Overweight Grandsons and Grandfathers' Starvation Exposure

by

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Abstract

Much of the increase in the prevalence of overweight and obesity has been in developing countries with a history of famines and malnutrition. Prior research has pointed to the association between overweight and famine exposure during developmental ages as one of several explanations and has hypothesized that ancestral famine exposure may play a role. Data limitations have prevented researchers from investigating the multigenerational effects of famine shocks on descendant overweight. This paper examines overweight among adult grandsons of grandfathers exposed to starvation during developmental ages. I study grandsons born to grandfathers who served in the Union Army during the US Civil War (1861-5) where some grandfathers experienced severe net malnutrition because they were POWs during times of extreme hardship. I find that male-line but not female-line grandsons of grandfathers who experienced a severe captivity during their growing years faced a 21% increase in mean overweight and a 2% increase in mean BMI compared to grandsons of non-POWs. This increase was mediated by fathers' and to a lesser extent own in-utero conditions, as proxied by season of birth, suggesting a dynamic process of inheritance. Male-line grandsons descended from grandfathers who experienced a harsh captivity faced a 22-28% greater risk of dying every year after age 45 relative to grandsons descended from non-POWs, with overweight accounting for 9-14% of the excess risk.

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Adults worldwide have become 1.5kg heavier in each decade between 1975 and 2014 and much of the increase in the prevalence of overweight and obesity has been in developing countries (NCD Risk Factor Collaboration, 2016, 2017). While the declining money and time costs of calories and energy dense foods and reduced physical job demands have undoubtedly played a role in this increase (Cutler et al., 2003; Philipson, 2001; Lakdawalla and Philipson, 2009), countries which have experienced malnutrition and famines may face higher risks. Overweight and obesity are associated both with in-utero and post-natal famine exposure (Conti et al., 2021; Lumey et al., 2021; Ravelli et al., 1976; Zhou et al., 2018; Fund et al., 2019; Abeelen et al., 2012) and nutrition in early life has a demonstrable but small effect on adult obesity (Martorell et al., 2001). The implication of biological, including epigenetic, and behavioral mechanisms in these associations raises the question whether ancestors' famine exposure could reverberate across generations to affect descendants' overweight and obesity. Limited intergenerational evidence suggests that it could: the children of fathers exposed prenatally to the Dutch Hunger Winter were more likely to be heavier or obese than the children of unexposed fathers and of exposed and unexposed mothers (Veenendaal et al., 2013).

This paper is the first to examine whether adult grandsons of grandfathers exposed to starvation during developmental ages were more likely to be overweight relative to their counterparts whose grandfathers were not exposed. It examines differences in overweight in response to grandfathers' exposure between male-line and female-line cousins and provides circumstantial evidence on some of the mechanisms behind multigenerational transmission of starvation exposure. It also investigates the implications of overweight for grandsons' longevity. The literature on famine exposure has not disentangled the direct effect of famine exposure on later own or descendant health from the indirect effect through overweight.

The developmental origins of disease hypothesis (Barker, 1992, 1994) has led to an

extensive literature examining the in-utero and early childhood origins of older age health (Lumey and van Poppel, 2013; Heijmans et al., 2008; Almond, 2006; Cook et al., 2019; Currie and Vogl, 2013), including how genetic endowments interact with both early and later life environments to produce health (van den Berg et al., 2022; Baker et al., 2022; Rosenquist et al., 2015). A growing literature suggests that health originates in past generations and is transmitted to current generations via inheritable changes in gene function triggered by the environment (epigenetics). Plant and animal studies support such inheritance (Heard and Martienssen, 2014). Because of data requirements evidence of transgenerational transmission in human populations is limited to a small set of studies (Kaati et al., 2007; Bygren et al., 2001; Bygren, 2013; Vågerö et al., 2018; van den Berg and Pinger, 2016; Costa, 2021), all of which point to paternal grandfather's slowing growing years as a critical period for transmission to male-line grandsons.

My data enable me to trace the effects of a paternal ancestral shock using clear treatment and control groups while controlling for a rich array of family and socioeconomic factors. I collected a cousin sample of grandsons born between 1877 and 1929 and descended from US Civil War (1861-5) veteran grandfathers who served in the Union Army during their growing years. Each male-line cousin is matched to at least one female-line cousin. Some of the grandfathers experienced a single, acute episode of net malnutrition, inflicted on soldiers in an as good as random manner, because they were POWs. Conditions in Civil War POW camps deteriorated sharply when prisoner exchanges stopped, leading to starvation, disease, and death from the combined effects of insufficient food, disease and exposure to the elements. I follow the grandsons descended from children born *after* the war to white Union Army veterans who had *both* male-line and female-line grandsons to obtain information on height and weight from WWII draft registration records. I examine Body Mass Index (BMI), defined as weight in kilograms divided by height in meters squared. Grandsons of grandfathers who were non-POW veterans and for-

mer POWs imprisoned when camp conditions were better provide controls for grandsons of ex-POWs imprisoned when camp conditions were at their worst.

The cohort I examine was not overweight by present-day US standards. I observe their height and weight prior to the post-WWII changes in the US economy which increased caloric density and lowered physical activity.[1] Veterans' grandsons belonged to the cohorts where those of higher socioeconomic status were heavier (Costa, 2015). Although the socioeconomic-BMI gradient has reversed in the US, a positive association between socioeconomic status and BMI still prevails in developing countries (Strauss and Thomas, 2008; Corsi and Subramanian, 2019).

I find that among *male-line* grandsons age 18 to 59 those whose grandfathers experienced a harsh captivity during their late *growing years* faced a roughly 0.06 increase in the probability of being overweight (a 21% increase relative to mean overweight) and a 0.4 increase in BMI (a 2% increase relative to mean BMI) compared to grandsons of non-POWs. The increase was even larger when both the father and the grandson faced poor in-utero conditions, as proxied by season of birth. There was no association between a veteran grandfather's ex-POW status and *female-line* grandsons' overweight even though there was an association between a veteran grandfather's overweight and his grandsons' overweight, regardless of descent from sons or daughters. Male-line (but not female-line) grandsons descended from grandfathers who experienced a harsh captivity faced a 22-28% increased risk of death every year after age 45, with the increase in overweight accounting for 9-14% of this increase. My circumstantial evidence is consistent with an epigenetic explanation.

The echoes of ancestral malnutrition in descendants' overweight and longevity implies that the benefits of policies which reduce net nutritional deficiencies, whether from insuf-

[1]The 1942 birth cohort marks the inflection point for increases in BMI in the US (Rosenquist et al., 2015).

ficient food or disease, can compound across generations and reduce health inequalities across families, regions, and countries. Overweight is associated with coronary heart disease, stroke, type 2 diabetes, and some cancers, among other conditions.[2] The medical costs of obesity are high (Cawley and Chad, 2012) and a high BMI is associated with reduced labor force participation rates among older men (Gruber and Kubik, 1997; Costa, 1996).[3] The epidemic of coronary heart disease in today's developed countries which peaked in the US in the 1960s was experienced by cohorts whose ancestors faced a low and variable food supply. The findings have implications for countries with a history of famines and malnutrition (Luke et al., 2021). Although individuals in these countries are thin by US standards, overweight arising from ancestral malnutrition can be a harbinger of poor later health and thus of reduced work levels at older ages.

1 Transmission of Overweight to Descendants

Body Mass Index (BMI) commonly is regarded as a function of energy expenditures (N), energy intake or food (F), and genetics (G),

$$\text{BMI}_t = b(N_{t-1}, F_{t-1}, G).$$

Energy expenditures include energy spent to earn income to buy goods and energy spent in leisure activities. Parents will influence their children's BMI in at least four ways. First, they will provide children with the wealth and human capital which determines how energy intensive their jobs are and the income children have to buy different types of foods and to engage in different types of leisure activities. Second, they affect the

[2] See https://www.cdc.gov/healthyweight/effects/index.html.

[3] The inverse association between obesity and wages in developed countries largely arises from correlated but unmeasured labor market attributes (Behrman and Rosenzweig, 2001).

stock of children's past consumption, i.e. they will introduce their children to foods and leisure activities which are habit forming. Third, they will invest in children's cognitive and non-cognitive skills which will enable their adult children to be better producers of health, including BMI. Fourth, parents provide children with a genetic inheritance. This genetic inheritance encompasses not just a fixed set of genes but also epigenetics, that is an heritable modification of gene expression whereby some gene functions are switched on or off.

BMI thus can be thought of as

$$\begin{aligned} \text{BMI}_t &= b(N_{t-1}, F_{t-1}, P_t) \\ P_t &= g(G, I_A, I_{t-1}) \end{aligned}$$

where the epigenome P_t depends on genes (G), ancestral investments (I_A), and own investments (I_{t-1}), including those during the prenatal period. Biological signatures of epigenetic change are associated with obesity in humans and changes in diet and exercise affect these signatures (see the review by Ling and Rönn (2019)). Animal studies provide evidence of the reversability of epigenetic signatures with maternal nutritional supplementation (Dolinoy et al., 2007; Bernal et al., 2013) and exercise of mature males in the case of metabolic health (McPherson et al., 2017). Both ancestral and own investments may have a higher payoff during critical periods such as ancestral slow growth ages when epigenetic modification is more likely or early and late gestation when epigenetic erasure and then reprogramming occurs (Bygren, 2013; Baxter and Drake, 2019). Individuals need not know that they are investing in their epigenome; they may simply make investments in their own health. This dynamic epigenetic inheritance is passed down to children at conception.

I will estimate the treatment effect $E(\text{BMI}_{t,D=1} - \text{BMI}_{t,D=0})$, where BMI is grandsons' BMI and the treatment (D=1) is the grandfather's exposure to starvation during his grow-

ing years. I will examine whether grandpaternal treatment to affect grandsons' BMI is consistent with epigenetic, habit formation, and socioeconomic pathways of transmission. These pathways are not necessarily mutually exclusive.[4]

The **epigenetic hypothesis** predicts for a paternal health shock or treatment

$$E(\text{BMI}_{t,D=1} - \text{BMI}_{t,D=0}) > 0 \text{ for male-line but not female-line grandsons}$$

Unlike other biological mechanisms, epigenetic imprinting is sex-specific. Because the Y chromosome is transmitted only to men, transmission of an epigenetic effect along the Y chromosome, as hypothesized in the Överkalix studies (Bygren et al., 2001; Pembrey et al., 2014), occurs only for sons and male-line grandsons.

The **epigenetic hypothesis** further predicts that the treatment effect will be stronger if the treatment occurs developmental transition ages, including during the grandfather's slow growing years (Bygren, 2013), and if own and fathers' in-utero conditions are poor (Baxter and Drake, 2019). While a **cultural hypothesis** with extreme sex patterning could lead to POW trauma transmitted to sons alone and the transmitted trauma in turn could lead to overweight, it is hard to reconcile a cultural hypothesis with mediation by in-utero conditions.

The **habit formation hypothesis** presupposes that grandfathers respond to starvation by over-eating, adopting a high fat diet and/or engaging in less physical activity, both in jobs and in daily life, leading to

$$E(\text{BMI}_{t,D=1} - \text{BMI}_{t,D=0}) > 0 \text{ for grandfathers.}$$

[4]Even if I could observe markers of $E(P_{t,D=1} - P_{t,D=0})$, strictly speaking, I could not identify $E(P_{t,D=1} - P_{t,D=0})$ because while an exogenous ancestral health shock will be uncorrelated with investments in P_t prior to the shock the shock can affect later investments in P_t, making the treatment exogenous to investments before it occurs but not to investments after it occurs.

Grandfathers' increase in BMI could arise from **biological** changes which impede the rate of weight loss (e.g., changes in endocrine function, carbohydrate and fat utilization, neuroendocrine signaling, and hormones secreted from the gastrointestinal tract) and these changes may persist.[5] Such changes may be more likely to persist if they occur during the growing years.

Habit formation would instill the grandfathers' unhealthy behaviors in their children and their children's children, leading to

$$E(\text{BMI}_{t,D=1} - \text{BMI}_{t,D=0}) > 0 \text{ for both male-line and female-line grandsons}$$

and to correlation between veterans' and grandsons' BMI.

$$\rho(\text{BMI}_V, \text{BMI}_G) > 0 \text{ for both male-line and female-line grandsons,}$$

where BMI_V is the veteran's BMI and BMI_G is the grandson's BMI. Extreme sex patterning in habit formation seems unlikely. In modern-day populations, the correlations of BMI between fathers and sons and fathers and daughters are comparable in China, Indonesia, England, and the US (Dolton and Xiao, 2017).

Alternatively, grandfathers' overweight may trigger an epigenetic change in their children and grandchildren. Evidence on whether paternal obesity is associated with greater glucose impairment in female or male offspring is mixed (Kaspar et al., 2020; MacKay et al., 2022). Without sex-specific transmission, this hypothesis is indistinguishable from habit formation. With sex-specific transmission, $\rho(\text{BMI}_V, \text{BMI}_G) > 0$ for either male- or female-line grandsons but not for both.

The **socioeconomic hypothesis** predicts that in a time period when a higher BMI was

[5] Obese individuals who participated in the television weight loss contest, The Biggest Loser, had a lower metabolic rate years after the end of the competition compared to their baseline.

associated with a higher socioeconomic status (Costa, 2015) and when fathers' socioeconomic status was inherited by both sons and daughters (Costa et al., 2018; Costa, 2021),

$E(\text{BMI}_{t,D=1} - \text{BMI}_{t,D=0}) < 0$ for grandfathers and both male-line and female-line grandsons.

Because occupational adjustments to health shocks are harder at older ages, the socioeconomic hypothesis predicts that BMI differences should be greater among the descendants of grandfathers who were treated at older ages because they would be more likely to have lower wealth and to be in lower status occupations.

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). My outcomes are both BMI and overweight (a BMI $\geq$ 25), where O is equal to one if the grandson was overweight or obese. The advantage of examining overweight is that the healthy BMI range is broad. I estimate the treatment effects $E(\text{BMI}_{NE} - \text{BMI}_0)$, $E(\text{BMI}_E - \text{BMI}_0)$, and $E(\text{BMI}_{NE} - \text{BMI}_E)$ and $E(O_{NE} - O_0)$, $E(O_E - O_0)$, and $E(O_{NE} - O_E)$ where the subscripts NE, E, and 0 represent non-exchange ex-POW, exchange ex-POW, and a non-POW, respectively.

2 Methods

Identification of the relationship between grandfathers' trauma and their grandchildren's BMI depends on the comparison of descendants of non-POW veterans and ex-POWs captured during the prisoner exchange period (before July 1863 or after June 1864) and the non-exchange period (between July 1863 and July 1864). Most POWs were exchanged immediately until mid-1863 when prisoner exchanges stopped as the two sides argued

over the terms, particularly the treatment of black soldiers (who could be enslaved) and their white officers (who could be hanged as the leaders of a slave insurrection). Men captured after mid-1863 faced more time in captivity and ever worsening conditions as the crowds of prisoners increased. Death rates, officially attributed to scurvy, diarrhea, and dysentery, rose (Costa and Kahn, 2007). Crowding at Andersonville, the most notorious Confederate camp, began to improve in September with transfers to other prison camps and unofficial exchanges (Marvel, 1994). Official exchanges began again in December of 1864.

Union Army military records for individual soldiers support evidence from captivity narratives and sporadic information on numbers of prisoners, rations, and death rates that conditions deteriorated sharply when the exchange system stopped. Among survivors to 1900 from a random sample of Union Army infantry soldiers, 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).[6] Among ex-POWs who survived to 1900, average time in captivity was 16 days for men captured before July 1863, 231 days for non-exchange period ex-POWs, and 125 days for men captured after June 1864. Veterans who survived both to 1900 and who still were in their growing years were more likely to be stunted at older ages if they had been non-exchange ex-POWs.[7] Photos of the era show men reduced to living skeletons and captivity narratives recount soldiers weighing less than 100 pounds when they returned home (Costa and Kahn, 2008).

How valid is using non-POWs and exchange ex-POWs as control groups for non-exchange ex-POWs? Concerns that exchange POWs were partially "treated" suggests

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

[7] 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 exchange ex-POWs, and 0.21 inches for non-POWs.

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.[8] Both comparisons most likely underestimate the true mortality cost of descending from a grandfather who experienced extreme stress because of selective within camp survival of the hardiest non-exchange ex-POWs. In a sample of POWs, 4% of men captured before July 1863 died in captivity versus 27% captured July 1863 or later (Costa and Kahn, 2007; Costa, 2012).

Recall that only the epigenetic hypothesis predicts transmission of the grandfather's ex-POW status to his male-line but not his female-line grandsons. I therefore test for BMI differences both by the grandfather's ex-POW status and by whether the son was descended from sons or daughters. I examine how BMI differences change as controls are added for the grandfather's overweight and his post-war socioeconomic characteristics and for the socioeconomic characteristics of the grandson and of his parents. I pool male-line and female-line grandsons into one sample. I account for unobservable veteran or veteran family characteristics by including a random effect. I estimate for grandson i in veteran family V, the linear regression and probit models

$$\begin{aligned} BMI_i &= \beta_0 + \beta_1 M_i + \beta_2 (M_i \times P_{E,iV}) + \beta_3 (M_i \times P_{N,iV}) + \beta_4 C_{iV} + \beta_5 C_i + \\ & \quad u_{iV} + \epsilon_i \end{aligned} \tag{1}$$

$$\begin{aligned} \Pr(O_i = 1|X) &= \Phi(\beta_0 + \beta_1 M_i + \beta_2 (M_i \times P_{E,iV}) + \beta_3 (M_i \times P_{N,iV}) + \beta_4 C_{iV} + \beta_5 C_i + \\ & \quad \beta_5 C_i + u_{iV} + \epsilon_i) \end{aligned} \tag{2}$$

[8] I have not uncovered anything in the historical record which implies that men who surrendered in different time periods were different 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.

where O_i is a dummy variable equal to one if the grandson was overweight, M is a dummy variable equal to one if the grandson was a male-line grandson, $P_{E,iV}$ and $P_{N,iV}$ indicate that the grandfather was an exchange or non-exchange ex-POW (non-POW is omitted), C_{iV} is a vector of controls specific to the veteran and C_i is vector of controls specific to the grandson, u_{iV} is the error term common to all grandsons of a given veteran, and ϵ_i is the error term specific to a grandson. I cluster the standard errors on the veteran.

My basic controls are the grandson's age group when BMI was reported, his quarter and region of birth, and the enlistment characteristics of his grandfather. I then examine whether the results persist when I control for the grandfather's overweight circa 1900 and for the grandfather's post enlistment occupational class, the fathers' socioeconomic characteristics, the geographic proximity of the grandfather to the grandchild, the parents' years of education, and the grandson's years of education and occupation in 1940.

I estimate the impact of grandfather's ex-POW status within and across male and female lines. I first difference and estimate $(\hat{\beta}_{M=1,POW=N} - \hat{\beta}_{M=1,POW=0})$, $(\hat{\beta}_{M=0,POW=N} - \hat{\beta}_{M=0,POW=0})$, $(\hat{\beta}_{M=1,POW=E} - \hat{\beta}_{M=1,POW=0})$, $(\hat{\beta}_{M=0,POW=E} - \hat{\beta}_{M=0,POW=0})$, $(\hat{\beta}_{M=1,POW=N} - \hat{\beta}_{M=1,POW=E})$, and $(\hat{\beta}_{M=0,POW=N} - \hat{\beta}_{M=0,POW=E})$, where $\hat{\beta}$ is either the OLS coefficient or the marginal, $M = 1$ indicates male-line, $M = 0$ indicates female-line, and grandfather's ex-POW status is $POW = N$ (non-exchange), $POW = E$ (exchange), or and $POW = 0$ (non-POW). I then double-difference to obtain

$$
\begin{aligned}
DD_{N0} &= (\hat{\beta}_{M=1,POW=N} - \hat{\beta}_{M=1,POW=0}) - (\hat{\beta}_{M=0,POW=N} - \hat{\beta}_{M=0,POW=0}), \\
DD_{E0} &= (\hat{\beta}_{M=1,POW=E} - \hat{\beta}_{M=1,POW=0}) - (\hat{\beta}_{M=0,POW=E} - \hat{\beta}_{M=0,POW=0}), \\
DD_{NE} &= (\hat{\beta}_{M=1,POW=N} - \hat{\beta}_{M=1,POW=E}) - (\hat{\beta}_{M=0,POW=N} - \hat{\beta}_{M=0,POW=E}).
\end{aligned}
$$

I investigate how the grandson's and son's season of birth mediates the effect of grandfather's ex-POW status among male-line grandsons, the only line for which I find an as-

sociation between grandfather's ex-POW status and grandson BMI. I interact the grandfather's ex-POW status with the male-line grandson's and son's season of birth, which for these cohorts proxies for late gestational maternal nutrition (Doblhammer and Vaupel, 2001), to estimate

$$BMI_i = \beta_0 + \beta_1(W_i \times W_{Fi} \times P_{N,iV}) + \beta_2(W_i \times W_{Fi} \times P_{E,iV}) + \beta_3 C_{iV} + \beta_3 C_{iV} + \epsilon_i, \quad (3)$$

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 omit grandsons in-utero or born during WWI or the Influenza Pandemic to avoid confounding season of birth with wartime fertility selection or Pandemic effects.

I investigate whether transmission of overweight differs between the male and female lines by establishing the correlation between a veteran's overweight and his grandsons' overweight. I run regressions for male-line and female-line grandsons separately of the form

$$BMI_i = \beta_0 + \beta_1 P_{E,iV} + \beta_2 \times P_{N,iV} + \beta_3 C_i + \beta_4 O_{Vi} + \epsilon_i. \quad (4)$$

where O_{Vi} is a dummy equal to one if the veteran grandfather was overweight.

I examine the implications of overweight for grandsons' longevity by running Cox proportional hazard models for both male-line and female-line grandsons. My sample consists of all matched cousins where both survived to age 45 conditional on both having

BMI observed prior to age 45.[9] 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

$$\beta_0 + \beta_1 P_{E,Vi} + \beta_2 P_{N,Vi} + \beta_4 C_{Vi} + \beta_5 C_i \text{ or} \tag{5}$$

$$\beta_0 + \beta_1 P_{E,Vi} + \beta_2 P_{N,Vi} + \beta_3 O_i + \beta_4 C_{Vi} + \beta_5 C_i \tag{6}$$

where O_i is a dummy indicator equal to one if the grandson was overweight. I cluster on the grandfather and stratify on birth cohort. As explained in the Appendix, I also conduct a formal mediation analysis to determine whether a male-line grandson's BMI mediates the effect of grandfather's ex-POW status on male-line grandsons' mortality (see Appendix Equations A.8 and A.9).

3 Data

My analytical sample consists of 3,048 male-line grandsons and their 3,177 female-line grandson cousins, descended from grandfathers who were age 17-24 during the non-exchange period. Union Army soldiers were growing rapidly until age 21 and then more slowly until age 25 (Wilson and Pope, 2003). All grandsons have self-reported information on height and weight from draft cards. BMI was calculated from height and weight and I trimmed the top and bottom 0.5% of the BMI distribution to avoid outliers potentially

[9] A grandfather's ex-POW status was not associated with male-line grandsons' mortality prior to age 45 but was with mortality after age 45 (Costa, 2021). Examining mortality after age 45 would introduce selection in survival.

driven by incorrect information. I also have information on grandsons who were cousins and whose grandfathers were age 25 or older during the non-exchange period, yielding an additional 1,069 white-male grandsons and the same number of female-line grandson cousins.

All grandsons descended from children born after the war to white Union Army veterans who survived to 1900. I constructed this transgenerational database by building on databases of Union Army veterans and their children, over-sampling ex-POWs. Veterans and their children and grandchildren were traced through birth, death, and census records. The databases have been used and described in detail in Costa et al. (2018) and Costa (2021). Life expectancies are similar to those obtained from genealogies of the northern-born. Because linkage was carried out using multiple sources and focused on entire families, linkage rates are extremely high relative to what is typical using historical data. For example, 96% of veterans were linked to the 1880 census and 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 97% of grandsons and 96% of granddaughters were linked to the 1940 census (Costa, 2021).

Men born between 1877 and 1929 (inclusive) registered for the draft under several selective service acts which ended in 1947. Men born between 1877-1897 were part of the "Old Man's Draft" implemented to inventory manpower. Conditional on being alive in 1940, 99% of grandsons are linked to their draft cards. 98% of grandchildren have usable BMI information, including after the tails are trimmed (see Appendix Table A.1). Linkage rates were high regardless of descent from sons or daughters or grandfathers' ex-POW status. Grandsons' BMI by age group was similar that observed among examined military service registrants whose height and weight were measured (Karpinos, 1958) and, as expected, grandsons' BMI increases with age (see Appendix Table A.2).

The sample of ex-POW descendants is biased towards healthy survivors. Veterans had

to survive POW camps and live to 1900. They were healthy enough to marry and have children after the war. Their children had to survive to have children. Grandsons who survived to draft age were more likely to be healthy. There is no evidence of selection on socioeconomic status or of marriage selection after the war (see the Appendix, section A.1).

My dependent variables are BMI and the fraction overweight, defined as a BMI of 25 or more. Only small fractions of the analytical sample were underweight (BMI < 18) or obese (BMI ≥ 30). Average age when height and weight were reported was 33 (see Appendix Table A.3).

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 the veteran's overweight and for grandfathers, fathers, and grandsons, occupational class, property ownership, educational characteristics, and geographic and demographic controls. Details and variable means are in the Appendix, section A.2.

4 Veterans' Overweight

Ex-POWs in their late 40s and early 50s were more likely to be overweight compared to non-POWs. Figure 1 shows that among veterans who survived to 1900 and who had children surviving to age 45 (and thus eligible to be in the sample), the distribution of BMI measured circa 1900 is shifted to right when comparing non-exchange ex-POWs with non-POWs and with exchange ex-POWs. Controlling for veterans' pre-enlistment and post-war characteristics, a non-exchange ex-POW was 1.8 times more likely to be overweight and had a BMI that was greater by 0.7 than that of a non-POW. Compared to an exchange ex-POW, a non-exchange ex-POW ex-POW was 1.4 times more likely to be

overweight and his BMI was greater by 0.7 (see the Appendix, section A.3).

5 Grandsons' Overweight

The BMI of male-line grandsons of non-exchange ex-POWs increased after a BMI of 25 compared to the BMI of grandsons descended from non-POWs (see Figure 2, which plots BMI densities by grandfather's ex-POW status for both male-line and female-line grandsons), The BMI of male-line grandsons of exchange ex-POWs relative to non-POWs also increased after a BMI of 25 but the increase was less than that observed for grandsons of non-exchange ex-POWs. In contrast, among female-line grandsons, the BMI of grandsons descended from non-exchange ex-POWs rarely exceeds of non-POWs and exchange ex-POW descendants. The greater BMI of male-line grandsons comes from their higher weight. They were not taller than female-line grandsons (see Appendix Figure A.1).

Table 1 compares male-line and female-line grandsons descended from grandfathers at risk of captivity at ages 17-24 to show that both BMI and the probability of overweight increased among male-line grandsons descended from non-exchange ex-POWs relative to non-POWs but the same was not true for female-line grandsons. The increase in BMI and in the probability of overweight was roughly 0.4 and 0.06, respectively, for male-line grandsons descended from non-exchange ex-POWs compared to non-POWs whereas for female-line grandsons, the increases were either small or negative. The double-difference estimates yield increases of 0.4 in BMI and 0.06 in the probability of overweight. Male-line grandsons descended from exchange ex-POWs did not have a statistically significantly different BMI compared to male-line grandsons descended from non-POWs. In comparing male-line grandsons descended from non-exchange ex-POWs to those descended from exchange ex-POWs, the increase in BMI was 0.3 and the increase in overweight was 0.08. The double-difference estimates imply an increase of 0.4 in BMI and of 0.08 in over-

weight.

The results in Table 1 are similar when I include controls for the veteran's post-war socioeconomic status and his overweight circa 1900, the father's socioeconomic status, parents' education, and own socioeconomic status and education. The double-difference estimates for grandfather's non-exchange ex-POW status relative to non-POW status yield increases of 0.5 in BMI and 0.07 in the probability of overweight. Results are marginally stronger when I redefine the sample to include only cousins whose ages when BMI was observed did not differ by more than five years (N=2,384). A male-line grandson descended from a non-exchange ex-POW rather than a non-POW had a BMI which was greater by 0.634 (σ =0.253,p-value=0.011) whereas a female-line grandson had a BMI which was lower by 0.185 (σ =0.247, p-value=0.456).

Quantile regressions demonstrate that the biggest increases in BMI for male-line grandsons descended non-exchange ex-POWs relative to non-POWs are at the 75th rather than the 50th or 25th quantile. Nonetheless, there are increases at all quantiles (see Appendix Table A.6).

Veterans' overweight is associated with higher BMI among both male-line and female-line grandsons. Among female-line grandsons, grandfathers' overweight increased BMI by 0.7. Among male-line grandsons, grandfathers' overweight increased BMI by 0.6 to 0.5, with the association falling as additional controls, including the grandfather's ex-POW status, were added (see Appendix Table A.7).

Season of birth mediates the relationship between grandfathers' ex-POW status and their male-line grandsons' BMI. Table 2 shows that the relationship is strongest when both fathers and grandsons were born in the first half of the year, with BMI increasing by 1.1 for grandsons descended from non-exchange ex-POWs relative to non-POWs. In contrast, when both fathers and sons were born in the second half of the year, BMI increased by only 0.3. The difference of 0.8 is statistically significant at the 5% level. The father's

season of birth was a stronger mediator of the relationship between the grandfather's ex-POW status and his male-line grandsons' BMI than grandsons' season of birth. Season of birth was a weaker mediator for the BMI of grandsons descended from non-exchange relative to exchange ex-POWs.

The relationship between grandsons' BMI and grandfathers' ex-POW status is seen among male-line grandsons whose grandfathers were at risk of captivity during but not after their growing years (see Appendix Figure A.2). In contrast, among veteran grandfathers the increase in BMI between non-exchange ex-POWs and non-POWs, while greatest among veterans captive during their growing years, was not statistically significantly different from that observed among veterans held captive at older ages (see Appendix Figure A.3).

5.1 Magnitudes

The increase of 0.06 in the fraction overweight among male-line grandsons descended from non-exchange ex-POWs during their growing years compared to male-line grandsons descended from non-POWs represents a 21% increase relative to mean overweight of 0.29 among all grandsons. The increase in BMI relative to the mean is more modest: a 0.4 increase in BMI represents a 2% increase relative to mean BMI of 23.67. A 1.1 increase in BMI for a male-line grandson who was born in the first half of the year to a father also born in the first half of the year and descended from a non-exchange ex-POW relative to a non-POW is a 5% increase relative to mean BMI.

The increase in BMI among male-line grandsons by the grandfather's ex-POW status was smaller than that observed among veterans by their own ex-POW status, as expected from mediation by season of birth. While the increase in BMI of 0.4 was statistically distinguishable from an increase of 0.7 (as observed among veterans), the percentage increase

relative to BMI was more modest: the increase in BMI among veterans was 3% relative to mean BMI whereas for male-line grandsons the increase was 2%.

The magnitude of the relationship between male-line grandchildren's overweight and their grandfathers' non-exchange ex-POW status is on par with estimates of overweight after exposure to the Dutch Hunger Winter. The odds of overweight were 1.6 (albeit statistically insignificant) for women exposed at age 18 and higher to the Dutch Hunger Winter compared to women with no exposure (Abeelen et al., 2012) and the odds of overweight at age 18 were 1.3 for men exposed in utero to the Dutch Hunger Winter compared to their unexposed peers (Lumey et al., 2021). Estimating the relationship between male-line grandsons' overweight and their grandfathers' non-exchange ex-POW status using a logit model for comparability leads to an odds of overweight of 1.4 for grandsons descended from non-exchange ex-POW veterans relative to non-POWs (see Appendix Table A.8). These magnitudes are greater than the 1.1 increase in overweight among women exposed to the Chinese famine in utero (Zhou et al., 2018).

My estimates of increases in BMI are lower than those observed in studies of the Dutch Hunger Winter but similar to those seen in other studies. Among the children of women exposed in-utero to the Influenza Pandemic, BMI was 0.4 or 2% higher compared to non-exposed controls (Cook et al., 2019). Among elderly Holocaust survivors BMI was 0.8 higher compared to non-exposed controls (Fund et al., 2019), or 3% higher relative to the mean. In contrast, the increase in the BMI of children of men in utero during the Dutch Hunger Winter was 1.4 higher, an increase of 6% relative to the mean (Veenendaal et al., 2013).

6 Grandsons' Overweight and Their Mortality

Overweight grandsons were more likely to die at any age after age 45 than non-overweight grandsons (see Figure 3). The differences were particularly large among male-line grandsons. Among male-line grandsons, the overweight lived on average 26.5 years after age 45 compared to 29.4 years for the non-overweight, a difference of 2.9 years. Among female-line grandsons, mean years lived after age 45 for the overweight was 27.0 years compared to 29.3 years for the non-overweight, a difference of 1.7 years. Some of this difference in overweight and longevity between male-line and female-line grandsons is because grandfathers' ex-POW status was associated with the longevity of male-line grandsons only (see Figure 4 and Costa (2021)). Among male-line grandsons surviving to age 45, those descended from a non-exchange ex-POW lived an additional 27.5 years whereas those descended from a non-POW lived an additional 29.3 years or 1.8 more years. In contrast, female-line grandsons were longer-lived if descended from non-exchange ex-POWs (29.3 years) rather than non-POWs (28.5 years).

Grandfather's ex-POW status during their growing years predicted male-line grandsons mortality independent of grandsons' overweight and grandsons' overweight predicted mortality of all grandsons independent of grandfather's ex-POW status. The association between a grandfather's ex-POW status and his male-line grandsons' mortality could be explained in part by grandsons' overweight (see Table 3). Male-line grandsons whose paternal grandfathers were non-exchange ex-POWs during their growing years were 1.28 times more likely to die at any age after age 45 compared to grandsons whose paternal grandfathers were non-POWs, controlling only for the veteran grandfathers' enlistment characteristics and for the grandsons' birth year, quarter and region of birth, and age when BMI was reported. The hazard ratio fell to 1.25 controlling for the grandsons' overweight and to 1.23 controlling for grandpaternal, paternal, and own socioeconomic characteris-

tics. Male-line grandsons descended from exchange ex-POWs were 1.17 to 1.18 times more likely to die compared to those descended from non-POWs. Controls for overweight lead to respective 9 and 5% decline in the association between non-exchange and exchange ex-POW relative to non-POW descent and the odds of dying at any age after age 45. Additional controls for post-war and contemporary socioeconomic status lead to an additional 6 and 1% decline in the association.

Grandfathers' ex-POW status was not associated with the mortality of female-line grandsons but their own overweight was, increasing the likelihood of dying by 1.18. Among grandsons descended from veterans who were at risk of being non-exchange ex-POWs at age 25 or higher, grandsons descended from non-exchange ex-POWs were as likely to die as grandsons descended from non-POWs (see Appendix Table A.9).

A formal mediation analysis reveals that grandsons' BMI accounts for roughly 14% of the total effect of non-exchange ex-POW status on male-line grandsons' mortality (see Appendix Table A.10), Grandfather's non-exchange ex-POW relative to non-POW status increased mortality risk every year after age 45 by 21.9%. The direct effect was 18.9%. The indirect effect of overweight was 3.0% or 14% of the total effect. The total effect of being an exchange ex-POW relative to a non-POW was a 26.9% increase in mortality risk every year after age 45 but the effect was not mediated by BMI.[10]. There was no statistically significant effect of having a grandfather who was a non-exchange relative to an exchange ex-POW and overweight did not intermediate this effect.

[10] A greater magnitude for the association between exchange ex-POW relative to non-POW descent compared to the association non-exchange ex-POW relative to non-POW descent also is seen when I run separate regressions with only two ex-POW categories.

7 Conclusion

The transmission of overweight to grandsons descended from ex-POWs malnourished during their late growing years has implications for populations today. Transgenerational inheritance which manifests in overweight suggests that ancestral factors during growing years may play a role in establishing metabolic capacity. Because grandsons' overweight explained at most 14% of the association between grandfathers' ex-POW status and grandsons' longevity, the findings suggest that past famine exposures are likely to manifest themselves in more ways than in overweight and are consistent with the argument in Luke et al. (2021) that metabolic disease in India is not driven by obesity. Although my evidence on the mechanisms driving the association between grandfathers' ex-POW status and grandsons' longevity was circumstantial, my findings of sex-specific transmission, transmission during the grandfather's growing years, and mediation by in-utero conditions are consistent with an epigenetic mechanism and thus with studies demonstrating transgenerational transmission of paternal harvest shocks and famine during the slow growing years in humans to affect their health and longevity (Kaati et al., 2007; Bygren et al., 2001; Bygren, 2013; Vågerö et al., 2018; van den Berg and Pinger, 2016; Costa, 2021). While policy makers cannot undo past famines, the mediation of grandfathers' ex-POW exposure by fathers' and own season of birth suggests that the benefits of adequate maternal nutrition could compound across generations by mitigating and even reversing the generational reach of ancestral exposures.

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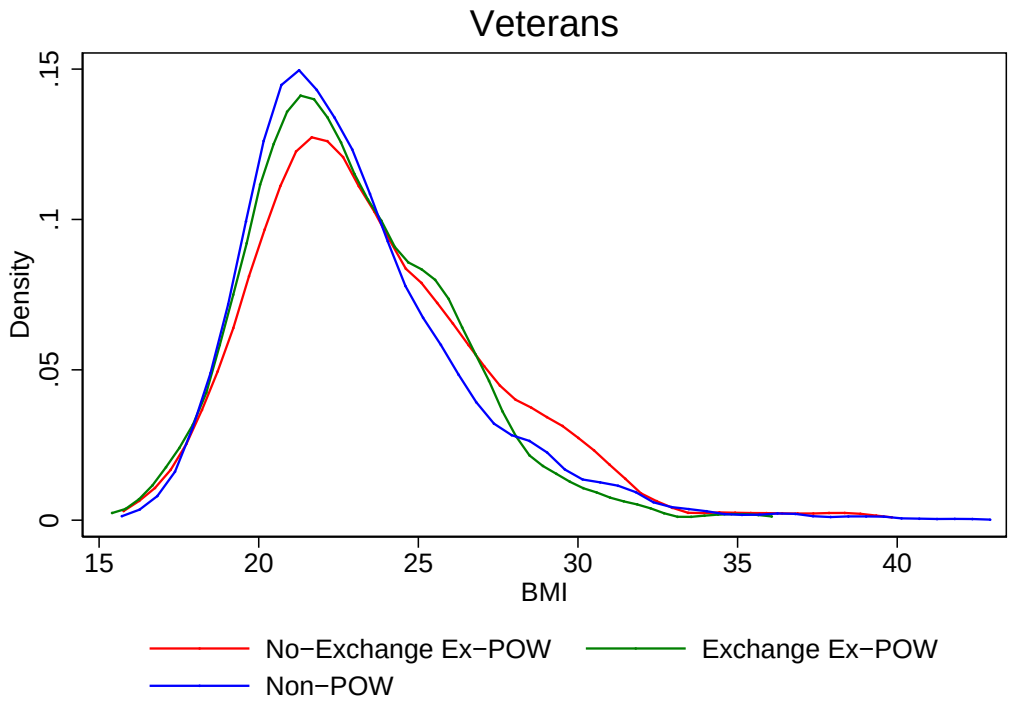
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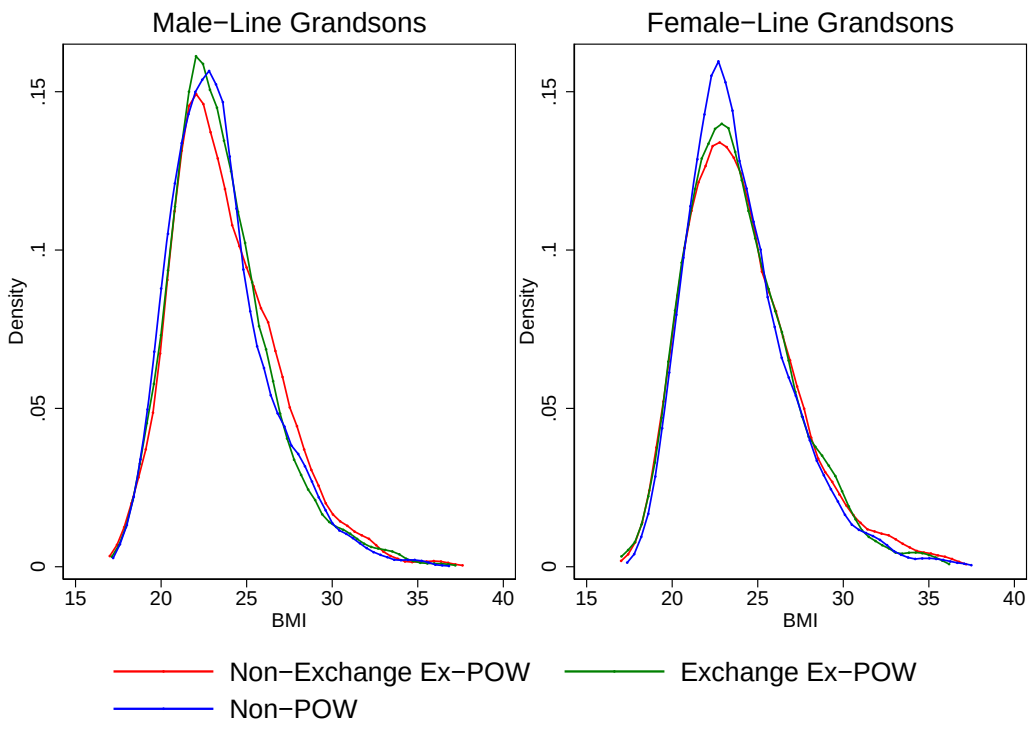
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Figure 1: Density of Veterans' BMI by their Ex-POW Status



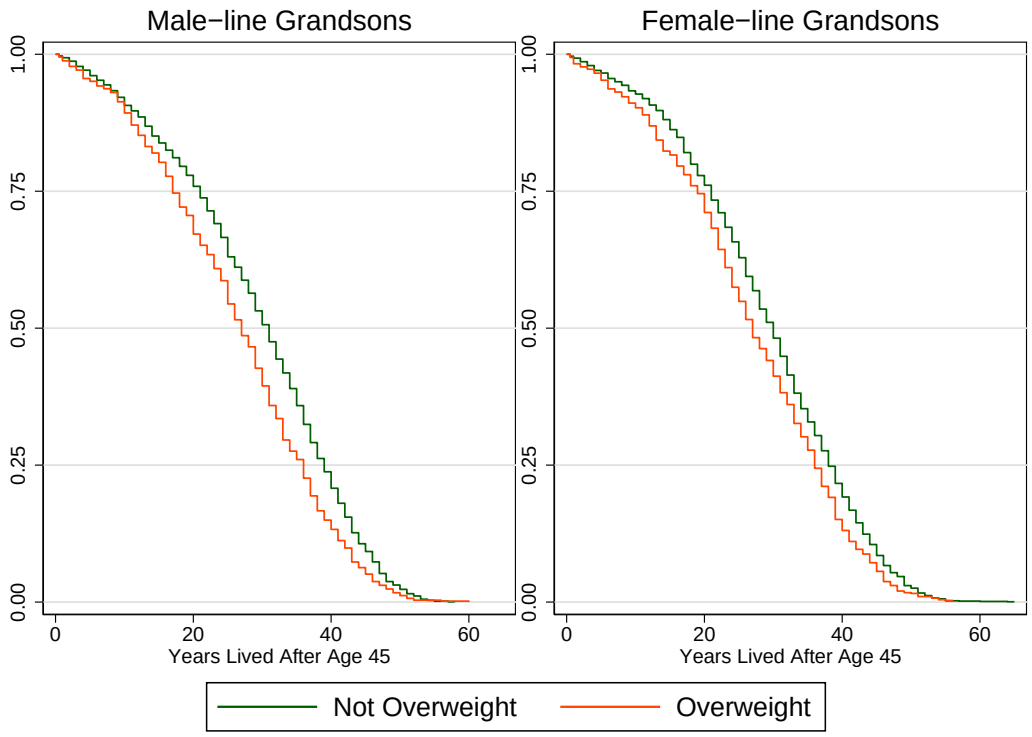
The density is estimated using an Epanechnikov kernel.

Figure 2: Density of Male-Line Grandsons BMI by Grandfather's Ex-POW Status



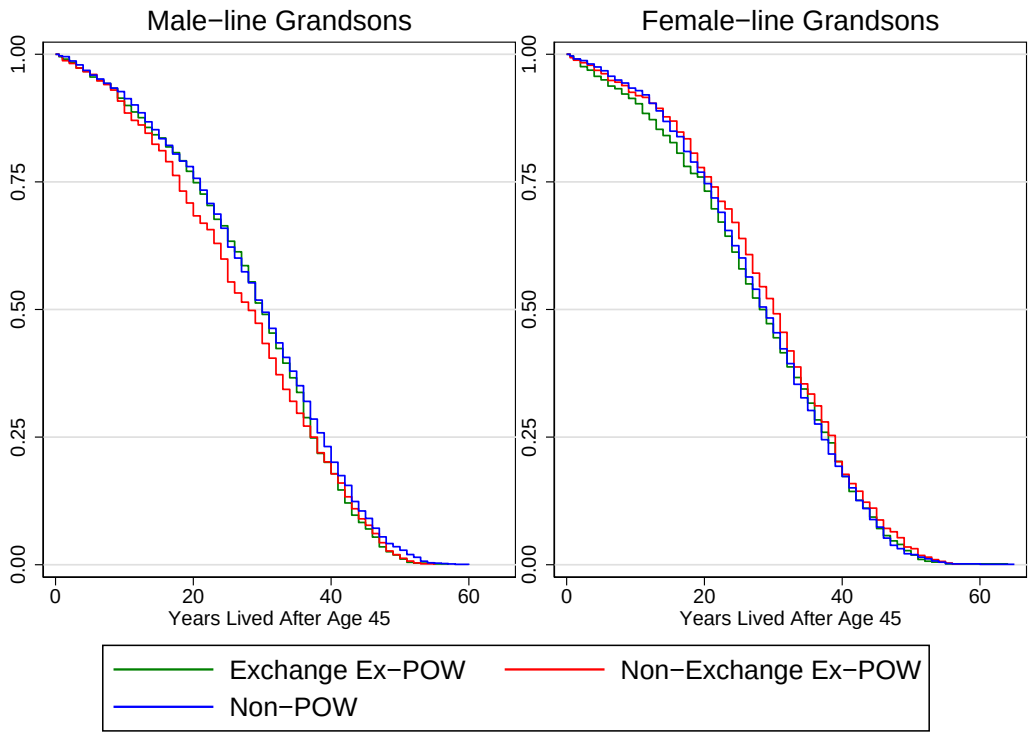
The density is estimated using an Epanechnikov kernel.

Figure 3: Kaplan-Meier Survival Curves, Survival and Overweight for Male-Line and Female-Line Grandsons



2,484 male-line grandsons and 2,390 female-line grandsons. All grandsons survived to age 45, reported height and weight prior to age 45 and have a cousin from an opposite sex line. Survival is measured in years lived after age 45.

Figure 4: Kaplan-Meier Survival Curves, Survival and Grandfather's Ex-POW Status for Male-Line and Female-Line Grandsons



2,484 male-line grandsons and 2,390 female-line grandsons. All grandsons survived to age 45, reported height and weight prior to age 45 and have a cousin from an opposite sex line. Survival is measured in years lived after age 45.

Table 1: Grandsons' BMI and Overweight and Grandfathers' Ex-POW Status

	Male-line				Female-line			
	BMI	Over-weight	BMI	Over-weight	BMI	Over-weight	BMI	Over-weight
Grandfather was								
Exchange Ex-POW	0.115	0.009	0.123	0.012	0.114	0.028	0.077	0.022
Relative to Non-POW	(0.172)	(0.042)	(0.165)	(0.040)	(0.179)	(0.044)	(0.178)	(0.043)
	[0.504]	[0.829]	[0.458]	[0.770]	[0.526]	[0.525]	[0.668]	[0.614]
Non-exchange Ex-POW	0.433**	0.090**	0.431**	0.083*	-0.007	0.028	-0.055	0.014
Relative to Non-POW	(0.182)	(0.044)	(0.179)	(0.043)	(0.179)	(0.042)	(0.177)	(0.041)
	[0.017]	[0.042]	[0.016]	[0.052]	[0.969]	[0.503]	[0.756]	[0.739]
Non-exchange Relative to	0.318*	0.081*	0.308*	0.071	-0.121	0.000	-0.132	-0.008
Exchange Ex-POW	(0.188)	(0.045)	(0.186)	(0.044)	(0.191)	(0.044)	(0.189)	(0.043)
	[0.091]	[0.074]	[0.098]	[0.103]	[0.528]	[1.000]	[0.485]	[0.852]
DD Exchange Ex-POW	0.001	0.019	0.046	0.026				
Relative to Non-POW	(0.215)	(0.038)	(0.216)	(0.037)				
	[0.996]	[0.625]	[0.830]	[0.479]				
DD Non-exchange Ex-POW	0.440**	0.062**	0.486**	0.069**				
Relative to Non-POW	(0.207)	(0.030)	(0.206)	(0.030)				
	[0.033]	[0.042]	[0.018]	[0.021]				
DD Non-exchange Relative	0.439*	0.081**	0.440*	0.079**				
to Exchange Ex-POW	(0.250)	(0.035)	(0.247)	(0.034)				
	[0.079]	[0.020]	[0.075]	[0.020]				
R^2								
Within	0.076		0.081					
Between	0.157		0.190					
Overall	0.099		0.114					
Test $var(u) = 0$, $\bar{\chi}^2(1)$	181.55		123.18					
	[0.000]		[0.000]					
Post-war controls	N	N	Y	Y	N	N	Y	Y

Estimated using the random effects specifications in Equations 1 and 2. DD=double difference. 6,225 observations. 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, respectively. Controls include the age group when height and weight were reported, quarter of birth, region of birth, and the veteran's occupational class at enlistment, year of enlistment, whether he was wounded in the war, 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. Post-war controls are a dummy variable indicating if the veteran was overweight circa 1900, the veteran's occupation in 1880, the number of siblings in the grandson's household, whether the veteran was living in the same county as the grandson, whether the veteran was in the same household as the grandson, whether the grandson's father was ever a farmer, a laborer, or a property owner, parents' and own years of education, and occupational class in 1940. The Breusch and Pagan Lagrangian multiplier test was used for random effects ($var(u) = 0$).

Table 2: Male-line Grandsons' BMI, Own and Fathers' Season of Birth and Grandfathers' Ex-POW Status

Row		Born in Winter? Grandson	Father	Coef-ficient	Std Err	P-Value
	Grandfather was					
1	Non-exchange ex-POW relative to non-POW	Y	Y	1.121***	0.291	0.000
2		Y	N	0.252	0.379	0.506
3		N	Y	0.608*	0.311	0.051
4		N	N	0.311	0.341	0.361
5	Exchange ex-POW relative to non-POW	Y	Y	0.477	0.305	0.118
6		Y	N	-0.253	0.321	0.430
7		N	Y	0.643**	0.312	0.039
8		N	N	0.049	0.337	0.884
9	Non-exchange relative to exchange ex-POW	Y	Y	0.644**	0.324	0.047
10		Y	N	0.506	0.403	0.210
11		N	Y	-0.035	0.370	0.925
12		N	N	0.262	0.363	0.471
13	Row 1 - Row 4			0.810**	0.409	0.048
14	Row 1 - Row 2			0.869*	0.464	0.061
15	Row 1 - Row 3			0.513	0.367	0.163

Estimated using Equation 3. 2,660 observations. Male-line grandsons born during WWI or the Influenza Pandemic are excluded. Standard errors are clustered on the veteran. The symbols *, **, and *** indicate significance at the 10, 5, and 1 percent level, respectively. Controls include the age group when height and weight were reported, quarter of birth, region of birth, and the veteran's occupational class at enlistment, year of enlistment, whether he was wounded in the war, 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. Post-war controls are a dummy variable indicating if the veteran was overweight circa 1900, the veteran's occupation in 1880, the number of siblings in the grandson's household, whether the veteran was living in the same county as the grandson, whether the veteran was in the same household as the grandson, whether the grandson's father was ever a farmer, a laborer, or a property owner, parents' and own years of education, and occupational class in 1940.

Table 3: Grandsons' Mortality After Age 45 (Hazard Ratios) and Their Overweight and Grandfathers' Ex-POW Status

		Male-line Grandsons				Female-line Grandsons		
Grandfather was								
Non-POW		1.000	1.000	1.000		1.000	1.000	1.000
Exchange Ex-POW		1.182***	1.173***	1.171***		1.037	1.039	1.041
		(0.071)	(0.071)	(0.069)		(0.069)	(0.069)	(0.069)
		[0.006]	[0.008]	[0.007]		[0.580]	[0.563]	[0.543]
Non-exchange Ex-POW		1.275***	1.251***	1.234***		0.953	0.959	0.969
		(0.083)	(0.082)	(0.079)		(0.060)	(0.061)	(0.063)
		[0.000]	[0.001]	[0.001]		[0.443]	[0.508]	[0.628]
Non-exchange Ex-POW		1.079	1.067	1.054		0.919	0.923	0.931
relative to Exchange Ex-POW		(0.064)	(0.063)	(0.060)		(0.061)	(0.062)	(0.063)
		[0.201]	[0.275]	[0.359]		[0.202]	[0.234]	[0.287]
Grandson was overweight	1.225***		1.208***	1.205***	1.184***		1.183***	1.183***
	(0.061)		(0.060)	(0.059)	(0.055)		(0.055)	(0.055)
	[0.000]		[0.000]	[0.000]	[0.000]		[0.000]	[0.000]
Test of proportional hazards	37.94	35.96	37.76	64.01	58.31	59.36	59.22	71.63
assumption, df=	30	31	32	60	30	31	32	60
	[0.151]	[0.2474]	[0.223]	[0.338]	[0.002]	[0.002]	[0.002]	[0.145]
Post-war controls	N	N	N	Y	N	N	N	Y

2,484 male-line grandsons and 2,390 female-line grandsons. 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, respectively. Controls include the age group when height and weight were reported, quarter of birth, region of birth, and the veteran's occupational class at enlistment, year of enlistment, whether he was wounded in the war, 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. Post-war controls are a dummy variable indicating if the veteran was overweight circa 1900, the veteran's occupation in 1880, the number of siblings in the grandson's household, whether the veteran was living in the same county as the grandson, whether the veteran was in the same household as the grandson, whether the grandson's father was ever a farmer, a laborer, or a property owner, parents' and own years of education, and occupational class in 1940.

ON-LINE APPENDIX

Appendix

A.1 Sample Representativeness

Table A.1 demonstrates that linkage rates were comparable by descent from sons or daughters and by the grandfather's ex-POW status.

Table A.2 shows that mean BMI of grandsons, estimated from self-reported height and weight, was similar to BMI estimated from mean measured height and weight of selective service registrants examined for military service. As expected, mean BMI increases with age.

The sample of ex-POWs is biased towards healthy survivors. Men had to survive POW camps. Crowding was the most important determinant of camp survivorship (Costa and Kahn, 2007). More men meant fewer rations per person (and by June 1864 corn bread and cornmeal were the principal staples at Andersonville), more contamination from human excrement and other filth, and more competition for shelter, blankets, and clothing. Although there was trade with the outside world, men who had been prisoners for long had nothing left to trade.

Individual determinants of camp survivorship included age (extreme deprivation was cruel to those above age 30 and the very young), height (the tall needed but did not receive bigger rations), occupation (farmers fared poorly probably because they had few skills within the camp), and rank (commissioned officers received better treatment and sergeants controlled food distribution). Men imprisoned with more comrades were more likely to survive (Costa and Kahn, 2007).

After leaving the camps, men are lost to follow-up until the pension program becomes close to a universal system with the passage of the law of 1890. However, the very ill (disproportionately ex-POWs) were eligible for pensions and they also died prior to 1900.

The veterans who had been ex-POWs and who survived to 1900 did not suffer disproportionately from mental health problems (Costa, 2021), perhaps because they found some meaning in their suffering as saviors of the Union who had wiped the sin of slavery from the land, a narrative reinforced by veterans' organizations, former prisoner associations, reunions, and prison memoirs (Gardner, 1998).

Veterans who had children after the war, and thus whose grandsons are in the sample, were more likely to be healthy. Non-exchange ex-POWs were less likely to marry than non-POWs (and thus to be in the sample) but conditional on marriage, they had the same number of children and grandchildren (Costa et al., 2018; Costa, 2021). Veterans' children in turn were more likely to be healthy if they survived to have children.

Grandsons who survived to draft age were more likely to be healthy. There is evidence of excess early childhood mortality among male-line grandsons descended from non-exchange ex-POWs (Costa, 2021).

There is no evidence of selection on socioeconomic status. Neither veterans' socioeconomic status nor veterans' children socioeconomic status was correlated with veterans' ex-POW status, perhaps because socioeconomic status was established prior to health declines (Costa et al., 2018; Costa, 2021). There is evidence of occupational change away from farming but it was not accompanied by declines in socioeconomic status. After the war non-exchange ex-POWs were more likely to be artisans and less likely to be farmers than their non-POW counterparts. Their sons and sons-in-law in turn were more likely to be artisans and less likely to be farmers but the association was much diminished. There is no evidence indicating that a veteran's ex-POW status increased his or his sons or sons-in-laws' probability of being a laborer or of not owning a home (Costa, 2021).

There is no evidence of marriage selection among veterans by ex-POW status. Non-exchange ex-POWs who married after the war did not marry "down" relative to non-POWs: their fathers-in-law had the same wealth in 1860. Their wives also had the same

mortality experience. The children of non-exchange ex-POWs did not marry sicker spouses than the children of non-POWs. The mortality experience of children's spouses was the same (Costa, 2021).

Higher mortality after age 45 among male-line but not female-line grandsons descended from non-exchange ex-POWs relative to non-POWs (Costa, 2021) implies that, if BMI is a harbinger of premature mortality, I will underestimate the effect of the veteran's non-POW status on male-line grandsons' overweight among those older than age 45.

A.2 Sample Means

Tables A.3 and A.4 present sample means for grandsons and their parents and veteran grandfathers, respectively.

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. 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 overweight circa 1900 and 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. 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. Fathers were slightly less likely to have ever been farmers if their father or father-in-law was a non-exchange ex-POW.

I control for differences between grandchildren with age groups when BMI was measured (18-19, 20-24, 25-29, 30-34, 35-39, 40-44, 45-49, and 40-59), region of birth, the number of siblings, years of education, occupational group in 1940, 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. The latter two variables could proxy for the grandfather's longevity, socioeconomic status or for a direct influence of the grandfather on the grandchild. As expected from how the sample was constructed, the sample was primarily a Northern sample.

A.3 Veterans' BMI and Overweight

Table A.5 presents the odds ratios from a logit regression and the coefficients from an OLS regression where the dependent variables are, respectively, a dummy variable equal to one if the veteran was overweight and BMI. I estimate for veteran j

$$BMI_j = \beta_0 + \beta_1 P_{Ej} + \beta_2 P_{Nj} + \beta_3 C_j \quad \text{(A.1)}$$

$$\Pr(O_j = 1|X) = \text{logit}^{-1}(\beta_0 + \beta_1 P_{Ej} + \beta_2 P_{Nj} + \beta_3 C_j), \quad \text{(A.2)}$$

where P_{Nj} indicates non-exchange captivity, P_{Ej} indicates exchange captivity (non-POW is the omitted category), and C represents a vector of controls. The controls are the veteran's age in 1900, his occupational class at enlistment, his year of enlistment, whether he

was wounded in the war, 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. Post-war controls are occupation in 1880, a dummy equal to one if the veteran owned less than $100 in personal property in 1870, and population density in 1880 county of residence.

Figure A.3 shows results from an OLS regression where the dependent variable is the veteran's BMI circa 1900 and his ex-POW status is interacted with age group when at risk of severe captivity (17-20, 21-24, and 25+). That is, for veteran j

$$BMI_j = \beta_0 + \beta_1(A_j \times P_{Nj}) + \beta_2(A_j \times P_{Ej}) + \beta_3 C_j. \tag{A.3}$$

where A_j represents the age groups, P_{Nj} indicates non-exchange captivity, P_{Ej} indicates exchange captivity (non-POW is the omitted category), and C_j represents a vector of controls. The controls are the veteran's age in 1900, his occupational class at enlistment, his year of enlistment, whether he was wounded in the war, 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. Post-war controls are occupation in 1880, a dummy equal to one if the veteran owned less than $100 in personal property in 1870, and population density in 1880 county of residence.

BMI differences between non-exchange ex-POWs and non-POWs are greatest among veterans at risk of non-exchange captivity between ages 17-24 and lowest among veterans at risk of non-exchange captivity after age 25; however, the differences were not statistically significant. The reductions in BMI differences between non-exchange ex-POWs and non-POWs at age 25+ are largely driven by veterans at risk of a harsh captivity above age 30, perhaps because only the healthiest POWs older than 30 survived the camps (Costa, 2012).

A.4 Grandsons' BMI and Overweight

Figure A.1 shows that male-line grandsons who were descended from non-exchange ex-POWs were heavier than those descended from non-POWs but that there were no differences in height by grandpaternal ex-POW status. There were no differences by grandfathers' ex-POW status among female-line grandsons.

Table A.6 examines the relationship between grandsons' BMI and the grandfather's ex-POW status at the 25th, 50th, and 75th BMI quantiles. Estimates are from a quantile regression. To ensure convergence at all quantiles, I limit the number of post-war controls to a dummy variable indicating if the veteran was overweight circa 1900, the veteran's occupation in 1880, the number of siblings in the grandson's household, whether the veteran was living in the same county as the grandson, whether the grandson's father was ever a farmer, a laborer, or a property owner, parents' and own years of education, and whether the grandson was in a farm occupation in 1940.

Table A.7 presents results from OLS regressions where for grandson i

$$BMI_i = \beta_0 + \beta_1 P_{E,Vi} + \beta_2 P_{N,Vi} + \beta_4 C_i \tag{A.4}$$

$$BMI_i = \beta_0 + \beta_3 O_{Vi} + \beta_4 C_i \tag{A.5}$$

$$BMI_i = \beta_0 + \beta_1 P_{E,Vi} + \beta_2 P_{N,Vi} + \beta_3 O_{Vi} \beta_4 + C_i \tag{A.6}$$

where O_{Vi} is a dummy variable indicating if the veteran was overweight. Estimates are from separate regressions for male- and female-line grandsons.

Figure A.2 plots the increase in BMI by the veteran age group when at risk of severe captivity. I divide veterans ages into those at risk of non-exchange captivity between ages 17-20, 21-24, and age 25+. I estimate OLS regressions for male-line and female-line

grandsons, separately, where the dependent variable is BMI,

$$BMI_i = \beta_0 + \beta_1(A_i \times P_{E,Vi}) + \beta_2(A_i \times P_{N,Vi}) + \beta_3 C_i. \tag{A.7}$$

where A_i represents the age groups, P_N indicates non-exchange captivity, P_E indicates exchange captivity (non-POW is the omitted category), and C represents a vector of controls. The controls are own age group, quarter and region of birth, the veteran grandfather's enlistment characteristics and his occupational class in 1880, the father's socioeconomic status, the parents' education, and own education and occupational class in 1940.

Figure A.2 shows that male-line grandsons were heavier if descended from non-exchange ex-POWs captive at ages 17-24 but not age 25+. Female-line grandsons were heavier only if descended from non-exchange ex-POW grandfathers captive at ages 25 or older. I cannot explain the pattern among female-line grandsons with socioeconomic factors given the full set of controls. The pattern is inconsistent with the absence of an ex-POW mortality effect among grandchildren from either male or female lines descended from veterans age 25 or older (Costa, 2021). Given that grandsons descended from veterans at risk of captivity after their growing years constitute a relatively small proportion of the data, I cannot exclude chance findings.

Table A.8 presents the odds ratios for male-line and female-line grandsons and differences in differences from logit regressions where the dependent variable is overweight. A random effects accounts for veteran effects.

A.5 Grandsons' BMI and Later Mortality

Table A.9 shows that among grandsons descended from veterans at risk of being non-exchange ex-POWs after their growing years, there was no association between a grandfather's mortality and his non-exchange ex-POW relative to non-POW status. Controlling

for post-war socioeconomic factors, a unit increase in BMI increased the odds of dying every year after age 45 by 1.03 for both male-line and female-line grandsons.

Table A.10 presents results from a formal mediation analysis using a counterfactual in which I treat whether a grandson was overweight as a mediator for the relationship between grandfather's ex-POW status and the grandson's longevity. I specify the grandson's expected longevity (Y_i) given the veteran's ex-POW status (the treatment, D_i), the mediator (M_i) indicating whether he was overweight, and controls (C_i) as

$$E[Y_i|D_i, M_i, C_i] = \theta_0 + \theta_1 D_i + \theta_2 M_i + \theta_3 (D_i \times M_i) + \theta_4 C_i \tag{A.8}$$

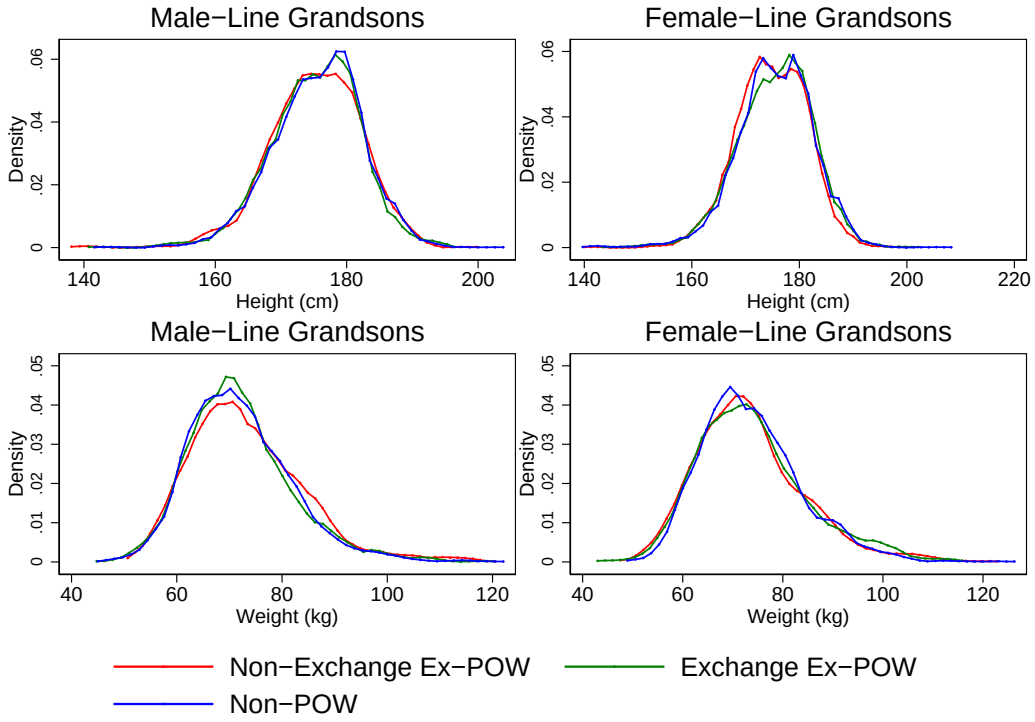
where

$$E[M_i|D_i, C_i] = \beta_0 + \beta_1 D_i + \beta_2 C_i \tag{A.9}$$

I estimate Equation A.8 using a Cox proportional hazards model and Equation A.9 using a logistic regression. I run separate equations for three grandfather treatments: 1) non-exchange ex-POW versus non-POW, 2) exchange ex-POW versus non-POW and 3) non-exchange versus exchange ex-POW. I then calculate the proportion of the total effect due to mediation with the grandson's overweight (natural indirect effect) and the mediated interaction, setting the values of the control variables to their means.[11] The identification assumption is that there are no unobserved confounders jointly influencing grandsons' longevity and overweight, i.e. no post-captivity confounders.

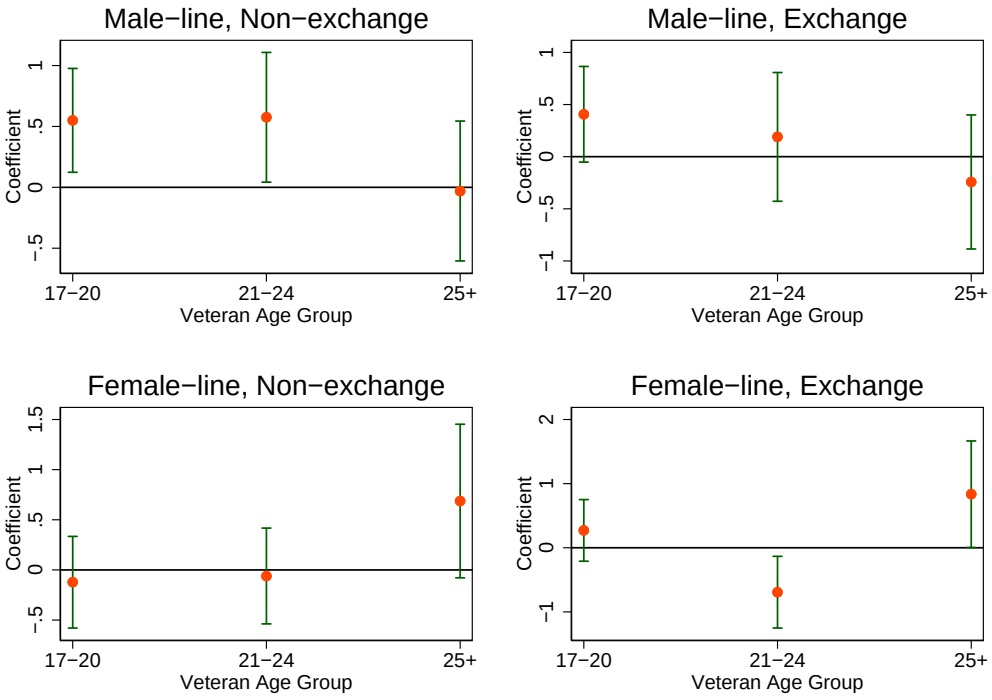
[11] See the discussions by Celli (2021) and Belloco (2021).

Figure A.1: Density of Grandsons' Height and Weight by Grandfather's Ex-POW Status and Descent from Sons or Daughters



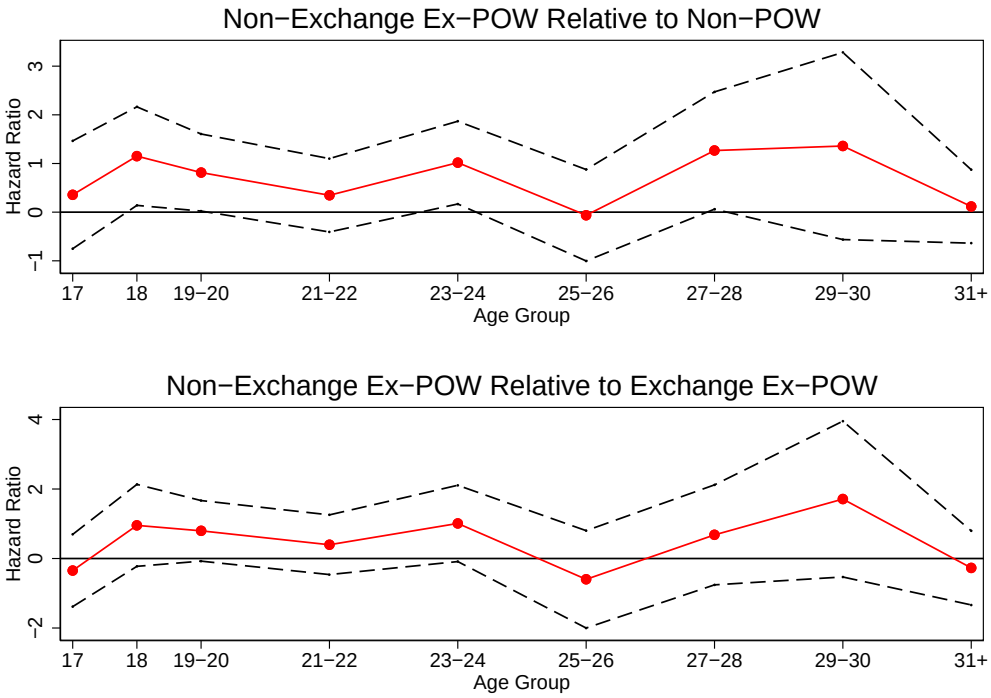
The densities are estimated using an Epanechnikov kernel.

Figure A.2: Grandfather's Age When at Risk of Non-Exchange Captivity and Male-Line Grandsons' Increase in BMI



Coefficients are estimated from an OLS regression where the dependent variable is the veteran's BMI. The controls are own age group, quarter and region of birth, the veteran grandfather's enlistment characteristics and his occupational class in 1880, the father's socioeconomic status, the parents' education, and own education and occupational class in 1940. Standard errors were clustered on the veteran.

Figure A.3: Veterans' Ages When at Risk of Non-Exchange Captivity and Their Increase in BMI



Increases in BMI are estimated from an OLS regression where the dependent variable is the veteran's BMI circa 1900. Controls include the veteran's age in 1900, his occupational class at enlistment, his year of enlistment, whether he was wounded in the war, 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. Post-war controls are occupation in 1880, a dummy equal to one if the veteran owned less than $100 in personal property in 1870, and population density in 1880 county of residence.

Table A.1: Linkage Rates by Descent

	Veteran Grandfather's Status			
	Non-POW	Exchange Ex-POW	Non-Exchange Ex-POW	All
Linkage rate to draft cards				
Male-line grandsons	98.7	99.1	99.1	98.9
Female-line grandsons	98.4	99.0	98.4	98.6
Linkage and useable height and weight information				
Male-line grandsons	97.6	98.5	98.4	98
Female-line grandsons	97.5	97.9	97.3	97.5

All grandsons were alive in 1940 and born between 1877 and 1929 (inclusive).

Table A.2: Mean BMI by Age Group

Age	National Sample	Union Army Grandsons	
		All	Non-POW Descendant
18-19	21.823	21.948	21.943
20-24	22.595	22.646	22.636
25-29	23.509	23.176	23.153
30-34	23.974	23.792	23.676
35-37	24.216	24.008	23.788
38-44		24.510	24.478
45-59		24.977	24.982

National BMI is calculated from Karpinos (1958) and is for white selective service registrants who were examined and measured. BMI for the grandson sample is calculated from self-reported height and weight.

Table A.3: Variable Means, Grandsons

	All Veterans			Veterans at Risk at Ages 17-24		
	Veteran Grandfather's Status			Veteran Grandfather's Status		
	Non-POW	Exchange Ex-POW	Non-Exchange Ex-POW	Non-POW	Exchange Ex-POW	Non-Exchange Ex-POW
Birth year	1907.40	1907.49	1907.53	1908.10	1907.74	1907.88
Death year	1979.56	1979.63	1979.51	1980.37	1979.62	1979.87
Age height and weight was reported	33.66	33.63	33.60	32.92	33.37	33.26
BMI	23.65	23.72	23.92	23.57	23.71	23.85
Fraction underweight	0.01	0.01	0.01	0.01	0.01	0.01
Fraction normal weight	0.71	0.69	0.66	0.72	0.70	0.68
Fraction overweight, not obese	0.25	0.26	0.28	0.24	0.25	0.28
Fraction obese	0.03	0.04	0.05	0.03	0.04	0.04
Height (inches)	69.15	69.07	68.94	69.19	69.03	69.01
Weight (pounds)	160.87	161.10	161.82	160.54	160.76	161.65
Years of education	9.49	9.49	9.69	9.59	9.40	9.68
Years of education of wife	9.97	9.90	10.14	10.07	9.92	10.19
Years lived	72.16	72.14	71.98	72.27	71.88	71.99
Number of siblings	4.49	4.61	4.53	4.44	4.65	4.54
Veteran living in the same county	0.35	0.35	0.30	0.36	0.36	0.30
Veteran living in the same household	0.03	0.04	0.03	0.03	0.05	0.03
Born in						
New England	0.02	0.02	0.06	0.03	0.02	0.05
Mid-Atlantic	0.15	0.11	0.23	0.15	0.11	0.24
East North Central	0.32	0.29	0.30	0.31	0.30	0.28
West North Central	0.31	0.36	0.26	0.30	0.37	0.26
Border	0.11	0.13	0.07	0.10	0.12	0.07
Other	0.10	0.09	0.08	0.11	0.07	0.09
Occupation in 1940						
Professional and technical	0.04	0.05	0.05	0.04	0.04	0.05
Farmer	0.10	0.12	0.09	0.10	0.11	0.09
Managers, officials and proprietors	0.05	0.06	0.06	0.05	0.06	0.06
Clerical and kindred and sales	0.09	0.08	0.10	0.09	0.07	0.10
Craftsmen	0.13	0.13	0.13	0.12	0.13	0.13
Operatives and service workers	0.19	0.18	0.18	0.19	0.18	0.17
Farm laborers	0.06	0.06	0.05	0.06	0.07	0.05
Laborers	0.10	0.10	0.11	0.11	0.11	0.11
Non-occupation or unclassifiable	0.24	0.23	0.24	0.25	0.24	0.25

Table A.4: Variable Means, Veteran Grandfathers and Parents

	All Veterans			Veterans at Risk at Ages 17-24		
	Veteran Grandfather's Status			Veteran Grandfather's Status		
	Non-POW	Exchange Ex-POW	Non-Exchange Ex-POW	Non-POW	Exchange Ex-POW	Non-Exchange Ex-POW
Veteran grandfathers' characteristics						
BMI circa 1900	22.60	22.97	23.35	22.74	22.72	23.14
Fraction who were						
Overweight	0.23	0.27	0.29	0.24	0.24	0.28
US-born	0.86	0.85	0.83	0.86	0.85	0.86
Enlistees in city with 50,000+ people	0.03	0.04	0.04	0.03	0.05	0.04
Wounded	0.33	0.35	0.28	0.34	0.37	0.29
Year of enlistment	1862.19	1861.89	1861.73	1862.14	1861.79	1861.73
Veterans' occupations at enlistment						
Farmer	0.70	0.72	0.64	0.71	0.72	0.64
Professional/proprietor	0.02	0.02	0.01	0.02	0.01	0.01
Artisan	0.11	0.11	0.11	0.10	0.09	0.11
Laborer	0.15	0.12	0.21	0.15	0.13	0.21
Unknown	0.02	0.04	0.02	0.02	0.05	0.03
Veterans' occupations in 1880						
Farmer	0.59	0.65	0.50	0.58	0.63	0.48
Professional/proprietor	0.04	0.04	0.05	0.05	0.04	0.06
Artisan	0.09	0.09	0.14	0.07	0.08	0.14
Laborer	0.21	0.18	0.26	0.23	0.21	0.27
No occupation	0.03	0.01	0.02	0.04	0.01	0.02
Grandsons' fathers were						
Ever farmers	0.53	0.54	0.48	0.52	0.55	0.47
Ever laborers	0.45	0.44	0.47	0.47	0.44	0.47
Ever owners	0.70	0.71	0.68	0.69	0.71	0.67
Years of education of						
Grandsons' fathers	7.35	7.71	7.73	7.49	7.67	7.73
Grandsons' mothers	7.86	8.01	8.04	7.95	8.15	8.07

Table A.5: Veterans' Overweight and BMI and Ex-POW Status

Dependent Variable:	Overweight		BMI c. 1900	
	Odds Ratio	Odds Ratio	Coef-icient	Coef-icient
Veteran was				
Exchange Ex-POW	1.236	1.238	-0.019	-0.016
Relative to Non-POW	(0.186)	(0.184)	(0.216)	(0.213)
	[0.159]	[0.152]	[0.931]	[0.942]
Non-exchange Ex-POW	1.774***	1.756***	0.716***	0.695***
Relative to Non-POW	(0.268)	(0.266)	(0.253)	(0.251)
	[0.000]	[0.000]	[0.005]	[0.006]
Non-exchange Relative to	1.436**	1.419**	0.735***	0.710***
Exchange Ex-POW	(0.234)	(0.232)	(0.240)	(0.238)
	[0.027]	[0.033]	[0.002]	[0.003]
Post-war socioeconomic characteristics	N	Y	N	Y

3,274 observations. 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, respectively. Controls include the veteran's age in 1900, his occupational class at enlistment, his year of enlistment, whether he was wounded in the war, 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. Post-war controls are occupation in 1880, a dummy equal to one if the veteran owned less than $100 in personal property in 1870, and population density in 1880 county of residence.

Table A.6: Grandsons' BMI and Grandfathers' Ex-POW Status at Different Quantiles

	Male-line Quantile			Female-line Quantile		
	25	50	75	25	50	75
Grandfather was						
Exchange Ex-POW	0.169	0.340*	0.524**	-0.088	-0.072	-0.016
Relative to Non-POW	(0.168)	(0.195)	(0.257)	(0.190)	(0.223)	(0.026)
	[0.316]	[0.081]	[0.042]	[0.645]	[0.746]	[0.541]
Non-exchange Ex-POW	0.287*	0.287	0.685**	-0.183	-0.173	0.004
Relative to Non-POW	(0.152)	(0.187)	(0.253)	(0.177)	(0.187)	(0.024)
	[0.060]	[0.124]	[0.007]	[0.302]	[0.355]	[0.857]
DD Exchange Ex-POW	0.264	0.441	0.369			
Relative to Non-POW	(0.235)	(0.300)	(0.364)			
	[0.262]	[0.142]	[0.311]			
DD Non-exchange Ex-POW	0.470**	0.460**	0.540**			
Relative to Non-POW	(0.208)	(0.225)	(0.275)			
	[0.024]	[0.041]	[0.049]			

Estimated using quantile regressions. DD=double difference. 6,225 observations. 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, respectively. Controls include the age group when height and weight were reported, quarter of birth, region of birth, and the veteran's occupational class at enlistment, year of enlistment, whether he was wounded in the war, 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. Post-war controls are a dummy variable indicating if the veteran was overweight circa 1900, the veteran's occupation in 1880, the number of siblings in the grandson's household, whether the veteran was living in the same county as the grandson, whether the grandson's father was ever a farmer, a laborer, or a property owner, parents' and own years of education, and whether the grandson was in a farm occupation in 1940.

Table A.7: Grandsons' BMI and Grandfathers' Overweight and Ex-POW Status

	Male-line Grandsons				Female-line Grandsons			
Grandfather was								
Exchange Ex-POW	0.169		0.165	0.161	0.051		0.002	0.012
Relative to Non-POW	(0.190)		(0.186)	(0.178)	(0.192)		(0.191)	(0.192)
	[0.373]		[0.375]	[0.366]	[0.790]		[0.990]	[0.952]
Non-exchange Ex-POW	0.496**		0.477**	0.490***	-0.054		-0.128	-0.144
Relative to Non-POW	(0.193)		(0.188)	(0.186)	(0.197)		(0.191)	(0.190)
	[0.010]		[0.011]	[0.009]	[0.784]		[0.503]	[0.448]
Veteran was overweight		0.558***	0.542***	0.534***		0.680***	0.692***	0.692***
		(0.168)	(0.167)	(0.163)		(0.178)	(0.178)	(0.180)
		[0.001]	[0.001]	[0.001]		[0.000]	[0.000]	[0.000]
Post-war controls	N	N	N	Y	N	N	N	Y

3,048 male-line grandsons and 3,177 female-line grandsons. Estimates were done separately for male-line and female-line grandsons using Equation A.4. 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, respectively. Controls include the age group when height and weight were reported, quarter of birth, region of birth, and the veteran's occupational class at enlistment, year of enlistment, whether he was wounded in the war, 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. Post-war controls are the veteran's occupation in 1880, the number of siblings in the grandson's household, whether the veteran was living in the same county as the grandson, whether the veteran was in the same household as the grandson, whether the grandson's father was ever a farmer, a laborer, or a property owner, parents' and own years of education, and occupational class in 1940.

Table A.8: Male-line Grandsons' Overweight and Grandfathers' Ex-POW Status, Odds Ratios

	(1)	(2)	(3)	(4)
Grandfather was				
Exchange Ex-POW	0.987	1.007	1.101	1.075
Relative to Non-POW	(0.146)	(0.143)	(0.154)	(0.150)
	[0.931]	[0.961]	[0.490]	[0.603]
Non-exchange Ex-POW	1.436**	1.423**	0.990	0.944
Relative to Non-POW	(0.212)	(0.205)	(0.132)	(0.127)
	[0.014]	[0.014]	[0.942]	[0.668]
Non-exchange Relative to	1.454**	1.413**	0.899	0.878
Exchange Ex-POW	(0.228)	(0.216)	(0.129)	(0.125)
	[0.017]	[0.024]	[0.460]	[0.362]
DD Exchange Ex-POW	0.896	0.937		
Relative to Non-POW	(0.152)	(0.158)		
	[0.519]	[0.698]		
DD Non-exchange Ex-POW	1.450**	1.508**		
Relative to Non-POW	(0.245)	(0.254)		
	[0.028]	[0.015]		
DD Non-exchange Relative to	1.617**	1.610**		
Exchange Ex-POW	(0.314)	(0.310)		
	[0.013]	[0.013]		
Post-War Controls	N	Y	N	N

Random effects estimates. 6,225 observations. 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, respectively. Controls include the age group when height and weight were reported, quarter of birth, region of birth, and the veteran's occupational class at enlistment, year of enlistment, whether he was wounded in the war, 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. Post-war controls are a dummy variable indicating if the veteran was overweight circa 1900, the veteran's occupation in 1880, the number of siblings in the grandson's household, whether the veteran was living in the same county as the grandson, whether the veteran was in the same household as the grandson, whether the grandson's father was ever a farmer, a laborer, or a property owner, parents' and own years of education, and occupational class in 1940.

Table A.9: Grandsons' Mortality After Age 45 (Hazard Ratios) and Their Overweight and Grandfathers' Ex-POW Status, Descendants of Grandfathers at Risk After Their Growing Years

		Male-line Grandsons				Female-line Grandsons		
Grandfather was								
Non-POW		1.000	1.000	1.000		1.000	1.000	1.000
Exchange Ex-POW		0.805**	0.796**	0.759***		1.063	1.066	1.016
		(0.082)	(0.082)	(0.073)		(0.115)	(0.116)	(0.118)
		[0.033]	[0.027]	[0.004]		[0.574]	[0.553]	[0.893]
Non-exchange Ex-POW		0.940	0.936	1.005		1.095	1.070	1.066
		(0.097)	(0.096)	(0.101)		(0.139)	(0.138)	(0.152)
		[0.552]	[0.519]	[0.964]		[0.476]	[0.601]	[0.656]
Non-exchange Ex-POW		1.168	1.176	1.324**		1.030	1.003	1.049
relative to Exchange Ex-POW		(0.134)	(0.136)	(0.152)		(0.124)	(0.123)	(0.141)
		[0.175]	[0.162]	[0.014]		[0.807]	[0.981]	[0.807]
Grandson's BMI	1.019		1.021	1.030**	1.025*		1.025*	1.027*
	(0.013)		(0.013)	(0.014)	(0.015)		(0.015)	(0.016)
	[0.143]		[0.107]	[0.025]	[0.085]		[0.094]	[0.093]
Test of proportional hazards	37.18	32.68	33.30	62.96	38.16	39.98	40.53	81.86
assumption, df=	30	31	32	60	30	31	32	60
	[0.172]	[0.385]	[0.404]	[0.372]	[0.146]	[0.129]	[0.143]	[0.032]
Post-war controls	N	N	N	Y	N	N	N	Y

794 male-line grandsons and 685 female-line grandsons. 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, respectively. Controls include the age group when height and weight were reported, quarter of birth, region of birth, and the veteran's occupational class at enlistment, year of enlistment, whether he was wounded in the war, 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. Post-war controls are a dummy variable indicating if the veteran was overweight circa 1900, the veteran's occupation in 1880, the number of siblings in the grandson's household, whether the veteran was living in the same county as the grandson, whether the veteran was in the same household as the grandson, whether the grandson's father was ever a farmer, a laborer, or a property owner, parents' and own years of education, and occupational class in 1940.

Table A.10: Mediation of Grandfathers' Ex-POW Status and Male-line Grandsons' Mortality by Grandsons' BMI

—	Coefficient	Std. Err.	P-value
Grandfather was non-exchange ex-POW relative to non-POW			
Total effect	0.219**	0.088	0.013
Controlled direct effect	0.189**	0.088	0.032
Interaction only	-0.005	0.013	0.718
Mediated interaction only	0.005	0.019	0.773
Pure indirect effect	0.030**	0.013	0.019
Grandfather was exchange ex-POW relative to non-POW			
Total effect	0.269***	0.092	0.003
Controlled direct effect	0.254***	0.093	0.006
Interaction only	0.010	0.014	0.472
Mediated interaction only	-0.005	0.007	0.474
Pure indirect effect	0.010	0.008	0.207
Grandfather was non-exchange relative to exchange ex-POW			
Total effect	0.083	0.070	0.235
Controlled direct effect	0.089	0.070	0.206
Interaction only	-0.021	0.016	0.185
Mediated interaction only	0.014	0.012	0.231
Pure indirect effect	0.000	0.007	0.944

Estimated from Equations A.8 and A.9. The symbols *, **, and *** indicate significance at the 10, 5, and 1 percent level, respectively. Controls include the age group when height and weight were reported, quarter of birth, region of birth, and the veteran's occupational class at enlistment, year of enlistment, whether he was wounded in the war, 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. Post-war controls are a dummy variable indicating if the veteran was overweight circa 1900, the veteran's occupation in 1880, the number of siblings in the grandson's household, whether the veteran was living in the same county as the grandson, whether the veteran was in the same household as the grandson, whether the grandson's father was ever a farmer, a laborer, or a property owner, parents' and own years of education, and occupational class in 1940.