# Survival in 19th Century Cities: The Larger the City, the Smaller Your Chances

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Although it is widely known that, during the 19th century, life expectancy was substantially lower in cities than in rural areas, the difference in survival rates by urban size and rural environmental characteristics is less widely known.[1] Further, the longitudinal impact of lifetime mobility on life expectancy during this period rarely has been studied.

We examine these less explored subjects on urban mortality penalty using historical data of Union Army veterans' lifetime socioeconomic and health records collected by the Center for Population Economics. In particular the differentials in survival rate by urban size are estimated at three stages of life: birth, late adolescence, and death. We also exploit the association that existed between rural area survival rates and the local malaria ecology to differentiate rural areas.

Our survival analyses show a significant hierarchy in survival rates by urban size. It is consistently found for all the stages of lifetime. The results of geographical mobility analyses suggest that late adolescence and adulthood may be an important period for the urban mortality penalty. While the data permit us to document the magnitude of the urban mortality penalty, it persists after the inclusion of all our explanatory variables. While we cannot yet explain why it occurred, we are able to narrow the search for an explanation.

## I

There is a well-developed literature on urban versus rural mortality rates. Vinovskis, correcting the earlier work of Jaffe and Lourie, found that, in Massachusetts towns with an 1830 population

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[1] For example, in 1899, Weber (1899) reported life expectancy at birth in the cities of Massachusetts was almost seven years less than that in the state as a whole. See also Condran and Crimmins (1980), Glover (1921), Haines (1977), United Nations (1953), Vinovskis (1981), and Woods et al. (1988).

of 10,000 or more, life expectancy at ages 10 to 14 was 46.7 years. In towns with less than 1,000 inhabitants, it was 52.5 years.[2]

In 1900, the U.S. Bureau of the Census created an official Death Registration Area (DRA) which included ten states and the District of Columbia. Using the DRA, it was estimated that white males born in rural areas had a life expectancy at birth in 1901 that was ten years higher than that for white males born in cities. For white females, life expectancy at birth was seven years higher in rural areas than in cities.[3] For blacks, male and female, in the District of Columbia, life expectancy at birth was about four years less than it was for the DRA as a whole.[4]

As late as 1939, actuaries for the Metropolitan Life Insurance Company reported life expectancy at birth for white males was 64.07 years in rural areas as compared to 61.45 years in urban areas. For white females, the figures were 67.46 and 66.20 years, respectively. Although a small urban penalty remained, differences by urban size had largely disappeared for whites, but it persisted for blacks.[5]

With the aid of the Union Army database, we can look at the urban mortality penalty in several ways.[6] As a first step, we have identified 25,044 veterans who were not deserters that survived the Civil War. We have death records for 17,950 of this group. Of the remaining 7,094 individuals, we can locate 1,173 in the Union Army pension records that provide dates of regular medical examinations. Finally, of the 5,921 that remain, we looked to see if they could be linked to the 1900 or 1910 Census. This gives us the ability to construct an 1866-1900 survival rate by dividing the number of veterans in any class we can ascertain were alive in 1900 by those we know survived the Civil War.[7]

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[2] Massachusetts had a good system of birth and death registrations in the early 19th century. Vinovskis (1972), Jaffe and Lourie (1942). Other scholars reporting similar disparities in the second half of the 19th century are Condran and Crimmins (1980), Haines (1977), Higgs (1973), and Yasuba (1961).

[3] By 1910, these differences were about eight years for men and six years for women.

[4] Glover (1921). The problems with the original DRA are well known. The coverage was limited, only 26.3 percent of the U.S. population. The included states were more urban, had a larger percentage of foreign residents, and a smaller percentage of black residents than the U.S. population as a whole. Moreover, blacks in the DRA were four times more likely to live in urban areas than blacks in the U.S. as a whole. Consequently, scholars have concluded the Census Bureau overestimated mortality for whites and especially for blacks. See Haines (1998) and Preston and Haines (1991).

[5] For whites, see Dublin, Lotka, and Spiegelman (1949); for blacks, Ewbank (1987), Haines (2001, 2002), and Preston and Haines (1991).

[6] This article is based on historical data collected by the 'Early Indicators of Later Work Levels, Disease, and Death' project, which is sponsored by the National Bureau of Economic Research, the National Institutes of Health, the Center for Population Economics at the University of Chicago, and Brigham Young University. The primary sample for the project consists of 35,570 white males mustered into the Union Army during the Civil War, who are chosen randomly from the company books stored at the National Archives in Washington, D.C. In addition, the project provides lifetime military, medical, and socioeconomic information on these individuals by linking the veterans to other historical documents: the military, pension and medical records, the surgeons' certificates data, and the census records data. The database and its detailed information are available at http://www.cpe.uchicago.edu.

[7] We could also calculate 1866-1910 survival rates, but we are only presenting this for illustrative purposes as we are unable to calculate similar rates for any other time periods using the full Union Army sample.

We begin by defining six mutually exclusive areas. The urban places are classified into four groups on the basis of population size in the 1860 census. Together they include 94 of the 100 largest cities in 1860.[8] Rural areas are classified into two groups on the basis of the estimated probability of contracting malarial fever (intermittent or intermittent fever as broadly called by 19th-century physicians).

The malaria risk was estimated by looking at county level environmental factors.[9] A high-malaria area was one with an estimated risk of 0.25 or greater, while a low-malaria area had a risk below 0.25.[10] The South had a more malarial environment than the North, which means there is a relatively low number of veterans from high-malaria areas. Nevertheless, malaria was much more widespread geographically in the nineteenth century than it is today, extending as far north as Madison, WI.

Table 1 presents the survival rates of Union Army veterans according to where they were born and where they resided in 1860. The survival rate is the percentage of veterans in each group who survived the war and then lived to at least 1900. Since the average veteran was born in 1839, this is essentially the proportion of veterans who survived into their early 60s. These rates clearly reveal the urban mortality penalty.

In terms of birth place, on average, 50 % of veterans born in urban places who survived the war lived to 1900. The figure is 13 % higher on average for those born in rural places. Foreign-born veterans had the lowest survival rates when sorted by place of birth (35.1%), but they are four to five years older than non-foreign born veterans. As will be shown in the next section, when the birth date is taken into consideration, the experience of the foreign-born appears less dire. Immigration into large cities has been proffered as a partial explanation for the urban mortality penalty, but, excluding foreign-born veterans, the penalty is still present.

Veterans belonging to the Urban 1 group (cities with 1860 populations greater than 100,000) had the lowest survival rate, followed by those living in Urban 2 (and between 50,000 and 100,000). Urban 3 and 4 (populations between 25,000 and 50,000 and between 9,552 and 25,000) had approximately equal rates, but they are lower than any rural places. By a relatively slim margin, those with a low-malaria rural birth place had a slightly higher survival rate than those from a high-malaria one. Those with unknown birth places had low survival rates, with only foreign birth places lower.

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[8] The remaining 6 were in the Confederacy.

[9] See Hong (2007) for malaria risk estimation. The estimation results suggest that a malarial environment can be characterized by warmer, wetter, and flatter areas, but extremely hot temperatures can stop the development of the parasite. Using the estimated malaria risk, he found that Union Army recruits from the most malarial rural counties were about 1.1 inch shorter at enlistment and about 13% more susceptible to infectious diseases during the war than were those from the least malarial counties because of malnutrition in childhood and immune disorders by malaria infections.

[10] The U.S. Census Bureau (1885, Section 8) provides maps and tables suggesting that more than 30 deaths per 1,000 were caused by malarial fevers in the most malarial areas including the Mississippi and Missouri River valleys, Southern and South West Central Regions, and Gulf areas. From the 1880 malaria risk index (0.0009-0.5616) which was estimated by the method of Hong (2007), the risk index cutting off these most or high-malarial areas is 0.25.

**Table 1**. Survival Rate of Union Army Veterans by Birth Place and 1860

| Type of Place | Classification | Sample Size | Average birth year | Survival Rate * 100 (1866-1900) |
|---|---|---|---|---|
| Birth Place | U.S. Urban | | | |
| | Urban 1 | 852 | 1839.4 | 44.01 |
| | Urban 2 | 146 | 1840.1 | 47.26 |
| | Urban 3 | 216 | 1840.2 | 54.63 |
| | Urban 4 | 399 | 1839.7 | 57.64 |
| | U.S. Rural | | | |
| | High-Malaria | 2,187 | 1839.4 | 62.19 |
| | Low-Malaria | 10,417 | 1839.0 | 64.27 |
| | Foreign | 5,951 | 1835.2 | 35.14 |
| | Unknown | 4,876 | 1837.4 | 39.46 |
| Residence in 1860 | Urban 1 | 235 | 1833.4 | 30.64 |
| | Urban 2 | 34 | 1835.9 | 47.06 |
| | Urban 3 | 75 | 1837.9 | 42.67 |
| | Urban 4 | 186 | 1836.2 | 42.47 |
| | High-Malaria | 1,203 | 1838.2 | 58.94 |
| | Low-Malaria | 6,471 | 1837.7 | 60.83 |
| | Unknown | 285 | 1836.9 | 62.46 |

*Notes* : The survival rate is the percentage of veterans in each group who survived the war and then lived to at least 1900. See the text for the classification of urban and rural places.

The sample sizes for this second panel are much smaller due to the necessity of linking the Union Army database to the 1860 Census; the urban mortality penalty is larger. Consistent with the "Ferrie Constant," our match rate was approximately one-third. The inclusion of information concerning residence in 1860 reduces the sample size by roughly three-fourths, from 17,950 to approximately 4,500. The inclusion of information concerning place of death reduces that by another one-third to approximately 3,000.

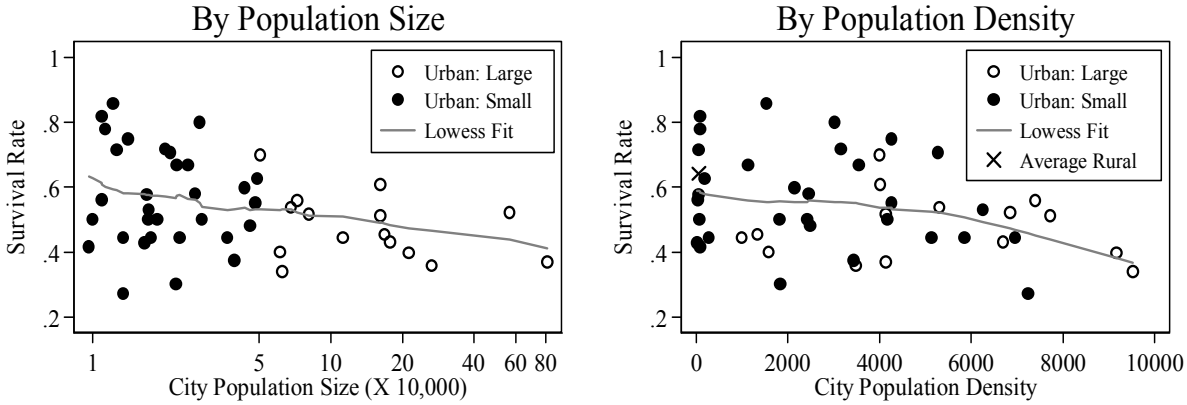
With respect to the lower panel, Table 1 again reveals considerable variability within the urban strata. Veterans belonging to the Urban 1 group had the lowest survival rate. Those living in Urban 2 had a relatively high survival rate; this is partially attributable to the small size of the Urban 2 sample. Urban 3 and 4 had approximately equal rates. All four urban survival rates are lower than rural places.

Of veterans who resided in Urban 1 in 1860, the largest cities, before they were recruited, and who also survived the war, only about 31% survived to 1900. This is consistent with a population belonging to a life table with $e_o = 25.0$. By contrast, 61% of veterans who lived in all rural areas combined in 1860 lived to 1900. This is consistent with a population belonging to a life table with $e_o = 45.0$.[11]

As a second step, we have examined the urban mortality penalty at the city level based on a veteran's birth place. We calculated a survival rate for each city where we could find at least six

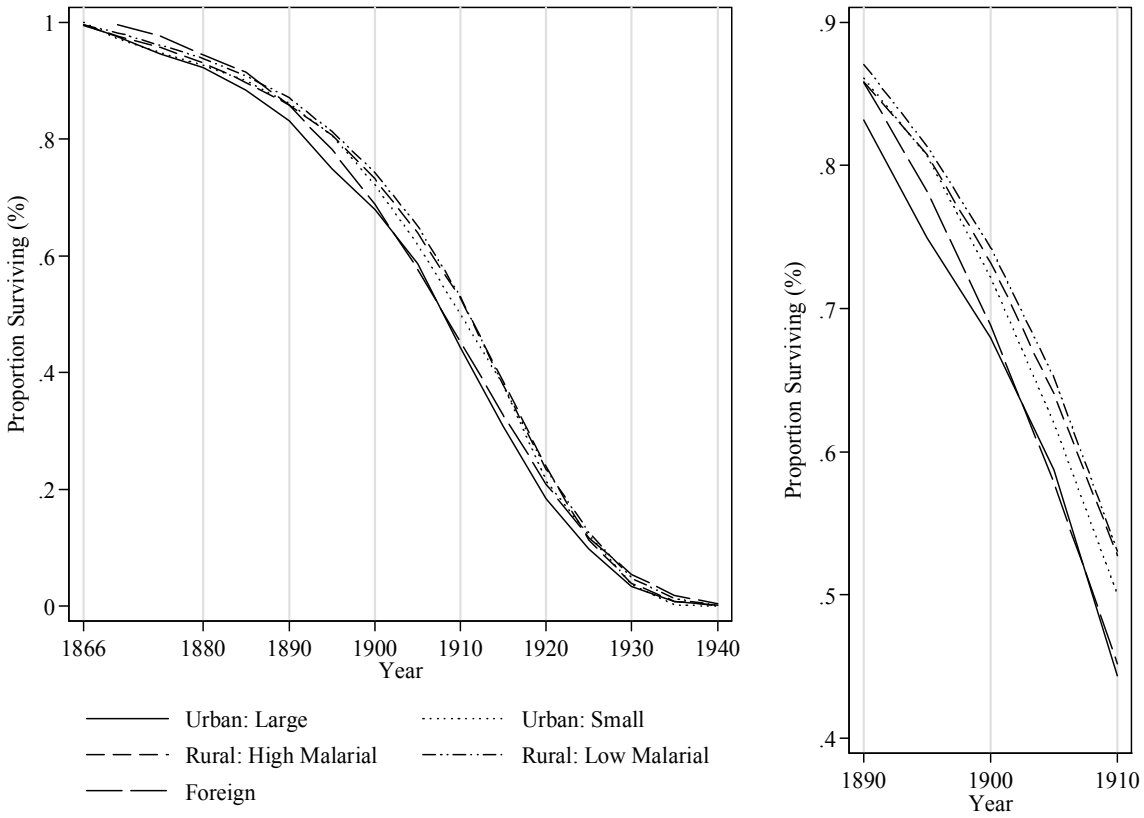
[11] We used Coale and Demeny's (1983) model of the West Female Life Table to estimate life expectancy at birth.

**Figure 1**. Aggregate Urban Mortality Penalty by City Population Size and Population Density




*Notes*: Out of the 100 largest cities in 1860, we selected those where more than 6 veterans were born and survived the Civil War. Population size in the panel on the left is log-scaled. City population density in the panel on the right is measured as population per square mile.

**Figure 2**. Observed Survival Curves by Type of Birth Place




*Notes*: The survival curves were constructed from data for the veterans who survived the Civil War and whose death years are known. The panel on the right provides an enlarged view of the period around 1900.

veterans born in that city who survived the war. It did not matter where they lived later; the crucial factor is that they were born there. As in Table 1, the city survival rate is calculated as the number of survivors in 1900 divided by the total number of surviving veterans who never deserted. Figure 1 presents two graphs of these survival rates versus both population and population density for those cities among 100 largest in 1860. As is immediately apparent, the larger cities, those with the open circles, tend to be among the lowest in terms of survival rates in the left-hand panel. The right-hand panel reveals there is also a downward-sloping relationship between survival rates and population density. It should be noted that the unit of observation in Figure 1 is the city, while the unit of observation in elsewhere in our work is the individual veteran.

Finally, we limited the data to those veterans we could find in the death records to minimize sample selection problems. Then we looked at survival rates across the years according to five possible birth places, three less than in Table 1. We have collapsed Urban 1 and Urban 2 into Urban: Large, and the second two urban areas into Urban: Small. Rural areas remain split into two groups, with a malaria risk of 0.25 still being the dividing point. The main reason for reducing the number of study areas is that the Union Army sample is biased toward rural areas, and given the need to link veterans to the 1860 Census in the larger analysis, we are concerned about sample sizes. In Figure 2, the survival rates to particular years have been graphed, with an adjustment of four years for the foreign born reflecting their earlier birth dates. The panel on the right provides an enlarged view of the period around 1900. Again, the urban mortality penalty is readily apparent.

Before 1890 when the law creating a service pension was passed, disability pensions were awarded to those who were severely injured and impaired during the Civil War. Many veterans were not eligible for a pension initially, and may not have been able to apply under the service pension law, especially if they died before the 1890s. Most of the information about death places is from the pension records. This implies that the sample found in the death records is more representative of those who lived longer. In consequence, the survival rates observed in Figure 2 are higher than those in Table 1. The results in Figure 2 and the following sections should be considered a lower bound of the urban mortality penalty.

## II

To investigate the urban mortality penalty in greater depth, we elected to use a Cox proportional hazard model that specifies the hazard for veteran *i* as $\lambda_i(t) = \lambda_0(t) \times \exp(X_i\beta)$, where $\lambda_0(t)$ is the hazard in the reference group at time *t*. The reference group is those non-deserting veterans who survived the Civil War; the time is measured as years since 1865. $X_i$ is an $n \times p$ matrix that includes *p* components associated with each of *n* veterans. The $\beta$'s are the estimated log hazard ratios, the multiplier by which the hazard is increased or decreased with a unit change in the associated component of *X* as compared to the reference group.

As a first step, we estimated hazard ratios reflecting a veteran's birth place, residence in 1860, and death place for all four urban areas, with simply "Rural" as the omitted category. We also included the birth year in this regression to control for age; the results are reported in Table 2. The first column is similar to Table 1 and Figure 2, but the inclusion of birth year shows a reduced hazard (higher survival) for the foreign born.

**Table 2**. Cox Hazard Ratio of Union Army Veterans
by Type of Places at Birth, in 1860, and at Death

Dependent Variable: Years to Death after the Civil War (1865)

| Variables | Type of Place | | | | | |
|---|---|---|---|---|---|---|
| | Birth Place | | Residence in 1860 | | Death Place | |
| | Hazard Ratio | z-value | Hazard Ratio | z-value | Hazard Ratio | z-value |
| Urban 1 | 1.2244 | 4.49 | 1.4568 | 4.17 | 1.5518 | 10.18 |
| Urban 2 | 1.3502 | 2.99 | 1.5573 | 2.21 | 1.4777 | 5.47 |
| Urban 3 | 1.1416 | 1.67 | 1.1663 | 1.15 | 1.0867 | 1.38 |
| Urban 4 | 1.1401 | 2.23 | 1.3821 | 3.72 | 1.1429 | 3.21 |
| Foreign | 1.1719 | 7.69 | | | | |
| U.S. Rural | Omitted | | Omitted | | Omitted | |
| Birth Year | 0.9234 | -64.68 | 0.9238 | -45.70 | 0.9200 | -60.62 |
| LR $\chi 2$ (p-value) | 3969.5 (0.000) | | 1890.3 (0.000) | | 3290.0 (0.000) | |
| n | 14,492 | | 6,569 | | 11,922 | |

*Notes* : The Cox regressions are conducted only for the veterans whose death year and place of birth, 1860 residence, or death place are known. The survival time in the regression is defined as the duration to death from the end of the Civil War.

As can be seen, the hazard ratios for the two larger urban classes and the two smaller urban classes are similar. The former two are larger than the smaller two, and the foreign born fall between them. All four are larger than rural places, the omitted category in each case. The hazard ratios increase over the period for Urban 1, but for the other three, they first increase, then decrease. The lowest ratio is that of Urban 3 for death places, and that is still more than eight percentage points higher than a rural death place. Again, it should also be noted that the sample size for 1860 residence is lower than the other two because of the need to link the Union Army sample to the 1860 Census.

Our larger analysis involves as much information as we have on a veteran's life cycle in the CPE database. The first panel of Table 3 repeats the exercise in Table 2, but, following Figure 2, Urban 1 and Urban 2 are combined into Urban: Large (large cities) and Urban 3 and Urban 4 are combined in Urban: Small (small cities). Other possible birth places are high malaria rural areas (Rural: High Malaria), low malaria rural areas (Rural: Low Malaria), and foreign. There are four possible residences in 1860, and five possible places of death. The additional death place is a situation where we are sure the place of death is a rural area, but the county does not appear in the death register.

In Table 3, the results of Cox regressions on the various locations are reported for the three time periods separately and in combination with other time periods. The only control variable included in this set of regressions is the birth year, and it is always about 0.92 and highly statistically significant. The coefficients for those in a particular life stage and place are also highly stable with one notable exception. The hazard ratio of being born in a large city is at least 0.15 less when residence in 1860 is included in the regression. It also diminishes, albeit by less, when death place is included in the regression. To the extent that, in the regression with all three dates included, the hazard ratio of having been born in a large city is much lower than having resided in one in 1860 or having died in one, there is reason to believe that the urban mortality penalty was not as significant when the veterans were born than it was later in their lives, that

**Table 3**. Hazard Ratio by Lifetime Locations

Dependent Variable: Years to Death after the Civil War (1865)

| Control variables | (1) | | (2) | | (3) | | (4) | | (5) | | (6) | | (7) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Haz. Ratio | z-value | Haz. Ratio | z-value | Haz. Ratio | z-value | Haz. Ratio | z-value | Haz. Ratio | z-value | Haz. Ratio | z-value | Haz. Ratio | z-value |
| Birth Place | | | | | | | | | | | | | | |
| Urban: Large | 1.2509 | 5.37 | | | | | 1.0965 | 1.12 | 1.1772 | 3.22 | | | 1.0623 | 0.62 |
| Urban: Small | 1.1477 | 2.88 | | | | | 1.1496 | 1.71 | 1.1475 | 2.45 | | | 1.2012 | 1.86 |
| Rural: High Malaria | 1.0372 | 1.39 | | | | | 1.0251 | 0.52 | 1.0379 | 1.14 | | | 1.0177 | 0.31 |
| Rural: Low Malaria | Omitted | | | | | | Omitted | | Omitted | | | | Omitted | |
| Foreign | 1.1791 | 7.80 | | | | | 1.1313 | 2.89 | 1.1841 | 6.51 | | | 1.1832 | 3.28 |
| Residence in 1860 | | | | | | | | | | | | | | |
| Urban: Large | | | 1.4746 | 4.69 | | | 1.4131 | 3.79 | | | 1.4783 | 3.58 | 1.4206 | 3.00 |
| Urban: Small | | | 1.3125 | 3.70 | | | 1.2483 | 2.59 | | | 1.3882 | 3.74 | 1.2535 | 2.19 |
| Rural: High Malaria | | | 1.0117 | 0.33 | | | 0.9874 | -0.27 | | | 0.9814 | -0.42 | 0.9680 | -0.58 |
| Rural: Low Malaria | | | Omitted | | | | Omitted | | | | Omitted | | Omitted | |
| Death Place | | | | | | | | | | | | | | |
| Urban: Large | | | | | 1.6011 | 11.86 | | | 1.6158 | 11.07 | 1.4867 | 5.16 | 1.5406 | 5.19 |
| Urban: Small | | | | | 1.1751 | 4.34 | | | 1.1863 | 4.22 | 1.1738 | 2.46 | 1.2453 | 3.11 |
| Rural: High Malaria | | | | | 1.0665 | 2.21 | | | 1.0724 | 2.15 | 1.1042 | 2.15 | 1.1329 | 2.44 |
| Rural: Low Malaria | | | | | 1.0755 | 3.33 | | | 1.0951 | 3.76 | 1.1319 | 3.47 | 1.1790 | 4.14 |
| Rural: Unknown | | | | | Omitted | | | | Omitted | | Omitted | | Omitted | |
| Birth Year | 0.9234 | -64.69 | 0.9238 | -45.74 | 0.9201 | -60.58 | 0.9209 | -41.57 | 0.9177 | -55.02 | 0.9170 | -39.24 | 0.9155 | -35.06 |
| LR $\chi 2$ (p-value) | 3970.6 (0.000) | | 1889.1 (0.000) | | 3302.0 (0.000) | | 1637.2 (0.000) | | 2940.0 (0.000) | | 1408.1 (0.000) | | 1203.8 (0.000) | |
| n | 14,492 | | 6,569 | | 11,922 | | 5,376 | | 9,945 | | 4,533 | | 3,732 | |

*Note*: We conducted Cox proportional-hazards survival regressions for types of birth place, 1860 residence and death place, and birth year without additional control variables.

urban conditions deteriorated over these years. A study of age-specific mortality for each of the three places (reported below) further emphasizes the importance of 1860 residence and death place in relation to birth place.

Table 4 presents the results of regressions that include all three stages. Recall the right-hand columns of Table 3 report the results when none of the control variables are included. Table 4 introduces various control variables in three steps. The first step involves socio-economic variables, the individual's wealth in 1860 and his occupation at enlistment.[12] Clearly there is a relationship between a rural residence and being a farmer, but the correlation is not as high as one might expect. The second step adds variables that reflect the veteran's wartime experience. In addition to the year of enlistment, there is data on initial rank, whether he experienced infections or illness, whether he had wounds or other injuries, and whether he was a POW. The final step adds variables that reflect health conditions later in life as reported in the Surgeon's Certificates for pension purposes.

Given the inclusion of all three stages, the hazard ratio for large urban birth place is, in fact, less than that of small urban birth places and less than rural birth places. It has the highest hazard

[12] Both a veteran's height at enlistment and the population density of the county in which he is located in 1860 are available. Both are highly correlated with other variables we report. When one or both are used in place of the variables we report, the explanatory power of the regression equation diminishes slightly. Thus, we elected not to report those regressions. Suffice to note that mortality tends to increase with increasing density.

**Table 4**. Hazard Ratio by Lifetime Locations and by Different Model

Dependent Variable: Years to Death after the Civil War (1865)

| Control variables | (1) | | (2) | | (3) | |
|---|---|---|---|---|---|---|
| | Haz. Ratio | z-value | Haz. Ratio | z-value | Haz. Ratio | z-value |
| Birth Place | | | | | | |
| Urban: Large | 1.0426 | 0.43 | 1.0440 | 0.44 | 0.9725 | -0.29 |
| Urban: Small | 1.1808 | 1.69 | 1.1730 | 1.61 | 1.1220 | 1.16 |
| Rural: High Malaria | 1.0435 | 0.76 | 1.0433 | 0.76 | 1.0480 | 0.83 |
| Rural: Low Malaria | Omitted | | Omitted | | Omitted | |
| Foreign | 1.1798 | 3.20 | 1.2043 | 3.53 | 1.2225 | 3.79 |
| Residence in 1860 | | | | | | |
| Urban: Large | 1.3376 | 2.47 | 1.2943 | 2.18 | 1.2398 | 1.80 |
| Urban: Small | 1.2137 | 1.87 | 1.2105 | 1.83 | 1.2840 | 2.38 |
| Rural: High Malaria | 0.9858 | -0.25 | 0.9865 | -0.24 | 1.0276 | 0.48 |
| Rural: Low Malaria | Omitted | | Omitted | | Omitted | |
| Death Place | | | | | | |
| Urban: Large | 1.5006 | 4.86 | 1.4954 | 4.80 | 1.4283 | 4.22 |
| Urban: Small | 1.2196 | 2.81 | 1.2204 | 2.82 | 1.2011 | 2.57 |
| Rural: High Malaria | 1.1575 | 2.84 | 1.1482 | 2.68 | 1.1557 | 2.79 |
| Rural: Low Malaria | 1.1853 | 4.27 | 1.1826 | 4.20 | 1.1632 | 3.77 |
| Rural: Unknown | Omitted | | Omitted | | Omitted | |
| Birth Year | 0.9174 | -29.75 | 0.9187 | -28.64 | 0.9181 | -28.72 |
| Other Specifications | | | | | | |
| SES Conditions around 1860 | YES | | YES | | YES | |
| Wartime Experiences | NO | | YES | | YES | |
| Later Health Conditions | NO | | NO | | YES | |
| LR $\chi 2$ (p-value) | 1234.5 (0.000) | | 1889.1 (0.000) | | 1423.4 (0.000) | |
| n | 3,732 | | 3,732 | | 3,732 | |

*Notes* : The control variables for each category of "other specifications" are listed in Table 5. The regression coefficients for the control variables in model (3) are presented in Table 5.

ratio for residences in 1860 for the first two regressions in Table 4, and falls just below small urban residences in the third. For urban death places, large cities have higher hazard ratios than small cities, than rural places, but there is little difference between the two rural places, with the low malaria areas having a slightly higher rate than the high malaria areas.

Table 5 presents the coefficients for the control variables that were generated from the regression involving all the control variables reported in Table 4. It should be noted that the coefficients presented in this table are almost identical in magnitude and statistical significance to those from the other regressions. It also is worth noting that, in the face of all these variables, the urban mortality persists.

The coefficient on birth year is again in the neighborhood of 0.92 and highly statistically significant. Veterans who were wealthier in 1860 had a statistically significant lower hazard ratio. The Census reported wealth as either property wealth (greater than $100) or real estate wealth. We used the sum of these two in our regressions. Breaking total wealth into its two components added nothing to the explanation. Few veterans had accumulated substantial

**Table 5**. Estimated Hazard Ratios for Other Control Variables

| Other Control Variables | Haz. Ratio | z-value |
|---|---|---|
| Birth year | 0.9181 | -28.72 |
| Socio-Economic Conditions around 1860 | | |
| 1860 individual wealth | 0.9856 | -2.39 |
| Dummy of occupation at enlistment | | |
| Professional worker | 1.1200 | 0.83 |
| Farmer | 0.8443 | -3.80 |
| White collar worker | 0.8918 | -1.07 |
| Blue collar worker | 0.9401 | -1.23 |
| Unemployed or unknown | Omitted | |
| Wartime Experiences | | |
| Enlistment year dummy | | |
| 1861 | 1.1381 | 1.87 |
| 1862 | 1.1076 | 1.58 |
| 1863 | 1.0499 | 0.56 |
| 1864 | 1.0022 | 0.03 |
| 1865 | Omitted | |
| Initial Rank: Private | 1.0642 | 1.15 |
| Dummy of wartime experience | | |
| Infections and illness | 1.0591 | 1.47 |
| Wounds and injuries | 0.9396 | -1.42 |
| POW | 0.9964 | -0.06 |
| Later Health Conditions | | |
| Dummy of later health conditions | | |
| Cardiovascular diseases | 0.8669 | -3.78 |
| Rheumatism/musculo-skeletal | 0.8400 | -4.81 |
| Respiratory | 0.9345 | -1.64 |
| Diarrhea | 0.9381 | -1.39 |
| Nervous System | 1.0401 | 0.72 |
| Genito-Urinary | 1.0275 | 0.47 |
| Infections | 1.0912 | 1.05 |
| Ear | 0.9126 | -1.81 |
| Endocrine | 1.1576 | 0.69 |
| Eye | 0.8573 | -3.29 |
| Gastrointestinal | 0.9076 | -1.82 |
| Poor Appearance | 0.8570 | -3.40 |
| Hernia | 0.8562 | -2.99 |
| Injuries | 0.9689 | -0.71 |
| Liver/Spleen/Gallbladder | 0.9988 | -0.02 |
| Neoplasm/Tumor | 0.9751 | -0.15 |
| Rectum/Hemorrhoids | 0.9373 | -1.49 |
| Varicose Veins | 1.0080 | 0.11 |
| Fevers | 0.9170 | -1.96 |
| LR $\chi 2$ (p-value) | 1423.4 (0.000) | |

*Notes*: 1860 individual wealth is obtained from the 1860 census records, summing real estate and personal property values. Later health conditions are found in the surgeons' certificates of the pension records. The other variables are found in the Union Army military records.

property wealth by 1860 when they would have been approximately age 20, an age at which few veterans had title to real estate. The only occupational category that's statistically significant is farmer, and, as noted, it is closely related to a rural residence. Clearly, much of the reported wealth could be the ownership of farmland.

Those who enlisted earlier were at greater risk; the hazard ratios decline uniformly as time passed. Having an initial rank of private increased one's risk. Wartime infections and illnesses were associated with greater risk, but wounds and injuries with less. Being wounded reduced one's hazard ratio. One would expect that some of the wounded veterans were discharged from service before the end of the war, returned home, and were less at risk for things that might affect them later in life. In short, spending less time at war increased one's longevity. Being a POW did not seem to have an effect. None of the wartime experience variables are statistically significant.

The variables associated with illness later in life include several that proved statistically significant, including cardiovascular diseases, rheumatism/musculo-skeletal diseases, eye diseases, poor appearance, and hernia; all were associated with a lower hazard ratio. As these are more likely to be diagnosed as one ages, the suspicion is that, the longer a veteran lived, the more likely they were to be identified with these

**Table 6**. Hazard Ratios of Native-Born Veterans by Liftime Locations

Dependent Variable: Years to Death after the Civil War (1865)

| Control variables | (1) All Veterans | | (2) Native-Born Only | | (3) All Veterans | | (4) Native-Born Only | |
|---|---|---|---|---|---|---|---|---|
| | Haz. Ratio | z-value | Haz. Ratio | z-value | Haz. Ratio | z-value | Haz. Ratio | z-value |
| Birth Place | | | | | | | | |
| Urban: Large | 1.0623 | 0.62 | 1.0893 | 0.84 | 0.9725 | -0.29 | 0.9990 | -0.01 |
| Urban: Small | 1.2012 | 1.86 | 1.2404 | 2.15 | 1.1220 | 1.16 | 1.1738 | 1.58 |
| Rural: High Malaria | 1.0177 | 0.31 | 1.0278 | 0.49 | 1.0480 | 0.83 | 1.0494 | 0.83 |
| Rural: Low Malaria | Omitted | | Omitted | | Omitted | | Omitted | |
| Foreign | 1.1832 | 3.28 | | | 1.2225 | 3.79 | | |
| Residence in 1860 | | | | | | | | |
| Urban: Large | 1.4206 | 3.00 | 1.3719 | 1.83 | 1.2398 | 1.80 | 1.2596 | 1.32 |
| Urban: Small | 1.2535 | 2.19 | 1.1391 | 1.08 | 1.2840 | 2.38 | 1.1506 | 1.15 |
| Rural: High Malaria | 0.9680 | -0.58 | 0.9414 | -1.02 | 1.0276 | 0.48 | 0.9965 | -0.06 |
| Rural: Low Malaria | Omitted | | Omitted | | Omitted | | Omitted | |
| Death Place | | | | | | | | |
| Urban: Large | 1.5406 | 5.19 | 1.4540 | 3.88 | 1.4283 | 4.22 | 1.3756 | 3.26 |
| Urban: Small | 1.2453 | 3.11 | 1.2930 | 3.33 | 1.2011 | 2.57 | 1.2523 | 2.89 |
| Rural: High Malaria | 1.1329 | 2.44 | 1.1396 | 2.43 | 1.1557 | 2.79 | 1.1684 | 2.84 |
| Rural: Low Malaria | 1.1790 | 4.14 | 1.1658 | 3.59 | 1.1632 | 3.77 | 1.1599 | 3.45 |
| Rural: Unknown | Omitted | | Omitted | | Omitted | | Omitted | |
| Birth Year | 0.9155 | -35.06 | 0.9151 | -32.05 | 0.9181 | -28.72 | 0.9181 | -25.97 |
| Other Specifications | | | | | | | | |
| SES Conditions around 1860 | NO | | NO | | YES | | YES | |
| Wartime Experiences | NO | | NO | | YES | | YES | |
| Later Health Conditions | NO | | NO | | YES | | YES | |
| LR $\chi 2$ (p-value) | 1203.8 (0.000) | | 899.2 (0.000) | | 1423.4 (0.000) | | 1051.4 (0.000) | |
| n | 3,732 | | 3,227 | | 3,732 | | 3,227 | |

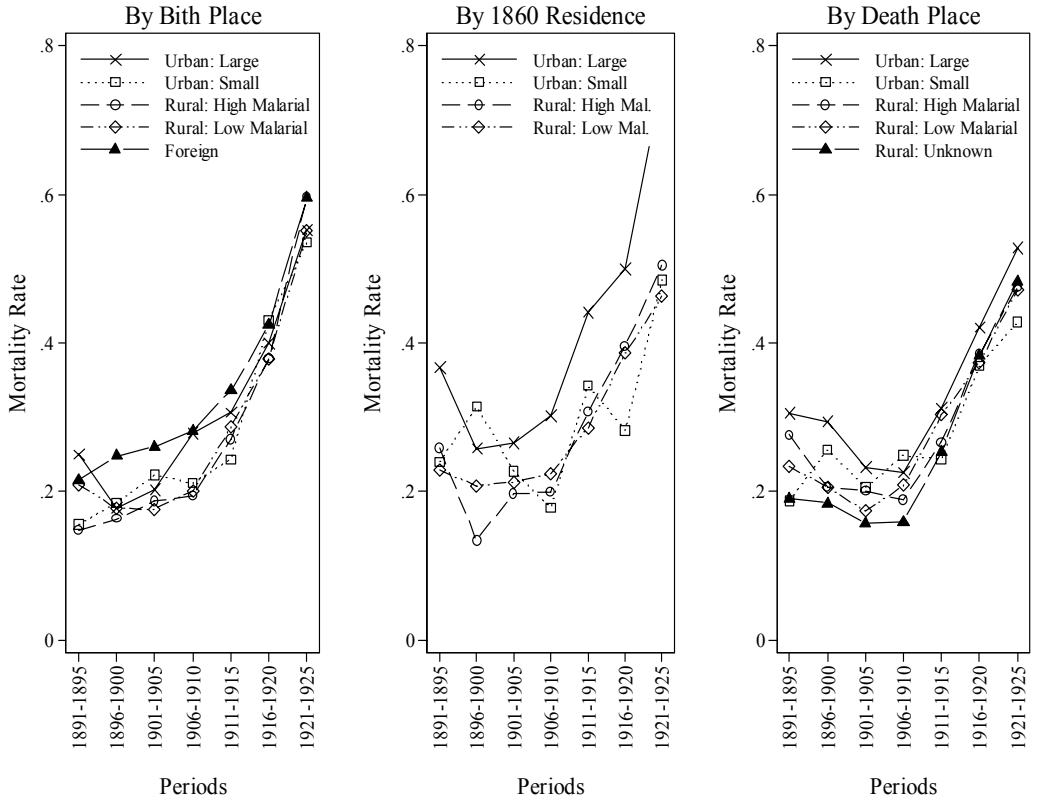
*Note* : Additional control variables for each category of "other specifications" are listed in Table 5.

conditions. It should be recalled that the pension roles expanded greatly with the liberalization of the rules in 1890 when the average surviving veteran was in his early 50s.

The results for regression 3 in Table 4, in which all three dates are present, are little different from the regressions in which they appear individually or in combination. The spread of the hazard ratios by life stage has become quite large. Again, this suggests that the urban mortality penalty may be more a function of what happened in late adolescence and adulthood rather than during one's formative years.

The effect of the foreign-born veterans was addressed by re-running two of the above regressions including only the native-born veterans. The results are in Table 6. As can be seen, the first pair of regressions includes none of the control variables other than birth year, while the second pair includes all of them. The left-hand side of each pair involves all of the veterans, while the right-hand side involves only the native-born. Excluding the foreign-born reduces the hazard ratio in smaller cities in 1860, but that is the only major difference. Although the effects are small, it is

**Figure 3**. Five-Year-Period Age-Specific Mortality Rate of Union Army Veterans
(aged 60 or more at the beginning year of each period)




*Notes*: We limited the sample to veterans who were 60 or older at the beginning year of each period. The mortality rate is calculated as total deaths during the period out of total veterans alive at the beginning of the period.

worth noting that the hazard ratios for all estimated birth places increase when the foreign-born are omitted, but they generally decrease for residence in 1860 and death place. It is possible that, the greater the proportion of foreign born in a city, the lower that city's survival rate for the native born. Regardless, the urban mortality penalty is apparent in each regression, and that penalty is more pronounced for the later stages of life.

To get a better handle on the three life stages, we examined age-specific death rates based on the veteran's location at each stage. The rate is for those 60 years of age and older who died in each five-year interval. We selected 60 as the appropriate age for the calculation given that the pool of pensioners increased with the reforms of the 1890s, when the average veteran was in his 50s and given the survival rates reported at the beginning of this paper are based on 1900. The age-specific death rates for each interval appear in Figure 3. What is immediately apparent is that, although all three panels are quite similar, the urban mortality penalty is most pronounced for panel b, for the residence in 1860. This is consistent with what was found in the regression analysis above. Panel c, for death place, indicates that large cities were generally the worst, but

the small cities are often indistinguishable from rural areas. Panel a, for birth place, shows that those born in large cities and outside the U.S. had the highest rates in general, and specifically from 1906-1915. It should be recalled that the foreign-born were four to five years older on average, so they turned 60 one period sooner than the native-born.

As a final step, we constructed a dummy variable that reflects three factors: a veteran's birth place, his residence in 1860, and his death place. We have assigned a three-digit number to each of the 100 possibilities (e.g., 432). The 100 possibilities result from the fact there are 5 possible birth places, 4 possible residences in 1860, and 5 possible death places. In each position, the number 1 reflects the larger city category (Urban: Large); 2, the smaller city category (Urban: Small); 3, the high malaria rural area (Rural: High Malaria); and 4, the low malaria rural area (Rural: Low Malaria). A "5 "in the first position indicates a foreign born veteran; a "5" in the final position indicates a veteran who died in a rural area for which the county was not recorded. Thus, "432" indicates a veteran born in a low malaria rural area, who resided in a high malaria rural area in 1860, and died in a small city. Because there are no veterans in some of these cells and very few in others, we have limited our analysis to those cells in which there are at least five veterans.

This regression includes a full set of control variables.[13] While they are not reported, the estimated coefficients for the control variables are essentially identical to those reported in Table 5. Birth year, which controls for age, once again has a hazard ratio of approximately 0.92. From the second life stage, personal wealth in 1860 has an effect, but the only occupation with a statistically-significant effect is farming. In general, those who enlisted later in the war had lower hazard ratios. Here, however, those who joined in 1865 have a ratio higher than for those who joined the previous year. Those with low initial rank had a higher hazard ratio than the reference group. Similarly, those veterans with recorded war illnesses, those who were wounded during the war, and those who had been POWs had lower than average hazard ratios. With respect to the third stage, all the statistically-significant coefficients on control variables reflecting the presence of later-life health conditions have hazard ratios less than one.

Table 7 presents the coefficients for the mobility variables in the three arrays, one for each of the three life stages. The reference group is those veterans who were born and lived in low malaria rural areas throughout their lives (444). The first panel shows these rates according to a veteran's birth place. Values of the hazard ratios over 1.5000 have been bolded.

Perhaps the first thing to observe is that there are no estimated coefficients reported for veterans born in a small city (2) or in a high malarial rural area (3) who resided in a large city (1) in 1860. There is only one coefficient for veterans born in a high malarial rural area who resided in a small city in 1860, and those are the veterans who died in rural areas where the county was not listed (5). We attribute the absence of estimates to a lack of data. Even though this regression is based on 3,684 observations, the relative lack of urban observations creates a void that begs to be filled.

[13] As above, we ran this regression with and without a variable reflecting the infant mortality rate in those counties for which it was available. As before, the results are essentially identical.

**Table 7a**. Coefficients of Mobility Sorted by Type of Birth Place

| Birth Place | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Large City | | Small City | | High Malaria Rural | | Low Malaria Rural | | Foreign | |
| 111 | 1.4829 | 211 | — | 311 | | 411 | | 511 | **1.6445** ** |
| 112 | | 212 | — | 312 | — | 412 | | 512 | 0.8831 |
| 113 | — | 213 | — | 313 | — | 413 | | 513 | |
| 114 | **1.6065** | 214 | — | 314 | — | 414 | | 514 | **2.5500** *** |
| 115 | 0.5801 | 215 | — | 315 | — | 415 | | 515 | **2.9412** *** |
| 121 | — | 221 | | 321 | — | 421 | | 521 | |
| 122 | **1.6648** | 222 | **1.6041** ** | 322 | — | 422 | **1.6955** ** | 522 | **2.5291** *** |
| 123 | — | 223 | — | 323 | — | 423 | — | 523 | — |
| 124 | — | 224 | 0.6656 | 324 | — | 424 | 1.2284 | 524 | **1.6853** |
| 125 | | 225 | 0.6205 | 325 | | 425 | 0.9849 | 525 | **1.5930** |
| 131 | | 231 | — | 331 | 0.8932 | 431 | | 531 | **1.9774** * |
| 132 | — | 232 | — | 332 | 0.6764 | 432 | 0.6842 | 532 | 1.1772 |
| 133 | | 233 | | 333 | 1.3351 *** | 433 | 0.7389 * | 533 | 1.4672 |
| 134 | — | 234 | | 334 | 1.1276 | 434 | 0.8923 | 534 | 0.9343 |
| 135 | 0.8287 | 235 | | 335 | 0.9484 | 435 | 0.7731 * | 535 | 1.2441 |
| 141 | 1.2678 | 241 | 1.3534 | 341 | 0.8314 | 441 | 1.1805 | 541 | **2.0370** *** |
| 142 | | 242 | 1.4236 | 342 | | 442 | 1.0606 | 542 | 0.9514 |
| 143 | | 243 | 1.4261 | 343 | 0.8180 | 443 | 1.0069 | 543 | 0.9581 |
| 144 | 0.8788 | 244 | 1.2541 | 344 | 0.9613 | 444 | Omitted | 545 | 1.2693 *** |
| 145 | 0.8963 | 245 | 1.3766 * | 345 | 0.8159 | 445 | 0.8726 *** | 545 | 0.9348 |

*Notes*: From the observations on 3,732 veterans employed in the previous analyses, we used 3,684 veterans here by limiting our analysis to the mobility groups with 5 or more observations. We denoted the groups without an observation by a hyphen (—); while the groups with 1-4 observations are left blank. The 'omitted' group is the reference group. Values of the hazard ratios over 1.5000 have been bolded. Besides mobility dummies, we controlled for birth year and the other control variables listed in Table 5. A single asterisk denotes statistical significance at the 90% level of confidence; two asterisks, 95%; three asterisks, 99%.

Of the 12 coefficients that exceed 1.5000, 2 are in the column reflecting a large city birth place and 8 in the column reflecting a foreign birth place. Of those 10, 6 involve living in a large city at another stage. For small cities, the largest coefficient is for those who moved to a large city after the war. For those born in low malaria rural areas, the hazard ratios are extremely high if they resided in a large city in 1860, even though they returned to rural areas after the war. This is attributable to small sample sizes. There are no bolded coefficients in the column for those born in high malaria rural areas.

If one looks just at those who remained in an area like their birth place, the urban mortality effect is quite apparent. The hazard ratio for large cities (111) is 1.4829; that for small cities (222) is 1.6041, and that for high malaria rural areas (333) is 1.3351. Recall that the omitted category in this regression is that for low malaria rural areas (444), which presumes that value is 1.000. Sample size may be an issue for large cities, as there are only 14 in 111. The numbers in the other three categories are 26, 159, and 1092, respectively.

The general impression we take from this panel is that those born in large cities and the foreign born who moved to large cities faced high hazard ratios. This panel gives the impression that the urban mortality penalty was present over all the life stages, that the initial years were an important component of that penalty, but perhaps not the most important.

**Table 7b**. Coefficients of Mobility Sorted by Type of 1860 Residence

| Residence in 1860 | | | | | | | |
|---|---|---|---|---|---|---|---|
| Large City | | Small City | | High Malaria Rural | | Low Malaria Rural | |
| 111 | 1.4829 | 121 | — | 131 | | 141 | 1.2678 |
| 112 | | 122 | **1.6648** | 132 | — | 142 | |
| 113 | — | 123 | — | 133 | | 143 | |
| 114 | **1.6065** | 124 | — | 134 | — | 144 | 0.8788 |
| 115 | 0.5801 | 125 | | 135 | 0.8287 | 145 | 0.8963 |
| 211 | — | 221 | | 231 | — | 241 | 1.3534 |
| 212 | — | 222 | **1.6041** ** | 232 | — | 242 | 1.4236 |
| 213 | — | 223 | — | 233 | | 243 | 1.4261 |
| 214 | — | 224 | 0.6656 | 234 | | 244 | 1.2541 |
| 215 | — | 225 | 0.6205 | 235 | | 245 | 1.3766 * |
| 311 | | 321 | — | 331 | 0.8932 | 341 | 0.8314 |
| 312 | — | 322 | — | 332 | 0.6764 | 342 | |
| 313 | — | 323 | — | 333 | 1.3351 *** | 343 | 0.8180 |
| 314 | — | 324 | — | 334 | 1.1276 | 344 | 0.9613 |
| 315 | — | 325 | | 335 | 0.9484 | 345 | 0.8159 |
| 411 | | 421 | | 431 | | 441 | 1.1805 |
| 412 | | 422 | **1.6955** ** | 432 | 0.6842 | 442 | 1.0606 |
| 413 | | 423 | — | 433 | 0.7389 * | 443 | 1.0069 |
| 414 | | 424 | 1.2284 | 434 | 0.8923 | 444 | |
| 415 | | 425 | 0.9849 | 435 | 0.7731 * | 445 | 0.8726 *** |
| 511 | **1.6445** ** | 521 | | 531 | **1.9774** * | 541 | **2.0370** *** |
| 512 | 0.8831 | 522 | **2.5291** *** | 532 | 1.1772 | 542 | 0.9514 |
| 513 | | 523 | — | 533 | 1.4672 | 543 | 0.9581 |
| 514 | **2.5500** *** | 524 | **1.6853** | 534 | 0.9343 | 544 | 1.2693 *** |
| 515 | **2.9412** *** | 525 | **1.5930** | 535 | 1.2441 | 545 | 0.9348 |

The second panel reflects a veteran's residence in 1860. Of the 12 bolded coefficients, 4 are in the column for large cities and 6 are in the column for small cities. By contrast, only 1 appears in the column for the high malaria rural areas and 1 in the column for low malaria rural areas. Both of the latter coefficients are for veterans who were foreign born and lived in a large city at the end of their lives. The general impression we take from this panel is that late adolescence may be an important period for the urban mortality penalty.

The final panel is organized around a veteran's place of death. 3 of the 12 bolded coefficients are in the column reflecting death in a large city, 4 are in the column for small cities. The remaining 5 all involve death in a rural place, 3 of which involve residence in a large city in 1860 and the other 2 residence in a small city in 1860. Of the 7 bolded coefficients from the first two columns, none suggests a veteran lived in a rural area during both the two previous stages. Only 1 (422) of those 7 is for a case where a veteran was born in a rural area and only 2 (531 and 541) are for a case where a veteran lived in a rural area in 1860.

In sum, the Cox hazard regressions indicate that the urban mortality penalty is likely to be important at all three life stages, but it may well be the case that the birth place played a less important role than places of residence later in life. These three panels further our impression that late adolescence is a period that warrants relatively more concern in future explorations.

**Table 7c**. Coefficients of Mobility Sorted by Type of Death Place

| Place of Death | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Large City | | Small City | | High Malaria Rural | | Low Malaria Rural | | Rural: Malaria Risk Unknown | |
| 111 | 1.4829 | 112 | | 113 | — | 114 | **1.6065** | 115 | 0.5801 |
| 211 | — | 212 | — | 213 | — | 214 | — | 215 | — |
| 311 | | 312 | — | 313 | — | 314 | — | 315 | — |
| 411 | | 412 | | 413 | | 414 | | 415 | |
| 511 | **1.6445** ** | 512 | 0.8831 | 513 | | 514 | **2.5500** *** | 515 | **2.9412** *** |
| 121 | — | 122 | **1.6648** | 123 | — | 124 | — | 125 | |
| 221 | | 222 | **1.6041** ** | 223 | — | 224 | 0.6656 | 225 | 0.6205 |
| 321 | — | 322 | — | 323 | — | 324 | — | 325 | |
| 421 | | 422 | **1.6955** ** | 423 | — | 424 | 1.2284 | 425 | 0.9849 |
| 521 | | 522 | **2.5291** *** | 523 | — | 524 | **1.6853** | 525 | **1.5930** |
| 131 | | 132 | — | 133 | | 134 | — | 135 | 0.8287 |
| 231 | — | 232 | — | 233 | | 234 | | 235 | |
| 331 | 0.8932 | 332 | 0.6764 | 333 | 1.3351 *** | 334 | 1.1276 | 335 | 0.9484 |
| 431 | | 432 | 0.6842 | 433 | 0.7389 * | 434 | 0.8923 | 435 | 0.7731 * |
| 531 | **1.9774** * | 532 | 1.1772 | 533 | 1.4672 | 534 | 0.9343 | 535 | 1.2441 |
| 141 | 1.2678 | 142 | | 143 | | 144 | 0.8788 | 145 | 0.8963 |
| 241 | 1.3534 | 242 | 1.4236 | 243 | 1.4261 | 244 | 1.2541 | 245 | 1.3766 * |
| 341 | 0.8314 | 342 | | 343 | 0.8180 | 344 | 0.9613 | 345 | 0.8159 |
| 441 | 1.1805 | 442 | 1.0606 | 443 | 1.0069 | 444 | | 445 | 0.8726 *** |
| 541 | **2.0370** *** | 542 | 0.9514 | 543 | 0.9581 | 545 | 1.2693 *** | 545 | 0.9348 |

Those explorations would be greatly enhanced by additional observations, especially for those born in small cities and high malaria rural areas.

III

Several explanations could be proffered for the urban mortality penalty. Rapid population growth taxed the limited ability of cities to provide even rudimentary sanitation. Water and sewer systems were inadequate, especially when faced with industrial pollution. The influx of native-born migrants from rural areas arrived with few natural defenses to diseases with which they had no previous exposure, while foreign immigrants introduced new diseases. Immigrants tended to crowd into tenements, which facilitated the spread of disease. Contaminated milk and food supplies were common.[14]

These results are a small first step at shedding light on these hypotheses. To the extent that population growth increased urban density, this clearly contributed to a worsening of the survival rate. Sanitation systems are likely to be important factors, but we lack information on rural areas comparable to what is available for urban areas.[15]

[14] Brown (forthcoming), Davis (1973), Duffy (1990), Haines (2001), McKeown and Record (1962), Meeker (1972, 1974), Melosi (2000), Preston and Haines (1991), Voegele (1994), and Williamson (1982, 1990).

[15] See also Cain and Rotella (2001).

Although the disparity between urban and rural mortality has been extensively studied, there has been relatively little work done on the urban mortality penalty. The relatively conventional (and some unconventional) measures that are readily available and used here do not offer a complete explanation. We feel it is reasonable to conclude from this initial statistical analysis that both socioeconomic and environmental variables contributed to that penalty. It appears that less emphasis should be placed on where veterans were born and more on where they lived later, particularly where they spent their adolescence. The urban mortality penalty persists throughout our analyses.

It is clear that a great deal more work needs to be done. These results seem filled with puzzles that can't be resolved without expanding the sample of urban veterans. This is especially true for veterans from small cities. It is also important to look within cities as well as across them. We have used a figure for the average individual wealth in a city, but wealth varied widely within cities, between neighborhoods with tenements and those with single family homes. The same is true, for example, of urban density. Finally, the variables themselves, particularly the environmental variables, need to be refined. This paper has narrowed the search for an explanation of the urban mortality penalty; but a successful completion of that search will require a project of much greater scope.

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