Was What Ail'd Ya' What Kill'd Ya'?*

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Using the *Early Indicators* life-cycle health histories of Union Army veterans, we compare the death certificates of veterans (and other documents and affidavits that declare a cause of death) to the conditions with which they were diagnosed by Civil War pension surgeons. We will 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 Union 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 where the source is detailed physical examinations, completed by a member of a local pension surgeon's board, detailing the health and disability status of Union Army veterans who applied for a pension.

The support for the idea that what ailed you is what killed you is limited at best. In sum, of the 8,332 veterans in our sample, 96.42 % 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.

We divide the sample into two groups. The first are "injured" veterans who were either injured during the war or developed a chronic condition related to wartime service and were thus immediately eligible for pension funds. The second, "uninjured" veterans, entered the pension system after the1890 reforms that made the pension available to many more veterans, first on the basis of the veterans' chronic disease conditions and then, after 1907, solely on the basis of age. Pension awards were related to veterans' health status, which was verified by the local pension surgeons' board according to examination standards and procedures set by the US Bureau of Pensions. The Bureau's disease definitions, while they differ from current disease classification schema, will be used in this analysis. Semantic and diagnostic differences arising from differences between 19th century medical knowledge and current medical understanding will be noted. This will be discussed in some detail below.

Pension surgeons did not diagnose conditions, *per se*. Rather, they described observed symptoms in vivid detail and, sometimes, would give what they believed to be the underlying medical

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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, and it is from these examinations, and from the veterans' death certificates, that we get our data.

I

The *Union Army Data Set* (UA) 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 US 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. 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% 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 after-effects 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 sequellae of disease and injury exposure—were only admitted to the pension after an 1890 act of Congress extended the Union Army pension to all veterans with any verifiable chronic health condition, regardless of its cause (exceptions were chronic diseases resulting from "vicious habits," which were not pensionable).

Pension History, and the Pension Data

All pensions required an examination by a surgeon's board located in the applicant veteran's county or congressional district. These surgeon's 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 Surgeon's recommendations were forwarded to the US Bureau of Pensions for a ruling on pension amount. For most pensioners, the maximum amount for an "Invalid Pension" was 12 to

[1] Fogel, Robert W,. 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."

18 dollars per month, receivable in person at the post office closest to the veterans' 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)	Vericose 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 dollars; veterans who were simply old applied under the 1907 law, which awarded 62-year-olds 12 dollars and 72-year-olds 15 dollars 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. Therefore, we have a fairly good idea of who was "injured" and who was "uninjured" prior to examination, and of who was sick and who was not sick once they were in the pension.

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, thus in the UA data set. Pensioners without successor applicants might still have a death date, since the Pension Bureau could only drop a pensioner with proof of death. In the UA data, death causes have been coded and classified according to the same nosology used to categorize the diseases on the surgeon's 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% of the UA ended up in the pension, either because they were qualified under a relevant statute or because they had a successor who applied on their behalf. Only about 60% were admitted to the pension as invalids; and 51% have surgeon's certificates. A not-entirely-overlapping 52% 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, less 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% of those who were admitted to the pension came in after 1890. Less than 1% came into the pension after 1907. Ten percent died before 1890; thirty percent, 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 surgeon's certificates; and who had both a recorded death date and a death cause or contributing cause, divided into pre-1890 and post-1890 pensioners—the "injured," and the "uninjured."

Data Limitations

Using the UA data is difficult, both because of certain biases that may be present and because it requires users to make certain assumptions about both the meaning of surgeon's certificates and about the relevance of medical history.

The inputting of the surgeon's data and the death cause data was designed, supervised, reviewed, and corrected by medical doctors at 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 this approach, the CPE doctors simply coded the symptoms separately without regard to comorbidities present. This is a reasonable approach in most cases. However, sometimes, this presents problems. Consider a case where a veteran is observed with what the surgeon calls "chronic diarrhea," and that he is also observed with "blindness." CPE doctors coded chronic diarrhea and blindness as separate conditions, unless the pension surgeon had noted that he 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 would many would diagnose as "congestive heart failure." Unless the pension surgeon noted "congestive heart failure" on the surgeon's certificate, we do not make such determinations. CPE doctors took the symptoms they were given and coded

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[2] See Cain, Louis P,. and Sok Chul Hong, "Survival in 19th Century Cities: The Larger the City, the Smaller Your Chances," *Explorations in Economic History*, October 2009.

[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: The University of Chicago Press, 2003).

them as conditions of lungs, kidneys, and heart; the three were assumed to be independent of one another. So, if the soldier ends up dying of pneumonia, it is 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, and 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. 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 cause. 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 build-up 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 sequellae, they will be noted by the surgeon. 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 build-up 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 sequellae (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 male infant mortality rates decline rapidly as infections became less important as causes of population death.[5] Fogel observed an 84% decline in urban infant mortality rate (IMR) disparities between 1890 and 1920, so that by 1930 the reduction in

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

[5] Drevenstedt, G.E., E. Crimmins, S. Vasunilashorn, C. Finch. "The Rise and Fall of Excess Male Infant Mortality." *Proceedings of the National Academy of Sciences*. 105, 2008.

disparity was nearly equal to the reduction in overall IMR.[6] This points to a decline in infection as a death cause. 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 sequellae of acute infectious disease exposure, as opposed to ischemic heart disease.[8] Also, that 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 infectious causes, even where infection rates remained high.[11] If chronic diseases are assumed to build up over the life course, and following, early life exposure to these insults results in later-life chronic disease, under such a regime, whether the condition that causes death is acute or chronic is of secondary importance.[12] Riley argues that mortality will be more likely to result from each acquisition of a chronic condition. So that, in essence, the most important condition in terms of mortality is your next condition, not the chronic conditions you now have.

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

9 Catalano, Ralph, and Tim Bruckner, "Child Mortality and Cohort Life Span: A Test of Diminished Entelechy," *International Journal of Epidemiology* 35(5) 2006.

10 Riley, James C., *Rising life expectancy: a global history* (Cambridge and New York: Cambridge University Press, 2001).

11 Bengtsson, Tommy, "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 Alter, George, 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," and "Displacing the Family: Union Army Pensions and Elderly Living Arrangements," *Journal of Political Economy* 105(6) 1997,

In subsequent sections of this paper, we present limited evidence for both views: that the long-term effects of chronic illness are important in predicting death cause; and 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, however. 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 for the first time, indicating 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.

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

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% of injured vets were rated for wounds as opposed to only 27% 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 early. In fact, about 16% 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 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

- 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% or more of the deaths are listed, and they account for over 80% 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	8 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 show a small difference between injured and uninjured.

Table 5
Conditions Rated by Visit after 1890

Percent Rated 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

Age At Death	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% 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 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 surgeon's 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 surgeon's 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 sequellae 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% 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 uninjured is basically similar to that of the uninjured.

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% 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.

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

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.

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	
	Injured percent	Uninjured percent	Injured years	Uninjured years
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% of those rated with a cardiovascular condition had such a condition listed as a cause of their death (50.0% 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 are 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

	Gastrointestinal		Genito-Urinary		Infectious Disease		Pulmonary		Tumor	
	Injured	Uninjured	Injured	Uninjured	Injured	Uninjured	Injured	Uninjured	Injured	Uninjured
Rated with:										
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, 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

We use a pooled logistic regression model for the discrete time hazards in the surgeons' certificates to further examine these data.[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

[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.

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 were each responsible for at least five percent of the veterans' deaths. We only considered the reported cause of 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 (=1 if the veteran died of that condition or = 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 (=1 if rated or =0 otherwise). In addition, a cubic polynomial of time is included in each regression (t, t^2 and t^3), as are controls for their age in 1840 (the median birth year of veterans at baseline) and an urban birth place (=1 if born in one of the top 100 urban places based on population size in the 1860 Census or a foreign birthplace and 0 otherwise).[14] We explored whether having been rated for a cardiovascular condition modified the effect of each of the other five conditions on cause-specific mortality. For each of these conditions, we included an interaction term between having been rated for that condition and having been rated for a cardiovascular condition. In the Appendix Table, we report the complete regression with all the coefficients (log hazard ratios) for a cardiovascular condition so that the form of these regressions is evident.

Tables 12, 13, and 14 report the hazard ratios for dying from a condition given that you had that condition (the "own" relationship) for the injured, the uninjured, and both groups together, respectively. Those that are not statistically significant are bolded. The other hazard ratios reported are those that are statistically significant at the five percent level. The interaction term for having the given condition and a cardiovascular condition only proves to be statistically significant for the uninjured in the cases of infectious disease and tumors.

Looking across the three tables, the hazard ratio for cause-specific mortality increases at an average rate of 7.1% per year of age, but it reaches 21.3% for the injured who died of a cardiovascular condition. Having been born in an urban area increases the hazard ratio for deaths attributed to cardiovascular and pulmonary conditions across the board, and that for tumors in the case of the injured (thus, the combined). It does not have a statistically significant effect for deaths due to genito-urinary, gastro-intestinal, or infectious disease conditions.

[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.

Table 12
Hazard Ratios for Injured Veterans

Died from	cardio-vascular	pulmonary	genito-urinary	gastro-intestinal	infectious disease	tumor
Rated with						
cardiovascular	1.474					
pulmonary	0.883	1.959			1.873	
genito-urinary			1.790	1.464		
gastro-intestinal		0.713		**0.777**		
infectious disease					**1.380**	
tumor					0.070	**1.052**
had cause x had cardio	-	N	N	N	N	N
diarrhea						
ear						
genl appearance						
hernia						
kidney-endocrine						
liver				1.599		
rectum-hemorroids			0.789		0.588	
nervous						
rheumatisn-m/s		0.708	0.817			
spleen						
vericose veins	1.234					
wounds						
eyes						
gall bladder		3.159		3.101		
urban	1.086	1.362	N	N	N	1.378
age1840	1.213	1.109	1.091	1.091	N	1.074
t	Y	Y	Y	Y	N	N
t2	Y	N	N	N	Y	N
t3	N	N	N	N	Y	N

Note: Numbers in bold type in this and the following three tables reflect hazard ratios that are not statistically significant at the 5% level.

The hazard for death due to a cardiovascular condition was less for those rated for a pulmonary condition and higher for those with vericose veins. For deaths from a pulmonary condition, the hazard was less for a veteran with a gastro-intestinal condition or rheumatism, while it increased for those with a gall bladder condition. Both rectum-hemorrhoids and rheumatism reduced the hazard for those who died from genito-urinary conditions. 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 reduced by both rectum-hemorrhoids and tumor and increased by a pulmonary condition. No condition had a statistically significant effect on the hazard of dying from a tumor.

Turning to the uninjured in Table 13, it is tumors that now reduce the hazard of dying from a cardiovascular condition, while vericose veins have the same effect as in the injured. Rheumatism continues to decrease the hazard of dying from a pulmonary condition, but a gastro-intestinal condition now increases one's hazard, and the effect of a gall bladder condition is no longer statistically significant. The hazard of dying from an infectious disease is reduced by being rated for the condition. A gastro-intestinal condition has the same effect, while a pulmonary condition raises the hazard. The hazard of dying from one of the other three conditions is increased by being rated for the condition, and that "own" effect is the only one that is statistically significant.

Table 13
Hazard Ratios for Uninjured Veterans

Died from	cardio-vascular	pulmonary	genito-urinary	gastro-intestinal	infectious disease	tumor
Rated with						
cardiovascular	1.187					
pulmonary		1.750			1.447	
genito-urinary			1.900			
gastro-intestinal		1.340		2.315	0.546	
infectious disease					**0.391**	
tumor	0.517					11.603
had cause x had cardio	-	N	N	N	4.433	0.210
diarrhea						
ear						
genl appearance						
hernia						
kidney-endocrine						
liver						
rectum-hemorroids						
nervous						
rheumatisn-m/s		0.799				
spleen						
vericose veins	1.231					
wounds						
eyes						
gall bladder						
urban	1.043	1.258	N	N	N	N
age1840	1.089	1.097	1.105	1.066	N	1.041
t	Y	Y	Y	Y	N	Y
t2	Y	N	N	N	N	N
t3	Y	N	N	N	N	N

Table 14 reports the results when the injured and uninjured are combined. Generally, the pattern, if not the magnitude, follows the pattern of the injured. The hazards associated with death from a cardiovascular condition remain the same, while those associated with a pulmonary condition are the same as the hazards that proved statistically significant in the injured case, but here ear conditions proved statistically significantly in reducing the hazard. For deaths attributable to a genito-urinary condition, rheumatism continues to reduce the hazard, but the effect of a rating for rectum-hemorrhoids is no longer statistically significant, while a rating for vericose veins now

Table 14
Hazard Ratios for All Veterans

Died from	cardio-vascular	pulmonary	genito-urinary	gastro-intestinal	infectious disease	tumor
Rated with						
cardiovascular	1.347					
pulmonary	0.883	1.872			1.652	
genito-urinary			1.828			
gastro-intestinal		0.819		**1.173**		
infectious disease					**1.016**	
tumor						4.272
had cause x had cardio	-	N	N	N	N	N
diarrhea						
ear		0.802				
genl appearance						
hernia						
kidney-endocrine						
liver						
rectum-hemorroids						
nervous						0.769
rheumatisn-m/s		0.755	0.840			
spleen						
vericose veins	1.234		1.276			
wounds						
eyes						
gall bladder		2.187		2.813		
urban	1.213	1.329	N	N	N	1.306
age1840	1.086	1.104	1.096	1.087	N	1.062
t	Y	Y	Y	Y	N	Y
t2	N	N	N	N	Y	N
t3	N	N	N	N	N	N

increases the risk in a statistically significantly fashion. The hazard of death from a gastro-intestinal condition is increased if one is rated for such a condition, but the effect is not statistically significant. A gall bladder continues to increase the hazard, but genito-urinary conditions no longer have a significant effect on the hazard. A rating for infectious disease now increases the hazard of dying from an infectious disease, but it is not statistically significant either. However, the hazard of dying from an infectious disease if one is rated for a pulmonary condition is increased. Finally, for tumors, it is now the case that having been rated for a nervous condition reduces the hazard of dying from tumors.

For the above 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 Union Army data set and the examination schedule and procedures or as a representation of an actual medical relationship between the condition and death.

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 (Table 14). Genito-urinary conditions causing death ranged from nephritis to hepatitis to pancreatic cancer. And within each of those deadly conditions, there's 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 (Table 14). 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 their wartime experiences in the camps or because they were 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 (Table 12). 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, 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.

Finally, we turn to the Riley-Alter insult hypothesis. Table 15 examines this hypothesis with the specific ratable conditions established by the pension board.[15] 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 injured (those in the pension before 1890) to determine if we could view the veterans as a single population. As before, the model includes a cubic polynomial of time, their age in 1840, and an indicator for whether they had an urban-foreign birth place.

Table 15
"Insults" Regression Result

	Hazard ratio	z
numconds	1.019	3.35
numcondinj~d	1.005	1.16
urban	1.189	6.40
age1840	1.096	45.65
t	Y	
t2	N	
t3	N	

The results indicate that for each additional condition with which a veteran was rated, the hazard ratio increased by 1.9%. There was no statistically significant difference between those who entered the pension before 1890 and those who entered later. Being born in an urban area increases the hazard, as does each year of age.

V

[15] See, for example, Riley, James C., *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.

In sum, we return to the question: was what ail'd ya' what kill'd ya'? Table 16 reports the coefficients for the "own" condition from Tables 12-14.

Table 16
Hazard of Dying from Condition if Rated for Condition

		injured	uninjured	all
cardio-	vascular	1.474	1.187	1.347
pulmonary		1.959	1.750	1.872
genito-	urinary	1.790	1.900	1.828
gastro-	intestinal	**0.777**	2.315	**1.173**
infectious	disease	**1.380**	**0.391**	**1.016**
tumor		**1.052**	11.603	4.272

Note: Numbers in bold type in this and the following three tables reflect hazard ratios that are not statistically significant at the 5% level.

In general, once a veteran was rated for a particular condition, his hazard of dying from that condition increased. For cardiovascular, pulmonary, and genito-urinary conditions, the experiences of the injured and the uninjured were relatively similar. For gastro-intestinal conditions, infectious diseases, and tumors, the experiences were vastly different.

For the three most common causes of death, cardiovascular, pulmonary, and genito-urinary, the answer to the titular question is "there's a good chance" for the injured and uninjured. For deaths due to gastro-intestinal conditions or tumors, that answer only applies to the uninjured, those who entered the pension after 1890. For infectious disease deaths, the answer is "it's unlikely" for both groups.

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.

Appendix Table
Complete Regression for All Veterans who Died of a Cardiovascular Condition

died_c	Coef.	Robust Std.Err.	z	P>|z|	Hazard Ratio
had_c	0.2976	0.0439	6.78	0.000	1.347
had_d	0.0276	0.0536	0.51	0.607	1.028
had_e	-0.0168	0.0500	-0.34	0.737	0.983
had_k	-0.2868	0.1944	-1.48	0.140	0.751
had_y	-0.0599	0.0458	-1.31	0.191	0.942
had_q	-0.0222	0.0524	-0.42	0.671	0.978
had_u	0.0320	0.0542	0.59	0.556	1.032
had_h	0.0006	0.0509	0.01	0.990	1.001
had_i	-0.0323	0.0641	-0.50	0.615	0.968
had_l	-0.0087	0.0621	-0.14	0.889	0.991
had_s	-0.0816	0.0776	-1.05	0.293	0.922
had_z	-0.4826	0.2796	-1.73	0.084	0.617
had_t	-0.1535	0.1336	-1.15	0.250	0.858
had_n	0.0944	0.0437	2.16	0.031	1.099
had_m	-0.0764	0.0468	-1.63	0.103	0.926
had_p	-0.0893	0.0431	-2.07	0.038	0.915
had_r	0.0398	0.0425	0.94	0.349	1.041
had_v	0.2330	0.0635	3.67	0.000	1.262
had_g	0.1075	0.0428	2.51	0.012	1.114
had_w	0.0117	0.0409	0.29	0.774	1.012
urban	0.1850	0.0426	4.35	0.000	1.203
age1840	0.0857	0.0033	25.76	0.000	1.089
t	0.0842	0.0139	6.08	0.000	1.088
t2	0.0004	0.0007	0.69	0.492	1.000
t3	0.0000	0.0000	-0.46	0.642	1.000
_cons	-6.0029	0.0877	-68.49	0.000	0.002

Logistic regression
Number of obs = 167714
Wald chi2(25) = 3053.21
Prob > chi2 = 0.0000
Log pseudolikelihood = -13485.161
Pseudo R2 = 0.1100
(Std. Err. Adjusted for 7544 clusters in recidnum)