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HEALTH SHOCKS OF THE FATHER AND LONGEVITY OF THE CHILDREN'S CHILDREN

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Health Shocks of the Father and Longevity of the Children's Children
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ABSTRACT

I document the transmission of a grandfather's net nutritional deprivation in young adulthood across multiple generations using the grandfather's ex-POW status in the US Civil War (1861-5). I uncover an association between a grandfather's ex-POW status and the longevity after age 45 of his sons and male-line grandsons but not of his daughters, granddaughters, female-line grandsons, children-in-law, or grandchildren-in-law. Male-line grandsons lost roughly a year of life at age 45, or 4% of remaining life expectancy, if descended from ex-POWs who suffered severe captivity conditions than if descended from non-POWs. I find that the grandfather's age at exposure, own education and own and father's poor late gestatational conditions, as proxied by season of birth, mediate this relationship. I rule out socioeconomic status, marriage and mortality selection, and cultural or psychological transmission from grandfather to grandson as explanations. I cannot rule out an epigenetic explanation.

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There is growing evidence that health can be transmitted across generations, leading to the persistence of poor health within families. Exposure of mothers to famines, infection, and psychological stress during pregnancy has been linked to poor health of children at birth and in adulthood (Barker 1992, 1994; Lumey and van Poppel 2013; Heijmans et al. 2008; Almond 2006) and to the health of grandchildren (Cook et al. 2019; Veenendaal et al. 2013). Whether and how a *paternal* health shock cascades across *multiple* generations to affect descendant health is understudied even though a link between health and ancestral living conditions may constitute an important source of differences in the stock of health capital across ethnic, racial and social groups and across places.

This paper provides evidence for *male-line multigenerational* transmission of a grandpaternal shock in *young adulthood* affecting older age longevity in a unique setting where the ancestral stressor is the grandfather's ex-POW status in the US Civil War (1861-5). Previously well-fed men were exposed to net nutritional deprivation from poor and insufficient food, disease and exposure to the elements before experiencing a return to good conditions. They also suffered from the trauma of captivity. Grandfathers' POW experience represents extreme stress, inflicted on soldiers in an as good as random manner. Conditions in Civil War POW camps deteriorated sharply when prisoner exchanges stopped, leading to starvation, disease, and death. Descendants of grandfathers who were non-POW veterans and former POWs imprisoned when camp conditions were better provide controls for descendants of ex-POWs imprisoned when camp conditions were at their worst.

I document sex-specific *multigenerational* transmission of longevity through the male-line by following grandchildren descended from children born *after the war* to White Union Army veterans. Male-line grandsons lost roughly a year of life at age 45, or 4% of remaining life expectancy, if descended from ex-POWs who suffered severe captivity conditions compared to those descended from non-POWs. I find no association between a grandfather's ex-POW status and the longevity after age 45 of his granddaughters, female-line grandsons, children-in-law, and grandchildren-in-law. I find that younger grandparental ages were more sensitive to transmission and that the grandson's educational level and the grandson's and son's late gestational conditions, as proxied by season of birth mediated transmission. I rule out socioeconomic status, marriage selection, and direct cultural and psychological transmission from grandfather to grandson as explanations for the association between a grandfather's ex-POW status and his male-line grandsons' longevity. While I cannot fully rule out indirect cultural and psychological transmission from grandfather to son to grandson, my evidence is more consistent with epigenetic transmission, that is, with an inheritable modification of gene function.[1]

Prior work showed that paternal ex-POW status was associated with *intergenerational* transmission of longevity. Sons born after the war to ex-POWs who had experienced a harsh capitivity were short-lived than their counterparts born to non-POWs or ex-POWs who faced better conditions during imprisonment. There were no differences among daughters and no differences among sons born before the war (Costa et al. 2018). A limitation of this work was that results from one generation alone could arise from chance outcomes. Chance outcomes are less likely if a grandfather's ex-POW status manifests itself in the longevity of later generations, particularly in an environment where children and grandfathers are not in the same household. While male-line but not female-line grandsons of ex-POWs who suffered a severe captivity were more likely to be overweight (Costa 2023), data were not available for granddaughters.

Several studies provide *circumstantial* evidence of transgenerational transmission through *epigenetic* imprinting in human populations. Although plant and animal studies provide proof of concept, evidence in humans is limited because of data needs, requiring controls for social and cultural factors and at least three generations if the first generation experienced a post-natal shock or four generations if the first suffered an in-utero shock

[1] For a review of the biological processes, see Ryan and Kuzawa (2020).

(Heard and Martienssen 2014).[2] Three sets of transgenerational studies of human populations examine grandchildren's outcomes and grandparents' food shocks during the vulnerable slow growth period *prior to puberty* (Kaati et al. 2007; Bygren et al. 2001; Vågerö et al. 2022, 2018; Van den Berg and Pinger 2016), finding that over-feeding leads to worse later life outcomes among male-line grandsons while under-feeding produces better outcomes. One study reports that under-feeding of males circa age 19 reduced the longevity of male-line grandsons (Bygren 2013) but transgenerational responses to environmental shocks in the late growing years are understudied. Drawbacks of the extant transgenerational studies of longevity is that evidence is limited to Sweden and, with the exception of Vågerö et al. (2018) which is underpowered, that statistical identification depends on an ancestral year of birth fixed effect.

Compared to prior transgenerational studies, my setting and data provide clearer treatment and control groups, including using those marrying into the family, a richer array of variables to rule out specific pathways of transmission, fewer direct grandfather cultural influences because of higher geographic mobility, minimal confounding from other stressors because POW stress was extreme and because it was orthogonal to other health shocks, and higher statistical power.[3]

1 Historical Background

More than million White men and almost 200,000 Black men served in the Union Army in the Civil War. Amost two-thirds of all White men of military age served (Fogel 1993).

[2]Because stress in the womb could affect either the fetus or the germ line, associations among grandchildren with a grandparent exposed in utero are considered intergenerational.

[3]I estimate power in the Överkalix studies to detect the authors' estimated hazard ratio of 1.45 to be 0.66. Power to detect a hazard ratio of this magnitude in the Uppsala Multigen Study is 0.48 (Vågerö et al. 2021). The power in my study to detect my estimated hazard ratio of 1.11 is 0.91.

Seven percent of all U.S. Civil War soldiers were imprisoned as POWs, compared to figures of 0.8 percent for World War II and 0.1 percent for the Korean War. Initially, prisoners were exchanged but by mid-1863 the exchange system broke down. Confederate president Jefferson Davis responded to the Emancipation Proclamation by decreeing that all former slaves captured as Union soldiers (approximately three-quarters of all Black men who served were former slaves) and their White officers could be turned over to the states, where leading a slave insurrection was a capital offense and where Black soldiers could be enslaved. Prisoner exchanges stopped as the two sides argued over the terms and did not commence again until the release of sick and wounded men in late 1864 and more widespread exchanges in early 1865 (Costa and Kahn 2008).

Men captured after mid-1863 faced more time in captivity and worsening conditions as crowds of prisoners increased. Death rates, officially attributed to scurvy, diarrhea, and dysentery, rose. Photographs of the era show men reduced to living skeletons. Average time in captivity was 16 days for men captured before July 1863, 231 days for men captured between July 1863 and June 1864, and 125 days for men captured after June 1864. Among survivors to 1900, wartime records mention scurvy for 11% of all non-POWs; 14% of ex-POWs captured before July 1863; 23% for ex-POWs captured between July 1863 and July 1864; and 14% for ex-POWs captured after June 1864 (Costa 2012).[4] Veterans captured between July 1863 and June 1864 during their growing years were more likely to be stunted at older ages than non-POWs or exchange period ex-POWs: the differences between height at first enlistment and the first height measurement after age 40 was 0.34 inches for non-POWs, 0.40 inches for ex-POWs before July 1863 or after June 1864, and 0.21 inches for ex-POWs captured between July 1863 and June 1864.

[4] Scurvy develops after 8-12 weeks of vitamin C deficiency.

2 Data

My three generation sample consists of White Union Army veterans who survived to 1900, their children, and grandchildren. A unique characteristic of this historical database is that I do almost as well in tracing daughters and granddaughters as in tracing sons and grandsons.

I constructed the unique transgenerational sample to oversample the grandchildren of ex-POWs by building on databases of Union Army veterans and their children (see Appendix A for details). I obtained birth and death information for grandchildren of all ex-POWs and of a subsample of non-POWs, matched on the enlistment characteristics of ex-POWs. I restricted the search to grandchildren of veterans with at least one child who survived to age 45 and who was born after the war but followed all grandchildren regardless of parent's age at death. I also obtained birth and death information for the wives of male-line grandchildren.

Veterans and veterans' children were linked to all available 1850-1940 censuses. Ninety-eight percent of veterans and 86% of their children are linked to at least one census. Conditional on being alive and younger than age 18 at the time of the census, 92% of grandchildren are linked to a census as children (Appendix A). Veterans' grandchildren and their spouses have been linked to the educational information in the 1940 census.

The sample is primarily a Northern sample. Twenty-two percent of grandchildren were born in the Northeast and 58% were born in the North Central region. Among the 92% of grandchildren with death dates, life expectancy of grandchildren of either sex at age 10 or greater was higher by about a year compared to that observed in Social Security area cohorts, probably because grandchildren were native-born and were concentrated in the more rural Midwest (Appendix A).

My analytical sample consists of all grandchildren who survived to age 45 and who descended from children born *after* the war. The sample contains 24,531 grandchildren from 13,959 children of 2,825 veterans (Appendix A). I exclude observations with age inconsistencies and I treat the nine living grandchildren in the sample as censored.

2.1 Variables

My main outcome variable is grandchildren's years lived after age 45. The main variable of interest is POW exposure, which I classify into non-exchange (captured between July 1863 and July 1864), exchange (captured before July 1863 or after June 1864), and non-POW. This classification proxies both for length of captivity and for captivity conditions. Unfortunately, I do not have systematic information on rations or other measures of within camp deprivation.

My control variables consist of three types: those which control for pre-war differences between grandfathers, those which control for post-war differences between grandfathers and parents, and those which control for differences between grandchildren. Control variables include occupational class, property ownership, educational characteristics, and geographic and demographic controls.

Pre-war differences between grandfathers include year of enlistment (which I treat as a dummy variable), occupation at enlistment (farmer, artisan, laborer, and unknown with professional and proprietor as the omitted category), enlistment in a city of 50,000 or more (i.e., one of the 13 largest and thus deadliest cities in the US in 1860), born in the US, and wounded in the war. Ex-POWs were more likely to be urban, less likely to be farmers, and more likely to have enlisted earlier than non-POWs (see Appendix B, section B.1). Exchange ex-POWs had some of the pre-war characteristics of non-exchange ex-POWs (e.g., fraction enlisting in 1861) but more closely resembled non-POWs in other characteristics (e.g., fraction who were laborers). Because there may be unobserved differences between the Union Army sample and the Andersonville sample, I also control for whether the veteran was from the Union Army sample.

My controls for post-war differences between grandfathers are occupation in 1880 (farmer, professional or proprietor, artisan, laborer, no occupation, and not found in the census). Non-exchange ex-POWs were less likely to be farmers and were more likely to be artisans than non-POWs or exchange ex-POWs (see Appendix B, section B.1). I control for grandchildren's childhood socioeconomic status with years of education of each parent and dummy variables indicating if the father (the veteran's son or son-in-law) was ever a laborer, a farmer, or a property owner. Male-line grandchildren of non-exchange ex-POWs were slightly less likely to have a father who was a farmer and more likely to have a father who was never a homeowner than the grandsons of non-POWs but there were no such differences for female-line grandchildren. There were no differences in fathers' laborer status by grandfathers' ex-POW status (Appendix B, section B.1).

I control for differences between grandchildren with birth year, the number of siblings, years of education (for those age 21+), and dummy variables indicating whether the veteran grandfather ever lived in the same household as the grandchild and whether the living veteran grandfather ever was in the same county as the grandchild (for variable means see Appendix B, section B.1). The latter two variables could proxy for the grandfather's longevity, socioeconomic status or for a direct influence of the grandfather on the grandchild.

3 Empirical Framework

Recall that my treatment is the grandfather's POW exposure which I group into none (non-POWs), exposure to harsh conditions (non-exchange ex-POWs or men captured between July 1863 and July 1864), and exposure to milder captivity conditions (exchange ex-POWs or men captured before July 1863 or after July 1864). Concerns that exchange POWs were partially "treated" suggests comparing descendants of non-exchange ex-POWs with descendants of non-POWs. Worries about selection on unobservables in who is captured argues for comparing descendants of non-exchange ex-POWs with descendants of exchange ex-POWs. However, I have not uncovered anything in the historical record which implies that men who surrendered in different time periods were different on unobservables from their comrades who were not captured. Men were captured in groups when officers made the decision to surrender or individually in the chaos of battle or on scouting missions.

My estimated treatment effects are underestimates because of selection. In a sample of POWs, 4% of men captured before July 1863 died in captivity versus 27% captured July 1863 or later, suggesting that only the hardiest non-exchange ex-POWs survived. The primary determinant of survival was camp conditions. The old (above age 30), the tall, those with a lower military rank, farmers, and those with fewer comrades in the camp were less likely to survive (Costa and Kahn 2007). Only the healthiest veterans would have married, had children and would have survived to 1900. Ex-POWs were more likely to have no children than non-POWs (12% versus 9%) because they were less likely to marry but among those who did have children there was no difference in the number of children (5.2 each) (Costa et al. 2018).

3.1 Specifications

My examination of longevity focuses on years lived after age 45 because deaths after age 45 are less likely to be from maternal mortality or violence, including combat. In addition, the extant transgenerational studies point to elevated mortality rates from type II diabetes, cardiovascular disease, and cancer (Bygren et al. 2001, 2014; Vågerö et al. 2018), all older age conditions.

My main specifications achieve four aims. The first is to establish male-line transmission of a grandfather's ex-POW status to affect longevity. The second is to examine how the inheritance of ex-POW stress changes across generations. The third is to identify critical ancestral transmission ages. The fourth is to investigate how own and father's in utero conditions, as proxied by season of birth, mediate inheritance of ex-POW status.

I examine the association between grandchildren's longevity and the grandfather's non-exchange ex-POW status relative to the grandfather's exchange ex-POW status *within* subsamples consisting of male-line grandsons, male-line granddaughters, female-line grandsons, and female-line granddaughters. Because mortality risk depends on years lived, I fit Cox proportional hazard models, clustered on the veteran grandfather and stratified on birth cohort, to obtain hazard ratios.[5] I specify

$$h_i(t) = h_0(t)\exp(\beta_x X_i)$$

where t is years lived after age 45, $h_0(t)$ is the baseline hazard and X_i is a vector of characteristics specific to each grandchild i. I specify $\beta_x X_i$ as

$$\beta_1 P_{Ei} + \beta_2 P_{Ni} + \beta_3 C_i \tag{1}$$

where P_{Ei} and P_{Ni} are dummy indicators equal to one if the grandfather was an exchange period POW or a non-exchange period POW, respectively, and C is vector of control characteristics. I control for enlistment characteristics of the grandfather and for the grandchild's year of birth. I cluster the standard errors on the veteran grandfather. I cannot pool grandsons and granddaughters and still maintain the proportional hazards assump-

[5] Cox hazard models are non-parametric. I later use parametric Gompertz models as well. The stratification on birth cohort allows the baseline hazard function to differ by birthcohort and permits me to account for changes in mortality over time.

tion, probably because of differences in mortality patterns by sex among these cohorts. I test for family effects, including those potentially due to socioeconomic status, marriage selection, or culture, by estimating Equation 1 on the wives of male-line grandsons.

I control for unobserved differences by ex-POW status by investigating the impact of ex-POW status on the mortality of grandsons and granddaughters *across* male and female lines. I run two separate regressions for grandsons and granddaughters and interact ex-POW status with a dummy indicator for male-line, M_i,

$$\beta_1(M_i \times P_{Ei}) + \beta_2(M_i \times P_{Ni}) + \beta_3 C_i. \tag{2}$$

For each ex-POW status type (N=non-exchange, E=exchange, 0=non-POW), I then estimate the hazard ratios for the male-line grandchild relative to the female-line grandchild: $D_{POW=N}$, $D_{POW=E}$, and $D_{POW=0}$. Because male-line and female-line samples may differ on unobservables, I compare the difference in hazard ratios across male and female line grandchildren for non-exchange ex-POWs to those for other ex-POW status types, i.e. I double-difference to obtain $D_{POW=N} - D_{POW=0}$ and $D_{POW=N} - D_{POW=E}$.

I test whether the mortality results are robust to post-war controls (C_{pi}) by modifying Equation 1 to control for the veteran's socioeconomic status after the war, the socioeconomic status of the grandchild's father, the number of siblings, and indicators of the physical proximity of the grandchild to the veteran during childhood. Direct cultural transmission requires physical proximity.

$$\beta_1 P_{Ei} + \beta_2 P_{Ni} + \beta_3 C_i + \beta_4 C_{pi} \tag{3}$$

I stratify both on birth cohort and census region of birth to control for cohort and region characteristics.

I establish the correlation between education and mortality and whether education mediates the effects of veteran ex-POW status among male-line grandsons age 21 or older in 1940 by modifying Equation 3 to add controls for education, including an interaction term between veterans' ex-POW status and education. If veterans' ex-POW status manifests itself in unexpected chronic disease shocks to the grandsons, the educated are better able to cope with the sequelae. I estimate

$$\beta_1(E_i \times P_{Ei}) + \beta_2(E_i \times P_{Ni}) + \beta_3 C_i + \beta 4 C_{pi}. \quad (4)$$

where E_i is either years of education or a dummy variable equal to one if the male-line grandson graduated from high school.

I investigate how the association between ancestral ex-POW stress and longevity changes across the generations by running a modified version of Equation 1 for separate samples of veterans' sons and veterans' male-line grandsons where each male-line grandson lived to age 45 and had a father who lived to age 45. I also run a modified version of Equation 1 to examine whether the veteran's ex-POW status predicts the longevity of his children-in-law, that is, the parents of the grandchildren and thus rule out any marriage selection effects.

I identify the sensitive transmission ages by modifying Equation 1 for male-line grandsons,

$$\beta_1(A_i \times P_N) + \beta_2(A_i \times P_E) + \beta_3 C. \quad (5)$$

where A_i represents age groups of non-exchange ex-POW captivity risk at ages 17, 18, 19-20, 21-22, 23-24, 25-26, 27-28, and 29+.

I examine the interaction between grandfather's ex-POW status and the grandson's and son's season of birth, arguably proxies for late gestational maternal nutrition for these cohorts (Doblhammer and Vaupel 2001). I estimate

$$\beta_1(W_i \times W_{Fi} \times P_{Ni}) + \beta_2(W_i \times W_{Fi} \times P_{Ei}) + \beta_3 C_i, \quad (6)$$

where W_i represents a winter (the first half of the year) birth for grandson i and W_{Fi} represents a winter birth for his father. I restrict the sample to male-line grandsons of veterans who were at risk of being non-exchange ex-POWs at ages when transmission is most likely.

3.2 Mechanisms

Table 1 summarizes the potential explanations for multigenerational transmission, the assumptions required for male-line only transmission, and tests to rule in or out the tranmission channel. The explanations are socioeconomic status, marriage selection, data issues, cultural or psychological transmission, and biological explanations such as selective survival in POW camps, mutations, and epigenetics.

The socioeconomic status channel posits that exposed veterans have lower socioeconomic status which is transmitted to their children and to their grandchildren and that it is socioeconomic status which affects longevity. Male-line only transmission requires that inheritance of low paternal socioeconomic status affects sons only. Although evidence from non-POWs shows that paternal occupational class is transmitted to both sons and daughters with transmission to daughters most likely occurring through marriage markets (Costa et al. 2022), I present several tests of the socioeconomic channel. I examine whether longevity results are robust to socioeconomic controls in Equations 3 and 4, whether socioeconomic status among veterans and their descendants is associated with the veteran's ex-POW status, whether children-in-law of exposed veterans are shorter lived than children-in-law of unexposed veterans (using a modified version of Equation 1) and, because labor market adjustments are more difficult at older ages, whether the findings are more pronounced among descendants of older rather than younger ex-POWs (Equation 5).

Transmission through marriage selection assumes that exposed veterans make lower quality marriages after the war, either to poorer or less healthy women than unexposed veterans. Their children may do the same. Lower longevity among descendants then arises from socioeconomic status or unobserved maternal health. Although there is no evidence that a veteran's ex-POW status was associated with marrying a wife from a poorer household after the war or from having a shorter-lived wife (Costa et al. 2018), I test whether the veteran's ex-POW status is correlated with the longevity of his children-in-law using a modified version of Equation 1.

Cultural or psychological mechanisms presuppose that an exposed veteran has mental health issues. I therefore examine whether a grandfather's ex-POW trauma predicts his own mental health. I account for direct exposure of the grandchild to the veteran by controlling for the geographic proximity of the veteran to the grandchild in Equation 3. One indirect unobserved exposure I can rule out based on past work is over-eating. While exposed veterans were more likely to be overweight compared to unexposed veterans if captured at older compared to younger ages, only the male-line grandsons of younger exposed veterans, not the male-line grandsons of older exposed veterans and not the female-line grandsons, were more likely to be overweight (Costa 2023).

Biological explanations include selective survival in POW camps, such as a genetic variant which enhances survival in camps but reduces survival outside camps; genetic mutations; and epigenetic changes in gene expression through DNA methylation, histone modification, changes in chromatin stability or changes in noncoding RNA. Because mortality selection in camps was greater at older ages (Costa and Kahn 2007), selective survival predicts that grandchildren of ex-POWs who were older at the time of captivity should be shorter lived in Equation 5. Although epigenetic transmission can happen at any age (Murphy et al. 2016) and in a short time frame (Ryan and Kuzawa 2020), epidemiological evidence (albeit from only one study) points to the slow period after puberty as sensitive to changes in the epigenome (Bygren 2013). Male-line grandsons of younger ex-POWs thus should be shorted-lived if descended from exposed veterans in Equation 5. Transmission to sons and male-line grandsons only could be explained by tranmission of an epigenetic effect along the Y chromosome, as hypothesized in the Överkalix studies (Bygren et al. 2001; Pembrey et al. 2014), because the Y chromosome is transmitted only to men. The Y chromosome is passed exclusively through sperm and a growing literature emphasizes the responsiveness of the sperm epigenome to environmental influences through noncoding RNA (Nätt and Öst 2020; Chen et al. 2016). Y chromosomal noncoding RNAs may in turn regulate DNA methylation and autosomal gene expression (Reddy et al. 2021).

I examine interactions with the in-utero environment, as proxied by season of birth, in Equation 6 because epigenetic signatures have been reversed in animal studies with maternal nutritional supplementation (Dolinoy et al. 2007; Bernal et al. 2013) and because interactions between imprinted genes on the X and Y chromosomes control placental size and thus fetal nourishment (Cunningham and Eghbali 2018). Epigenetic erasure and reprogramming occur in early and late gestation, respectively, suggesting that disruption of erasure or reprogramming because of poor nutrition could play a role in the interaction between epigenetic inheritance and the intrauterine environment (Baxter and Drake 2019).

Data issues are another potential explanation for observed multigenerational transmission. Because data may be more likely to be missing for daughters, I check if the results are robust to using different mortality assumptions for missing data. Because I may not be accounting for unobserved family factors, I compare male-line and female-line cousins and I also examine a small sample of grandchildren from fathers born before and after the war. I investigate whether large families unduly influence the results by restricting the sample to the oldest grandchild within each family line. I establish whether sample restrictions affect my results by examining whether the results change if I restrict to families where a veteran's child lived to age 55 or age 65 or if I examine mortality beginning at age 0 or age 20.

4 Results

Male-line grandsons who lived to age 45 lived 1 year less on average if descended from a non-exchange ex-POW (captured between July 1863 and July 1864 and thus exposed to the worse camp conditions) compared to an exchange ex-POW (captured either before July 1863 or after July 1864 and thus exposed to better conditions), that is 73 versus 74 years (Table 2). I do not observe differences among other lines nor among the wives of male-line grandsons.

Grandfathers' ex-POW status is related to grandchildren's longevity only among male-line grandsons controlling for the grandfather's characteristics at enlistment. Grandsons of male-line non-exchange ex-POWs were 1.11 times more likely to die at any age after age 45 than the male-line grandsons of non-POWs, controlling for own birth year and the grandfather's characteristics at enlistment (Table 3). They were 1.08 times more likely to die at any age after age 45 than the male-line grandsons of exchange ex-POWs. The hazard ratios were statistically significant at almost the 1% and at the 5% level, respectively. There were no statistically significant differences among male-line granddaughters and female-line grandchildren by grandfathers' ex-POW status. There was no statistically significant association between the mortality of wives of male-line grandsons and their grandfather-in-law's ex-POW status (Appendix B, section B.2).

Combining the grandson and granddaughter samples reveals statistically significant differences by line among grandsons but not granddaughters (Appendix B, section B.3).[6] Male-line grandsons of non-exchange ex-POWs were 1.08 times more likely than die than female-line grandsons whereas male-line grandsons of non-POWs from sons were 0.96 times as likely to die than those from daughters and male-line grandsons of exchange ex-POWs were 0.94 times as likely to die than female-line grandsons. The double-difference estimates imply that male-line grandsons of non-exchange ex-POWs were 1.12 times more likely to die than the male-line grandsons of non-POWs and 1.14 times more likely to die than the male-line grandsons of exchange ex-POWs.

Exchange ex-POWs probably were partially treated. The group includes men captive for only a few days and men held captive for more than 100 days. When I divided the exchange ex-POW category into those captured early (prior to July 1863) and those captured late (after June 1864), I found that male-line grandsons were a statistically significantly 1.13 times more likely to die at any age after age 45 if descended from a non-exchange ex-POW than from a POW captured in the early days of the war (Appendix B, section B.4). Male-line grandsons descended from exchange ex-POWs captured late in the war were 1.06 times as likely to die at any age after age 45 compared to male-line grandsons of non-POWs or of exchange ex-POW captured early in the war, but the hazard ratio was not statistically significant.

The results in Table 3 showing transmission to male-line grandsons only persist when I add controls for the veteran's post-war socioeconomic status, the father's socioeconomic status, the geographical proximity of the grandchild to the grandfather, the number of siblings, and own and parents' education (Tables 4 and 5). Male-line grandsons of non-exchange ex-POWs were 1.10 and 1.07 times more likely to die at any age after age 45 relative to grandsons of non-POWs and non-exchange ex-POWs, respectively.

[6] I cannot pool the grandson and granddaughter samples because the proportionality assumption is violated.

Paternal and own socioeconomic status, including education, was correlated with the mortality of all grandchildren (Tables 4 and 5). When I examined the interaction between high school education and grandfather's ex-POW status (see the last column of Table 5), I found that among those with an ex-POW grandfather, those with less than a high school education were a statistically significant 1.18 times more likely to die at any age whereas those with a high school education or more were a marginally, statistically significant 1.12 times more likely to die. While the difference of 1.06 across educational levels was not statistically significant, the evidence is consistent with the better management of chronic disease by the more educated. The absence of a change in the relationship between longevity and the grandfather's ex-POW status when I add controls is not surprising: grandfather's ex-POW status did not predict the socioeconomic status or education of his children or grandchildren. There is suggestive evidence that while veterans responded to the POW experience by making occupational adjustments, they did not lose status (Appendix B, section B.5). Most likely, health declined after socioeconomic status was established.

Table 3 also shows that controlling for the geographic proximity of the grandfather, a precondition for direct cultural transmission, does not change the results. Opportunities for contact may have been limited: less than 4% of grandchildren lived in the same house as their grandfathers and only one third ever lived in the same county (Appendix B, section B.1). Veteran grandfathers who survived to 1900 also may not have been pyschologically damaged: they did not suffer more mental health problems than non-POWs (Appendix B, section B.6).

The magnitude of the relationship between veterans' non-exchange ex-POW status and their male-line descendants' mortality attenuates across two generations who survived to age 45 but the attenuation is not statistically significant. Sons of non-exchange ex-POWs who survived to age 45 and who had a son who survived to age 45 were 1.17 times as likely to die at any age after age 45 compared to sons of non-POWs and 1.10 times as likely to die compared to sons of exchange ex-POWs (Table 6).[7] Their sons (the veteran's male-line grandsons) were 1.10 times as likely to die at any age after age 45 compared to the male-line grandsons of non-POWs, a 39% decline in the association across generations between male-line descendants longevity and the veteran's non-exchange ex-POW relative to non-POW status. Male-line grandsons were 1.08 times as likely to die at any age after age 45 if descended from non-exchange ex-POWs relative to exchange ex-POWs, a 13% decline across generations in the association between longevity and non-exchange ex-POW status relative to exchange ex-POW status. I cannot reject the hypothesis of no decline for either comparison.[8]

Veterans' sons who fathered daughters were 1.15 times as likely to die at any age after age 45 compared to the sons of non-POWs who fathered daughters, but there was no statistically significant relationship between veterans' ex-POW status and male-line granddaughters' mortality (see Table 6. There were no statistically significant associations between veterans' ex-POW status and the mortality of their daughters or their daughters' children (Appendix Table B10). I find no association between the veteran's ex-POW status and the longevity of the grandchildren's mothers and fathers who married into the veteran's family (Appendix B, section B.7).

Male-line grandsons descended from non-exchange ex-POWs faced elevated mortality only if their grandfathers were at risk of being non-exchange POWs at ages 19-24 (Figure 1). The point estimates indicate a sharp fall-off after ages 23-24; however, the width of the confidence intervals only allows me to infer that there is a statistically significant difference. Among all grandchildren descended from non-exchange ex-POWs exposed at

[7]Estimates of intergenerational transmission from veterans to sons in Table 6 are larger than those in Costa et al. (2018) perhaps because this sample is better matched on veteran characteristics.

[8]I cannot reject the hypotheses that 1.17 is equal to 1.10 ($\chi^2(1) = 0.82, p = 0.365$) or that 1.10 is equal to 1.17 ($\chi^2(1) = 0.14, p = 0.711$). Nor can I reject the hypothesis that 1.095 is equal to 1.083 ($\chi^2 = 0.13, p = 0.724$) or that 1.083 is equal to 1.095 ($\chi^2 = 0.05, p = 0.824$).

ages 19-24, male-line grandsons were 1.28 and 1.13 times more likely to die at any age after age 45 relative to male-line grandsons from non-POWs and exchange ex-POWs, respectively. The respective statistical significance was at the 1 and 5% level (Appendix B, section B.8). Note that socioeconomic status cannot explain why the correlation between paternal grandfathers' ex-POW status and grandsons' mortality is seen predominately among grandsons descended from veterans at risk of a harsh captivity during their growing years because a socioeconomic explanation predicts that older veterans would be the ones to lose status because it is costlier for them to make occupational adjustments.

The association between male-line grandsons' longevity and their grandfathers' ex-POW status was strongest among those born in winter (the first half of the year) to fathers also born in winter (Table 7). Male-line grandsons whose fathers were at risk of being non-exchange POWs at ages 19-24 were 1.45 times more likely to die at any age after age 45 if descended from an exchange ex-POW rather than a non-POW. If neither the grandson nor his father were born in winter, the hazard ratio was only 1.11. The differences between hazards were statistically significant. Hazard ratios ranged from 1.25 to 1.40 if only the grandson or son was born in winter. Comparing grandsons from exchange ex-POWs to non-POWs yielded statistically significant differences only when both the grandson and father were born in winter.

4.1 Robustness

Unobserved, time-invariant family factors specific to the veteran cannot account for the relationship between grandfather's ex-POW status and male-line grandsons' mortality. Comparing male-line and female-line cousins within families of veterans who had both male-line and female-line grandsons and who were at risk of captivity at ages 19-24 reveals that male grandsons were 1.31 times as likely to die if descended from non-exchange ex-POWs rather than non-POWs (Appendix B, section B.9). The results were similar to those obtained without veteran controls. Within the small set of male-line grandsons sharing a common veteran grandfather, those descended from sons born after the war to non-exchange ex-POWs faced a higher mortality risk than their cousins descended from sons born before the war if their paternal grandfathers were older, that is, born prior to 1830 or older than age 35 at the end of the war (Appendix B, section B.9). The sample is too small to determine if the risk of multigenerational transmission is higher when grandfathers are older at the time of exposure.

My findings do not depend on the undue influence of families with many descendants. Restricting the sample to the oldest child within each line yields a statistically significant association with the grandfather's ex-POW status similar to that in Table 3 (Appendix B, section B.10).

My results are not an artifact of the data collection process. Although granddaughters are slightly less likely to be linked to death records than grandsons, randomly assigning death years to grandchildren for whom this information is missing does not change the findings (Appendix B, section B.11). The results also are robust to different survivorship assumptions about veterans' children (Appendix B, section B.12).

Within my sample, the association between grandchildren's mortality and grandfathers' non-exchange ex-POW status is evident only after age 45 and only for male-line grandsons (Appendix A); however, the results are robust to examining mortality at different ages (Appendix B, section B.13). A caveat is that deaths prior to age 10 are underestimated in my sample and I find suggestive evidence that early childhood mortality was higher among male-line grandchildren of non-exchange ex-POWs compared to female-line grandchildren or grandchildren of non-POWs (see Appendix A). I thus am underestimating the full association between a grandfather's ex-POW status and the mortality of his male-line descendants.

5 Discussion

5.1 Magnitudes

Male-line grandsons' likelihood of being 1.1 times more likely to die if descended from a non-exchange ex-POW rather than a non-POW was a risk on par with that from father's socioeconomic status. A male-line grandson was 1.08 times more likely to die at any age after age 45 if the father was ever a laborer and was 0.92 times as likely to die if the father was ever a farmer. He was 1.12 times more likely to die if his father was never a home owner (Table 4). Compensating a male-line grandson for his grandfather's non-exchange ex-POW status would have required an additional one and a half years of education.[9]

Risk to male-line grandsons' longevity posed by grandfathers' harsh captivity conditions are large relative to present-day risks. Male-line grandsons descended from non-exchange ex-POWs lost a median 1.22 years of life (Appendix B, section B.14) compared to male-ine grandsons descended from non-POWs. The loss of life expectancy at age 45 (28.05 years in the 1910 cohort Social Security Area life tables (Bell and Miller 2005)) was 4%. In comparison, men age 50-54 in 1992 lost two years of life if they were current smokers and a half year of life if they were obese and gained 0.24 years of life if they were college rather than high school educated (Østbye and Taylor 2004).

Male-line grandsons' 1.3 times greater likelihood of dying if descended from a non-exchange ex-POW age 19-24 at captivity rather than a non-POW at risk at the same ages is comparable to that observed in Överkalix, Sweden. There, male-line grandsons whose grandfathers experienced a poor harvest circa age 19 faced a mortality risk 1.5 times greater than those whose grandfathers who experienced a normal harvest (Bygren 2013).

[9] An additional year of education decreased the odds of dying by 0.959 among those descended from non-POWs compared to a decrease of 0.972 among those descended from exchange ex-POWs (see the second column of coefficients in Table 5), thus $\ln(0.959)/\ln(0.972) = 1.48$ years of education would have been required.

5.2 Mechanisms

I ruled out socioeconomic status, marriage selection, data issues, direct psychological transmission from grandfather to grandson, and mortality selection as potential transmission mechanisms (see Appendix Table B20 for a summary). Although I could not fully rule out indirect psychological transmission from grandfather to son to grandson and genetic mutations, indirect psychological transmission requires evidence of psychological distress among veterans and separate household spheres for the sexes even at ages. Neither explanation can account for mediation with own and father's season of birth. I cannot rule out epigenetics as an explanation. If epigenetics is the explanation, my findings suggest that the disruption of epigenetic reprogramming in the second half of gestation (Baxter and Drake 2019) mediates ancestral factors and that early adulthood or the slow growing years after the adolescent growth spurt are sensitive ages for epigenetic transmission.

The findings raise two major questions. The first is what physiological explanations ages can account for the greater sensitivity ages 19-24 in my sample for transgenerational transmission. Union Army soldiers were growing rapidly until age 21 and then more slowly until age 25 (Wilson and Pope 2003). Their slow growth period coincides with the increase in risk among grandsons descended from grandfathers who had been non-exchange POWs at ages 19-24. Changes have been observed in sperm in response to diet (Nätt et al. 2019) but permanent changes in sperm would require changes to the male reproductive tract, whether in the testes, the epididymis, or epididural extracellular vesicles. Although there is evidence that noncoding RNA are transferred from the epididymis to sperm (Chen et al. 2016), that noncoding RNA may affect methylation patterns of downstream genes (Yang et al. 2022), and that paternal low protein consumption affects small RNA levels throughout the male reproductive tract (Sharma et al. 2016), we do not know why the male reproductive tract would be more sensitive during the late growing years.

The second major question is how an ancestral health shock should cascade across the generations. While I observed a decline in magnitudes from grandfathers to sons to grandsons, it was not a statistically significant decline. Apriori, it is unclear what, if any, type of change should be expected across generations. The inheritance of epigenetic marks across generations ranges from stability to total reset and even encompasses epigenetic recall, a facilitated response in descendants requiring an environmental inducer (Jablonka and Raz 2009). Kaati et al. (2007) and Vågerö et al. (2018) document generational skipping when the grandfather's stress is in the slow growth period prior to puberty. If the expression of epigenetic inheritance depends on genetic inheritance and on prior, including intrauterine, and current environmental conditions (as suggested by the findings on mediation by season of birth and education), changes in magnitudes across generations cannot be predicted.

Additional issues which are raised by the findings and which speak to their generalizability include why there is no mortality effect operating through socioeconomic status and why there is no evidence of mental health issues among veterans. The absence of a mortality effect operating through socioeconomic pathways is consistent with findings from in utero exposure to the Dutch Hunger Winter (Ekamper et al. 2014). In contrast, in utero exposure to the Chinese famine and to the Influenza Pandemic in the United States (but not in other countries) is correlated with own later educational attainment (Almond 2006; Almond et al. 2010; Wójcik et al. 2022). Explanations for why some experiences are associated with declines in health before rather than after socioeconomic status is established include differential effects of malnutrition and viral illnesses, fertility selection during WWI (Beach et al. 2022), marriage selection (Almond et al. 2010), mortality selection at young ages (Conti et al. 2021), differences in exposure duration and in the ability of the samples to capture rare outcomes such as schizophrenia.

The absence of mental health problems among ex-POWs in the sample could arise from the selection in who married and had children or from imbuing POW suffering with a higher purpose. Veterans' organizations, former prisoner associations, and prison memoirs emphasized that ex-POWs were the saviors of the Union who through their Christ-like suffering had wiped the sin of slavery from the land (Gardner 1998). Even when horrific experiences cannot be made meaningful, parents' trauma does not necessarily lead to psychopathologies among their children. Large, representative samples of Holocaust survivors find that both their children and grandchildren resemble controls and even have higher levels of education (Levav et al. 2007; Sagi-Schwartz et al. 2008; IJzendoorn et al. 2003). Class et al. (2014) find little influence of preconception, prenatal, and postnatal maternal stress exposure on risk of children's major psychiatric outcomes. Studies which find evidence for long-run influences of trauma find effects for both sexes (Vågerö and Rajaleid 2017) and disproportionate effects for girls in an historical population (Santavirta et al. 2018).

6 Conclusion

My findings raise several avenues for future research. My comparison between grandsons descended from non-POWs and exchange ex-POWs suggests that it is not the psychological trauma of captivity per se which is harmful; but, I cannot unpack starvation from the effects of psychosocial stress during captivity nor from the psychological trauma of starvation. I also cannot observe post-captivity responses to starvation. Post-captivity overfeeding, whether as a biological or psychological response, or overfeeding relative to a starvation norm established during the late growing years, could have triggered an epigenetic response which affected ex-POWs' sons and grandsons.

The positive association between a grandfather's harsh captivity experience and his male-line grandson's mortality contrasts with the negative association observed between the paternal grandfather's harvest experience in Sweden during the period prior to puberty and his male-line grandsons' mortality (Kaati et al. 2007; Vågerö et al. 2018). Findings which imply that is beneficial to have had ancestors who experienced hunger and harmful to have had ancestors who experienced plenty may arise not from the level of grandfathers' harvests but from the change in grandfathers' harvest types. The studies did not distinguish between changes in food availability versus changes in levels but Bygren et al. (2014)'s investigation of granddaughters' mortality by cause and changes in the paternal grandmother's harvest conditions led them to hypothesize that change in food availability induces gene expression responses and epigenetic processes. POWs experienced a rapid deterioration to starvation levels and then a return to good conditions.[10] Alternatively, overnutrition prior to puberty and undernutrition during the late growing years, particularly when combined with psychosocial stress may be harmful to descendants. Future research should examine whether changes or levels in food availability are associated with transgenerational transmission for different ancestral ages and how transmission patterns for nutritional versus psychosocial stress.

[10] I thank Olov Bygren for suggesting this hypothesis.

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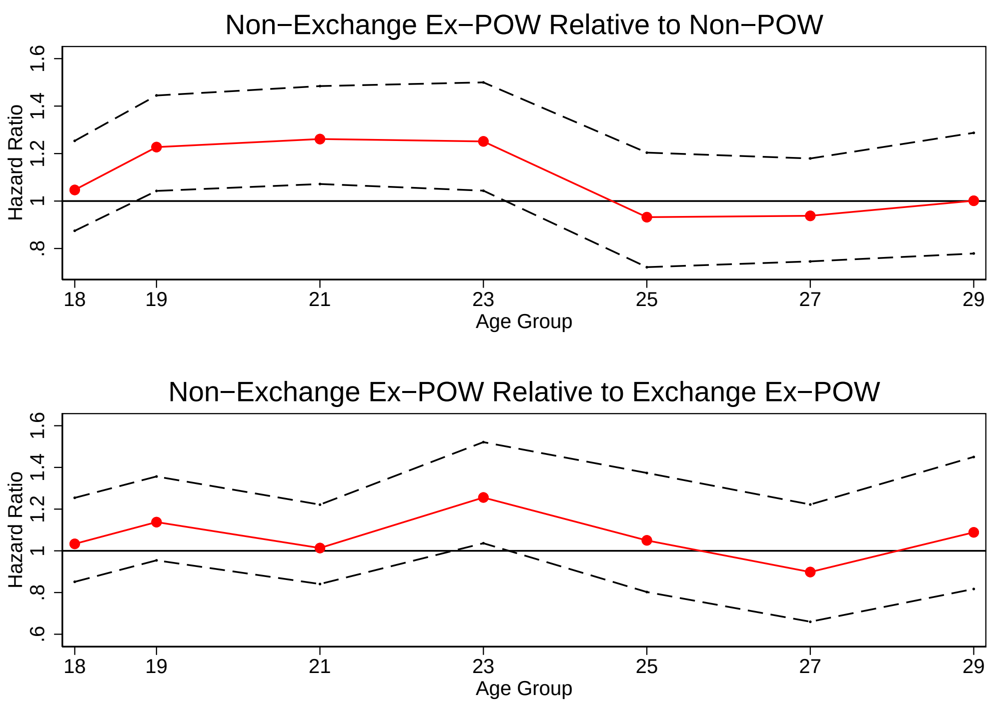
Figure 1: Grandfather's Age When at Risk of Non-Exchange Captivity and Male-Line Grandsons' Mortality



Coefficients (the circles) and 95% confidence intervals (dashed lines) are estimated from the Cox proportional hazards model of years lived after age 45 in Equation 5. Stratification is on birth cohort. Controls include birth year and the veteran's enlistment year, occupation at enlistment (farmer, artisan, laborer, professional or proprietor, and unknown), enlistment in a city with population of 50,000 or more, born in the US, wounded in the war, and in the original Union Army sample. Standard errors are clustered on the veteran. A test of the proportional hazards assumption using the Schoenfeld residuals yielded $\chi^2 = 33.64$, $\Pr > \chi^2(32) = 0.388$

Table 1: Potential Explanations for Multigenerational Transmission

Explanations	Mechanisms	Tests
Socioeconomic status (SES)	Exposed veteran has lower SES $\Longrightarrow$ Children have lower SES $\Longrightarrow$ Grandchildren have lower SES Lower SES $\Longrightarrow$ lower longevity Male-line only transmission requires extreme inheritance SES by sex but inheritance of SES is similar by sex (Costa et al. 2022)	Longevity results robust to SES controls? SES lower among exposed veterans and descendants? Are spouses shorter-lived? Not true for veterans' wives (Costa et al. 2018) Children-in-law of exposed veteran? Harder for veteran to adjust to health shock when older $\Longrightarrow$ grandchildren of older ex-POWs shorter-lived
Marriage selection	Exposed veteran makes worse marriage $\Longrightarrow$ children worse off Children of exposed veterans make worse marriages $\Longrightarrow$ grandchildren worse off Male-line only transmission requires maternal influences on sons only	No evidence wives of exposed veterans poorer or shorter-lived (PNAS) Are children-in-law of exposed veteran shorter-lived? Are they poorer?
Data issues	More missing data for daughters $\Longrightarrow$ female and female-line mortality under-estimated Unobserved time-invariant family factors Undue influence large families Age selection into sample	Use different assumptions for missing mortality data Compare male-line and female-line cousins Compare grandchildren from fathers born pre- vs post-war Examine oldest grandchild only Use different assumptions for survivorship of father, uncle or aunt and for dependent variable (years lived)
Cultural/ Psychological	Exposed veteran has mental health issues Grandchild has mental health issues from a) Direct exposure to veteran b) Indirect exposure to veteran through parent Male-line only transmission requires extreme family socialization by sex	Does the exposed veteran have mental health issues? Longevity results robust to controls for geographic proximity of veteran to grandchild? Evidence of over-eating among ex-POWs? Older ex-POWs more likely to be overweight after the war than younger ex-POWs but only male-line grandsons of younger ex-POWs were overweight (Costa 2023)
Biological	a) Selective survival in POW camps e.g., genetic variant enhances survival in camps but reduces survival outside camps b) Mutations c) Epigenetics Chromatin stability DNA methylation Histone modification Non-coding RNA Male-line only transmission requires male-line only genetic or epigenetic inheritance No erasure or reprogramming? In-utero selection?	Age when at risk of being POW and descendant longevity Greater mortality selection in camps at older ages (Costa and Kahn 2008) $\Longrightarrow$ grandchildren of older ex-POWs shorter-lived Late growing years critical ages for male-line epigentic transmission (Bygren 2013) Sensitivity testes, seminal vesicles, and epididymis $\Longrightarrow$ male-line grandsons of younger ex-POWs shorter-lived Epigenetic inheritance more likely when poorer intra-uterine environment (Dolinoy et al. 2007; Bernal et al. 2013) Interactions grandfather's ex-POW status with own and father's season of birth

Table 2: Grandchildren's Mean Years Lived by Ancestral Line and Grandfather's Ex-POW Status

	Male-line		Female-line		Wives of Male-line
Grandfather's Ex-POW status	Grand-sons	Grand-daughters	Grand-sons	Grand-daughters	Grand-sons
1) Non-POW	73.79	79.64	73.13	79.53	80.15
2) Exchange Ex-POW	73.60	79.78	72.62	79.27	80.50
3) Non-exchange Ex-POW	72.74	79.41	73.34	79.40	80.13
Difference 3)-1)	-1.05***	-0.23	-0.21	-0.13	-0.02
Difference 3)-2)	-0.86**	-0.37	0.72	0.13	-0.37

Years lived are conditional on survivorship to age 45. All grandchildren are descended from the child of a veteran born after the war. The symbols *** and ** indicate statistical significance at the 1 and 5% level.

Table 3: Hazard Ratios of Mortality by Grandfather's Ex-POW Status

	Male-line		Female-line	
Grandfather's ex-POW status	Grand-sons	Grand-daughters	Grand-sons	Grand-daughters
Non-POW	1.000	1.000	1.000	1.000
Exchange Ex-POW	1.029	1.027	1.065*	1.021
	(0.040)	(0.042)	(0.041)	(0.042)
	[0.459]	[0.517]	[0.099]	[0.614]
Non-exchange Ex-POW	1.113**	1.022	0.997	0.995
	(0.046)	(0.045)	(0.042)	(0.041)
	[0.011]	[0.621]	[0.934]	[0.910]
Non-exchange Ex-POW relative to Exchange Ex-POW	1.081**	0.995	0.935	0.975
	(0.043)	(0.042)	(0.038)	(0.039)
	[0.049]	[0.915]	[0.102]	[0.531]
Test of proportional hazards	15.12	17.71	15.36	13.11
assumption, χ^2, $\Pr > \chi^2(15)$	[0.4425]	[0.278]	[0.426]	[0.594]
Observations	6,685	6,055	6,140	5,644

Estimated from a Cox proportional hazards model in Equation 1 using years lived after age 45, stratifying on birth cohort, and controlling for birth year and the veteran's enlistment year, occupation at enlistment (farmer, artisan, laborer, professional or proprietor, and unknown), enlistment in a city with population of 50,000 or more, born in the US, wounded in the war, and in the original Union Army sample. Standard errors, clustered on the veteran are in parenthesis. P values are in square brackets. The proportional hazards assumption is tested using the Schoenfeld residuals. The symbols *, **, and *** indicate significance at the 10, 5, and 1 percent level.

Table 4: Hazard Ratios of Mortality by Grandfather's Ex-POW Status, Controlling for Fathers' Socioeconomic Status and Veterans' Post-War Characteristics

	Male-line		Female-line	
	Grand-sons	Grand-daughters	Grand-sons	Grand-daughters
Grandfather was				
Non-POW	1.000	1.000	1.000	1.000
Exchange Ex-POW	1.031	1.035	1.059	1.013
	(0.038)	(0.042)	(0.040)	(0.041)
	[0.403]	[0.386]	[0.128]	[0.756]
Non-exchange Ex-POW	1.104**	1.025	1.003	1.001
	(0.045)	(0.044)	(0.042)	(0.041)
	[0.014]	[0.572]	[0.951]	[0.979]
Grandchild's Father was				
a laborer at any time	1.083***	1.078***	1.162***	1.137***
	(0.031)	(0.030)	(0.035)	(0.035)
	[0.005]	[0.007]	[0.000]	[0.000]
a farmer at any time	0.923***	0.885***	0.909***	0.965
	(0.028)	(0.028)	(0.030)	(0.032)
	[0.009]	[0.000]	[0.003]	[0.276]
never a home owner	1.122***	1.017	1.111***	1.088***
	(0.032)	(0.032)	(0.034)	(0.033)
	[0.000]	[0.583]	[0.001]	[0.006]
Non-exchange Ex-POW				
relative to Exchange Ex-POW	1.070*	0.999	0.947	0.988
	(0.041)	(0.041)	(0.038)	(0.040)
	[0.077]	[0.803]	[0.178]	[0.775]
Test of proportional hazards	35.11	34.91	30.99	25.25
assumption, χ^2, $\Pr > \chi^2(27)$	[0.136]	[0.141]	[0.272]	[0.560]
Observations	6,685	6,055	6,140	5,644

Estimated from the Cox proportional hazards model in Equation 3 using years lived after age 45 and stratifying on birth cohort and census region of birth. Controls are for birth year; for the veteran's enlistment year, occupation at enlistment (farmer, artisan, laborer, professional or proprietor, and unknown), enlistment in a city with population of 50,000 or more, birth in the US, whether wounded in the war, whether in the original Union Army sample, 1880 occupation (farmer, artisan, laborer, professional or proprietor, not in the labor force, and not in the census), and whether a home owner; and whether the veteran was ever in the same county as the grandchild, was ever in the same household as the grandchild, and the total number of siblings in the family. Standard errors, clustered on the veteran, are in parentheses. P values are in square brackets. The proportional hazards assumption is tested using the Schoenfeld residuals. The symbols *, **, and *** indicate significance at the 10, 5, and 1 percent level.

Table 5: Male-line Grandsons' Hazard Ratios of Mortality and Grandfather's Ex-POW Status Controlling for Education

	Years of Education as Control	Interaction with Years of Education	High School Graduate as Control	Interaction with High School Graduate: Not High School Graduate	Interaction with High School Graduate: High School Graduate
Grandfather's ex-POW status					
Non-POW	1.000	0.959***	1.000	1.000	1.000
		(0.006)			
		[0.000]			
Exchange Ex-POW	1.015	0.959***	1.014	1.044	0.964
	(0.045)	(0.006)	(0.045)	(0.056)	(0.062)
	[0.744]	[0.000]	[0.758]	[0.416]	[0.574]
Non-exchange Ex-POW	1.167***	0.972***	1.158***	1.184***	1.116*
	(0.051)	(0.006)	(0.051)	(0.061)	(0.068)
	[0.000]	[0.000]	[0.001]	[0.001]	[0.073]
Years of education	0.962***				
	(0.006)				
	[0.000]				
Dummy=1 if high school graduate			0.849***		
			(0.028)		
			[0.000]		
Non-exchange Ex-POW relative to Exchange Ex-POW	1.150***	1.013***	1.142***	1.134**	1.157**
	(0.052)	(0.004)	(0.051)	(0.065)	(0.078)
	[0.002]	[0.003]	[0.003]	[0.029]	[0.030]
Non-exchange Ex-POW relative to Non-POW		1.013***			
		(0.004)			
		[0.002]			
Difference Non-Exchange Ex-Pow by not high school graduate				1.061	
				(0.074)	
				[0.397]	
Test of proportional hazards assumption	42.85	42.83	37.8	38.05	
	[0.047]	[0.047]	[0.127]	[0.179]	
df=	29	29	29	31	

4,679 observations. Estimated from the Cox proportional hazards model in Equation 4. I stratify on birth cohort and census region of birth. Controls are for birth year; for the veteran's enlistment year, occupation at enlistment (farmer, artisan, laborer, professional or proprietor, and unknown), enlistment in a city with population of 50,000 or more, birth in the US, whether wounded in the war, whether in the original Union Army sample, 1880 occupation (farmer, artisan, laborer, professional or proprietor, not in the labor force, and not in the census), and whether a home owner; and whether the veteran was ever in the same county as the grandchild, was ever in the same household as the grandchild, and the total number of siblings in the family. Standard errors, clustered on the veteran, are in parentheses. P values are in square brackets. The proportional hazards assumption is tested using the Schoenfeld residuals. The symbols *, **, and *** indicate significance at the 10, 5, and 1 percent level.

Table 6: Generational Associations: Sons’ and Male-Line Grandchildren’s Hazard Ratios of Mortality by Veteran’s Ex-POW Status Among Survivors to Age 45

Veterans:	Exchange Ex-POW Relative to Non-POW	Non-Exchange Ex-POW Relative to Non-POW	Non-Exchange Relative to Exchange Ex-POW	Test of Proportional Hazards Assumption	Obser-vations
Veterans’ Sons who were Fathers of Grandsons	1.064 (0.054) [0.222]	1.165** (0.072) [0.014]	1.095* (0.060) [0.099]	16.92 [0.324]	3,175
□ │ □	□ │ □	□ │ □	□ │ □		
Veterans’ Grandsons from Sons	1.016 (0.040) [0.682]	1.101** (0.047) [0.024]	1.083* (0.044) [0.048]	14.56 [0.483]	6,434
Veterans’ Sons who were Fathers of Granddaughters	1.072 (0.058) [0.200]	1.150** (0.071) [0.023]	1.073 (0.060) [0.205]	5.14 [0.991]	2,959
□ │ ○	□ │ ○	□ │ ○	□ │ ○		
Veterans’ Granddaughters from Sons	1.016 (0.042) [0.694]	1.033 (0.046) [0.475]	1.016 (0.043) [0.709]	16.80 [0.331]	5,812

Squares indicate male and circles indicate female. The sample is restricted to all grandchildren who survived to age 45 and who had a father who was a veteran’s son and who survived to age 45. Each row is from a single regression result from a modified version the Cox proportional hazards model in Equation 1 using years lived after age 45, stratifying on birth cohort, and controlling for birth year and the veteran’s enlistment year, occupation at enlistment (farmer, artisan, laborer, professional or proprietor, and unknown), enlistment in a city with population of 50,000 or more, born in the US, wounded in the war, and in the original Union Army sample. Standard errors, clustered on the veteran, are in parentheses. P values are in square brackets. The proportional hazards assumption is tested using the Schoenfeld residuals. The symbols *, **, and *** indicate significance at the 10, 5, and 1 percent level.

Table 7: Male-line Grandson's Hazard Ratios of Mortality after Age 45 by Veteran's Ex-POW Status and Grandson's and Son's Season of Birth, Conditional on Risk of Captivity at Ages 19-24

	Veteran's Descendant Born in Winter				
	Grandson	Son	Hazard Ratio	Std Err	P-Value
			Veteran was Non-exchange Ex-POW Relative to Non-POW		
1)	Y	Y	1.449***	0.143	0.000
2)	Y	N	1.395***	0.144	0.001
3)	N	Y	1.248**	0.112	0.014
4)	N	N	1.109	0.107	0.284
			Veteran was Exchange Ex-POW Relative to Non-POW		
	Y	Y	1.260**	0.116	0.012
	Y	N	1.146	0.118	0.186
	N	Y	1.242**	0.114	0.018
	N	N	0.964	0.095	0.710
			Veteran was Non-Exchange Relative to Exchange Ex-POW		
	Y	Y	1.150	0.110	0.145
	Y	N	1.217*	0.135	0.076
	N	Y	1.005	0.095	0.958
	N	N	1.150	0.116	0.165
			Differences		
1)-2)			1.039	0.129	0.761
1)-3)			1.161	0.136	0.203
1)-4)			1.307**	0.165	0.033

3,029 observations. I exclude grandsons in-utero or born during WWI or the Influenza Pandemic. Estimates are from the Cox proportional hazards model in Equation 6 and the hazard ratios are expressed to allow for easy comparisons across grandfather's ex-POW status within the grandson's half-year of birth. The test of the proportional hazards assumption was estimated using the Schoenfeld residuals with 23 degrees of freedom, $\chi^2 = 28, 19, p = 0.208$. Control variables include birth year and the veteran's enlistment year, occupation at enlistment (farmer, artisan, laborer, professional or proprietor, and unknown), enlistment in a city with population of 50,000 or more, born in the US, wounded in the war, and in the original Union Army sample. Standard errors, clustered on the veteran, are in parentheses. P values are in square brackets. The symbols *, **, and *** indicate significance at the 10, 5, and 1 percent level.

ON-LINE APPENDICES

Appendix A: Sample Construction

Figure A1 provides a schematic showing sample construction. I study the grandchildren of veterans drawn from two different longitudinal samples constructed from hand written military service and pension records (including detailed examining surgeons' exams), preserved in the National Archives, and from manuscript census schedules. The first sample is of 39,388 men in 330 randomly drawn Union Army volunteer infantry companies, collected by the program project, Early Indicators of Later Work Levels, Disease, and Death (NIA P01 AG10120, PI: Fogel). This sample is representative of the Northern population of military age in 1860 in terms of socioeconomic status (Fogel 1993) and will be referred to as the original Union Army sample. I restricted this sample to men who survived to 1900. The second sample, collected by the project Environmental Stress, Social Networks, and Older Age Health and Mortality (NIA R01 AG027960, PI: Costa), is of 1,041 ex-POWs imprisoned at the most notorious Confederate POW camp, Andersonville, and who survived until 1900. The men were randomly drawn from a list of Andersonville prisoners of war compiled by the National Park Service and will be referred to as the Andersonville sample.

A subsample of veterans' children is linked to death records and manuscript census schedules which provide occupational, residential, and family information under the program project Early Indicators, Intergenerational Processes, and Aging (NIA P01 AG10120, PI: Costa). Veterans were linked to any census or death record information not previously collected and the children's mothers were linked to their childhood censuses. The subsample was designed to over-sample children of ex-POWs. I traced the children of all 1,198 ex-POWs who survived to 1900 in the original Union Army and the Andersonville sample. I then drew a subsample of 9,343 non-POWs from the original Union Army sample matched on ex-POW demographic and socioeconomic characteristics at enlistment.

The final sample, referred to as the Veterans' Children's Census (VCC) sample, contains 54,568 children. Details about the samples and discussions of potential biases are provided in on-line codebooks, available at NBER's data web page[11], and also in Costa et al. (2017), Costa (2012), and the supplemental information to Costa et al. (2018). As discussed in the latter source, ex-POWs did not marry "down" and their ex-POW status was not correlated with the mortality of their wives.

I used the VCC sample to create a sample of veterans' grandchildren with an oversample of descendants of ex-POWs (NIA R21 AG064460, PI: Costa). I searched for birth and death information of all grandchildren of all ex-POWs and a subsample of grandchildren of non-POWs. I restricted the search to grandchildren of veterans with at least one child who survived to age 45 to obtain a larger sample of grandchildren at lower cost, but I followed all grandchildren regardless of their parent's age at death. The veterans' grandchildren sample contains 1,444 ex-POWs, their 8,190 children, and their 17,015 grandchildren and 1,381 non-POWs, their 8,596 children, and 18,6588 children. Birth and death information come from manuscript census records, Find a Grave, the Social Security-death index and applications, WWI and WII draft cards, state vital records (which include birth, marriage, and death indexes), Veterans' Administration records, obituaries, and public records indexes.

I found death dates for 87% of sons, 83% of granddaughters, 95% of grandsons, and 88% of granddaughters. I do not examine cause of death because information is missing for 88% of grandchildren. I am less likely to find a death date if the state has few vital records available on-line. Grandfather's ex-POW status does not predict having a death date.

The mortality pattern at age 10 or older in the sample was similar to that observed for Social security area cohorts even though life expectancy of grandchildren of either sex at

[11] See https://www.nber.org/programs-projects/projects-and-centers/union-army-data.

age 10 or greater was higher by about a year (Table A1), probably because grandchildren were native-born and were concentrated in the more rural Midwest. Deaths below age 10 are under-reported in the sample, as expected for cohorts born when state vital record keeping was sparse.

Figure A2 shows an association between grandchildren's mortality and grandfathers' non-exchange ex-POW status only after age 45 and only for male-line grandsons. However, I find suggestive evidence that childhood mortality was higher among male-line grandchildren of non-exchange ex-POWs. Ex-POWs of any type had fewer grandchildren of either sex from sons (see Table A3). Compared to a non-POW, the incidence ratio of having a male-line grandchild was 0.8. There was no effect of grandfather's ex-POW status on the number of grandchildren from daughters. Examining veterans' children who were married in 1910 revealed that while the veteran's ex-POW status was not correlated with the number of children ever born reported in the 1910 census, veterans' sons, but not daughters, had a slightly lower fraction of living children if descended from a non-exchange ex-POW rather than a non-POW or an exchange ex-POW (see Table A4). I suspect that any deaths would have been prior to age 10 because deaths prior to this age are not well represented in my sample.

Information on the households in which veterans' children and grandchildren grew up, including the father's occupation and home ownership, is available from linkage to the manuscript census records in the Veterans' Children Census samples. All veterans were linked to the 1850-1940 censuses, with the exception of the 1890 census which was destroyed in a fire. Linkage rates of veterans to individual censuses range from 94% in 1930 to 97% in 1910 (see Table A2). Veterans' children also were linked to all available 1870-1940 censuses. Among veterans' children who were alive at the time of the census, 87% of sons and 85% of daughters were linked to any census and linkage rates to individual censuses range from 94% in 1870 when children still were in the veteran's household to

81% in 1940. Grandchildren are in a census because they were in their parents' households with the exception of 1940, where I linked to educational information.[12] I obtained educational information for 65% of all grandchildren and for 74% of grandchildren age 21 or older in 1940 descended from veterans' children born after the war. Conditional on being alive and younger than age 18 at the time of the census, linkage rates for grandchildren range from 94% in 1900 to 97% in 1940.

[12]Only information on education was obtained from the 1940 census for financial reasons.

Figure A1: Construction of the Sample

Union Army
39,388 Volunteer Infantry Soldiers

Andersonville
1,041 ex-POWs who survived to 1900

Veterans who survived to 1900
1,999 ex-POWs (all available from Union Army and Andersonville)
9,343 non-POWs (subsample) matched on ex-POW characteristics at enlistment

Veterans' Children Census
1,506 ex-POWs and their 9,232 children
493 ex-POWs without children
8,453 non-POWs and their 45,236 children
890 non-POWs without children

Search for all grandchildren of ex-POWs and subsample of non-POWs (matched on enlistment characteristics) if the veteran had at least one child who survived to age 45

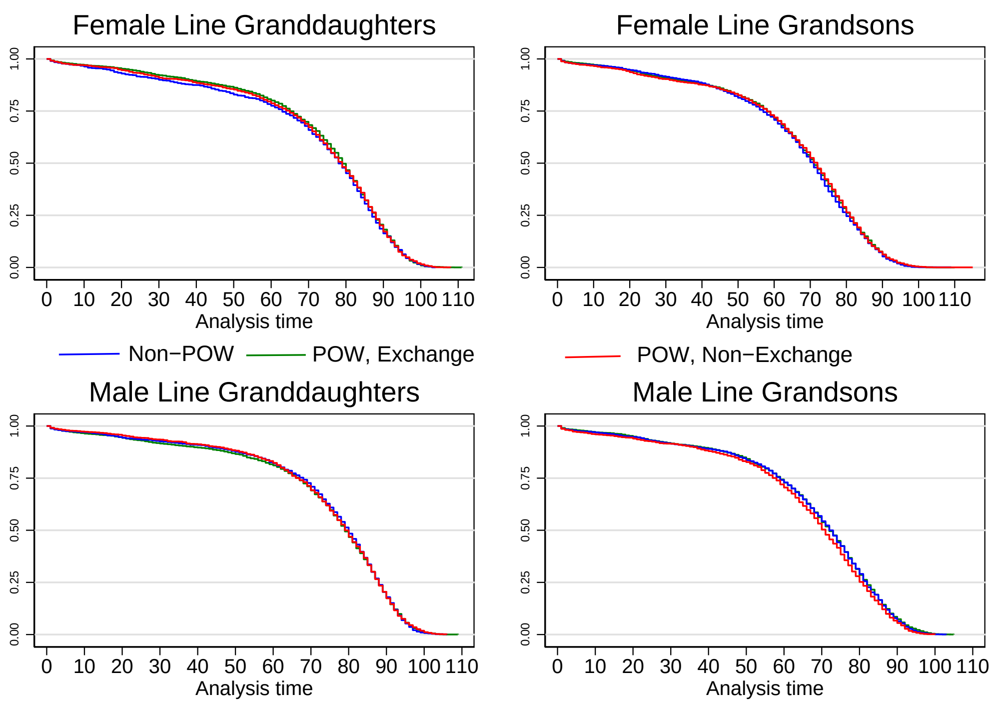
Number of Veterans, Veterans' Children, and Veterans' Grandchildren by Ex-POW Status

Veterans	1,444 ex-POWs	1,381 non-POWs
Children	8,190	8,596
Grandchildren	17,015	18,658
Male-line grandsons	4,324	5,133
Male-line granddaughters	4,144	4,882
Female-line grandsons	4,370	4,353
Female-line granddaughters	4,136	4,236

Number in Analytical Sample of Veterans' Grandchildren Surviving to Age 45 and Descended from Veterans' Children Born after 1866

Veterans	1,444 ex-POWs	1,381 non-POWs
Children	6,977	6,982
Grandchildren	11,981	12,550
Male-line grandsons	3,134	3,551
Male-line granddaughters	2,873	3,183
Female-line grandsons	3,144	2,997
Female-line granddaughters	2,828	2,816

Figure A2: Grandchildrens' Survival Curves by Grandfather's Ex-POW Status



Kaplan Meier survival curves estimated for years lived from birth until death.

Table A1: Life Expectancy by Cohort and Sex, Veterans' Grandchildren and US Population

	Veterans' Grandchildren		Social Security Area	
	b. 1890-1909	b. 1910-1930	b. 1910	b. 1920
Men				
Age 0	67	69	56	62
10	59	61	58	60
20	50	52	49	51
30	42	44	41	43
40	33	34	32	34
50	25	26	24	26
60	17	19	17	18
70	11	13	12	12
80	8	8	7	7
Women				
Age 0	74	76	64	69
10	66	68	65	67
20	58	59	56	58
30	50	50	48	50
40	41	41	39	40
50	33	32	30	31
60	24	24	22	23
70	17	16	15	15
80	12	10	9	9

Social Security Area life expectancies are from Bell and Miller (2005).

Table A2: Linkage Rates for Veterans, Veterans' Children, and Veterans' Grandchildren

	Veteran	Son of Veteran b. 1866+	Daughter of Veteran b. 1866+	Grandson of Veteran	Granddaughter of Veteran
Percentage with death year	100.0	87.1	82.5	94.5	88.3
linked to Census of					
1850	95.5				
1860	95.5				
1870	95.5	93.6	93.5		
1880	95.5	85.6	87.2		
1900	96.4	88.2	90.5	90.4	91.3
1910	96.5	87.1	87.4	93.8	94.0
1920	94.5	87.9	87.1	91.5	91.8
1930	94.3	89.7	87.4	94.2	93.5
1940	100.0	85.1	80.8	96.5	95.7
linked to any Census	97.7	86.7	84.6	91.7	92.5

Census linkage rates are for the living only (those with birth and death dates) and, in the case of grandchildren, for those age 0-17 at the time of the census.

Table A3: Grandfather Ex-POW Status and Number of Grandchildren by Type

	Male-line		Female-line	
	Grand-sons	Grand-daughters	Grand-sons	Grand-daughters
Grandfather was				
Non-POW	1.000	1.000	1.000	1.000
Exchange Ex-POW	0.799***	0.817***	0.950*	0.953
	(0.024)	(0.025)	(0.029)	(0.029)
Non-exchange Ex-POW	0.774***	0.810***	0.949*	0.977
	(0.024)	(0.026)	(0.030)	(0.031)

2,825 observations. Results are from Poisson regressions and include controls for characteristics at enlistment. Coefficients are incident ratios. Robust standard errors are in parentheses. The symbols *, **, and *** indicate significance at the 10, 5, and 1 percent level.

Table A4: Father's Ex-POW Status and Number of Births and Fraction of Children Surviving Reported in 1910

	Number of Children Ever Born		Fraction of Children Surviving	
	Sons	Daughters	Sons	Daughters
Grandfather was Non-POW				
Exchange Ex-POW	0.982	1.014	-0.004	0.005
	(0.033)	(0.036)	(0.012)	(0.011)
	[0.587]	[0.702]	[0.745]	[0.639]
Non-exchange Ex-POW	0.997	0.986	-0.023*	-0.003
	(0.035)	(0.036)	(0.013)	(0.011)
	[0.928]	[0.701]	[0.083]	[0.799]

3,072 married sons and 2,971 married daughters of veterans in 1910. The number of children and the number of living children was asked of married women only. Coefficients for the first two regressions are incident ratios from Poisson regressions. Coefficients for the last two regressions are from OLS regressions. All regressions control for the veteran's enlistment characteristics and cluster the standard errors on the veteran. The symbols *, **, and *** indicate significance at the 10, 5, and 1 percent level.

Appendix B: Additional Specifications

B.1 Means

Tables B1 and B2 present means showing characteristics of the veteran grandfathers, the parents of the grandchildren, and grandchildren's own characteristics.

B.2 Wives

Mortality after age 45 of wives of male-line grandsons who had survived to age 45 was not statistically, significantly related to their grandfather-in-law's ex-POW status (see Table B3 and its notes). Wives' mortality, however, was correlated with the life span of their husbands.

B.3 Difference-in-Difference Estimates

Table B4 presents estimates from the combined grandson and granddaughters samples.

B.4 Early and Late Non-Exchange Ex-POWs, Male-Line Grandsons

Table B5 reveals that among male-line grandsons it was the descendants of late, not early, exchange ex-POWs who faced a higher mortality risk compared to the descendants of non-POWs. However, the mortality risk of late exchange ex-POWs was statistically indistinguishable from the mortality risk of non-POWs. Low power may be a problem: less than 8% of male-line grandsons who survived to age 45 were descended from POWs captured in the early days of the war.

B.5 Socioeconomic Status and Education

I investigate the correlation between a veteran's ex-POW status and the socioeconomic status of his children by examining the relationship between ex-POW status and whether veterans' sons and sons-in-law were ever farmers, laborers, and never home owners. I estimate 6 probit models of the form

$$\Pr(Y_i = 0, 1) = \beta_0 + \beta_1 P_{Ei} + \beta_2 P_{Ni} + \beta_3 C_i \tag{B1}$$

for veterans' sons and for veterans' sons-in-law where $Y_i = 1$ if the son or son-in-law was ever a farmer, a laborer, or never a home owner. I present marginals.

I examine the association between veterans' ex-POW status and years of education of their grandchildren and grandchildren-in-law who were age 21 or older in 1940, the only census year in which education is available. I estimate 8 OLS models

$$\ln(\text{years of education})_i = \beta_0 + \beta_1 P_{Ei} + \beta_2 P_{Ni} + \beta_3 C_i \tag{B2}$$

for grandchildren in every line and for their spouses in every line.

I find no evidence that a grandfather's ex-POW status was related to the socioeconomic status or the wealth of his children. Table B6 shows that there was no relationship between a veteran's ex-POW status and his son ever being a laborer or never being a home owner. Among children linked to the 1930 census, there is no evidence that their veteran grandfathers' ex-POW status was correlated with the value of the home they owned (results not shown). Although the probabilities that veterans' sons and sons-in-law were farmers fell by 0.05 if their fathers or fathers-in-law were non-exchange rather than non-POWs, statistical significance disappeared and the magnitude was smaller once I controlled for the veteran's occupation in 1880 (results not shown).

I find suggestive evidence of occupational adjustments to poor health by veterans after the war but these were not necessarily associated withe reduced socioeconomic status. Controlling for occupation at enlistment, the probability that non-exchange ex-POW veteran grandfathers in 1880 were farmers was 0.09 lower than that of their non-POW counterparts and their probability of being artisans was 0.05 higher. Results were statistically significant at the 1% level (see Table B7). Relative to exchange ex-POWs, non-exchange ex-POWs had an 0.063 lower probabilitiy of being farmers and an 0.04 higher probability of being artisans. Ex-POW status was not associated with the probability of veterans being laborers or professionals/proprietors in 1880.

A grandfather's ex-POW status was uncorrelated with the years of education of his grandchild age 21 or older in 1940 (see Table B8).[13] Although I cannot observe grandchildren's socioeconomic status at older ages, the absence of an effect on education implies no effects of grandfathers' ex-POW status on grandchildren's socioeconomic status.

B.6 Mental Health of Veterans

Table B9 shows that the fraction of veterans who had mental health issues, particularly before age 70, did not differ by their ex-POW status. The fraction with severe psychopathologies such as insanity, depression, or alcholism was small. When I estimated a probit in which the dependent variable was equal to 1 when the veteran had a mental health issue and in which I controlled for the veteran's pre-war characteristics, the resulting marginals on ex-POW status were small and statistically insignificant.

[13] There also was no relationship between a grandfather's ex-POW stataus and whether his grandchild age 16 or older in 1940 had completed eighth grade (results now shown).

B.7 Longevity of Grandchildren's Parents who Married into the Family

I find no evidence that the mothers of male-line grandsons were less hardy, as proxied by mortality after age 45, if they married the sons of non-exchange ex-POWs rather than the sons of non-POWs (Table B11). There were no differences in mortality by father-in-law's ex-POW status among grandchildren's parents in other lines.

B.8 Mortality Among Those at Risk at Ages 19-24

Table B12 presents estimates of Equation 1 but restricting the sample to grandchildren descended from a veteran who was at risk of non-exchange captivity at ages 19-24.

B.9 Comparisons Among Cousins

I examine mortality among male-line grandsons by comparing male-line to female-line cousins *within* veterans' families. I restrict the sample to those families with grandsons descended from both lines and where the veteran was at risk of captivity at ages 19-24. I estimate

$$h_i(t) = h_0(t)\exp(\beta_x X_i)$$

where t is years lived after age 45, $h_0(t)$ is the baseline hazard and X_i is a vector of characteristics specific to each grandson i. I specify $\beta_x X_i$ as

$$\beta_1 M_i + \beta_2(M_i \times P_{Ei}) + \beta_3(M_i \times P_{Ni}) + \beta_4 C_i \qquad \text{(B3)}$$

where M_i is a dummy equal to 1 indicating if the grandson was from the male line, P_{Ei} and P_{Ni} are dummy indicators equal to one if the grandfather was an exchange period POW or a non-exchange period POW, respectively, and C is vector of control characteristics of the grandson. I control only for birth year and birth cohort. I stratify on the veteran and cluster on the family of the veteran's child. I can identify POW status effects for male-line grandsons only.

Table B13 reveals results very similar for male-line grandsons to those obtained without veteran controls in Table B12.

I examine mortality among male-line grandsons *within* veterans' families by comparing grandsons descended from fathers born before versus after the war. That is, I estimate

$$h_i(t) = h_0(t) \exp(\beta_x X_i)$$

where t is years lived after age 45, $h_0(t)$ is the baseline hazard and X_i is a vector of characteristics specific to each grandson i. I specify $\beta_x X_i$ as

$$\beta_1 A_i + \beta_2(A_i \times P_{Ei}) + \beta_3(A_i \times P_{Ni}) + \beta_4 C_i \tag{B4}$$

where A_i is a dummy equal to 1 if the father was born after the war, P_{Ei} and P_{Ni} are dummy indicators equal to one if the grandfather was an exchange period POW or a non-exchange period POW, respectively, and C is vector of control characteristics of the grandson. I control for the grandson's birth year and quarter of birth.

Table B14 shows that among male-line grandsons with grandfathers born before 1830 those descended from non-POWs faced a lower mortality risk if their fathers were born after the war; in contrast, those born to non-exchange ex-POWs were a statistically significant 3.00 times more likely to die at any age after age 45 if descended from fathers born after rather than before the war. Those born to exchange ex-POWs were a statistically insignificant 2.22 times more likely to die if descended from fathers born after rather than before the war. The association disappears among those descended from veterans born between 1830 and 1839. Older ages may be transition ages because of hormonal changes but the sample is underpowered to examine older ages.

B.10 No Siblings

When I kept only the eldest grandchild within each line, I found that male-line grandsons of non-exchange ex-POWs were 1.14 times as likely to die at any age after age 45 compared to non-POWs and 1.13 times as likely to die compared to exchange ex-POWs (see Table B15). Statistical significance was higher compared to that reported in Table 3.

B.11 Tests of Death Record Linkage Bias

I re-estimate Equation 1 under the assumptions that those grandchildren with missing death dates died between ages 0-95, 45-65, 65-95, and 85-95 at randomnly assigned ages (see Table B16. The results are robust to the inclusion of these observations.

B.12 Tests of Sample Construction Bias

A potential source of bias arises from following grandchildren only if a parent, aunt, or uncle descended from the veteran survived to age 45. I therefore re-estimate Equation 1 for male-line grandchildren under the assumption that a father, uncle, or aunt lived to age 55, 65, or 75 (see Table B17). The assocation between mortality and non-exchange ex-POW relative to non-POW status persists but I lose significance on the assocation between mortality and non-exchange ex-POW relative to exchange-POW status.

B.13 Mortality Effects at Other Ages

Table B18 shows that male-line grandsons were more likely to die if descended from non-exchange ex-POWs rather than non-POWs or exchange ex-POWs, regardless whether I examine years lived from age 0, 20, or 65 or 45 as in my main specifications. The association may be somewhat stronger at older compared to younger ages, as expected if the relationship arises from chronic disease.

B.14 Median Years Lived

I obtain the difference in median years lived among male-line grandsons by grandfathers' ex-POW status by running Equation 1 using a Gompertz hazards model and then estimating median years lived by grandsons by grandpaternal ex-POW status. See Table B19 for the results.

Table B1: Mean Characteristics of Veterans by Ex-POW Status

Veteran characteristics	Non-POW	Exchange Ex-POW	Non-Exchange Ex-POW
Born in the US	0.86	0.84	0.85
Born in Ireland	0.01	0.02	0.04
Enlisted in a city of 50,000+	0.03	0.04	0.04
Wounded	0.32	0.33	0.32
Enlistment occupation			
Farmer	0.71	0.69	0.62
Professional/proprietor	0.03	0.03	0.03
Artisan	0.11	0.12	0.13
Laborer	0.15	0.14	0.21
Unknown	0.01	0.03	0.03
Enlistment year			
1861	0.33	0.43	0.44
1862	0.38	0.38	0.43
1863	0.08	0.06	0.07
1864	0.21	0.12	0.06
1865	0.00	0.01	0.00
Occupation in 1880			
Farmer	0.56	0.61	0.50
Professional/proprietor	0.05	0.06	0.06
Artisan	0.09	0.09	0.14
Farmer laborer	0.03	0.03	0.03
Laborer	0.20	0.17	0.22
No occupation	0.03	0.01	0.01
Not in census	0.04	0.03	0.03
Years lived (conditional on living to 1900)	75.37	77.17	74.42

Mean characteristics are for veterans in the analytical sample, that is, all veterans with a grandchild who lived to age 45 and who descended from the child of a veteran born after the war.

Table B2: Mean Characteristics of Veterans' Grandchildren Surviving to Age 45 by Veteran's Ex-POW Status

Grandchildrens' characteristics	Non-POW	Exchange Ex-POW	Non-Exchange Ex-POW
Birth Year	1907.41	1907.80	1907.26
Father was veteran's son and was			
ever a laborer	0.26	0.25	0.26
ever a farmer	0.27	0.25	0.21
never a home owner	0.62	0.65	0.68
Father was veteran's son-in-law and was			
ever a laborer	0.18	0.19	0.19
ever a farmer	0.24	0.24	0.24
never a home owner	0.67	0.65	0.64
Number of siblings	4.37	4.37	4.41
Veteran living in the same county	0.34	0.35	0.32
Veteran living in the same household	0.03	0.05	0.04
Years of education (if age 21+ in 1940 census)	9.970	10.030	10.129
Years of education of spouse (if age 21+ and married in 1940)	9.708	9.743	9.856
Years lived	76.40	76.13	76.10
Years lived by			
parent who lived to age 45 and was			
veteran's son	73.58	73.61	72.56
veteran's son-in-law	73.94	73.15	74.29
veteran's daughter	75.89	75.97	75.90
veteran's daughter-in-law	76.51	76.14	77.04

Mean characteristics are for veterans' granchildren in the analytical sample, that is, all grandchildren who survived to age 45 and who descended from veterans' children born after the war.

Table B3: Hazard Ratios of Mortality After Age 45 for Wives of Male-Line Grandchildren by Grandfather-In-Law's Ex-POW Status

Grandfather-in-law was		
Non-POW	1.000	1.000
Exchange Ex-POW	0.988	0.990
	(0.031)	(0.031)
	[0.696]	[0.740]
Non-exchange Ex-POW	1.020	1.012
	(0.034)	(0.034)
	[0.552]	[0.722]
Lifespan of husband		0.991***
		(0.001)
		[0.000]
Test of proportional hazards	11.44	24.78
assumption, χ^2, $\mathrm{Pr} > \chi^2(14/15)$	[0.652]	[0.053]
Observations	6,109	6,109

Estimated from Cox proportional hazards models using years lived after age 45, censoring those who were still alive in 2021. All regressions control for own birth year and the veteran's, occupation at enlistment (farmer, artisan, laborer, professional or proprietor, and unknown), enlistment in a city with population of 50,000 or more, born in the US, wounded in the war, and in the original Union Army sample. Standard errors, clustered on the veteran are in parenthesis. P values are in square brackets. The proportional hazards assumption is tested using the Schoenfeld residuals. The symbols *, **, and *** indicate significance at the 10, 5, and 1 percent level.

Table B4: Hazard Ratios of Mortality by Grandfather's Ex-POW Status, Pooled by Sex Sample

Grandfather was	Grandsons Male-line	Grandsons Female-line	Granddaughters Male-line	Granddaughters Female-line
Non-POW	1.000	1.000	1.000	1.000
Exchange Ex-POW	1.036	1.053	1.020	1.028
	(0.038)	(0.039)	(0.038)	(0.040)
	[0.327]	[0.167]	[0.590]	[0.482]
Non-exchange Ex-POW	1.114***	0.991	1.015	1.008
	(0.043)	(0.040)	(0.041)	(0.039)
	[0.005]	[0.829]	[0.721]	[0.840]
Non-exchange Ex-POW relative to Exchange Ex-POW	1.075*	0.942	0.995	0.981
	(0.042)	(0.039)	(0.041)	(0.040)
	[0.066]	[0.150]	[0.896]	[0.633]
$D_{POW=N}$: Male-line Non-exchange Ex-POW relative to Female-line Non-exchange Ex-POW	1.078*		1.006	
	(0.042)		(0.042)	
	[0.055]		[0.880]	
$D_{POW=E}$: Male-line Exchange Ex-POW relative to Female-line Exchange Ex-POW	0.944		0.993	
	(0.034)		(0.038)	
	[0.108]		[0.843]	
$D_{POW=0}$: Male-line Non-POW relative to Female-line Non-POW	0.959		1.000	
	(0.026)		(0.029)	
	[0.119]		[0.482]	
$D_{POW=N} - D_{POW=0}$	1.123**		1.007	
	(0.053)		(0.052)	
	[0.013]		[0.897]	
$D_{POW=N} - D_{POW=E}$	1.141**		1.014	
	(0.059)		(0.058)	
	[0.012]		[0.807]	
Test of proportional hazards assumption, χ^2, $\Pr > \chi^2(17)$	17.78		21.41	
	[0.403]		[0.209]	
Observations	12,825		11,699	

Estimated from the Cox proportional hazards model in Equation 2 on the sample pooled by sex using years lived after age 45, stratifying on birth cohort, and controlling for birth year and the veteran's enlistment year, occupation at enlistment (farmer, artisan, laborer, professional or proprietor, and unknown), enlistment in a city with population of 50,000 or more, born in the US, wounded in the war, and in the original Union Army sample. Standard errors, and stratifying on birth cohort. Standard errors, clustered on the veteran are in parenthesis. P values are in square brackets. The proportional hazards assumption is tested using the Schoenfeld residuals. The symbols *, **, and *** indicate significance at the 10, 5, and 1 percent level.

Table B5: Male-Line Grandchildren's Hazard Ratios of Mortality by Grandfather's Ex-POW Status

Grandfather's ex-POW status	All	Grandfathers Risk Non-Exchange Ex-POW at Ages 17-24
Non-POW	1.000	1.000
Exchange Ex-POW, Early Capture	0.993	1.088
	(0.047)	(0.064)
	[0.889]	[0.152]
Non-exchange Ex-POW	1.119***	1.218***
	(0.047)	(0.061)
	[0.008]	[0.000]
Exchange Ex-POW, Late Capture	1.056	1.134**
	(0.050)	(0.065)
	[0.255]	[0.028]
Non-exchange Ex-POW	1.126**	1.119*
relative to Early Exchange Ex-POW	(0.058)	(0.068)
	[0.021]	[0.063]
Non-exchange Ex-POW	1.059	1.074
relative to Late Exchange Ex-POW	(0.048)	(0.056)
	[0.200]	[0.173]
Late Exchange Ex-POW	1.063	1.042
relative to Early Exchange Ex-POW	(0.059)	(0.069)
	[0.275]	[0.533]
Test of proportional hazards	15.33	10.49
assumption, χ^2, $\Pr > \chi^2(16)$	[0.500]	[0.788]
Observations	6,685	4,118

Estimated from a modifed version of the Cox proportional hazards model in Equation 1 using years lived after age 45, stratifying on birth cohort, and controlling for birth year and the veteran's enlistment year, occupation at enlistment (farmer, artisan, laborer, professional or proprietor, and unknown), enlistment in a city with population of 50,000 or more, born in the US, wounded in the war, and in the original Union Army sample. Standard errors, clustered on the veteran are in parenthesis. P values are in square brackets. The proportional hazards assumption is tested the Schoenfeld residuals. The symbols *, **, and *** indicate significance at the 10, 5, and 1 percent level.

Table B6: Veterans' Ex-POW Status and Children's Socioeconomic Status

	Veterans' Sons Were			Veterans' Sons-in-Law Were		
	Ever Laborers	Ever Farmers	Never Home Owners	Ever Laborers	Ever Farmers	Never Home Owners
Veteran was						
Non-POW (omitted)	0.000	0.000	0.000	0.000	0.000	0.000
Exchange Ex-POW	0.004	-0.024	0.008	-0.015	-0.030	-0.004
	(0.027)	(0.026)	(0.022)	(0.025)	(0.027)	(0.022)
	[0.896]	[0.362]	[0.718]	[0.535]	[0.271]	[0.873]
Non-exchange Ex-POW	0.017	-0.053*	0.019	-0.019	-0.052*	0.004
	(0.026)	(0.027)	(0.024)	(0.025)	(0.027)	(0.023)
	[0.521]	[0.053]	[0.418]	[0.455]	[0.057]	[0.879]
Non-exchange Ex-POW						
relative to Exchange Ex-POW	0.013	-0.029	0.011	-0.003	-0.022	0.008
	(0.026)	(0.027)	(0.023)	(0.024)	(0.026)	(0.222)
	[0.608]	[0.268]	[0.635]	[0.896]	[0.393]	[0.753]

4,261 observations for the regressions for sons and 3,767 observations for the regressions for sons-in-law. Results are from the marginals from probits estimated using Equation B1. Additional control variables include the birth year of the veteran's child and veteran's enlistment year dummies, occupation at enlistment (farmer, artisan, laborer, professional or proprietor, and unknown), enlistment in a city with population of 50,000 or more, born in the US, wounded in the war, and in the original Union Army sample. Standard errors, clustered on the veteran, are in parentheses and p-values are in square brackets. The symbols *, **, and *** indicate significance at the 10, 5, and 1 percent level.

Table B7: Veteran's Occupational Class in 1880 and His Ex-POW Status (Odds Ratios)

Veteran's 1880 Occupational Class:	Farmer	Professional/ Proprietor	Artisan	Laborer
Veteran was				
Non-POW (omitted)	0.000	0.000	0.000	0.000
Exchange Ex-POW	-0.027	0.023	0.016	-0.012
	(0.026)	(0.016)	(0.018)	(0.022)
	[0.298]	[0.153]	[0.379]	[0.587]
Non-exchange Ex-POW	-0.090***	0.027	0.053***	0.010
	(0.027)	(0.017)	(0.020)	(0.024)
	[0.001]	[0.125]	[0.009]	[0.692]
Non-exchange Ex-POW	-0.063**	0.003	0.038*	0.022
relative to Exchange Ex-POW	(0.026)	(0.018)	(0.020)	(0.022)
	[0.016]	[0.848]	[0.055]	[0.346]

2,423 observations. Results are the marginals from a multinomial probit in which the four occupational categories are farmer, professional or proprietor, artisan, and laborer. Additional control variables include the veteran's birth year, enlistment year dummies, occupation at enlistment (farmer, artisan, laborer, professional or proprietor, and unknown), enlistment in a city with population of 50,000 or more, born in the US, wounded in the war, and in the original Union Army sample. Standard errors are in parentheses and p-values are in square brackets. The symbols *, **, and *** indicate significance at the 10, 5, and 1 percent level.

Table B8: Grandfather's Ex-Pow Status and the Educational Attainment of Their Grandchildren and Grandchildren-In-Law

	Male-line		Female-line	
Grandfather's ex-POW status	Grand-sons	Grand-daughters	Grand-sons	Grand-daughters
Dependent Variable: Log(Years of Own Education)				
Non-POW	1.000	1.000	1.000	1.000
Exchange Ex-POW	0.013	0.003	0.006	0.000
	(0.019)	(0.020)	(0.022)	(0.022)
	[0.488]	[0.881]	[0.774]	[0.988]
Non-exchange Ex-POW	0.020	0.020	0.025	0.011
	(0.021)	(0.019)	(0.021)	(0.021)
	[0.325]	[0.287]	[0.238]	[0.596]
Observations	4,838	4,380	4,778	4,446
R-squared	0.049	0.063	0.064	0.053
Dependent Variable: Log(Years of Spouses' Education)				
Non-POW	1.000	1.000	1.000	1.000
Exchange Ex-POW	0.030	-0.007	0.000	-0.000
	(0.018)	(0.025)	(0.019)	(0.024)
	[0.102]	[0.778]	[0.991]	[0.989]
Non-exchange Ex-POW	0.031*	0.012	0.016	0.027
	(0.017)	(0.023)	(0.018)	(0.022)
	[0.066]	[0.594]	[0.357]	[0.213]
Observations	3,338	3,161	3,454	3,242
R-squared	0.049	0.048	0.053	0.054

The sample is limited to grandchildren age 21 or older. Estimated from the OLS equation in Equation B2. Additional control variables include the birth year of the veteran's child and veteran's enlistment year dummies, occupation at enlistment (farmer, artisan, laborer, professional or proprietor, and unknown), enlistment in a city with population of 50,000 or more, born in the US, wounded in the war, and in the original Union Army sample. Standard errors, clustered on the veteran, are in parentheses and p-values are in square brackets. The symbols *, **, and *** indicate significance at the 10, 5, and 1 percent level.

Table B9: Mental Health Problems Among Veterans by Ex-POW Status

	Non-POW	Exchange Ex-POW	Non-Exchange Ex-POW
Fraction veterans with			
Any mental health issue	0.134	0.153	0.157
Insanity	0.022	0.022	0.033
Depression	0.010	0.011	0.012
Alcoholism	0.001	0.003	0.002
Any mental health issue before age 70	0.104	0.141	0.118
Marginals from probit, dependent variable is			
Any mental health issue		0.011	0.013
		(0.019)	(0.019)
		[0.537]	[0.493]
Any mental health issue before age 70		0.026	0.000
		(0.018)	(0.018)
		[0.149]	[0.985]

2,825 observations. Marginals are from a probit in which the dependent variables is a dummy equal to 1 if the veteran suffered from mental problems or from mental health problems before the war. Additional control variables include the veteran's birth year, enlistment year dummies, occupation at enlistment (farmer, artisan, laborer, professional or proprietor, and unknown), enlistment in a city with population of 50,000 or more, born in the US, wounded in the war, and in the original Union Army sample. Standard errors are in parentheses and p-values are in square brackets. The symbols *, **, and *** indicate significance at the 10, 5, and 1 percent level.

Table B10: Generational Associations: Daughters' and Female-Line Grandchildren's Hazard Ratios of Mortality by Veteran's Ex-POW Status Among Survivors to Age 45

Veterans:	Exchange Ex-POW Relative to Non-POW	Non-Exchange Ex-POW Relative to Non-POW	Non-Exchange Relative to Exchange Ex-POW	Test of Proportional Hazards Assumption	Obser-vations
Veterans' Daughters	0.982	1.093	1.112*	4.01	2,670
who were Mothers	(0.054)	(0.063)	(0.062)		
of Grandsons	[0.742]	[0.124]	[0.054]	[0.998]	
Veterans'	1.060	1.003	0.947	13.76	5,688
Grandsons	(0.042)	(0.043)	(0.040)		
from Daughters	[0.139]	[0.939]	[0.192]	[0.544]	
Veterans' Daughters	1.076	1.037	0.964	14.38	2,959
who were Mothers	(0.060)	(0.060)	(0.054)		
of Granddaughters	[0.190]	[0.535]	[0.511]	[0.497]	
Veterans'	1.039	0.993	0.956	14.18	5,232
Granddaughters	(0.043)	(0.041)	(0.043)		
from Daughters	[0.364]	[0.878]	[0.288]	[0.512]	

Circles indicate female and squares indicate male. The sample is restricted to all grandchildren who survived to age 45 and who had a mother who was a veteran's daughter and who survived to age 45. Each row is from a single regression result from a Cox proportional hazards model using years lived after age 45, stratifying on birth cohort, and controlling for birth year and the veteran's enlistment year, occupation at enlistment (farmer, artisan, laborer, professional or proprietor, and unknown), enlistment in a city with population of 50,000 or more, born in the US, wounded in the war, and in the original Union Army sample. Standard errors, clustered on the veteran, are in parentheses. P values are in square brackets. The proportional hazards assumption is tested using the Schoenfeld residuals. The symbols *, **, and *** indicate significance at the 10, 5, and 1 percent level.

Table B11: Hazard Ratios of Mortality After Age 45 for Fathers and Mothers of Grandchildren Within Each Line by Father-In-Law's Ex-POW Status

	Veterans' Children-in-Law Who Were			
	Daughters-In-Law and Mothers of Male-line		Sons-In-Law and Fathers of Female-line	
	Grand-sons	Grand-daughters	Grand-sons	Grand-daughters
Veterans's Ex-POW status				
Non-POW	1.000	1.000	1.000	1.000
Exchange Ex-POW	1.172*	1.023	1.042	1.044
	(0.098)	(0.094)	(0.088)	(0.085)
	[0.057]	[0.807]	[0.627]	[0.597]
Non-exchange Ex-POW	1.043	1.022	0.997	0.975
	(0.081)	(0.090)	(0.092)	(0.082)
	[0.584]	[0.805]	[0.974]	[0.763]
Non-exchange Ex-POW relative to Exchange Ex-POW	0.89	0.999	0.957	0.934
	(0.068)	(0.089)	(0.079)	(0.079)
	[0.125]	[0.995]	[0.592]	[0.418]
Test of proportional hazards	14.09	22.95	60.4	37.38
assumption, χ^2, $\Pr > \chi^2(15)$	[0.169]	[0.011]	[0.000]	[0.000]
Observations	3,467	2,926	3,477	3,095

The fathers and mothers in the sample are not related to the veteran. Estimated from Cox proportional hazards models using years lived after age 45, stratifying on veterans' enlistment characteristics and whether in the Union Army sample, and controlling for own birth year and the veteran's, occupation at enlistment (farmer, artisan, laborer, professional or proprietor, and unknown), enlistment in a city with population of 50,000 or more, born in the US, and wounded in the war. Standard errors, clustered on the veteran are in parenthesis. P values are in square brackets. The proportional hazards assumption is tested using the Schoenfeld residuals. The symbols *, **, and *** indicate significance at the 10, 5, and 1 percent level.

Table B12: Grandchildren's Hazard Ratios of Mortality by Grandfather's Ex-POW Status Conditional on Grandfather at Risk of Being a No-Exchange Ex-POW at Ages 19 to 24

	Male-line		Female-line	
Grandfather's ex-POW status	Grand-sons	Grand-daughters	Grand-sons	Grand-daughters
Non-POW	1.000	1.000	1.000	1.000
Exchange Ex-POW	1.138**	1.035	1.066	1.052
	(0.066)	(0.061)	(0.059)	(0.063)
	[0.026]	[0.563]	[0.246]	[0.395]
Non-exchange Ex-POW	1.284***	1.068	0.953	1.018
	(0.074)	(0.069)	(0.051)	(0.055)
	[0.000]	[0.307]	[0.369]	[0.746]
Non-exchange Ex-POW relative to Exchange Ex-POW	1.127**	1.032	0.893	0.967
	(0.061)	(0.063)	(0.049)	(0.055)
	[0.027]	[0.604]	[0.039]	[0.561]
Test of proportional hazards	9.23	26.71	12.94	7.83
assumption, 13 df	[0.755]	[0.014]	[0.453]	[0.854]
Observations	3,394	3,051	3,171	2,929

The sample has been restricted to grandchildren whose grandfathers were age 19-24 when at risk of being a no-exchange ex-POW. Estimated from the Cox proportional hazards model in Equation 1 using years lived after age 45, stratifying on birth cohort, and controlling for birth year and the veteran's enlistment year, occupation at enlistment (farmer, artisan, laborer, professional or proprietor, and unknown), wounded in the war, and in the original Union Army sample. I exclude as controls whether the veteran was US-born and whether the veteran enlisted in a large city to satisfy the proportional hazards assumption. Standard errors, clustered on the veteran, are in parentheses. P values are in square brackets. The proportional hazards assumption is tested using the Schoenfeld residuals. The symbols *, **, and *** indicate significance at the 10, 5, and 1 percent level.

Table B13: Male-Line Grandsons' Hazard Ratios of Mortality After Age 45 Within Families, Across Male-line and Female-line Comparison

	Hazard Ratio	Std Err	P-Value
Veteran Grandfather was			
Non-exchange ex-POW relative to non-POW	1.313**	0.140	0.010
Exchange ex-POW relative to non-POW	1.094	0.119	0.411
Non-exchange relative to exchange ex-POW	1.200**	0.108	0.042

4,900 observations. Estimates are from the Cox proportional hazards model in Equation B3. Stratification is on the veteran. Standard errors are clustered on the veteran's child. The test of the proportional hazards assumption was estimated using the Schoenfeld residuals with 8 degrees of freedom, $\chi^2 = 11, 09, p = 0.197$. The symbols *, **, and *** indicate significance at the 10, 5, and 1 percent level.

Table B14: Male-Line Grandsons' Hazard Ratios of Mortality After Age 45 Within Families by Descent from Sons Born Before or After the War

Veteran was born:	before 1830	1830-1839
Veteran's son born after relative to before the war and veteran was		
Non-POW	0.665	0.995
	(0.169)	(0.121)
	[0.108]	[0.965]
Exchange ex-POW	2.222	1.660
	(1.374)	(0.511)
	[0.196]	[0.100]
Non-exchange ex-POW	3.001**	0.727
	(1.622)	(0.224)
	[0.041]	[0.300]
Veteran was Non-exchange relative to	1.353	0.438***
Exchange ex-POW and son born the war	(0.691)	(0.134)
	[0.553]	[0.007]
	6.88	3.05
	[0.441]	[0.880]
Test of proportional hazards	6.88	3.05
assumption, χ^2, Pr $> \chi^2(7)$	[0.441]	[0.880]
Observations	211	662

The sample consists of male-line grandsons only, where each male-line grandson born after the war is matched to a male-line grandson born before the war. Estimated from the Cox proportional hazards models in Equation B4, Appendix C, section using years lived after age 45, All regressions control for own birth year and own quarter of birth, stratify on the veteran, and cluster on the father. Standard errors are in parenthesis. P values are in square brackets. The proportional hazards assumption is tested using the Schoenfeld residuals. The symbols *, **, and *** indicate significance at the 10, 5, and 1 percent level.

Table B15: Grandchildren's Hazard Ratios of Mortality by Grandfather's Ex-POW Status Among *Oldest* Grandchild Within Each Line

	Male-line		Female-line	
	Grand-sons	Grand-daughters	Grand-sons	Grand-daughters
Grandfather was				
Non-POW	1.000	1.000	1.000	1.000
Exchange Ex-POW	1.012	1.020	1.054	1.025
	(0.049)	(0.054)	(0.051)	(0.055)
	[0.813]	[0.710]	[0.276]	[0.645]
Non-exchange Ex-POW	1.143***	1.015	1.015	1.059
	(0.059)	(0.057)	(0.057)	(0.057)
	[0.009]	[0.786]	[0.799]	[0.286]
Non-exchange Ex-POW				
relative to Exchange Ex-POW	1.130**	0.996	0.962	1.033
	(0.055)	(0.054)	(0.050)	(0.054)
	[0.013]	[0.934]	[0.456]	[0.539]
Test of proportional hazards	4.03	7.25	19.36	10.01
assumption, χ^2, $\Pr > \chi^2(15)$	[0.998]	[0.950]	[0.198]	[0.819]
Observations	3,108	2,948	2,738	2,591

The samples are restricted to the oldest sibling within each line. Estimated from the Cox proportional hazards model in Equation 1 using years lived after age 45, stratifying on birth cohort, and controlling for birth year and the veteran's enlistment year, occupation at enlistment (farmer, artisan, laborer, professional or proprietor, and unknown), enlistment in a city with population of 50,000 or more, born in the US, wounded in the war, and in the original Union Army sample. Standard errors, clustered on the veteran are in parenthesis. P values are in square brackets. The proportional hazards assumption is tested using the Schoenfeld residuals. The symbols *, **, and *** indicate significance at the 10, 5, and 1 percent level.

Table B16: Hazard Ratios for Mortality Under Different Mortality Assumptions about Ages Death of No-Finds

	Male-line		Female-line		Male-line		Female-line	
	Grand-sons	Grand-daughters	Grand-sons	Grand-daughters	Grand-sons	Grand-daughters	Grand-sons	Grand-daughters
Grandfather was Non-POW	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	No-Finds Assumed to Die Age 0-95				No-Finds Assumed to Die Age 65-95			
Exchange Ex-POW	1.042	1.045	1.062	0.995	1.053	1.044	1.054	0.985
	(0.041)	(0.041)	(0.040)	(0.040)	(0.041)	(0.041)	(0.040)	(0.039)
	[0.300]	[0.259]	[0.111]	[0.910]	[0.187]	[0.267]	[0.164]	[0.708]
Non-exchange Ex-POW	1.115**	1.012	0.981	0.980	1.121***	1.009	0.967	0.973
	(0.047)	(0.043)	(0.040)	(0.042)	(0.047)	(0.043)	(0.040)	(0.041)
	[0.010]	[0.775]	[0.639]	[0.643]	[0.006]	[0.836]	[0.413]	[0.516]
Test of proportional hazards	16.72	19.5	17.34	12.32	18.9	17.85	15.8	13.62
assumption	[0.404]	[0.244]	0.364	0.722	[0.274]	[0.333]	[0.467]	[0.627]
Observations	6,976	6,595	6,340	6,077	7,175	7,047	6,519	6,425
Grandfather was	No-Finds Assumed to Die Age 45-95				No-Finds Assumed to Die Age 85-95			
Exchange Ex-POW	1.054	1.022	1.066*	1.019	1.054	1.055	1.020	0.969
	(0.041)	(0.040)	(0.040)	(0.040)	(0.040)	(0.042)	(0.040)	(0.039)
	[0.174]	[0.588]	[0.087]	[0.634]	[0.170]	[0.177]	[0.609]	[0.439]
Non-exchange Ex-POW	1.129***	0.993	0.962	0.998	1.113***	1.004	0.966	0.963
	(0.046)	(0.042)	(0.039)	(0.042)	(0.045)	(0.043)	(0.040)	(0.040)
	[0.003]	[0.863]	[0.349]	[0.952]	[0.009]	[0.925]	[0.400]	[0.362]
Test of proportional hazards	‘17.47	18	16.55	11.27	25.25	17.45	20.78	14.24
assumption	[0.356]	[0.324]	[0.415]	[0.792]	[0.066]	[0.357]	[0.187]	[0.581]
Observations	7,175	7,047	6,519	6,425	7,175	7,047	6,519	6,425

Estimated using Equation 1 and examining years lived after age 45 in a sample which randomly assigns death ages to grandchildren for whom death date is unknown. All regressions control for own birth year and the veteran's, occupation at enlistment (farmer, artisan, laborer, professional or proprietor, and unknown), enlistment in a city with population of 50,000 or more, born in the US, wounded in the war, and in the original Union Army sample and stratify on birth cohort. Standard errors, clustered on the veteran, are in parenthesis. P values are in square brackets. The proportional hazards assumption is tested using the Schoenfeld residuals. The symbols *, **, and *** indicate significance at the 10, 5, and 1 percent level.

Table B17: Hazard Ratios for Mortality under Different Assumptions of Father, Uncle, or Aunt's Age of Death

Grandfather's ex-POW status	Father, Uncle, or Aunt Lived to Age 55	65	75
Non-POW	1.000	1.000	1.000
Exchange Ex-POW	1.028	1.033	1.038
	(0.040)	(0.041)	(0.043)
	[0.487]	[0.409]	[0.372]
Non-exchange Ex-POW	1.119***	1.112**	1.108**
	(0.047)	(0.048)	(0.050)
	[0.008]	[0.014]	[0.024]
Non-exchange Ex-POW relative to Exchange Ex-POW	1.089**	1.076*	1.067
	(0.044)	(0.044)	(0.046)
	[0.034]	[0.072]	[0.127]
Test of proportional hazards	15.52	16.99	19.03
assumption, 16 df	[0.487]	[0.386]	[0.267]
Observations	6,606	6,440	5,863

Estimated using Equation 1 and examining years lived after age 45 in samples which require at least one father, uncle or aunt to have lived to the specified age. All regressions control for own birth year and the veteran's, occupation at enlistment (farmer, artisan, laborer, professional or proprietor, and unknown), enlistment in a city with population of 50,000 or more, born in the US, wounded in the war, and in the original Union Army sample and stratify on birth cohort. Standard errors, clustered on the veteran, are in parenthesis. P values are in square brackets. The proportional hazards assumption is tested using the Schoenfeld residuals. The symbols *, **, and *** indicate significance at the 10, 5, and 1 percent level.

Table B18: Male-Line Grandsons' Hazard Ratios of Mortality by Grandfather's ex-POW Status, Different Dependent Variables

	Dependent Variable is Years Lived From		
Grandfather's ex-POW status	Age 0	Age 20	Age 65
Non-POW	1.000	1.000	1.000
Exchange Ex-POW	1.019	1.016	1.043
	(0.038)	(0.038)	(0.044)
	[0.607]	[0.669]	[0.317]
Non-exchange Ex-POW	1.105**	1.103**	1.121***
	(0.044)	(0.044)	(0.049)
	[0.011]	[0.015]	[0.009]
Non-exchange Ex-POW	1.085**	1.085**	1.074*
relative to Exchange Ex-POW	(0.041)	(0.041)	(0.045)
	[0.030	[0.032]	[0.088]
Test of proportional hazards	15.76	14.02	13.64
assumption, 15 df	[0.398]	[0.524]	[0.553]
Observations	7,652	7,269	5,053

Estimated from the Cox proportional hazards model in Equation 1 using years lived after age 0, 20, or 65, stratifying on birth cohort, and controlling for birth year and the veteran's enlistment year, occupation at enlistment (farmer, artisan, laborer, professional or proprietor, and unknown), enlistment in a city with population of 50,000 or more, born in the US, wounded in the war, and in the original Union Army sample. Standard errors, clustered on the veteran are in parenthesis. P values are in square brackets. The proportional hazards assumption is tested using the Schoenfeld residuals. The symbols *, **, and *** indicate significance at the 10, 5, and 1 percent level.

Table B19: Mortality after Age 45 Among Male-Line Grandsons of Non-POWs, Gompertz Specification

Grandfathers:	All		At Risk at Age 17-24	
Grandfather's ex-POW status	Regression Coefficients	Median Years Lived	Regression Coefficients	Median Years Lived
Non-POW (omitted)	0.000	29.900***	0.000	30.261***
		(0.286)		(0.393)
		[0.000]		[0.000]
Exchange Ex-POW	0.030	29.558***	0.113**	28.980***
	(0.040)	(0.361)	(0.049)	(0.425)
	[0.455]	[0.000]	[0.022]	[0.000]
Non-exchange Ex-POW	0.107**	28.671***	0.196***	28.037***
	(0.043)	(0.397)	(0.051)	(0.437)
	[0.012]	[0.000]	[0.000]	[0.000]
Difference Non-exchange Ex-POW	0.078*	0.887*	0.083*	0.943*
and Exchange Ex-POW	(0.040)	(0.462)	(0.047)	(0.526)
	[0.055]	[0.055]	[0.073]	[0.073]
Difference Non-exchange Ex-POW		1.229**		2.224***
and Non-POW		(0.488)		(0.578)
		[0.012]		[0.000]
Difference Exchange Ex-POW		0.341		1.281**
and Non-POW		(0.457)		(0.559)
		[0.455]		[0.022]
Observations	6,685		4,118	

At risk = at risk of being a non-exchange ex-POW. Estimated from a Gompertz hazards model using years lived after age 45. Stratification is on birth cohort. Controls include birth year and the veteran's enlistment year, occupation at enlistment (farmer, artisan, laborer, professional or proprietor, and unknown), enlistment in a city with population of 50,000 or more, born in the US, wounded in the war, and in the original Union Army sample. Standard errors, clustered on the veteran are in parentheses. P values are in square brackets. The symbols *, **, and *** indicate significance at the 10, 5, and 1 percent level.

Table B20: Summary of Results for Multigenerational Transmission

Explanations	Tests
Socioeconomic status	Longevity results are robust to SES controls SES not lower among exposed veterans and descendants Children-in-law of exposed veteran are not shorter-lived Grandchildren of older ex-POWs not shorter-lived Daughters as likely to inherit SES as sons (Costa et al. 2022)
Marriage selection	Children-in-law of exposed veteran are not shorter-lived and are not poorer Wives (post-war marriages) of exposed veterans are not shorted and are not from poorer households (PNAS)
Data issues	Robust to different mortality assumptions for missing data Robust to cousin comparison Robust to comparison of grandchildren of fathers born pre- vs post-war Robust to restricting sample to oldest grandchild within each line Robust to different sample restrictions on family or own survivorship
Cultural/ Psychological	No evidence exposed veterans have mental health issues Longevity results are robust to controls for geographic proximity of the veteran to his grandchild Older exposed veterans more likely to be overweight but only grandchildren of younger veterans overweight (Costa 2023)
Epigenetic	Sex-specific transmission consistent with Y chromosome transmission Grandchildren of younger not older exposed ex-POWs shorter-lived, consistent with (Bygren 2013) and not mortality selection Grandchildren of exposed ex-POWs faced highest mortality risk if born in the winter and to fathers born in the winter, consistent with (Dolinoy et al. 2007; Bernal et al. 2013)