Mortality Differences in the U.S. Oldest-Old Population by Nativity

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Abstract

Nativity is one of the factors affecting survival at adult ages. In this study the influence of this factor on survival at ages above 80, in the period 1979–2000, in both the total and white populations of the United States has been investigated. The results suggest that mortality of foreign-born males is lower than mortality of native males, however, the survival of females is mostly unaffected by the nativity status. Several possible explanations are provided. Additionally, comparisons of life expectancy at age 80 in the period 1979–2000 in the United States, Sweden and Japan show that a high proportion of foreign-born in the U.S. elderly population has no significant influence at the results of international comparisons.

Human life expectancy continues to increase. Japanese females are enjoying now more than 85 years of life expectancy at birth. Among them 76% are expected to become octogenarians and about 41% will reach age 90 (Ministry of Health, Labour and Welfare, 2004). Prospects of survival for United States are also impressive: about 43% of males and 59% of females are expected to live beyond age 80 (Arias, 2002). Such unprecedented gains in human longevity of the modern era generated considerable interest among demographers to mortality at advanced ages (Condran et al. 1991; Kannisto, 1994; Kannisto et al. 1994; Himes et al.; Kannisto, 1996; Thatcher et al., 1998). One of the main findings was significant reductions in death rates over last several decades (Kannisto, 1994). This challenged the widely-held belief that mortality at very old ages is intractable simultaneously adding to the research agenda investigation of factors influencing survival at such ages.

One of the factors frequently associated with survival at adult ages in the United States is the person's place of birth or nativity. Various studies (Krueger and Moriyama, 1967; Kitagawa and Hauser, 1973; Kestenbaum, 1986; Fang et al. 1997; Swallen, 1996; Hummer et al., 1999) of foreign-born in the United States report that immigrants residing in the United States live longer than native persons. Multivariate analysis further reveals that nativity has an independent effect on survival at adult ages persisting even after controlling for certain differences in native and foreign-born populations (Rogot et al., 1992; Rogers et al., 1999; Singh and Siahpush, 2001). At present however, there is no convincing evidence existing whether mortality differentials attributed to nativity persist at advanced ages as well. Some evidence available from previous studies (Krueger and Moriyama, 1967; Kestenbaum, 1986; Swallen, 1996) suggests that mortality of foreign-born population is significantly lower than that of native at adult ages but converge to it as age increases becoming eventually higher at the very old ages. Such mortality pattern is usually termed a "mortality crossover" and it has been observed frequently on comparing black and white death rates in the United States (Coale and Kisker, 1986).

Due to the immigration history the U.S. mortality data offer a unique opportunity to carry out a reliable investigation of mortality differentials by nativity at advanced ages. In particular high proportions of foreign-born permit reliable estimation of death rates and comparisons between native and foreign-born populations. This study utilizes all available statistics on foreign-born over the period 1979–2000 and uses an advantageous method for estimating death rates at very old ages making by this means comparisons more reliable. Special efforts have been undertaken on assessing plausibility of the observed trends in death rates as differences in reporting nativity in census data and death certificates might bias mortality differentials considerably. In addition, evaluation whether high proportion of foreign-born in the U.S. very old population might affect international comparisons has been carried out.

Data and Methods

Death rates at ages 80 and over in the period 1979–2000 have been estimated by method of almost extinct generations. The main assumption underlying this method is that migration is negligible at very old ages so it can be ignored in computations of death rates. In this case population at any age x for a single cohort can be computed by cumulating deaths above x and by adding survivors of this cohort at 1.1.2001 (dd.mm.yyyy) if the cohort is not extinct. If there are no survivors, the method reduces to the well-known method of extinct generations

(Vincent, 1951). Application of this method requires deaths tabulated by calendar year, age and year of birth together with population or survivor estimates by single year of age in the last year with available data. Deaths by nativity have been tabulated from individual death certificates records for period 1979–2000 provided by National Center for Health Statistics. Data have been received either directly from the NCHS or downloaded from the ICPSR web site[1]. Data received directly from the NCHS included additional information on date of birth making death tabulations more precise. If information for some variables was missing such cases have been always included in tabulations by distributing them proportionally according to the distributions observed in the data. The number of missing cases was, however, small to affect results in any substantial way.

On death certificates information on nativity is available from the "STATE OF BIRTH" variable. If a person was born in one of the 50 States, District of Columbia, Puerto Rico, Virgin Islands or Guam he was included in the native population; if he was born in Canada, Cuba, Mexico or remainder of the world he was included in the foreign-born population. In the year 1979 19% of all deaths above 80 were foreign-born with those with unknown nativity constituting 0.55%; in 1990 these figures are 13% and 1.45%, and in 2000 are 9.2% and 0.5%, respectively. Survivor estimates at 1.1.2001 have been computed by three different methods due to discrepancies found in the census 2000 data and strong evidence of inconsistency in the reporting of nativity on death certificates and census data following from the analysis of trends in death rates.

First set of the survivor estimates (the PSR90 survivor estimates hereafter) was computed from the Public Use Microdata Sample file (PUMS). The file contains *"records representing 5-percent or 1-percent samples of the occupied and vacant housing units in the U.S. and the people in the occupied units. Group quarters people also are included. The file contains individual weights for each person and housing unit, which when applied to the individual records, expand the sample to the relevant total*" (U.S. Census Bureau, 2003). Question on place of birth is included only on the long form of the census questionnaires distributed approximately to 1/6 of all households. Information collected from such questionnaires is further sub-sampled to produce the PUMS data set. As a first step population by nativity was tabulated employing weights provided with the PUMS data set. Variable CITIZEN was used to separate population in native and foreign-born groups. People who were born in the United States, Puerto Rico, Guam, U.S. Virgin Islands,

[1] www.icpsr.org

American Samoa, Northern Marianas or abroad of American parent were included in the native population, and people who were U.S. citizens by naturalization or not citizens of the United States into the foreign-born population. As a next step population was promoted from 1.4.2000 to 1.1.2001 using available deaths for the year 2000 and assuming there is no migration. Finally the age group 90+ (the highest age until tabulations are possible) was distributed by single year of age with the SR(90+) method (Thatcher et al., 2002).

Dissemination of the PUMS data by Census Bureau is intended to provide users with an opportunity to carry out any custom tabulations they need. In this respect this data set should represent a random sample of population of the United States at time of the 2000 census. For our computations it means that that sum of native and foreign born population should closely approximate age structure of the U.S. population available from the 100% sample (data set SF1, table PCT12). Such comparison however reveals a significant deviation from the expected random pattern with discrepancies mounting at higher ages. Generally, the PUMS population was significantly higher at ages 80–89 but considerably lower at ages 90+. In particular male population tabulated from the PUMS data was 1% higher at ages 80–84, 10.3% higher at ages 85–89 and 4% lower at ages 90+. For females these numbers are 2.7%, 3.8% and -3.2%, respectively. The reasons for such discrepancies are unknown. Comparing census population with the PUMS 1% data (the data set similar to the PUMS 5% data set used here but covering 1% of total population while offering more details on the sampled population) reveals similar pattern of deviation suggesting that the observed pattern is not random rather attributed to some data processing mechanism e.g. computation of weights of individual observations or measures taken to protect confidentiality of the data. One of the measures undertaken to protect confidentiality was, for example, age perturbation of the large households i.e. the age of household members was modified if the household contained 10 people or more.

The second set of survivor estimates was, therefore, an attempt to correct for such discrepancies by adjusting the PUMS population estimates by nativity to be in correspondence with the 100% census totals. Using the PSR90 survivor estimates obtained at previous step proportion of foreign-born population was computed for all ages from 80 to 110, and subsequently applied to the census population to obtain absolute numbers. As before this population was promoted from 1.4.2000 to 1.1.2001, and the redistribution of the population 90+ by single age group was carried out with the SR(90+) method as before . The last step was not dictated by lack of age detail above 90 as in case of the PSR90 estimates; it has been necessary due to strong evidence of inflation of census population in the highest age groups, especially above 100. Such inaccuracies are usually caused by age exaggeration in the census returns. In its turn proportion of population 90+ was found to be consistent with that observed in Nordic countries and Japan so the size of population 90+ was accepted as a valid one and used further in the SR(90+) method. Application of the SR(90+) method can be regarded in this case as a correction for age misreporting in the oldest segment of the U.S. population. These survivor estimates based on the adjustment to the census totals were labeled as CADJ90.

The last set of survivor estimates (SR) presented here was produced entirely from the observed deaths by the survivor ratio method without making use of any information from the census 2000. As discussed by Thatcher et al. (2002) this method produces lower survivor estimates for the population with declining mortality due to built-in assumptions about survivor ratios. It is important however to include it in the comparisons because the resulting mortality estimates are based entirely on the death statistics—even if the death rates in recent years might be biased upwards by incorporating such survivor estimates in the computations of death rates the relative differences between native and foreign-born populations might be significantly less affected.

Finally these computations have been repeated for the white population of the United States in order to control for different racial compositions of native and foreign-born populations. Survivor estimates for the whites are based on the "White, Alone" population reported both in the PUMS and in the 100% census data.

Results

Sensitivity of death rates to survivor estimates at 1.1.2001 is shown in Figure 1. One can see that until 1995 death rates for all three sets of survivor estimates are nearly the same but they start to diverge afterwards. This pattern is expected as population at age *x* for any cohort is sum of survivors and deaths above this age. For years before 1995 survivor estimates have a negligible influence on death rates as almost all population is due to accumulation of deaths. For years after 1995 survivor estimates have increasingly higher influence at the death rates and Figure 1 shows the extent of sensitivity of the death rates to the survivors computed by different methods.

Second important observation is that death rates for foreign-born population are much more sensitive to survivor estimates than those for native populations. Due to smaller size—

proportion of the foreign-born males aged 80+ at 1.1.2001 was about 8.9% and females about 8.2%—the foreign-born population is more vulnerable both to misreporting errors in the nativity status and to sampling errors in the PUMS data. Moreover, a sudden upturn in death rates at ages above 90 for the foreign-born females in case of the PSR90 or the CADJ90 survivors appear to be highly implausible (Fig. 1, panels d and h) because at lower ages death rates are either stagnant or declining making it is strikingly inconsistent with patterns of mortality changes observed in the reliable international statistics (Kannisto-Thatcher Database). For males such pattern is also apparent (Fig. 1, panel b) though less striking. In addition the white males adhere to this pattern as well in the case of the PSR90 survivor estimates (Fig. 1, panel f). Therefore the observed trends is likely to be a product of underreporting of foreign-born populations in the PUMS data rather a real feature of the studied data sets making foreign-born death rates in the last five years less reliable than for the previous years.

For native populations of males no inconsistencies in death rates between all three methods of survivor estimates were found. The death rates do vary between methods in the period 1995–2000: those based on the SR estimates are the highest and stagnant, those based on the PSR90 estimates are the lowest and declining, and those based on the CADJ90 are occupying an intermediate position (Fig. 1, panels a and e). The stagnant trends observed in the death rates based on the SR survivor estimates are expected as they manifest essentially the assumptions upon which this method is built. Two other sets of survivor estimates result in declining trends which is not of concern as such trends have been observed for other countries as well (Kannisto, 1994). In fact these estimates might approximate reality more closely than the death rates based on the SR survivors.

In female native populations (Fig. 1, panels c and g) all three sets of survivors results in very close estimates of death rates. The survivor estimates match data on deaths reasonably well without introducing any abnormalities in the trends of death rates. All three methods suggest that female native mortality was nearly stagnant over the entire period of observation which is the main reason behind high correspondence between estimates based on the SR and other two methods.

Age-specific schedules of death rates for total and white populations are shown in Figures 2 and 3, respectively. All estimates are based on the census adjusted survivor estimates (CADJ90) at 1.1.2001. For period 1979–1994 (recall that for this period survivor estimates have virtually no influence on the death rates) pattern to be observed is clear and simple: for males foreign-born death rates are lower than native while for females they are nearly the same. Over age male mortality curves converge with some indication that native death rates drop below level of the foreign-born at age about 105 (Fig. 2). However, the observed mortality crossover, to some degree present in the data for females as well, is likely to be artificial because of errors in age reporting among blacks included in the total population. The reasoning is as follows. First, it does not exist for whites (Fig. 3) so it is driven mostly by low death rates for black population where misreporting at extreme ages found to be much more common (Preston et al., 1996) compared to whites (Hill et al. 2000). Second, male death rates start to decline after age 105—the most authors do not find such declines credible because it is not observed in the reliable international statistics (Coale and Kisker, 1990). All of it makes existence of such crossover doubtful.

In the period 1995–2000 pattern of mortality differentials by nativity has changed drastically. Already at age 85 female foreign-born death rates overpassed native, and male foreign-born death rates converged to level of native at the same age. For whites such changes are also visible but less marked. What would be the reason for such abrupt changes in the age-specific pattern? As shown above the estimates of death rates in this period are highly influenced by the survivor estimates with particularly implausible results obtained for the female foreign-born population (Fig. 1). Therefore this change in the pattern could be simply an artifact of disagreement between census and vital statistics data (e.g. underreporting of elderly foreign-born population in the census 2000) because death rates in Figures 2 and 3 are based on the CADJ90 survivor estimates. This possibility is further checked by comparing foreign-born death rates computed entirely from the data on deaths (the SR survivor estimates) with death rates for native populations (Fig. 4). One can see that pattern observed for the earlier periods is re-emerged in this figure; the only exception is that the death rates of female foreign-born is now lower as well compared to their native counterparts. Furthermore, on examining mortality for total population it was found that female death rates were in fact on a rise in the later 1990s while male continued to decline—making allowance for such trends would move the female curve in Fig. 4 up while the male curve will go down thus reinforcing agreement with mortality differentials found in the earlier periods.

Final part of the analysis has been devoted to international comparisons of the U.S. survival by nativity at advanced ages. Figure 5 shows trends in life expectancy at age 80 for United States, Sweden and Japan. Data for the United States is shown separately for native, foreign-born and total populations. Among males the U.S. foreign-born population appears to be the longest lived group which was overtaken by Japanese males only in the year 2000.

On average the U.S. native population shows a persistent disadvantage of 0.4 years as compared to foreign-born population while life expectancy of the total U.S. population (native and foreign-born together) is only 0.06 years higher than that of native population because of small size of the foreign-born population. Life expectancy of Swedish males has been on average lower by about 0.85 years than life expectancy of the U.S. foreign-born population and by 0.43 years than life expectancy of native population. Pace of increase[2] in male life expectancy over the period 1979–2000 is similar for United States and Sweden, ranging from 0.39 years per decade (*ypd*) for the U.S. total population to 0.46 *ypd* for the foreign-born; the pace of Japanese life expectancy is almost double of it equaling 0.77 *ypd*. With such high pace of increase Japanese life expectancy overrun the U.S. life expectancy in 1995.

Among females the U.S. life expectancy differentials due to nativity are barely perceptible as mortality of foreign-born females is very similar to that of native. Over 1979–2000 it changed a little which makes it outstanding comparing with improvements in life expectancy in Japan and Sweden. Life expectancies in both countries have been increasing at an appreciable pace: 0.59 and 1.52 *ypd*, for Sweden and Japan, respectively. This tendency led to that the Japanese life expectancy overrun the U.S. life expectancy already in 1993 and the gap between Sweden and the United States has been considerably reduced until 2000.

Discussion

Even if mortality differentials by nativity have been long observed and documented the most of this work has been focusing on infant or adult mortality differences (Kleinman et al., 1991; Rogers et al., 1999; Singh and Siahpush, 2001). Only few studies report results for extreme aged (Kestenbaum, 1986; Swallen, 1996). In this study all available data from vital statistics over the period 1979–1950 have been utilized which makes it the largest undertaking of its kind in the studies of mortality differentials at advanced ages: information from 17,203,376 death certificates has been processed in order to obtain mortality estimates presented here. Among them 2,343,093 death certificates have been identified as foreign-born. The studied population universe includes institutionalized population ordinarily excluded from the Current Population Survey and the National Health Interview Survey conducted by Census

[2] The pace of increase has been computed by fitting ordinary least square line to the observed trends in life expectancy.

Bureau on a regular basis. This is of a particular importance for examination of mortality differentials at advanced ages due to large populations of elderly residing in nursing homes.

From methodological point of view, the present study differs from others in the method used for estimation of mortality at advanced ages. The current method permits to obtain more reliable mortality estimates leading to more accurate conclusions regarding differences in death rates. The method of almost extinct generations used here does not rely equally on the observed deaths and census population for computation of death rates. Instead, the population at risk is computed mostly from data on deaths which are commonly recognized for higher reliability over population statistics (Condran et al., 1991). The reliability of mortality estimates obtained here is further supported by examination of longitudinal trends in death rates (Fig. 1). Irregularities in the otherwise stable trends in death rates point out that foreign-born population aged 90 and over in census 2000 is likely to be underestimated relative to deaths recorded in vital statistics. Therefore simple matching of deaths and census estimates for computation of death rates at advanced ages is less preferable than the method used in this study as it might lead to the biased results.

There certain limitations in the estimates presented here. First of all, inference regarding mortality differentials in the period 1995–2000 where survivor estimates of non-extinct cohorts have greater influence on the resulting death rates is less certain than for earlier years. Second, confounding effects of socio-economic status, racial/ethnic composition, health and behavioral factors, regional distribution of foreign-born population within the United States is not taken into account. To which extent such factors might affect findings reported in this study is largely unknown. Third, age misreporting or age exaggeration in the data on deaths might bias results presented here. The bias would be especially large if quality of age reporting is different for native and foreign-born populations. Should we expect that age reporting for foreign-born is worse, potentially leading to lower mortality estimates and artificial better survival of foreign-born at advanced ages? Probably it is not the case. Large part of population analyzed here is likely to arrive in the United States in the first half of the 20th century with high influx of immigrants from Europe. Vital statistics systems in Europe were significantly better established than in the United States at that time so we would expect that higher proportion of immigrants posses a birth certificate resulting in better reporting of age. An additional support to this point of view is provided by study of Deutch (1973) reporting that foreign-born claimants applying for social security retirement benefits were likely to be in possession of birth certificates than native, 25% vs. 21%, respectively. If age reporting is better among foreign-born the mortality differentials presented here would be underestimated.

One of the main findings of this study is that male foreign-born population has better survival at advanced ages than native (Fig. 2, 3). Obviously, whether a person was born in the United States or outside cannot be either a protective or deleterious factor *per se*: nativity is best viewed as a proxy measure for a large array of factors associated with migration of human populations—one of nature's unplanned experiments according to Haenszel (1961). Among others differences due to nativity might reflect differences due to health selection for immigration, both at individual level and as a result of governmental health screening programs, improved adaptation abilities, prior exposure to another environment, health related and behavioral differences among immigrants, and differences in genetic composition.

This finding is consistent with generally better survival of foreign-born populations found either in studies based entirely on vital statistics and census data (Krueger and Moriyama, 1967; Kestenbaum, 1986; Swallen, 1996) or in studies on socio-economic determinants of mortality (Kitagawa and Hauser, 1973; Rogot et al., 1992; Rogers et al., 1999; Singh and Siahpush, 2001). A remarkable fact is that improved survival of male foreign-born exists also at very old ages suggesting that certain factors have a long lasting effect on survival.

For females, the results obtained are somewhat unexpected. No significant differences in mortality between native and foreign-born were found; yet such differences exist for males (Fig. 2, 3). There are several explanations possible for this seemly paradoxical result. First of all health selection might be dependent on an immigrant status. It is plausible, for example, that decision to immigrate is influenced largely by health status of a principle immigrant and to a lesser degree by health conditions of his or her dependents. A depended or sponsored immigrant relies on support from the principle one so health selection effect might be significantly weaker among the dependents even if they belong to the same family and share common environment, behavioral and health related habits. Because several decades ago males were more likely to migrate and to be involved in the labor force this can explain mortality advantage of male foreign-born and lack of differences in female survival in the today's elderly populations. Several studies provide further support to this hypothesis of differential selection. Kitagawa and Hauser (1973) found that male white foreign-born experienced 13% lower mortality at ages 35–64 in 1960 while female mortality was only 2% lower (it was even higher in their other methods of computations). Krueger and Moriyama (1967) showed that male foreign-born death rates at ages 35–65 in the period 1959–1961 were considerably lower than native while female differences were far more modest. Kliewer (1991) in his analysis of suicide mortality in Australia reached the conclusion that “migration is more deleterious for females than males". Testing this hypothesis of differential selection is not straightforward as it requires analyzing family migration histories. People, who 80 years or older in the period 1979–2000 arrived in the United States during last several decades making collection of necessary data a formidable task.

Another possible explanation for lack of effect of nativity on female survival is a quicker adaptation of females to the new environment. Convergence of death rates between foreign-born and native populations has been observed in studies of Kitagawa and Hauser (1973), Kestenbaum, (1986), Young (1986), Kliewer (1991), Trovato (1993) and Swallen (1996). According to the acculturation hypothesis as length of residence in the destination country increases mortality differentials between foreign-born and native population tend to diminish. Quicker adaptation of females to the new environment resulting in generally faster convergence of mortality curves for females might explain lack of differences in survival at advanced ages. Testing of this hypothesis is also difficult as accurate data on length of stay in the United State are not widely available. However, investigation of interaction terms between sex, nativity and age in the multivariate models of (Rogers et al., 1999; Singh and Siahpush, 2001) might prove useful for gaining more insights into this problem.

Examination of age-specific differences in mortality has also resulted in some useful findings (Fig. 2, 3). Several studies reported some evidence of mortality crossover between foreign-born and native death rates at advanced ages: Krueger and Moriyama (1967) at the time of the 1960 census; Kestenbaum (1986) at the time of the 1980 census and Swallen (1996) at time of the 1990 census. Foreign-born death rates appear to be lower at adult ages but higher at older ages. No possible explanations have been put forward. Contrary to the earlier findings no convincing evidence of mortality crossover has been found here, not at least until age 100. On computing death rates in the year 2000 (not shown here) based on the PSR90 survivor estimates—this way is much similar to the methods of computation of death rates in all these studies—we indeed observe a crossover: at age 86 for males and 87 for females. Moreover there is also a crossover between female foreign-born and male native curves at age about 90. Further, estimates of female and male foreign-born turned out to be nearly the same after 95. This implausible age-specific pattern of female foreign-born mortality in 2000 together with abnormalities in the trends in death rates discussed above, nonexistence of such phenomenon for earlier years and analysis of death rates based on the SR survivor estimates (Fig. 4) leads to conclusion that the mortality crossover is due to undercount of foreign-born population at the highest ages in the PUMS data rather than a real life phenomenon.

International comparisons (Fig. 5) show that high proportion of foreign-born in the U.S. very old population doesn't modify level of mortality in any substantial way providing no explanations of the observed international differences. Changes in life expectancy for native and foreign-born were highly in parallel suggesting that they are governed by some common factors affecting both native and foreign-born mortality in a similar way. Even if proportion of foreign-born in the total U.S. population aged 80+ has dropped significantly from 19% in 1979 to 8% in 2001 it did not have any noticeable effect on the life expectancy trends. Comparisons among females revealed adverse developments in the U.S. life expectancy which was nearly stagnant over the last two decades and even declined in the late 1990s. Such development was rather usual compared with Sweden and Japan, and this worrisome tendency requires further investigation.

A dearth of studies on mortality differentials at advanced ages hinders our understanding which factors are important for further improvements in survival at advanced ages. The data resources available on population of elderly are notably less rich than that for adult and young ages. In addition they are often plagued by inaccuracies and deficiencies in the data making mortality estimation difficult. Nevertheless, a more thorough analysis addressing these challenges is pressing due to continuing population aging.

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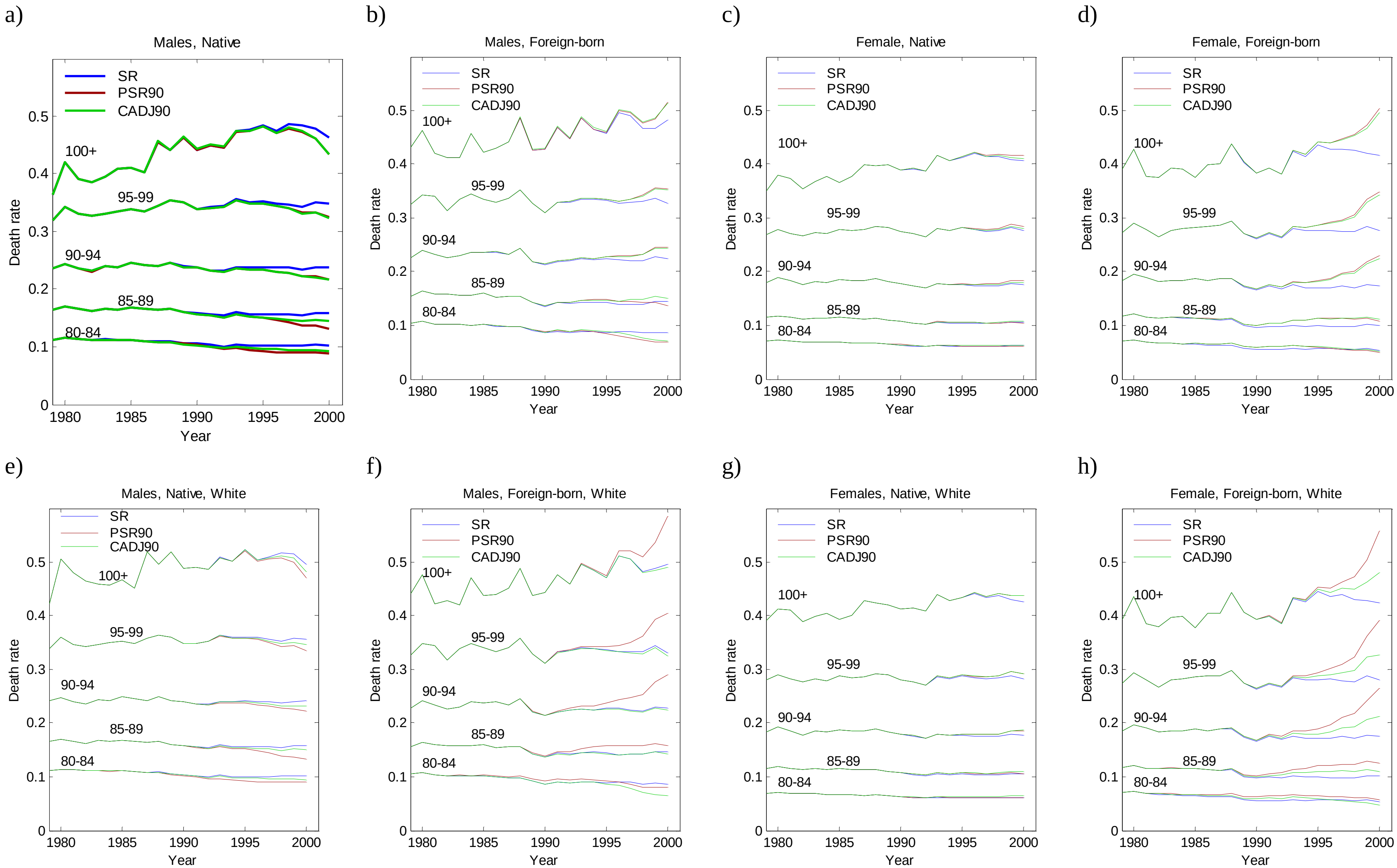
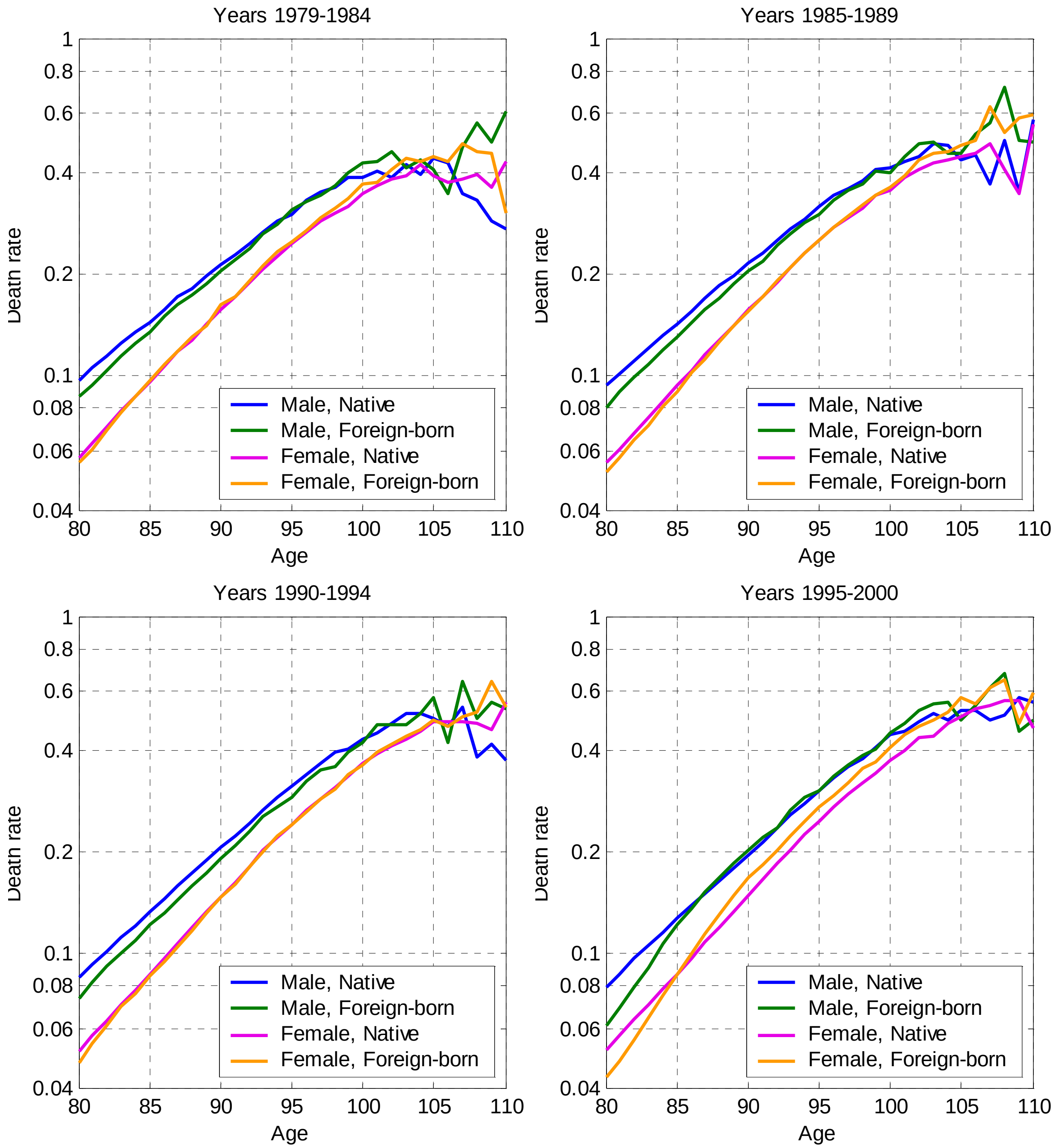
Figure 1. Sensitivity of death rates to survivor estimates of non-extinct cohorts at 1.1.2001.



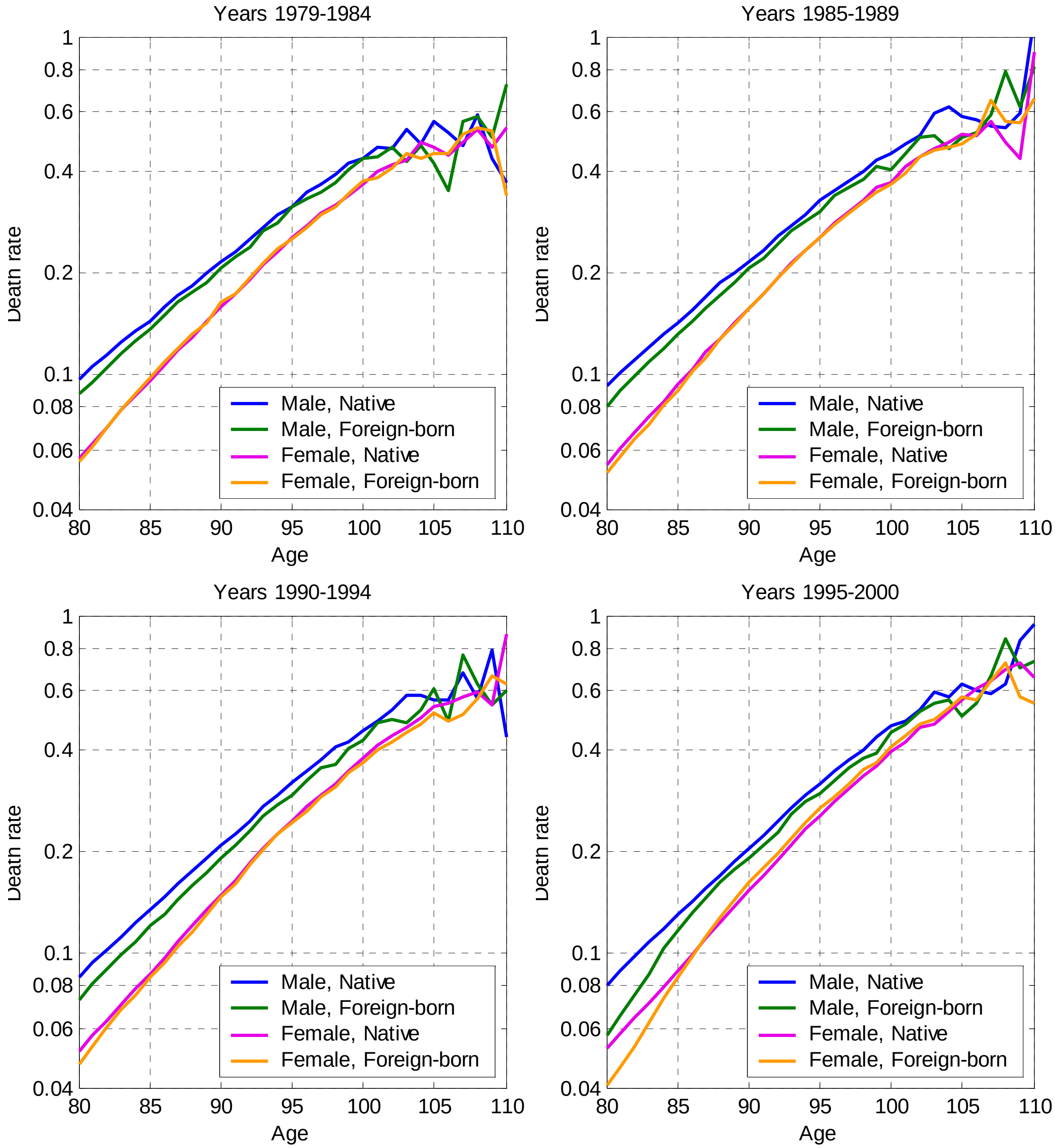
The SR, PSR90, CADJ90 are different methods of survivor estimates (see text)

Figure 2 Age-specific schedules of death rates by nativity, total population of the United States.



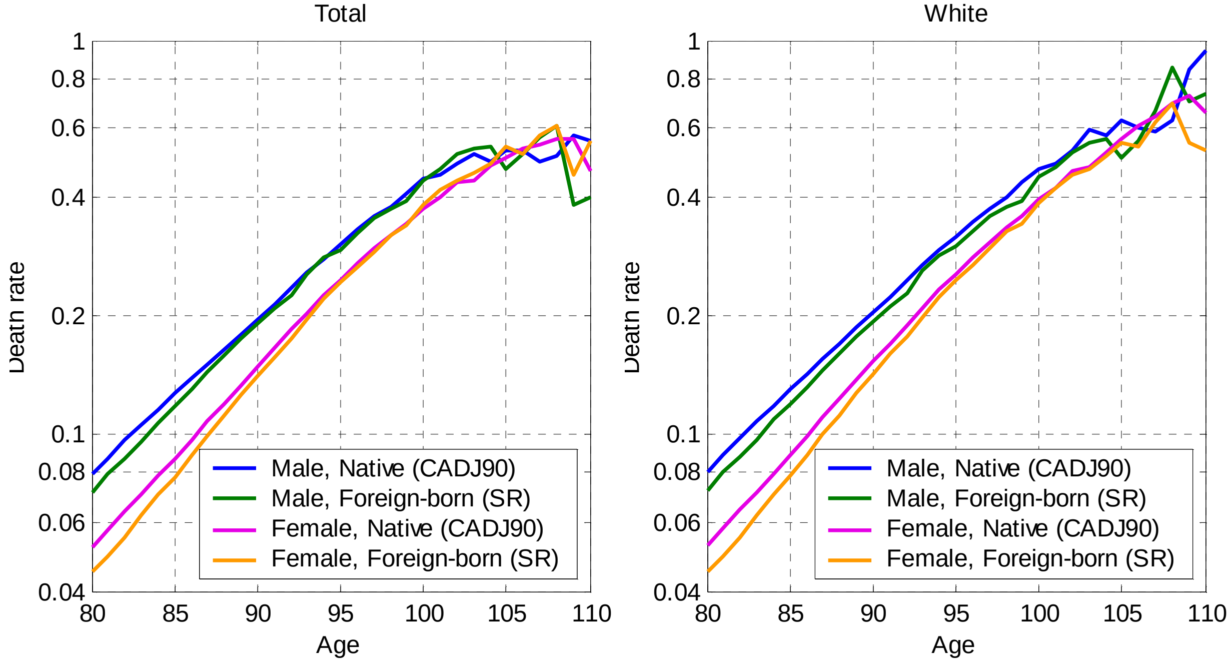
Death rates are based on the CADJ90 survivor estimates (see text).

Figure 3 Age-specific schedules of death rates by nativity, white population of the United States.



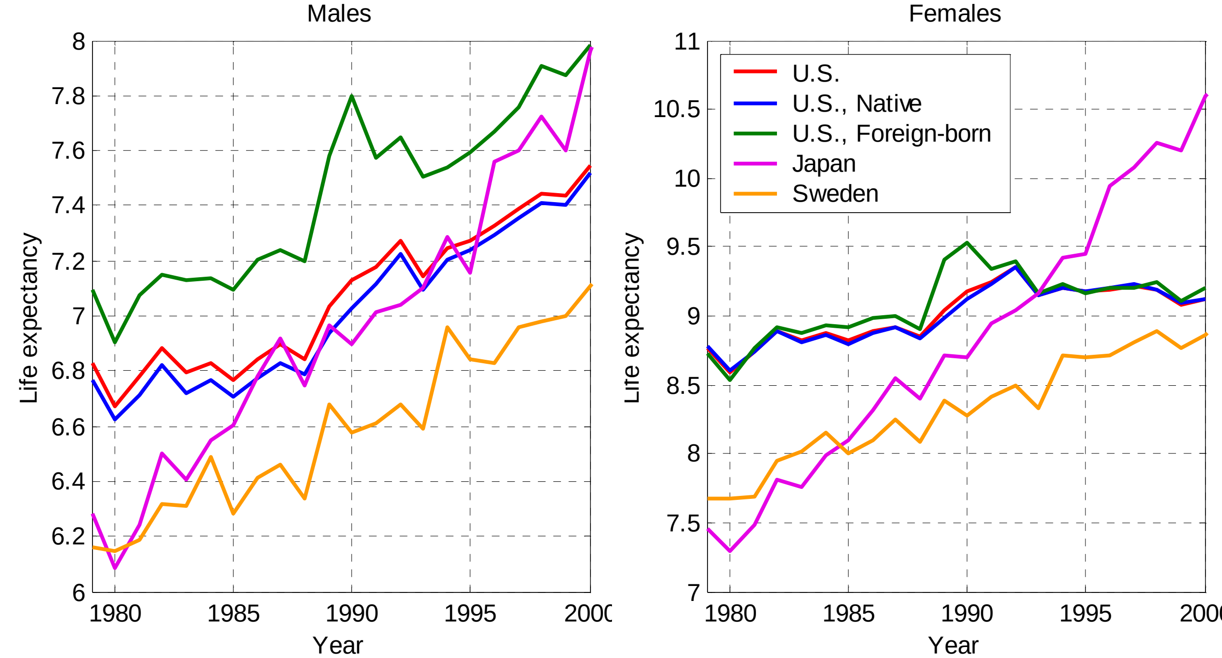
Death rates are based on the CADJ90 survivor estimates (see text).

Figure 4 Age-specific schedules of death rates in the period 1995–2000 by nativity. Death rates for foreign-born populations are based on the SR survivor estimates.



The SR and CADJ90 are different methods for computing survivor estimates (see text).

Figure 5 Life expectancy at age 80 in the United States, Sweden and Japan.



Estimates for the United States are based on the CADJ90 survivor estimates (see text).