Press, New York, 1994. Republished: "The Population of the United States".

Figure 1. Motor Vehicle Fatality Rates Per 100,000 Licensed Drivers by Age

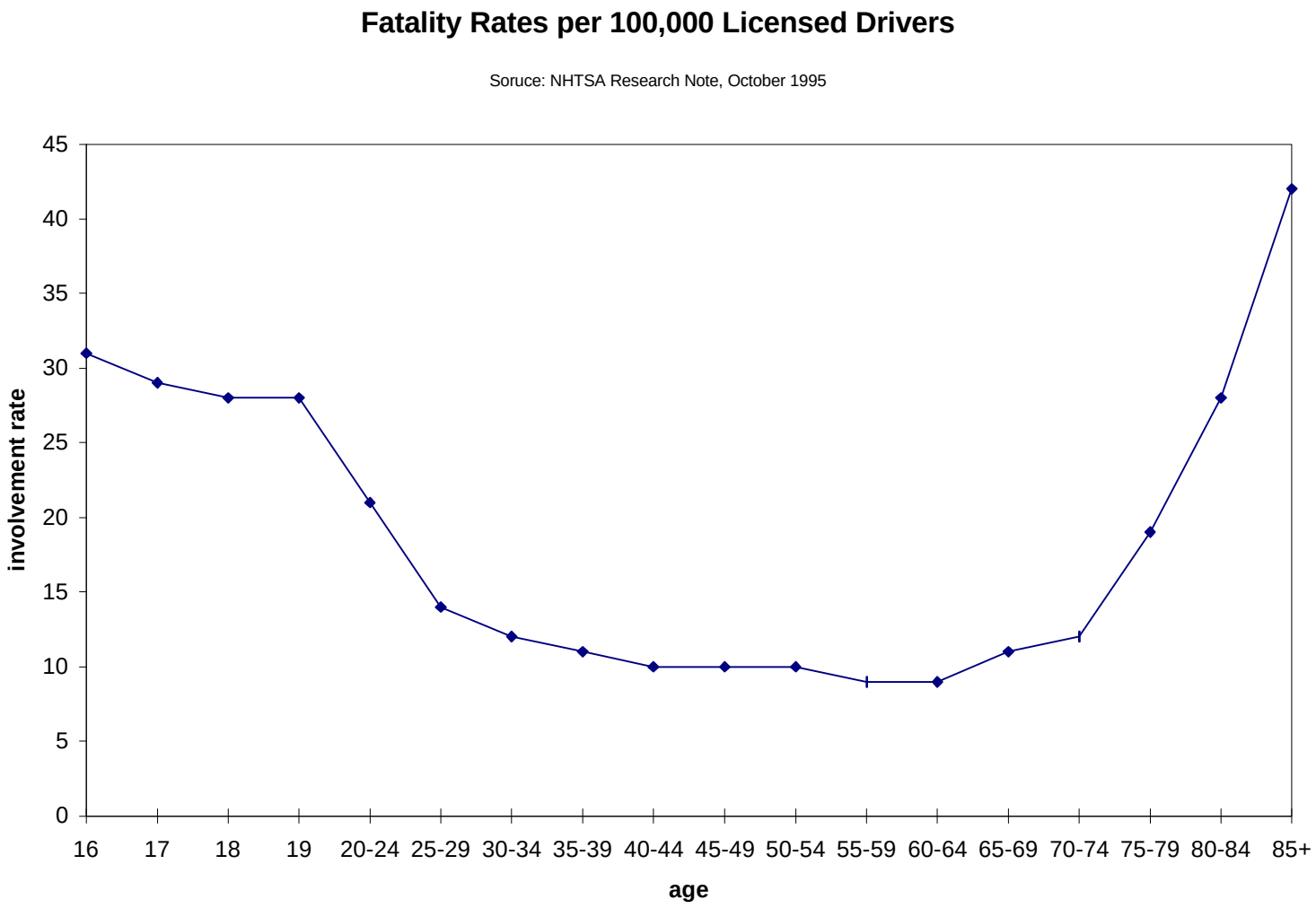


Figure 2: Population Projections for U.S. Residents

(U.S. Bureau of Census)

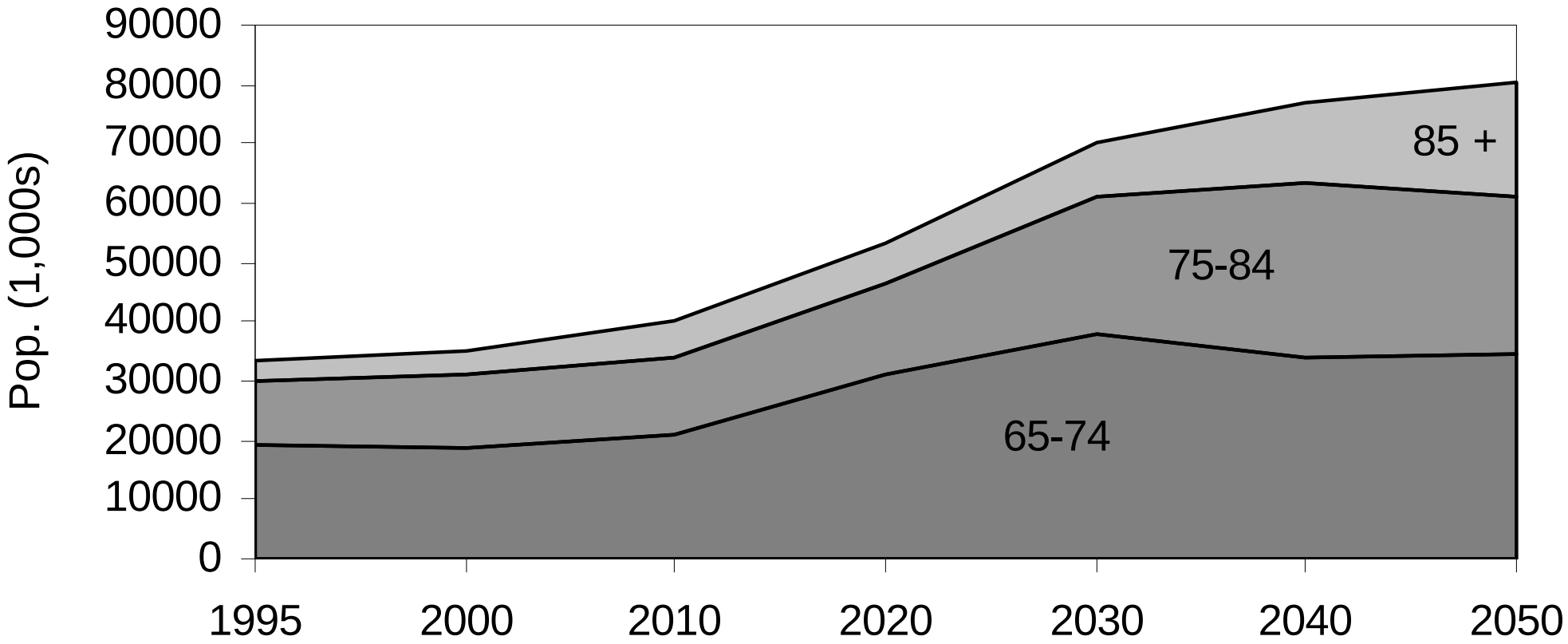


Figure 3: Age Composition of Nations with 10 Million or More Inhabitants: 1995

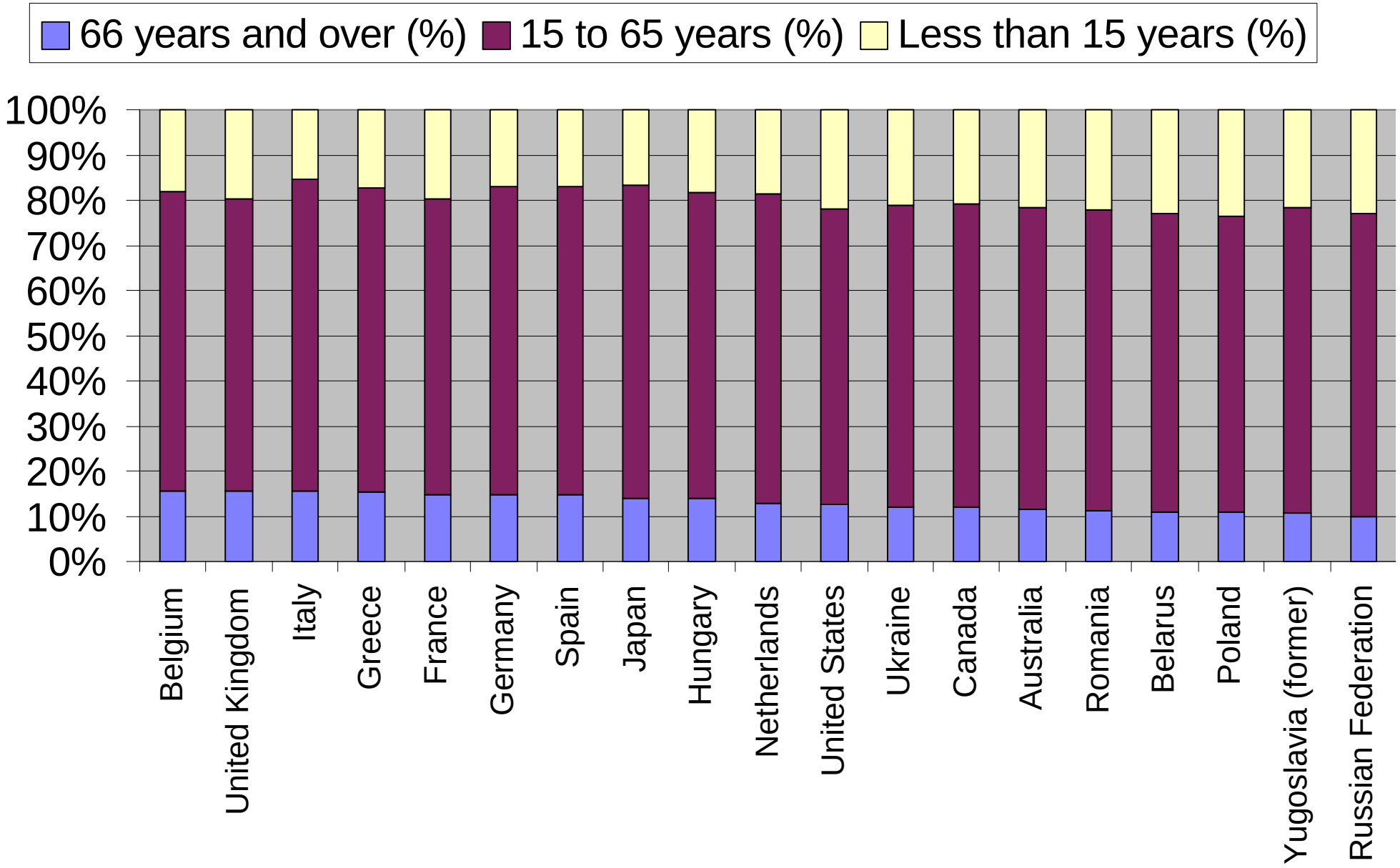


Figure 4: Age Distribution of United States Population Age 65+

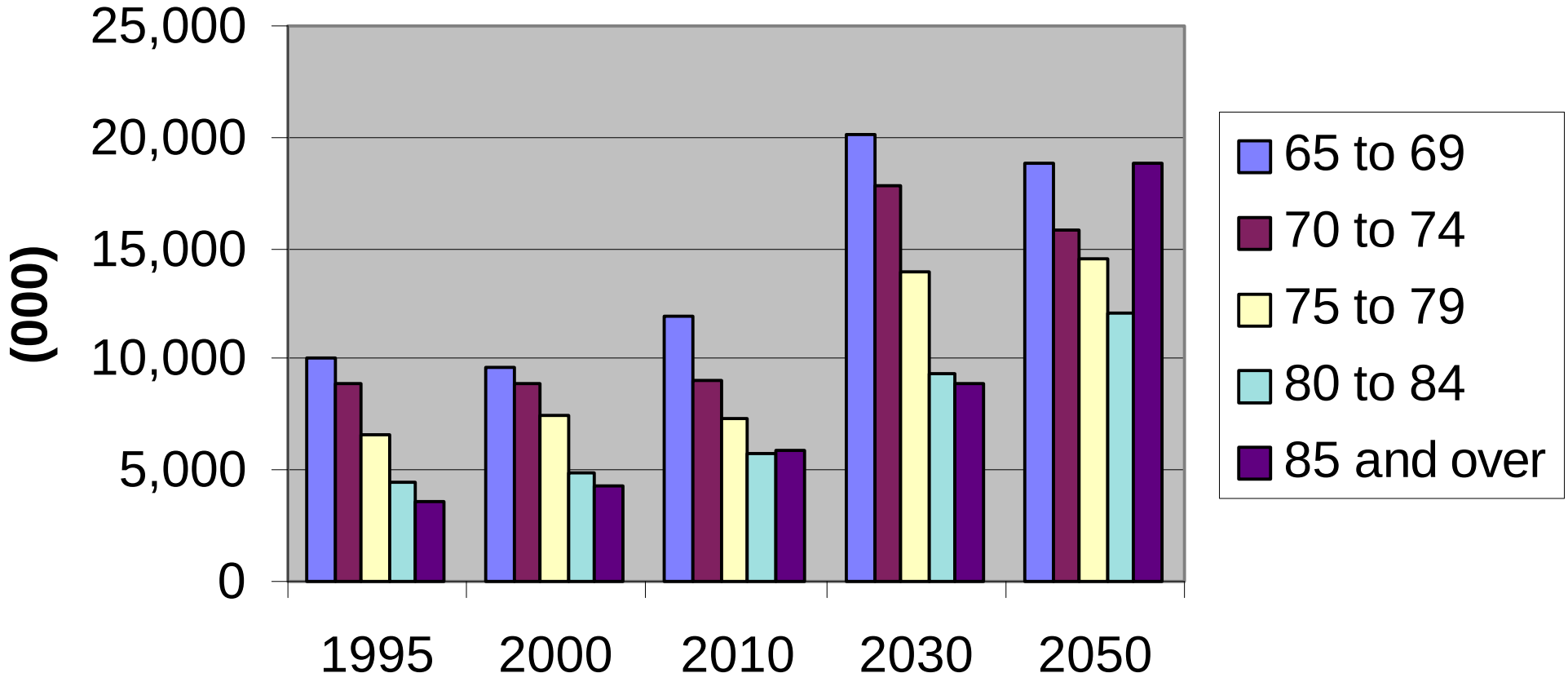
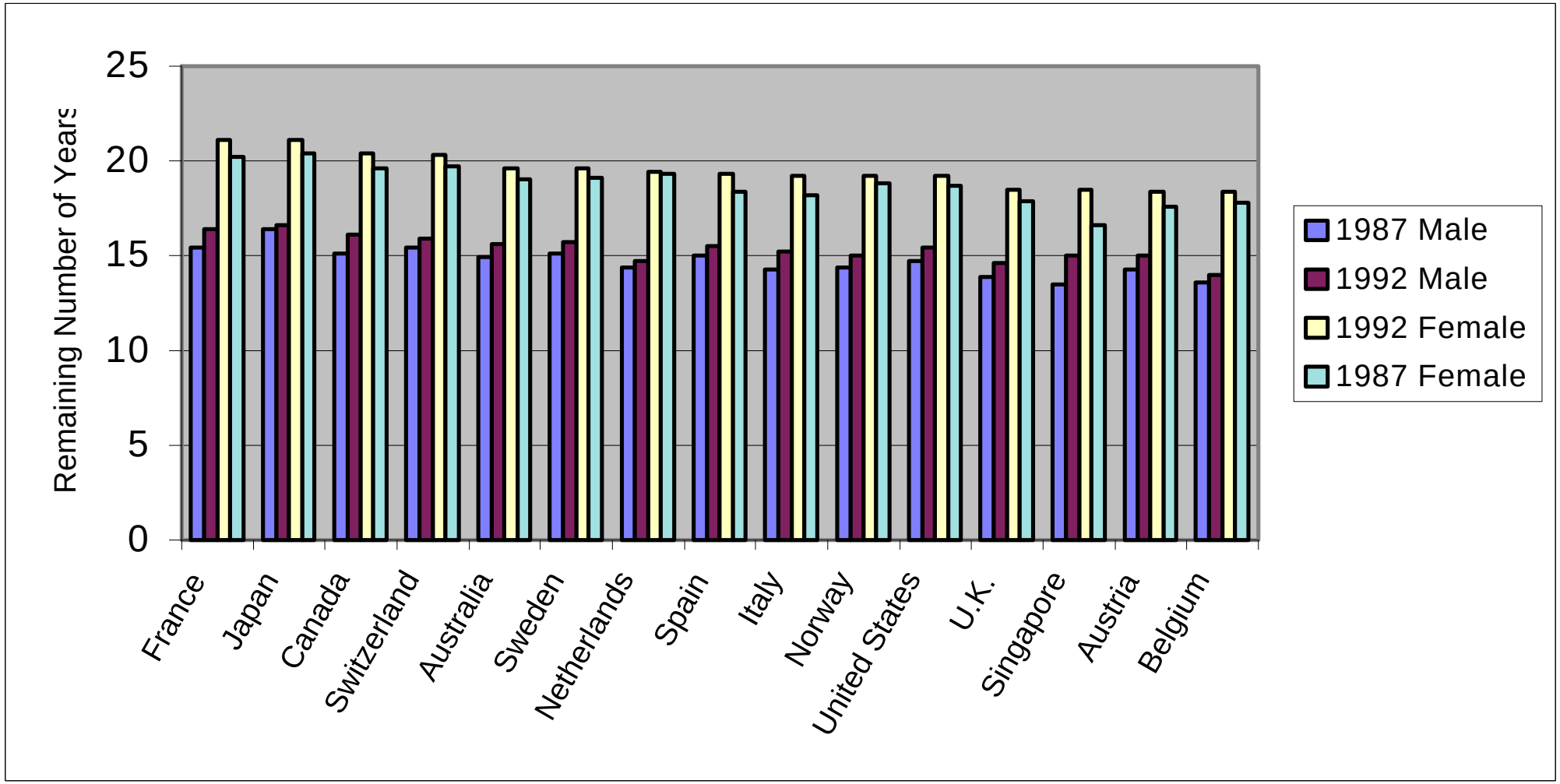


Table 5: Life Expectancy at Age 65 by Sex for Selected Countries, 1987 and 1992



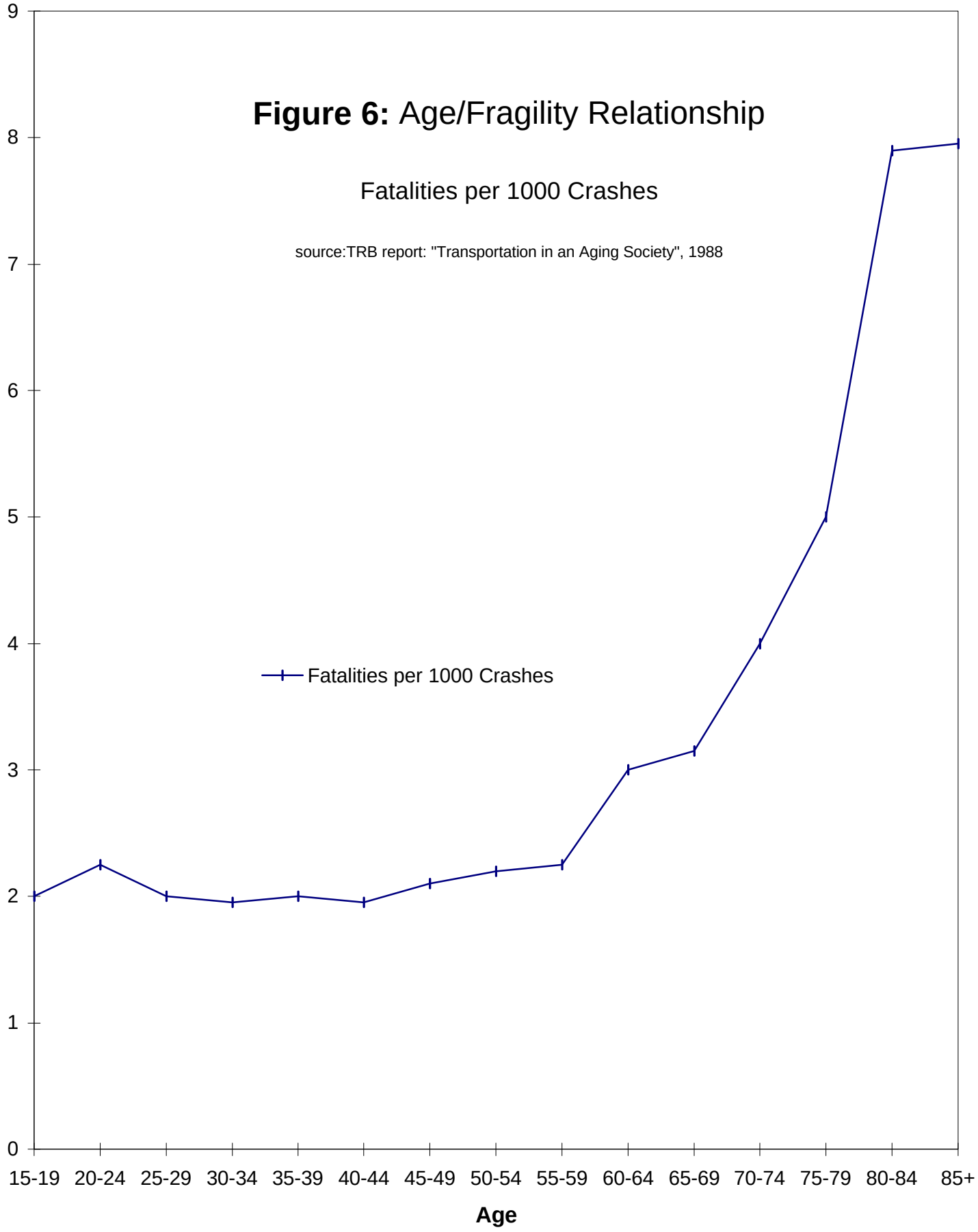


Figure 6: Age/Fragility Relationship
Fatalities per 1000 Crashes
source:TRB report: "Transportation in an Aging Society", 1988
Fatalities per 1000 Crashes
9
8
7
6
5
4
3
2
1
0
15-19
20-24
25-29
30-34
35-39
40-44
45-49
50-54
55-59
60-64
65-69
70-74
75-79
80-84
85+
Age

Figure 7: Road Accident Deaths per 100,000 All Ages, 1994

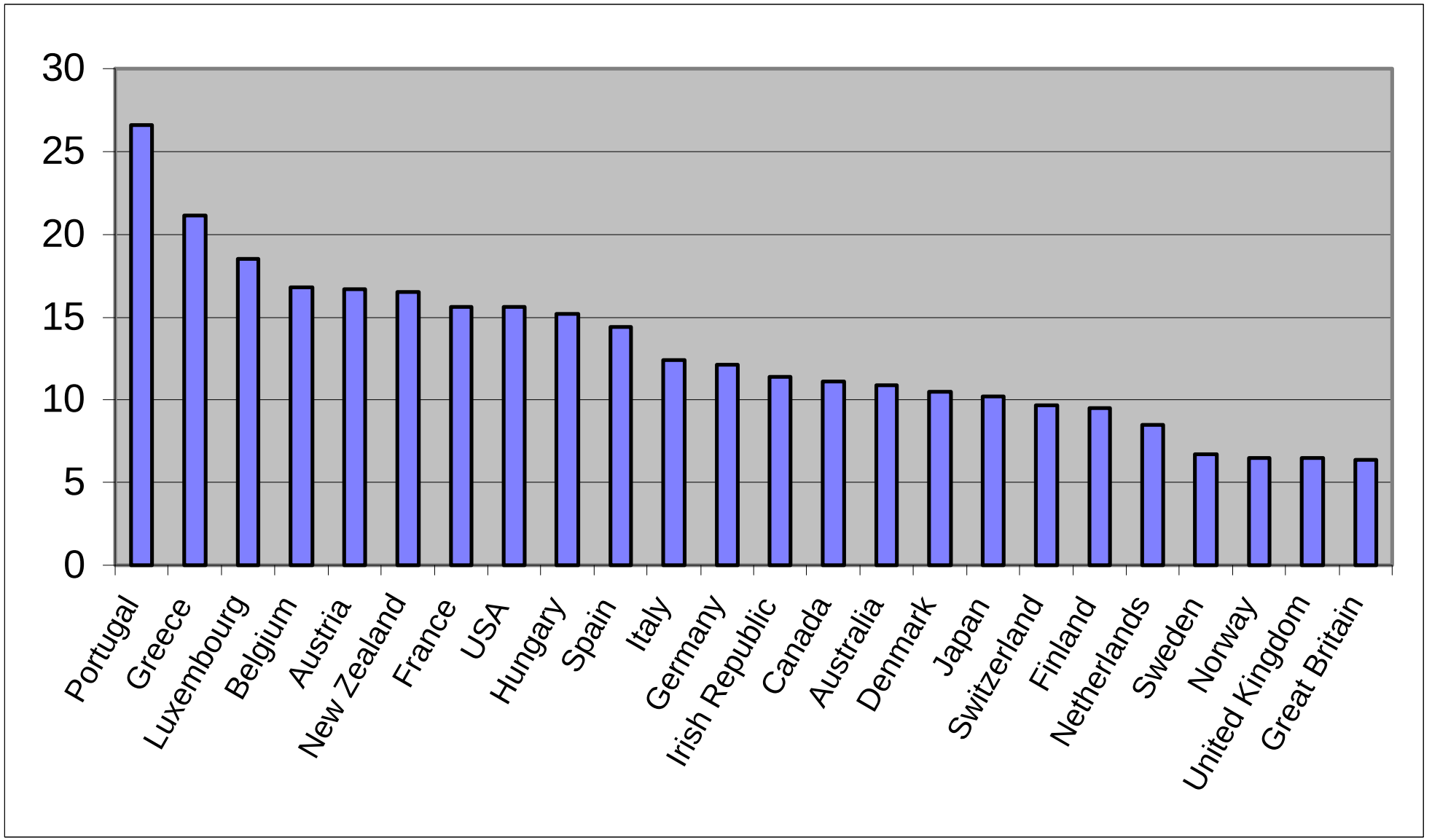


Figure 8: Day and Night Fatalities with a Driver Older Than 64 years of Age

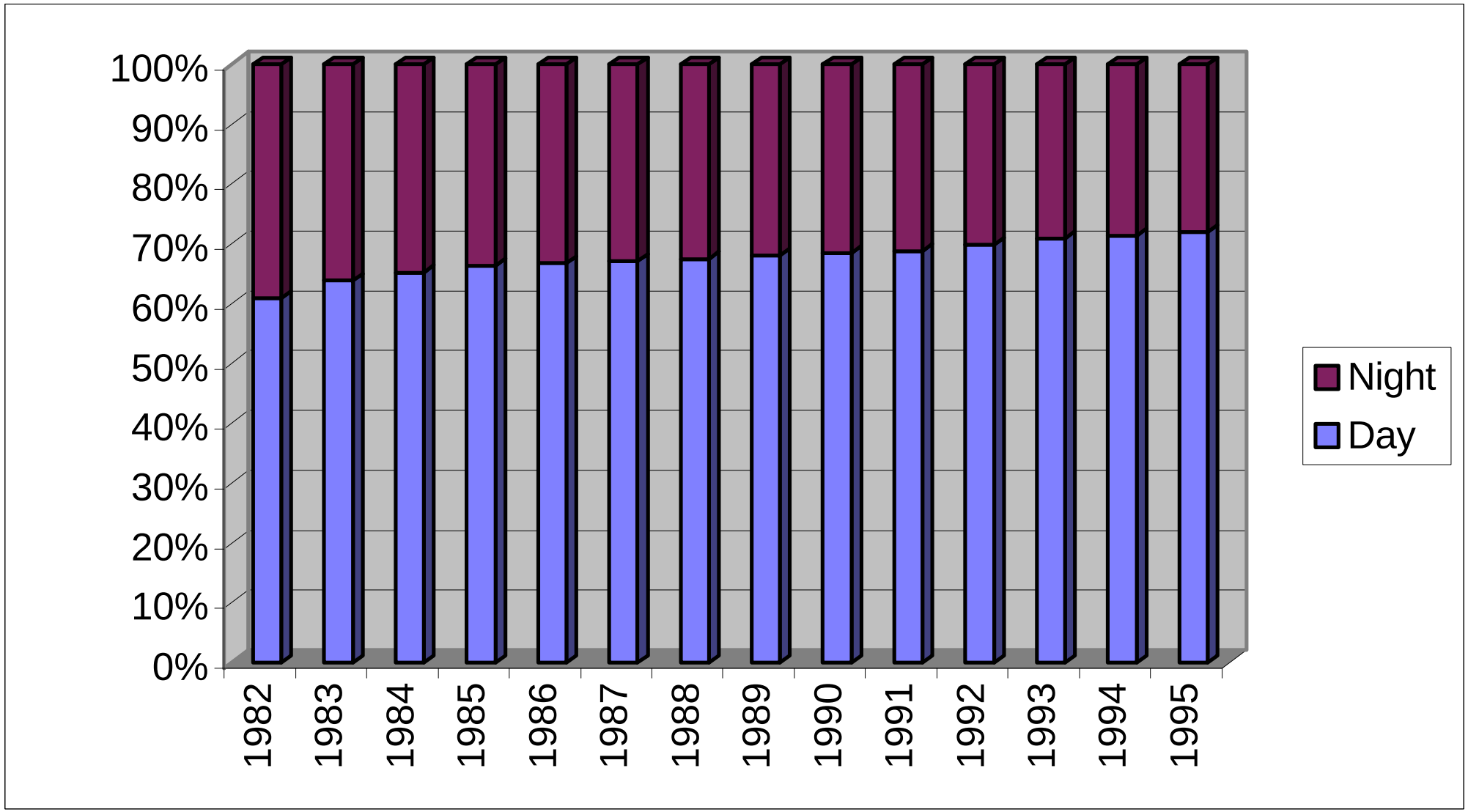


Figure 9: Road Accident Deaths per 100,000 Age 65 Plus, 1994

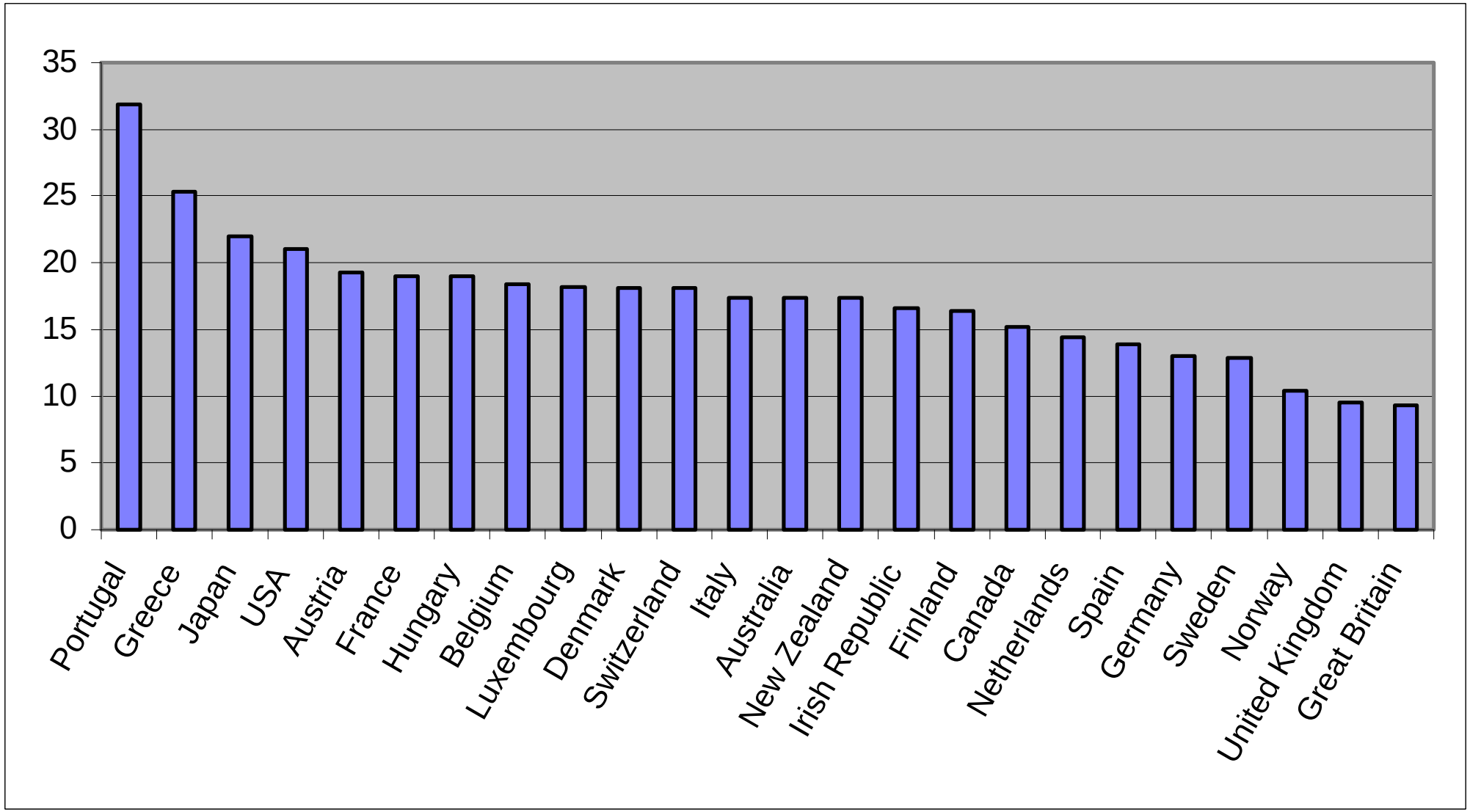


Figure 10: Dependency Ratios, 1995