College Completion by Cohort, Age and Gender, 1967 to 2015

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This report is released to inform interested parties of ongoing research and to encourage discussion of work in progress. In addition to data from the Current Population Survey, this paper uses data obtained from the public-use file of the National Longitudinal Mortality Study. .*The views expressed on methodological or operational issues are those of the author and are not necessarily those of the U.S. Census* Bureau*.* or *sponsors* of the National Longitudinal Mortality Study*: the National Heart, Lung, and Blood Institute, the National Cancer Institute, the National Institute on Aging, and the National Center for Health Statistics*. *Any error or omission is the sole responsibility of the author.*

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A common way of describing the course of educational attainment over time, among demographers, is in terms of cohort succession. This description rests on the premise that, for much of the life course, level of education is a relatively fixed characteristic. Mare (1995) states, "because most people get their schooling during their childhood, teens, and 20s, the reported average educational attainments of the various age groups observed in each census provide a good indication of the trend in attainment across the birth cohorts represented in the census."

The pattern of cohort succession is plain to see in the expansion of high school completion in the U.S. population over the course of the latter 20th century. Overall, the population 25 and older with high school or higher education went from 25 percent in 1940 to 87 percent in 2009. During this time, young people were in the vanguard. In 1947, 25 to 29 year olds were 18 percentage points above the total adult (25 and older) population. They maintained an advantage throughout the period, replenishing the population with better-educated adults, as their elders aged and died (see Ryan and Siebens 2012).

In recent years, some doubt has been shed on this model as a result of several factors – possible changes over time in age patterns of attainment, a shift in the focus of researchers and policy makers to college completion rather than high school, and an increasing interest in gender differences in education. It was in this sense that Wilson et al. (2011) stated, "significant changes in the distribution of educational attainment and the demographics of those being educated in recent decades … have altered the relevance of the cohort succession model."

This paper examines the cohort succession model by taking advantage of a large collection of data from the Current Population Survey (CPS), from 1967 to 2015. Most previous work has been based on extracts involving a smaller set of years. By enlarging the data set in this way, I am able to follow a number of birth cohorts across a large portion of their lives to see how age-period-cohort patterns have played out over this time. The paper is exploratory in nature, and does not explicitly test statistical hypotheses. The intent here is to see if observed demographic trends work in ways that could plausibly explain observed educational patterns. Formal models will be developed in future research.

The educational progress of men and women

The long advance of educational attainment of the second half of the twentieth century leading into the present is sometimes characterized as one of uninterrupted progress. However, as seen in

Figure 1, completion of college has not always advanced among younger people, especially for men. The thirty-year period from 1976 to 2006 was one with no advance in college attainment among men 25 to 29, even as the measured economic returns to college were increasing, overall college attainment (at all ages) was increasing, and women were experiencing a steady advance. In more recent years even more curious things were taking place. Since 2000, young men have no longer been ahead of the total male population in college attainment – no longer "taking the lead" as the cohort succession model would have it. This provides our first hint that the relationship of educational attainment and age may be more complicated than is generally assumed.

Figure 2 shows the educational trajectory of five birth cohorts of women, ten years apart in year of birth. The data are smoothed by taking three consecutive birth cohorts and averaging their attainment levels across three years, making each point a mean value based on nine cells (3 birth years, 3 years of age). The first value at the lower left shows that bachelor's degree holders were around 9 percent of women born from 1934-1936 when they were under 35 years. By 2010, when this group of women was 74-76 years old, the proportion with a bachelor's degree had reached 17 percent.

Looking at Figure 2 as a whole, three things stand out. First, the idea that educational progress across time is importantly shaped by the progress of one cohort over another is confirmed. Second, the classical idea that people finish their schooling by age 25 seems not to describe these cohorts very well. Third, the process is not even. That can be seen by the smaller gap between the 1955 and 1965 cohorts compared to some of the other gaps. In fact, the set of cohorts illustrated in Figure 2 is unusual for its clear and regular progress within and across cohorts. Looking at a series that starts in a different year or looking at men's attainment results in complications that will need to be explained. Before we can explain these complications, however, we need to understand the underlying pattern of attainment that emerges as a cohort ages. In later research I hope to build on this to examine trends in differences between men and women.

In this paper I will explore factors that possibly underlie the age pattern of attainment found in Figure 2. A simple first step in doing so is to fit a simple regression to the attainment patterns seen in the figure. For the cohort of women born in 1936, the predicted percent with a bachelor's degree at age 27 is 9 percent. This increases by 2 percentage points with each decade of age for the cohort, according to the model. Subsequent cohorts are modeled to be higher both in the level at age 27 and the rate at which bachelor's degrees tend to increase with age. Looking at the observed and predicted patterns, the linear probability models seem to fit exceedingly well.

That a linear trend in probability of college completion fits the observed data is surprising, to say the least. Of the factors that might be supposed to influence the growth in college completion as a cohort ages, few would be expected to act evenly across the life course. The factors that come to mind include the following:

- Continuing education: Possibly the most obvious way for education levels to increase in a cohort of people is for an increasing number to attain degrees. One would expect this effect to decline with age, however.

- Differential mortality: While continuing education is likely to affect those at younger ages, lower mortality among those with higher education would be expected to affect the composition of a population as it reached older ages (Hummer and Lariscy 2011).

- Immigration and emigration: The impact of immigration on bachelor's level education should be fairly neutral (see, e.g. Davis and Bauman 2006). However, the effect of immigration on age patterns of attainment has not been examined in this context.

- Reporting error: Although the reliability of survey questions on educational attainment has generally been found to be reasonably high, there has been relatively little work on the degree to which bias might affect reports by age.

To understand how education has changed over time, we need to take reasonable account of these various factors in the measurement of education across the life course. Most of these are observable in the available data. The only factor that lies beyond easy measurement is reporting error. Before the possibility of reporting error is seriously considered, I will try to account for the impact of other effects.

The paper will hopefully shed light on several areas of research that could be improved by better understanding of age patterns of attainment. These include the rise in women's educational attainment, the effect of labor market opportunities on educational decisions, the educational impact of immigration, and the measurement of differential mortality by education.

Data

The data used for this analysis are from three sources, all associated with the Current Population Survey (CPS). First, data on the educational attainment of cohorts is constructed from the Annual Social and Economic (ASEC) supplement files, commonly referred to as the March supplement, from 1967 to 2015. There were a total of 4.26 million unweighted cases in the focal age range of 29 to 79 in the data, with a minimum of 64 thousand per year in the early 1970s, and as many as 114 thousand per year in the expanded sample in place since 2001. Data on college graduation and nativity are taken from Current Population Survey October School Enrollment supplement files from 1994 to 2014. There were 1.6 million cases in the same age range, generally 70 to 80 thousand each year. Data on mortality by education is taken from the National Longitudinal Mortality Study (NLMS), which consists of mortality records linked to responses from earlier CPS interviewees. The files used in this paper were the 6-year follow-up files, which consisted 1.26 million CPS records linked to 70 thousand death records that occurred within 6 years of CPS interviews that took place from the 1980s through the early 2000s. For data privacy and confidentiality reasons, the public use file does not report date of interview, but does provide age and the amount of time elapsed between interview and death. This was sufficient for the current purpose, as the idea was to describe the mortality regime in existence generally during a period, rather than to trace exact period mortality effects.

Mortality

Differential mortality favoring the better educated is a well-established feature of the U.S. population (Hummer and Lariscy 2011). Table 1 shows mortality rates by education and age from the NLMS (Johnson 2015). These data follow the expected pattern with mortality higher for those who are older, less educated and male. Along with absolute levels of mortality, age is associated with a larger absolute difference in mortality between those with less than a bachelor's degree and those with a bachelor's degree or higher. As expected, then, the impact of mortality on the distribution of education levels in the population is larger at older ages.

The NLMS data consist of death records linked to CPS samples collected over three time periods (early 1980s, early 1990s and early 2000s). Rates of mortality were falling over this time period (Arias 2015). However, there is no clear time pattern to the difference between those with higher and lower education levels. A weakness of these data is the lack of coverage of earlier time periods, when mortality would be higher still. With the lack of clear trend in mortality differentials here, it was decided not to attempt backward projection. For birth cohorts to be examined in this paper, I used the mortality rates for the time period closest to the one appropriate for each age level. For this paper, the assumption is that the mortality regime of the 1980s was close enough to portray the situation affecting earlier time periods.

College graduation

There are a number of questions on the October CPS enrollment supplement that can be used to infer college graduation. First, if a person under the age of 29 reports having a bachelor's degree, he or she is asked if it was received in the current calendar year or before the current year (YRDEG). Those in the former category can be considered a new graduate. Another question, addressed to all respondents, asks about enrollment in school the previous year (PELASTGD). A person who was enrolled in college the previous year, and now has a bachelor's degree, can similarly be considered a new graduate.

Neither of these measures is without problems. People who report that they graduated in the current calendar year do not include those who graduated since the previous October, but not within the calendar year (December graduates). People who report having been enrolled in college the previous year might have been in a non-degree program or studying for a second degree, rather than earning the degree they report holding. For further details on this point, see Schmidt and Siebens (forthcoming). If we take the cross section of the two measures (current-year graduation vs. last-year enrollment) we see that of those who graduated in the current year, 76 percent also recorded they were enrolled in college as a senior in the previous year. Conversely, 66 percent of last year's seniors recorded that they graduated in the current year. Both provide similar estimates of annual graduation – 930 thousand for the current year graduation estimate, versus 1.1 million for those who went from senior in college last year to having a bachelor's degree this year.

Since our focus is on the population over the age of 29, the current-year graduation measure based on YRDEG is not of help, so I use the measure based on last year's enrollment.

Until recently, there have been no easily-available data to verify the age patterns of graduation observed in the CPS. However, institutional data released by the National Center for Education Statistics through the Integrated Postsecondary Data System (IPEDS) began to include graduation by age starting with the 2011-2012 school year. Table 2 shows the comparison between CPS and IPEDS for 2012 through 2014. The level of agreement here, while not perfect, provides some degree of reassurance that CPS patterns are reasonable.

Immigration

Another contributor to the number with a bachelor's degree is immigration. While many immigrants to the U.S. have low levels of education, the number with higher levels of education is also large (Ryan and Bauman 2016). Moreover, the age pattern of immigration by education is not balanced. Older arrivals to the United States are weighted more towards the higher end of the scale. The number of immigrants with a bachelor's degree can be determined from CPS data by combining information on education, nativity, and year of entry to the U.S.[1] Of the recent immigrants measured in the October CPS data, 40 percent of those who were between the ages of 25 and 49 on arrival had a bachelor's or higher education.

Combining mortality, graduation and immigration

Figure 3 shows the influence of graduation and immigration taken together. The highest line in the graph shows the number who report having ever earned a bachelor's or higher degree, among CPS respondents born in 1971 to 1975, by age. Cumulatively adding up the number who report having graduated in the past year, shown in the lowest line of figure 3, seems to be lower than the total who report they have ever graduated. This is similar to the finding in table 3 that CPS estimates of the number of recent graduates below the age of 25 are smaller than those from IPEDS. The lines for cumulative graduates and number with degrees continue to diverge at older ages, but much of the difference in slope, if not in level, is explained by adding in an estimate of the number of people with a bachelor's degree who entered the country in the past year (the middle line in the graph). Importantly, the phenomenon of increasing college graduation past the age of 30 is evident in these data whether this is measured by status indicators (having graduated from college) or by cumulating the flow of graduates. The CPS data are consistent in showing a pattern of growth in college graduation that continues to middle age, and this pattern is confirmed by comparison to administrative data sources.

Data on college graduation and immigration are available in CPS only in relatively recent years, the latter since 1994. Since the purpose of the paper is to examine cohorts across as much as possible of their life-span, I needed a way to project these observed rates over a broader period of time. This was accomplished by regressing immigration and graduation levels on sex, age, and cohort, and using the models to orovide estimates of college graduation at early ages among cohorts born earlier in the

[1] The number who moved in within the past year was determined by taking an appropriate fraction of the number who entered within the past two or three years. CPS data vary from year to year on the number of years included in the category of most recent arrivals among the foreign-born.

century.[2] The models were separately run for men and women, and included age, cohort and age by cohort interactions (results are available from the author). Mortality, as mentioned earlier, was applied directly to birth cohorts at the appropriate ages, with mortality before the 1980s held to be equal to that which prevailed in the 1980s. Estimates of bachelor's attainment and mortality used mid-year populations in the denominator so that they would correspond to appropriate life-table rates.

Figures 4 and 5 show the probabilities favoring bachelor's attainment for sample cohorts, examined from age 29 through 74. Indicators are constructed differently in each instance, and do not fit on the same vertical scale. But certain aspects of the patterns over age and cohort can be seen. Immigration of the college-educated did not exceed the proportion in the general population, leading to a mostly negative effect on college attainment for the cohort born in 1936 to 1940. In later cohorts, such as the one born in 1956 to 1960, immigration emerged as a force favoring college attainment. At younger ages, as expected, the effect of graduation was higher, while differential mortality affected the proportion of the population with a bachelor's degree at higher ages.

The rates observed in Figures 4 and 5 were then applied to overall rates of bachelor's attainment using multi-state (increment-decrement) life-table models (Schoen 1975, 1988, Rogers and Ledent 1976). The model uses linear interpolation to determine levels between observation points, and takes the form,

$$\mathbf{l}(x+1) = (\mathbf{I}+\tfrac{1}{2}\mathbf{m}(x))^{-1} \ (\mathbf{I}-\tfrac{1}{2}\mathbf{m}(x))\, \mathbf{l}(x)$$

Where $\mathbf{l}(x)$ is a vector of the observed number in each state at age x, $\mathbf{l}(x+1)$ is the projected number in each state at age $x+1$, $\mathbf{m}(x)$ is a matrix of flow rates between states, and $\mathbf{I}$ is the identity matrix. Our interest is in the observed pattern of bachelor's attainment beyond the peak years of graduation age 21 to 26. I have chosen to examine the ages 29 through 79. The model then takes the number with a bachelor's degree at 29 and moves forward from there, comparing the number that would be expected from the given regime of graduation, immigration and mortality to the levels of attainment reported by respondents. This is done separately for males and females for ten 5-year cohorts ranging from those born in 1926-1930 to those born in 1971-1975. For the earliest two cohorts,

[2] For the cohort born in 1926-1930, direct estimates were not available for ages 38-63, for 1931-1935, direct estimates were not available for ages 33-58, for 1936-1940, direct estimates were not available for ages 29-53, for 1941-1945, direct estimates were not available for ages 29-48, for 1946-1950, direct estimates were not available for ages 29-43, 1951-1955, direct estimates were not available for ages 29-38, 1956-1960 29 -33.

bachelor's attainment at age 29 is not observed, so the earliest observed age is used as the baseline. The latest cohort (1971-1975) is observed only through age 44.

Figure 6 shows the observed pattern for males born in 1926-1930. At age 29, the observed and modeled numbers with a bachelor's degree and without a bachelor's degree agree, by construction. Beyond that age, the curve showing the observed numbers seems to lie somewhat above the model curve for both the non-bachelor's and bachelor's populations. However, the slopes of the curves seem to be reasonably close. Since the choice of age 29 as a starting point is somewhat arbitrary, and there is a fair degree of sampling variation from year to year, the vertical position of the model curve is not as important as the overall shape.

Figure 7 shows the male 1926-1930 cohort in terms of the percentage with a bachelor's degree. Once again, there may be slight differences between the observed and modeled proportions, but the overall slopes are reasonably close. Figure 8 shows the female cohort of 1926-1930, with similar patterns evident. Figure 9 shows a more recent cohort, males born in 1966-1970. Overall, the modeled level of bachelor’s attainment is in close agreement with the observed levels.

Figure 10 shows one of the few cohorts where there is a visible discrepancy between the modeled and observed trends. The observed percent with a bachelor’s degree at age 33 is 8 percent, and that moves up to 10 percent by age 36. The model, which matches the rate at age 33 by design, does not move beyond 8 percent in this range, and doesn’t catch up with the observed rate at higher ages. The choice of matching the two curves at age 33 is relatively arbitrary, chosen because it is the closest observed data point above age 29. If another starting point were chosen, the lines might be found to agree much better. It will require further work to see if there is anything different about the few cohorts where differences of this nature are seen.

With 10 cohorts and 2 sexes, it would take many pages to show the reader all the graphs that describe the observed and modeled trends. But little would be gained. For every cohort, the level of agreement between the observed growth in college attainment and the results of a simple model involving reports of college completion, arrival in the U.S. with a bachelor’s or higher education, and differential mortality.

Discussion

Although this paper has not tested hypotheses, I believe it has moved us closer to being able to say whether observed patterns of college attainment might be explained in terms of graduation, immigration and mortality. In general, I would characterize these results as promising. In particular, it does not seem to be necessary to invoke measurement bias to explain observed cohort patterns of attainment by age. That, of course, is far from proof that measurement bias is not a problem. In order to show that measurement error is not a driving factor in increasing apparent attainment among older members of a given cohort would require more direct tests of measurement consistency. However, the current results show that one needn't presume measurement error has caused this pattern. As it turns out, CPS respondents report rates of college graduation that agree with administrative sources, they are consistent in their reports of attainment and graduation, and that their reports are entirely consistent with the observed growth in college completion across the life course.

For those wishing to explore long-term trends in education, these findings may indicate that the conundrum of dealing with the age-period-cohort model is lessened. In particular, the results cast doubt on the assumption that college graduation is concentrated in a short age span at the beginning of adulthood. It might be that period effects impact college enrollment across the age spectrum, and that later life shifts will help identify these influences.

There are additional steps that need immediate attention. An improved, formal construction of these models might lead to better inference of places where statistical differences between observed and modeled graduation levels remain. Visual inspection of graphs doesn't go far enough in this regard.

Even though the current modeling exercise needs improvement and development, there is enough here to show that it might not necessary or even appropriate to ascribe educational changes beyond age 29 to measurement problems. There is every possibility that this is a real, long-standing phenomenon, and that our models of education in the life course cannot and should not assume that education is fixed early in life.

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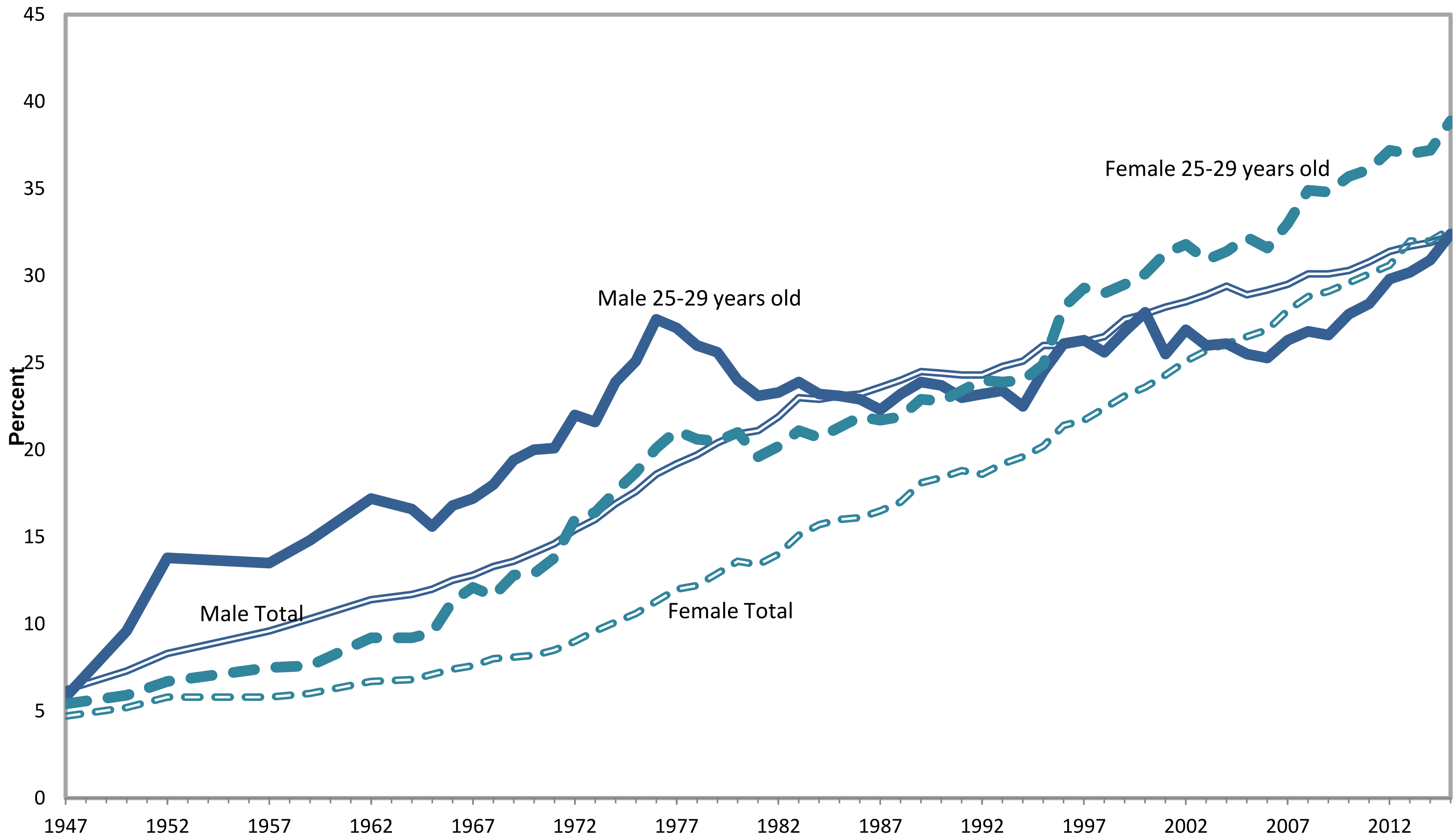
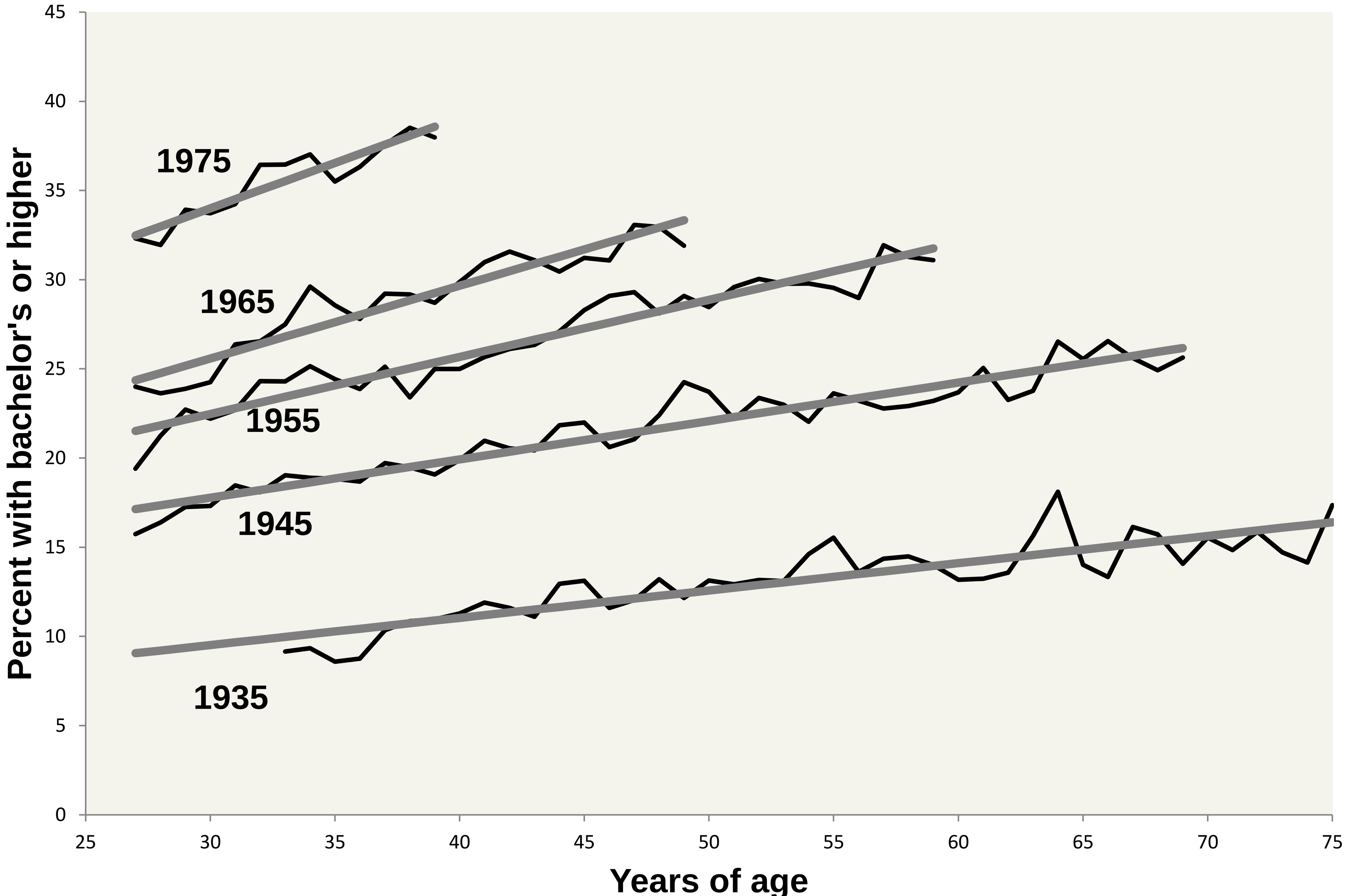
Figure 1: Percent of Population 25 Years and Older, and 25 to 29 Years, with Bachelor's Degree or Higher by Sex: 1947-2015



Sources: U.S. Census Bureau. 1947, 1952-2002 March Current Population Survey, 2003-2014 Annual Social and Economic Supplement to the Current Population Survey; 1940-1950 Census of Population.

United States Census Bureau

Figure 2: Percent of Women with a Bachelor's or Higher Degree by Birth Cohort and Age, with Regression Lines



Source: U.S. Census Bureau, Current Population Survey

Table 1
Average Death Rate for Age Groups by Education, Across Three Time Periods

Sex and age	People who have completed less than college			People with a college degree or higher			Difference		
	File 1: early 1980s	File 2: early 1990s	File 3: early 2000s	File 1: early 1980s	File 2: early 1990s	File 3: early 2000s	File 1: early 1980s	File 2: early 1990s	File 3: early 2000s
Males									
24 to 29	0.0014	0.0014	0.0012	0.0011	0.0016	0.0014	0.0004	-0.0003	-0.0003
30 to 34	0.0018	0.0016	0.0015	0.0009	0.0014	0.0011	0.0009	0.0002	0.0004
35 to 39	0.0023	0.0024	0.0019	0.0011	0.0013	0.0013	0.0011	0.0011	0.0006
40 to 44	0.0033	0.0029	0.0023	0.0019	0.0020	0.0014	0.0014	0.0008	0.0009
45 to 49	0.0052	0.0048	0.0040	0.0030	0.0021	0.0019	0.0023	0.0027	0.0021
50 to 54	0.0086	0.0070	0.0056	0.0047	0.0038	0.0027	0.0039	0.0032	0.0030
55 to 59	0.0138	0.0121	0.0086	0.0075	0.0062	0.0040	0.0062	0.0059	0.0046
60 to 64	0.0215	0.0178	0.0136	0.0130	0.0102	0.0061	0.0086	0.0076	0.0075
65 to 69	0.0318	0.0276	0.0207	0.0210	0.0179	0.0110	0.0108	0.0096	0.0097
70 to 74	0.0483	0.0422	0.0307	0.0322	0.0300	0.0196	0.0161	0.0122	0.0111
75 to 79	0.0714	0.0634	0.0482	0.0520	0.0476	0.0347	0.0193	0.0158	0.0135
80 to 84	0.1027	0.0961	0.0744	0.0974	0.0806	0.0599	0.0052	0.0155	0.0146
85 to 89	0.1493	0.1417	0.1220	0.1404	0.1285	0.1192	0.0089	0.0132	0.0028
Females									
24 to 29	0.0005	0.0006	0.0008	0.0012	0.0007	0.0010	-0.0007	0.0000	-0.0003
30 to 34	0.0008	0.0009	0.0009	0.0008	0.0009	0.0009	0.0000	0.0000	-0.0001
35 to 39	0.0012	0.0010	0.0013	0.0010	0.0012	0.0012	0.0002	-0.0001	0.0002
40 to 44	0.0017	0.0017	0.0016	0.0018	0.0013	0.0010	-0.0001	0.0005	0.0006
45 to 49	0.0028	0.0027	0.0024	0.0024	0.0016	0.0014	0.0003	0.0012	0.0010
50 to 54	0.0045	0.0038	0.0037	0.0040	0.0025	0.0023	0.0005	0.0012	0.0014
55 to 59	0.0071	0.0069	0.0059	0.0056	0.0052	0.0027	0.0015	0.0017	0.0032
60 to 64	0.0110	0.0102	0.0084	0.0081	0.0069	0.0056	0.0029	0.0033	0.0028
65 to 69	0.0161	0.0165	0.0133	0.0127	0.0113	0.0072	0.0034	0.0052	0.0060
70 to 74	0.0245	0.0233	0.0196	0.0190	0.0181	0.0145	0.0055	0.0052	0.0051
75 to 79	0.0371	0.0356	0.0291	0.0300	0.0337	0.0219	0.0071	0.0019	0.0071
80 to 84	0.0571	0.0587	0.0494	0.0456	0.0447	0.0477	0.0115	0.0141	0.0017
85 to 89	0.0889	0.0928	0.0775	0.0951	0.0898	0.0858	-0.0062	0.0031	-0.0083

Source: National Longitudinal Mortality Study

Table 2

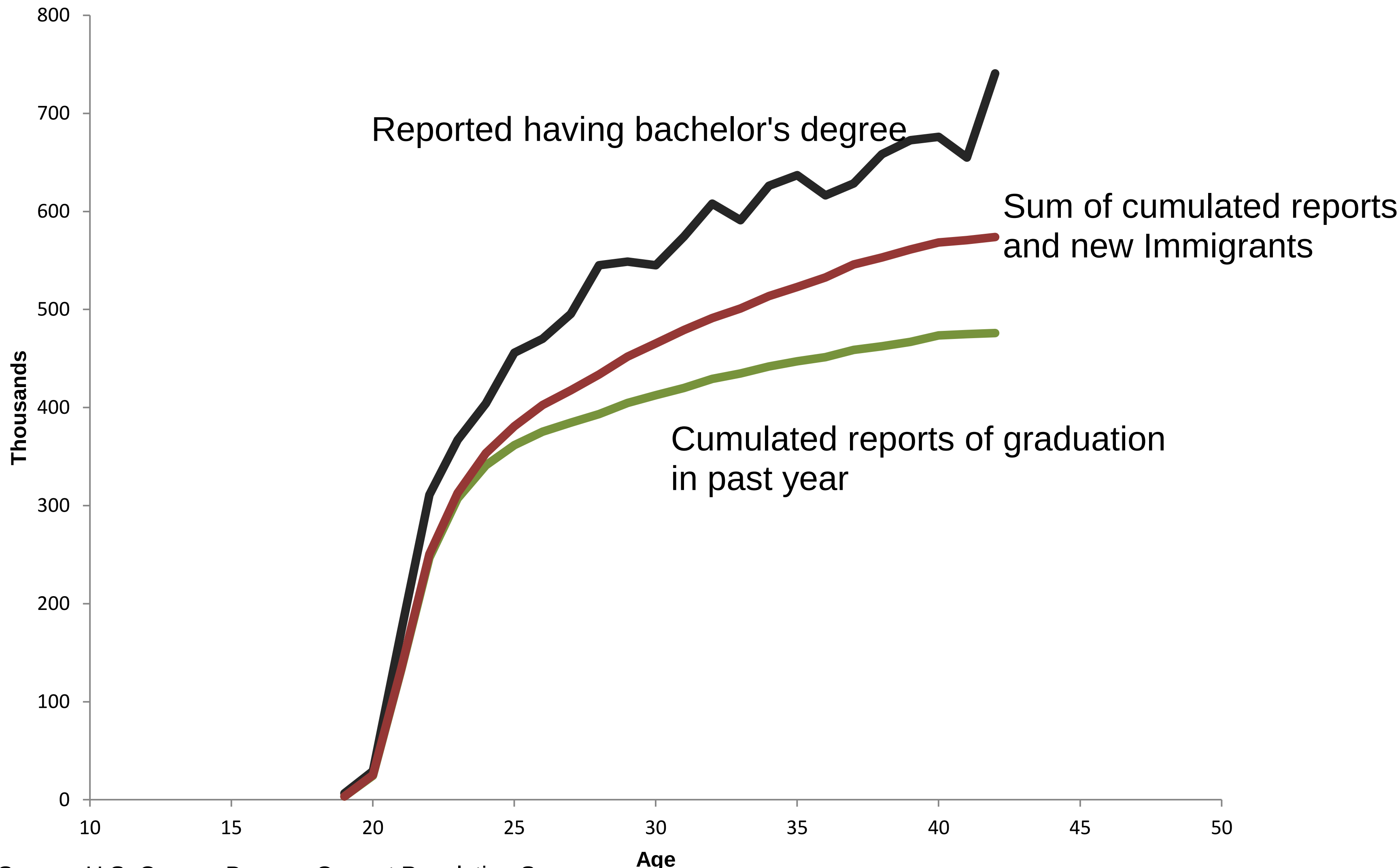
Estimates of the Number of New College Graduates, by Age, from Administrative and Survey Data, 2012 to 2014

Age	Integrated Postsecondary Education Data System (IPEDS)			Current Population Survey (CPS)		
	2012	2013	2014	2012	2013	2014
Total /1	1,777,778	1,839,025	1,869,660	1,564,948	1,571,070	1,719,880
Under 25	1,164,082	1,204,000	1,227,853	990,750	1,039,520	1,086,000
25 to 39	458,739	481,339	480,352	419,913	394,650	481,700
40 and over	137,070	146,438	147,166	154,285	136,900	152,180

Source: U.S. Census Bureau

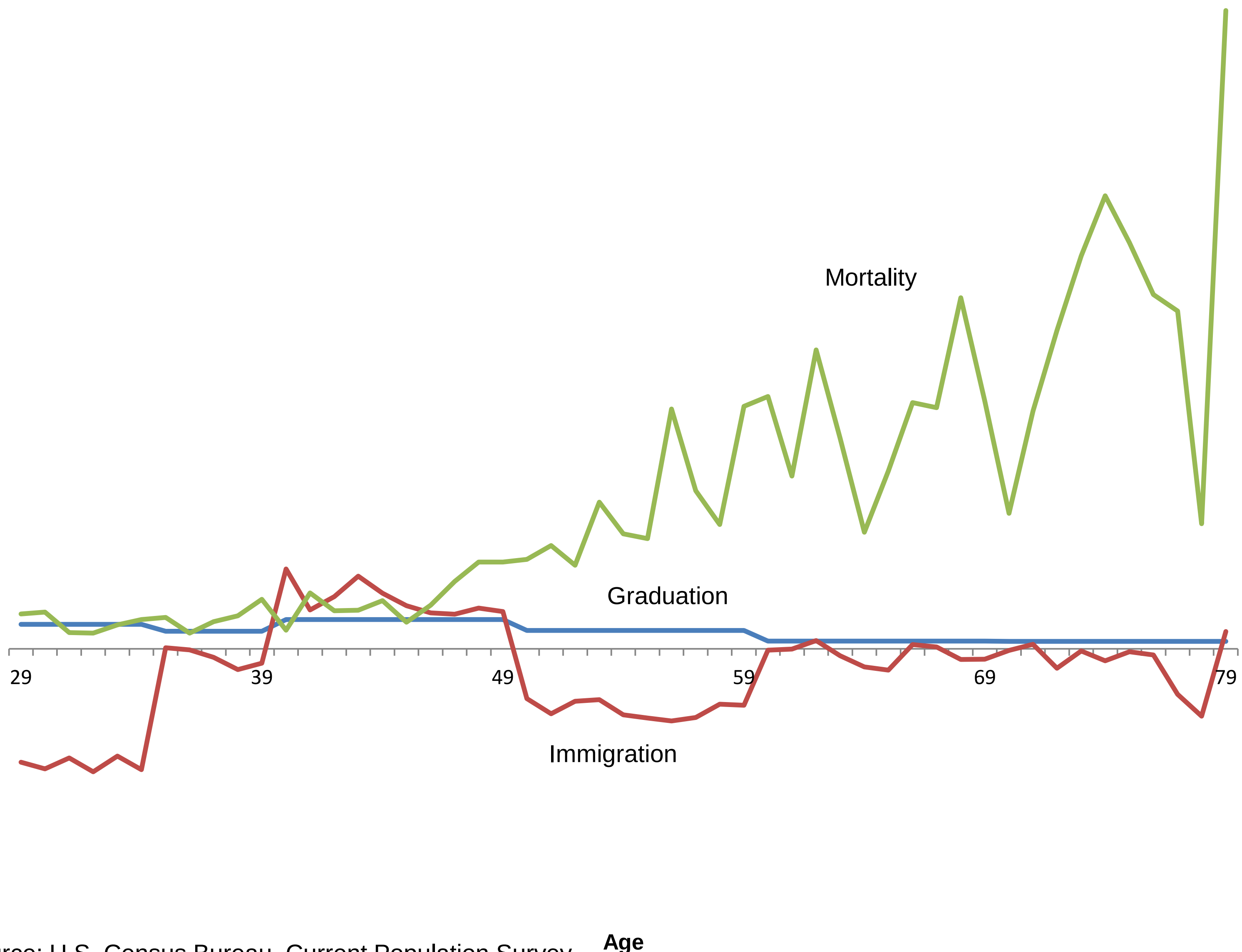
1. Total includes a small number of graduates with unreported age in IPEDS

Figure 3: Cumulative College Graduates by Age, Reported, and Calculated from Graduation and Immigration Reports, Males Born 1971 to 1975



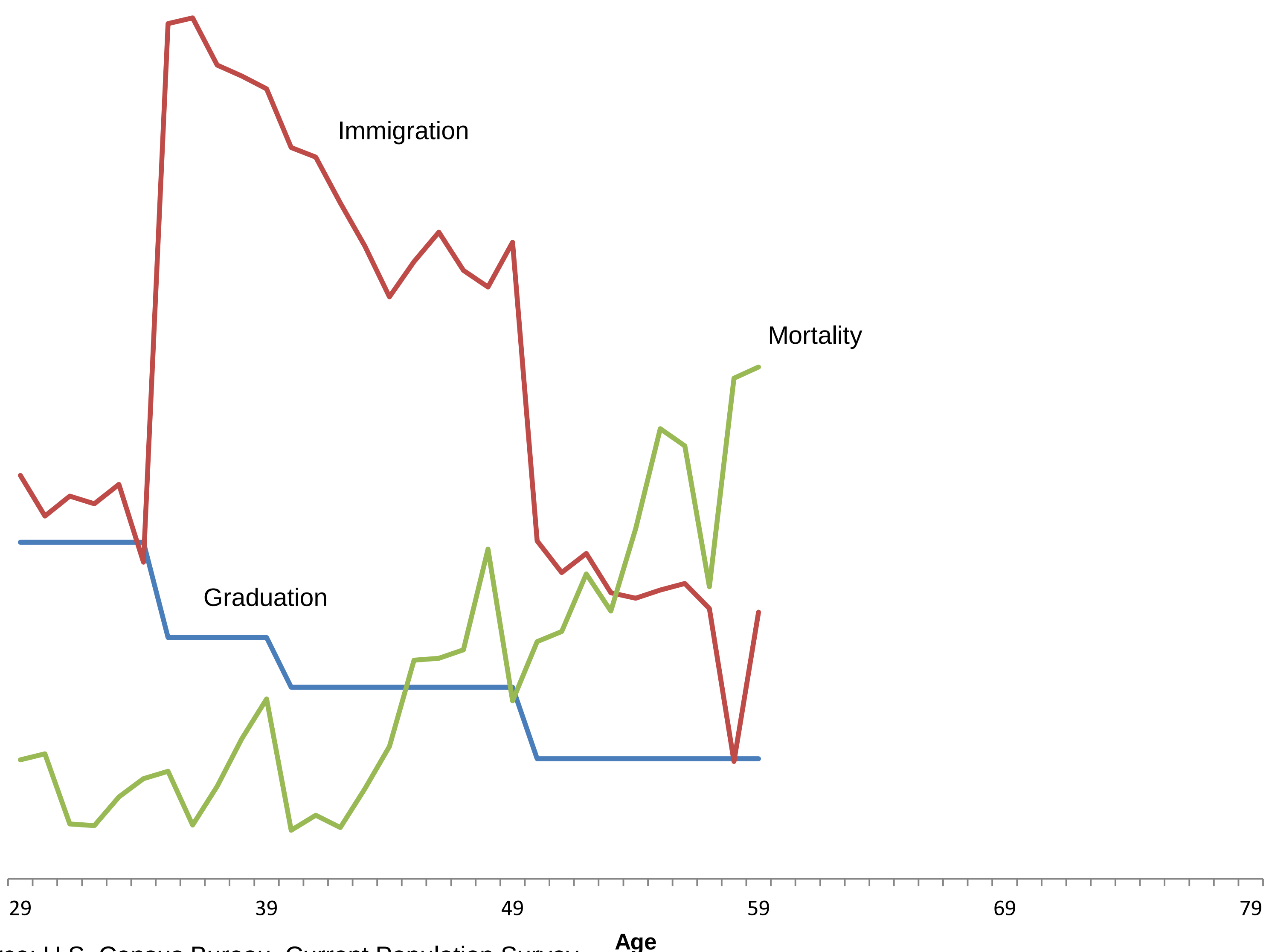
Source: U.S. Census Bureau, Current Population Survey

Figure 4: Males Born 1936-1940: Rate of Bachelor's Attainment and Differential Mortality by Age



Source: U.S. Census Bureau, Current Population Survey

Figure 5: Males Born 1956-1960: Rate of Bachelor's Attainment and Differential Mortality by Age



Source: U.S. Census Bureau, Current Population Survey

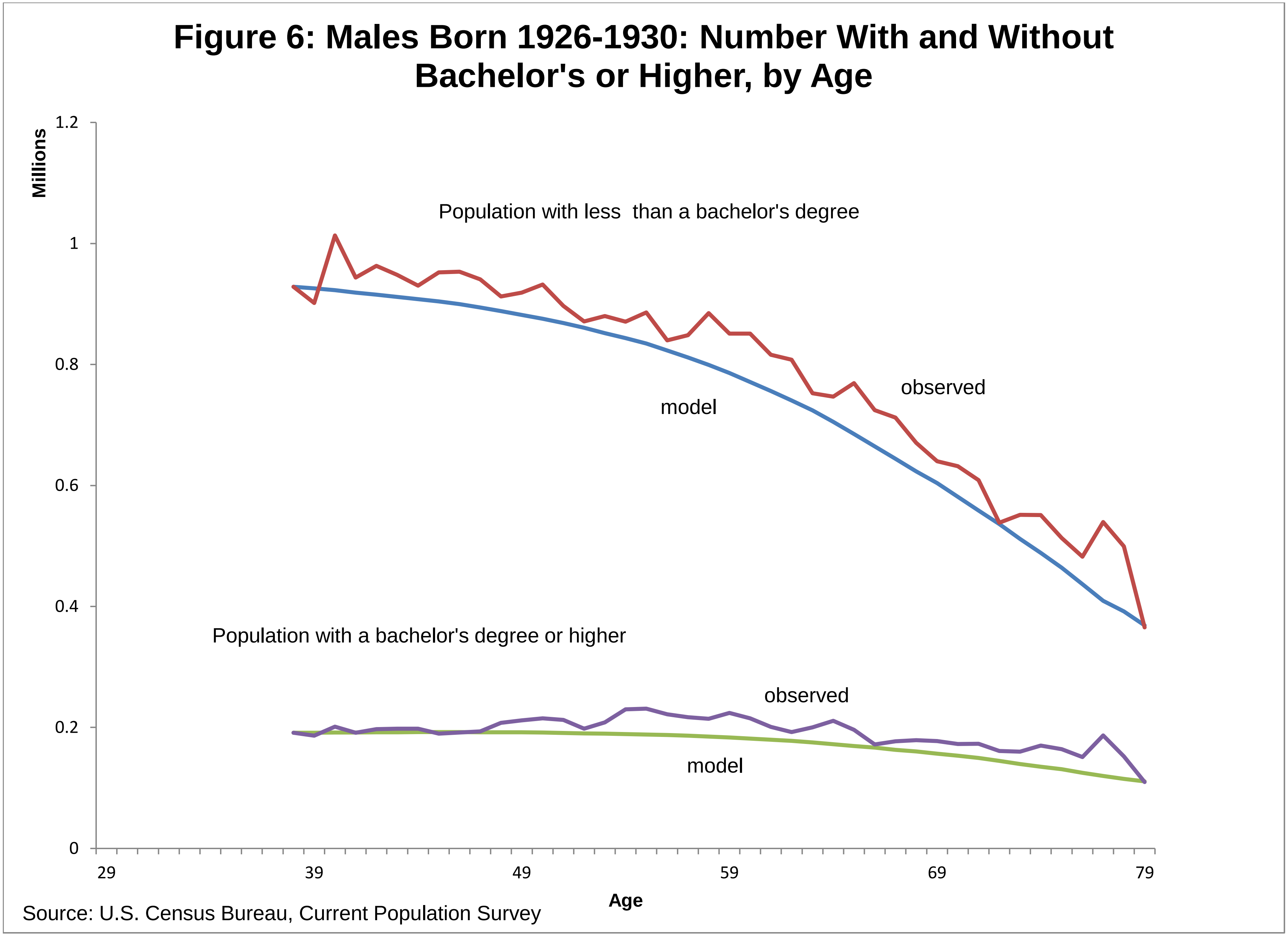
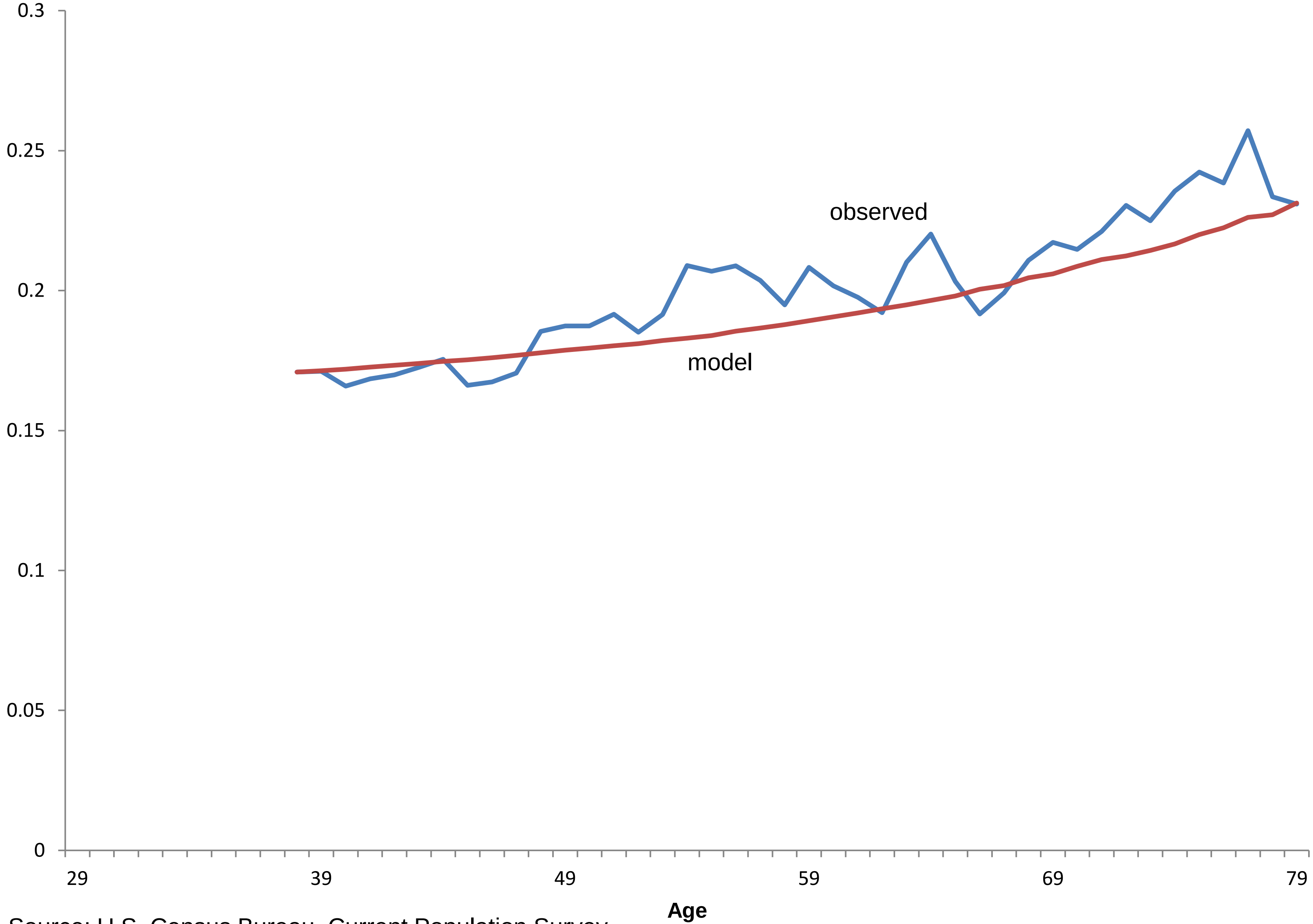


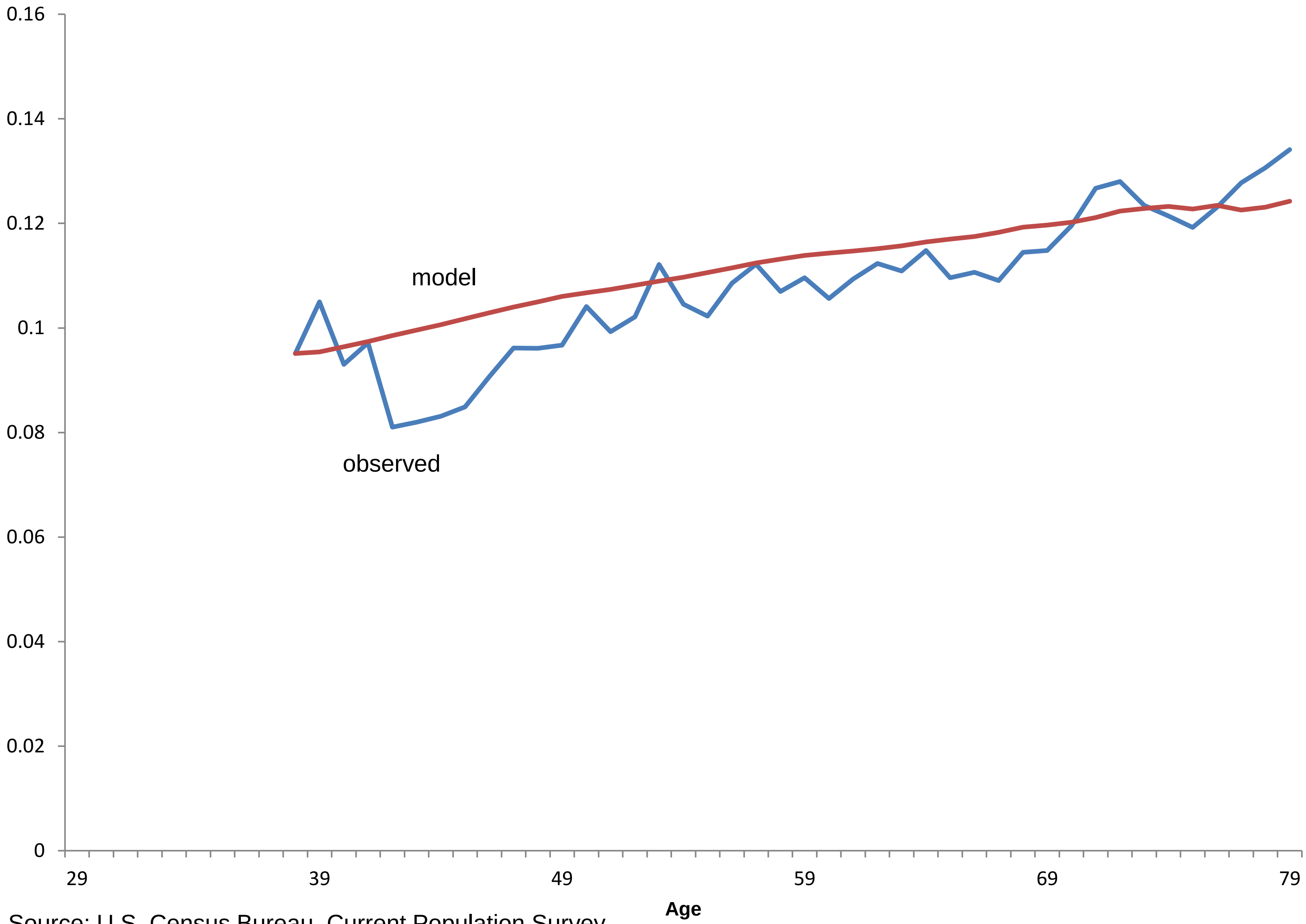
Figure 6: Males Born 1926-1930: Number With and Without Bachelor's or Higher, by Age
Millions
1.2
1
0.8
0.6
0.4
0.2
0
Population with less than a bachelor's degree
observed
model
Population with a bachelor's degree or higher
observed
model
29
39
49
59
69
79
Age
Source: U.S. Census Bureau, Current Population Survey

Figure 7: Males Born 1926-1930: Observed and Modeled Proportion with Bachelor's Degree or Higher, by Age



Source: U.S. Census Bureau, Current Population Survey

Figure 8: Females Born 1926-1930: Observed and Modeled Proportion with Bachelor's Degree or Higher, by Age



Source: U.S. Census Bureau, Current Population Survey

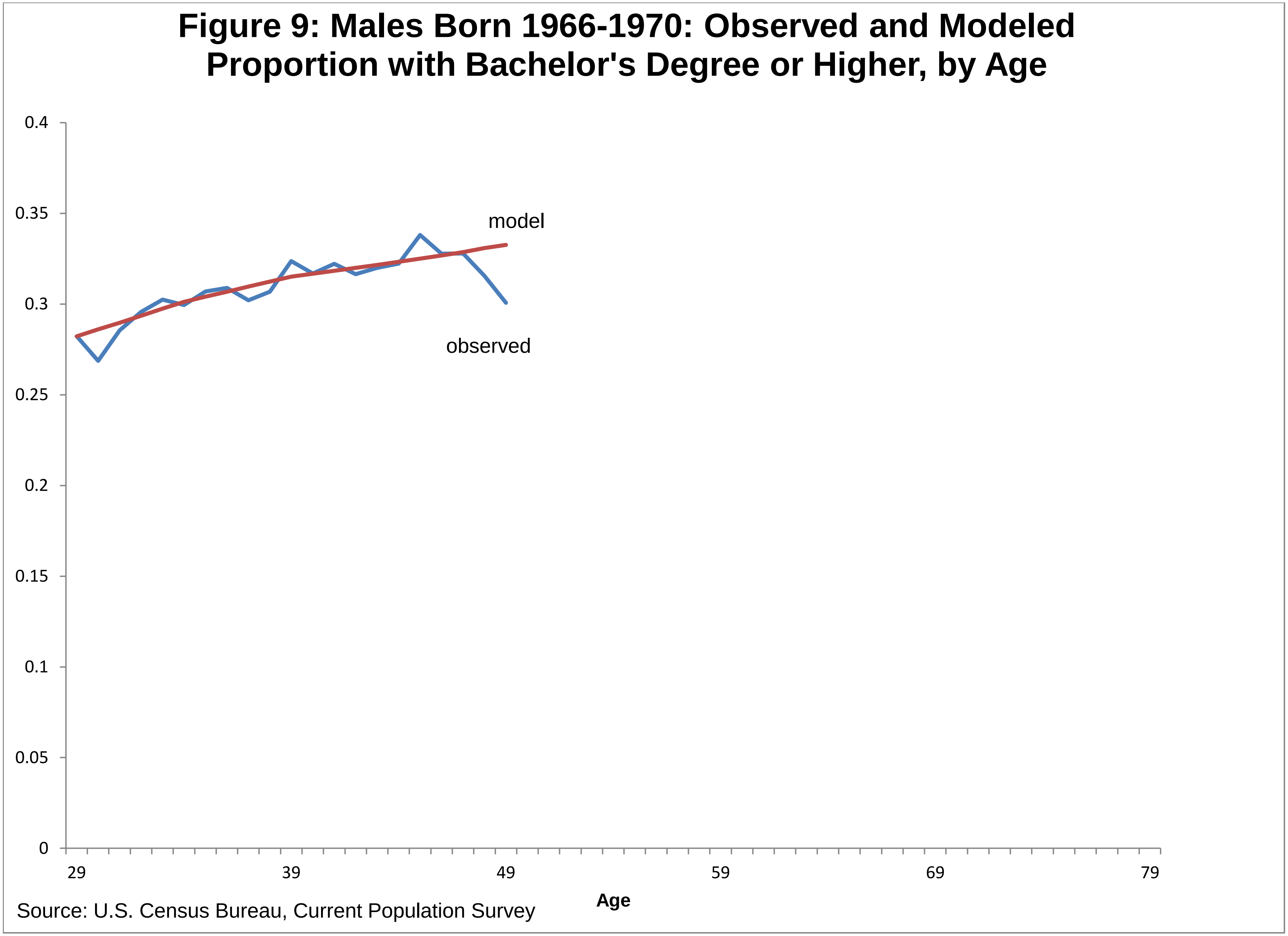
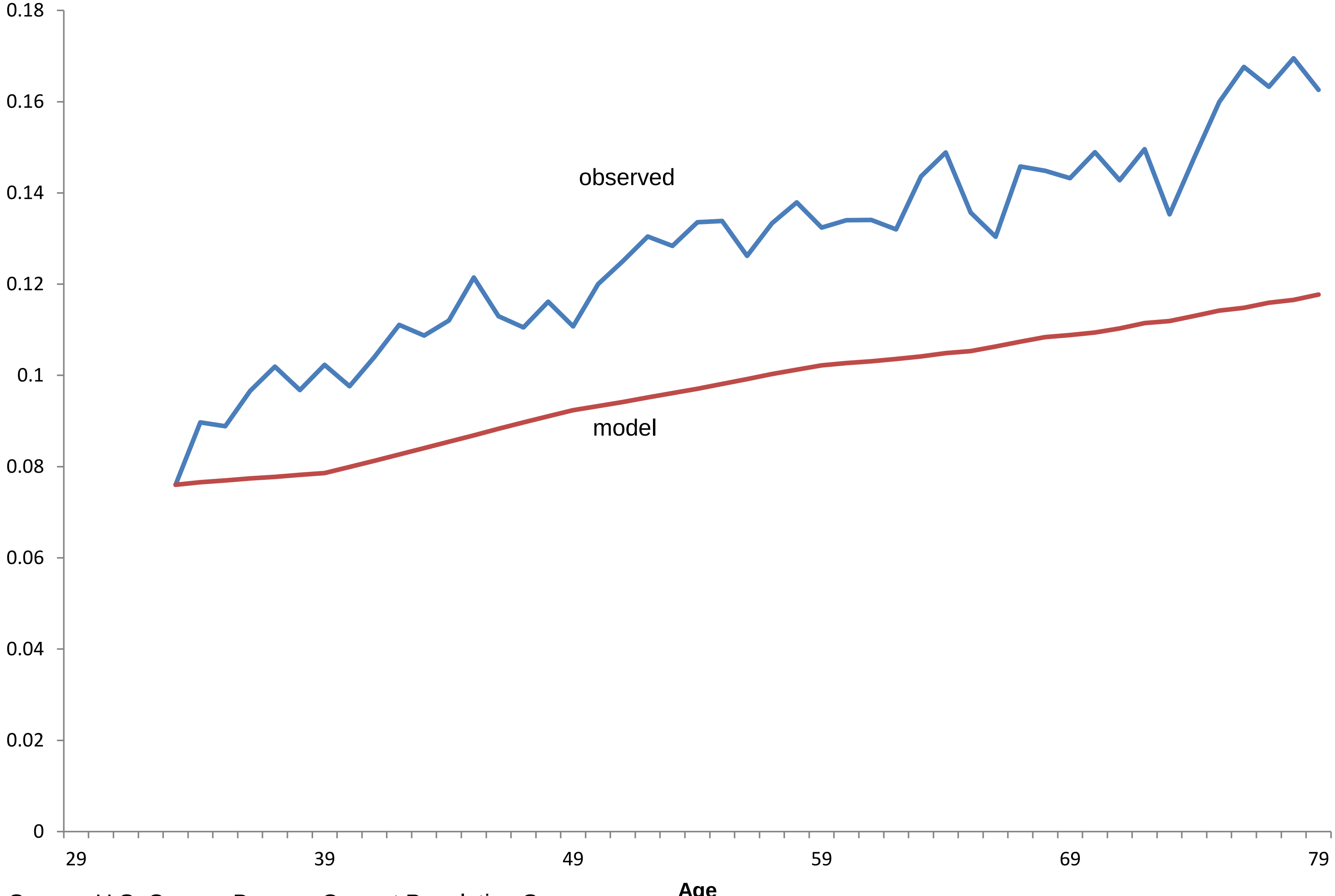


Figure 9: Males Born 1966-1970: Observed and Modeled Proportion with Bachelor's Degree or Higher, by Age
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
model
observed
29
39
49
59
69
79
Age
Source: U.S. Census Bureau, Current Population Survey

Figure 10: Females Born 1931-1935: Observed and Modeled Proportion with Bachelor's Degree or Higher, by Age



Source: U.S. Census Bureau, Current Population Survey