Differences in Mortality Trends between New York and California, 1980-2010

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Abstract *Background.* Geographic variations in mortality in the United States are well documented. Newly produced estimates permit, for the first time, the reconstruction of age-specific mortality trends and reliable cross-state comparisons of mortality by single calendar year and single year of age. Such an analysis is important because it provides a more complete account of the levels, trends and differentials in mortality than the decennial life tables published by the vital statistics system.

Data and Methods. Complete life tables by single calendar year for New York State and for California have been computed from death records provided by the National Center for Health Statistics (NCHS) and from population estimates prepared by the Census Bureau by applying the methods developed for the Human Mortality Database (HMD).

Results. Over the years 1980-1996, life expectancy at birth in California has been persistently higher than in New York, by 1.5 to 2 years for males and 1 year for females. Over the period 1996 to 2010, New York caught up with California so that levels of life expectancy at birth in both states are currently (2010) about the same. The analysis of age-specific mortality rates suggests that most of the convergence results from a reduction of the excess adult mortality that used to characterize New York State compared to California. Below age 21, the peculiar pattern of mortality differences remains unchanged: infant mortality in New York has always been higher than in California, while adolescent mortality (at ages 15-21) is significantly higher in California.

Introduction

Geographic variations in mortality in the United States are well documented (Wilmoth et al., 2011; Kulkarni et al., 2011). Age-specific differences in survival and their dynamics over time are less known. Mortality differentials by states can be explored by using the set of official life tables by states prepared by the National Center for Health Statistics (NCHS) at the time of each census. These decennial life table series provide a useful but incomplete picture of mortality trends by state. More detailed and timely account of the levels, trends and differentials in mortality can only be produced from an examination of annual trends in death

rates and by cross-state comparisons of mortality by single calendar year and single age group.

Data on deaths and births from the vital registration system of U.S., population estimates prepared by the U.S. Census Bureau and the methodology developed for the Human Mortality Database (2007) permit reliable estimation of annual complete life tables by states. In this article we present results for New York and California and compare mortality between the two states with special emphasis on age-specific differences in survival.

Data and methods

Our analysis is based on detailed life tables computed by single calendar year for the period 1980-2010 for New York State and for California. The life tables were constructed using death and birth statistics produced by the National Center for Health Statistics (NCHS)[1] and population estimates prepared by the Census Bureau. The data were processed following a methods protocol developed for the Human Mortality Database by the authors with other colleagues, based on standard techniques of formal demography[2]. This protocol includes a number of tests for data quality that were implemented to assess the reliability of the mortality estimates for each state.

Death counts by state of residence for 1980-2010 have been tabulated by sex, single year of age and year of birth from the individual death certificates data available in the U.S. Mortality Multiple Cause Files for each calendar year[3] to produce the numerators for the rates. The method specific implemented here is directly derived from that used to produce the overall U.S. mortality series in the HMD (2013). A combination of SAS and MATLAB scripts were written to process the state data in this manner.

Population exposures by sex, age and state for every calendar year were computed using birth statistics published on-line by the NCHS[4] and population estimates by sex, age and state produced by the U.S. Census Bureau[5]. Considering the problematic nature of the information available from vital records for deaths at very old ages (Coale and Kisker, 1990; Condran, Himes, and Preston, 1991), we computed our own population estimates at age 80 and above by applying the extinct cohort method (Thatcher et al., 2002).

Trends in life expectancy at birth (Fig. 1) and trends in age-specific death rates (Fig. 2) are based directly on the data from the computed complete life tables. No adjustments of the original data or resulting mortality estimates have been applied to the life tables except at very old ages where the death rates were smoothed with Kannisto curve[2].

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[1] All vital statistics data by state had to be tabulated on site in RDC by the first author and released only after careful review within the NCHS data center. For confidentiality reason, the published files have not systematically included the information relative to the state of residence (of the deceased for the death certificates, of the mother for births records) since 1989 and no geographic information is available whatsoever since 2004.

[2] http://www.mortality.org/Public/Docs/MethodsProtocol.pdf

[3] http://www.cdc.gov/nchs/data_access/VitalStatsOnline.htm

[4] http://www.cdc.gov/nchs/data_access/VitalStatsOnline.htm

[5] http://www.census.gov/popest/index.html

A display of the death rate ratios through Lexis maps offers a more concise and revealing graphical way of exploring age- and time-specific differences in survival (Vaupel et al., 1998, Andreev, 2002). Fig. 3 shows such maps for the ratios of death rates in California to those in New York for each sex. Each map is based on the death rates for both states for the entire set of the complete life tables for years 1980 to 2010. Each of the 3,410 rectangles per figure corresponds to a single ratio of a single age death rate for New York over the corresponding rate for California with a color gradient chosen according to the scale on the right. The scale divides the ratio surface into ten areas: four magenta areas with different hues are used to depict an excess of mortality in NY; four blue hues are used to depict an excess of mortality in CA, and light gray areas indicate that death rates in both states are about the same. The higher is the ratio, the darker the hue, whether magenta or blue.
Such a selection of scale levels and colors allows us to convey both qualitative and quantitative information about mortality differences in NY as compared to CA over age and time. Both maps present ratios of all death rates in the entire set of complete life tables for 1980-2010. No smoothing methods or formal statistical tests were implemented to produce these figures.

Figure 4 and Table 1 present the contributions of the death rates by age group to differences in life expectancy at birth in NY and CA for three decades: 1980-89, 1990-99 and 2000-09. A decomposition algorithm proposed by Andreev et al. (2002) was applied to each of these ten-year periods to assess the contribution of death rates at each single year of age to the overall difference in life expectancy between the two states.

All points above the curve indicate that the death rates for the corresponding ages are lower in California than in New York states while all points below the curve show the opposite. The curves on Figure 4 are normalized to sum to 100 to ease interpretation of the results. In this way, the contribution of each year of age to the overall difference in survival can be read as a percentage and the contribution of five-year or ten-year age groups is simply computed as the sum of the contributions of each single year of age in the age group, as in Table 1. The age groups were selected from previous analysis by grouping together ages at which the death rates were consistently higher or lower in one state as compared to the other

Results

Life expectancy at birth in both states has been increasing since 1980 (Fig. 1, upper panel). Until 1995 gains in life expectancy were rather moderate: about 2.5 years for males, and 2 years for females over this 15-year period. The growth was in parallel for both states and sexes except for a decline in New York in the late 1980s. After 1995, the pace of increase accelerated and by 2010 life expectancy at birth reached historically high levels of 78 and 82 for males and females, respectively. The highest gains were observed in NY males where life expectancy grew by 6 years, from 72.1 in 1995 to 78.1 in 2010, followed by CA males who

gained 5.1 of life, NY females with an increase of 4 years and CA females with an increase of 3.1 years.

The largest health disparities between states are found in the period 1980-1995. For males, life expectancy at birth in NY was on average 1.6 years lower than in CA, while females in NY lived on average one year less than females in CA (Fig 1., lower panel). Due to more rapid reductions of mortality in NY after 1995, the existing gap in life expectancy between the two states virtually disappeared by 2008. After 2008 growth in NY somewhat slowed down and one can observe re-appearance of the gap, both in males and females, though the absolute difference is small: 0.4 and 0.2 years for males and females, respectively.

Trends in age-specific death rates by 5-year age groups are shown in Fig. 2. Infant mortality in NY has been consistently higher than in CA for the entire period of observation. Only in the last few years, infant mortality in NY started to approach levels of infant mortality in CA. Most reductions in mortality occurred over 1980-2000 when mortality levels were almost halved as compared with their levels in the early 1980s. After 2000, the rates of decline slowed down considerably: in CA virtually no progress in reduction of infant mortality is observed except for some progress in the last two years of the series while in NY infant mortality was still going down but at a very steady pace. At ages 1-15, death rates were very nearly the same in both states except for boys in CA, where one can observe elevated levels of mortality as compared with NY around 1990. Reductions in mortality at these ages were persistent and continual over time.

At teen ages, 15-19, we observe consistently higher death rates in CA as compared with NY. The differences are more pronounced for boys than for girls. Until 1995, male mortality was either constant or steadily increasing while after 1995 death rates dropped down significantly, and stayed approximately at a constant level after the late 1990s. Death rates of boys in CA are still higher than death rates of boys in NY. For girls, reductions in mortality were more uniform over time, and mortality excess in CA is less marked than for boys. Over time, death rates, by and large, converged and now mortality levels in both states are very close. At ages 20-24, mortality level and trends in both states have also been close for all years except for some excess of mortality for young males in California.

At ages above 25, death rates were significantly higher in NY than in CA, both for males and females. Due to more rapid decline of mortality in NY after 1995, mortality levels in both states converged. For ages 25-65, mortality levels are now quite close, practically indistinguishable. For ages above 65, the gap in mortality has been reduced significantly but death rates in NY are still higher than those in CA. At very high ages, 90 and over, no significant difference in death rates was found.

Over time, male death rates at ages 25-50 were increasing in both states until about 1995, when a sudden change of trend took place death rates dropped markedly over a short period of 2-3 years and, once a new, record low, level was reached, continued its steady downward trend. The reversal of mortality trends benefitted most the NY males: before the mid-1990s the

level of male mortality in NY was much higher than in CA, but after this period it dropped to a level comparable with that in CA. Trends of mortality levels in NY females resemble those for males, but both the increase in mortality and the reversal around 1995 are less pronounced. Female death rates in NY are also higher than in CA, but the excess is much less marked. Trends of female mortality in CA were also less volatile: death rates were steadily declining with no sudden increases or setbacks.

At ages 50 and higher, mortality trends were more regular. Both for males and females, mortality declined over the entire period, virtually at a linear pace. For very high ages, however we can observe some acceleration in mortality decline after 2000. Reduction of mortality was more rapid in NY and among males and led to convergence of death rates both between states and sexes.

A concise display of age-specific differences in survival in NY and CA and of their dynamics over time is provided in Fig. 3. Each square in this figure shows the ratio of death rates in NY to that in CA for a given year and age. The color of the square is assigned according to the scale on the right: ratios higher than one are painted in magenta, ratios less than one are painted in blue, and those close to one are painted in gray. Magenta areas on the map shows ages and years where mortality in NY was higher in CA, and blue areas shows ages and years where mortality was lower, or, equivalently, mortality in CA was higher.

For males, the large magenta area covering ages 21 and up and years from 1980 to the mid-1990s shows the excess of mortality in NY as compared with CA. The largest differences, as depicted by the darker magenta hues, are found at ages 30-40 in the late 1980s. In the late 1990s, this area largely fades away indicating convergence of mortality levels in both states. Higher male mortality in NY still remains in the late 2000s as revealed by magenta blemish in the upper right corner. A distinct ridge in 2001 at ages about 24-50 is due to elevated mortality caused by the terror attacks of September 11, 2001. The excess of infant mortality is also visible in this map though it is less evident as it refers only to a single age group and depicted by a single magenta line at the bottom of the map.

The dark blue area at ages 15-21 stretching through the entire period reveals excess teenage mortality in California. The pattern of mortality differences is quite stable over time and there are no signs of convergence. Even if male mortality was declining in both states, the relative disadvantage of CA at these ages remained unchanged.

For females, observed mortality differences over age and time resemble those of males. Excess female mortality before 1995, however, is less spread over ages and concentrates more at ages 30-40, as shown by Lexis rectangles in dark magenta colors where ratios of deaths rates are higher than 1.5. Above age 60, the excess of female mortality is less pronounced as indicated by light magenta Lexis triangles corresponding to ratios between 1.0 and 1.05. Over time, this feature largely disappears and in the last 5 years, some minor excess of mortality is observed only at ages above 70. Excess of teenage mortality in CA (blue area, ages 15-21) is also present in the female population but overall the differences are smaller than for males.

Age-specific death rates affect the level of life expectancy at birth. To ascertain the contribution of death rates at different age groups to differences in life expectancy at birth between states, we applied a decomposition algorithm proposed by Andreev *et al.* (2002) for the life tables computed for decades: 1980-89, 1990-99, and 2000-10. The three decades are characterized by different mortality regimes: in the 1980s, differences in life expectancy in NY and CA were large, and the pattern of mortality differences was stable over age; in the late 1990s mortality declined very fast at adult ages and convergences of life expectancies took place; and in the 2000s mortality levels were close and mortality differences between states were small.

Figure 4 shows age-specific contributions of death rates expressed as percent of the total to the differences in life expectancy by state. The largest single-age contribution as shown by the peak at age zero is due to higher infant mortality in NY. In the 1980s higher infant mortality in NY was responsible for 9% of the difference for males and for 13% for females (Table 1). Over time, in the 2000s, regardless significant reductions in infant mortality, its contribution increased to 12% and 17% of the total, respectively. The result may be counterintuitive but a life saved at birth contributes more to the total time lived by a population than a life saved at older ages. If single ages are considered, higher infant mortality in NY remains today the largest contributor to differences in life expectancy at birth.

For adult males in the 1980s and 1990s, we observe negative contributions at ages 1-19 and a more or less flat pattern for 20-79. The overwhelmingly largest contribution, close to 100%, is coming from ages above 20 while higher teenage mortality in California provides a negative contribution to the gap in life expectancies at birth about 5%. In the last decade the pattern of decomposition changed markedly: the negative contribution at ages 1-19 tripled and reached -14 percent, the middle age groups lost their importance and their contribution stands now at 14 percent, the ages 60 and over, on contrary, gained importance and bear about 89 percent of the total difference of 0.4 years (Table 1).

For females, teenage mortality is also lower in NY and provides a negative contribution to the difference in life expectancy. The contribution, however, is significantly lower as compared with males: -3 and 2 percent of the total for 1980-2000, and -12 percent for the 2000s. Similar to males, the ages above 20 also provide the largest contribution for females, on average more than 90 percent in all three decades but in the 2000s the pattern is different from that of males. The largest positive contribution is coming from age group 20-79, 100 percent of the total, while contribution of ages above 80 is negative, -3 percent. This suggests that the largest survival advantage of females in CA, as measured by the impact on life expectancy at birth, is due to lower death rates at ages 20-79, while at the highest ages, 80 and over, NY is doing slightly better.

Table 1. Contributions of the death rates by age group to differences in life expectancy at birth between New York and California

	Males			Females		
LEB	1980-89	1990-99	2000-10	1980-89	1990-99	2000-10
CA	71.8	73.8	76.8	78.5	79.8	81.5
NY	70.3	72.5	76.4	77.4	79	81.3
Diff.	1.5	1.3	0.4	1.1	0.8	0.2
Decomposition of difference by age (percent of the total)						
AGE						
0	9	8	12	13	11	17
1-19	-5	-5	-14	-3	-2	-12
20-59	55	55	14	36	53	42
60-79	33	33	64	33	27	56
80+	9	10	24	20	10	-3
All ages	100	100	100	100	100	100

Discussion

The analysis conducted in this article suggests that over last 30 years both New York and California experienced significant gains in life expectancy at birth. The largest increase over 1980-2000 was found in NY, males, 8.5 years, followed by CA males, 7.5 years, NY females, 6 years, and CA females, 5.1 years. However, the gains in life expectancy at birth were not uniform over time: until the mid-1990s, life expectancy at birth was increasing rather slowly, while after 1995 the pace of increase accelerated significantly. The acceleration of increase is attributed mostly to a reversal of adverse trends in young adult mortality, death rates at ages 25-50, which were on the rise until about 1995 but then dropped down sharply over a short period of 2-3 years, especially for males. The mid-1990s can be considered as a turning point in the trends of adult mortality for both states. At higher ages, 50 and over, the reduction of death rates was also remarkable but changes were more stable over time and similar across sexes and states.

Over the last 30 years, the gap in life expectancy at birth that existed in the 1980s between states largely disappeared due to more rapid reductions in mortality in NY as compared with CA. Life expectancy is still higher now in CA but the differences are small: 0.4 years for males, and 0.2 years for females. The main driving factor for convergence of mortality levels in two states has been a reduction in the excess of adult and old age mortality that existed in NY in the 1980s and 1990s. Mortality differentials that existed in infancy and adolescence remained practically unchanged over time: infant mortality is higher in NY and adolescent mortality is higher in California.

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Acknowledgments
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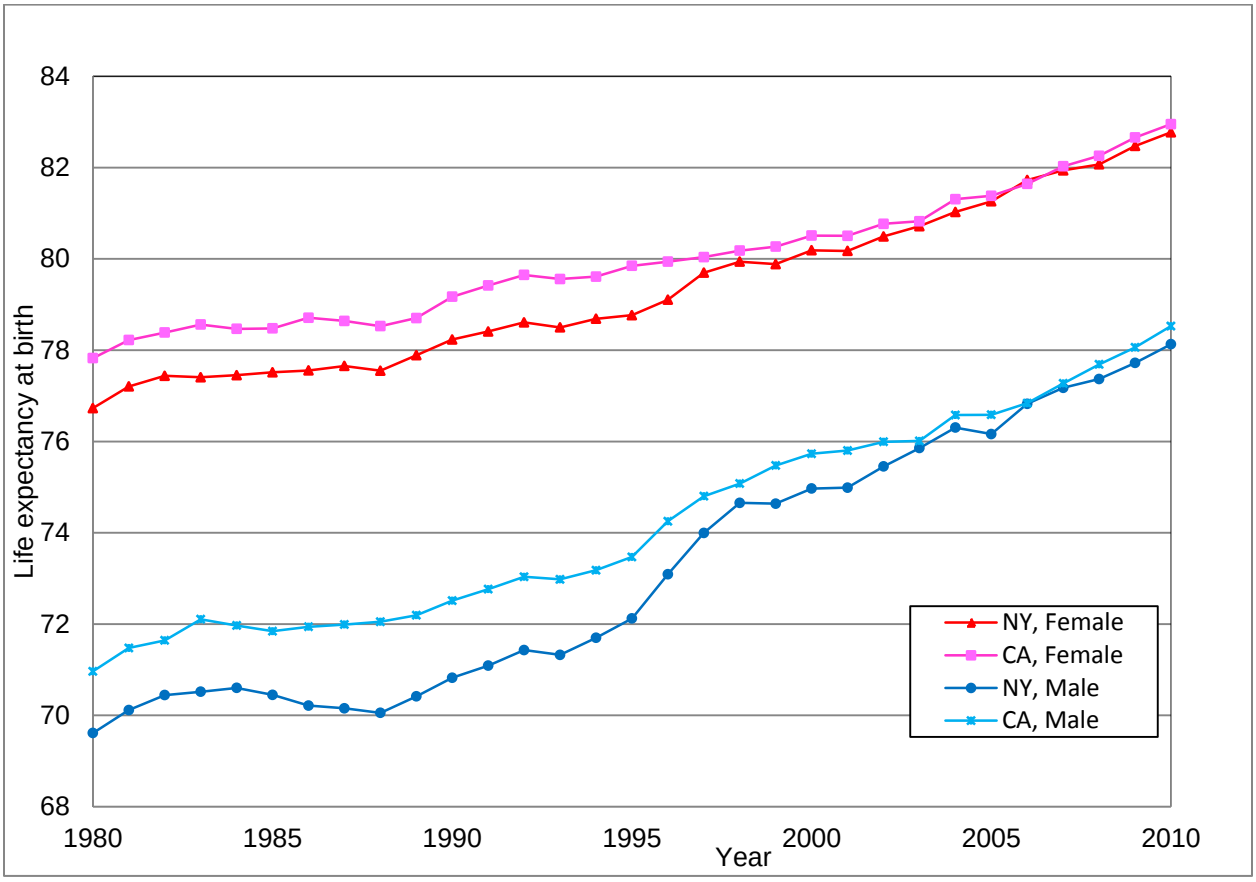
Figure 1. Trends in life expectancy at birth in California and New York, years 1980-2010



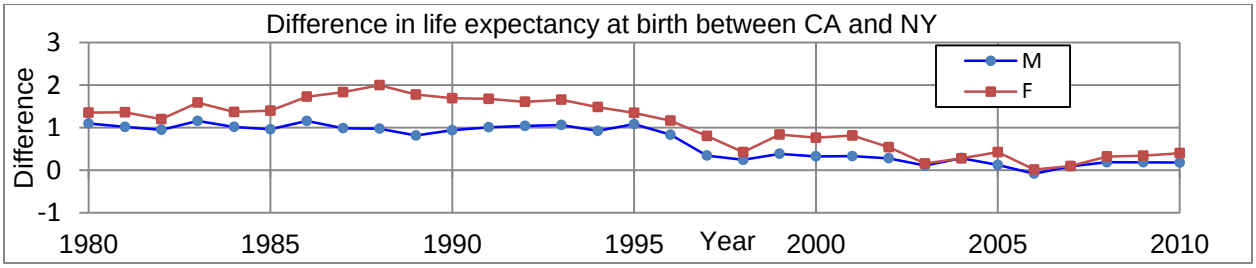


Figure 2. Trends in age-specific death rates in New York and California

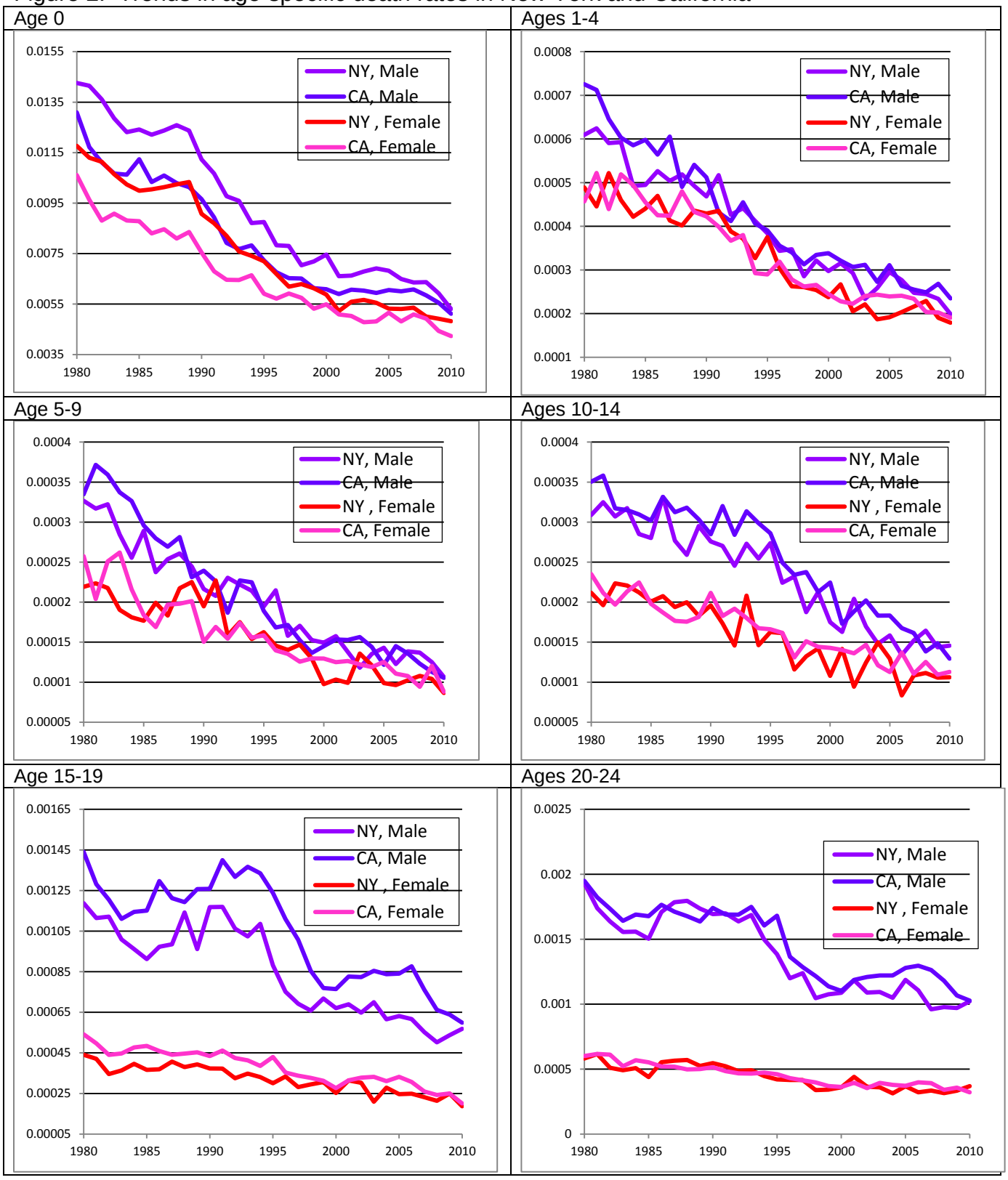
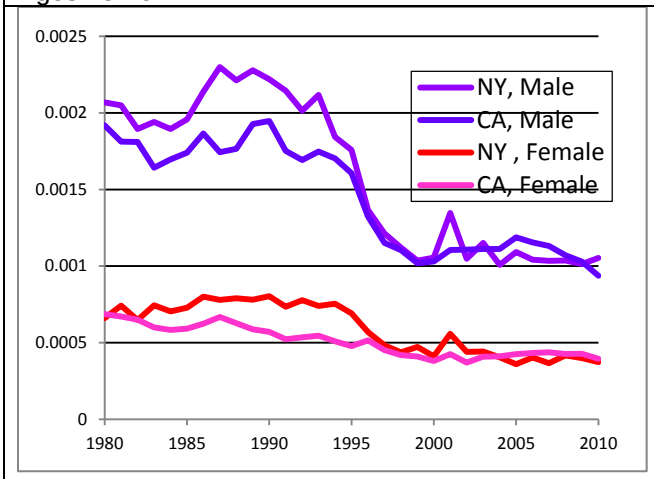
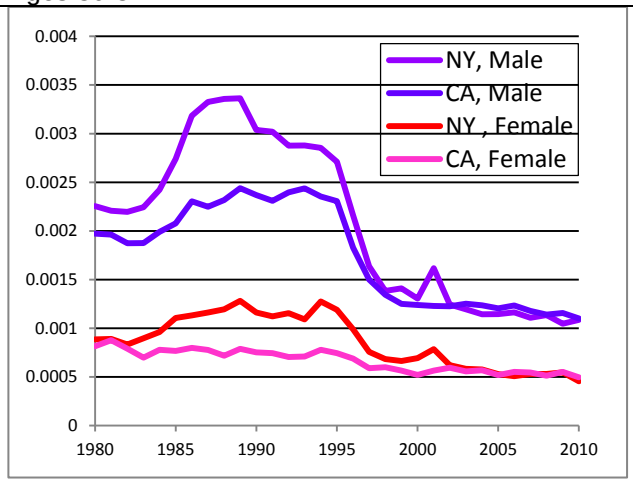


Figure 2. (cont.)

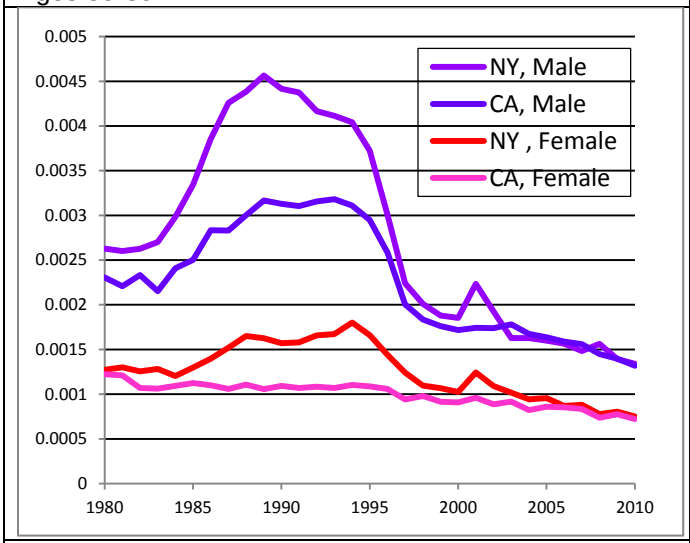
Ages 25-29



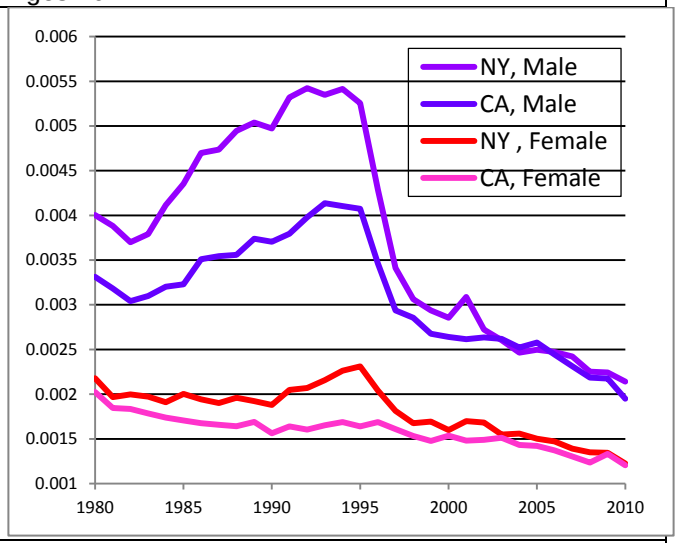
Ages 30-34



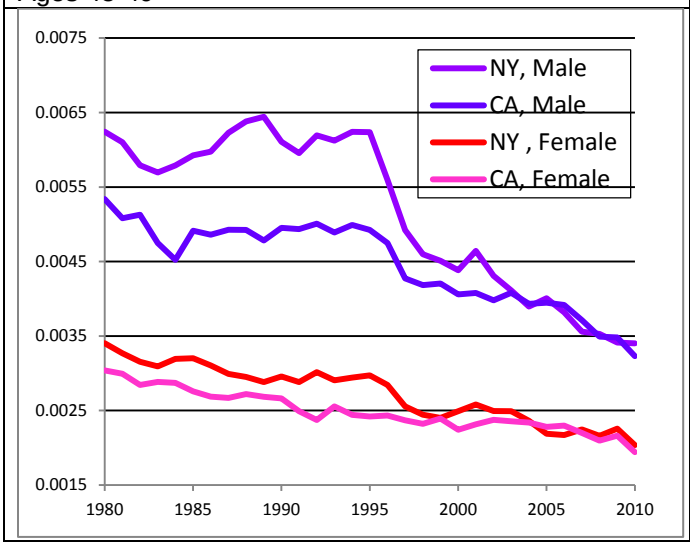
Ages 35-39



Ages 40-44



Ages 45-49



Ages 50-54

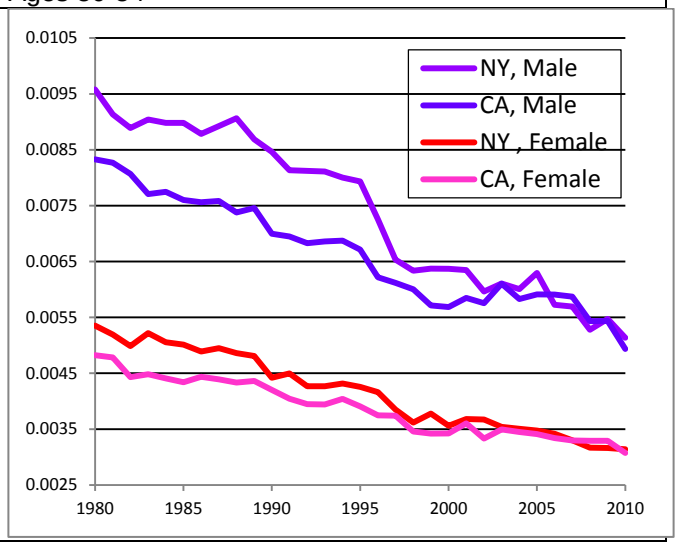
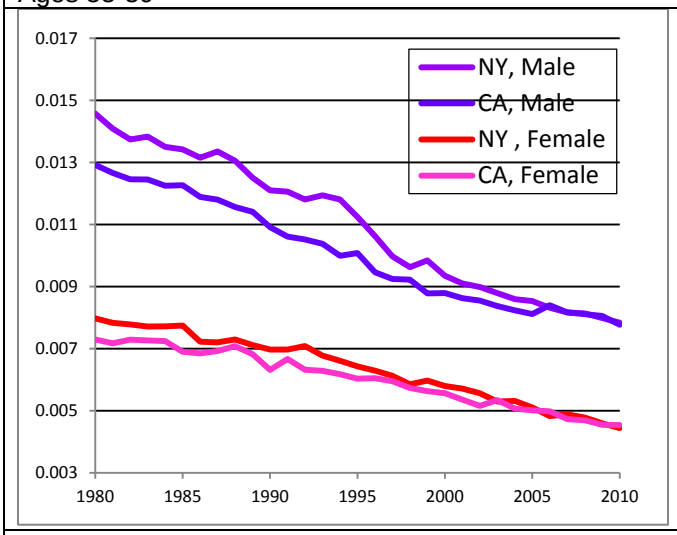
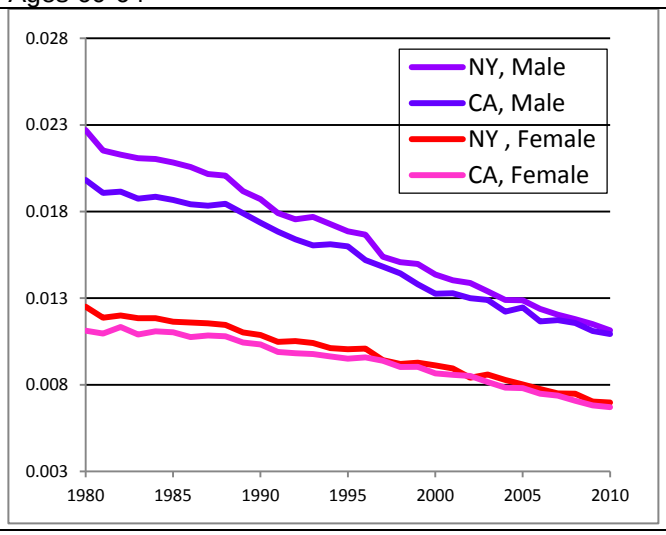


Figure 2. (cont.)

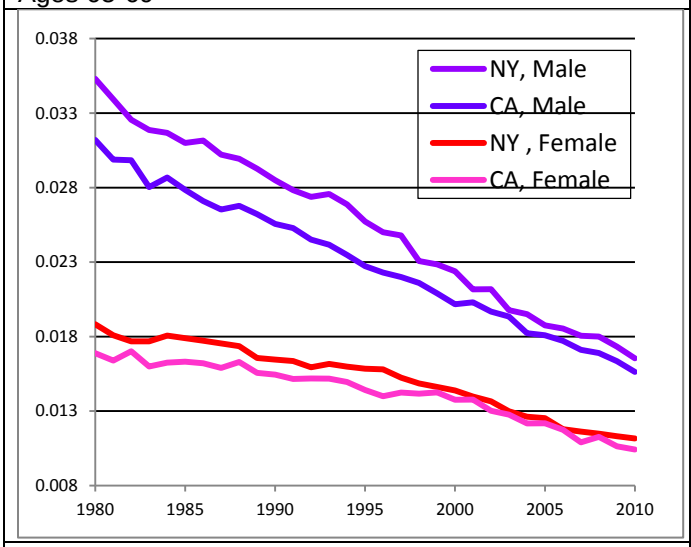
Ages 55-59



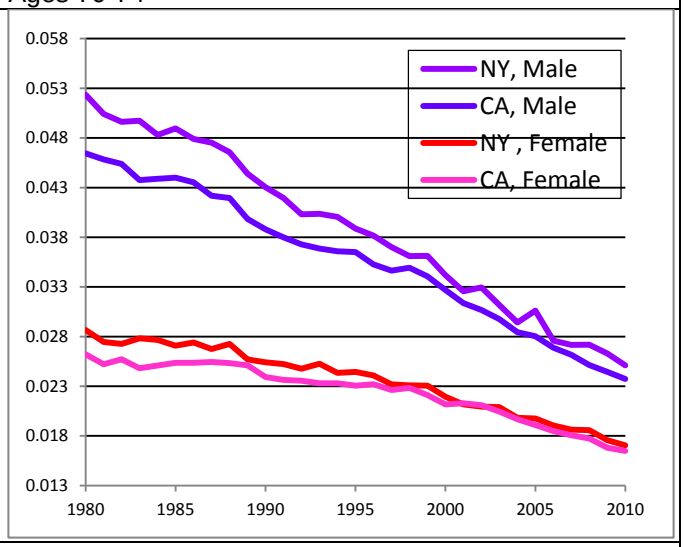
Ages 60-64



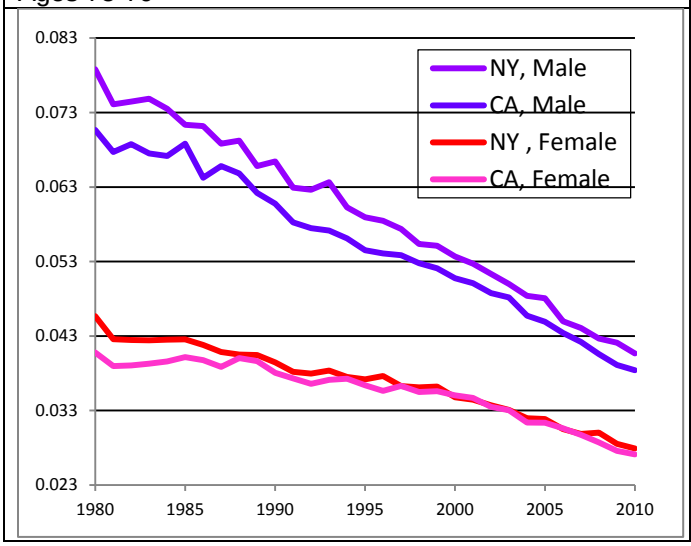
Ages 65-69



Ages 70-74



Ages 75-79



Ages 80-84

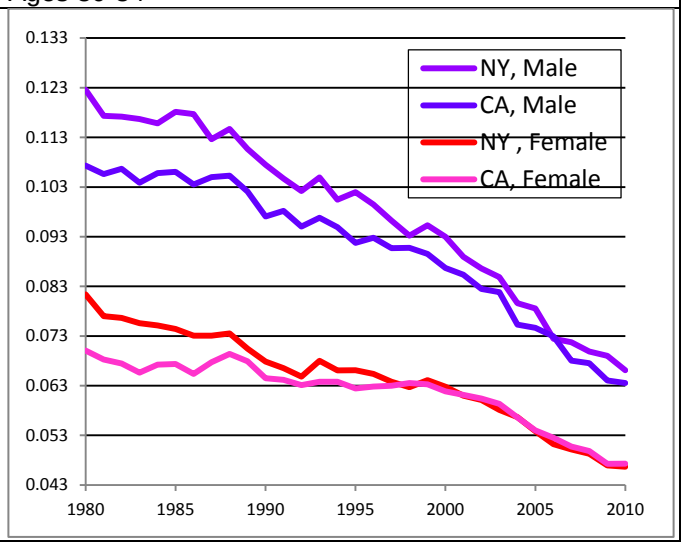
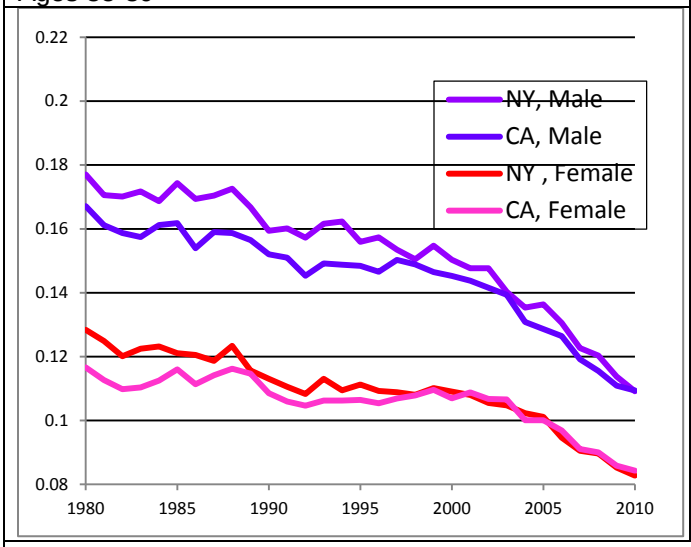
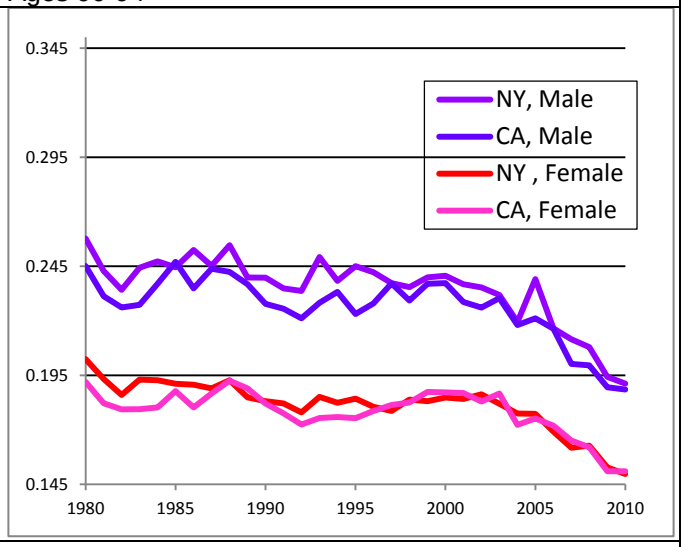


Figure 2. (cont.)

Ages 85-89



Ages 90-94



Ages 95-99

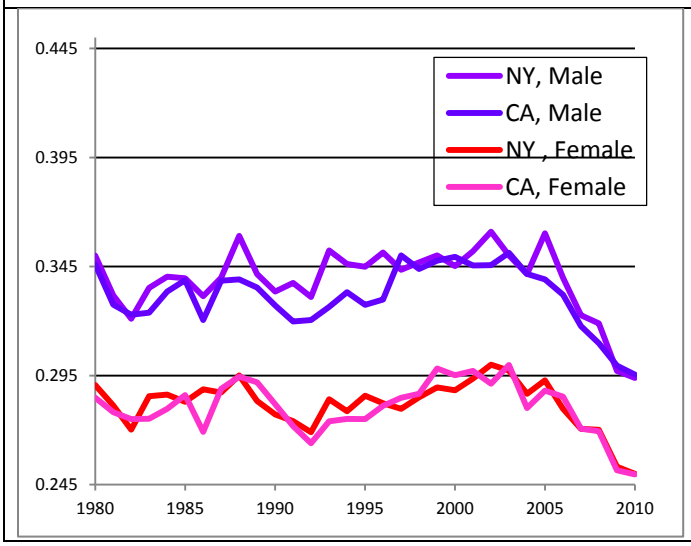


Figure 3. Ratio of death rates in New York to death rates California by age and calendar year

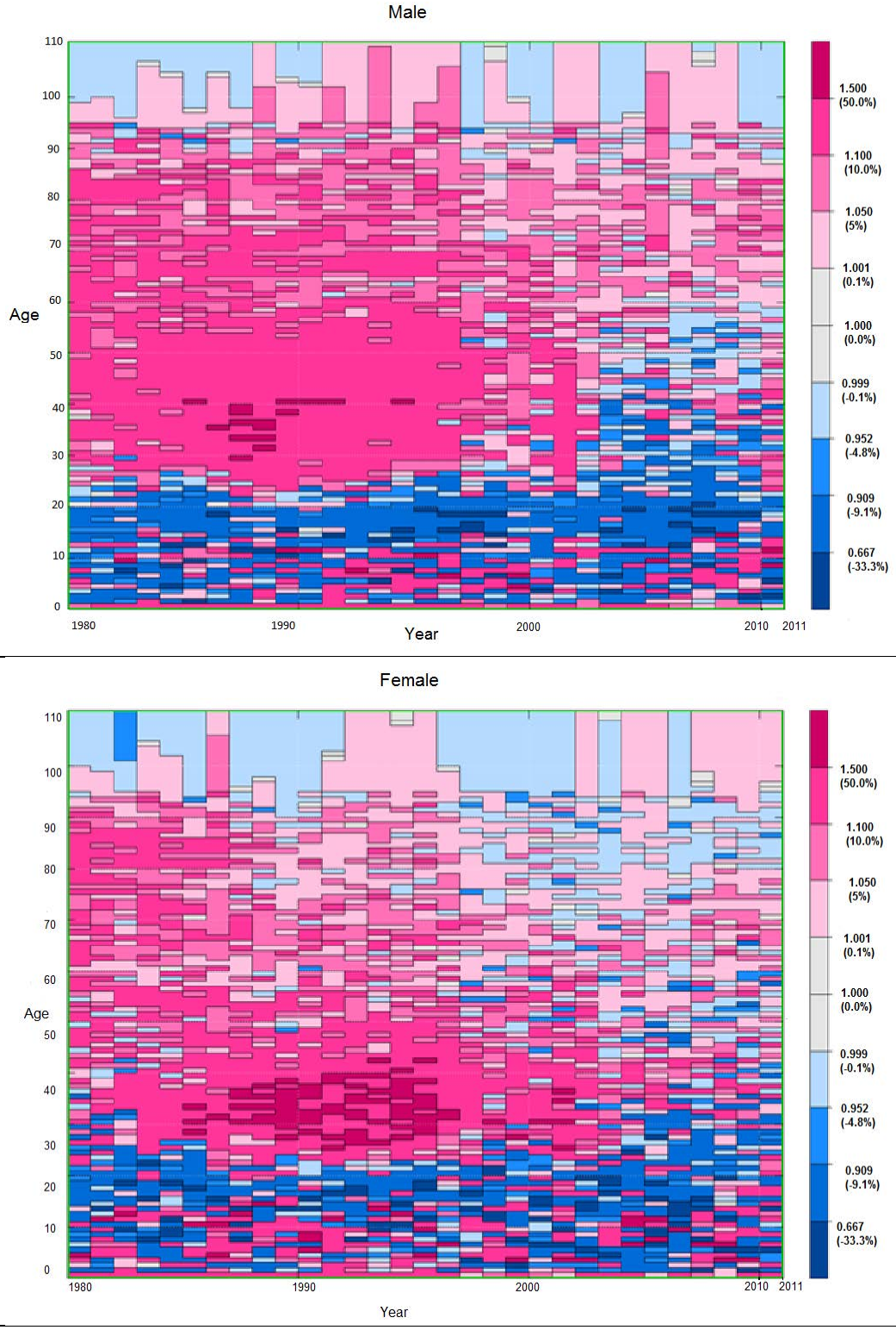
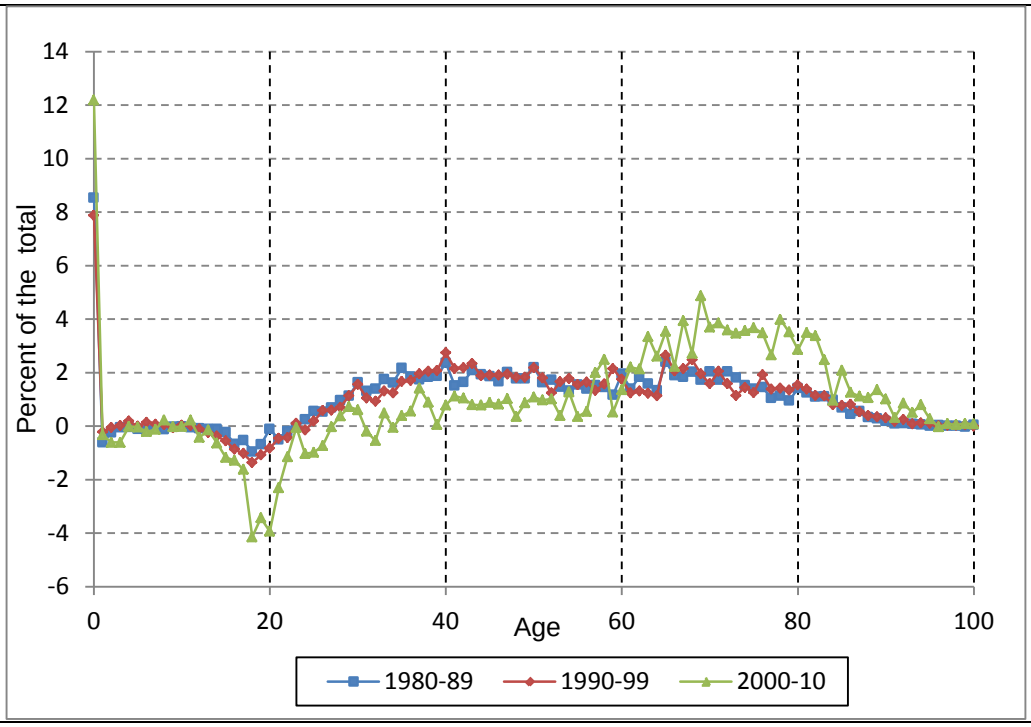


Figure 4. Decomposition of the difference in life expectancy at birth between California and New York by single-year age group for the 1980s, 1990s and 2000s

Males



Females