

CHANGING CHRONIC DISEASE RATES AND LONG-TERM DECLINES IN FUNCTIONAL LIMITATION
AMONG OLDER MEN*

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ABSTRACT

Functional limitation (difficulty in walking, difficulty in bending, paralysis, blindness in at least one eye, and deafness in at least one ear) in the United States has fallen at an average annual rate of 0.6% among men age 50 to 74 from the early twentieth century to the early 1990s. 24% of this decline is attributable to reductions in the debilitating effects of chronic conditions, 37% to reduced chronic disease rates, and the remainder is unexplained. The findings have implications for theories of the impact of declining mortality rates on elderly health.

Introduction

Functional limitation among older men in the United States has improved greatly since the beginning of the twentieth century. Among men age 60 to 74 at the beginning of the century 50% had difficulty bending, 31% difficulty walking, 4% were partially paralyzed, 4% were blind in at least one eye, and 4% deaf in at least one ear. In contrast, among men in the same age group in the early 1990s, only 16% had difficulty bending, 11% had difficulty walking, 3% were partially paralyzed, 3% were blind in at least one eye, and 3% were deaf in at least one ear. The decline in functional limitation in this time period among men age 50 to 64 is of a similar order of magnitude. (Trends and sources are reviewed later in the text.)

This paper uses a longitudinal data set on Union Army veterans and recent health surveys to document the decline in functional limitation among men age 50 to 64 and 60 to 74 in the United States between the early 1900s and the early 1990s. It examines whether these declines can be explained by reductions in the debilitating effects of chronic conditions or by the decline in chronic disease rates. Even with no decline in chronic disease rates, functional limitation may have improved because medical technology allows both for short-term symptom relief and for long-term control of chronic conditions. For example, Fries et al. (1996) find up to a 30% reduction in long-term disability in patients with rheumatoid arthritis with consistent use of disease-modifying antirheumatic drug-based treatment strategies. But, although medical care may reduce disability rates for a given level of sickness, it may lead to worse average health because technology may allow frailer individuals to survive (Riley 1989; Verbrugge 1984). Because medical treatment in the past was ineffective at best, I can contrast the impact of untreated and treated chronic disease on functional limitation.

The findings have implications for our understanding of why the health of different cohorts has been changing in the United States both over the long-run and during the 1980s (Costa 2000;

Culter and Richardson 1997; Freedman and Martin 1999, 2000; Manton, Corder, and Stallard 1997a) and for theories of the impact of declining mortality rates on elderly health. One view holds that rising longevity may increase both chronic disease and disability rates (e.g. Gruenberg 1977; Verbrugge 1984). Another view is that the onset of chronic disease and therefore disability can be postponed until the limit of life is reached (Fries 1980, 1986). A third view is that even though declines in mortality may increase the prevalence of chronic disease, the rate of progression of chronic disease and therefore of disability may fall (Manton 1982). Freedman and Martin (2000)'s findings that between 1984 and 1994 the self-reported prevalence of 8 out of 9 chronic conditions increased, but that these conditions had less debilitating effects on functioning provides some support for this view. Comparing long-term disability and chronic disease trends will help us further distinguish between these theories. The first theory predicts that both chronic disease and disability rates should be increasing whereas the second theory predicts that both should be decreasing. The third theory predicts that disability rates should be declining but allows for increases in chronic disease rates.

In previous research (Costa 2000), I established that the burden of chronic disease at older ages was extremely high in the past and documented the roles played by reduced infectious disease rates and by the shift from manual to white collar work in the long-term decline in chronic disease rates. This research also suggested that there was some evidence that chronic conditions have now become less disabling, but it examined few chronic conditions and only one functional limitation and did not investigate why chronic conditions have now become less disabling. In this paper I examine this issue more formally and for a larger set of conditions. My findings have implications for the role of increased medical knowledge in declining disability rates. Chronic conditions may have become less disabling because of the increased efficacy of medical care, better diagnoses and thus earlier recognition of diseases at less severe stages, better treatment and management of illness on the part of individuals apart from what medical care

they receive, definitional differences in chronic conditions, and declining frailty, among other factors. Although I will not be able to determine why a chronic condition has become more or less disabling, declines in the debilitating effects of chronic conditions represent an upper bound estimate of the effect of increases in medical knowledge.

The paper begins with a description of the data. Section 3 discusses trends in functional limitation and in specific chronic disease rates. Section 4 explains how declines in functional limitation can be decomposed into the portions attributable to reductions in the debilitating effects of chronic disease and to declining chronic disease rates. The actual decompositions are presented in section 5. Section 6 concludes with a discussion of the implications of the findings.

Data

The data used in this paper are drawn from the records of the Union Army pension program, covering 85% of all Union Army veterans by the 1900 census and 90% by the 1910 census (Costa 1998:160). The program was established in 1862 to provide pensions to both regular and volunteer recruits who were severely disabled as a direct result of military service. By 1890 the program became a universal disability program for veterans and by 1904 it officially became a universal old-age pension program. The Pension Bureau meticulously compared pension applications with army records and affidavits from former comrades and from neighbors to verify the identity, age, and service record of applicants. As part of this program, a board of three physicians working under contract from the Pension Bureau (the examining surgeons) gave veterans a full physical exam. These exams are available both for veterans whose pension application or bid for a pension increase was rejected and for men whose applications were accepted. I use the resulting detailed medical exams to construct functional limitation variables and variables for specific symptoms, signs, and conditions for a sample of white veterans (see the Data Appendix for description of the

data).

I compare the Union Army data with random samples of the American non-institutionalized white, male population drawn from the 1988-1994 National Health and Nutritional Examination Survey (NHANES) and from the 1994 and 1995 National Health Interview Surveys (NHIS). These datasets contain functional limitation variables and variables for specific symptoms, signs, and conditions either from a medical exam (NHANES) or from self-reports (NHANES and NHIS).

Table 1 compares the variables in the Union Army data with those from NHANES and NHIS. I create 5 functional limitation variables. The first variable is difficulty in walking. In the Union Army data this indicator is equal to one if the examining surgeons ever noted a gait abnormality (e.g. “lame,” “shuffles”, “leg drags”) or general difficulties in walking (“locomotion impaired,” “crippled,” “cannot walk”). I compare this variable with an indicator equal to one if an interviewee in NHANES reported difficulty in walking a quarter of a mile or reported lameness. I also compare this variable with self-reported difficulty in walking a quarter of a mile in NHIS. The second limitation indicator is difficulty in bending. In the Union Army data this indicator variable is equal to one if the examining surgeons noted general difficulties in bending (“cannot touch floor”, “cannot straighten”). In NHANES and NHIS difficulty in bending is based upon a physician report and a self-report, respectively. The other limitation indicators are paralysis, blindness in one eye, and deafness in one ear. These have the advantage of not being socially constructed. Deafness in one ear is used only to study disability trends because in neither the Union Army data nor in NHANES was any of the chronic conditions a significant predictor. However, in 1900 a surgeons’ report of an infectious disease other than malaria or typhoid was a significant predictor of deafness. All other limitation variables are used both to study trends and the relationship between disability and chronic disease.

The specific symptoms, signs, and conditions that I examine in my analysis of functional limitation determinants are adventitious sounds (abnormal breath sounds that include crackles

or rales, rhonchi, and wheezes or pleural friction rubs), absent or decreased breath sounds, back problems, joint problems, heart murmurs, congestive heart failure, stroke, irregular pulse, varicose veins, hemorrhoids, poor circulation, arteriosclerosis, and tachycardia. These conditions do not require any diagnostic equipment that was unavailable to nineteenth century physicians. However, in the case of heart murmurs, irregular pulse, tachycardia, arteriosclerosis, and congestive heart failure, diagnoses have become more specific. The examining surgeons may have noted all murmurs, even harmless ones. The examining surgeons' use of hard arteries as a detection criterion provides evidence of peripheral arteriosclerosis which may be evidence of either atherosclerosis (cholesterol and fatty plaques in the blood) or of such other disease states as diabetes mellitus or systemic or local inflammation. Prevalence rates in NHIS are for atherosclerosis. In the Union Army data congestive heart failure is defined using edema, cyanosis, and dyspnea as the diagnostic criteria. A more precise diagnosis (used in examining trends) might include not only edema, cyanosis, and dyspnea, but also include cardiomegaly and exclude co-existing respiratory conditions and asthma.

Table 2 summarizes potential biases (and their direction) that might arise in comparing the prevalence of functional limitation and of chronic conditions between the Union Army dataset and NHANES and NHIS. One source of bias arises from the time frame in which a limitation is noted. Prevalence rates calculated for the Union Army data are based upon a condition ever being noted in an exam. Those in NHANES are based either upon one exam or upon an interviewee ever being told by a doctor that he had a specific condition. Prevalence rates in NHIS are for conditions an individual had in the last 12 months. Because a condition is more likely to be noted in multiple exams, prevalence rates in the Union Army sample may be overstated relative to those in NHANES or NHIS. But, because men are likely to develop a condition between the time of the last exam and either 1900 or 1910, prevalence rates in the Union Army sample may be understated.

A second source of bias arises from differences in diagnostic training and in diagnostic criteria. Nineteenth century physicians were more accustomed to direct observation and therefore may have been more careful in detecting conditions. Their definitions, however, were looser. Both of these factors could bias prevalence rates upward in the Union Army sample relative to NHANES and NHIS.

A third source of bias arises from improvements in coping with limitations and from differences in our notions of what constitutes disability. Better assistive devices allow individuals to walk with greater ease, thus biasing Union Army prevalence rates upward. But, at a time when many individuals probably labored in pain from chronic conditions, functional limitations in the Union Army dataset may be biased downward because poor health was the norm.

A fourth source of bias arises from the nature of the examined populations. Men who survived the Civil War may have been permanently scarred by camp illnesses and battle wounds, biasing estimates upward. However, because men in poor health were never inducted into the army, this will impart a downward bias. The growth in institutionalization rates will impart an upward bias.

A fifth source of bias arises from the selective nature of the information in the Union Army sample. I can observe functional limitations and chronic conditions only for men with a surgeons' exam. Not all men have a surgeons' exam and exams were less likely for men who qualified for a pension on the basis of age, as many did in 1900. In calculating prevalence rates I assume that men without a surgeons' exam are in perfect health. Prevalence rates will therefore be biased downward. In examining the relationship between chronic conditions and disability, I restrict myself to men with a surgeons' exam. This could bias the coefficients either upward (only very severe conditions are observed) or downward (minor conditions may be correlated with severe limitations).

Finally, the sixth source of bias arises from increases in survivorship rates. For example, a much smaller percentage of stroke victims survived before the ability to maintain adequate

oxygen, nutritional, and fluid intake after the initial stroke and the availability of anticoagulant and antiplatelet drugs to prevent subsequent strokes. Stroke was one of the primary causes of death in the past. Among Union Army veterans, 11% of men who were age 50-64 in 1900 died of cerebrovascular disease.¹ Stroke today is commonly associated with atherosclerosis or hypertension. Rates of hypertension are high in recent data (at least 36% among men age 60-74). We do not know rates of hypertension in the past because examining surgeons lacked the technology to diagnose hypertension in Union Army veterans, but stroke mortality rates suggest that they were high and that therefore prevalence rates for arteriosclerosis may be underestimated.

Functional Limitations and Chronic Disease Trends

Table 3 shows that functional limitation as measured by difficulty in walking, difficulty in bending, paralysis, blindness in at least one eye, and deafness in at least one ear was much higher among Union Army veterans age 50-64 and 60-74 than among men of the same age groups in either NHANES or NHIS. Note that rates are high for Union Army veterans regardless of how functional limitations are calculated – 1) under the assumption that men without a surgeon’s exam had no functional limitations, 2) only for men with a surgeon’s exam, or 3) predicted from probits that control for the veteran’s war-time experience.²

¹The other major killers were heart disease (25%) and urinary problems (13%). Cause of death rates were calculated excluding men who died during the influenza epidemic.

²Values were predicted for the entire sample from a probit in which the dependent variable was the measure of functional limitations and the independent variables were age, dummy variables for occupation, dummy variables indicating what disease a veteran had while in the army, and dummies for whether the veteran had ever been wounded in the war, had ever been discharged for disability, or had ever been a POW. The latter three dummies were set equal to 0 to obtain

Table 3 implies that functional limitation declined substantially over the course of the twentieth century. Among men age 50-64 difficulty in walking declined by 0.7% per year and difficulty in bending and paralysis declined by 0.9% per year from 1900 to 1991 (the midpoint of NHANES). Using the NHIS, difficulty in walking fell by 0.8% per annum. During these same years blindness in at least one eye and deafness in at least one ear declined by 0.6% per year. Among men age 60-74 the declines in difficulty in walking and in bending and in paralysis were 0.7 to 0.8% per year between 1910 and 1991. In this time span blindness in at least one eye and deafness in at least one ear declined by 0.2 to 0.3% per year. Declines in functional limitations were sharper in recent decades. The average decline between 1910 and 1991 (0.6% per year) is lower than the 0.5 to 1.0% per year observed by Cutler and Richardson (1997) between 1980 to 1990, the 0.9 to 2.3% per year found by Freedman and Martin (1998) between 1984 and 1993, the 0.9% per year observed by Crimmins, Saito, and Reynolds (1997) between 1982 and 1993, and the yearly 1.1% and 1.5% between 1982 and 1989 and 1989 and 1994, respectively, found by Manton, Corder, and Stallard (1997a).³

Table 4 shows that declines in functional limitation have been accompanied by a large decline in chronic disease rates. The prevalence of decreased breath sounds declined by about 0.6% per annum and that of adventitious sounds by about 0.9 to 1.1% per year. The annual rate of decline for back problems was 0.2 to 0.4% and for joint problems 0.4 to 0.5%. The largest declines in prevalence rates are observed in heart and circulatory conditions. The prevalence of _____
predictions.

³There may be cycles in health since the 1970s. Although clinician reports document continuous improvements in health since the 1970s (Waidmann, Bound, and Schoebaum 1995), self-reported health declined during the 1970s (Chirikos 1986; Colvez and Blanchet 1981; Crimmins 1990; Poterba and Summers 1987; Verbrugge 1984). Some of the differences in these studies may be attributable to differences in health measures and in reference periods.

heart murmurs, irregular pulse and tachycardia declined by 0.9 to 1.0% per per year from the beginning of the century to the beginning of the 1990s. The prevalence of varicose veins and poor circulation declined by 0.7 to 0.9% per annum and that of hemorrhoids by 0.8 to 1.0%. The time trend in other conditions such as cataracts, stroke, arteriosclerosis, or congestive heart failure is harder to pinpoint because examining surgeons may have been more likely to note the final condition than the underlying cause (loss of vision rather than cataracts, paralysis rather than stroke), because of low survivorship rates (stroke), or because of the increased specificity of diagnoses (arteriosclerosis, congestive heart failure). The chronic disease trend results are similar to those obtained by Costa (2000) for a smaller sample and a more limited set of conditions.

How credible are the high chronic disease rates observed in the Union Army sample? The high prevalence of respiratory disorders are consistent with exposure to acute respiratory illnesses and to such occupational hazards as dust, fumes, and animal waste, hair, and feathers. The high prevalence of joint and back problems observed in 1900 and 1910 are consistent with analyses of skeletal remains from the American frontier which report a high prevalence of degenerative joint disease (osteoarthritis), nonarthritic joint changes resulting from habitual postures, and fractures arising from traumas (e.g. Larsen et al. 1995). Although the declines in murmurs, irregular pulse, and tachycardia may reflect the more careful examinations of surgeons accustomed to direct observation as well as looser definitions, the high prevalence rates for irregular pulse, tachycardia, poor circulation, and varicose veins are consistent with the high prevalence rate of valvular heart disease (39% among men age 60-74 in 1910).⁴

⁴The relationship between valvular heart disease and varicose veins or tachycardia is much looser than for irregular pulse or tachycardia.

Methods

Functional disability (difficulty in walking, difficulty in bending, paralysis, blindness in at least one eye, and deafness in at least one ear) can be related to chronic conditions through probit regressions of the form

$$\text{Prob}(D_{\text{UA}} = 1) = \Phi(X_{\text{UA}}\beta_{\text{UA}}) \quad (1)$$

$$\text{Prob}(D_{\text{NHANES}} = 1) = \Phi(X_{\text{NHANES}}\beta_{\text{NHANES}}) \quad (2)$$

$$\text{Prob}(D_{\text{NHIS}} = 1) = \Phi(X_{\text{NHIS}}\beta_{\text{NHIS}}) \quad (3)$$

where D is an indicator variable that is equal to one if an individual had a specific functional limitation, the matrix X includes dummy variables for specific chronic conditions, a dummy variable for whether a veteran had ever been wounded in the war (for the UA sample specification), a dummy variable indicating whether an individual was an amputee (unavailable in the NHIS specification), and age, and Φ is the cumulative normal distribution. I do not control for socioeconomic factors because these variables are not comparable across datasets. Because specific chronic conditions and functional limitation for men in 1900 and 1910 are known only for those with a surgeons' exam, the Union Army sample is restricted to men with a surgeons' exam.

Two different specifications are used for the Union Army sample. In the first specification the dummy variables for specific chronic conditions are dummies for adventitious sounds, decreased breath sounds, back problems, joint problems, murmurs, congestive heart failure, stroke, irregular pulse, and cataracts. This specification contains chronic conditions that can be compared with those found in NHANES. The second specification uses chronic condition dummies for murmurs, varicose veins, hemorrhoids, poor circulation, arteriosclerosis, and tachycardia. This specification can be compared with that used for NHIS.⁵ The specifications do not explicitly account for

⁵Although the assumption in this paper is that a condition that leads to greater functional

comorbidities either because interaction terms between the disease dummies were insignificant predictors (e.g. joint problems and heart conditions in the Union Army sample) or because of small sample sizes (e.g. murmurs in NHANES).

Declines in functional limitation can be decomposed into the proportions attributable to reductions in the debilitating effects of chronic disease and to reductions in chronic disease rates. The probability of functional limitation in the Union Army sample, P^{UA} , and the probabilities of functional limitation in NHANES and NHIS, P^{NHANES} and P^{NHIS} , are

$$\begin{aligned} P^{UA} &= P^{UA}(X_{UA}\beta_{UA}) + U_{UA} \\ P^{NHANES} &= P^{NHANES}(X_{NHANES}\beta_{NHANES}) + U_{NHANES} \\ P^{NHIS} &= P^{NHIS}(X_{NHIS}\beta_{NHIS}) + U_{NHIS} \end{aligned}$$

where $P^{UA}(X_{UA}\beta_{UA})$, $P^{NHANES}(X_{NHANES}\beta_{NHANES})$, and $P^{NHIS}(X_{NHIS}\beta_{NHIS})$ are predicted probabilities and where U is an error term. The difference in functional limitation between the Union Army sample and NHANES and NHIS can be written as

$$\begin{aligned} P^{UA} - P^{NHANES} &= [P^{UA}(X_{UA}\beta_{UA}) - P^{UA}(X_{NHANES}\beta_{UA})] + \\ & [P^{UA}(X_{NHANES}\beta_{UA}) - P^{NHANES}(X_{NHANES}\beta_{NHANES})] + \\ & [U_{UA} - U_{NHANES}] \end{aligned} \tag{4}$$

$$\begin{aligned} P^{UA} - P^{NHIS} &= [P^{UA}(X_{UA}\beta_{UA}) - P^{UA}(X_{NHIS}\beta_{UA})] + \\ & [P^{UA}(X_{NHIS}\beta_{UA}) - P^{NHIS}(X_{NHIS}\beta_{NHIS})] \\ & [U_{UA} - U_{NHIS}], \end{aligned} \tag{5}$$

where for each equation the first term in square brackets represents the difference attributable to changes in chronic disease rates (the X's), the second term in square brackets represents the limitation is worse, some arrhythmias may cause few or no symptoms but are associated with an adverse prognosis whereas other arrhythmias, although symptomatic, are benign.

differences due to changes in functional form (the β s), and the third term in square brackets the differences due to unobservables (the U's). These unobservables include uncontrolled disease states, uncontrolled differences in diagnostic capabilities, and uncontrolled nutritional and environmental changes. Predicted values for the Union Army sample are calculated by setting whether a veteran was ever wounded during the war or was an amputee equal to 0 so that the terms in brackets will reflect differences attributable either to differences in chronic disease rates or to differences in functional form.

Changes in functional form will depend upon the increased efficacy of medical care, better diagnoses and thus earlier recognition of disease at a less severe stage, better treatment and management of illness on the part of individuals apart from what medical care they receive, definitional differences in chronic conditions, and changes in frailty. The change attributable to the β s represents the overall impact of reductions in the debilitating effects of chronic disease on functional limitation under the assumption of no omitted variable bias. The change attributable to the β s therefore represents an upper bound estimate of the effect of increased medical knowledge on disability.

Although the Union Army data are compared to both NHANES and NHIS, comparing the Union Army data to NHANES allows me to examine a broader set of functional limitations and of chronic conditions. Comparisons with NHIS provide a further confirmation and permit me to examine additional chronic conditions.

Results

Table 5 shows that in the past chronic conditions had a larger impact on difficulty in walking or in bending among men age 50 to 64 than they did in the 1990s. Irregular pulse and varicose veins were more likely to be significant predictors of difficulty in walking and in bending in the

Union Army data than in NHANES or NHIS. Congestive heart failure was a significant predictor of difficulty in walking and in bending in the Union Army sample and in NHANES. Murmurs were significant predictors of difficulty in walking and in bending in the Union Army data but not in the NHIS. Arteriosclerosis was a significant predictor of difficulty in walking in both the Union Army data and in NHANES but was a significant predictor of difficulty in bending only in the Union Army data. Tachycardia was a significant predictor of difficulty in walking and in bending only in the Union Army data (though the point estimates are substantial in NHIS). Poor circulation affected mainly difficulty in walking in both the Union Army data and in NHIS, with larger point estimates in the NHIS. The results for stroke are mixed but suggest that stroke was a significant predictor both in the Union Army data and in NHANES. Back problems were significant predictors of these functional limitations in both the Union Army data and in NHANES. Joint problems are consistently significant predictors of difficulty in walking and in bending both in the Union Army data and in NHANES; the point estimate is larger in the Union Army data. The results for men age 60 to 74 were similar, with the exception of adventitious sounds (see Table 6). These were significant predictors of both difficulty in walking and in bending in the Union Army sample but not in NHANES.

Differences in the etiology of heart and circulatory conditions may explain why these conditions predict both difficulty in walking and in bending in the Union Army data, but only difficulty in walking in the more recent data. Rheumatic fever and rheumatic arthropathies while in the army predicted heart and circulatory conditions at older ages (Costa 2000). Heart and circulatory conditions may therefore have been accompanied by arthropathies resulting from rheumatic fever. Indeed, the correlation between heart and circulatory problems and joint problems was very high. More than 80% of men who had arteriosclerosis or congestive heart failure in 1900 also had joint problems. 70% of men with murmurs or tachycardia in 1900 also had joint problems. However, when in the Union Army sample joint problems were interacted with heart and circulatory

dummies, the coefficients on the resulting interaction terms were insignificant.

In the case of paralysis and blindness, the main predictors in the Union Army data and in NHANES were similar (stroke and cataracts), but the point estimates were larger in the Union Army data (see Table 7). In the case of deafness (not shown), none of the chronic conditions were either significant or substantial predictors of deafness.

Using the regression results presented in Tables 5, 6, and 7 to decompose changes in functional limitation between the Union Army data and NHANES into the fractions due to reduced chronic disease rates and to changes in functional form (the debilitating effects of chronic disease) shows that both are important (see Table 8). Among men age 50 to 64 reductions in the debilitating effects of chronic conditions account for 11% of the decline in difficulty in walking observed between the Union Army data and NHANES, 41% of the decline in difficulty in bending, 61% of the decline in paralysis, and 23% of the decline in blindness. The figures attributable to reduced chronic disease rates are 26, 40, 4, and 36%, respectively. Among men age 60 to 74 reductions in chronic disease rates are on the whole more important than reductions in the debilitating effects of chronic disease. 9% of the difference in difficulty in walking is explained by changes in the β s and 37% by changes in chronic disease rates. 51% of difficulty in bending is explained by changes in chronic disease rates and 33% by changes in the β s. 69% of the decline in paralysis is explained by changes in the β s and more than all of the decline in blindness. Averaging over both age groups and over 5 measures of functional limitation (including deafness) implies that 28% of the decline in functional limitation can be explained by reductions in the debilitating effects of chronic disease.⁶ Averaging over difficulty in walking and in bending alone, the decline in the debilitating effects of chronic conditions explains 24% of the decline in functional limitation in these two measures. Another 37% was explained by reduced chronic disease rates and the

⁶I assume that reductions in the debilitating effects of chronic conditions explain 0% of the decline in deafness.

remaining 22 to 39% was unexplained.

Declines in the debilitating effects of chronic disease also explain a substantial fraction of the differences in functional limitation between the Union Army sample and NHIS. Reductions in the debilitating effects of chronic disease may explain up to 57% of the decline in difficulty in bending between the Union Army data and NHIS and reduced chronic disease rates only 22% of the decline. Reductions in the debilitating effects of chronic disease account for a smaller fraction of the decline in difficulty in walking between the Union Army and NHIS (at most 26%); lower chronic disease rates account for 25% of the decline. On average, reductions in the debilitating effects of chronic disease explain up to 42% of the decline in functional limitation between the Union Army data and NHIS as measured by difficulty in walking and in bending. Reduced chronic disease explain 24% of the decline, with the remaining 34% unexplained. Results differ according to whether the Union Army data are compared with NHANES or NHIS, because of differences in control variables, particularly joint and back problems, which can only be controlled for in NHANES.

Implications

This paper has shown that functional limitation as measured by difficulty in walking, difficulty in bending, paralysis, blindness in at least one eye, and deafness in at least one ear has fallen at an average rate of 0.6% per year among men age 50 to 64 and age 60 to 74 from the early twentieth century to the early 1990s. This rate of decline is not as pronounced as that in the 1980s and early 1990s (Crimmins, Saito, and Reynolds 1997; Cutler and Richardson 1997; Freedman and Martin 1998; Manton, Corder, and Stallard 1997a), suggesting that a large proportion of the decline in disability at older ages has occurred only recently.

I attributed 24% of the decline in functional limitation as measured by difficulty in walking

and in bending from the early 1900s to the early 1990s to reductions in the debilitating effects of chronic conditions and 37% to reduced chronic disease rates. The remaining 39% was unexplained and could be accounted for by unobserved disease states, unobserved differences in diagnostic capabilities, and unobserved nutritional and environmental changes.

The findings suggest that theories of elderly health need to account both for declines in chronic disease rates and for declines in the debilitating effects of chronic disease. Although stroke survivorship has increased, permanent paralysis associated with stroke has fallen since the beginning of the twentieth century. Although arthritis is still widely prevalent and debilitating, it is now less debilitating. On the whole, both reduced chronic disease rates and reduced functional limitation associated with chronic disease rates are important in explaining the long-term decline in functional limitation. But, reduced chronic disease rates may be more important. The long-term pattern differs from that prevailing since the mid-1980s in which reductions in the debilitating effects of chronic disease are more important (Freedman and Martin 2000) and this finding is consistent with the rapid growth since the 1960s of therapies targetted at the elderly.

Several explanations can account for declines in chronic disease rates among the elderly. For the specific chronic conditions examined in this paper, 19% of the decline in chronic disease rates can be accounted for by reduced infectious disease rates (particularly rheumatic fever, typhoid, malaria, and acute respiratory conditions) and 13% by occupational shifts from manual to white collar work.⁷ The remaining 68% is unexplained and can be accounted for by unobserved reduced infectious disease rates, unobserved reduced job risk, improvements in nutritional intake during the growing years (including in utero), the decreased use of wood smoke and salt as food preservatives, or improved knowledge of health habits and of preventive medicine, among

⁷In Costa (2000), I argued that for the conditions examined in that paper 29% of the decline in older age chronic conditions was due to occupational shifts and 18% to reduced infectious disease rates. The results are not contradictory. A different set of conditions was examined.

other factors (Barker 1992, 1994; Costa 2000; Elo and Preston 1992; Fogel and Costa 1997; Manton, Stallard, and Corder 1997b). These results imply that of the 37% of the decline in functional limitations attributable to chronic disease rates, 9% can be accounted for by reduced infectious disease rates and 7% by occupational shifts.⁸ Public health measures that reduced crowding, improved sanitation, and produced filtered and chlorinated water; swamp drainage; and the depopulation of rural areas where malaria was prevalent may therefore have played a role in reducing disability rates at older ages by reducing chronic disease rates.

Several explanations can account for reductions in the debilitating effects of chronic disease. These include the increased efficacy of medical care, better diagnoses and thus earlier recognition of a disease at a less severe stage, better treatment and management of illness on the part of individuals apart from what medical care they receive, definitional differences in chronic conditions, and changes in frailty. These factors are in turn influenced by innovations in medical care and therefore both private and public research expenditures; public health campaigns that increase individuals' awareness of risk factors; the rise in educational levels; the rise in incomes; and, the increasing availability of health care. Although this paper was not able to determine why chronic disease is now less debilitating, understanding why has important policy implications. If

⁸I decomposed the decline in functional limitation between the Union Army sample and NHANES and NHIS into the proportions attributable to reduced infectious disease rates and to occupational shifts by decomposing the change in chronic conditions (the X's) into these two factors. I first obtained predicted values of chronic disease rates from probit regressions on the Union Army sample under the assumptions that infectious disease rates were zero and that the occupational distribution resembled the recent one. I then used the predicted values of chronic disease rates obtained from these probits together with the regressions from section 5 for the Union Army sample to predict functional limitation. The full set of results can be obtained from NBER Working Paper no. 7605, <http://www.nber.org>.

medical innovations and improved diagnoses played a large role then reductions in the debilitating effects of chronic conditions may not necessarily improve the fiscal outcomes for programs such as Medicare. Cutler and Sheiner (forthcoming) predict that if technological change in medicine continues at its historic rate, then even if disability rates continue to fall at their recent rates, medical costs will still rise. If continued innovations in medical care are needed to improve disability rates, then, despite reductions in chronic disease rates and in the debilitating effects of chronic disease, the financing of medical care will continue to remain an issue well into the future.

Data Appendix

The Union Army data set is comprised of three different data sets: the military service and pension data, the records of the examining surgeons, and the census data. The military service and pension data and the census data are available from the Interuniversity Consortium on Political and Social Science Research (ICPSR) as *Aging of Veterans of the Union Army: Military, Pension, and Medical Records, 1820-1940 (ICPSR 6837)*, *Aging of Veterans of the Union Army: United States Federal Census Records, 1850, 1860, 1900, 1910 (ICPSR 6836)*, and *Aging of Veterans of the Union Army: Surgeons' Certificates, 1860-1940 (ICPSR 2877)*. The principal investigator is Robert Fogel. The data are also available from the National Bureau of Economic Research, <http://www.nber.org>, and from the Center for Population Economics at the University of Chicago, <http://www.cpe.uchicago.edu>.

The records used in this paper represent a 58% sample of the final sample that will be available. By 1900, approximately 10% of veterans were not collecting a pension, either because their applications had been rejected or because they had not yet applied for a pension. A surgeons' exam is available for 90% of all men who had a pension in 1900. Veterans had every incentive

to undergo a complete medical examination because those with a severe chronic condition, particularly if it could be traced to war-time experience, were eligible for larger pensions. The surgeons rated the severity of specific conditions using detailed guidelines provided by the Pension Bureau. Men for whom a surgeons' exam is missing tended to be men who entered at a late age and received a pension on the basis of age. In estimating prevalence rates for the sample as a whole, I assume that these men did not have the specific functional limitation or chronic disease that I examine. In estimating the relationship between functional limitation and chronic conditions (Equation 1) I restrict the sample to men with a surgeons' exam. In estimating the relationship between chronic conditions and infectious disease and occupation (Equation 6) I further restrict the sample to men found in either the 1900 or 1910 census.

Men who entered the Union Army were probably healthier than the population as a whole. An examination of men who were rejected for military service suggests that mean height for the population was about 0.18 inches less than the mean of the recruits. Once men entered the service, rural farmers, who were the better nourished segment of society, were more likely to die because they lacked immunities to such common camp diseases as measles and typhoid (Lee 1997). However, men who survived the war (regardless of occupation) were only 0.02 inches shorter than all recruits at enlistment, suggesting that the war itself induced minimal survivorship bias.

Although little is known about the experience of Union Army veterans from the time they left the service until they appear on the pension rolls, several tests indicate that this sample is representative of the general population in terms of wealth and circa 1900 in terms of mortality experience. Among all adult males age 20 and over in the households to which recruits were linked in the 1860 census, mean wealth was similar to that found in a random sample, suggesting that military service was not very selective of men of lower socioeconomic status. In fact, 95% of the sample consisted of volunteers. Cohort life expectancies of veterans who reached age 60 between

1901 and 1910 resemble cohort life expectancies found in genealogies and the distribution of deaths from specific causes for all veterans who died between 1905 and 1915 does not differ significantly from the distribution of expected number of deaths from those causes in the death registration states in 1910 (Costa 1998: 197-212).

How representative of the health of the general population are the disability rates calculated for the entire Union Army sample? Because all Union Army veterans survived to young adult ages without any substantial physical handicaps and because of high infectious disease rates at young ages (e.g. scarlett fever or congenital rubella), the prevalence of blindness and deafness was probably higher in the general population. Disability may have been higher in the general population because the proportion of immigrants was higher in the general population and these men experienced a worse disease and nutritional environment in early childhood.

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Table 2: Potential Biases in Comparing Functional Limitation and Chronic Condition Prevalence Rates Across the Union Army Dataset and NHANES or NHIS

	Conditions Affected
Upward (UA compared to NHANES or NHIS)	
condition more likely to be noted in multiple exams	all
more careful examinations	all
looser definitions	murmurs, irregular pulse, tachycardia, arteriosclerosis, congestive heart failure
assistive devices have improved	difficulty walking
institutionalization rates have risen	all
scarring from wartime experience	all
Downward (UA compared to NHANES or NHIS)	
can develop a condition between last exam and 1900 or 1910	all
assuming men without surgeons' exam in perfect health	all
surgeons may have noted outcome instead of cause	stroke, cataracts
if qualify on basis of age alone then have fewer surgeons' exams	all in 1910
low survivorship for some conditions	all, particularly stroke
social construction of disability	difficulty walking or bending
healthiest served in army	all

Note. UA=Union Army datasets, NHANES=National Health and Nutrition Examination Survey, NHIS=National Health Interview Survey.

Table 3: Functional Limitation Rates (%) by Age, 1900/1910-1994

	UA 1900/1910	Predicted UA 1900/1910	Surgeons' UA 1900/1910	NHANES 1988-94	NHIS 1994
Age 50-64					
Difficulty bending	44.4	39.0	49.3	7.5	8.0
Difficulty walking	28.5	20.9	31.7	10.4	8.1
Paralysis	4.8	4.8	5.5	0.9	
Blindness in at least one eye	3.4	2.8	3.7	1.5	
Deafness in at least one ear	3.2	2.9	3.6	1.4	
Age 60-74					
Difficulty bending	53.8	49.7	59.5	16.1	10.7
Difficulty walking	36.6	30.9	40.8	13.8	13.3
Paralysis	6.1	6.0	6.9	2.7	
Blindness in at least one eye	4.5	3.8	4.9	3.1	
Deafness in at least one ear	4.1	3.7	4.5	2.7	

Note. UA=Union Army, NHANES=National Health and Nutrition Examination Survey, NHIS=National Health Interview Survey. Sample weights were used for NHANES and NHIS. Results from “Predicted UA” are predictions from a probit regression in which the controls were age, dummies indicating wartime diseases, occupational dummies, and dummies indicating whether the veteran has ever been wounded during the war, had been discharged for disability, or had been a POW. These last three dummies were set equal to 0 to obtain predicted values. Results from “Surgeons’ UA” are means obtained from the UA sample restricted to men who had a surgeons’ exam.

Table 4: Prevalence Rates (%) of Chronic Conditions, Signs, and Symptoms, 1900-1994

	Age 50-64			Age 60-74		
	UA 1900	NHANES 1988-94	NHIS 1994	UA 1910	NHANES 1988-94	NHIS 1994
Decreased breath sounds	11.9	5.1		15.4	8.3	
Adventitious sounds	20.1	3.4		29.1	4.0	
Back problems	39.2	32.4		47.5	30.2	
Pain/tenderness/swelling in joints	44.8			54.1	35.2	
Ever diagnosed arthritis		20.1			32.7	
Missing limbs, fingers, or toes	3.3	0.1		3.7	1.0	
Cataracts	4.1	3.8		6.6	16.1	
Heart murmur	27.9	2.0	1.6	38.7	3.8	1.7
Congestive heart failure						
Ever diagnosed		3.9			7.0	
(Edema, cyanosis, or dyspnea)	2.7			8.9		
(Above plus cardiomegaly and no co-existing respiratory)	2.0			6.1		
Ever diagnosed stroke	0.3	3.2		0.6	5.2	
Arteriosclerosis	1.7		2.2	9.2		4.7
Irregular pulse	32.4	4.4		43.7	8.6	
Tachycardia	19.2		2.2	27.0		3.4
Varicose veins	7.9		2.6	10.1		3.4
Hemorrhoids	30.7		8.2	36.1		4.7
Poor circulation	4.0		0.9	4.1		1.4

Note. UA=Union Army, NHANES=National Health and Nutrition Examination Survey, NHIS=National Health Interview Survey. Sample weights were used for NHANES and NHIS. A chronic condition is noted in the NHIS if the person had the condition in the last 12 months. A self-reported chronic condition is noted in NHANES if it was ever diagnosed. Symptoms and signs were noted in physician examinations. In UA a chronic condition is noted if it was ever mentioned in an exam. The UA sample is not restricted to men with a surgeons' exam.

Table 5: Impact of Chronic Conditions on Difficulty in Walking or in Bending, Men 50-64, 1900-1994

	Difficulty Walking		Difficulty Bending	
	$\frac{\partial P}{\partial x}$	$\frac{\partial P}{\partial x}$	$\frac{\partial P}{\partial x}$	$\frac{\partial P}{\partial x}$
Specification 1	UA	NHANES	UA	NHANES
	1900	1988-94	1900	1988-94
Adventitious sounds	-0.015 (0.017)	0.081 (0.094)	-0.025 (0.021)	-0.020 (0.045)
Decreased breath sounds	0.004 (0.021)	0.061 (0.069)	-0.004 (0.025)	-0.031 (0.033)
Back problems	0.116** (0.015)	0.066* (0.034)	0.292** (0.016)	0.009 (0.019)
Joint problems	0.139** (0.014)	0.151** (0.039)	0.418** (0.014)	0.081** (0.026)
Murmurs	-0.024 (0.015)	-0.036 (0.087)	0.012 (0.018)	0.054 (0.075)
Congestive heart failure	0.087* (0.040)	0.228** (0.083)	0.147** (0.046)	0.094* (0.050)
Stroke	0.165 (0.117)	0.256** (0.118)	0.085 (0.125)	0.012 (0.046)
Irregular pulse	0.048** (0.015)	-0.089 (0.044)	0.002 (0.018)	0.030 (0.047)
Specification 2	UA	NHIS	UA	NHIS
	1900	1994-95	1900	1994-95
Murmurs	0.031* (0.014)	-0.004 (0.068)	0.137** (0.015)	0.048 (0.077)
Varicose veins	0.172** (0.024)	0.001 (0.057)	0.045† (0.024)	0.011 (0.058)
Hemorrhoids	-0.013 (0.013)	-0.122* (0.032)	0.024† (0.015)	
Poor circulation	0.140** (0.033)	0.139 (0.141)	0.032 (0.033)	0.066 (0.130)
Arteriosclerosis	0.129** (0.050)	0.156* (0.079)	0.229** (0.047)	-0.004 (0.060)
Tachycardia	0.061** (0.016)	0.116 (0.084)	0.051** (0.017)	0.078 (0.080)

Note. UA=Union Army, NHANES=National Health and Nutrition Examination Survey, NHIS=National Health Interview Survey, 1994 and 1995. Standard errors are in parentheses. Coefficients are derivatives from a probit regression in which the dependent variable was whether the individual had difficulty in walking or difficulty in bending and where additional independent variables included age in years and dummy variables indicating whether the Union Army veteran had ever been wounded in the war, whether the individual was an amputee, or whether the individual ever had cataracts. In specification 2, hemorrhoids perfectly predicted a 0 outcome for difficulty in bending. Derivates represent discrete changes from 0 to 1.

† p < .10; * p < .05; ** p < .01

Table 6: Impact of Chronic Conditions on Difficulty in Walking or in Bending, Men 60-74, 1910-1994

	Difficulty Walking		Difficulty Bending	
	$\frac{\partial P}{\partial x}$	$\frac{\partial P}{\partial x}$	$\frac{\partial P}{\partial x}$	$\frac{\partial P}{\partial x}$
Specification 1	UA	NHANES	UA	NHANES
	1910	1988-94	1910	1988-94
Adventitious sounds	0.039* (0.019)	0.073 (0.087)	0.053** (0.020)	0.011 (0.068)
Decreased breath sounds	0.014 (0.023)	0.203** (0.070)	-0.009 (0.026)	0.120 [†] (0.062)
Back problems	0.138** (0.018)	0.063 [†] (0.037)	0.282** (0.018)	-0.011 (0.028)
Joint problems	0.139** (0.018)	0.152** (0.032)	0.430** (0.017)	0.240** (0.030)
Murmurs	-0.003 (0.018)	0.076 (0.097)	0.047* (0.019)	-0.002 (0.073)
Congestive heart failure	0.099** (0.029)	0.177** (0.065)	0.102** (0.032)	0.060 (0.051)
Stroke	0.242** (0.095)	0.179* (0.081)	0.025 (0.034)	0.128** (0.071)
Irregular pulse	0.085** (0.018)	-0.001 (0.059)	0.036 [†] (0.019)	0.110* (0.064)
Specification 2	UA	NHIS	UA	NHIS
	1910	1994-95	1910	1994-95
Murmurs	0.064** (0.017)	0.025 (0.080)	0.163** (0.016)	0.040 (0.075)
Varicose veins	0.153** (0.025)	0.121* (0.069)	0.071** (0.024)	0.045 (0.060)
Hemorrhoids	-0.026 (0.016)	-0.138 (0.059)	0.020 (0.016)	-0.113 (0.053)
Poor circulation	0.137** (0.033)	0.419** (0.124)	0.012 (0.033)	0.150 (0.117)
Arteriosclerosis	0.154** (0.026)	0.124* (0.063)	0.179** (0.023)	0.009 (0.051)
Tachycardia	0.101** (0.018)	0.116 [†] (0.071)	0.068** (0.017)	0.110 [†] (0.068)

Note. UA=Union Army, NHANES=National Health and Nutrition Examination Survey, NHIS=National Health Interview Survey, 1994 and 1995. Standard errors are in parentheses. Coefficients are derivatives from a probit regression in which the dependent variable was whether the individual had difficulty in walking or difficulty in bending and where additional independent variables included age in years and dummy variables indicating whether the Union Army veteran had ever been wounded in the war (if applicable), whether the individual was an amputee, or whether the individual ever had cataracts. Derivates represent discrete changes from 0 to 1.

[†] p < .10; * p < .05; ** p < .01

Table 7: Impact of Stroke and Cataracts on Paralysis and Blindness, Men 50-64 and 60-74, 1900-1994

	Paralysis		Blindness	
	UA 1900/1910 $\frac{\partial P}{\partial x}$	NHANES 1988-94 $\frac{\partial P}{\partial x}$	UA 1900/1910 $\frac{\partial P}{\partial x}$	NHANES 1988-94 $\frac{\partial P}{\partial x}$
Age 50-64				
Stroke	0.784** (0.088)	0.067** (0.048)		
Cataracts			0.363** (0.031)	0.042* (0.030)
Age 60-74				
Stroke	0.701** (0.081)	0.128** (0.045)		
Cataracts			0.343** (0.028)	0.044** (0.017)

Note. UA=Union Army, NHANES=National Health and Nutrition Examination Survey, NHIS=National Health Interview Survey. Standard errors are in parentheses. Coefficients are derivatives from a probit regression in which the dependent variable was whether the individual had paralysis, blindness in at least one eye, or deafness in at least one year. Independent variables in all regressions included age in years and dummy variables indicating whether the Union Army veteran has ever been wounded in the war and whether the individual was an amputee, and dummy variables for adventitious sounds, decreased breath sounds, back problems, joint problems, murmurs, arrhythmias, congestive heart failure, stroke, and cataracts. Only coefficients that were statistically significant in at least one regression are presented. Decreased breath sounds perfectly predicted paralysis in NHANES. Derivates represent discrete changes from 0 to 1.

† p < .10; * p < .05; ** p < .01

Table 8: Decomposition of Functional Limitation Among Men 50-64, 1900-1994, and Among Men 60-74, 1910-1994

	Difficulty			
	walk- ing	bend- ing	Para- lysis	Blind- ness
UA and NHANES, Age 50-64				
ΔP	21.3	41.8	4.6	2.2
$(\Delta X)\beta$	5.6	16.7	0.2	0.8
$X(\Delta\beta)$	2.3	17.2	2.8	0.5
ΔU	13.4	7.9	1.6	0.9
UA and NHANES, Age 60-74				
ΔP	27.0	43.4	4.2	1.8
$(\Delta X)\beta$	10.1	22.3	0.4	-0.4
$X(\Delta\beta)$	2.4	14.2	2.9	1.9
ΔU	14.5	6.9	0.9	0.3
UA and NHIS, Age 50-64				
ΔP	23.6	41.3		
$(\Delta X)\beta$	2.8	5.5		
$X(\Delta\beta)$	6.0	23.6		
ΔU	14.8	12.2		
UA and NHIS, Age 60-74				
ΔP	27.5	48.8		
$(\Delta X)\beta$	6.8	10.6		
$X(\Delta\beta)$	7.1	27.3		
ΔU	13.6	10.9		

Note. UA=Union Army, NHANES=National Health and Nutrition Examination Survey, NHIS=National Health Interview Survey. ΔP is calculated from Table 3 using results for men with a surgeons' exam and is the difference in prevalence rates for functional limitations across years. $(\Delta X)\beta$ was calculated as the difference in predicted functional limitation measured at the values of X and of β in the UA data and predicted functional limitation measured at the values of β in the UA data and X in the NHANES or NHIS data. $X(\Delta\beta)$ was calculated as the difference in predicted functional limitation measured at the values of β in the UA data and X in the NHANES or NHIS data and predicted functional limitation measured at the values of β and X in the NHANES or NHIS data. ΔU is the difference in unobservables. All estimated coefficients (both significant and non-significant) were used to decompose the change in rates. In the Union Army sample the value of the dummy variable for whether a veteran was ever wounded in the war was set equal to 0, that of the dummy variable indicator for whether the veteran was an amputee was set equal to the NHANES value, and age was set equal to the median age in the NHANES sample. Predicted functional disability in the Union Army sample is based upon men with a surgeons' exam only.