WAS WHAT AIL'D YA' WHAT KILL'D YA'?

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ABSTRACT

Making use of those Union Army veterans for whom death certificates are available, we compare the conditions with which they were diagnosed by Civil War pension surgeons to the causes of death on the certificates. We divide the data between those veterans who entered the pension system early because of war injuries and those who entered the pension system after the 1890 reform that made it available to many more veterans. We examine the correlation between specific conditions and death causes to gauge support for the hypothesis that death is attributable to something specific. We also examine the correlation between the accumulation of rated conditions to time until death to gauge support for the "insult hypothesis." In general, we find support for both hypotheses. Examining the hazard ratios for dying of a specific condition, there is support for the idea that what ail'd ya' is what kill'd ya'.

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Using the Early Indicators life cycle health histories of Union Army veterans, we compare the conditions with which they were diagnosed by Civil War pension surgeons to the death certificates of veterans (and other documents that declare a cause of death). We examine specific chronic disease conditions and death causes to gauge support for the hypothesis that death is likely attributable to a single chronic condition, and we will present evidence in regard to the "insult hypothesis" of mortality.

The Union Army data is a sample of white males who were mustered into the army. We have limited the data to those veterans for whom we had at least one medical exam and a death cause. The information on medical examinations are part of the "surgeons' certificates" data set; they are the product of detailed physical examinations completed by a local pension surgeons' board, detailing the health and disability status of Union Army veterans who applied for a pension. The death cause comes from a death certificate or some alternative document that declares a cause of death.

Our sample is divided into two groups. The first are "injured" veterans who were either injured during the war or developed a chronic condition related to wartime service; this group was immediately eligible for pension funds. The second, "uninjured" veterans, entered the pension system after the 1890 reforms that made the pension available to many more veterans, first on the basis of any chronic disease condition and then, after 1907, on the basis of age. Pension awards were related to veterans' health statuses as recorded on the surgeons' certificates. The examinations were conducted according to examination standards and procedures set by the U.S. Bureau of Pensions. The Bureau's disease definitions, while they differ from current disease classification schema, are used in this analysis. Semantic and diagnostic differences arising from

the disparity between 19th century medical knowledge and current medical understanding are noted. This is discussed in detail below.

Pension surgeons did not diagnose conditions per se; rather, they described observed symptoms in vivid detail and, sometimes, would provide what they believed to be the underlying medical condition. We do not attempt to resolve discrepancies arising from the inexactness associated with the reporting of symptoms. If, for example, a veteran had a cardiovascular problem that entitled him to a pension, a change in the severity of his condition or the presence of a new condition entitled him to an increase in pension amount. In each case, the veteran had to be examined by a pension board surgeon to confirm a change in health status. We have not attempted to deal with the problem of increasing severity. Our analysis assumes the existence of a condition from the first examination that results in a rating for that condition.

There is support for the idea that what ailed veteran is what killed them. In the aggregate, of the 8,332 veterans in our sample, 96.42 percent of them were diagnosed with one or more of the 20 chronic conditions that qualified a veteran for a pension; the average number of diagnosed conditions was 4.71. In 44.7 percent of the cases, a diagnosed condition was listed as a cause of death, and in 51.2 percent of the cases, a diagnosed condition was listed as either the cause or a contributing cause of death.

I

The Union Army (UA) data set consists of the military, pension, census and lifetime medical records of 35,330 white men from 25 northern states who served as infantrymen in 331 companies in the Union Army during the U.S. Civil War. The data were collected under the auspices of Robert Fogel's *Early Indicators of Later Work Levels, Disease, and Death* project at the University of Chicago Booth School of Business' Center for Population Economics (CPE). The data set has been shown to be representative of white northern men who served in the Civil War, and more generally, of white northern men who became adults during the 1860s.[1]

Over 85 percent of the UA sample survived the war; the rest succumbed to injury or disease. In the years between 1861 and 1890, veterans who were wounded or who experienced chronic aftereffects of wartime disease exposure were entitled to pensions in amounts related to the severity of their injuries. In the present study, we refer to these pre-1890 pensioners collectively as "the injured." The "uninjured"—those who escaped the war without long-term sequelae of disease and injury exposure—were only admitted to the pension system after an 1890 act of Congress extended the UA pension to all veterans with any verifiable chronic health condition, regardless of cause (exceptions were chronic diseases resulting from "vicious habits," which were not pensionable).

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[1] Robert W. Fogel and Dora L. Costa, "A theory of technophysio evolution, with some implications for forecasting population, health care costs, and pension costs," *Demography* 34(1), 1997, "The Demography of Aging."

Pension History, and the Pension Data

All pensions required an examination by a surgeons' board located in the applicant veteran's county or congressional district. These surgeons' boards were each comprised of three politically appointed, trained physicians who, despite the primitiveness of diagnostic techniques and the unavailability of effective treatments for most chronic diseases, were nevertheless thorough examiners and vivid describers of any physical abnormality they could see, feel, smell, or, in extreme cases, taste.

In the UA data set, these records are coded and classified according to a nosology similar to ICD-9, with 20 general classifications (see Table 1). The records of these examinations and the surgeons' recommendations were forwarded to the U.S. Bureau of Pensions for a ruling on pension amount, which was often around $12 to $18 per month, receivable in person at the post office closest to the veteran's home address.

Pension eligibility was further liberalized by administrative rule in 1904, extending the pension to those who were "disabled by reason of age." In 1907, the pension was fully extended to all veterans over 62 years of age. By 1912, the UA pension payments were increased on a graduated basis, with older pensioners receiving larger pensions.

Table 1

Ratable Conditions

Cardiovascular	Respiratory
Diarrhea	Gastro-intestinal
Ear diseases	Rheumatism/Musculo-skeleton
General appearance	Spleen
Hernia	Tumor (neoplasm)
Infectious disease	Genito-urinary
Endocrine disease (kidney)	Varicose veins
Liver	Wound
Rectum/Hemorrhoids	Eye disorder
Nervous system	Gall bladder

Pension applicants could apply under whatever law they thought would be most lucrative. Therefore, sick people generally applied under the 1890 law, which for full disability or blindness paid up to $50; veterans who were simply old applied under the 1907 law, which awarded 62-year-olds $12 and 72-year-olds $15 per month. These incentives serve our purposes now by insuring that sick people generally were examined by surgeons to verify their disabilities and that well people, or people who didn't believe they were ill, applied under the age rule.

Pensions could be inherited upon proof of death cause and date by 1) parents of unmarried soldiers killed in action; 2) minor dependents of veterans who died during or after the war; and 3) widows of pensioners who died during or after the war. Successors to veterans' pensions provided death certificates, death notices, sworn affidavits, and other registers to prove the death cause and date of their veterans, and these records ended up in the veterans' pension files (and subsequently in the UA data set). Pensioners without successor applicants might still have a death date since the Pension Bureau could usually only cease payment with proof of a veteran's death.

In the UA data, death causes have been coded and classified according to the same nosology used to categorize the diseases on the surgeons' certificates. For example, a soldier who was diagnosed with an arrhythmia and who died of congestive heart failure would be coded as having a cardiovascular condition and having died of a cardiovascular condition.

About 71 percent of Union Army soldiers were represented in the pension system, either because they were qualified under a relevant statute or because they had a successor who applied on their behalf. Only about 60 percent were admitted to the pension system as invalids; 51 percent have surgeons' certificates. A not-entirely overlapping 52 percent have a death cause. For this paper, we care most about the death cause and disease history. And so, even though the data contain some 15,387 death causes, fewer than 8,400 have both a medical history and a death cause. Death causes favor those who died during service (those lacking a medical history); those with widows or successors; and those who were still living in 1907 (i.e., the healthy).

About 43 percent of those who were admitted to the pension system came in after 1890. Less than 1 percent came into the pension system after 1907. Ten percent died before 1890 and 30 percent died before 1900. Over half our sample was dead by 1920, and nearly all were gone by 1930 when the cohort of men who were in the Union Army would have been in their early 90s. Cain and Hong have examined causal factors in this precipitous die-off in detail.[2] In the present study, we are not concerned with the timing of the deaths as much as we are with why men in that cohort died. As noted, we use a subsample of 8,332 UA men who were pensioners, who had surgeons' certificates and both a recorded date of death and a death cause or

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[2] See Louis P. Cain and Sok Chul Hong, "Survival in 19th century cities: The larger the city, the smaller your chances," *Explorations in Economic History* 46(4), 2009.

contributing cause. This subsample was then divided into pre-1890 and post-1890 pensioners—

the "injured," and the "uninjured."

Data Limitations

Using the UA data is difficult, not only because of certain biases that may be present, but also

because it requires users to make certain assumptions about both the meaning of surgeons'

certificates and about the relevance of medical history.

The inputting of the surgeons' data and the death-cause data was designed, supervised,

reviewed, and corrected by medical doctors at the CPE.[3] Medical doctors also coded the disease

descriptions by the pension surgeons to reflect signs and symptoms of chronic disease. These are

not diagnoses that require a more holistic approach, where each soldier's entire medical history

would be examined to determine underlying conditions related to the symptoms reported.

Because of the expense of that approach, the CPE doctors simply coded the symptoms separately

without regard to comorbidities. This is a reasonable approach in most cases. However,

sometimes this presents problems. Consider a case where a veteran is observed with what the

surgeons call "chronic diarrhea" and that he is also observed with "blindness." CPE doctors

coded chronic diarrhea and blindness as separate conditions, unless the pension surgeons had

noted that they thought the two conditions were related, in which case the CPE doctors would

note the relationship. Consider another case where a veteran is observed with "pneumonia,"

"disease of heart," and "failure of kidneys," which many would diagnose as "congestive heart

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[3] "Reflections on the 'Early Indicators' project: A partial history," in Dora Costa, ed., *Health and Labor Force Participation over the Life Cycle: Evidence from the Past* (Chicago: University of Chicago Press, 2003).

failure." Unless the pension surgeons noted "congestive heart failure" on the surgeons' certificate, CPE doctors did not make such determinations. CPE doctors took the symptoms supplied and coded them as conditions of lungs, kidneys, and heart; the three were assumed to be independent of one another. So, if the soldier ended up dying of pneumonia, it was coded as a lung-related (pulmonary) death rather than a cardiovascular death. Modern death-cause data have similar problems, but modern medical histories contain diagnoses, whereas the UA data set does not. For this reason, without additional work by medical doctors, we cannot make diagnostic determinations about the chronic disease causes of death. We can only talk about correlations between comorbidities and death causes.

The data contain information on multiple causes and contributing causes of death. We used MICAR/SUPERMICAR/ACME software provided by the Centers for Disease Control for use in coding diseases and death causes in the modern healthcare industry to determine which of the multiple causes was the most plausible. We then used that cause (and the most probable contributing cause) in our analyses. To the extent that this approach drops what the software considers to be causes that are implausible, it limits the amount of information we really have concerning a veteran's death. The software also limits us to the extent that historical death causes are less reflective of the current understanding of medical conditions. For example, many soldiers died of yellow, green, or red "softening." This is thought to be indicative of different types of hemorrhage or possibly of different stages of one type of hemorrhage. Our analysis is limited to the extent that this distinction matters one way or the other; we code this as "hemorrhage" and assume that the color modifiers are not significant. There are other such cases where historical terms for infectious illness require that we generalize the death cause more than

modern medical studies would do. Without holistic analysis of individual health histories, general death causes are the best we can do.[4]

Finally, pension surgeons were legally prohibited from treating the medical conditions they observed and were legally required to substantiate that the conditions they noted were chronic, as opposed to acute, ailments. For our study, this means that we will lack information about the buildup of conditions that are acute unless those conditions result in death, in which case it would show up as a death cause. On the other hand, if an acute condition has long-term sequelae, it would be noted by the surgeons. For example, if an acute infection leaves a soldier with chronic bronchitis, the bronchitis will be noted, but its infectious origin will not. So, our analysis will be able to say something about the buildup of conditions that are rated by surgeons to be disabling, but it will say nothing about the effects of repeated exposure to infections and other acute, episodic conditions, except as those effects are related to detectable scars or sequelae (i.e., we won't know about a gunshot wound in 1885, but we will know every imaginable thing about the scar tissue it leaves behind).

The Literature

The UA pension period (1860–1930) saw infection decline as a death cause. Male infant mortality rates declined rapidly as infections became less important as causes of population death.[5] Fogel observed an 84 percent decline in urban infant mortality rate (IMR) disparities between 1890 and 1920, so that by 1930 the reduction in disparity was nearly equal to the

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[4] CPE doctors plan to develop appropriate algorithms for determining probable disease diagnoses based on the surgeons' data in the near future.

[5] Greg L. Drevenstedt, Eileen M. Crimmins, Sarinnapha Vasunilashorn, and Caleb E. Finch, "The rise and fall of excess male infant mortality," *Proceedings of the National Academy of Sciences* 105, 2008.

reduction in the overall infant mortality rate.[6] Other research has equated these declines in infant death to declines in infant disease exposure, which have resulted in reduced mortality at later ages.[7]

Costa found that cardiovascular conditions in the 19th century were mostly the long-term sequelae of acute infectious disease exposure, as opposed to ischemic heart disease.[8] Also, these scarring effects of acute disease exposure are important indicators of lifetime disability and mortality declines since the UA period. Chronic "scars" of acute disease exposure have been found to reduce life span below the expected level throughout the 19th century.[9]

These and other findings on chronic disease and mortality point to the mortality or health transition in the 19th century—that as the infectious environment improved, later life disability and chronic conditions would have been more important as causes of death. This also implies that a population with reduced acute disease-related death would have higher levels of chronic disease at every age.

Riley argued that health transitions happen for a variety of causes, some of which are related to the type of conditions, some of which are more related to comorbidity.[10] The UA period was one of radical decline in infectious illness. It also saw a reduction in deaths by

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[6] Robert W. Fogel, *The Escape from Hunger and Premature Death: Europe, America and the Third World, 1700–2100* (Cambridge: Cambridge University Press, 2004).

[7] Fogel and Costa, *op. cit.* See also Angus Deaton, "Health, inequality, and economic development," *Journal of Economic Literature* 41(1), 2003, and "Measuring poverty in a growing world (or measuring growth in a poor world)," *Review of Economic Statistics* 87(1), 2005.

[8] Dora L. Costa, "Changing chronic disease rates and long-term declines in functional limitation among older men," *Demography* 30(1), 2002.

[9] Ralph Catalano and Tim Bruckner, "Child mortality and cohort life span: A test of diminished entelechy," *International Journal of Epidemiology* 35(5), 2006.

[10] James C. Riley, *Rising Life Expectancy: A Global History* (Cambridge and New York: Cambridge University Press, 2001).

infectious causes, even where infection rates remained high.[11] If chronic diseases are assumed to

accumulate throughout the life course and early-life exposure to insults results in later-life

chronic disease, it is of secondary importance whether the cause of death was acute or chronic.[12]

Riley argues that mortality will be more likely to result from each acquisition of a chronic

condition. So, in essence: the most important condition, in terms of mortality, is your next

condition, not the chronic conditions you now have.

In subsequent sections of this paper, we present limited evidence for both views: first,

that the long-term effects of chronic illness are important in predicting death cause; and second,

that an insult, or the interaction between old insults and a newly acquired insult—a soldier's next

acquired insult, whether acute or infectious—is a plausible predictor of death cause.

II

As noted, the veterans are divided into injured and uninjured. There seem to be persistent and

possibly important differences in the timing of the onset of a condition between injured and

uninjured veterans. Table 2 shows how much more or less likely injured veterans were to be

observed with specific conditions at each of the first three examinations after 1890. The first

column shows the injured were being diagnosed with new conditions at their first visit after 1890

at a greater rate than the uninjured veterans who were entering the pension system for the first

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[11] Tommy Bengtsson, "The great mortality decline: Its causes and consequences," in Núñez, C-E., ed., *Debates and Controversies in Economic History* (Madrid: Fundación Ramón Areces e Fundación Fomento de la Historia Económica, 1998).

[12] George Alter and James C. Riley, "Frailty, sickness, and death: Models of morbidity and mortality in historical populations," *Population Studies* 43(1) 1989. See also Fogel, *The Escape from Hunger and Premature Death* and Costa, "Changing chronic disease rates," *Demography* 39(2) 2002 and "Displacing the family: Union Army pensions and elderly living arrangements," *Journal of Political Economy* 105(6) 1997.

time. This indicates that with repeated pre-1890 observation, injured veterans or their surgeons may have had a more thorough understanding of the veterans' physical conditions, making them more likely to be rated for pension increases. The second and third exams, however, show dissimilarities that are much less likely to be artifacts of the data, and they indicate that the uninjured were catching up to the injured in terms of the number and type of conditions.

With respect to the data on death causes, Table 3 shows the average age at which injured and uninjured veterans died by the number of conditions with which they were diagnosed prior to death. On average, the injured were diagnosed with a little less than one-half more condition before death than the uninjured (4.86 v. 4.45). This was in part due to the fact that 43.7 percent of injured veterans were rated for wounds as opposed to only 27 percent of uninjured. On average, the uninjured veterans lived roughly four years longer, but a good deal of this difference is likely attributable to injured veterans entering the pension system early. In fact, about 16 percent of the injured veterans in the pension died before the uninjured veterans were even eligible. The table suggests some support for the insult hypothesis as the incremental age narrows for each additional condition.

Table 2

Newly Rated Conditions at Examinations After 1890
Injured During War / Uninjured During War

Condition	Examinations		
	First - Full Rating History[+]	Second	Third
Cardiovascular	1.471***	0.737***	0.813**
Diarrhea	2.230***	0.699**	0.97
Ear Diseases	1.336***	0.932	0.873
General Appearance	1.966***	0.740***	0.737***
Hernia	1.097	0.663***	0.816
Infectious Disease	2.519***	0.782	0.896
Endocrine Disease	0.826	0.535	0.557
Liver	2.102***	0.942	0.959
Rectum / Hemorrhoids	1.359***	0.861*	0.811*
Nervous System	2.657***	1.01	0.825*
Respiratory	1.437***	0.700***	0.773**
Gastrointestinal	1.693***	0.795**	0.97
Rheumatism / Musculo-skeletal	1.063**	0.682***	0.561***
Spleen	1.791***	1.284	1.367*
Tumor	1.655**	0.923	0.722
Genito-Urinary	1.579***	0.939	0.823
Varicose Veins	1.842***	0.81	0.65
Wound	2.278***	0.576***	0.577***
Eye Disorder	1.322***	0.813*	0.716**
Gallblader	2.711***	0.951	~

+ includes all conditions ever rated before 1890 among injured,
only first condition rating among uninjured

Table 3

Average Age at Death

Number of conditions	Injured		Uninjured	
	Age	n	Age	n
3	67.2	705	72.5	511
4	69.5	682	73.0	453
5	71.5	613	74.5	408
6	72.6	512	74.5	312
7	73.8	436	75.5	230
8	74.7	318	74.5	169
9	75.4	243	75.4	110
10	75.7	169	74.9	67
Overall Avg	69.1	5237*	73.2	3095

Note: Average age at death for injured veterans with 0 conditions is only 55.4 (n = 449).

Next, we evaluate the specific causes of death, which we have coded according to the same nosology used for the chronic conditions in the pension surgeons' data. The distribution of death by cause for the injured and uninjured together is indicated in Table 4. Only those causes responsible for 5 percent or more of the deaths are listed, and they account for over 80 percent of the total deaths. We will focus our analysis on this subset of six causes.

Table 4

Cause of Death on Death Certificate

Cause of death	Frequency	Percent
Cardiovascular	3138	37.66
Pulmonary	1067	12.75
Genito-Urinary	912	10.95
Gastrointestinal	677	8.13
Infectious Disease	619	7.43
Tumor	444	5.33
Other	1475	17.75
	8332	100

The disease histories of the injured and uninjured were similar. Table 5 gives the percentage of veterans who were diagnosed with the above conditions by their first and second examinations after 1890. If one allows for the fact that the injured have had many more visits with the surgeons prior to 1890 (because of their early pension eligibility), the table shows a small difference between injured and uninjured. A chi-squared test of the percentages for the second visit cannot reject the null hypothesis that the percentages are equal between the two groups.

Table 5

Conditions Rated by Visit after 1890

	First Visit (%)		Second Visit (%)	
	Injured	Uninjured	Injured	Uninjured
Cardiovascular	38.6	26.2	52.8	44.5
Infectious Disease	10.0	4.0	11.8	6.5
Tumor	1.2	0.7	1.6	1.2
Pulmonary	24.7	17.2	31	44.1
Genito-Urinary	8	5	11.9	9.2
Gastrointestinal	16.7	9.9	24.6	39.8
n	3996	3095	3187	2273

As shown in Table 6, for conditions such as tumors and genito-urinary, the age at death

was similar for the two groups. For the others, the injured died at earlier ages, particularly when

an infectious disease was involved. It seems likely that the wound that led to admission in the

pension prior to 1890 created a greater susceptibility to infectious disease.

Table 6

Death by Age for Injured vs. Uninjured

	Injured		Uninjured	
Cause of Death	Age	n	Age	n
Cardiovascular	72.5	1900	75.2	1253
Infectious disease	56.5	434	65.2	185
Tumor	71.8	261	72.6	183
Pulmonary	68.7	665	73.0	397
Genito-Urinary	73.2	532	74.5	380
Gastrointestinal	66.5	322	70.2	127

III

The next step is to examine the link between listed conditions and death causes. We concentrate

on the six death causes responsible for at least 5 percent of the deaths as reported in Table 4.

Nosological Concerns

While the nosology is the same for listed conditions and death causes, reality can be quite

different. The typical cardiovascular conditions that qualify a veteran for a pension include

indications of valvular disease, myocarditis and hypertrophy, and atherosclerosis; all that may

have been reported by the surgeon, however, is "disease of heart." Typical death causes

recorded as attributable to cardiovascular conditions include "heart disease chronic," valvular

damage, arteriosclerosis, hemorrhage, stroke, indicators of chronic congestive heart failure, and "disease of heart."

Pulmonary conditions are neither as clear nor as related. What typically appears on the surgeons' certificates are conditions such as lung disease, catarrh, congestion, and bronchitis of various types. The death certificates are dominated by pneumonia of various types (including many that are assumed in ICD guidelines to be acute), embolisms, and bronchitis. Clearly, pneumonia may result when a body is no longer able to cope with other conditions, but if it appeared on the death certificate (and it commonly did so), it was recorded as a pulmonary condition.

Gastrointestinal conditions often contained the words "chronic diarrhea," but it could not have been what one would consider chronic diarrhea today. Most likely it was persistent, episodic (acute) tropical gastroenteritis. Similar wording appeared on death certificates as well as congestion, tubercular infections, and intestinal conditions likely related to infectious disease.

The genito-urinary (kidney) problem listed on the surgeons' certificates was almost always chronic kidney disease. The death certificates were more expansive and included uremia, nephritis, Bright's and Addison's disease, prostate conditions, and cystitis. Two-thirds of "acute" designations on death certificates are genito-urinary conditions.

The infectious diseases that qualified one for a pension are largely malaria and tuberculosis, plus chronic sequelae of infection. Malaria and tuberculosis are the two chronic infectious diseases found on death certificates, but acute infectious conditions are even more likely to appear as a cause of death.

Finally, tumors were extremely difficult to identify in these years when examination was limited to what you could see with a magnifying glass, hear through a stethoscope, feel, or smell.

While an autopsy would make it possible to identify when death was attributable to a tumor, autopsies were not normally performed on the veterans in order to determine a death cause.

Cardiovascular

We begin with cardiovascular disease, which was the most frequent cause or contributing cause of death in our sample, appearing on 43.9 percent of all certificates. For those who were rated for a cardiovascular condition, Table 7 reports the frequency distribution of causes of death. The frequency among the injured is basically similar to that of the uninjured, and once again a chi-squared test is unable to reject the hypothesis that this is the case.

Table 7

Death Cause if Rated Cardiovascular

Death Cause	Injured (%)	Uninjured (%)
Cardiovascular	36.3	43.0
Infectious Disease	5.2	5.3
Tumor	5.0	6.1
Pulmonary	11.9	12.0
Genito-Urinary	10.2	12.9
Gastrointestinal	5.4	3.1
Other	26.0	17.6
	100.0	100.0
n	2851	1769

As can be seen, roughly two-fifths of those with a rated cardiovascular condition had a cardiovascular condition listed as a cause of death. An additional one-fourth had either a pulmonary or genito-urinary condition listed as the cause of death. The rest is split between a variety of causes including tumors, which (based on the diagnosis of the doctor signing the death

certificate) only accounted for only 5–6 percent of the cases. As noted earlier, this is probably an underestimate based on the limitations of diagnosis at the turn of the 20th century.

In Table 8, we look at the inverse of Table 7, the conditions with which veterans who died of a cardiovascular condition were rated. As in Table 7, a chi-squared test cannot reject the hypothesis that the two sets of proportions are equal. Almost two-thirds of those who died of a cardiovascular condition had been rated for one, but almost a third had been rated with a pulmonary condition, and almost half of the injured with a gastrointestinal condition.

Table 8

Rated Conditions for Those Whose Death Cause Was Cardiovascular

Rated Condition	Injured (%)	Uninjured (%)
Cardiovascular	64.6	60.7
Infectious Disease	12.3	7.8
Tumor	2.5	1.7
Pulmonary	33.7	31.8
Genito-Urinary	17.6	15.1
Gastrointestinal	46.1	25.8
n	2210	1444

There were several specific conditions that fell under the rubric "cardiovascular." Table 9 reports the frequency distribution of these specific conditions for those who were rated for cardiovascular. We know what type(s) of cardiovascular condition(s) each veteran had, but, in general, if he died of a cardiovascular condition, we don't know what type killed him.

Table 9

Percent of Rated for Cardiovascular with a Specified Condition

	Injured (%)	Uninjured (%)	Total (%)
Arteriosclerosis	14.5	11.1	13.2
Cyanosis	33.1	28.7	31.4
Dyspnoea	55.5	56.0	55.7
Enlarged Heart	67.6	62.0	47.6
Impaired Circulation	7.6	4.6	24.5
Murmur	62.7	56.5	48.9
Oedema	30.3	23.3	44.7
n	2851	1769	4620

Where a cardiovascular condition was listed as a cause or contributing cause of death, the differences between the injured and uninjured were relatively small, both with respect to the age at which they were first diagnosed and the number of years they lived after the diagnosis with the exception of the before-50 age group when many of the uninjured would have been ineligible for a pension.

Table 10

Cardiovascular as a Cause and Contributing Cause of Death

	Age at which first observed (%)		Mean life after diagnosis (years)	
	Injured	Uninjured	Injured	Uninjured
Before 50	22.1	15.1	37.2	27.2
In 50s	23.4	28.0	19.1	20.6
In 60s	15.7	15.2	11.8	11.6
70 and after	3.4	2.5	7.1	6.1
Never Rated	35.4	39.3		
n	2210	1444		

The Other Five Death Causes

Given that 43.2 percent of those rated with a cardiovascular condition had such a condition listed as a cause of their death (50.0 percent if contributing causes are included), there might be some evidence that what ail'd ya was indeed what kill'd ya'. That impression changes immediately when one looks at Table 11, which is identical to Table 8 for the other five causes. For veterans who died of the other major causes, they were more likely to have been rated with a cardiovascular condition than anything else.

Table 11

Rated Conditions for Those Whose Death Cause Was Other than Cardiovascular

Rated with:	Gastrointestinal (%)		Genito-Urinary (%)		Infectious Disease (%)		Pulmonary (%)		Tumor (%)	
	Injured	Uninjured	Injured	Uninjured	Injured	Uninjured	Injured	Uninjured	Injured	Uninjured
Cardiovascular	51.1	25.9	56.1	62.7	37.7	51.0	50.6	53.0	54.1	57.4
Gastrointestinal	29.8	35.0	28.8	26.0	21.3	21.9	23.7	24.9	32.0	27.2
Genito-Urinary	19.9	12.1	25.3	20.8	11.4	14.3	13.0	13.0	12.5	16.9
Infectious Disease	10.6	10.2	13.9	7.7	15.9	10.5	12.2	8.0	12.1	5.6
Pulmonary	30.7	33.8	31.4	32.1	39.8	40.0	45.3	34.6	33.8	33.8
Tumor	1.9	1.3	2.7	3.0	1.0	1.9	1.5	2.1	5.3	9.7
n	423	157	697	504	517	210	849	485	281	195

As can be seen, for all five of the other major conditions, with two exceptions, a larger percentage had been rated for a cardiovascular condition than had been rated for the condition on their death certificate. Those two exceptions are the uninjured veterans who had been diagnosed with a gastrointestinal condition and the injured veterans who died of an infectious disease. The uninjured who died of a gastrointestinal condition are the only group in Table 11 where the condition on their death certificate was the condition with which the largest share of the deceased

was rated. For the injured veterans who died of an infectious disease, the rated condition that received the largest share was pulmonary.

For the injured who died of a gastrointestinal condition, both a cardiovascular and a pulmonary condition were rated more often than a gastrointestinal condition. For the uninjured, the ranking was gastrointestinal, pulmonary, and then cardiovascular. For those who died of a genito-urinary condition or tumors, more were rated with cardiovascular, pulmonary, and gastrointestinal conditions than with a genito-urinary condition or a tumor. Those three were also more common for those who died of infectious diseases with some variation in the order, as the exception testifies. For those who died of a pulmonary condition, cardiovascular conditions are rated at a higher percentage, with pulmonary second and gastrointestinal third.

IV

To further examine these data, we use a pooled logistic regression model for the discrete time hazards in the surgeons' certificates.[13] We adopt 1890 as the baseline; the regressions include only those veterans who were alive in 1890, whether they received a pension before that year or not. Initially, the group is the 8,332 defined above, but the program eliminated the veterans for which there was only one visit to a surgeon. This means that the effective sample size was reduced to 7,544.

We began by looking at those who died of the six particular conditions (cardiovascular, pulmonary, genito-urinary, gastro-intestinal, infectious disease, and tumor) that each were responsible for at least 5 percent of the veterans' deaths. We only consider the reported cause of

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[13] There are well-defined problems that emerge when this specification is used with a fixed population. Each group has a survivor rate of 1 at the start, and they each have a rate of 0 by some year.

death; we did not include contributing causes in this analysis. In these regressions, the

dependent variable is a time-dependent indicator for having died of a particular condition (equal

to 1 if the veteran died of that condition or equal to 0 if the veteran was alive, censored, or died

of another cause that year). In each regression, we include an indicator for whether a veteran was

rated for one of the twenty specific conditions that would have made him pensionable (equal to 1

if rated or equal to 0 otherwise). Controls are included for an urban birthplace (equal to 1 if born

in one of the top 100 urban places based on population size in the 1860 Census or a foreign

birthplace and equal to 0 otherwise) and their age in 1840 (the median birth year of veterans at

baseline).[14] We include a variable for whether they were injured (equal to 1 if they were in the

pension before 1890 and equal to 0 otherwise) and an interaction term between injured and

whether or not they had received a rating for the condition listed as their cause of death. In

addition, a linear time trend is included in each regression.[15]

Table 12 reports the hazard ratios for dying from a condition given that you had that

condition (the "own" relationship) and the other variables discussed above. In the top panel, the

results for the six conditions are grouped, and the hazard ratios for cause-specific mortality

appear on the principal diagonal of this panel. The middle panel reports the ratios for the other

fourteen conditions, while the bottom panel reports the results for the control variables. It should

be noted that the coefficient on the interaction term is not statistically significant at conventional

test levels in all regressions except the one for those who died of gastro-intestinal problems. For

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[14] See Cain and Hong, *op. cit.*, for more on the hazard of urban life among these veterans. The hazard
function for the foreign born closely followed that for urban born.

[15] Alternative specifications of the time trend were estimated, but standard statistical tests led to the
conclusion that a parsimonious linear specification was all that was necessary. We also explored whether
having been rated for a cardiovascular condition modified the effect of each of the other five conditions
on cause-specific mortality, but an interaction term between having been rated for that condition and
having been rated for a cardiovascular condition did not add any explanatory power.

the five regressions where this term is not statistically significant, it is reasonable to look at a regression that combines the injured and the uninjured. This is not true for those who died of a gastro-intestinal condition.

Looking across that principal diagonal, a veteran's hazard of dying from a cardiovascular condition increases by 25 percent if he had been rated with such a condition. The hazard of dying from a pulmonary or genito-urinary condition increases by approximately 50 percent if such a condition had been rated. This is the same increase as for a gastro-intestinal condition, but this is the condition for which the injured and uninjured need to be considered separately (the complete regressions are not reported here). The hazard ratio for the injured is just under 0.8 and is statistically significant; whereas for the uninjured it is over 2.00, but not statistically significant. This suggests there may be important differences between the form gastro-intestinal conditions take between the two groups. For tumors, the hazard increases by a factor of four. For infectious diseases, the ratio increases by 15 percent, an increase that is not considered to be statistically significant.

The hazard for death due to a cardiovascular condition was less for those rated for a pulmonary condition and higher for those with a poor general appearance and varicose veins. For deaths from a pulmonary condition, the hazard was less for a veteran with a gastro-intestinal, ear or rheumatism/musculo-skeleto condition, while it increased for those with a gall bladder condition. Rheumatism reduced the hazard for those who died from genito-urinary conditions, while varicose veins increased it. The hazard of dying from a gastro-intestinal condition actually decreased for those rated with the condition, but liver, genito-urinary, and gall bladder conditions all increased the hazard. The hazard of dying from an infectious disease was increased by a

pulmonary condition and reduced by an ear condition. A nervous condition reduced the hazard of dying from a tumor.

For the hazard of dying with a gastro-intestinal condition, the combined regression suggests that the hazard was increased by the presence of a hernia or gall bladder condition. Looking at the separate regressions, no other condition has a statistically significant effect on the hazard ratio for the uninjured, but a genito-urinary, liver, or (particularly) gall bladder condition increases the hazard. Once again, the difference between the two groups requires more study.

The hazard ratio increases at approximately 8 percent a year for all the conditions that killed these veterans except infectious disease; fatal infections could strike veterans at any age. Having been born in an urban area increases the hazard ratio for deaths attributed to cardiovascular, pulmonary or tumor conditions.

For these regressions, unexpected associations between disease conditions and death causes present areas for future testing and research. Several unexpected associations might be explicable as artifacts of the UA data set and the examination schedule and procedures or as a representation of an actual medical relationship between the condition and death.

Table 12

Hazard Ratios for Injured Veterans

Rated with:	Cardiovascular	P>|z|	Pulmonary	P>|z|	Genito-urinary	P>|z|	Gastro-intestinal	P>|z|	Infectious disease	P>|z|	Tumor	P>|z|
cardiovascular	1.250	0.000	1.003	0.966	1.053	0.517	0.796	0.052	0.971	0.789	1.036	0.755
pulmonary	0.906	0.021	1.582	0.000	0.872	0.087	0.925	0.518	1.633	0.000	0.982	0.869
genito-urinary	1.030	0.580	1.032	0.742	1.578	0.001	1.223	0.153	0.994	0.971	0.953	0.744
gastro-intestinal	0.982	0.730	0.811	0.029	0.948	0.571	1.544	0.036	0.871	0.377	1.105	0.476
infectious disease	0.954	0.460	0.991	0.938	1.156	0.218	1.097	0.584	1.150	0.623	0.978	0.899
tumor	0.863	0.266	0.775	0.287	1.067	0.754	0.759	0.482	0.524	0.191	4.484	0.000
diarrhea	1.007	0.904	0.888	0.219	1.013	0.891	1.172	0.274	0.876	0.365	1.011	0.938
ear	0.977	0.639	0.800	0.013	0.964	0.696	1.135	0.357	0.685	0.017	1.011	0.934
general appearance	1.107	0.017	1.036	0.625	1.094	0.255	0.847	0.163	1.187	0.107	1.084	0.477
hernia	0.995	0.918	0.897	0.233	1.107	0.248	1.299	0.039	0.969	0.839	1.106	0.427
kidney-endocrine	0.747	0.134	1.016	0.962	0.731	0.403	0.666	0.485	0.641	0.333	0.391	0.195
liver	0.985	0.808	1.005	0.966	0.951	0.661	1.373	0.061	1.272	0.184	0.949	0.752
rectum-hemoroids	0.925	0.094	0.973	0.743	0.912	0.283	1.071	0.607	0.854	0.220	1.111	0.399
nervous	1.082	0.074	1.098	0.227	1.047	0.572	0.993	0.957	1.052	0.694	0.765	0.027
rheumatism-m/s	1.046	0.290	0.759	0.000	0.843	0.026	0.896	0.322	0.919	0.426	0.875	0.222
spleen	0.921	0.282	1.041	0.783	0.734	0.058	0.998	0.990	0.895	0.597	0.925	0.719
vericose veins	1.249	0.000	1.032	0.797	1.278	0.033	1.139	0.471	0.853	0.434	1.298	0.123
wounds	0.988	0.780	1.004	0.961	1.053	0.498	1.007	0.952	1.060	0.614	0.946	0.615
eyes	0.943	0.196	0.960	0.599	1.011	0.899	0.992	0.948	0.990	0.943	0.941	0.610
gall bladder	0.611	0.081	2.194	0.029	0.865	0.784	2.631	0.036	1.327	0.692	1.119	0.861
urban	1.210	0.000	1.326	0.000	1.142	0.090	1.086	0.478	0.989	0.924	1.317	0.011
age1840	1.088	0.000	1.105	0.000	1.095	0.000	1.084	0.000	0.998	0.796	1.060	0.000
injured	1.038	0.542	0.955	0.614	0.959	0.611	1.669	0.000	0.867	0.255	1.160	0.173
inj X rated death cause	1.129	0.120	1.170	0.249	1.157	0.404	0.612	0.033	1.392	0.320	0.493	0.099
time	1.102	0.000	1.082	0.000	1.100	0.000	1.054	0.000	0.954	0.000	1.087	0.000
constant	0.002	0.000	0.001	0.000	0.001	0.000	0.001	0.000	0.081	0.000	0.000	0.000

First, within-cause or within-condition heterogeneity makes it difficult to determine if a particular relationship ought to be expected. For example, the hazard of death by genito-urinary condition appears to be increased by the presence of varicose veins. Genito-urinary conditions causing death ranged from nephritis to hepatitis to pancreatic cancer. And within each of those deadly conditions, there is also variation. For example, while nephritis and varicose veins might both be symptoms of a cardiovascular condition, nephritis had other causes, including infection.

Second, a protective condition might simply be one that is so severe that it protects against death by any condition but itself (or a related condition). Consider the protection against death by tumor offered by nervous conditions. This might indicate simply that brain injuries and brain infections are more likely to cause death than even an extremely advanced tumor.

Third, unexpected relationships between disease conditions and causes of death might be a result of the differential detectability of specific diseases. Some diseases, like arteriosclerosis, stroke, and tumor, were not detectable by surgeons until they reached extreme severity. The presence of these conditions might have indicated a higher hazard of death by certain conditions, or a higher hazard of contracting an acute condition leading to death. Conversely, the presence of rheumatism was easy to observe (it only required the presence of pain or tenderness in the joints and muscles) and was nearly ubiquitous at older ages. It might have indicated heartiness as much as anything else. Also, easily detectable conditions that were more likely to strike younger men, such as wounds, hernias, and hemorrhoids that were the result of wartime experience, might simply be chronic, non-deadly conditions that indicate a soldier's ability to survive.

Fourth, uninjured soldiers could have been protected against death by infectious causes from previous exposure to an infectious disease. This might be a medically verifiable relationship, whereby a veteran gained immunity to future infectious conditions because of his

wartime experiences in the camps or because he was born in an urban area where the infectious disease environment was much different than in a rural area. Also, there is the now known association between infectious diseases and chronic conditions and tumors.

Finally, differences in the chronicity of diseases and death causes might underlie the unexpected associations between them. Gastro-intestinal conditions tended to be protective against death as a result of a gastro-intestinal condition among the injured. This may be simply that the gastro-intestinal conditions noted on surgeons' certificates were not deadly conditions and didn't increase a soldier's hazard of contracting a deadly gastro-intestinal condition, but that they were more likely to weaken his system in other ways. For example, mild, tropical enteritis need not be a harbinger of death by stomach ulcer or of chronic diarrhea of infectious origin, but it might indicate imminent death by another less immediate cause.

We briefly turn to the Riley-Alter insult hypothesis. Table 13 examines this hypothesis with the specific ratable conditions established by the pension board.[16] In this data, the dependent variable is the number of deaths occurring in a year. The independent variable "numconds" is the total number of unique rated conditions for each veteran each year beginning in 1890. We also included an interaction term between the number of conditions and number of injured (those in the pension system before 1890) to determine if we could view the veterans as a single population. The model includes a linear time trend, their age in 1840, and an indicator for whether they had an urban-foreign birth place.

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[16] See, for example, James C. Riley, *Sickness, Recovery and Death: A History and Forecast of Ill Health* (Iowa City: University of Iowa Press, 1989) and Riley and George Alter, "The epidemiological transition and morbidity," *Annales de Démographie Historique*, 1989.

Table 13

"Insults" Regression Result

	Hazard ratio	z
numconds	1.018	3.18
numcondinj~d	1.006	1.21
urban	1.188	6.38
age1840	1.096	45.40
t	Y	

The results indicate that for each additional condition with which a veteran was rated, the hazard ratio increased by 1.8 percent. There was no statistically significant difference between those who entered the pension system before 1890 and those who entered later. Being born in an urban area increases the hazard, as does each year of age.

V

In sum, we return to the question: was what ail'd ya' what kill'd ya'? In general, once a veteran was rated for a particular condition, his hazard of dying from that condition increased. All the coefficients on the principal diagonal of Table 12 are greater than one, and all save that for infectious diseases are statistically significantly greater than one at the 95 percent level of confidence.

Why this is so requires further research. All these associations, both expected and unexpected, will be the subject of future work with the Union Army data set that will require the analysis of more disaggregated disease and death variables than are currently publicly available.

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