Early-Life Experience and Old-Age Mortality: Evidence from Union Army Veterans

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ABSTRACT

This study examines the relation between risk exposures in early life and hazard of mortality among 12,000 Union Army veterans aged 50 and over in 1900. Veterans' risk exposures prior to enlistment as approximated by birth season and country, residential location, height at enlistment, and occupation prior to enlistment significantly influence their chance of survival after 1900. These effects are robust irrespective of whether or not wartime stress and socioeconomic well-being circa 1900 are taken into account, however, they are sensitive to the particular life stage in later life that has been selected for survival analysis. Whereas some of the effects such as being born in Ireland, coming from big cities, and occupation mainly influence survival between 1900 and 1910, the effects of being born in autumn, residential locations, and being the tallest third are more salient on survival after 1910. Compared to corresponding findings from more recent cohorts, the exceptional rigidity of the effects of risk exposures prior to enlistment on old-age mortality among the veterans highlights the harshness of living conditions in their early life.

INTRODUCTION

Death is an instantaneous event, yet its timing can usually be predicted by weighing exposures to risk factors throughout the life course, from conception to the final stage of life. This is especially the case for today's OECD countries where most deaths are caused by degenerative diseases in old age that evolve over a long period of time. Among all deaths in the United States in 1981, the proportion of deaths at age 65 and over was about 62 percent (Myers, 1989). Due to the aging of the American population and the compression of mortality into older age, the corresponding proportion increased to 74 percent[1] in 2002. With this trend continuing, it can be expected that old-age mortality will play an increasingly predominant role in determining life span in the future. A successful identification of the life-course determinants of old-age mortality and delineation of their pathways thus is crucial for a better understanding of mortality trends in the past and its possible trajectories in the future.

The past two decades have witnessed a growing interest in the relation between early-life conditions and mortality in later life. Accumulative evidence from a number of studies suggests that the nutritional and epidemiological environment at birth–as approximated by birth weight, birth season and place, mothers' health conditions during pregnancy, and infant mortality rates circa birth–can have a long lasting impact on morbidity and mortality in later life (e.g. Barker and Osmond 1992; Barker 1998; Avchen et al 2001; Doblhammer and Vaupel 2001; Bengsston and Lindström 2003; Fogel 2004; Costa

[1] Calculated from the 2002 mortality report by the National Center for Health Statistics of the United States. http://www.cdc.gov/nchs/fastats/pdf/mortality/nvsr53_05t03.pdf.

and Lahey 2005). Childhood conditions such as exposure to diseases, malnutrition, and poverty can all pose a threat to well-being in later life (e.g. Elo and Preston 1992; Hayward and Gorman 2004; Davey-Smith et al 2001; Blackwell et al 2001; Luo and Waite 2005). Height, as a proxy of net intake of nutrition during growing years (Fogel et al. 1983; Fogel 1993; Riley 1994), was also found to be related to adulthood mortality (e.g. Waaler 1984; Costa 1993; Fogel and Costa 1997; Fogel 2004).

In light of these empirical findings, two questions are in need of further clarification. The first question concerns whether and to what extent socioeconomic conditions in later life can modify the observed impact of early-life conditions on survival in later life. Since risk exposures in early life can indirectly influence chance of survival in old age through its effect on adulthood SES, a comprehensive understanding of the impact of earlier exposures on health and mortality in later life requires bringing in adulthood SES. Current literature has failed to yield a consistent finding on this topic. Whereas results from several studies show that adjusting for adulthood SES substantially attenuates or even abolishes the effects of early-life conditions on later mortality (e.g. Ben-Shlomo and Davey-Smith 1991; Hayward and Gorman 2004), findings from some other studies document the significant impacts of early-life conditions on mortality at old ages even after SES in later life having been taken into account (e.g. Costa and Lahey 2005; Benggston and Lindström 2003).

The second pending issue pertains to the identification of the life stage(s) in later life when risk exposures in early life can have a significant impact on health and survival, a topic that has received little attention in previous studies. To say that risk exposures in early life can negatively influence chance of survival in later life does not necessarily mean that the impact is active across all life stages in later life. This is because, on the one hand, the effects of risk exposures in early life can be latent for a long time before their manifestation (Elo and Preston 1992); on the other hand, since frailer individuals and individuals who experienced serious health insults during early life are presumably to die earlier, mortality selection can modify or even reverse the observed relation between early-life conditions and mortality, depending on which life stage in later life has been selected for analysis. In other words, the relation between risk exposures in early life and mortality in later life might be contingent on age, the confirmation of which calls for an examination of how the effects of earlier risk exposures can change as a function of age in later life.

The purpose of this study is to tackle the two issues detailed above through a sensitivity analysis of the effects of risk exposures in early life on old-age survival among Union Army veterans who fought the American Civil War. This sensitivity analysis consists of two parts. The first part concerns whether and to what extent bringing in veterans' wartime exposures and SES in old age can modify the impact of risk exposures in early life on their chance of survival in old age. Analyses in the second part examine how the impact of earlier exposures on mortality changes at different life stages in old age, in the hope to identify the life stage in which earlier risk exposures pose a more salient impact and to infer the possible role of mortality selection in the causal pathway from risk exposures in early life to chance of survival in old age.

The findings from this study and their implications will be scrutinized in the historical context of the nineteenth–century United States. Most of Union Army veterans were born between 1825 and 1845, exposed to a far more adverse epidemiological environment all through their life compared to today's Americans. Infectious diseases posed a serious threat to veterans' health. In Massachusetts, death rates for respiratory tuberculosis declined from 365 per 100,000 in 1861 all the way to 37 per 100,000 in 1945, a remarkable reduction of 90 percent (Bureau of the Census 1949, p.48). The average number of chronic conditions per Union Army veteran at age 50 to 54 is three, as compared to one for American males in the same age group in the 1990s (Fogel 2004, p.91). Given the unprecedented improvement in the epidemiological environment since the nineteenth century, it becomes important to examine how exposures in early life were related to old-age mortality in the past, and to what extent this relation has changed over time.

DATA

The data used in this study comes from the Union Army sample (Fogel 2000, 2001) that contains detailed records on major life events from childhood to death for roughly 36,000 Union Army soldiers who fought the American Civil War. These records provide abundant information on demographic profiles prior to enlistment, military service, pension application, medical records from both wartime and postwar physical examinations, and socioeconomic conditions from 1850 to 1910 for those veterans who have been successfully linked to the US censuses in this period. By integrating relevant information from all sources, the working sample for this study includes life-cycle records for about 12,000 veterans who survived to 1900 and who applied for pensions prior to 1900. **Table 1** lists veterans' three life stages as well as the variables used to characterize each life stage.

(Table 1 about here)

An important issue concerns how to handle missing values for the variables used in this study. For most variables listed in **Table 1**, the proportion of cases with missing values is less than 10 percent. Due to the difficulties encountered in linking the Union Army sample to the 1900 census, however, socioeconomic variables such as occupation in 1900, marital status, owning or renting house and so forth turned out to have a significant proportion of cases with missing values, ranging from 18 to 41 percent. In this study, to retain most cases for data analysis, missing values for these variables have been coded as "unknown" so that cases with missing values can still stay in the analysis.

The Union Army sample provides rich demographic information on veterans' life experiences prior to enlistment. About 80 percent of the veterans were born between 1830 and 1845. In terms of country of birth, 83 percent of the veterans were native-born, 5.7 percent were born in Germany, and 3.7 percent in Ireland. 6.6 percent of the veterans came from one of the 25 largest cities in 1860, with a minimum population of 37,000. More than 85 percent of the veterans lived in the North Central and North Atlantic regions prior to enlistment. Based on information from the 1860 census, the average value of personal property for a married veteran is about $400; the average value of real estate is about $1,171.

Height at enlistment shows considerable variation with the tallest third about 5.4 inches taller than the shortest third, after age at enlistment has been adjusted.

Analysis of possible sample selection bias indicates that the Union Army sample is generally representative of the population of white recruits into the Union Army. During the Civil War, approximately 95 percent of white males between age 18 and 25 in the United States were examined and approximately 75 percent of the examinees were inducted (Fogel et al. 1983). Comparisons between the Union Army sample and the northern population in the same age group suggest these two groups resemble each other in terms of wealth in 1850 and 1860 and in terms of mortality circa 1900 (Fogel et al 2001). The wealthiest whites in the early 1860s, however, might be less represented in the sample since some of them could have paid a substitution fee to have others enlist for them.[2]

RESEARCH DESIGN AND METHODS

The basic framework that guides the empirical analyses in this study is illustrated in **Figure 1**, where the main causal relationships as well as the mean age and timing for the major life events experienced by veterans are presented. On average, each veteran spent about two years in military service. The average age at the first physical examination is 47 years old when BMI and disease information was recorded.

(Figure 1 about here)

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[2]Based on information from the 1860 census, Wilcox (1992) presented the antebellum wealth distribution across occupational groups. Comparison between his finding and what I have found in the Union Army Sample suggests that professionals and proprietors in the Union Army sample were not as wealthy as their counterparts in the general population.

The focal dependent variable is the hazard rate of dying at any time after 1900 given that a veteran has survived to 1900, which is modeled in the Cox Proportional Hazard (CPH) analysis as a function of exposures to risk factors across three life stages: early life, wartime experience and socioeconomic conditions circa 1900. Mathematically, the CPH modeling can be expressed as:

$$h(t) = [h_0(t)] \exp(b_1x_1+b_2x_2+\ldots b_nx_n)$$

Where:

h (t) = the hazard function at time t. In this study it represents mortality risk at time t.

h_0 (t) = the baseline hazard, resembling the constant in multivariate regression analysis.

$x_1, x_2 \ldots x_n$ = explanatory variables in the model.

$b_1, b_2 \ldots b_n$ = estimated coefficients in the CPH model. For example, if x_1 is a continuous variable, b_1 can be interpreted as: 'For each unit increase in x_1, the relative hazard becomes exp (b_1) as much, holding constant the other explanatory variables in the model.'

An important assumption of the CPH analysis is the proportionality of hazard, that is, the effect of changing values for a certain explanatory variable on the hazard rate is constant, independent of time. In practical applications, it is usually the case that the proportionality assumption does not hold for all the explanatory variables adopted in the CPH models. Even when this assumption has been moderately violated, in most cases the CPH analysis can still be resilient and generate relatively unbiased estimates of the coefficients, since the CPH models are extraordinarily general and nonrestrictive (Allison 1984; Wu 2003).

The sensitivity analysis of the effects of veterans' risk exposures in early life on survival after 1900 consists of four CPH models. Model 1 uses risk exposures in early life to predict mortality risk after 1900; Model 2 is the full model where explanatory variables characterizing all three life-stages are used to predict mortality risk. Model 3 uses the same explanatory variables as in Model 2 to predict mortality risk within 10 years after 1900, whereas Model 4 focuses on predicting mortality risk after 1910. Comparisons between results from Model 1 and 2 are expected to reveal whether and to what extent an incorporation of exposures in wartime and later life can modify the effects of early-life exposures on mortality risk in old age. The decomposition of survival after 1900 into the first ten years in Model 3 and after the first ten years in Model 4 makes it feasible to reveal the specific period after 1900 in which risk exposures in early life pose a more salient impact on chance of survival. Meanwhile, such decomposition also allows for an inference of the possible role of mortality selection through comparing the direction of the coefficients for a particular predictor from these two models. For example, if a certain variable shows negative effects on survival in the first ten years after 1900, but the effects start to reverse when survival after 1910 is concerned, it becomes reasonable to infer that mortality selection in the period between 1900 and 1910 results in the reversed effects.

RESULTS

(Table 2 about here)

As indicated in **Table 2**, season of birth shows a significant impact on old-age survival among veterans. Results from Model 1 indicate that being born in autumn (September to November) is associated with a six percent lower mortality risk than being born in spring (March to May). This effect is statistically significant at α=0.05 level. Comparisons between results from Model 1 and 2 suggest the effect persists when both wartime distress and old-age conditions have been taken into account, although its level of statistical significance declines slightly. This finding is consistent with what has been reported in most previous studies, where it was found that being born in autumn or the fourth quarter is associated with lower mortality risk (e.g. Doblhammer and Vaupel 2001; Lerchl 2004; Costa and Lahey 2005).

Explanations for the effect of birth season cannot be separated from the seasonal variation in birth weight that has long been used as an indicator of nutritional well being *in utero* and a strong predictor of neonatal health and even health in adulthood (e.g. Carlson 1984; Kramer 1987; Barker and Osmond 1992; Barker 1998). Low birth weight has been widely regarded as a health hazard that poses a serious threat to neonatal health. An increasing number of studies have identified a seasonal pattern in birth weight, with spring births on average having higher birth weight than births in other seasons (e.g. McGrath et al. 2006; Selvin and Janerich 1971; Roberts 1975; Murray et al., 2000).

The Union Army sample does not contain information on birth weight. Based on information on height at enlistment, however, information on birth weight can be inferred, because adult height is closely related to birth weight. Sørensen et al. (1999) examined the relation between birth weight and adult height among a group of young Danish men. Their findings suggest a strong positive association between birth weight and adult height: for subjects with birth weight less than 2,500 g, mean height was 175.7 cm, while for those with birth weight more than 4,501 g, mean height was 184.1 cm. **Figure 2** illustrates the relation between season of birth and height at enlistment among Union Army veterans, after age at enlistment has been taken into account. Veterans born in spring are on average taller than those born in other seasons. Therefore, it becomes reasonable to infer that being born in spring is also associated with the highest birth weight among the veterans, which is consistent with what the literature says.

(Figure 2 about here)

A paradox now surfaces. If spring-born veterans are better nurtured *in utero* than those born in autumn, how could they end up with a higher mortality risk in old age? Two explanations seem plausible here. One is mortality selection prior to 1900. If a higher proportion of autumn-born veterans died before they could survive to 1900, leaving those exceptionally robust ones survived to 1900, mortality risk after 1900 for autumn-born veterans would appear lower than that for spring-born veterans. Such selection of mortality can happen any time prior to 1900 including infancy, childhood, wartime, or in the postwar period prior to 1900.

The other plausible explanation lies in the seasonal pattern in the incidence of infectious diseases. It has been documented that influenza and acute viral respiratory tract infections peak in winter and early spring (e.g., Shek and Lee 2003; Greene et al. 2006), whereas tuberculosis and typhoid fever are found to be more frequent in summer (e.g., Leung et al. 2005; Douglas et al. 1996; Hamze and Vincent 2004). Being born in autumn when temperatures gradually cool implies a relatively benign epidemiological environment in the initial days of infancy, which could lower the chance of being infected with diseases. It should also be noted that since autumn is the harvest season, young mothers are usually well provided for at this time of the year so that they can provide quality breastfeeding to their newborns.

An important finding from this study is that the survival advantage associated with autumn-born does not come into effect until late into old age. This can be illustrated through a comparison between results from Model 3 and 4. In the initial 10 years after 1900, being born in autumn shows no significant advantage in survival, as indicated by results from Model 3. But this changes in Model 4, where the relative mortality risk after 1910 for veterans who were born in autumn is six percent lower than for those born in spring. The current literature on the relation between birth season and adulthood mortality misses the fact that such a relation is contingent on the life stage at which mortality differentials have been analyzed. In other words, age can be an important modifier of the relation between birth season and adulthood mortality, a confirmation of which calls for a sensitivity analysis that examines how this relation changes as a function of age.

Birthplace also plays an important role in old-age survival. Veterans born in Germany and Ireland had significantly higher mortality risk than their native-born counterparts. This is especially true for veterans born in Ireland whose relative mortality risk is 21 percent higher than for native-born veterans (Model1). The relative mortality risk for veterans from other countries (mostly France, Norway, Sweden, and Switzerland) is about 14 percent lower compared to native-born veterans. A comparison between results from Model 1 and 2 suggests that all these observed effects of birth country in Model 1 are robust with or without controlling for wartime distress and socioeconomic conditions circa 1900.

A review of the results from Model 3 and 4, however, highlights a difference in the timing of the effects of birthplace. The negative effects associated with being born in Germany do not become significant until after 1910, when the average age of survived veterans is about 70 years old. By contrast, the survival disadvantage posed by being born in Ireland is most salient in the initial 10 years after 1900, with an excessive mortality risk of 40 percent as compared to that for native-born veterans. Interestingly, for veterans who were born in other countries, their mortality risk is about six percent higher than for native-born veterans in the first 10 years after 1900, but this effect gets reversed in Model 4 when mortality after 1910 is concerned, with a relative mortality risk 28 percent lower than for native-born veterans. Such a reverse in the direction of effect implies that mortality selection between 1900 and 1910 contributes to the substantially lower mortality risk after 1910 for those veterans born in other countries.

The excessive mortality risk for veterans who were born in Ireland could be related to the Great Famine, also termed as the Potato Famine, in the 1840s. Although the famine broke out in 1845 when an airborne fungus wiped out most of the potato crop in Ireland, structural factors preceding the famine had impacted life well before, including overpopulation, rural violence, volatile food prices, capital shortages, and the decline of the cotton industries resulting from the mechanization of textile industries (Mokyr 1983). These unfavorable structural factors together with the Great Famine had a profound demographic impact on both sides of the Atlantic. Within Ireland, population growth before the 1840s was replaced by a long period of population decline lasting into the twentieth century. The famine also unleashed an unprecedented emigration flow to North America (O'Rourke 1995). This is clearly illustrated in **Figure 3**, which shows the number of immigrants from four countries to the United States from 1841 to 1860. Immigrants from Ireland skyrocketed starting from 1845, with a peak in 1851 when more than 200,000 Irish migrated to the United States in a single year. Given the far-reaching negative effects posed by the Great Famine on nutrition and well-being, it becomes no surprise that Ireland-born veterans had a lower chance of survival in old age as compared to their US-born counterparts.

(Figure 3 about here)

Similarly, as indicated in **Figure 3**, the early 1850s also witnessed a hike in the number of immigrants from Germany. Nearly one million German immigrants entered the United States in the 1850s, including many refugees from the 1848 revolutions in Europe. The main factor behind this immigration flow was economic hardship caused by unemployment, wars, crop failure and starvation in Germany in this period. These miseries early in life could have negatively influenced chance of survival in old age for Germany-born veterans.

There is also evidence indicating that even after their arrival in the United States, veterans from Ireland and Germany did not fare as well as native-born Americans. **Figure 4** presents the difference in wealth between veterans from these two countries and those born in the United States, based on information from the 1860 census. These information is only available for some older veterans, most of whom had already been married by 1860 and who have been successfully linked to the 1860 census. The main economic advantage of US-born veterans is their real estate, the value of which is substantially higher than that for veterans born in Germany or Ireland.

(Figure 4 about here)

Given the predominant share of immigration from Germany and Ireland in the United States in the mid nineteenth century, the findings here suggest that the health status of immigrants in the United States in the mid-nineteenth century was worse than native-born Americans. This is consistent with the estimate that the American height advantage over Western and Northern Europeans was in between three to nine centimeters in the middle of the nineteenth century (Komlos and Baur 2004). Height records at enlistment from the Union Army sample suggest that foreign-born veterans were on average about one inch shorter than native-born veterans.

Residential location prior to enlistment makes a significant difference in veterans' chance of survival in old age. Coming from big cities prior to enlistment–defined as one of the 25 largest cities in 1860 with a minimum population of 37,000–is associated with an elevated mortality risk of 15 percent (Model 1). [3] This effect remains virtually the same in Model 2 where variables characterizing wartime distress and socioeconomic conditions circa 1900 have been incorporated in the analysis. Similar findings were also documented in previous studies where urban settings are shown to be associated with poor health in both Europe and the United States in the nineteenth century (Preston 1977; Riley 2001, Fogel et al. 2001, Fogel 2004, Haines 2001, Wilson and Pope 2003). Haines' study (2001) on the urban mortality transition in the United States from 1800 to 1940 suggests that sustained mortality

[3] Calculated from the 1860 census by the Census Bureau of the United States.

transition in the United States did not start until about the 1870s. Thereafter, the decline of urban mortality proceeded faster than in rural areas, and the urban penalty was eliminated around 1940. However, Preston's review (1977) on the rural-urban disparity in mortality found that the rural advantage lasted all the way to 1960s in the United States, England and Wales, although the advantage shrank over time. An opposite pattern has been identified in developing countries where public health programs and medical expenditures have been disproportionately directed towards large urban areas, which in turn results in lower mortality rates there (Preston 1977; Fogel 2004).

Several factors might account for the survival disadvantage associated with living in urban areas in the nineteenth century. First, the higher population density in urban areas means more hosts for communicable diseases and easier transmission of water and airborne diseases. Crowded housing is a big contributing factor to the prevalence of tuberculosis in nineteenth-century Western Europe (Riley 2001). Infectious diseases such as tuberculosis, cholera, typhoid fever, small pox, and malaria caused most of premature deaths in the nineteenth century, which has been well elaborated in the paradigm of the epidemiological transition (Omran 1971). Even in the late twentieth century communicable diseases together with maternal and perinatal causes, and nutritional deficiencies, still account for the majority of deaths in India and sub-Saharan Africa (Murray and Lopez 1996; Heuveline et al. 2002). Second, public health infrastructure such as water treatment and delivery, sewage removal, and housing failed to keep pace with the increase of city population. The delivery of pure water and the removal of waste in big cities in the second half of the nineteenth century required major advances in hydraulic equipment, pipes to deliver the water and carry off the waste, and in new construction techniques required to build tunnels over long distances, which were usually beyond the capacity of the city governments at that time (Fogel 2004). Third, the booming manufacturing sector in urban areas in the late nineteenth century resulted in more air and water pollution. For example, Wilson (2003) described the trend in the prevalence of chronic respiratory diseases among Union Army veterans. One of the key findings in his study is that the prevalence rate increased between 1895 and 1910. Wilson conjectured that one of the contributing factors could be the deteriorating air quality in urban areas in this period. Finally, inadequacy in understanding the disease process seriously hampered endeavors by public health agencies to combat communicable diseases in most nineteenth century. Speculations on the linkage between bacteria and infectious diseases began prior to the nineteenth century, but the science of microbiology did not become established until after 1850 (World Health Organization 2003). The lack of knowledge also complicated water delivery in urban areas, which posed a big challenge for public health in the nineteenth century. For instance, in 1897 about half of all American municipalities used lead water pipes (Troesken 2003). But few people at that time were aware of the hazards caused by the use of lead pipes. Troesken's investigation suggests that in the average town in 1900, the use of lead pipes increased infant mortality and stillbirth rates by 25 to 50 percent.

Results from Models 3 and 4 further suggest that the survival disadvantage associated with coming from big cities only becomes significant in the period from 1900 to 1910, but not in the period after 1910. Veterans from big cities had a 21 percent higher mortality risk than those from rural areas in the period from 1900 to 1910. This effect becomes attenuated and insignificant in Model 4 when mortality risk after 1910 is concerned. The findings here indicate that the urban penalty in mortality is contingent on the life stage selected for mortality analysis, something previous studies have overlooked.

The results from the four CPH models also reveal a geographic pattern on mortality distribution among the veterans, with coming from North Atlantic region associated with a higher mortality risk as compared to coming from other regions prior to enlistment. In reference to veterans from North Atlantic region, the mortality risk is reduced for veterans from South Atlantic, North Central, South Central, and Other region by 9 percent, 10 percent, 11 percent and 23 percent respectively, as indicated in Model 1 where only early-life exposures are used to predict mortality risk. [4] Most of the survival advantages associated with coming from regions other than the North Atlantic, however, become attenuated or insignificant in Model 2 where wartime distress and socioeconomic conditions circa 1900 are brought into analysis. This implies that some of the effects of residential region prior to enlistment on mortality risk in old age are correlated with the effects of variables characterizing living conditions in later life, and when these variables are taken into account, the effects of residential regions in early life become smaller and less salient.

A plausible explanation for the elevated mortality associated with the North Atlantic region is the huge influx of immigrants in this area during most of the nineteenth century. Big port cities like New York, Boston and Philadelphia were usually the entry places for most

[4] 'Other region' includes mainly western states.

immigrants from European countries. Compared with veterans from other regions, veterans from the North Atlantic presumably had a higher chance of exposure to pathogens and viruses imported from foreign countries during their years of growth. Another possible factor lies in the rapid industrialization of this region that could have resulted in an increased level of water and air pollution in the places where the veterans lived prior to enlistment. These environmental insults in early life can have a negative impact on veterans' health in later life (e.g. Elo and Preston 1992; Hayward and Gorman 2004; Davey-Smith et al 2001; Blackwell et al 2001; Luo and Waite 2005).

Mortality selection intervenes in the relation between residential region prior to enlistment and mortality risk in old age. Veterans from the South Central region prior to enlistment had a mortality risk in the initial 10 years after 1900 that was 16 percent higher than for veterans from the North Atlantic region. However, after 1910 the corresponding gap in mortality risk became 17 percent lower. This reversal of the effect suggests that since the weakest veterans from the South Central region had been selected out by mortality, those who survived the first 10 years after 1900 were healthier than their counterparts from North Atlantic region after 1910. The similar reversal of the effect of residential regions prior to enlistment is also observed for veterans from the North Central region, although the effect is of a smaller scale.

Height at enlistment shows a negative association with the chance of survival after 1900. After adjusting for age at enlistment, veterans with height in the top third had an elevated mortality risk compared to those with height in the bottom one third, as indicated by results from Model 1, 2 and 4 (8, 10 and 14 percent higher, respectively). Such a finding contradicts some previous findings reporting that being taller is in general associated with a lower mortality risk (e.g. Waaler 1984; Costa 1993; Jousilahti et al. 2000). One plausible explanation could be that since the veterans in this study were relatively old, with an average age above 60 in 1900, a higher proportion of short veterans could have died out before they could survive to 1900. As a result, short veterans who survived to 1900 had a better chance to survive than their taller counterparts.

An alternative explanation for the elevated mortality risk for taller veterans lies in the survival advantages of being short in old age. In a comprehensive review of the relation between height and longevity, Samaras et al. (2003) conclude that findings based on millions of deaths suggest that shorter, smaller bodies have lower death rates and fewer diet-related chronic diseases, especially past middle age. This review also notes that smaller animals within the same species generally live longer. In their conclusion, Samaras et al. put forward a counter-argument for the well-documented association between shorter stature and higher risk of cardiovascular diseases by pointing out that this association is caused more by Western lifestyle and diet than by short stature per se, since many populations of short people in Asia and Africa are almost free of cardiovascular diseases until Western lifestyle and dietary changes occur. When these changes do occur, the narrower coronary blood vessels of shorter people are more prone to clogging, which can eventually lead to an elevated risk of developing cardiovascular diseases.

Part of the controversies involved in the height-mortality relation results from the different samples used in empirical analysis. Studies on this topic often differ in their sample selection, with a wide range of variation covering different age, gender, racial groups and cohorts and with different sample sizes. Consequently, a cautious description of the height-mortality association calls for not only an inspection of the relationship itself, but also a probe into how this revealed association and its magnitude could change across demographic groups. For instance, age is an important modifier of the association between height and mortality. An examination of results from the four CPH models suggests that the negative impact on survival of being in the tallest third on survival only becomes significant after 1910, but not between 1900 and 1910. Moreover, the height-mortality association might be disease-specific. The risk of deaths from cancer unrelated to smoking tended to increase with height, particularly for haematopoietic, colorectal and prostate cancers. Stomach cancer mortality is inversely associated with height (Davey-Smith et al. 2000).

The results also reveal a patterned occupational disparity in mortality risk. Veterans who were farmers prior to enlistment had the lowest mortality risk in old age. In reference to the mortality risk for farmers, the mortality risk for artisans, manual labors, professionals and proprietors, and veterans from other occupations is elevated by 13 percent, 9 percent, 8 percent and 16 percent respectively (Model 1). The finding that being a farmer is significantly associated with lower mortality risk in later life among Union Army veterans has also been documented in several other studies (e. g. Costa 2003; Costa and Lahey 2005; Su 2005). Results from Model 2 further suggest that the survival advantage associated with farmers relative to other occupations is robust regardless of whether or not wartime distress and socioeconomic conditions circa 1900 are taken into account.

The effects of occupation on mortality risk are more salient in the initial 10 years after 1900 than after 1910. This is especially true for veterans who were professionals and proprietors prior to enlistment, whose mortality risk is 21 percent higher than veterans who were farmers prior to enlistment in the period between 1900 and 1910, as indicated in results for Model 3. The corresponding gap is four percent lower in results for Model 4, when mortality risk after 1910 is concerned. Such a drastic change suggests the survival disadvantages for veterans who were professionals and proprietors prior to enlistment were mainly concentrated in the initial 10 years after 1900. Once these veterans had survived to 1910, their mortality risk became even lower than those who were farmers prior to enlistment. This could be explained by mortality selection, as a higher proportion of weak veterans who were professionals and proprietors prior to enlistment died in the initial 10 years after 1900, leaving those who could survive to 1910 even more robust than veterans who were farmers prior to enlistment. Since most professionals and proprietors lived in urban areas in early twentieth century, such a finding could also imply a significant improvement in the living environment in urban areas in the northern United States after 1910.

How can the occupational disparity in mortality risk observed in this study be accounted for? An individual's occupation conveys such rich health-related information as income, working environment, education level and skills, stress, and access to health care. In the nineteenth and early twentieth centuries, occupation usually denotes place of residence, since most people lived close to their workplace due to limited public and private transportation. The foremost factor behind farmers' survival advantage in old age is rural residence, a far more favorable epidemiological environment in the nineteenth century compared to urban residence. Living in rural areas implies access to relatively clean water and air, and a reduced chance of exposure to infectious diseases due to the lower population density. Furthermore, in an era without refrigerators, rural residence is also associated with a stable supply of fresh milk, vegetables, meat and fruits. A recent study by Craig (2004) found that the widespread use of mechanical refrigeration in the processing, shipping, and storing of perishable commodities in the United States began only in the 1890s. This study concluded that the adoption of refrigeration in the late-nineteenth-century United States increased dairy consumption by 1.7% and overall protein intake by 1.25% annually after the 1890s, which significantly contributed to the increase in height in the twentieth century.

A good indication of farmers' higher nutritional status relative to those from other occupations during years of growth is their taller stature at enlistment as indicated in **Figure 5**, which indicates that the average height for veterans who were farmers at enlistment is notably taller than that for veterans from other occupations, in all ages considered. Above age 24, the shortest stature is observed among manual labors. The persistence of farmers' height advantage in all ages suggests that difference in birth cohorts cannot account for farmers' taller stature. The findings here are consistent with Wilson and Pope's study (2003) on the determinants of height among Union Army veterans, which found that urbanization and region are two important predictors of veterans' height.

(Figure 5 about here)

It should be noted that the height advantage for farmers cannot be used to explain their survival advantage in old age, since as mentioned earlier, the tallest third of this sample had an elevated mortality risk in old age. Therefore, the survival advantage for farmers must result from factors other than what height has captured. On the one hand, the benefits associated with living in rural areas–such as a more favorable epidemiological environment and easier access to fresh food–cannot be completely captured by height. Moreover, the benefits are expected to be in effect even after adult height has been achieved, as long as veterans still live in the countryside. On the other hand, mortality selection might explain farmers' survival advantage in old age. Lee's study (2003) on wartime morbidity and mortality among the UA veterans suggest that former farmers and rural residents are more likely to contract and die from diseases during the Civil War. Lee attributed the health advantages associated with veterans who were non-farmers to their prior exposure to infectious diseases, which could have given them immunity while in service. If veterans who were farmers had already gone through a harsher mortality selection during war than veterans from other occupations, this can partially explain why the surviving farmers could be more robust in old age than veterans who had occupations prior to enlistment, since a higher proportion of the weak farmers died during the Civil War.

Veterans who were artisans, manual laborers, or who came from "other" occupations prior to enlistment had a higher mortality risk in old age than those who were professionals and proprietors. The survival advantage for professionals and proprietors relative to the former three groups can be explained by the higher economic status of professionals and proprietors, which should provide them with better shelter, food, and health care. But since all these four groups shared an unfavorable urban setting, their mortality risk turned out to be substantially higher than that of farmers. The wealth of professionals and proprietors failed to buy them a survival advantage over farmers in the nineteenth century.

CONCLUSIONS

This study examines the relation between veterans' risk exposures prior to enlistment and their chance of survival after 1900 under alternative model specifications. The results from this sensitivity analysis indicate that risk exposures in veterans' early life–as approximated by birth season and country, coming from big cities, residential region prior to enlistment, height, and occupation–significantly influence veterans' chance of survival in old age. These effects are in general robust irrespective of whether or not exposures in wartime and old age are taken into account, which implies that the main effects of risk exposures in early life on old-age survival cannot have been mediated through wartime distress or old-age SES.

Results from the sensitivity analysis reveal that most of the effects of earlier exposures on old-age survival are contingent on the specific life stage in old age that has been selected for analysis. A decomposition of survival after 1900 into two periods, as this study has shown, provides insights into mortality differentials among the veterans. Whereas some of the effects fully unfolded in the initial 10 years after 1900, others did not express themselves until after 1910. This implies that the different findings on the relation between early-life exposures and old-age survival in the current literature might not result from the relation per se, but from the different age periods in each sample. Comparisons across studies will become more meaningful if this age factor can be taken into account.

Findings from this study also suggest that mortality selection has intervened in the relation between exposures over the life course and mortality in old age. This has been indicated by the reversal of mortality risk between the two periods after 1900 for veterans who were born in "other countries", who lived in South Central region, or who were professionals and proprietors prior to enlistment. These veterans were more likely to die in the first 10 years after 1900 as compared to their corresponding reference categories, but their relative risk of mortality became lower after 1910.

By comparing to relevant findings from similar studies using more recent data, this study allows for an examination of the historical trend in the relation between exposures earlier in life and mortality risk in old age. Previous studies have documented the relative importance of childhood SES and adulthood SES in health or mortality disparity (e.g. Ben-Shlomo and Davey-Smith 1991; Marmot et al. 2001; Hayward and Gorman 2004; Luo and Waite 2005). A convergent finding from these studies is that whereas exposures in early life are important in explaining health or mortality differentials in later life, adjusting for adulthood or current SES can substantially mitigate or even abolish the effects of exposures in earlier life. Such a finding contrasts with what have been found in this study that shows the negative effects of risk exposures prior to enlistment on old-age mortality are robust regardless of whether or not SES in old age has been taken into account. The rigidity of the impacts of exposures earlier in life has also been documented in several other studies using historical samples (e.g. Benggston and Lindström 2003; Costa and Lahey 2005).

Thus, the pooled evidence suggests that risk exposures earlier in life play a more important role in mortality disparity among Union Army veterans than among more recent cohorts. In other words, the importance of early-life exposures in mortality disparity in late life has declined over time. This finding is consistent with the well-documented declining importance of month of birth in mortality disparity over time (Doblhammer and Vaupel 2001). How to account for this trend? The rigidity of the impacts of exposures prior to enlistment on old-age survival among the veterans has to do with the harshness of living conditions in the nineteenth-century United States, when malnutrition, famines, and infectious diseases posed grave threat to health, and when public health interventions such as massive immunization and effective treatments of diseases were virtually impossible. Veterans who were exposed to diseases, malnutrition or famine during infancy or childhood could have a life long disadvantage in health, which cannot be easily modified or reversed by living conditions in adulthood. By contrast, for those in later cohorts whose living conditions in early life were substantially improved, the reduced level of risk exposures, in both number and severity, in early life opens a higher possibility for modification or even reversal by living conditions in adulthood.

Findings from this study also cast light on trends in mortality disparity across occupational groups in the United States since the early twentieth century. In comparison with the distinctive occupational disparity in mortality that has been revealed in studies using data from more recent cohorts (e.g. Kitigawa and Hauser 1973; Mare 1990; Rogers, Hummer and Nam 2000), the moderate differentials in risk of mortality by occupation at enlistment point to the increasing occupational disparity in mortality over time. This finding is consistent with the increasing mortality disparity across SES groups in the United States that has been documented in several other studies (Crimmins and Saito 2001; Pappas et al. 1993; Preston and Elo 1995).

In relation to native-born Americans, the health status of immigrants to the United States has experienced a remarkable transition since the nineteenth century. Evidence from the Union Army sample suggests that immigrants to the United States prior to the Civil War had poorer health than native-born Americans, as indicated by a shorter stature and higher risk of mortality in old age. However, this trend has been reversed in the late twentieth century when both male and female immigrants have longer life expectancy than US-born Americans (Singh and Miller 2004).

LIMITATIONS AND DIRECTIOS FOR FUTURE RESEARCH

An important limitation of this study is that no information on diseases and cause-specific mortality has been incorporated into the analyses. To a large extent the diseases that veterans developed in late life can be regarded as the proximate causes of their deaths. The exclusion of socioeconomic well-being circa 1900 as the essential pathway through which early exposures influence chance of survival in old age, as suggested by this study, further points to the possibility that more of the effects of earlier exposures on old-age mortality could be mediated through their effects on the development of chronic conditions in old age. Future studies can evaluate how veterans' risk exposures prior to enlistment and during wartime influenced their risk of developing chronic diseases, becoming disabled, or dying from a certain disease or a combination of diseases in old age. A complicated issue confronting these studies concerns the coding of diseases and causes of death, as well as cases with missing information on these variables in the Union Army sample. Given the importance of these information and the additional insights they provide, however, such an endeavor would be well worth it.

The other limitation of this study is the lack of ecological variables that can be used to characterize veterans' epidemiological environment at different life stages. Season and place of birth as used in this study provide some general information about veterans' initial risk exposures, but they are far from enough. If further information on infant mortality rates, famines, infectious diseases, immigration flow, source of drinking water, terrain features and so forth at the township or county level becomes available, veterans' exposures to risk factors at different life stages can be more accurately characterized and thus push the analyses to a higher level.

REFERENCES

Allison, P.D. 1984. *Event History Analysis.* Beverly Hills, CA: Sage Publication, Inc.

Avchen, R.N., Scott, K.G., & Mason, C.A. 2001. Birth Weight and School-age Disabilities: A Population-based Study. *American Journal of Epidemiology*, 154: 895 - 901.

Barker, D.J.P. 1998. *Mothers, Babies and Health in Later Life, 2nd ed.* Edinburgh, London, New York: Churchill Livingstone.

Barker, D.J.P. & Osmond C. 1992. Infant Mortality, Childhood Nutrition, and Ischaemic Heart Disease in England and Wales. In D.J.P. Barker (Ed.), *Fetal and Infant Origins of Adult Disease* (pp. 23-27). London: British Medical Journal.

Bengsston, T. and Lindström, M. 2003. Airborne Infectious Diseases during Infancy and Mortality in Later Life in Southern Sweden, 1766–1894. *International Journal of Epidemiology,* 32: 286-294.

Ben-Shlomo, Y. & Davey-Smith, G. 1991. Deprivation in Infancy or in Adult Life: Which is More Important for Mortality Risk? *Lancet,* 337: 530-4.

Blackwell, D.L., Hayward, M.D., & Crimmins, E.M. 2001. Does Childhood Health Affect Chronic Morbidity in Later Life? *Social Science and Medicine,* 52: 1269- 1284.

Carlson, E.D. 1984. Social Determinants of Low Birth Weight in a High-risk Population. *Demography,* 21: 207-215.

Costa, D.L. 1993. Height, Weight, Wartime distress, and Older Age Mortality: Evidence from the Union Army Records. *Explorations in Economic History,* 30: 424-449.

Costa, D.L. 2003. Understanding Mid-Life and Old Age Mortality Declines: Evidence from Union Army Veterans. *Journal of Econometrics,* 112(1): 175-92.

Costa, D. & Lahey, J. 2005. Becoming Oldest-old: Evidence from Historical U.S. Data. *Genus,* LXI(no.1): 125-161.

Craig, L.A., Goodwin, B., & Grennes, T. 2004. The Effect of Mechanical Refrigeration on Nutrition in the United States. *Social Science History,* 28(2): 325-336.

Crimmins, E.M., & Saito, Y. 2001. Trends in Healthy Life Expectancy in the United States, 1970-1990: Gender, Racial, and Educational Differences. *Social Science and Medicine*, 52: 1629-1641.

Davey-Smith, G., Gunnell D., & Ben-Shlomo, Y. 2001. Life-course Approaches to Socioeconomic Differentials in Cause-specific Adult Mortality. In D. Leon & G. Walt (Eds.), *Poverty Inequality and Health: an International Perspective* (pp. 88-124). New York: Oxford University Press.

Davey-Smith, G., Hart, C., Upton, M., Hole, D., Gillis, C., Watt, G., & Hawthrone, V. 2000. Height and risk of death among men and women: aetiological implication of associations with cardiorespiratory disease and cancer mortality. *Journal of epidemiology and community health,* 54(2): 97-103.

Doblhammer, G. & Vaupel, J.W. 2001. Lifespan Depends on Month of Birth. *Proceedings of the National Academy of Sciences*, 98(5): 2934-2939.

Elo, Irma T. & Preston, S.H. 1992. Effects of Early-Life Conditions on Adult Mortality: A Review. *Population Index,* 58: 186-212.

Fogel, R.W. 1993. New Sources and New Techniques for the Study of Secular Trends in Nutritional Status, Health, Mortality, and the Process of Aging. *Historical Methods,* 26: 5-43.

Fogel, R.W. 2000. *Public Use Tape on the Aging Veterans of the Union Army: Federal Census Records, 1850, 1860, 1900, 1910 Version C-3*. Center for Population Economics University of Chicago, Graduate School of Business, and Department of Economics. Brigham Young University.

Fogel, R.W. 2000. *Public Use Tape on the Aging Veterans of the Union Army: Military Pension and Medical Records, 1860-1940 Version M-5*. Center for Population Economics University of Chicago, Graduate School of Business, and Department of Economics. Brigham Young University.

Fogel, R.W. 2001. *Public Use Tape on the Aging Veterans of the Union Army: Surgeon's Certificates, 1862-1940. Version S-1 Standardized.* Center for Population Economics University of Chicago, Graduate School of Business, and Department of Economics. Brigham Young University.

Fogel, R.W. 2004. Changes in the Disparities in Chronic Disease during the Course of the Twentieth Century. NBER Working Paper No. 10311.

Fogel, R.W. 2004. *The Escape from Hunger and Premature Death 1700–2100*. New York: Cambridge University Press.

Fogel, R.W. & Costa, D.L. 1997. A Theory of Technophysio Evolution, with Some Implications for Forecasting Population, Health Care Costs, and Pension Costs. *Demography,* 34 (1): 49–66.

Fogel, R.W., Engerman, S.L., & Floud, R. 1983. Secular Changes in American and British Stature and Nutrition. *The Journal of Interdisciplinary History*, 14(2): 445-81.

Fogel, R.W. et al. 2001. Early Indicators of Later Work Levels, Disease and Death. Grant submitted to National Institutes of Health. Center for Population Economics, Graduate School of Business, University of Chicago. Typescript.

Greene, S.K., Lonides, E.L., & Wilson, M.L. 2006. Patterns of Influenza-associated Mortality among U.S Elderly by Geographic Region and Virus Subtype, 1968-1998. *American Journal of Epidemiology,* 163(4): 316-326.

Haines, M. 2001. The Urban Mortality Transition in the United States, 1800–1940. NBER Historical Paper 134.

Hamze, M. & Vincent, P. 2004. Typhoid Fever in North Lebanon: A 8-year Study (1992-1999) Using the Widal Test. *East Mediterranean Health Journal,* 10(1-2): 180-6. French.

Hayward, M.D. & Gorman, B.K. 2004. The Long Arm of Childhood: The Influence of Early-life Social Conditions on Men's Mortality. *Demography,* 41: 87-107.

Heuveline, P., Guillot, M., & Gwatkin, D.R. 2002. The Uneven Tides of the Health Transition. *Social Science and Medicine,* 55(2): 129-138.

Jousilahti, P., Tuomilehto, J., Vartiainen, E, Eriksson, J. & Puska, P. 2000. Relation of Adult Height to Cause-specific and Total Mortality: A Prospective Follow-up Study of 31,199 Middle-aged Men and Women in Finland. *American Journal of Epidemiology,* 151(11): 1112-20.

Kitigawa, E. & Hauser, P. 1973. *Differential Mortality in the United States: A Study in Epidemiology*, Cambridge, MA: Harvard University Press.

Komlos, J.& Baur, M. 2004. From the Tallest to (One of) the Fattest: the Enigmatic Fate of the American Population in the 20th Century. *Economics and Human Biology,* 2(1): 57-74.

Kramer, M.S. 1987. Determinants of Low Birth Weight: Methodological Assessment and Meta-analysis. *Bulletin of World Health Organization,* 65: 663-737.

Lee, C. 2003. Prior Exposure to Disease and Later Health and Mortality: Evidence from Civil War Records. In D.L. Costa (Ed.), *Health and Labor Force Participation over the Life Cycle: Evidence from the Past* (pp. 51-88), Chicago: University of Chicago Press.

Lerchl, A. 2004. Month of Birth and Life Expectancy: Role of Gender and Age in a Comparative Approach. *Naturwissenschaften*. 91(9): 422-5.

Leung, C.C, Yew, W.W., Chan, T.Y.K., Tam, C.M., Chan, C.Y., Chan, C.K., Tang, N., Chang, K.W., & Law, W.S. 2005. Seasonal Pattern of Tuberculosis in Hong Kong. *International Journal of Epidemiology,* 34: 924-930.

Luo, Y. & Waite, L.J. 2005. The Impact of Childhood and Adult SES on Physical, Mental, and Cognitive Well-being in Later Life. *Journals of Gerontology-Series B: Psychological Sciences and Social Sciences.* 60(2): S93-S101.

Mare, R.D. 1990. Socio-economic Careers and Differential Mortality among Older Men in the United States. In J. Vallin, S. D'Souza, & A. Palloni, *Measurement and Analysis of Mortality: New Approaches* (pp. 362-87). Oxford: Clarendon Press.

Marmot, M., Shipley, M., Brunner, E., & Hemingway, H. 2001. Relative Contribution of Early Life and Adult Socioeconomic Factors to Adult Morbidity in the Whitehall II Study. *Journal of Epidemiology and Community Health*. 55(5): 301-7.

McGrath, J.J, Saha, S., Lieberman, D.E, & Buka, S. 2006. Season of Birth is Associated with Anthropometric and Neurocognitive Outcomes during Infancy and Childhood in a General Population Birth Cohort. *Schizophrenia Research*, 81(1): 91-100. Epub 2005 Oct 20.

Mokyr, J. 1983. *Why Ireland Starved: A Quantitative and Analytical History of the Irish Economy, 1800-1850.* London: Allen and Unwin.

Murray, C.J.L., & Lopez, A.D. 1996. The Global Burden of Disease: A Comprehensive Assessment of Mortality and Disability from Diseases, Injuries, and Risk Factors in 1990 and Projected to 2020. Cambridge: Harvard University Press for the World Health Organization and The World Bank.

Murray, L.J., O'Reilly, D.P., Betts, N., Patterson, C.C., Davey-Smith, G., & Evans, A.E. 2000. Season and Outdoor Ambient Temperature: Effects on Birth Weight. *Obstetrics and Gynecology,* 96: 689-695.

Myers, G.C. 1989. Mortality and Health Dynamics at Older Ages. In L. Ruzicka, G. Wunsch, & P. Kane (Eds.), *Differential Mortality: Methodological Issues and Biosocial Factors*. Oxford: Clarendon Press.

Omran AR. 1971 The epidemiologic transition. A theory of the epidemiology of population change. *Milbank Mem Fund Q.* Oct;49(4):509-38.

O'Rourke, K. 1995. Emigration and Living Standards in Ireland Since the Famine. *Journal of Population Economics,* 8(4): 407-421.

Pappas, G., Queen, S., Hadden, W., & Fisher, G. 1993. The Increasing Disparity in Mortality between Socioeconomic Groups in the United States, 1960 and 1986. *New England Journal of Medicine,* 329(2): 103-109.

Preston, S. H. 1977. Mortality Trends. *Annual Review of Sociology,* 3: 163-178.

Preston, S.H. & Elo, I.T. 1995. Are Educational Differentials in Adult Mortality Increasing in the United States? *Journal of Aging and Health,* 7(4): 476-496.

Riley, J. 1994. Height, Nutrition and Mortality Risk Reconsidered. *Journal of Interdisciplinary History,* 24 (3): 465–492.

Riley, J.C. 2001. *Rising Life Expectancy: A Global History.* New York: Cambridge University Press.

Roberts, D.F. 1975. Environment and the Fetus. In D.F. Roberts & A.M. Thomson (Eds.), *The biology of human fetal growth*, London: Taylor and Francis.

Rogers, R.G., Hummer, R.A., & Nam, C.B. 2000. *Living and Dying in the USA: Behavioral, Health, and Social Differentials in Adult Mortality.* San Diego, CA: Academic Press.

Samaras, T.T., Elrick, H., & Storms, L.H. 2003. Is Height Related to Longevity? *Life Sciences,* 72: 1781-1802. Review.

Selvin, S., Janerich, D.T. 1971. Four Factors Influencing Birth Weight. *British Journal of Preventive and Social Medicine,* 25(1): 12-6.

Shek, L.P.C. & Lee, B.W. 2003. Epidemiology and Seasonality of Respiratory Tract Virus Infections in the Tropics. *Pediatric Respiratory Reviews,* 4: 105-111.

Singh, G.K. & Miller, B.A. 2004. Health, Life Expectancy, and Mortality Patterns among Immigrant Populations in the United States. *Canadian Journal of Public Health,* 95(3): 114-121.

Sorensen, H.T., Sabroe, S., Rothman, K.J., Gillman, M., Steffensen, F.H., Fischer, P., & Sorensen, T.I.A. 1999. Birth Weight and Length as Predictors for Adult Height. *American Journal of Epidemiology,* 149(8): 726-9.

Su, D. 2005. Body Mass Index and Old Age Survival: A Comparative Study between the Union Army Records and the NHANES-I Epidemiological Follow-up Sample. *American Journal of Human Biology,* 17: 341-354.

The Bureau of the Census. 1949. *Historical Statistics of the United States, 1789-1945: A supplement to the Statistical Abstract of the United States.* Washington, D.C.: Bureau of the Census.

Troesken, W. 2003. Lead Water Pipes and Infant Mortality in Turn-of-the Century Massachusetts. NBER Working Paper 9549.

Wilson, S.E. 2003. The Prevalence of Chronic Respiratory Disease in the Industrial Era: The United States, 1895-1910. In D.L. Costa (Ed.), *Health and Labor Force Participation over the Life Cycle: Evidence from the Past* (pp. 147-180), Chicago: The University of Chicago Press.

Wilson, S.E. & Pope, C.L. 2003. The Height of Union Army Recruits: Family and Community Influences. In D.L. Costa (Ed.), Health and Labor Force Participation over the Life Cycle: Evidence from the Past (pp. 113-46), Chicago: The University of Chicago Press.

World Health Organization. 2003. *Emerging Issues in Water an Infectious Disease*. ISBN 92 4 159082 3. Available online at: http://www.who.int/water_sanitation_health /emerging/emerging.pdf.

Wu, L.L. 2003. Event History Models for Life Course Analysis. In J.T. Mortimer & M. J. Shanahan (Eds.), *Handbook of the Life Course* (pp. 477-502). New York: Kluwer Academic /Plenum Publishers.

Appendix 1: Tables

Table 1: Variables Characterising Three Life Stages (N=11,978)

Early Life (Birth to Enlistment)	Mean or %	**Old Age (Circa 1900)**	Mean or %
Birth Year	1839	Age in 1900	61.2
Birth Season		BMI Adjusted by Age**	
Spring	26.9	1st Quintile	19.6
Summer	23.7	2nd Quintile	21.4
Autumn	24.1	3rd Quintile	22.6
Winter	25.3	4th Quintile	24.0
Birth Country		5th Quintile	27.5
United States	83.2	Living in Big Cities in 1900	
Britain	2.7	In Big Cities	14.5
Canada	2.7	Not in Big Cities	67.3
Germany	5.7	Unknown	18.1
Ireland	3.7	Residential Area in 1900	
Other Countries	2.0	North Atlantic	21.7
Coming from Big Cities	6.6	South Atlantic	3.5
Residential Regions		North Central	49.2
North Atlantic	27.5	South Central	3.6
South Atlantic	4.3	Western States	3.4
North Central	58.3	Unknown	18.6
South Central	4.1	Occupation in 1900	
Other	5.8	Farmer	24.7
Wealth in 1860*		Artisan	8.5
Personal Property Value ($)	395.2	Manual Labor	7.5
Real Estate Value ($)	1171.7	Professional	10.8
Height Adjusted by Age (Inch)		Other	7.9
Shortest One Third	64.9	Unknown	40.5
Middle One Third	67.6	Marital Status in 1900	
Tallest One Third	70.3	Married	73.5
Occupation at Enlistment		Single	4.1
Farmer	59.8	Widowered	9.6
Artisan	17.3	Divorced	0.7
Manual Labor	12.0	Unknown	12.1
Professional	6.1	Literacy in 1900	
Other	4.8	Able to Read	77.3
		Unable to Read	4.1
Wartime (Enlistment to Discharge)		Unknown	18.6
Age at Enlistment	23.9	Own or Rent House in 1900	
Enlisted as a Private	91.4	Own	50.9
Injured during War	32.2	Rent	20.0
Prisoner of War	8.7	Unknown	29.2
Exposed to Higher Casualty	50.3	Age at Death	75.9

Source: The Union Army Sample.

*Information on wealth in 1860 is only available for those veterans who were already married in 1860 and who have been successfully linked to the 1860 census.

**Based on information from the first physical examination after the Civil War.

Table 2: Risk Exposures in Early Life and Mortality: A Sensitivity Analysis

Explanatory Variables	Mean or %	Hazard Ratio			
		Predicting Survival After 1900		1900 to 1910	After 1910
		Model 1 (Early Life)	Model 2 (Full Model)	Model 3 (Full Model)	Model 4 (Full Model)
Age in 1900	61.2	1.09***	1.09***	1.09***	1.09***
Exposures in Early Life					
Birth Season		*			
Spring	26.9	Omitted	Omitted	Omitted	Omitted
Summer	23.7	1.00	1.00	0.97	1.02
Autumn	24.1	0.94**	0.95*	0.98	0.94*
Winter	25.3	0.97	0.98	0.93	1.00
Birth Country		***	***	***	***
United States	83.2	Omitted	Omitted	Omitted	Omitted
Britain	2.7	0.99	0.97	1.03	0.94
Canada	2.7	1.01	0.99	0.97	0.99
Germany	5.7	1.09**	1.09*	1.06	1.11*
Ireland	3.7	1.21***	1.21***	1.40***	1.10
Other Countries	2.0	0.86**	0.83**	1.06	0.72***
Coming from Big Cities	6.6	1.15***	1.12**	1.21**	1.06
Residential Regions		***	***	***	**
North Atlantic	27.5	Omitted	Omitted	Omitted	Omitted
South Atlantic	4.3	0.91*	0.92	0.84	0.96
North Central	58.3	0.90***	0.94	1.04	0.90*
South Central	4.1	0.89**	0.90	1.16	0.82**
Other	5.8	0.77***	0.75***	0.63***	0.77***
Height Adjusted by Age		***	***	**	***
Short	32.5	Omitted	Omitted	Omitted	Omitted
Middle	33.9	1.02	1.01	0.90**	1.05
Tall	33.6	1.08***	1.10***	1.00	1.14***
Occupation at Enlistment		***	***	***	***
Farmer	59.8	Omitted	Omitted	Omitted	Omitted
Artisan	17.3	1.13***	1.14***	1.20***	1.11***
Manual Labor	12.0	1.09**	1.08**	1.14**	1.06
Professional	6.1	1.08*	1.04	1.21**	0.96
Other	4.8	1.16***	1.17***	1.19**	1.17**
Exposures in Wartime					
Enlisted as a Private	91.4		0.99	0.97	0.97
Injured during War	32.2		1.00	0.98	1.01
Prisoner of War	8.7		1.07*	0.92	1.13***
Exposed to Higher Casualty	50.3		1.03	1.06	1.02

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	Mean or %	Predicting Survival After 1900		1900 to 1910	After 1910
		Model 1 (Early Life)	Model 2 (Full Model)	Model 3 (Full Model)	Model 4 (Full Model)
Exposures in Old Age					
BMI Adjusted by Age			***	***	***
1st Quintile	19.6		Omitted	Omitted	Omitted
2nd Quintile	21.4		0.94*	0.91	0.96
3rd Quintile	22.6		0.99	1.00	1.00
4th Quintile	24.0		0.99	0.94	1.01
5th Quintile	27.5		1.13***	1.17**	1.11***
Living in Big Cities in 1900					
Not in Big Cities	67.3		Omitted	Omitted	Omitted
In Big Cities	14.5		1.05	1.01	1.07*
Unknown	18.1		0.88	0.79	0.94
Residential Area in 1900				***	
North Atlantic	21.7		Omitted	Omitted	Omitted
South Atlantic	3.5		1.02	1.20	0.98
North Central	49.2		0.95	0.88	1.00
South Central	3.6		0.98	0.74*	1.07
Western States	3.4		1.14	1.31*	1.12
Unknown	18.6		1.00	1.03	1.03
Occupation in 1900					
Farmer	24.7		Omitted	Omitted	Omitted
Artisan	8.5		1.04	1.05	1.05
Manual Labor	7.5		1.06	0.99	1.10*
Professional	10.8		0.98	0.93	1.00
Other	7.9		1.06	1.06	1.07
Unknown	40.5		1.01	1.01	0.99
Marital Status in 1900			***		***
Married	73.5		Omitted	Omitted	Omitted
Single	4.1		1.13**	0.98	1.16**
Widowered	9.6		1.14***	1.07	1.17***
Divorced	0.7		1.29**	1.39*	1.17
Unknown	12.1		0.86	0.58*	0.93
Literacy in 1900					
Able to Read	77.3		Omitted	Omitted	Omitted
Unable to Read	4.1		1.08	1.09	1.09
Unknown	18.6		1.04	1.02	1.06
Own or Rent House in 1900			***	***	
Own	50.9		Omitted	Omitted	Omitted
Rent	20.0		1.09***	1.18***	1.05
Unknown	29.2		1.07*	1.12*	1.07
Number of Cases	11,978	10,535	9,022	9,022	6,440
Chi-square		2,666	2,452	1,403	1,278
Degree of Freedom		20	48	48	48

*Source: The Union Army Sample. * p<0.1; ** p<0.05; *** p<0.01. Mean or Percentage was calculated based on the whole sample*

Appendix 2: Figures

Figure 1: Old Age Mortality in a Life Course Perspective

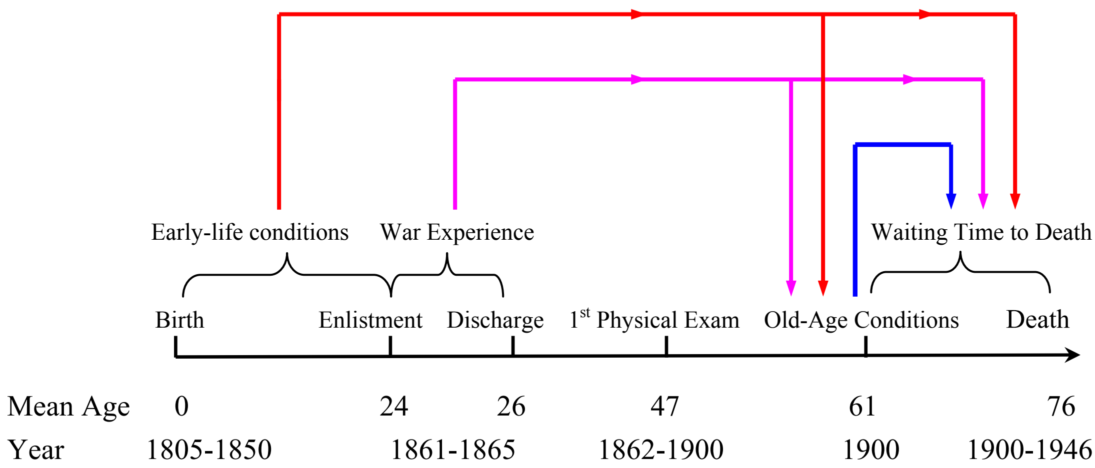
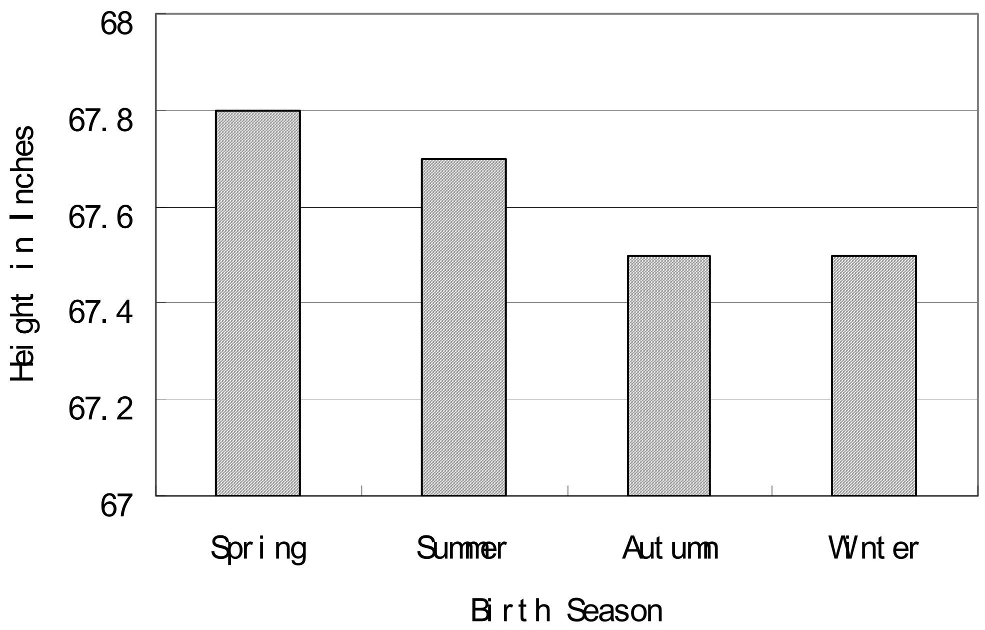
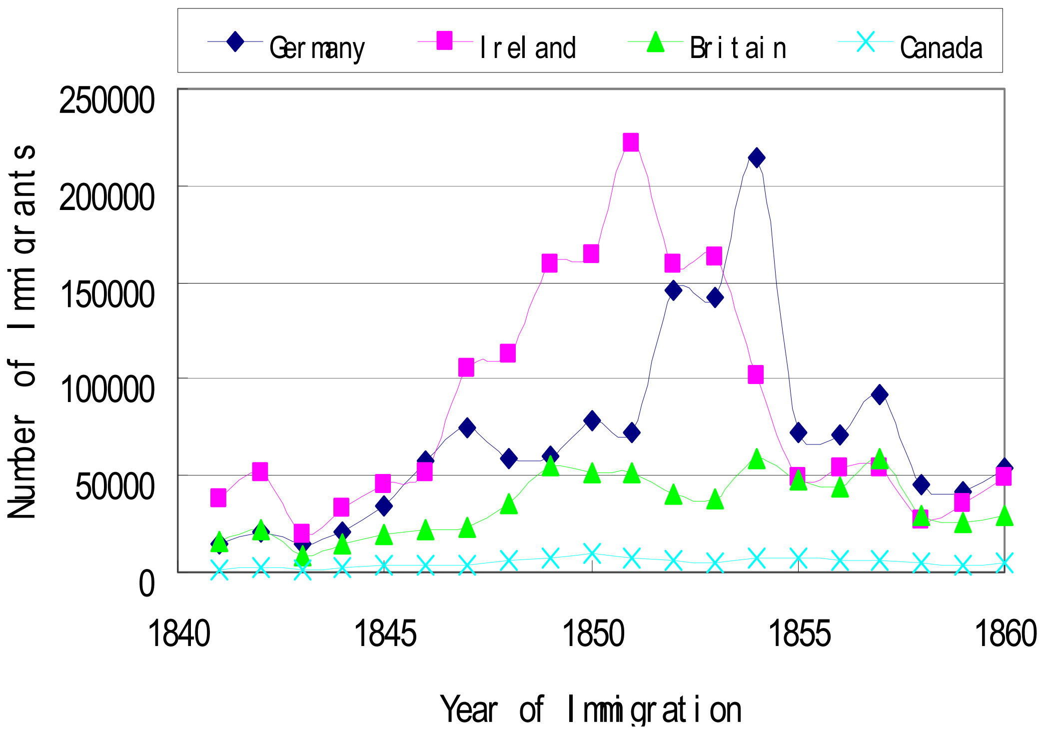


Figure 2: Birth Season and Height at Enlistment



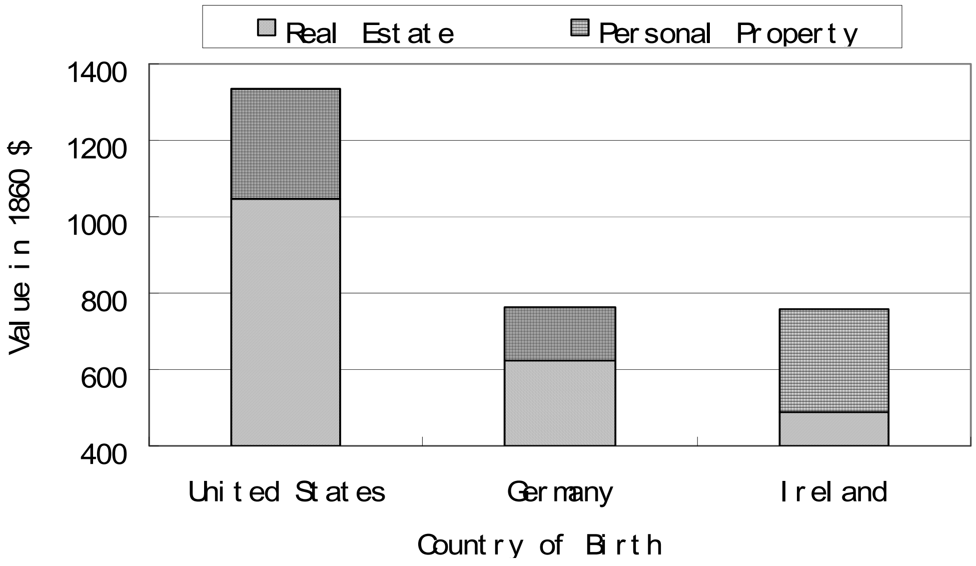
Source: the Union Army Sample.

Figure 3: Immigration to the U.S. by Country from 1840 to 1860



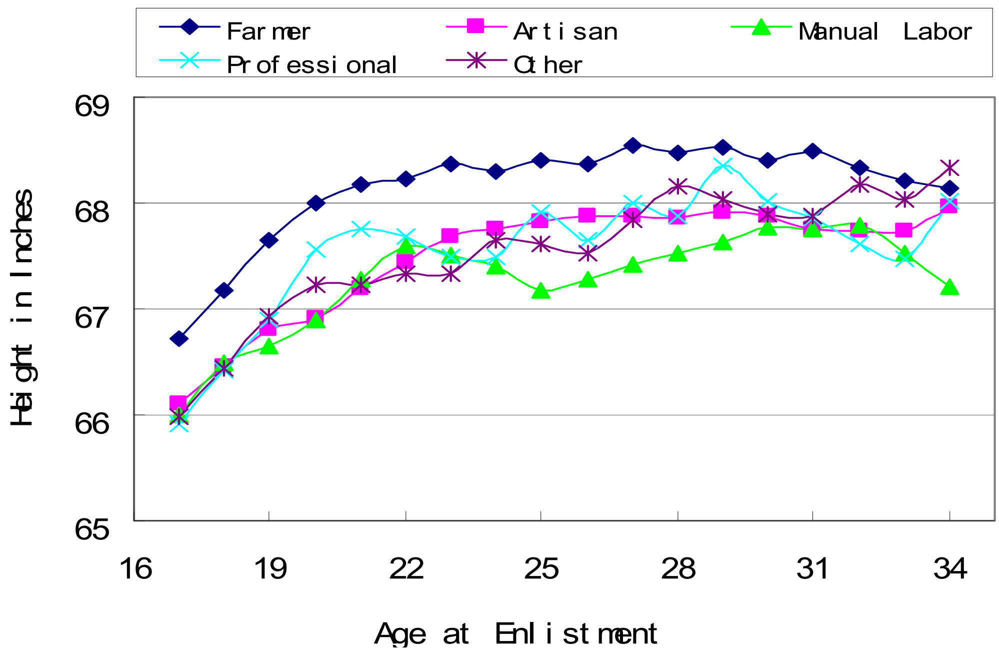
Source: Constructed based on information from *Historical Statistics of the United States 1789-1945: A Supplemental to the Statistical Abstract of the United States.* Bureau of the Census. 1949. Washington, D.C.

Figure 4: Wealth in 1860 by Country of Birth



Source: the Union Army Sample.

Figure 5: Occupational Difference in Height at Enlistment



Source: the Union Army Sample. The curves have been smoothed by using three-age moving average.