Survival after the World War I: An Analysis of Life Course Data of WWI Veterans and Family Members Using the Utah Population Database Linked to the 1930 US Census

In this project, we examined survival outcomes of male World War I veterans, who were conscripted between the ages of 18 and 45, and their spouses. We aimed not only to gain additional knowledge about population health effects of the WWI, but also to gain insight into effects of complex emergencies, such as large-scale military conflicts, using WWI as a case study. We hypothesized that survival outcomes for WWI veterans will differ significantly from those of the general population. Military draft, training and potential exposure to combat are associated with major stressors, which may have long term consequences for surviving veterans' physical and mental health. At the same time, those drafted to serve in the WWI may have been healthier than some of their peers who were not conscripted. Furthermore, in our analysis we capture only the men who survived not only the WWI, but also until the time of the 1930 US Census, thus possibly omitting the less robust individuals or who were drafted but died before 1930. Thus, due to potential health selection occurring both before and after the war, we may observe better survival outcomes for among the WWI veterans compared to the general population. In addition, we expect that the extent of survival advantage or disadvantage experienced by veterans will vary by cause of death. We also hypothesized that spouses of the veterans will experience poorer or better survival outcomes compared to the general population.

DATA AND METHODS

We relied on the Utah Population Database (UPDB) as our primary source of data for this project. The database combines and links records from various sources, including vital records, family history records, US Census records, WWI conscription records and other sources. Specifically, we used the 1930 US records linked to death certificates issued in the state of Utah to capture key demographic information about WWI veterans and their family members. The information on one's veteran status was obtained from the 1930 US Census.

To test our first hypothesis regarding differences in survival outcomes between WWI veterans and men who did not serve, we estimated two sets of Cox proportional hazard models. In the first set of models we compared all-cause and cause-specific mortality outcomes of WWI veterans alive at the time of the 1930 US Census to mortality outcomes of men who did not serve in the WWI, matching the veteran and general population on birth year. In the second set of models, we compared mortality outcomes of veterans to those of their brothers who did not serve. The latter allowed us to better understand the extent of the effect of military service on mortality by disentangling it from the influence of shared ancestry and early life environment. We further restricted the sample of veterans to men who were 29 years old or older at the time of the 1930 Census. To test our second hypothesis, we estimated similar models for spouses of WWI veterans matched by birth year to the general population of women.

In all models, we adjusted for socioeconomic status, as captured in 1930, by controlling for *occupational score* and, specifically, *farming* occupation, and for *homeownership*. We also controlled for *marital status* in models comparing survival outcomes of veterans to the general population and to their brothers. This variable was excluded from the models focusing on veterans' spouses, as being married to a WWI veteran was the main criterion for inclusion in the analysis. All models were stratified by *birth year* to account for variation in baseline mortality hazards and adjust for birth year matching. All analyses were performed using R statistical software version 3.4.1 (https://www.R-project.org) and 'survival' statistical analysis package (https://CRAN.R-project.org/package=survival).

RESULTS

Descriptive statistics of the samples are presented in Table 1. Figure 1 displays mortality hazard ratios and 95% confidence intervals obtained from the stratified Cox models results comparing survival outcomes for WWI veterans to those of the general population. The results indicate that WWI veterans experience a significant survival advantage when it comes to all-cause mortality (HR = 0.9292, 95% CI between 0.8954 and 0.9643). There

are also significant differences in mortality hazard ratios for certain causes of death, namely, mortality from neoplasms (HR = 0.8776, 95% CI between 0.7892 and 0.9760), diseases of the circulatory system (HR = 0.9454, 95% CI between 0.8968 and 0.9966) and mental, psychoneurotic and personality disorders. The latter category of causes of death is the only one on which, WWI veterans appear to be significantly disadvantaged with a mortality hazard ratio almost double that of the general population (HR = 1.922, 95% CI between 1.1279 and 3.2760).

When survival outcomes of WWI veterans are compared to those of their brothers (Figure 2), veterans do not show statistically significant advantage or disadvantage with regard to all-cause and cause-specific mortality with one exception being, again, mental, psychoneurotic and personality disorders. For these causes, veterans exhibit statistically significant survival disadvantage with a mortality hazard ratio almost triple that of their brothers (HR = 2.8957, 95% CI between 1.2681 and 6.612).

Figure 3 shows mortality hazard ratios for spouses of WWI veterans compared to the general population. There is no statistically significant difference in hazard ratios for these two groups with regard to all-cause mortality. However, when it comes to cause-specific mortality, WWI veterans' spouse experience significant mortality advantage from diseases of digestive system (HR = 0.7703, 95% CI between 0.6290 and 0.9434) and infectious diseases or parasites (HR = 0.5732, 95% CI between 0.3682 and 0.8923). They also experience a survival disadvantage when it comes to mortality from mental, psychoneurotic and personality disorders (HR = 1.3727, 95% CI between 1.0179 and 1.8513).

DISCUSSION

The results partially support our initial hypothesis, stating that there will be significant differences in survival outcomes between men who served in the WWI and those who did not. WWI veterans exhibit an advantage with regard to all-cause mortality and mortality from neoplasms and diseases of the circulatory system when compared to the general population, likely due to health selection processes occurring both before and after the war. However, this advantage dissipates when survival outcomes of veterans are compared to those of their brothers who did not serve in the WWI. This finding suggests that some of the advantage observed when veterans are compared to the general population may stem from phenotype and/or familial environment WWI veterans likely shared with their brothers. Our second hypothesis regarding the difference in survival outcomes for spouses of WWI veterans is also supported: although veterans' spouses do not differ significantly from the general population on all-cause mortality, there are significant differences on specific causes of death. It is worth noting that the survival advantage for diseases of the digestive system and infectious and parasitic diseases found among the WWI veterans' spouses is not observed among veterans themselves. The potential sources of this advantage warrant further investigation.

The most prominent difference in cause-specific mortality hazard ratios observed both for veterans (in comparison to the general population and in comparison to brothers) and for their spouses is the disadvantage associated with mortality from mental, psychoneurotic and personality disorders. It appears that exposure to draft, training and combat, as well as being married to an individual with history of such exposure, makes one more susceptible to death caused by one or multiple conditions that fall within this broad cause of death category, such as paranoia, schizophrenia, dementia, alcoholism and unspecified psychotic and non-psychotic mental disorders. This is consistent with findings from studies focusing on health of veterans of WWI and other military conflicts that show increased risk of developing mental health conditions and suffering from substance abuse in this population [1-5]. Interestingly, Jones et al. 2002 [6] indicate that less than a quarter of the sample of British WWI veterans with post-combat syndromes exhibited neuropsychiatric system, while others suffered from syndromes with absent psychological or cognitive symptoms or functional heart syndromes. However, our analysis suggests prominent presence of mental health conditions among WWI veterans.

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4.   Seal, K.H., et al., *Trends and risk factors for mental health diagnoses among Iraq and Afghanistan veterans using Department of Veterans Affairs health care, 2002–2008.* 2009. **99**(9): p. 1651-1658.
5.   Bremner, J.D., et al., *Chronic PTSD in Vietnam combat veterans: Course of illness and substance abuse.* 1996. **153**(3): p. 369.
6.   Jones, E., et al., *Post-combat syndromes from the Boer war to the Gulf war: a cluster analysis of their nature and attribution.* Bmj, 2002. **324**(7333): p. 321.

TABLES

Table 1. Descriptive Characteristics of the Sample

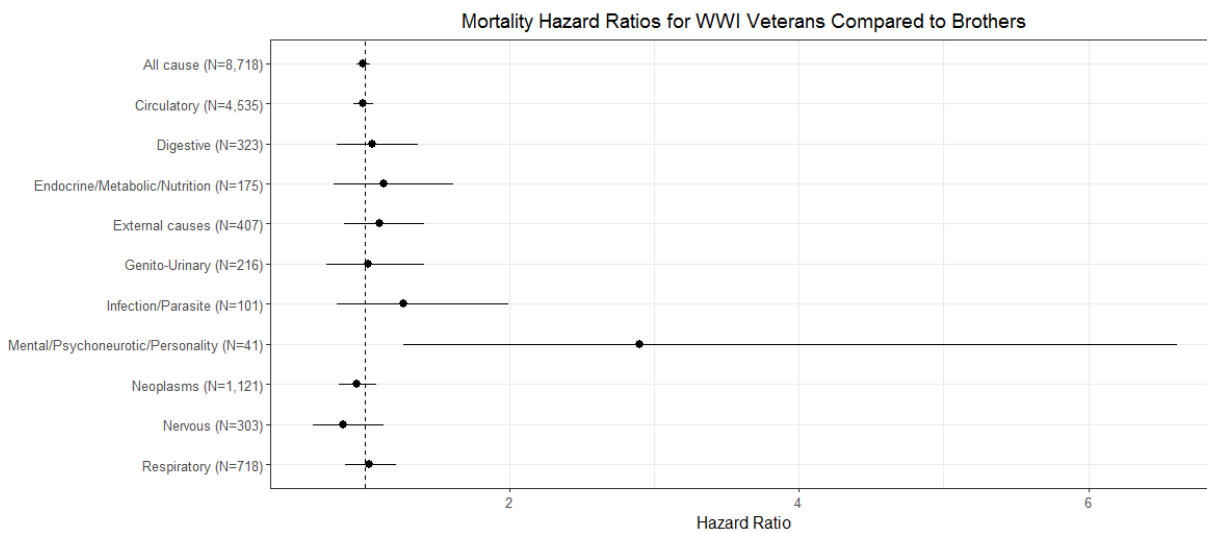|	Veterans	General population (male)	Brothers	WWI Veterans' Spouses	General population (female)
Birth year	1894 [1845-1900]	1894 [1845-1900]	1888 [1848-1900]	1898 [1859-1912]	1898 [1859-1912]
Death year	1967 [1931-2001]	1968 [1931-2001]	1963 [1931-2001]	1977 [1931-2006]	1976 [1931-2009]
Marital status in 1930:					
Married	3558 (0.91)	7278 (0.93)	4434 (0.92)		6100 (0.90)
Never married	281 (0.07)	395 (0.05)	258 (0.05)		517 (0.08)
Previously married	79 (0.02)	161 (0.02)	108 (0.02)		183 (0.03)
Renter	1397 (0.36)	2639 (0.34)	1131 (0.24)	1285 (0.38)	2491 (0.37)
Farmer	823 (0.21)	1955 (0.25)	1483 (0.31)		
Bottom quartile of occupational scores	283 (0.07)	595 (0.08)	369 (0.08)	3275 (0.96)	6064 (0.90)
Number of deaths by cause:					
Circulatory	2005 (0.51)	3880 (0.50)	2530 (0.53)	1708 (0.50)	3287 (0.48)
Digestive	149 (0.04)	283 (0.04)	174 (0.04)	118 (0.04)	294 (0.04)
Endocrine/Metabolic/Nutrition	81 (0.02)	167 (0.02)	94 (0.02)	122 (0.03)	280 (0.04)
External causes	193 (0.05)	401 (0.05)	214 (0.05)	98 (0.03)	166 (0.02)
Genito-urinary	92 (0.02)	165 (0.02)	124 (0.03)	59 (0.02)	143 (0.02)
Infection/Parasite	54 (0.01)	103 (0.01)	47 (0.01)	21 (0.01)	73 (0.01)
Mental/Psychoneurotic/Personality	29 (0.01)	32 (0.00)	12 (0.00)	63 (0.02)	89 (0.01)
Neoplasms	500 (0.13)	1049 (0.13)	621 (0.13)	440 (0.13)	833 (0.12)
Nervous	101 (0.03)	229 (0.03)	202 (0.04)	92 (0.03)	213 (0.03)
Respiratory	353 (0.09)	653 (0.08)	365 (0.08)	203 (0.06)	402 (0.06)
Right-censored	21	149	14 (0.00)	133 (0.04)	358 (0.05)
Total	3,918	7,834	4,800	3,402	6,800

Note. For continuour variables, mean and [range] are reported. For discrete variables, proportions are reported in parentheses.

FIGURES

Figure 1. All-cause and cause-specific mortality hazard ratios for WWI veterans compared to the general population.

Mortality Hazard Ratios for WWI Veterans Compared to General Population

All cause (N=11,752)		
Circulatory (N=5,885)		
Digestive (N=432)		
Endocrine/Metabolic/Nutrition (N=248)		
External causes (N=594)		
Genito-Urinary (N=257)		
Infection/Parasite (N=157)		
Mental/Psychoneurotic/Personality (N=61)		
Neoplasms (N=1,549)		
Nervous (N=330)		
Respiratory (N=1,006)		

Hazard ratio: 1.0, 1.5, 2.0, 2.5, 3.0
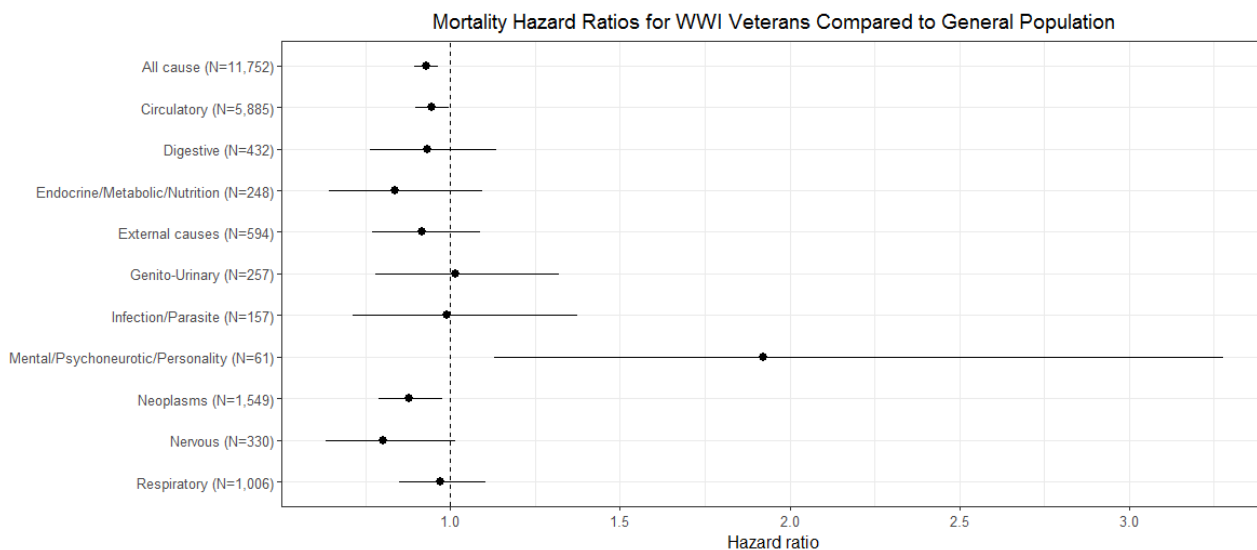
Figure 2. All-cause and cause-specific mortality hazard ratios for WWI veterans compared to brothers with closest birth year.

Mortality Hazard Ratios for WWI Veterans Compared to Brothers

All cause (N=8,718)		
Circulatory (N=4,535)		
Digestive (N=323)		
Endocrine/Metabolic/Nutrition (N=175)		
External causes (N=407)		
Genito-Urinary (N=216)		
Infection/Parasite (N=101)		
Mental/Psychoneurotic/Personality (N=41)		
Neoplasms (N=1,121)		
Nervous (N=303)		
Respiratory (N=718)		

Hazard Ratio: 2, 4, 6

Figure 3. All-cause and cause-specific mortality hazard ratios for spouses of WWI veterans compared to the general population.

Mortality Hazard Ratios for Spouses of WWI Veterans Compared to General Population