

PREDICTING OLDER AGE MORTALITY TRENDS

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Abstract

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Improving early prenatal and postnatal conditions account for at least 16 to 17 percent of the decline in ten year mortality rates of 60-79 year olds between 1900 and 1960-80. Historical trends in early prenatal and postnatal conditions imply that while the baby-boom cohort may be particularly long-lived compared to past cohorts, mortality rates may not fall as steeply for the cohorts born after 1955 as for earlier cohorts.

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1 Introduction

Life expectancy at older ages has increased sharply in the OECD countries during the twentieth century. In 1900 a 60 year old Italian, Frenchman, or Englishman could expect to live another 13 years and a Swede another 16 years. By 1950 life expectancies at age 60 had risen to 17 and 18 years, respectively. By the end of the century a 60 year old Italian, Frenchman, or Swede could expect to live another 23 years and an Englishman another 21 years.¹ This unexpected increase in life expectancy, while one of the major accomplishments of the last century, has strained social security systems and remains poorly understood, making forecasts of future mortality trends problematic. One particularly intriguing line of research has argued, not without controversy, that aging begins at or even before birth. Maternal health and nutrition pre-program in-utero the later onset of chronic disease. In addition, poor nutrition and infectious disease in early infancy can have a permanent scarring effect (Barker 1992; Barker 1994).

This paper investigates the contribution of early life environmental factors to the twentieth century mortality decline and investigates whether aging is less likely to begin at birth as humans have gained more and more control over their environment. As a proxy for the early life environment we use season of birth. Doblhammer and Vaupel (2001) present convincing evidence that in recent populations those 50 year old and over born in the northern hemisphere live longer if they were born in the fourth quarter instead of the second quarter whereas in the southern hemisphere the pattern is exactly reversed. They argue that those born in the second quarter, after the long winter months, experienced reduced intrauterine growth. The populations they examined were for the most part born in the twentieth century when the mortality transition was already well under way. But, to understand the twentieth century decline in older age mortality, we need to examine a population that reached old age at the beginning of the twentieth century. A unique longitudinal data

¹See *Human Mortality Database*, University of California, Berkeley and Max Planck Institute for Demographic Research. Available at www.mortality.org or www.humanmortality.de.

set allows us to examine the effect of quarter of birth on older age mortality in an American population that was at least age 60 in 1900. We compare quarter of birth effects in this population with those observed in the American population of the same age in 1960-80. This allows us to quantify the importance of the changing relationship between season of birth and older age mortality to the twentieth century mortality decline and to provide suggestive evidence on future mortality trends.

2 Empirical Framework and Data

The past population that we examine is one of white men who fought for the Union in the American Civil War of 1861-65 and who were alive in 1900.² We have detailed data on their individual characteristics and can follow them until death. Our recent population is one of men and women of all races in the 1960-80 micro-census samples. Because we cannot follow these individuals until death, we create age, sex, cohort, and quarter of birth cells and calculate 10 year mortality rates for each cell across the census years. Because we are calculating mortality rates from cell sizes and because age misreporting increases with age we limit the sample to the native-born age 60-79. To ensure comparability across samples we also restrict the Union Army sample to the native-born age 60-79 and examine 10 year mortality rates.

We estimate season of birth effects in the Union Army data by running a probit regression of the form

$$\text{Prob}(\text{death}=1) = \Phi(\alpha + \gamma_1 Q_1 + \gamma_2 Q_2 + \gamma_3 Q_3 + \delta X) \quad (1)$$

where death is death within 10 years, Q_1 , Q_2 , and Q_3 are the first (January-March), second (April-June), and third (July-September) quarters, with the fourth quarter (October-December) omitted,

²The Union Army data were collected by a team of researchers led by Robert Fogel and are available at <http://www.cpe.uchicago.edu>.

and the X is a vector of control variables including age, occupation at enlistment and in 1900, size of city of residence at enlistment and in 1900, household personal property wealth in 1860, marital status in 1900, wartime wound and infectious disease experience, and POW status. We present derivatives for quarter of birth, i , effects, $\beta_i = \frac{\partial P}{\partial Q_i}$.

Using the census micro-samples we construct ten year mortality rates across the 1960-80 micro census samples for a group which is defined by age, sex, cohort, and quarter of birth.³ We then estimate weighted OLS regressions of the form

$$m = \alpha + \beta_1 Q_1 + \beta_2 Q_2 + \beta_3 Q_3 + \delta X + u \quad (2)$$

where m is the mortality rate, Q_1 , Q_2 , and Q_3 are the first, second, and third quarters of birth (the fourth is omitted), X is a vector of age, sex, and cohort controls, and u is an error term. The weights are equal to cell sizes. (We also experimented with a logarithmic specification, but the linear specification gave us a better fit.)

We attribute the difference in ten year mortality rates due to a change in the coefficients on season of birth as

$$Q_{1,UA}(\beta_{1,UA} - \beta_{1,R}) + Q_{2,UA}(\beta_{2,UA} - \beta_{2,R}) + Q_{3,UA}(\beta_{3,UA} - \beta_{3,R}) \quad (3)$$

using the recent function and as

$$Q_{1,R}(\beta_{1,UA} - \beta_{1,R}) + Q_{2,R}(\beta_{2,UA} - \beta_{2,R}) + Q_{3,R}(\beta_{3,UA} - \beta_{3,R}) \quad (4)$$

using the Union Army function, where the β s are the estimated coefficients from the Equation 2 or the derivatives of the coefficients in Equation 1 and where the subscripts UA and R indicate the

³The census samples are available at <http://www.ipums.umn.edu>.

Union Army sample and the recent sample respectively. Note that we are assuming that ten year mortality rates both in the Union Army sample and in the more recent census sample can be written as linear functions of quarter of birth using the estimated coefficients or their derivatives. Also note that season of birth effects represent a lower bound estimate of the effect of early life conditions. As we show in Costa and Lahey (2003), men who grew up in large cities, where infectious disease was endemic, were permanently scarred even controlling for later residence and season of birth.

3 Results and Interpretation

Table 1 shows that quarter of birth predicts older age mortality in both the Union Army sample and in the more recent population, but that the effect of quarter of birth has lessened. Union Army veterans born in either the second or the third quarter had higher mortality rates by 0.04 than those born in the fourth quarter, a 9 percent increase in the mean 10 year mortality rate of 0.45.⁴ In contrast, in 1960-80 those born in the second rather than the fourth quarter experienced an 0.03 increase in mortality rates, an increase of 8 percent relative to the mean 10 year mortality rate of 0.36. Those born in the third rather than the fourth quarter had mortality rates higher by 0.01, a 4 percent increase in the mean 10 year mortality rate. When we expanded our age category to include 50 year olds as well, we found no quarter of birth effects.

Why were spring and summer such bad seasons to be born in? We can rule out social differences in the distribution of births. In the Union Army data, household wealth in 1860 (either own or parents') is a good indicator of household wealth during the growing years. But, there was no difference in either mean total household personal property wealth or real estate wealth in 1860 between those born in the spring and summer and those born in other quarters. (T-tests yielded $P > |t| = 0.621$ and $P > |t| = 0.909$, respectively.) We also looked at measures of the father's

⁴Kanjanapitkul (2002) was the first to notice that men born in the second quarter in the Union Army data had shorter life spans than men born in the fourth quarter.

occupational status by quarter of birth for all children age 10 or less in the micro-sample of the 1900 census, the only early census which identifies month of birth. But, there was no difference in the father's mean occupational score or his Duncan socioeconomic index between those children born in the spring and summer and those born in other quarters or those children born in the spring and those born in other quarters. (The differences were significant at only the 20% level.) We can also rule out any mortality selection effects in early life as potential explanations for our season of birth effects. As we discuss below, infant mortality peaked in the summer months, implying that babies born in the spring and summer who survived should be the longest-lived if only the fittest survive a high mortality regime.

Past patterns in mortality and birth weights suggest that seasons affected both the adequacy of maternal diets and infectious disease incidence in early infancy and in pregnancy. The mortality of infants and of children below age two peaked in the summer because of diarrhea and its sequelae throughout the nineteenth century, starting to dampen in the late nineteenth and early twentieth century but persisting until 1920 (Condran and Lentzer 2003). Children born in the spring and summer, particularly if they were not breast-fed, may have experienced low weight gain in infancy, which would increase their risk of coronary heart disease later in life (Eriksson et al. 2001). As the summer mortality peak dampened, the older age mortality effect of a summer birth may have declined.

Poor nutritional intake and maternal infection from respiratory disease during the winter months may have led to low birth weights and high prematurity rates.⁵ A study of a rural North Carolina mill town begun in 1939 found that in the spring vitamin levels were at their lowest point (Beardsley 1989: 204). Data on birth weight and prematurity rates from Johns Hopkins in the first third of the twentieth century suggest that those born during the spring (March-May) had lower birth weights than those born at other times of the year and that those born during the second quarter

⁵The winter mortality peak from respiratory disease did not dampen until 1920 (Michael Haines, personal communication).

(April-June) had higher prematurity rates (see Figure 1). But, even among full-term babies, those born in the spring weighed 73 grams less than those born in the summer, controlling for gestational age, the sex and race of the child, cohort, and mother's demographic characteristics. Low birth weight is associated with hypertension and coronary heart disease (Roseboom et al. 2001) and with cerebral hemorrhage (Roseboom et al. 2001; Eriksson et al. 2000).

Cause of death information in the Union Army data is consistent with predictions of higher coronary heart disease rates for men born in the spring and summer. Men born in the third compared to the fourth quarter were 1.3 times more likely to die of heart disease. Men born in the second quarter were 1.7 times as likely to die of stroke as those born in the fourth quarter and those born in either the first or third quarter were 1.6 times as likely to die of stroke as those born in the fourth quarter.⁶

Declining infectious diseases rates, particularly from summer water-borne diseases, and an improving food supply reduced the older age mortality impact of season of birth effects between 1900 and 1960-80. The declining impact of season of birth accounts for roughly 16 to 17 percent of the 0.087 difference in the 10 year mortality rates of Union Army veterans and of Americans in 1960-1980. (Equations 3 and 4 yield 0.014 and 0.015, respectively, which represents 16 and 17 percent of the difference in 10 year mortality rates.) Because differences in the seasonality of births in the two samples are negligible, the difference in ten year mortality rates due to changes in season of birth is virtually zero.⁷

⁶Results on cause of death are from independent competing risk hazard models that control for demographic and socioeconomic characteristics. The respective hazard ratios were 1.251, 1.701, 1.583, and 1.596 with respective standard errors of 0.156, 0.362, 0.336, and 0.347.

⁷The fractions born in the first, second, third, and fourth quarters were 0.261, 0.252, 0.241, and 0.245, respectively, in the Union Army sample. The respective fractions for Americans in 1960-1980 were 0.266, 0.232, 0.257, and 0.245.

4 Predicting Future Mortality Trends

The season of birth mortality effects that we estimated both for men age 60-79 in 1900 and for men and women of that age in 1960-80 arose from poor maternal nutrition and from infectious disease exposure in early infancy. The baby-boom generation (born 1945-1964) grew up at time when infectious disease was rare and when the food supply was not as limited by agricultural seasonality and this generation may not even experience an adverse effects of being born in either the spring or summer. Data from the 1960s show that the birth weight seasonality pattern has shifted from that observed in the past. The birth weights of babies born in 1959-1967 in New York peaked between March and May and reached a trough between June and August (Selvin and Janerich 1971). National natality data for the United States show that between 1968 and 2000 the lightest black babies are now born from May to August and the lightest white babies are born from June through August (see Figure 2). Current seasonality patterns may depend in part upon interactions between vitamin D and the mother's RH factor (Gloria-Bottini et al. 2000). However, if there is an adverse older age mortality effect of being born in the summer, it too has diminished. Figure 2 shows that seasonal fluctuations in birth weight have dampened, particularly among blacks, whose seasonal birth weight pattern was more pronounced than that of whites in the 1960s. Increases in vitamin supplementation may account for the flattening out of the birth weight curve over the second half of the twentieth century.

Trends in birth weight seasonality suggest that improving prenatal and early postnatal conditions will lead to a continuing decline in older age mortality. Season of birth effects alone suggest that in 2025 10 year mortality rates at ages 60-79 will be at least 3 percent lower than those of the elderly in 1960-80.⁸ Although a 3 percent decline over 55 years is modest, recall that between 1900 and 1960-80, a 70 year time span, the diminishing impact of season of birth on mortality

⁸We assume that the coefficients on season of birth in a mortality regression would be 0 for the baby-boom generation and calculate the difference in 10 year mortality rates due to changes in the coefficients using the 1960-80 function.

rates led to a 3 percent decline in mortality rates.

5 Conclusion

Our findings provide both good and bad news for social security systems. The cohort which will reach age 70 in 2025 was born in 1955 after sharp improvements in prenatal and postnatal conditions and this cohort may be particularly long-lived compared to past cohorts. Because of long-run fertility trends, this baby-boom cohort will also be a very large cohort relative to later cohorts, straining pay-as-you-go systems. However, the difference in early life conditions for cohorts born in 1955 instead of 1995 was not as stark as that for cohorts born in 1915 instead of 1955. The rate of mortality declines may therefore diminish after 2025 because any further changes could not come from improving early life factors – they would need to come from improvements in medical care or in health habits.

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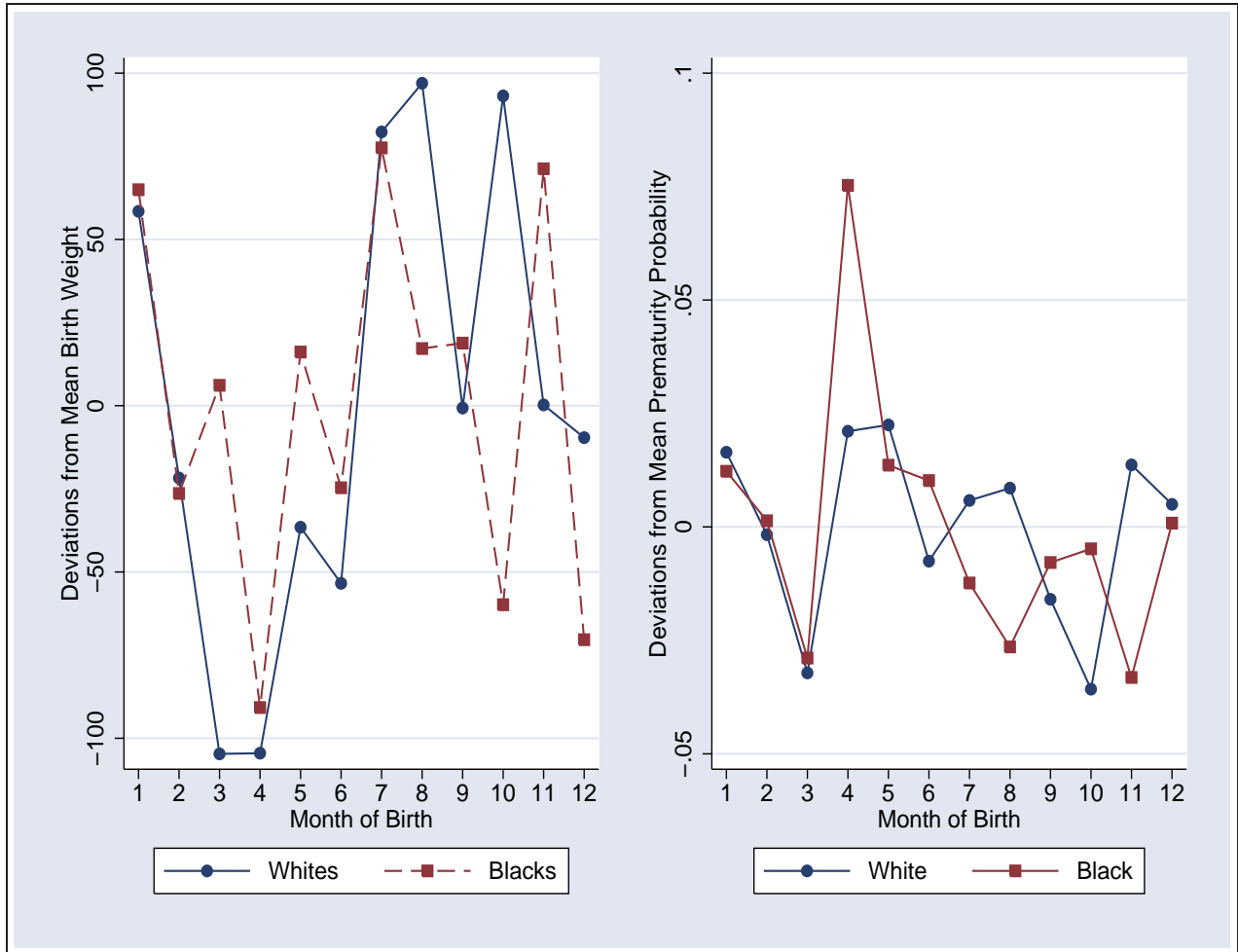
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Table 1: Comparison of the Effects of Quarter of Birth on Ten Year Mortality Rates of 60-79 Year Olds, Native-Born Union Army Veterans, 1900, and Native-Born Americans, 1960-1980

	UA Veterans		1960-1980	
	$\frac{\partial P}{\partial x}$	Std Err	Coef- icient	Std Err
Dummy=1 if born in				
First quarter	0.020	0.022	0.003	0.005
Second quarter	0.042*	0.023	0.030‡	0.006
Third quarter	0.041*	0.023	0.013†	0.006
Fourth quarter				
Observations	4927		128	
Pseudo R ² /R ²	0.036		0.984	

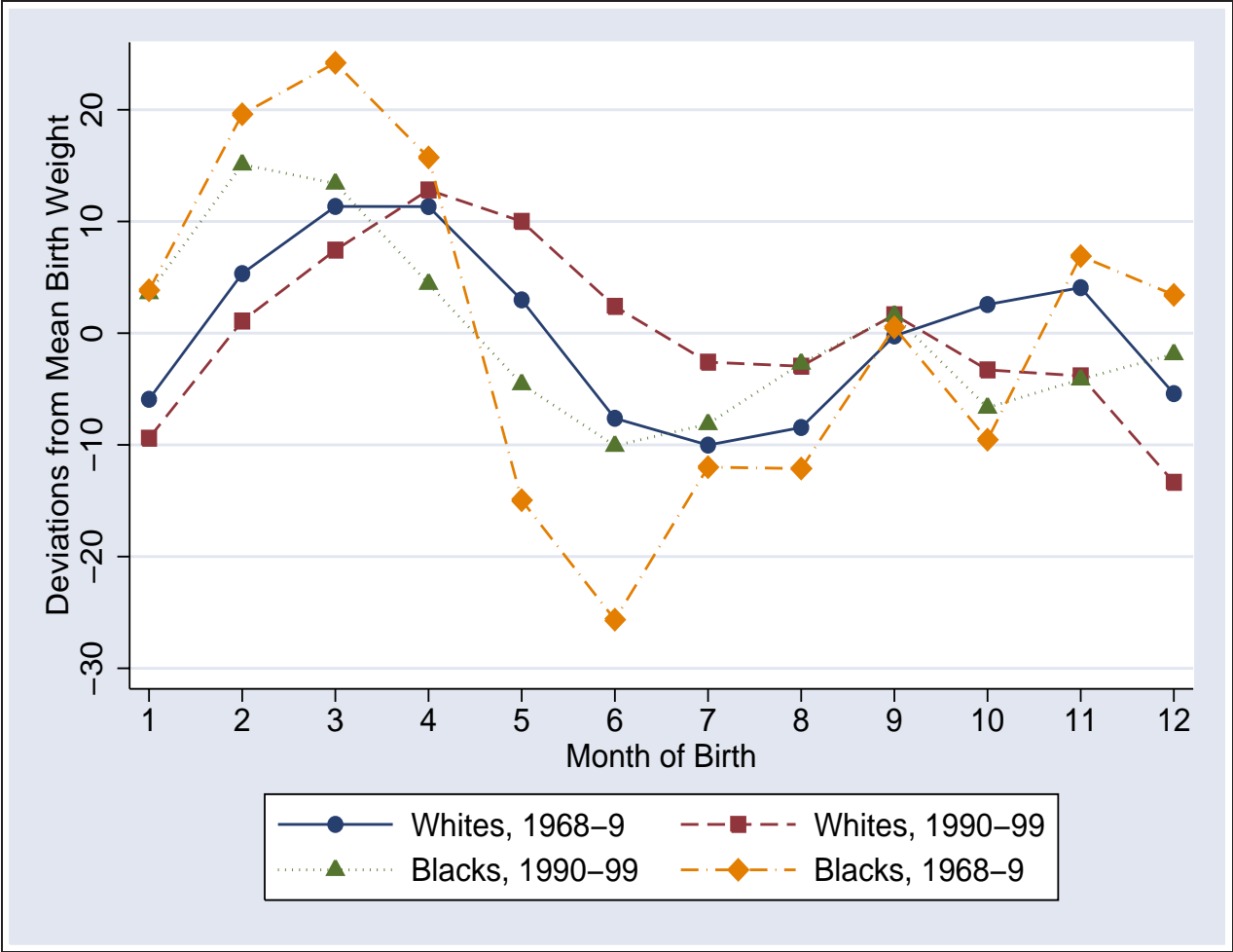
The Union Army regression results are from a probit equation on individual level data in which the dependent variable is whether the veteran died within 10 years of being observed alive in 1900 (see Equation 1). The 1960-1980 results are from a weighted ordinary least squares equation using group-level data (see Equation 2). See the text for the control variables. Ten year mortality rates in the Union Army sample are 0.445 and in 1960-1980 are 0.358. The symbols ‡ and † indicate that the coefficient is statistically significantly different from zero at the 1 and 5 percent level, respectively.

Figure 1: Deviations from Mean Birth Weight and Mean Prematurity Probability, Johns Hopkins University Hospital, 1897-1935



Estimated from the indoor and outdoor records of Johns Hopkins Hospital described in Costa (forthcoming). All birth weights (and deviations from mean birth weight) were measured in grams.

Figure 2: Deviations from Mean Birth Weight, National United States Data, 1968-9 and 1990s



Calculated from various issues of *Vital Statistics of the United States*.