

# The burden of disease of Union Army veterans\*

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## Abstract

This note applies indicators of burden of disease to the veterans of the Union Army to study the patterns of morbidity and mortality of the Civil War veterans in terms of years of life lost due to premature death (YLLs), years lived with disability (YLDs), and disability-adjusted life years (DALYs). It identifies cardiovascular, rheumatism and injuries as the principal conditions responsible for YLDs in historical populations and infectious diseases and chronic diarrheas as the main conditions responsible for YLLs. The note compares the disease burden of Union Army veterans with of rich and poor countries at the end of the twentieth century. It finds that the burden of disease in 1890 correlates with the burden of disease in middle income regions like Latin America and the formerly socialist economies.

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# 1 Introduction

This note applies indicators of burden of disease to the veterans of the Union Army in order to study the patterns of morbidity and mortality of Civil War veterans. The paper employs measures derived from the Global Burden of Disease (GBD) developed by Murray and Lopez [11]. We consider years of life lost due to premature death (YLLs), years lived with disability (YLDs), and disability-adjusted life years (DALYs). All measures were obtained from individual data and medical histories of the recruits in the surgeon's certificates collected by Fogel [3].

The purpose of this note is to quantify the effect of different conditions and their severity on the health of Union Army veterans. In particular, the use of burden of disease measures serves to determine the changes in health related to changes in ages of onset and changes in disability rates. As Fogel [4] has pointed out, the recent increase in life expectancy does not appear to have worsen off health since the age of onset has increased and the severity of chronic conditions has declined over the twentieth century. As it follows from the discussion in Murray and Chen [9], Murray and Chen [10], and Riley [13], these changes are fundamental to understand modern morbidity change.

The data employed in the paper is drawn from the Early Indicators Project described in Fogel [3]. Since the Early Indicators contains individual data, we are able to overcome some of the limitations of the GBD study. For example, to measure disability, the GBD applies disability rates based on aggregate measures of health status (or measures developed for the average individual). Although the measures of disability were obtained by physicians, the GBD assessment of severity is done by indirect inferences related to particular conditions and not individualized cases. In contrast, the content of every surgeon's certificate in the Union Army includes the medical assessment of the veteran's health and disability measures determined by individual evaluations of health at each examination. Also, since the Union Army data follows individuals over time, we are able to establish *life time* measures of disease burden and not just *cross section* estimates as in the GBD.

The paper focuses on adults older than 45 years of age alive between 1862 and 1940. Veterans of the Union Army experienced several conditions at the same time with long duration and moderate disability rates but we find that the main conditions responsible for premature death, besides injuries, are infectious diseases and fevers, and chronic diarrhea. In general those conditions had

early ages of onset and high fatality rates. The main cause of disabilities were cardiovascular and rheumatism/musculoskeletal conditions. Overall, veterans in the Union Army lost about three years by disabilities related to both conditions. That represents fifty percent of all YLDs. In total, the average number of years lost due to premature death and disability were 11 and 7.

The comparison with the disease burden of rich and poor countries at the end of the twentieth century indicates that the health conditions of the Union Army correlate with middle income regions like Latin America and the formerly socialist economies.

The paper proceeds as follows. In the second section we present an overview of the measures and data employed. The third section presents our findings and a brief comparison of historical and modern populations. Finally, the fourth section concludes.

## **2 Data and methods**

This section briefly describes the data used and the measures employed by the GBD. More detailed information on the Union Army data set can be found in Fogel [3], and a complete analysis of burden of disease measures in Murray and Lopez [11].

### **2.1 Union Army data set**

The Union Army data set contains 35,570 men out of a randomly drawn sample of 39,616 males mustered into the Army during 1861-1865. The sample is restricted to white males from 331 companies chosen randomly out of more than 20,000 from the National Archives records at Washington D.C. The data includes military, socioeconomic, and medical information from several sources on these men throughout their lifetimes. The “Military, Pension and Medical Records” and the “Surgeons’ Certificates” compiled wartime records and military documents including applications made by veterans for pension support. Associated with these pension applications are detailed physical examinations, completed by physicians, that certify the veterans’ health and disability status. The surgeons’ certificates contain 87,223 medical exam records for 17,721 pensioners (an average of 4.92 exams per veteran) from 1862 to 1940. A medical examination was given every time a Civil War’s veteran applied for a new pension or renewed an old one.

For each recruit, physicians would assess the recruit’s general health and diagnose any specific disability or disabilities he suffered. Physicians, appointed by the Bureau of Pensions, assigned a disability rate for every condition to reflect its severity and the impact of that condition on the veteran’s capacity to perform manual labor and produced a certificate. The physicians were also instructed to estimate the total disability rate based on the veteran’s total inability to do manual labor and not on the sum of the specific diseases’ ratings. These disability rates were a determining factor for monthly pensions awarded by the Pension Bureau.<sup>1</sup>

Because examining physicians had very detailed instructions regarding patient examination and disability measurement, the Surgeon’s certificates are relatively uniform. However, since the purpose of the exam was qualification for pension support, only “pensionable” conditions were likely to be recorded in the examinations.<sup>2</sup>

The data set contains basic physiological measures and numerical ratings for individual conditions at the time of the medical examination.<sup>3</sup> The conditions presented by the veterans were classified in the following groups: i) Cardiovascular, ii) Diarrhea, iii) Gastrointestinal, iv) General appearance (blood, nutrition and skin, gum and teeth and muscles), v) Genito-urinary, vi) Hernias, vii) Infectious diseases/fevers, viii) Injury/gun shot wounds (GSW), ix) Liver, x) Neoplasm/tumors, xi) Nervous disorders, xii) Rectum/hemorrhoids, xiii) Respiratory, xiv) Rheumatism/musculoskeletal (MSK), xv) Other (ear, endocrine, eye, spleen, gallbladder, and varicose veins). These conditions are later matched to the diseases analyzed by the GBD in an attempt to compare the burden of disease for the Union Army and modern day populations.

Table 1 presents the aggregate measures of onsets and disability in the sample. The table includes averages and standard deviations (in parentheses). On average, the number of cases diagnosed was 6,809 with fifty percent of all cases rated. Liver and genito-urinary conditions presented the lowest percentage of rated to diagnosed cases and hernias and rheumatism the highest fraction of rated cases. The most common conditions were rheumatism/MSK and cardiovascular diseases, and the least common were neoplasm/tumors, infectious diseases, and hernias. The ages of

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<sup>1</sup>Linares [7] includes a detailed study and methodological revision of the disability rates in the surgeons’ certificates.

<sup>2</sup>In several cases conditions were listed even if the applicant did not qualify for pension assistance.

<sup>3</sup>Each veteran’s pension file also includes information on his birth, residences after discharge, a summary of military and medical wartime experience, and family information.

onset varied from age 47 for injuries to age 58 for genito-urinary and on average, veterans suffering from neoplasm/tumors and infectious diseases lived 0.74 and 1.42 years respectively. Veterans diagnosed with cardiovascular conditions, injuries/GSW, rheumatism and general appearance lived more than ten years after their first diagnosis. On average, Union Army veterans were diagnosed at the age of 53 and lived 7 years after their first diagnose.

Table 1. Average age of onset and disability rates, Union Army.

Disease	Cases diagnosed	Cases rated	Age at first diagnosis	Years lived after first diagnosis	Average disability rate
Cardiovascular	10,714	7,431	54.97 (8.94)	11.07 (11.59)	10.58 (5.93)
Diarrhea	4,734	3,601	51.34 (9.45)	5.74 (10.96)	9.76 (5.28)
Gastrointestinal	7,563	2,212	53.02 (8.79)	8.61 (11.90)	7.87 (4.82)
General appearance	13,930	3,350	51.24 (9.79)	16.55 (12.85)	12.10 (12.68)
Genito-urinary	8,486	1,828	58.02 (8.56)	7.78 (10.06)	7.83 (6.06)
Hernias	3,133	2,621	55.01 (10.05)	3.31 (8.34)	10.60 (4.43)
Infectious/fevers	1,258	900	52.71 (9.41)	1.42 (5.80)	9.36 (5.77)
Injury/GSW	7,860	5,685	47.51 (12.49)	10.42 (14.56)	10.91 (8.76)
Liver	6,100	1,075	54.13 (8.59)	6.64 (10.75)	7.83 (6.35)
Neoplasm/tumor	794	239	57.10 (9.32)	0.74 (4.00)	10.30 (10.36)
Nervous	7,416	2,084	53.90 (10.59)	7.92 (11.68)	14.02 (15.32)
Rectum/hemorrhoids	6,517	4,421	53.02 (8.10)	7.47 (11.31)	7.91 (4.32)
Respiratory	9,048	4,508	53.17 (9.70)	9.87 (12.12)	8.39 (6.30)
Rheumatism/MSK	11,487	8,868	52.96 (8.35)	13.13 (12.29)	9.11 (5.68)
Other	3,096	1,144	56.74 (8.77)	3.15 (6.66)	10.39 (8.09)
Mean	6,804	3,331	53.65	7.59	9.79

Disability rates varied little among conditions. The average disability rate for the sample is 9.79

percent and the highest disability rates were associated with nervous conditions, general appearance, hernias, and cardiovascular diseases. Liver, genito-urinary, and gastrointestinal conditions exhibited low disability rates.

## 2.2 Burden of disease measures

DALYs measure the impact of premature mortality and early onset of disease in a single indicator of disease burden. DALYs measure health outcomes as the product of two events: the number of years lost due to premature mortality (YLLs) and the number of years lost due to disability (YLDs). Although the measures are not described directly in this terms, both indicators “price” the time individuals are affected by a given condition according to a series of assumptions on the willingness to pay for mortality and morbidity changes. The assumptions underlying the measures have been extensively debated on conceptual, empirical and ethical basis but no current alternative is free from similar criticisms, see Murray and Lopez [12], and Murray and Acharya [8].

Consider an individual whose age of onset of a given condition (or premature death) is  $a$ . The disease burden due to that condition (or premature death) is

$$\int_a^{a+L(a)} D(x)Cxe^{-\beta x}e^{-r(x-a)}dx = Ce^{ra} \int_a^{a+L(a)} xP(x)dx. \quad (1)$$

The interpretation of additional terms in the formula is as follows, Murray and Lopez ([11], 64-66).  $C$  is a constant that normalizes the pricing function due to unequal age weights and  $L(a)$  is the duration of the condition in the case of disabilities or the standard life expectancy at age  $a$  in the case of death.  $r$  and  $\beta$  are the rate of discount and the age-weighting parameter.

The second equality represents the claim that burden of disease measures “price” the time spent in different health states. There is no reference to behavioral aspects or implicit valuation methods in Murray and Lopez [11]. Rather, the GBD study imposes a functional form on  $P(x)$  by  $P(x) = D(x)e^{-(r+\beta)x}$  and a constant disability rate  $D(x) = D$  with  $P'(x) < 0$ . Behind  $P'(x) < 0$  there are assumptions on time discounting and age-weighting.<sup>4</sup> Both assumptions consider that

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<sup>4</sup>Note that the constant term outside the pricing function,  $Ce^{ra}$ , is approximately equal to one for  $C = 0.1658$  if  $a = 60$  and  $r = 0.03$ . In that sense the pricing of disability is carried out in relative terms. No reference on how  $C$  is computed is present in Murray and Lopez [11]. Murray and Achaya ([8], footnote 5) just mention that  $C$  “is introduced so that the use of non-uniform age-weights does not affect the total number of DALYs in the world in

current health changes are more important than future ones. Instead of reviewing each aspect behind their formulation, we take the values specified for the year 1990 in the GBD study. Still, it is important to note that the discussions on age weighting  $\beta$  and discounting  $r$  are rather weak because it is impossible to identify both terms separately. Since the GBD measures are designed for a representative individual, there is a one-to-one correspondence between aging and time lived. In other words, their valuation formula can be written only as a function of  $r + \beta$ .

Measures of burden of disease also simplify the treatment of co-morbidities. As Murray and Achaya [8] note, “In the DALY measure we have simply added the disability weights of independent co-morbidity that is due solely to chance.” In the GBD report, the total burden is obtained as the sum of the burden in different conditions. Since examining physicians in the Union Army also reported total disability rates, we consider an alternative calculation based on these measures.

### 2.3 DALYs for the Union Army

We used equation (1) to compute both YLLs and YLDs. We employed the same value of the relevant parameters as in the GBD:  $\beta = 0.04$ ,  $r = 0.03$ ,  $C = 0.1658$ . For YLLs, we applied a particular instance of equation (1) in which the years of life are not weighted by any disability measure, i.e.,  $D(x) = 1$ . For YLDs we assigned a value to  $D(x)$ . In contrast to Murray and Lopez [11] we do not consider  $D$  to be constant for each disease and date. A constant disability rate implicitly assumes that there are no interactions between the disability caused by the disease and the individual’s age. Since we have access to more detailed information about the way an individual’s disability progressed over time due to any given health condition we allow  $D(x)$  to vary over time.

YLLs need the age at death and the life expectancy at that age. Age of death,  $a$  in (1), comes from our data set while life expectancy at age  $a$ ,  $L(a)$  is taken from the male life table for the United States in 1920 from Keyfitz and Flieger [5]. Life expectancy at birth was 54.8 years. We considered YLLs by causes of death based on information from the Pension records and the codification of diseases of Canavese and Linares [2]. Since veterans often showed several causes of death (due to different contributing factors), we considered the first condition listed.

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1990.”

For YLDs, we need specific weights given by the disability rates. We can follow the evolution of YLDs over time and, therefore, introduce different values  $D(x)$  as new information from the medical records becomes available. We take  $D(x)$  at any point in time to be the prevailing disability assessed by the examining doctor. That is, at each time the veteran undergoes a new examination, we update his disability based on the new rate. Following the coding developed in Linares [7], the disability measures are expressed in rates with  $0 \leq D(x) \leq 1$ . Since we only have discrete observations of disability ratings and examinations, we consider a discrete version of the YLD formula.

To study YLDs, we assumed that the age of onset of the disease,  $a$  in (1), is the age at which the veteran had the first diagnosis in the sample. Since there is no previous medical information, it is not possible to determine the exact date at which the veteran first experienced the condition. This indicator may be biased because of the administrative requirements for pension application. Before 1890, only war related diseases were pensionable so it is very likely that the veteran already had the disease before he could report it. However, as Canavese and Linares [2] show, the bias tends to be small since the years at which veterans were unable to report the disease are often the healthiest years of an individual. Besides, in 1890 the average age on the sample is 45 years which is the lower bound we consider in the computations.

We perform two aggregation exercises. First, we calculate the total YLD of a given individual, by simply adding his condition-specific YLDs and second, we average condition-specific YLDs across veterans to obtain the amount of years loss to a given disease across the sample.

### 3 Main findings

Table 2 presents YLLs by causes of death for the sample.<sup>5</sup> Most veterans died due to cardiovascular and respiratory conditions, and injuries/GSW since the sample includes deaths during the Civil War. However, since cardiovascular conditions have later onsets, the number of years lost by premature mortality is lower than in the case of injuries that have earlier onsets. The number of years lost by premature mortality is also high for infectious diseases and diarrheas because these

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<sup>5</sup>Deaths coded under general appearance are related to old age, debility, asthenia, erysipelas, inanition, emaciation and prostration. Other causes of death include conditions that could not be coded as part of the surgeon's group such as abscess, atrophy, bad treatment, breakdown, congestion, convulsion and alike.



conditions had a large impact on the mortality of recruits during service.

Table 2. YLLs (in years) for Union Army veterans, 1861-1920.

Diseases	Number of veterans	YLLs
Cardiovascular	2,568	5.63
Diarrhea	1,407	24.09
Gastrointestinal	431	10.12
General appearance	607	9.68
Genito-urinary	998	5.85
Hernias	45	8.70
Infectious/fevers	1,673	24.79
Injury/GSW	2,146	24.98
Liver	187	10.26
Neoplasm/tumor	519	5.86
Nervous	596	8.36
Rectum/hemorrhoids	22	12.57
Respiratory	2,428	14.27
Rheumatism/MSK	201	11.27
Other	487	7.55
Other causes of death	494	18.53
Missing causes of death	8,952	6.39
No. Observations	23,780	

Table 3 presents the summary of YLDs for the veterans of the Union Army. Each entry in Table 3 represents the per capita number of years lost due to the presence of a disease given an individual disability measure for that condition. For instance, the number of years lost due to disabling cardiovascular conditions alone was 0.9. Since the average number of co-morbidities in the sample was relatively large, most of the disease burden in the Union Army was the result of a large number of simultaneous conditions. The simultaneous presence of cardiovascular, rheumatism and injuries accounts for half of the years lost due to disabilities. The three diseases had a disproportionate effect in the health of veterans although their contribution to the number of years lost by premature mortality was not particularly important, Table 2. The low contribution to premature mortality is due to the fact that veterans afflicted by cardiovascular, rheumatism and injuries had relatively earlier onsets, long durations, high disability rates but low fatality rates at early ages.

Table 3. Burden of disease (in years) for Union Army veterans, 1861-1920.

Diseases	Total number of diseases	Age in 1891		
		45 – 59	≥ 45	≥ 60
Cardiovascular	8.53	0.92	0.90	0.86
Diarrhea	9.97	0.50	0.51	0.54
Gastrointestinal	9.57	0.21	0.19	0.15
General appearance	7.83	0.31	0.37	0.57
Genito-urinary	9.07	0.14	0.14	0.17
Hernias	8.22	0.35	0.37	0.45
Infectious/fevers	10.50	0.11	0.11	0.11
Injury/GSW	7.44	0.95	0.95	0.92
Liver	10.07	0.09	0.10	0.10
Neoplasm/tumor	9.49	0.02	0.02	0.02
Nervous	8.79	0.29	0.30	0.34
Rectum/hemorrhoids	9.43	0.47	0.45	0.37
Respiratory	8.56	0.48	0.46	0.38
Rheumatism/MSK	8.14	1.01	1.06	1.22
Other	10.12	0.17	0.18	0.25
Total YLDs		6.84	7.03	7.71
YLLs		12.31	11.73	9.68
DALYs		19.16	18.77	17.39
No. Observations		17,923	23,004	5,081

Veterans aged 45 or more lost 11 years by premature mortality and 7 years due to disability. Overall, in terms of DALYs, the total number of YLDs is lower than YLLs but this could be the result of our choice of the life table used for comparison. There are small differences across age groups. Veterans aged 60 or more lost more years due to disabling conditions than to premature death. As expected, the number of years lost by premature death declines for older populations, but the years lost due to disability increases due to the increase in disability rates. The increase in YLDs with age holds for almost all conditions but it is particularly important for rheumatism/MSK and hernias.

As we mentioned before, since examining physicians in the Union Army provided an overall characterization of disability for some veterans, with a total disability rating, we can consider an alternative measure of disease burden based on total ratings in the sample, Table 4. As the table shows, the number of years lost due to a disability declines with the use of the total rate. This is the case because several conditions can produce the same total level of disability if contributing diseases have low impact on the total inability to do manual labor.

Table 4. Burden of disease (in years) for Union Army veterans. Total ratings, 1861-1920.

Disability rating	Age					
	45 – 59		$\geq 45$		$\geq 60$	
	Total	Specific	Total	Specific	Total	Specific
YLDs	5.34	12.55	4.81	11.85	7.77	15.80
YLLs	5.11	5.11	5.27	5.27	4.38	4.38
DALYs	10.44	17.66	10.07	17.12	12.15	20.18
No. Observations	8,302		6,822		1,480	

Since the GBD studies health status at a given moment of time, 1990, the results of Table 3 are not comparable with the disease burden of modern rich and poor countries. To obtain comparable results, we estimated YLLs and YLDs for the cross section of veterans in 1891. We considered 1891 because as a result of the 1890 Disability Act, the number of veterans making applications and the number of examinations increased. The Act of 1890 provided pensions based only on time of service in the Civil War, honorably discharge or any non-War related disability, see Linares [6].

Table 5 presents YLDs per capita. Qualitatively, they still indicate the high burden associated with rheumatism/MSK, cardiovascular conditions and injuries, especially at later ages. The results from Table 5 are compared to measures of disease burden in the modern countries specified in the GBD study. The regions are: Established market economies (EME), Formerly socialist Europe (FSE), China (CHN), India (IND), Other Asia and islands (OAI), Sub-Saharan Africa (SSA), Latin America and Caribbean (LAC), Middle Eastern Crescent (MEC), Union Army veterans (UA). The comparison is carried out according to the matching of conditions presented in the Appendix.

Table 5. YLDs (per thousand) for males ages 45 or more.

Diseases	Estab. market econ.	Former socialist Europe	China	India	Other Asia & islands	Sub- Sah. Africa	Latin Amer. Carib.	Middle East. Cresc.	Union Army
Cardiovasc.	10.764	18.521	10.525	17.436	10.722	8.935	10.417	15.611	14.139
Diarrhea	0.126	0.125	0.943	0.269	0.278	0.387	0.389	0.278	11.043
Gastrointest.	0.890	0.938	1.705	1.885	2.426	3.129	1.417	2.639	3.085
Gen. app.	1.213	1.750	1.738	3.115	5.167	1.387	1.444	5.611	5.811
Genito.-urin.	2.055	2.771	3.885	3.500	4.278	6.774	5.528	14.194	2.165
Inf./fev.	0.031	0.146	1.549	3.500	3.630	2.710	0.750	1.056	2.168
Injury/GSW	3.346	7.729	5.033	7.769	6.444	11.839	8.333	4.889	20.140
Liver	1.409	1.625	2.057	3.013	3.111	1.516	2.639	1.556	1.797
Neopl./tumor	7.803	6.667	4.426	2.244	4.019	4.065	3.444	2.111	0.393
Nervous	17.803	17.313	13.525	13.205	15.778	13.742	22.111	11.278	6.362
Resp.	7.929	13.854	31.139	11.526	7.167	14.742	9.139	6.417	9.793
Rheum./MSK	6.850	7.146	5.689	4.064	10.278	5.290	16.869	3.861	20.764
Other	5.110	3.167	6.533	20.987	15.648	30.903	12.722	17.472	3.733
Total	65.331	81.750	88.746	92.513	88.944	105.419	95.222	86.972	101.395

We do not consider an explicit comparison of YLLs or DALYs. Comparisons with these measures and separate age groups are available upon request. As Table 5 shows, the total number of YLDs per capita for several conditions is similar in the Union Army and all the demographic regions studied in the GBD. Only injuries, chronic diarrhea and rheumatism have a larger effect in the Union Army with neoplasm/tumor and nervous conditions having a reduced participation. Cardiovascular, gastrointestinal, genito-urinary, infectious diseases, liver, and respiratory conditions are well within the bounds of the YLDs of current countries.

The high presence of injuries is due to the effects of the Civil War. However, the most dramatic long run improvement in health between 1890 and 1990 is due to diarrhea. Its YLD among the Union Army was 11.043, ten times larger than the YLD in China during 1990 (0.943), the highest in the sample for this condition. Although veterans were particularly vulnerable to diarrhea during the war, differences of this magnitude are very likely due to changes in medical care and prevention. Diarrhea and other communicable diseases have been largely conquered during the last century lowering its disabling effect among adults.

Rheumatism and musculoskeletal conditions also have a larger effect on the Union Army veterans. These conditions have long lasting effects, very low fatality rates (see Blanck et al. [1]) and a high prevalence at later ages. For all those reasons, they produced a high number of years lost

due to disability in 1890.

Neoplasm and tumors have larger effects in the twentieth century than in nineteenth century America. YLDs in the Union Army are only 0.393 while in 1990 they are between 2.111 in Middle East Crescent and 7.803 in established market economies. Degenerative diseases have become more prevalent as people escape from preventable conditions and live long enough to develop neoplasm and tumors. In fact, even among the twentieth century countries, these conditions are more important the higher the degree of economic development. Nervous conditions also have larger effects in the twentieth century. As the GBD concluded, mental illnesses also had a very high worldwide disabling sequelae in 1990.

The total number of YLDs for the Union Army in 1890 is below Sub-Saharan Africa and above all the other regions. Taking the Union Army as a reference for developed countries (or established market economies), Table 5 indicates that health improved considerably between 1890 and 1990. Over the course of a century the total number of years lost due to disabling conditions declined by about 40 percent. Almost all regions studied in the GBD have lower YLDs in 1990 compared to the level of disability in 1890 in the Union Army. Only sub-Saharan Africa lost more years due to disabling conditions in 1990 compared to the Union Army in 1890.

For the purpose of the study, we summarized the relation between YLDs across countries by the correlation coefficient, Table 6. Each entry in the table has two values. The first one represents standard correlation coefficients and the values in parentheses represent rank correlations. Overall, the correlation between current regions is larger than the correlation with the Union Army. However, the experience of the veterans has a positive correlation with all the regions and a relatively high correlation with Latin America and formerly socialist Europe. Once rank correlations are considered, the Union Army also correlates with other Asia and islands.

Table 6. Correlations for YLDs per capita (per thousand).

	Established market economies EME	Formerly socialist Europe FSE	China CHN	India IND	Other Asia & islands OAI	Sub- Saharan Africa SSA	Latin America, Caribbean LAC	Middle Eastern Crescent MEC	Union Army UA
EME	1.00 (1.00)	0.90 (0.94)	0.58 (0.94)	0.60 (0.66)	0.76 (0.80)	0.41 (0.74)	0.84 (0.87)	0.47 (0.63)	0.20 (0.29)
FSE		1.00 (1.00)	0.71 (0.93)	0.63 (0.74)	0.63 (0.84)	0.35 (0.77)	0.71 (0.86)	0.47 (0.68)	0.40 (0.45)
CHN			1.00 (1.00)	0.51 (0.82)	0.40 (0.88)	0.45 (0.88)	0.47 (0.92)	0.29 (0.73)	0.20 (0.36)
IND				1.00 (1.00)	0.86 (0.92)	0.87 (0.85)	0.64 (0.82)	0.81 (0.81)	0.16 (0.39)
OAI					1.00 (1.00)	0.79 (0.81)	0.90 (0.93)	0.73 (0.81)	0.23 (0.45)
SSA						1.00 (1.00)	0.60 (0.82)	0.72 (0.78)	0.07 (0.26)
LAC							1.00 (1.00)	0.55 (0.73)	0.42 (0.41)
MEC								1.00 (1.00)	0.003 (0.21)
UA									1.00 (1.00)

The correlation with both established market economies and sub-Saharan Africa is low. That is, in general terms, the experience of the Union Army could be considered to be similar to the disease burden of middle income countries and not too correlated to high or low income countries.

## 4 Conclusion

This paper estimates, for the nineteenth century America, measures of health status comparable to the ones currently available and used to study the burden of disease of modern countries. In addition to *cross-sectional* estimates, we considered *life-time* burden of disease measures. Veterans of the Union Army lost an average of 24 years due to premature death caused by injuries and gunshot wounds, infectious diseases and diarrhea. Although some of the impact is due to the effects of the Civil War, these conditions were highly prevalent for the veterans after the war. Among the conditions for which there is little reason to believe that were triggered by the war itself, the major causes of premature death were respiratory (14.27 years), rectum/hemorrhoids

(12.57) and rheumatism (11.27). With respect to disabilities, the most disabling diseases were rheumatism (1.06 YLDs), injury (0.95), and cardiovascular (0.90).

Since there is no available measure for *life-time* burden of disease in current countries, we consider cross-sectional estimates for a comparison between 1890 and 1990. Chronic diarrhea and rheumatism had a disproportionate effect on the health of Union Army veterans and very little impact on the health of modern countries, possibly due to improvements in sanitation and working conditions. Neoplasm/tumors, and nervous conditions have larger effects on the burden of disease of modern countries. Overall, veterans of the Union Army had a burden of disease sixty percent higher than established market economies in 1990 and less favorable conditions than modern countries with the exception of sub-Saharan Africa. The burden of disease in 1890 correlates with the burden of disease in middle income regions like Latin America and the formerly socialist economies.

## 5 Appendix

This Appendix describes the matching for the conditions used in the comparison of the Union Army and modern countries. To facilitate the comparison, only the diseases that could be identified with one of the thirteen categories in the Surgeons Certificates data set were selected from the GBD study. For example, the GBD study lists five different categories for diseases of the cardiovascular system. All five were considered to be prevalent in Union Army veterans and were taken up as the best-match with the cardiovascular system category in the surgeon's certificates data set. On the other hand, for the neoplasm/tumor category, cancerous conditions peculiar to the female sex, for example, cervical cancer were excluded from the GBD study; prostate cancer, peculiar to the male sex, was included. Diseases like chlamydia and syphilis were categorized under infectious diseases. AIDS, only a present-day affliction in the GBD study, was excluded from this category to maintain the compatibility of any comparison with the Union Army. General appearance, which for Union Army soldiers included information on the condition of teeth and gums along with information on a soldier's gait and skin condition, included dental conditions from the GBD. The GBD study provides data on eight regional groups for diseases in both treated and untreated forms. Only the data for untreated forms, in order to maintain a consistency in the comparison, was used in all

calculations.

The conditions were organized as follows. Cardiovascular system: Cerebrovascular, inflammatory, ischemic and rheumatic heart diseases, other heart diseases. Diarrhea: Diarrhoeal diseases. Gastrointestinal system: Appendicitis, peptic ulcer, other digestive diseases. General appearance: Dental caries, edentulism, periodontal disease. Genito-urinary system: Benign prostatic hypertrophy, nephritis and nephrosis, other genito-urinary diseases. Infectious Diseases: Chlamydia, gonorrhoea, malaria, syphilis, tuberculosis. Injury: Drownings, falls, fires, poisonings, road traffic accidents, self-inflicted injuries, violence, war, other unintentional injuries. Liver: Cirrhosis of the liver. Neoplasm/tumor: Bladder, bronchus, colon, liver, lung, mouth, oesophagus, oropharynx, pancreas, prostate, rectum, stomach, and trachea cancers, leukaemia, lymphomas, multiple myeloma, melanoma, other cancers. Nervous system: Alcohol use, bipolar disorder, dementia, drug use, epilepsy, multiple sclerosis, Parkinson disease, schizophrenia, unipolar major depression, other neuro-psychiatric conditions. Respiratory system: Asthma, COPD, lower respiratory infections, upper respiratory infections, other respiratory conditions. Rheumatism/MSK: Osteoarthritis, rheumatoid arthritis.

Other includes ear, endocrine system, eye for the GBD study and ear, endocrine, eye, gallbladder, spleen, varicose veins for the Union Army. In the GBD they included. ear: Otitis media. Endocrine system: Diabetes mellitus, endocrine disorders, iodine deficiency. Eye: Cataracts, glaucoma.

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