Body Mass Index and Health among The Union Army Veterans

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ABSTRACT

This paper explores the relationship between BMI and several health conditions among Union Army veterans who had their first medical examinations between 1891 and 1905. We find that used as a proxy of nutrition, BMI contributes to explain morbidity and mortality differentials among the veterans.

The findings suggest that being underweight poses a serious threat to health, as indicated by highest disability ratings, highest risk of developing cardiovascular, gastrointestinal, and respiratory diseases, and higher mortality risk. However, the association is disease specific. Being underweight is protective against rheumatism and musculoskeletal diseases.

Although we did not find a significant impact of baseline BMI on development of diseases later on, we found that gaining weight significantly reduced the risk of developing gastrointestinal diseases.

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I. Introduction

Anthropometric measures such as height and weight adjusted for height, or Body Mass Index (BMI), have proven to be useful for the study of health in modern and historical populations. The use of these measures relies on the idea that height and weight reflect prior nutritional record of how much individuals have eaten and how much food energy they demand. As Riley pointed out, height is most reliable as an indicator of previous nutritional status, but BMI is more valuable in conveying recent nutritional status, after an individual's growth has been completed (Riley, 1994). Since these indicators bespeak the general ability of an individual to cope with his/her external environment, an ability instrumental in forestalling the onset of many diseases, it stands to reason that the nutritional status, as indicated by height or BMI, can serve as a guide in assessing not just general health but also the prevalence of specific conditions.

The 20th century witnessed an increase in human body weight. Among white American males, average adult BMI has increased from 22.6 in the late 19th century to 28.0 at the end of the 20th century. This ongoing trend has drawn attention to how BMI is linked to mortality and morbidity (Su, 2003). While many studies have focused on the relationship between BMI and mortality (Waller, 1984; Riley, 1994; Calle et al., 1999; Durazo et al., 1998; Costa, 1993; Fogel and Costa, 1997; Allison et al. 1997), few have explored the relationship between BMI and diseases, and of those, only a few have looked at the problem from a historical point of view.

The purpose of this paper is to determine the impact of nutritional status on both morbidity and mortality among a very data-rich sample of 19th century individuals. Specifically, we want to address the following questions: How was BMI associated with risk of diseases? Were individuals with lower or higher BMI more likely to develop certain chronic conditions? What was the impact of BMI on short-term and long-term survival? Since many demographic or socioeconomic factors could also influence a veteran's health, we try to tease out the effects of BMI and changes in BMI on health by controlling the effects of other relevant factors.

One of the pioneering works in this respect is Costa's relating health status, BMI, and labor force participation among older men (Costa, 1996). She measured Union Army veterans' BMIs and relative risk of certain chronic conditions in order to investigate the relationship between health and retirement among older men. Although her study pertains to the relationship between BMI and health, its main focus is on the labor force participation of older veterans. Furthermore, Costa developed this study when the collection of the sample was not yet completed and, therefore, had to concentrate on a small part of the sample.

There are some recent studies that relate overweight and obesity with the risk of developing some specific chronic conditions such as cardiovascular diseases diabetes, gallstones, strokes or cancer. Most of these studies belong to the medical literature and highlight the medical aspects but do not consider socioeconomic factors that could have an impact on that relationship (Bhargava, 2003; Hime, 2000; Wilson, et al., 2002; Field, et al., 2001; Kim, 2000; Kurth, et al., 2002 Gustafson, et al., 2003; Thompson, et al., 1999; Van, 1985; Calle, et al., 2003; Rexrode, et al., 1997).

The paper proceeds as follows. In the second part we present an overview of the data employed. The third section uses regression analysis to determine the impact of BMI on the occurrence of the disease. The fourth section includes a causal analysis of the interaction between BMI, weight change, and diseases. In the fifth section we analyze the effect of BMI at first examination on subsequent survival. And the last section concludes our analysis and findings.

II. Description of the Data

We use the information collected on the Union Army veterans for the Civil War pension program. The Union Army data contains the records, dating from between 1861 and 1940, of 35,570 white men who belonged to 333 companies and contains socioeconomic as well as medical information. The medical information is recorded in the Surgeon's Certificates data for about 50% of the veterans who claimed to have various disabilities. The medical examination for evaluating such claims was performed by a group of physicians that measured the disability of the individuals in terms of their ability to do manual work.

Congress originally established the basic system of pension laws called the General Law that limited the benefit to those who could prove their disabilities were a result of the war. Later, in 1890, the Disability Act was approved, marking the beginning of a more universal pension program that only required pensioners to have served in the military for 90 days. Introduced in 1907, the Old Age Law gave veterans the opportunity to apply for an old age pension that paid more money than did the disability pension. This sequencing of the laws creates potential biases in parts of the sample. With its clause about war-related conditions, the pre-1890 system constrained the diseases a veteran could claim. In turn, the 1907 law encouraged relatively healthy veterans to opt for a pension based on old age instead of the disability pension system, and therefore introduced a potential bias in the sample. To avoid these biases, we restricted our study to a smaller sub-sample that covers a veteran's claim for disability pension between 1891 and 1905; these 15 years represent the largest number of applications. Our analysis considers 5,945 men that had their first examination between 1891 and 1905.

To determine whether the veteran had a specific disease, we used dummies that indicate whether the veteran received a disability rating for having it. We included the information from the related variables when one rate was given from more than one disease and was not mentioned specifically in the rating variable of that disease group. The scope of our analysis is restricted to five of the most frequent diseases: rheumatism-musculoskeletal, cardiovascular, respiratory, gastrointestinal, and rectum/hemorrhoids. Table 1 shows the number of veterans per disease for those veterans who received their first medical examination between 1891 and 1905. Table 2 presents some of the most important characteristics of the chosen five diseases such as the average age at first examination, the average sum of ratings in the first exam, and the number of diseases found the first time the veterans were examined between 1890 and 1905.

The prevalence rates of these diseases by age group are shown in Graph 1. We found that by far, the most prevalent disease is rheumatism/musculoskeletal with levels over 40 %. As the veteran gets older, there is an increasing trend of cardiovascular and a decreasing pattern of gastrointestinal, respiratory and rectum/hemorrhoids diseases.

Doctors were instructed to measure the weight and height of the veteran in each medical examination, which allowed us to calculate BMI for the Union Army Veterans. Graph 2 shows BMI for the veterans who were examined for the first time divided by age groups. The average BMI is 23.3 and it generally decreases as the veterans age. Graph 3 shows the distribution of the BMI at first exam into categories. Approximately 60% of the recruits had BMI between 20 and 25, considered as normal levels of BMI, almost 20% of the recruits were overweight or with BMI between 25 and 30, 10% were underweight with BMI under 20, and less than 5% were obese with BMI over 30.

Table 3 describes the explanatory variables used in the regressions. Besides age at first examination, we incorporated in the analysis the linked information of the 1900 census for state of residence, occupation and marital status. A set of dummies was created to denote if the veteran worked as a farmer, professional, artisan, manual worker, or if he was dedicated to another occupation. To determine the place of residence, we identified by zones, according to census classification of that year, if the veteran was living in states placed in one of the five areas: North or South Atlantic, North or South central, or in other area. The last set of dummies from the census was created to know the veteran's marital status. In the regressions we also use other Union Army variables to determine additional effects, a set of dummies specifying the birth cohort, the number of diseases the person was rated at first exam and another variable to show the company's death rate to which the veteran belonged initially at the war.

III. BMI and Diseases

In this section we analyze the relationship between BMI and health. We first evaluate the association between the BMI and the overall health, measured through the severity of the diseases[1] and the number of conditions the veteran presented at first examination[2]. Then we explore how the BMI is associated with each of the specific diseases.

For the initial purpose we ran two OLS regressions in which we evaluated the relationship between BMI and the overall veteran's health condition at the first examination. In the first regression, the dependent variable is the sum of disability ratings at first examination. (Table 4) The other uses the number of conditions the veteran had at first examination as dependent variable. (Table 5) The regressions include some socioeconomic factors that could affect the dependent variables like age, state of residence, occupation, marital status, birth cohort and the rate of the death in each company to which the veteran belonged when he was in service.

The association between BMI and severity of the diseases shows that compared to normal BMI, underweight increases disability ratings by a statistically significant average 0.016. Obese veterans show also higher ratings and overweight veterans lower ratings, although these last two categories are not statistically significant. BMI categories had no significant

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[1] We use the sum of disability ratings registered by doctors in one specific exam. Although this indicator is not telling exactly the overall health of individuals, since several conditions not necessarily contribute to more severity of the overall individual's health, this indicator comes out to be the best in order to approximate the total rate given also by doctors and known for some examinations. (Canavese and Linares, 2002).

[2] The number of conditions assumes that all conditions have the same weight on the individual's health. A veteran could have one condition and shows worst health status than another veteran with several number of diseases, no very severe. In spite of this fact, we think that a greater number of conditions show in general, worst health than a lower number.

association with the number of conditions the veteran had at first exam. Then our results support the idea that underweight veterans had in general worst health conditions.

Besides the BMI, other variables contribute to explain the severity of the disease. Compared to veterans who lived in North Atlantic area, those living in the North Central states were more likely to have higher disability ratings, and those living in the South tended to have lower ratings. This suggests that environmental conditions were worse in the central states. Veterans who happen to be divorced in 1900 were more likely to show higher disability ratings than married people at the same time, and those who were born before 1835 were showing lower levels of ratings than veterans born between 1836 and 1840. The number of diseases has also a significant association with the severity of the individual's health condition.

The number of diseases is significantly explained by the place of residence. Those veterans who lived in South Central or Other States areas had fewer diseases on average than those of North Atlantic area. As for cohort effect, those born before 1830 tended to have more diseases than those born between 1835 and 1840.

We then address a more specific question: how BMI categories are related to the occurrence of specific diseases? To answer this question we ran a set of logistic regressions where the dependent variables were dummies representing the occurrence of each of the five studied diseases (Table 6). Our results show a disease specific association: underweight veterans had a significantly higher risk of having cardiovascular (39%), respiratory (34%) and gastrointestinal conditions (72%) and lower risk of having rheumatism/musculoskeletal diseases (17%), compared to veterans with normal weight. Rectum/hemorrhoids also shows lower risk but it is not statistically significant.

Although the effect is not statistically significant, overweight and obese veterans, were more likely to develop cardiovascular conditions and less likely to have the other four diseases.

By evaluating socioeconomic factors related to the occurrence of the disease, we can identify regional differences. Using North Atlantic as reference, veterans from the rest of the regions are significantly less likely to have cardiovascular and those from the South and Other states, mostly western, showed lower probabilities of having rheumatism/musculoskeletal. To live in the North Central and South Atlantic states increased the odds of having respiratory diseases and rectum/hemorrhoids.

We also observed a disease specific cohort effect on the occurrence of the diseases. Compared to veterans born between 1836 and 1840 those who were born after 1840 had a significant risk of having cardiovascular diseases and rectum/hemorrhoids and those who were born before 1835 of having rheumatism/musculoskeletal.

Finally widowed veterans in 1890 had less risk of cardiovascular, respiratory and rheumatism conditions than married ones the same year.

Our results support the idea of a clear association between BMI and health for the Union Army veterans. In general, underweight veterans were more likely to present worse health conditions than veterans with normal weight, which is evident through higher probability of having certain conditions like cardio, respiratory and gastrointestinal and higher disability ratings. However the association is disease specific, to be underweight is protective against rheumatism/musculoskeletal.

IV. BMI, Weight change, and diseases: A Longitudinal Analysis

The causal direction between BMI and a certain disease can be both ways, but the cross-sectional analysis of information from the first physical examination cannot discern causality. In an effort to capture the possible causal impact of BMI on diseases, our analysis in this section addresses a further question: how does a veteran's BMI at the first examination influence his risk of developing certain disease at the second examination, given that this disease was not reported at the first examination? To evaluate the role of the BMI in the later development of the diseases, we take into account not only the direct effect of the initial BMI but also the changes in weight a veteran experienced from that moment to the point where he was diagnosed with the disease. In our paper, we assess the impact of BMI by controlling for change in weight after the first examination.

The longitudinal nature of the Union Army data set makes such a task feasible. Out of 5,945 veterans who had their first examination between 1891 and 1905, 3,732 veterans had a second examination in the same period. Among these veterans, 3,718 furnished information on weight at both examinations: 432 veterans had the same weight, 1,947 veterans lost weight, and 1,339 veterans gained weight.

We ran five Cox regressions and in each of them the dichotomous event variable was whether a veteran was diagnosed with a specific disease at the second examination. The sample for each regression includes those veterans who had at least two examinations between 1891 and 1905, and who were not diagnosed with a certain disease at their first examination. Besides age and the socioeconomic variables, we incorporated in previous regressions; we have also added number of diseases at the first examination and weight change between first and second examinations into the explanatory variables.

The regression results, as indicated in Table 7, show that BMI at the first examination does not have a significant impact on the risk of developing the five diseases at the second examination. Received wisdom would lead one to expect a strong causal connection between BMI, both obesity and underweightedness, and health conditions at a later stage. But, although the signs and magnitudes of the coefficients display large effects, their levels of statistical significance are far below the ones that would warrant confidence in the results. In only a few instances those levels reach 75%. We approached this exercise hoping to disentangle the causality between BMI and health but the tests remain inconclusive. It is not possible to establish firmly that BMI affects health status but neither is it possible to prove the reverse link. Probably, the current data are not adequate for this task because they do not follow up the veterans at regular and close intervals.

In terms of the association between weight change and risk of developing diseases, we found that veterans who gained weight after the first examination were 38.3% less likely to have gastrointestinal diseases compared to those who lost weight. Increased BMI seems to have been a protection against gastrointestinal conditions. As for other diseases, veterans who gained weight had higher risk of having cardiovascular and rectum/hemorrhoids than those who lost weight, although, once again, the coefficients are not statistically significant.

While the tests are inconclusive when it comes to establish a causal relation between BMI and health status, other socioeconomic variables perform much better. There is significant evidence suggesting that veterans born in the later birth cohorts were associated with remarkably higher risk of developing all the five diseases at the second examination. For instance, compared with veterans who were born between 1836 and 1840, veterans who were born after 1845 were 2.2 times more likely to develop cardiovascular diseases and 1.3 times more likely to develop rheumatic diseases at their second examination, after controlling for all the other variables in the Cox regression. Why were the later birth cohorts more likely to develop diseases at the second exam than the earlier birth cohorts? A plausible explanation lies in the rapid urbanization and large flow of immigration in this period, meaning that those born in later cohorts had more exposure to infectious diseases and poor sanitary conditions in their infanthood and childhood. (Higgs, 1979; Mechel, 1985).

V. The Impact of BMI on Survival of the Union Army Veterans

In this section we consider the effect of BMI at first examination on subsequent survival. Since more veterans had their first physical examinations in 1891 than in any other single year, we selected all those who were first examined in 1891 as our survival sample, with 1,040 veterans. To evaluate the effect of BMI on survival under different circumstances, we specified three Cox proportional hazard models: while model 1 included all deaths after 1891, model 2 and 3 focused on those veterans who survived beyond 1900. There are two purposes for this specification. One is to control for possible spurious causation in the sense that for veterans who had serious diseases at the examination, their short survival after the examination could be more a result of said disease(s) than of their BMI. The other objective is to incorporate the socio-economic information from the census into our analysis for veterans who survived to 1900 and can be linked with the 1900 census data. Therefore, the only difference between model 2 and 3 is that the latter added a set of variables from the 1900 census into the survival analysis.

Results for the three Cox proportional hazard models, as indicated in Table 8 tell a converging story: compared to veterans with normal weight, veterans with lower or higher weight had higher mortality risk after their examination. For example, results from model 1 suggest that the odds of dying for underweight veterans is 21.5 percent higher than that for veterans with normal weight, and this effect is statistically significant. Obese veterans suffered an even higher mortality risk, and this is especially the case in model 2 and 3 where deaths prior to 1900 were excluded, but this effect is not significant in all three models. According to results from Model 3, mortality risk for obese veterans is 35.7 percent higher than veterans with normal weight, and for overweight veterans the percentage is 7.7 higher. The percentage increase for obese veterans is significant only at a level of 83% whereas the estimate for overweight veterans is even more fragile: its significance level is 53%. Overall, it is hard to reject the null hypothesis of no effect of obesity or overweightedness although it should be noticed that the signs of the coefficients, if significant, would be in keeping with recent findings of a U-shaped relation between BMI and health (Waaler 1984; Calle et al. 1999; Durazo et al. 1998; Engleland et al. 2003; Costa 1993; Fogel and Costa 1997).

A comparison between results from model 1 and those from the other two models suggests that the effect of being underweight on survival becomes less salient when deaths from the first nine years of follow up were excluded, as indicated by smaller coefficients and no statistical significance. The reason could be that, since underweightedness is associated with certain diseases, these diseases maybe responsible for a large proportion of the observed effect of being underweight on survival. Once we account for the effect of diseases by removing the early deaths, the effect of being underweight on mortality becomes smaller.

There is a geographic pattern of mortality distribution, as results from model 3 indicate. Using North Atlantic regions as the reference category, we found that mortality risk for veterans from South Atlantic regions was 35 percent lower. The corresponding figure for veterans from other states, which includes mostly western states, was 30 percent higher. Both effects are statistically significant. The central states are associated with a lower mortality risk, but the effect is not significant. What could account for the higher mortality in North Atlantic region than that for most of the other regions? One possible explanation is the health advantage of rural areas over urban areas in the latter half of the 19th century, which has been well documented in some previous studies (Fogel, 1991; Haines, 2001; Wilson and Pope, 2003). Since the North Atlantic region had the highest level of urbanization and accommodated most of the immigrants to the United States in the 19th century, the higher population density and underdeveloped public sanitary conditions could result in more exposure to diseases and higher mortality in this region.

In terms of the occupational difference in mortality, we found that professionals had the lowest mortality, followed by farmers, manual labor workers, artisans, and the other occupations with the highest mortality. The only significant effect was observed for being in other occupations, which is associated with 26.9 percent higher mortality risk, as compared to farmers.

Veterans' marital status also played a role in mortality. Compared with being married, being widowed, divorced, or single, were all associated with a higher mortality risk. This effect becomes significant in the case of divorced veterans. For them, the mortality risk after 1900 is 2.6 times higher than married veterans, which is consistent with current studies where marriage is revealed to have beneficial effects on health (Waite, 2000).

VI. Conclusions

This paper explored the relationship between BMI and health among the Union Army veterans. Taking all the findings into account, we conclude that, used as a proxy of nutritional status, BMI helps explain morbidity and mortality differentials among the Union Army veterans.

Consistent evidence suggests that being underweight is associated with serious health disadvantages, as indicated by the highest level of disability rating, the highest risk of developing cardiovascular, respiratory, and gastrointestinal diseases, and a relatively higher mortality level. The only beneficial effect of being underweight we observed lies in its association with a significantly lower risk of developing rheumatism and musculoskeletal diseases at the first examination.

To tackle the problem of possible reversed causation between BMI and diseases, we performed a longitudinal analysis using BMI at the first examination to predict disease risk at the second examination, after controlling for the effects of weight change. We found that, compared with those who lost weight, veterans who gained weight were less likely to develop gastrointestinal and respiratory diseases at their second examination. We did not find a statistically significant impact of BMI at the first examination on diseases at the second one.

Although the statistical tests performed here fail to establish conclusively a causal relation between BMI and health, this is not a serious indictment of the results: by the very origin of this data base, without a consistent follow up of veterans, it may not be the right tool to address this issue beyond doubt. A strong causal relation could exist without been born out by these data. With more refined data on the actual onset of conditions, a longitudinal analysis like the one carried out here could help ascertain the right direction of causality. This remains a direction for future research. But what can be proven already constitutes strong evidence of an association between low weight and different diseases in the XIXth century. Low weight has a numerically important and statistically significant effect on health conditions for the veterans in the sample.

The picture of the XIXth century US that emerges from this study is far removed from the one that baffles students of the much more affluent XXth century. While in recent years obesity has emerged as a major culprit of all kinds of health conditions, this study shows a US grappling with issues we now associate with backward economies in the Third World: health deterioration due to suboptimal food intake. As the advantages of increased BMI on health and survival have been mostly achieved, it is now the negative effects associated with obesity the ones that become more salient.

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VII. Appendix

Table 1

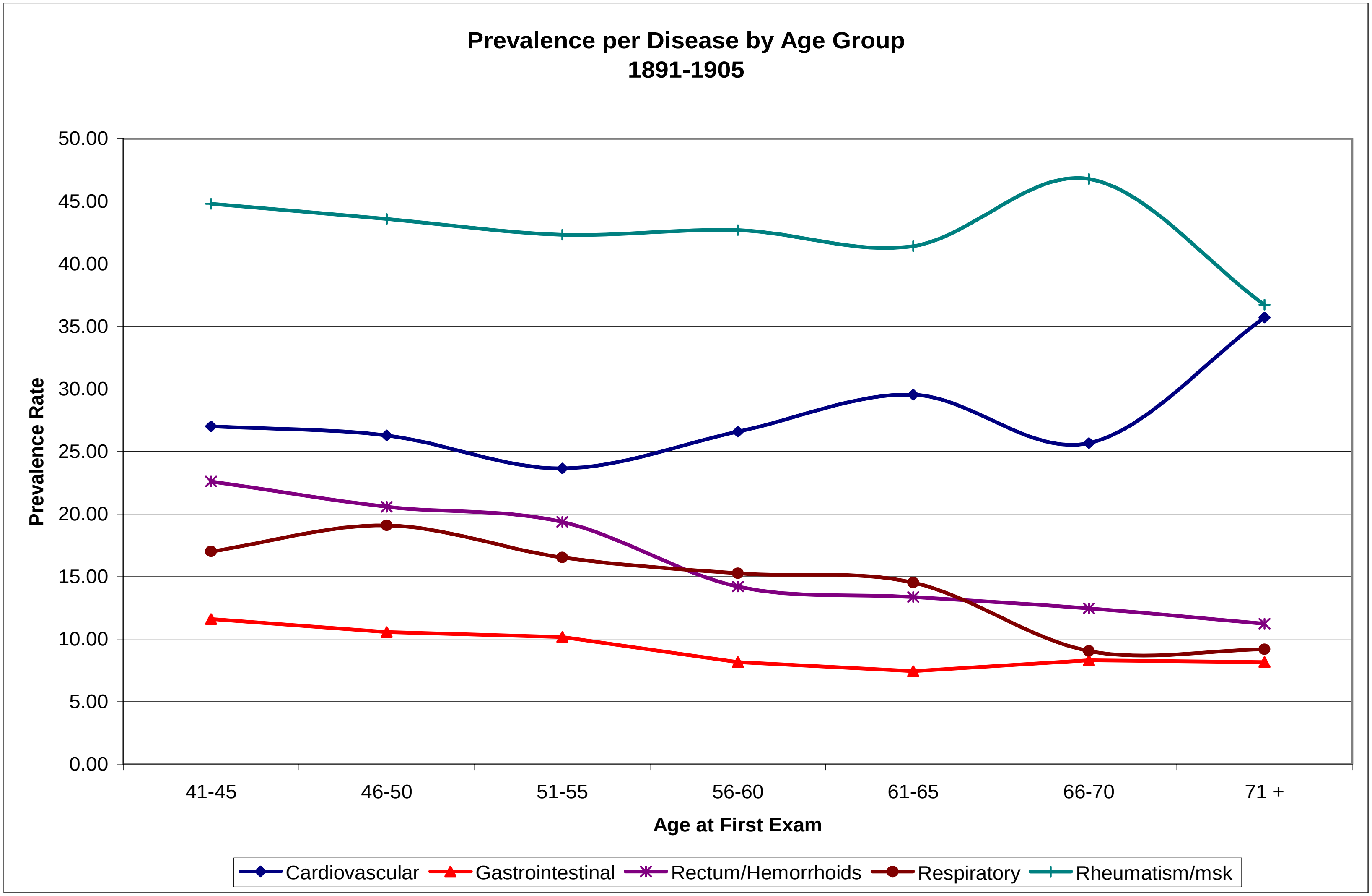
Number of UA Veterans per Disease First exam 1891-1905	
Disease	**Number Veterans**
Rheumatism/MSK	2,544
Cardiovascular	1,535
Rectum/Hemorrhoids	1,062
Respiratory	969
Injury/GSW	901
Eyes	691
General Appearance	676
Ear	627
Hernias	595
Gastrointestinal	565
Diarrhea	536
Nervous	374
Genito-Urinary	278
Liver	272
Varicose Veins	223
Infectious/Fevers	128
Spleen	89
Neoplasm/Tumor	49
Endocrine	21
Gallbladder	1
Average number of conditions	2.04

Table 2

Main Statistics of Diseases at 1st Exam 1891-1905						
Diseases	**Age at 1st Exam**		**Rates***		**Number of Diseases**	
	Observations	Mean	Observations	Mean	Observations	Mean
Rheumatism/MSK	2,386	53.5	2,445	0.168	2,544	2.72
Rectum/Hemorrhoids	1,000	52.4	1,036	0.187	1,062	3.18
Cardiovascular	1,453	53.9	1,450	0.199	1,535	3.07
Respiratory	911	52.7	931	0.180	969	2.97
Gastrointestinal	535	52.8	545	0.186	565	3.74

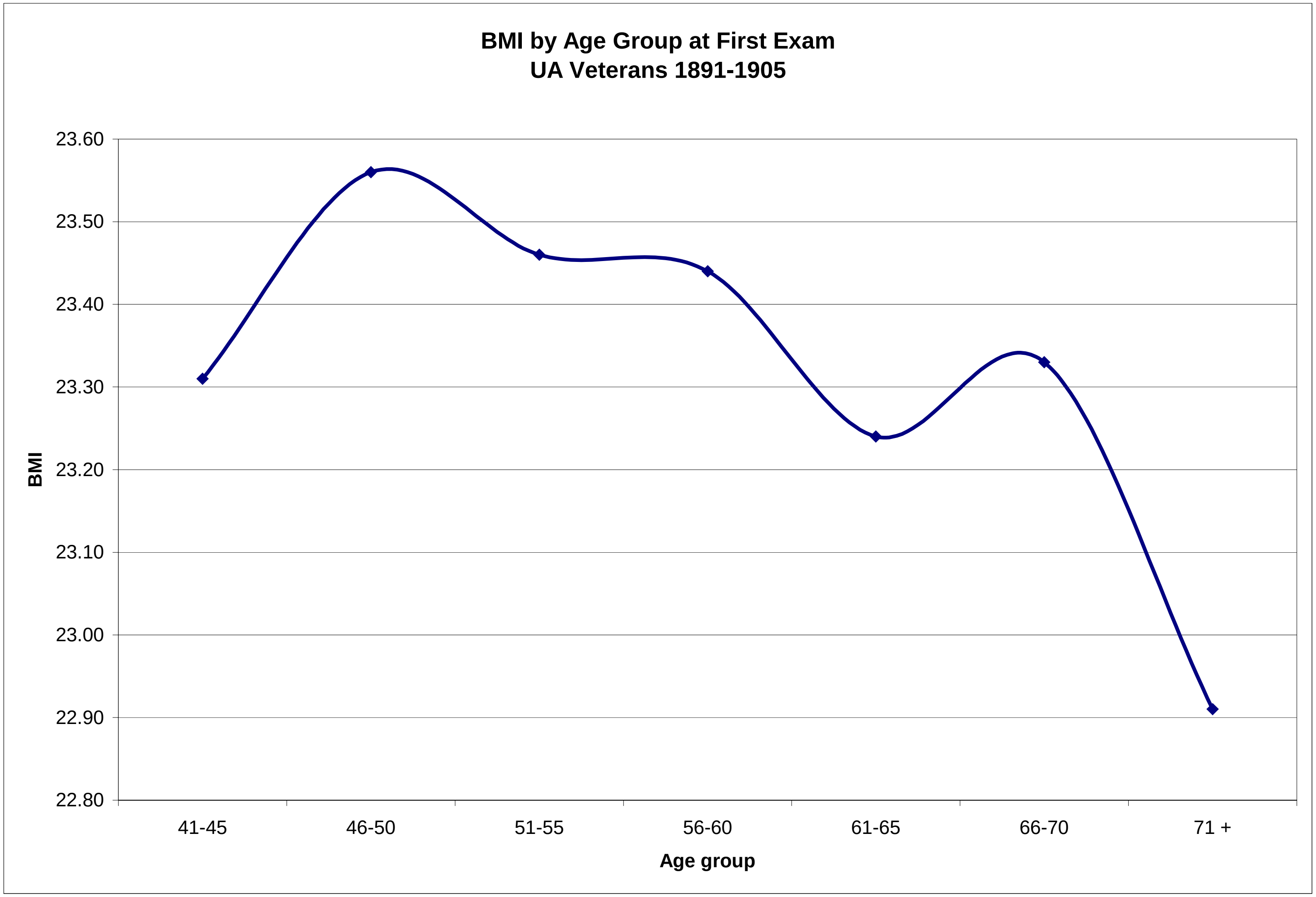
(*) Sum of rates per all conditions veterans were rated at 1st exam.

Graph 1

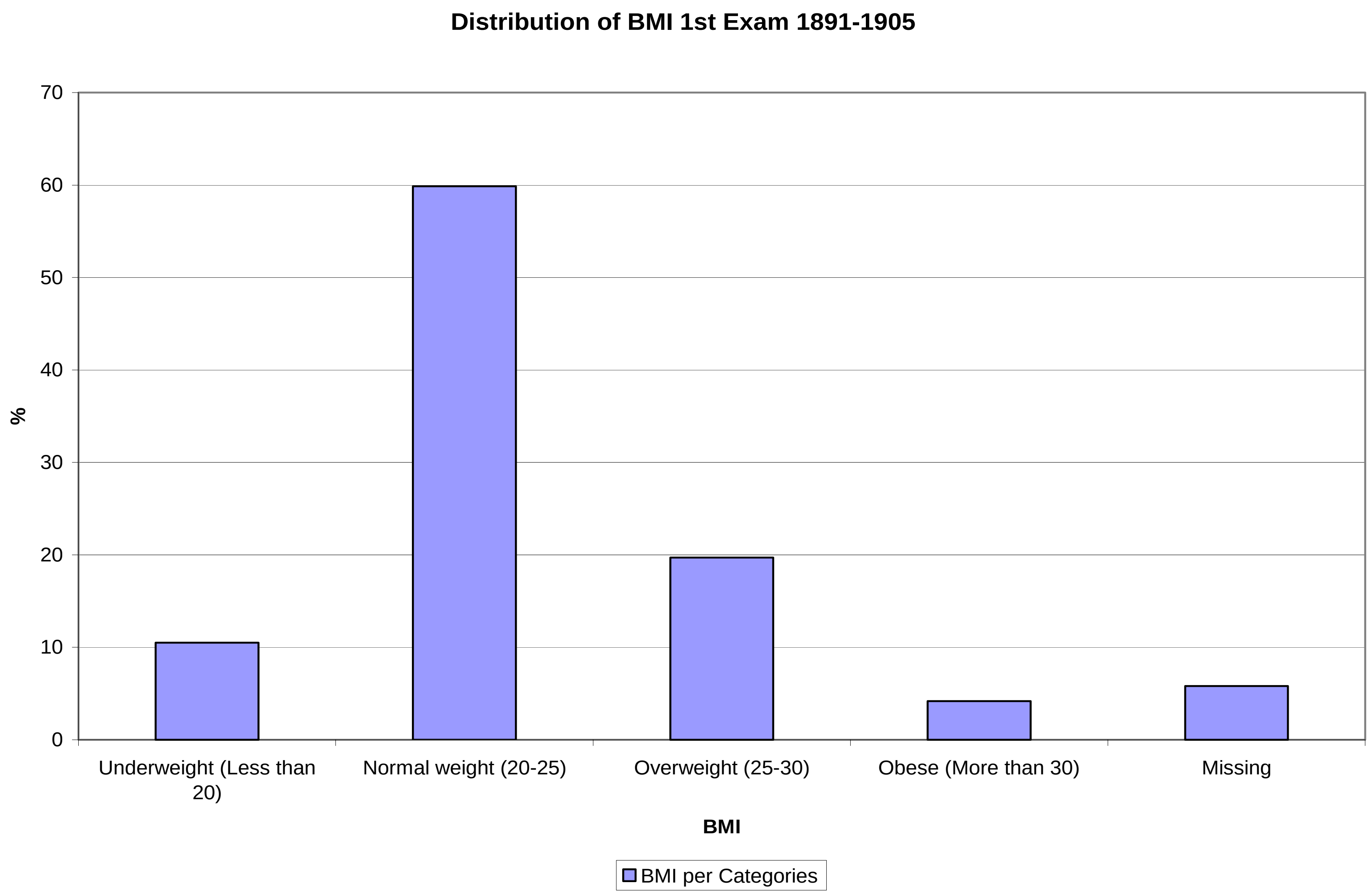


Prevalence per Disease by Age Group
1891-1905
Prevalence Rate
50.00
45.00
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
41-45
46-50
51-55
56-60
61-65
66-70
71 +
Age at First Exam
Cardiovascular
Gastrointestinal
Rectum/Hemorrhoids
Respiratory
Rheumatism/msk

Graph 2


BMI by Age Group at First Exam
UA Veterans 1891-1905
23.60
23.50
23.40
23.30
23.20
23.10
23.00
22.90
22.80
BMI
41-45
46-50
51-55
56-60
61-65
66-70
71 +
Age group

Graph 3



Distribution of BMI 1st Exam 1891-1905
70
60
50
40
30
20
10
0
%
Underweight (Less than 20)
Normal weight (20-25)
Overweight (25-30)
Obese (More than 30)
Missing
BMI
BMI per Categories

Table 3

Main Statistics of Explanatory Variables at 1st Exam 1891-1905					
Variables	**Description**	**Observations**	**Mean**	**Min**	**Max**
Age at First Exam	Age of veterans at first exam	5,547	55.63	40.00	84.00
BMI at First Exam	BMI of veterans at first exam	5,600	23.42	13.90	47.06
Dummies per Area of residence in 1900 Census		3,965			
North Atlantic	Include Connecticut, Massachusetts, Maine, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, and Vermont		0.28	0.00	1.00
South Central	Include Alabama, Arkansas, Kentucky, Louisiana, Mississippi, Oklahoma, Indian Territory, Tennessee and Texas		0.04	0.00	1.00
South Atlantic	Include District of Columbia, Delaware, Florida, Georgia, Maryland, North Carolina and South Carolina		0.06	0.00	1.00
North Central	Include Iowa, Illinois, Indiana, Kansas, Michigan, Minnesota, Missouri, North Dakota, Nebraska, Ohio, South Dakota, Wisconsin		0.54	0.00	1.00
Other States	Include mostly western states, Hawai and Alaska.		0.08	0.00	1.00
Dummies per Occupation in 1900 Census		2,880			
Farmer	Farmer and Agricultural Laborers.		0.38	0.00	1.00
Artisan	Artisans		0.16	0.00	1.00
Professional	Professional and Proprietors		0.21	0.00	1.00
Manual Labor	Manual Labor		0.13	0.00	1.00
Other Occupations	Include Service, semiskilled,operative, unidentifiable, not classified.		0.12	0.00	1.00
Dummies per Marital Status in 1900 Census		3,958			
Married			0.81	0.00	1.00
Widow			0.11	0.00	1.00
Divorce			0.01	0.00	1.00
Single			0.07	0.00	1.00
				0.00	1.00
Dummies per Birth Cohort		5,547			
Before 1830			0.12	0.00	1.00
1831-1835			0.13	0.00	1.00
1836-1840			0.23	0.00	1.00
1841-1845			0.37	0.00	1.00
After 1845			0.15	0.00	1.00
Company's Death Rate During War	Death rate at the initial company	5,835	0.15	0.00	0.200
Average Number of Diseases at First Exam		5,888	2.06	0.00	10.00

Table 4

OLS Regression 1891-1905 Dependent Variable = Ratings at 1st Exam	
Variables	**Coefficients**
Constant	0.2037 (0.15375)
BMI (refer. = Normal Weight)	
Underweight	0.0167 *** (0.00593)
Overweight	-0.0028 (0.00433)
Obese	0.0110 (0.0087)
Age at 1st exam	-0.0074 (0.00555)
Age^2/10 at 1st exam	0.0009 * (0.000505)
State of residence in 1900 (refer. = North Atlantic)	
South Central	0.0117 (0.01006)
South Atlantic	0.0075 (0.01209)
North Central	0.012 ** (0.0039)
Other States	-0.0044 (0.00747)
Occupation in 1900 (refer. = Farmer)	
Artisan	-0.0048 (0.00518)
Professional	0.0459 (0.00477)
Manual Labor	-0.0074 (0.00551)
Other Occupations	0.0029 (0.0057)
Marital Status in 1900 (refer. = Married)	
Widow	-0.0004 (0.00603)
Divorce	0.0401** (0.01981)
Single	0.0091 (0.00755)
Cohort (refer. = "1836-1840")	
Before 1830	-0.0215 ** (0.01091)
1831-1835	-0.0115 ** (0.00685)
1841-1845	0.0064 (0.00533)
After 1845	0.0080 (0.00787)
Company's Death Rate During War	-0.1160 (0.08004)
Number of Diseases at 1st Exam	0.0329 *** (0.00133)
Number of observations	2,272
Adj R^2	0.2367

***Significant at 1%, **Significant at 5%, * Significant at 10%.
Standard errors in parenthesis.

Table 5

OLS Regression 1891-1905 Dependent Variable = Number of Diseases at 1st Exam	
Variables	**Coefficients**
Constant	1.6626
	(2.11652)
BMI (reference = Normal Weight)	
Underweight	0.0563
	(0.0975)
Overweight	-0.1103
	(0.06876)
Obese	-0.0834
	(0.13256)
Age at 1st exam	0.0152
	(0.07554)
$Age^2/10$ at 1st exam	-0.0019
	(0.0068)
State of residence in 1900 (refer. = North Atlantic)	
South Central	-0.2770 *
	(0.15624)
South Atlantic	-0.2958
	(0.1962)
North Central	0.0208
	(0.06254)
Other States	-0.2330 **
	(0.11548)
Occupation in 1900 (refer. = Farmer)	
Artisan	-0.1053
	(0.08309)
Professional	-0.0042
	(0.07627)
Manual Labor	0.0549
	(0.08946)
Other Occupations	-0.1275
	(0.09063)
Marital Status in 1900 (refer. = Married)	
Widow	-0.1308
	(0.09432)
Divorce	-0.0004
	(0.31305)
Single	-0.1820
	(0.1197)
Cohort (reference = "1836-1840")	
Before 1830	0.27125 *
	(0.15581)
1831-1835	0.0474
	(0.10667)
1841-1845	0.0956
	(0.0813)
After 1845	-0.0329
	(0.11479)
Death rate company	0.8063
	(1.29665)
Number of observations	2,716
Adj R^2	0.004

***Significant at 1%, **Significant at 5%, * Significant at 10%.
Standard errors in parenthesis.

Table 6

Logistic Regressions per Disease 1891-1905 Dependent Variable = Presenting the Disease at 1st Exam (Dummies)					
Variables	**Diseases Diagnosed at 1st Exam**				
	Cardiovascular	**Rheumatism/MSK**	**Respiratory**	**Gastrointestinal**	**Rectum/Hemorr.**
Constant	-3.6462	-4.5241	-5.5810	0.0261	1.7363
	(3.3429)	(3.2668)	(4.6678)	(4.9163)	(4.5105)
BMI (refer. = Normal Weight)					
Underweight	0.3296 **	-0.2995 **	0.2927 *	0.5434 ***	-0.1855
	(0.1527)	(0.1432)	(0.1729)	(0.1998)	(0.1831)
Overweight	0.0052	-0.1592	-0.1435	-0.1218	-0.0116
	(0.1149)	(0.1003)	(0.1372)	(0.1713)	(0.1241)
Obese	0.3080	-0.0975	-0.0552	-0.5322	-0.2928
	{0.2049}	(0.1918)	(0.2526)	(0.3796)	(0.2565)
Age at 1st exam	0.0704	0.1766	0.1588	-0.1178	-0.1024
	(0.119)	(0.1171)	(0.1701)	(0.1756)	(0.1634)
Age^2/10 at 1st exam	-0.0032	-0.0176 *	-0.0155	0.0121	0.0047
	(0.0107)	(0.0106)	(0.0156)	(0.0158)	(0.0149)
State of residence in 1900 (refer. = North Atlantic)					
South Central	-0.6034 **	-0.4322 *	0.1101	-0.1484	0.2164
	(0.2791)	(0.2359)	(0.3138)	(0.3953)	(0.292)
South Atlantic	-0.3912	-0.1354	1.0447 ***	-0.7306	0.1662
	(0.3423)	(0.2902)	(0.3231)	(0.6098)	(0.384)
North Central	-0.3437 ***	-0.0417	0.3667 ***	0.0688	0.4749 ***
	(0.1024)	(0.0911)	(0.1268)	(0.1521)	(0.1195)
Other States	-0.5479 ***	-0.7818 ***	0.0574	-0.2015	0.3571
	(0.205)	(0.1855)	(0.2456)	(0.2989)	(0.2196)
Occupation in 1900 (refer. = Farmer)					
Artisan	-0.0675	-0.0540	0.0216	-0.3453	-0.0540
	(0.1382)	(0.1226)	(0.1662)	(0.2248)	(0.1593)
Professional	-0.1205	-0.3307 ***	0.2103	0.1657	0.1834
	(0.1284)	(0.1148)	(0.1454)	(0.1799)	(0.1385)
Manual Labor	-0.2282	0.0784	0.0043	0.1145	0.2240
	(0.1541)	(0.1315)	(0.1799)	(0.2117)	(0.161)
Other Occupations	-0.2444	-0.1252	0.0198	-0.1010	-0.0046
	(0.1545)	(0.1325)	(0.1812)	(0.2262)	(0.1703)
Marital Status in 1900 (refer. = Married)					
Widow	-0.3151 *	-0.2634 *	-0.3847 *	0.2714	-0.0317
	(0.1706)	(0.1433)	(0.2125)	(0.2215)	(0.1793)
Divorce	0.2566	-1.1009 *	-0.6053	0.6782	-0.7343
	(0.5022)	(0.5706)	(0.7557)	(0.6405)	(0.7554)
Single	-0.3205	-0.1310	-0.4311	-0.0469	-0.4507 *
	(0.2165)	(0.1782)	(0.2631)	(0.304)	(0.2508)
Cohort (refer. = "1836-1840")					
Before 1830	0.1176	0.5075 **	-0.1259	-0.4835	-0.2272
	(0.2512)	(0.2328)	(0.3486)	(0.4116)	(0.3425)
1831-1835	-0.2394	0.2806 *	-0.1655	-0.2652	-0.0026
	(0.1896)	(0.1576)	(0.2278)	(0.2825)	(0.2061)
1841-1845	0.5042 ***	0.106	0.1889	0.2736	-0.1848
	(0.1374)	(0.1208)	(0.1589)	(0.1988)	(0.1518)
After 1845	0.5824 ***	0.1078	0.2485	0.2547	-0.4409 **
	(0.19)	(0.1711)	(0.2202)	(0.2767)	(0.2208)
Company's Death Rate During War	-1.4592	0.3277	-2.5277	2.7834	5.1214 **
	(2.1853)	(1.9358)	(2.525)	(3.277)	(2.4871)
Number of observations	2,550	2,550	2,550	2,550	2,550

***Significant at 1%, **Significant at 5%, * Significant at 10%.
Standard errors in parenthesis.

Table 7

Cox Regressions for Presenting the Disease at 2nd Exam										
	Diseases Diagnosed at 2nd Exam									
Variables	**Cardiovascular**		**Rheumatism/MSK**		**Respiratory**		**Gastrointestinal**		**Rectum/Hemorrhoids**	
	Coefficient	**Hazard Ratio**	**Coefficient**	**Hazard Ratio**	**Coefficient**	**Hazard Ratio**	**Coefficient**	**Hazard Ratio**	**Coefficient**	**Hazard Ratio**
BMI at 1st Exam (refer. = Normal Weight)										
Underweight	0.188	1.207	0.095	1.100	-0.447	0.640	0.338	1.402	0.336	1.399
	(0.186)		(0.204)		(0.369)		(0.29)		(0.261)	
Overweight	-0.031	0.970	0.082	1.085	0.170	1.186	-0.073	0.930	-0.054	0.947
	(0.128)		(0.134)		(0.176)		(0.201)		(0.198)	
Obese	-0.082	0.922	0.024	1.024	-0.486	0.615	-0.248	0.781	-0.430	0.651
	(0.255)		(0.253)		(0.426)		(0.394)		(0.462)	
Age at 1st exam	0.241	1.273	0.392 *	1.480	0.518	1.679	0.323	1.381	0.378	1.459
	(0.191)		(0.224)		(0.349)		(0.37)		(0.334)	
Age^2/10 at 1st exam	-0.010	0.990	-0.028	0.973	-0.042	0.959	-0.024	0.976	-0.032	0.969
	(0.017)		(0.021)		(0.033)		(0.035)		(0.031)	
State of residence in 1900 (refer.= North Atlantic)										
South Central	0.163	1.177	-0.822 **	0.440	0.116	1.123	-0.647	0.523	0.021	1.022
	(0.265)		(0.396)		(0.388)		(0.527)		(0.453)	
South Atlantic	-0.414	0.661	-0.942 **	0.390	-0.402	0.669	-0.904	0.405	0.277	1.320
	(0.356)		(0.486)		(0.608)		(0.73)		(0.541)	
North Central	-0.025	0.975	0.019	1.019	0.021	1.022	0.017	1.017	0.519 ***	1.680
	(0.115)		(0.119)		(0.17)		(0.173)		(0.196)	
Other States	-0.383	0.682	-0.862 ***	0.422	-0.509	0.601	-1.076 **	0.341	-0.070	0.932
	(0.234)		(0.288)		(0.402)		(0.52)		(0.415)	
Occupation in 1900 (refer. = Farmer)										
Artisan	-0.142	0.867	0.347 **	1.415	0.452 **	1.572	-0.200	0.818	-0.300	0.741
	(0.167)		(0.155)		(0.219)		(0.234)		(0.246)	
Professional	0.099	1.104	-0.339 **	0.712	0.127	1.136	-0.576 **	0.562	-0.308	0.735
	(0.143)		(0.165)		(0.222)		(0.236)		(0.227)	
Manual Labor	0.327 **	1.387	0.048	1.050	0.089	1.093	-0.326	0.722	-0.517 *	0.596
	(0.152)		(0.18)		(0.246)		(0.259)		(0.288)	
Other Occupations	-0.055	0.946	-0.238	0.789	0.081	1.085	-0.637 **	0.529	-0.370	0.691
	(0.174)		(0.193)		(0.257)		(0.284)		(0.271)	
Marital Status in 1900 (refer.= Married)										
Widow	-0.024	0.976	0.108	1.114	-0.110	0.896	-0.003	0.997	-0.182	0.833
	(0.189)		(0.18)		(0.274)		(0.285)		(0.294)	
Divorce	-0.650	0.522	0.033	1.034	-0.038	0.962	0.160	1.174	-0.365	0.694
	(0.719)		(0.397)		(0.725)		(0.72)		(1.015)	
Single	0.255	1.290	0.046	1.047	-0.370	0.691	-0.372	0.689	-0.418	0.659
	(0.203)		(0.248)		(0.393)		(0.423)		(0.393)	
Cohort (refer.= "1836-1840")										
Before 1830	-0.663 *	0.515	0.040	1.041	-0.358	0.699	0.104	1.109	0.63	1.878
	(0.357)		(0.397)		(0.686)		(0.63)		(0.625)	
1831-1835	0.235	1.265	0.290	1.337	0.083	1.086	-0.230	0.794	0.842 **	2.320
	(0.194)		(0.222)		(0.348)		(0.389)		(0.339)	
1841-1845	0.828 ***	2.289	0.734 ***	2.083	0.729 ***	2.073	0.628 **	1.874	0.625 **	1.868
	(0.173)		(0.18)		(0.245)		(0.26)		(0.275)	
After 1845	1.159 ***	3.186	0.862 ***	2.369	1.31 ***	3.707	1.019 **	2.770	1.175 ***	3.239
	(0.262)		(0.282)		(0.354)		(0.41)		(0.389)	
Company's Death Rate During War	-0.521	0.594	1.317	3.732	0.967	2.630	1.732	5.651	-0.021	0.979
	(2.491)		(2.829)		(3.861)		(3.841)		(3.921)	
Number of Diseases at 1st Exam	-0.030	0.971	-0.170 ***	0.844	-0.114 *	0.892	0.022	1.023	-0.142 **	0.868
	(0.042)		(0.049)		(0.061)		(0.068)		(0.071)	
Weight change from 1st to 2nd exam (refer.= Less)										
Same weight	0.064	1.066	-0.058	0.944	0.065	1.067	0.081	1.084	0.153	1.165
	(0.162)		(0.176)		(0.237)		(0.231)		(0.253)	
More weight	0.152	1.165	-0.042	0.959	-0.036	0.965	-0.484 **	0.617	0.104	1.109
	(0.111)		(0.119)		(0.168)		(0.187)		(0.174)	
Total Number of observations	1,502		1,111		1,606		1,724		1,548	
Event	392		337		174		166		162	
Censored	1,110		774		1,432		1,558		1,386	
Chi^2	84.57 (df = 24)		94.97 (df = 24)		32.11 (df = 24)		36.68 (df = 24)		43.21 (df = 24)	

***Significant at 1%, **Significant at 5%, * Significant at 10%.
Standard errors in parenthesis.

Table 8

Cox Regressions for Survival after 1891						
Variables	All Death after 1891		All Death after 1900		All Death after 1900	
	Coefficient	Hazard Ratio	Coefficient	Hazard Ratio	Coefficient	Hazard Ratio
BMI at 1st Exam (reference = Normal Weight)						
Underweight	0.195 **	1.215	0.132	1.141	0.135	1.145
	(0.092)		(0.113)		(0.115)	
Overweight	0.066	1.069	0.059	1.061	0.075	1.077
	(0.086)		(0.103)		(0.104)	
Obese	0.202	1.224	0.239	1.27	0.305	1.357
	(0.191)		(0.224)		(0.226)	
Age at 1st exam	0.209 ***	1.232	0.182 ***	1.2	0.208 ***	1.231
	(0.057)		(0.07)		(0.071)	
Age^2/10 at 1st exam	-0.012 **	0.988	-0.009	0.991	-0.011 *	0.989
	(0.005)		(0.006)		(0.006)	
Company's Death Rate During War	-0.814	0.443	-0.423	0.655	-1.191	0.304
	(1.515)		(1.788)		(1.815)	
Number of Diseases at 1st Exam	-0.025	0.976	0.01	1.01	0.02	1.02
	(0.024)		(0.029)		(0.029)	
State of residence in 1900 (refer.= North Atlantic)						
South Central					-0.292	0.747
					(0.232)	
South Atlantic					-0.425 **	0.654
					(0.206)	
North Central					-0.146	0.864
					(0.101)	
Other States					0.258 **	1.295
Occupation in 1900 (refer. = Farmer)						
Artisan					0.185	1.203
					(0.137)	
Professional					-0.105	0.900
					(0.126)	
Manual Labor					0.091	1.096
					(0.174)	
Other Occupations					0.238 *	1.269
Marital Status in 1900 (refer.= Married)						
Widow					0.078	1.081
					(0.126)	
Divorce					1.272 ***	3.569
					(0.37)	
Single					0.017	1.017
					(0.155)	
Total Number of observations	1,040		747		747	
Event	1,040		747		747	
Censored	0		0		0	
Chi^2	228.52 (df = 7)		214.46 (df =7)		251.05 (df = 18)	

***Significant at 1%, **Significant at 5%, * Significant at 10%.

Standard errors in parenthesis.