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Volume Title: The Evolution of Retirement: An American Economic History, 1880-1990

Volume Author/Editor: Dora L. Costa

Volume Publisher: University of Chicago Press

Volume ISBN: 0-226-11608-5

Volume URL: http://www.nber.org/books/cost98-1

Publication Date: January 1998

Chapter Title: Work and Disease

Chapter Author: Dora L. Costa

Chapter URL: http://www.nber.org/chapters/c6110

Chapter pages in book: (p. 60 - 84)

# 4 Work and Disease

Illnesses were more important than any other cause in bringing about premature superannuation.

Ohio Health and Old Age Insurance Commission (1919)

Health is a critical component of labor supply. Among middle-aged men today chronic conditions such as heart disease, arthritis and other musculoskeletal conditions, and respiratory disorders substantially reduce hours worked and the probability of participation, and this reduction in labor supply accounts for up to 45 percent of the decline in earnings observed among middle-aged men (Bartel and Taubman 1979; Burkhauser et al. 1986; Pincus, Mitchell, and Burkhauser 1989). Because the prevalence of chronic disabilities rises with age, the effects of health at older ages are especially pronounced. In virtually all studies, poor health leads to retirement.[1]

I begin this chapter by reviewing long-term trends in health. Some researchers have argued that average health has worsened both over the last twenty years and over the last hundred years because improvements in medical efficacy have permitted the survival of those afflicted with chronic conditions (Riley 1989; Verbrugge 1984). Their arguments imply that worsening average health may explain rising retirement rates and underscore the importance of establishing health trends. I then proceed to investigate whether health has become more or less important to the retirement decision since the nineteenth century. Participation rates were higher in the past, but were they uniformly higher, or were the disabled more or less likely to work relative to the healthy? The shift from the manufacturing and agricultural to the service sectors, increasing mechanization, and the shortening of the workday have lessened the expenditure of physical energy required for jobs, thus easing the incorporation of the disabled into the labor force. Improved control or alleviation of chronic conditions provided by innovations such as hypertensive drugs used in the care of arthritis has also eased the incorporation of the disabled into the labor force. But the low retirement incomes that prevailed at the beginning of the century meant that men may not have been able to afford to consider themselves disabled. As a result, men who by today's standards would be clearly disabled may have been participating in the labor force even if they were working with pain.

## 4.1 Trends in Health

Scholars have compared the health of modern and past populations using data on life expectancy, time lost from work, prevalence of chronic conditions, and anthropometric measures such as height and weight adjusted for height. The difficulty in using life expectancy as a measure of health is that life expectancies can be high and health poor if advances in medical technology lead to the increased survival of people suffering from chronic conditions. Using time lost from work avoids these problems, but this measure may be affected by cultural factors, economic incentives, or the distribution of income or wealth. For example, an individual from a poor household may be more likely to work when ill or disabled than an individual from a rich household. This section therefore examines trends in prevalence rates of chronic conditions, in heights, and in weight adjusted for height.

### 4.1.1 Chronic Conditions

Few surveys of past populations provide detailed information on chronic conditions that is comparable to recent data. Although early health surveys are available, they often confounded acute and chronic conditions and recorded only chronic conditions that caused an illness. Thus, an individual with arthritis might be listed as having arthritis only if the condition temporarily flared up and disabled him for a few days. These surveys were based on self-reported data, and health awareness may have been much lower in the past. One early data source that does not share these problems is the Union army records. Only chronic conditions, neither acute conditions nor bouts of illness brought on by chronic conditions, qualified a man for a pension. Physicians, not veterans, judged the presence of a chronic condition.

Table 4.1 contrasts disease rates among Union army veterans sixty-five years of age or older in 1910 with disease rates, adjusted to account for differences in the age distribution, among World War II veterans in the 1980s. Disease rates for World War II veterans are estimated from a 1983 survey that reports whether a veteran ever had a disease and from successive years of the National Health Interview Survey (NHIS), 1985–88, which reports whether an individual had a condition in the twelve months prior to the interview. Because nineteenth-century medical technology could not cure chronic conditions, disease rates for Union army veterans are estimated under the assumption that, if an examining surgeon ever judged a veteran to have a specified chronic condition, that condition was permanent. The Union army data are therefore most comparable to the 1983 survey. Although prevalence rates of chronic diseases that occurred during the twelve months preceding the National Health Interview are not directly comparable to the Union army data, a comparison with

**Table 4.1 Comparison of the Prevalence of Chronic Conditions among Union Army Veterans in 1910, Veterans in 1983 (reporting whether they ever had specific chronic conditions), and Veterans in NHIS 1985–88 (reporting whether they had specific chronic conditions during the preceding 12 months), Aged 65 and above (%)**

| Disorder | Union Army Veterans | 1983 Veterans | Age-Adjusted 1983 Veterans | NHIS 1985–88 Veterans |
|---|---|---|---|---|
| Skin or musculoskeletal | 68.4 | 48.1 | 47.5 | 45.8 |
| Musculoskeletal | 67.7 | 47.9 | 47.2 | 42.5 |
| Digestive | 84.0 | 49.0 | 48.9 | 18.0 |
| Hernia | 34.5 | 27.3 | 26.7 | 6.6 |
| Diarrhea | 31.9 | 3.7 | 4.2 | 1.4 |
| Genitourinary | 27.3 | 36.3 | 32.3 | 8.9 |
| Central nervous, endocrine, metabolic, or blood | 24.2 | 29.9 | 29.1 | 12.6 |
| Circulatory | 90.1 | 42.9 | 39.9 | 40.0 |
| Heart | 76.0 | 38.5 | 39.9 | 26.6 |
| Varicose veins | 38.5 | 8.7 | 8.3 | 5.3 |
| Hemorrhoids | 44.4 | | | 7.2 |
| Respiratory | 42.2 | 29.8 | 28.1 | 26.5 |
| Neoplasms | 2.2 | 13.1 | 11.5 | 9.2 |

*Note:* Among veterans in 1983, the prevalence of all types of circulatory diseases will be underestimated because of underreporting of hemorrhoids. The variable indicating whether the 1983 veteran ever had hemorrhoids is unreliable. Neoplasms in the NHIS are estimated as the sum of prevalence rates of neoplasms of the skin, digestive systems, prostate, and respiratory systems. No allowance is made for the fact that an individual may have multiple kinds of neoplasms, so this number should be interpreted as an upper bound. However, people with multiple neoplasms are more likely to be institutionalized and hence not included in the NHIS.

the 1983 data that report whether a veteran ever had a chronic condition might explain why chronic conditions among the elderly have declined since 1910.

Musculoskeletal, heart, and digestive disorders were the major chronic conditions among the elderly in 1910 and still remain so to this day. Table 4.1 shows that the prevalence rates of musculoskeletal, digestive, heart, and respiratory disorders and of varicose veins were considerably higher among Union army veterans than among the veterans surveyed in 1983 or in the NHIS survey. Although neoplasms and genitourinary conditions were much more common among veterans surveyed in 1983 than among Union army veterans, physicians in 1910 were unable to diagnose these disorders at early stages. The large difference in prevalence rates for conditions of the digestive, genitourinary, central nervous, endocrine, metabolic, and blood and blood-forming systems, according to whether those conditions are reported as being ever experienced or as existing during the previous twelve months, indicates that many conditions in these categories that could not be cured in 1910 can now be treated effectively.

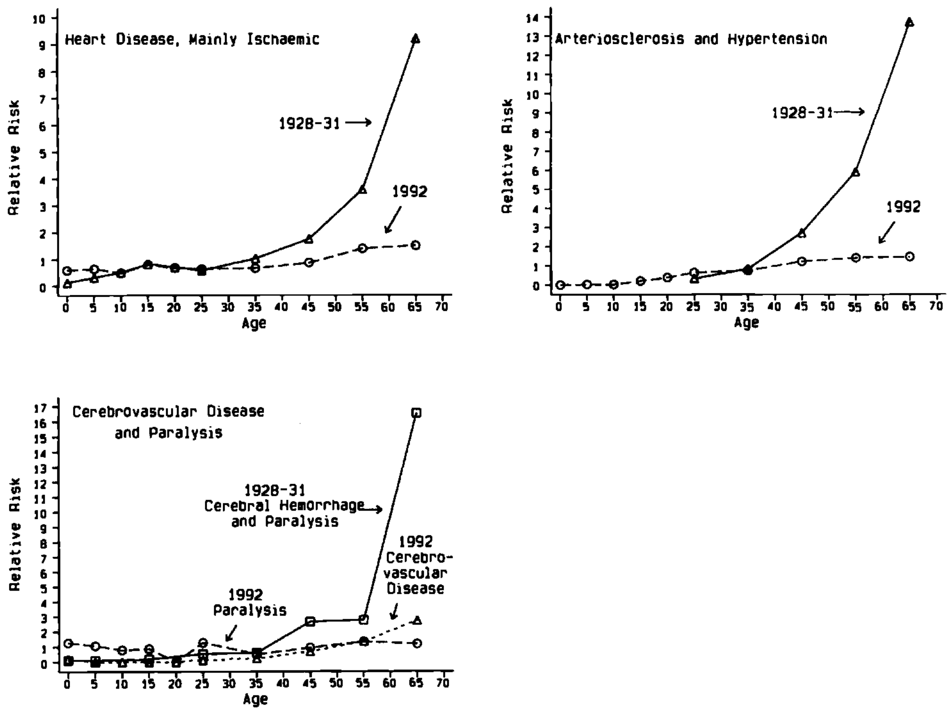


**Fig. 4.1 Relative risk of ischaemic heart disease, arteriosclerosis and hypertension, and cerebrovascular disease and paralysis among whites, both sexes, 1928–31 and 1992**

*Note:* Calculated from Collins (1935) and the 1992 National Health Interview Survey. Relative risk of a specific form of heart disease, $R_i$, at age $i$ is calculated as $R_i = H_i/(\sum N_i H_i/N) = H_i/\bar{H}$, where $H_i$ is the prevalence rate of heart disease at age $i$, $N_i$ is the number of individuals of age $i$, $N = \sum N_i$, and $\bar{H}$ is the prevalence rate over all ages.

The health of the elderly relative to their counterparts today remained poor for several decades after 1910. The National Health Survey of 1935–38 and the Committee on the Costs of Medical Care's 1928–31 survey, both random surveys of households within selected cities, provide suggestive evidence. Although prevalence rates for most chronic conditions listed in the two surveys are not comparable to recent data because of different definitions that produce undercounting in the older data, prevalence rates for specific conditions such as blindness are unlikely to be undercounted.[2] Furthermore, it is possible to compare the prevalence rates of the elderly with those of the general population. If the relative risk of a specific condition rose much more sharply with age in the past than today, then, relative to the general population, the elderly of the past fared worse than the elderly today.

Figure 4.1 performs this comparison, plotting the relative risk of ischaemic heart disease, arteriosclerosis and hypertension, and cerebrovascular disease and paralysis by age group for white men and women in 1928–31 and in 1992.

Table 4.2 **Rates of Blindness in Both Eyes per 100,000 Persons, 1935–38 and 1992**

| | 1935–38 | | 1992 | |
|---|---|---|---|---|
| Age | Men | Women | Men | Women |
| 55–64 | 213 | 163 | 38 | 162 |
| 65–74 | 522 | 405 | 158 | 61 |
| 75–84 | 942 | 1,213 | 385 | 159 |
| 85–89 | 2,010 | 3,536 | 1,683 | 1,437 |

*Note:* The 1935–38 rates are from Britten (1941). Although prevalence rates are given for earlier ages as well, those prevalence rates are an underestimate because many children born blind were previously institutionalized. The 1992 prevalence rates are calculated from the 1992 National Health Interview Survey. Because the percentage of the population that is blind in both eyes is relatively small, the rate of blindness does not increase continuously in 1992. For comparison with the 1935–38 survey, the 1992 NHIS was restricted to men below 90 years of age. Note that, when no age restriction is imposed, the rate of blindness rises to 2,049 for men and 1,389 for women.

Provided that undercounting in the 1928–31 survey does not depend on age, figure 4.1 accurately represents increases in relative risk with age and tells us that the increase in cardiovascular disease with age was much sharper in the past than it is today.

The elderly of the 1930s were much more likely to be blind. Table 4.2 compares rates of blindness in both eyes per 100,000 persons by age as estimated from the 1935–38 National Health Survey (Britten 1941) and from the 1992 National Health Interview Survey. Especially striking is the sharp increase in blindness at older ages in 1935–38 relative to 1992. Britten (1941) calculated that, in 1935–38, the annual incidence of new cases of blindness among men rose from 11 per 100,000 at ages fifty to fifty-nine to 31 at ages sixty to sixty-nine, 42 at ages seventy to seventy-nine, and 107 at ages eighty to eighty-nine. Among women the annual incidence of new cases of blindness rose from 9 per 100,000 at ages fifty to fifty-nine to 24 at ages sixty to sixty-nine, 81 at ages seventy to seventy-nine, and 232 at ages eighty to eighty-nine. The most common causes of blindness in 1935–38 were cataracts (34 percent), degenerative diseases (23 percent), glaucoma (18 percent), and general infectious diseases (11 percent). Today cataracts can be treated easily, and causes of glaucoma, such as diabetes, are now more readily controlled.

Reductions in occupational hazards have also contributed to the improving health of the elderly. In 1935–38, when 70 percent of losses of fingers arose from occupational injuries, 25 percent of men and 3 percent of women age sixty-five or older had lost one or more fingers (U.S. Public Health Service 1938). In contrast, the respective figures were only 7 and 1 percent in 1992 (estimated from the National Health Interview Survey).

Not only did earlier cohorts suffer high rates of chronic disease in old age, but they also suffered high rates of chronic disease at young adult ages. Among the Union army cohort the prevalence of tuberculosis, hernias, varicose veins, deafness, epilepsy, clubfoot, and deformities of the hand was higher in

1861–65 than in 1985–88. At ages thirty-five to thirty-nine hernia rates, for example, were more than three times as prevalent in the 1860s as in the 1980s. Of special note is the much higher prevalence of clubfoot in the 1860s, a birth anomaly that suggests that damage during the fetal stage and during birth was more likely in the past than it is today (Fogel 1994).

My comparison of chronic disease rates among Union army veterans and recent veterans, of blindness rates in the 1930s and today, and of the relative risk of heart disease in the 1930s and today suggests that average health has improved considerably, but many chronic conditions cannot be compared over such a long time span. Different disease definitions used in the past sometimes confounded acute and chronic conditions. Chronic conditions were enumerated only if they resulted in illness. Changes in prevalence rates within disease categories that, for example, have led to arteriosclerosis displacing valvular heart disease as the most common form of heart disease may invalidate comparisons of prevalence rates over three-quarters of a century. In addition, the comparison of prevalence rates by itself does not give much insight into how the large decline in chronic conditions occurred. Fortunately, anthropometric measures provide insight. Height and weight adjusted for height permit me to relate disease prevalence to cumulative nutritional status during developmental ages as measured by height and to current nutritional status as measured by the Body Mass Index (BMI), or the Quetelet Index, which is defined as body weight in kilograms divided by the square of body height measured in meters. These anthropometric health proxies have the additional advantage of being measured consistently across time.

### 4.1.2 Height

Adult height is a measure of cumulative nutritional status over all the growing years, including the fetal stage and early infancy. Mean heights are consistently lower in deprived populations. This does not necessarily imply that the level of nutrient intake is lower in a deprived population, but it may mirror a worse disease environment, overcrowding, a harsher climate, greater physical exertion, or the mother's poor health. Large height differentials are present between high- and low-income groups in developing countries, were present in the Western world in the past century, and still persist in the West, albeit in much diminished magnitude.[3]

Height and mortality are related. Mortality first declines with height, to reach a minimum at heights close to 185 centimeters, and then starts to rise (see fig. 4.2). This is true not only among modern Norwegians, the largest population for which both height and subsequent mortality are known, but also among Union army veterans. In the case of Union army veterans, the relation between height and mortality remains unchanged when controlling for such socioeconomic covariates as occupation, nativity, and urbanization. A similar relation is found between height and self-reported health status among modern American males and between height and the probability of rejection for military service among Union army soldiers (Fogel 1994). Height appears to be

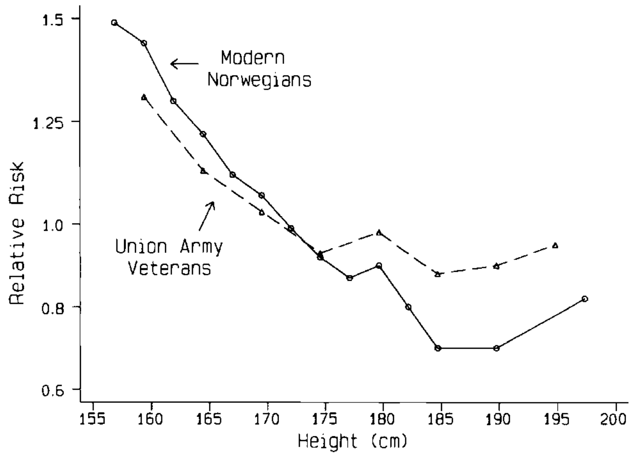


**Fig. 4.2 Comparison of relative mortality risk by height among modern Norwegian males and Union army veterans circa 1900**

*Source:* Costa and Steckel (1997).

*Note:* Height for 309,554 modern Norwegians was measured at ages forty to fifty-nine, and the period of risk was seven years. Height of 322 Union army veterans aged twenty-three to forty-nine was measured at enlistment, and the period of risk was from age fifty-five to age seventy-five. Calculated from the data in Waaler (1984) and from the Union army sample.

inversely related to heart and respiratory diseases and positively related to the hormonal cancers (Barker 1992), suggesting that the high relative risk of heart disease at older ages observed in 1928–31 may be partially related to poor conditions early in life.

Data from developing countries imply that the effect of height on productivity is substantial. Using data for rural south India, Deolaliker (1988) finds that the elasticity of wage rates with respect to heights is in the range of 0.28–0.66. Haddad and Bouis (1991) report that wages in the rural Philippines are strongly influenced by height. In an extension, Foster and Rosenzweig (1992) find that height and calories have particularly large effects on piece-rate wages. Data from the antebellum American South show that height and weight were positively associated with slave market value, suggesting that better-fed, healthier slaves were more productive (Margo and Steckel 1982).

Americans born in the past century and at the beginning of this century were stunted by today's standards. Men who served in the Union army were almost four centimeters shorter than men born in 1970. The Norwegian height curve suggests that, had the distribution of heights in the Union army sample been the same as among American males in 1991, older-age mortality rates would have fallen by 9 percent. Some subsequent cohorts fared even worse. Average heights for the native born reached a nadir in the 1880s, and those born in that decade were almost nine centimeters shorter than cohorts born in 1970. Thereafter, average height improved rapidly (see fig. 4.3).

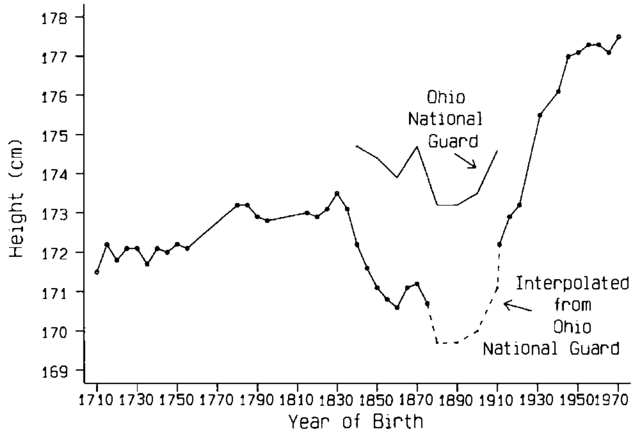


**Fig. 4.3 Mean heights of white, native-born males by birth cohort, 1710–1970**
*Source:* Costa and Steckel (1997).

### 4.1.3 Body Mass Index

Body Mass Index (BMI), a measure of current nutritional status, may be an even stronger predictor of productivity, morbidity, and mortality than height. It measures not only nutritional intake but also the effect of illness, climate, and physical exertion. The relation between weight and mortality among Union army veterans measured at ages fifty to sixty-four and observed from age fifty until age seventy-five resembles that seen among modern Norwegian males (Costa and Steckel 1997). Mortality risk first declines rapidly at low weights as BMI increases, stays relatively flat over BMI levels from the low to the high twenties, and then starts to rise again, but less steeply than at very low BMIs (see fig. 4.4). The similar mortality pattern across these two very different populations suggests that standards derived from recent populations can be applied to past populations. Therefore, had it been possible to shift the BMI distribution of Union army veterans one standard deviation to the right so that the mean would be equivalent to that prevailing in modern Norway, the 14 percent reduction in the mortality rate implied by the Norwegian curve would explain roughly 20 percent of the total decline in mortality above age fifty from 1900 to 1986, a percentage greater than that explained by changes in height.

When height and weight are simultaneously related to mortality through a mortality surface, it becomes obvious that optimal weight varies with height. To minimize their mortality risk, the shorter should be heavier and the taller leaner (Fogel 1994). When BMI curves are plotted by cause of death, there is a strong U shape for obstructive lung disease, stomach cancer, and cerebrovascular disease, a very slight U shape for cardiovascular disease and diabetes, and none at all for colon cancer, tuberculosis, and lung cancer (Waaler 1984). When Waaler (1984) deleted from his sample men who died within five years

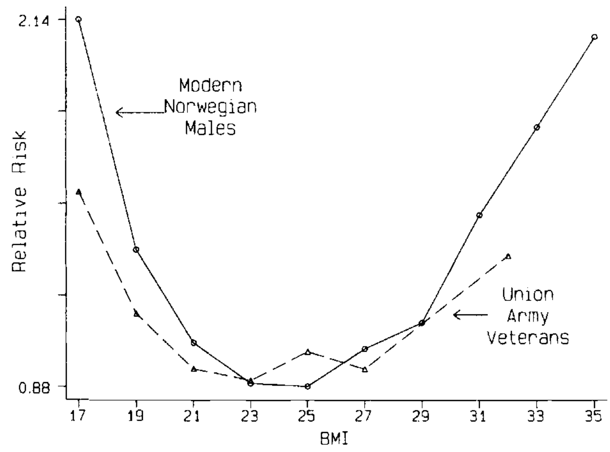


**Fig. 4.4 Comparison of relative mortality risk by BMI level among men fifty years of age, Union army veterans circa 1900 and modern Norwegians**

*Source:* Costa and Steckel (1997).

*Note:* In the Norwegian data BMI for 79,084 men was measured at ages forty-five to forty-nine, and the period of risk was seven years. BMI of 550 Union army veterans was measured at ages forty-five to sixty-four, and the observation period was twenty-five years. Calculated from the data in Waaler (1984) and from the Union army sample.

after measurement, the U shape was even more pronounced. A thirty-two-year follow-up study of a cohort measured at age eighteen found that the most obese men had higher mortality rates from coronary heart disease, whereas the leanest men had higher mortality rates from cancer (Hoffmans, Kromhout, and de Lezenne Coulander 1989).

BMI is also correlated with ill health. A plot of BMI against self-reported health status shows the same U-shaped pattern for males aged fifty to sixty-four as seen for mortality risk (see fig. 4.5). When height and weight are simultaneously related to ill health through a surface, the resulting surface is similar to that for mortality and predicts a decline of 6 percent per decade in ill health among the elderly from 1910 to the 1980s (Fogel 1994). This predicted decline is consistent with Manton, Corder, and Stallard's (1993) findings on the decline in disability rates among the elderly between 1982 and 1989 and is consistent with the decline in chronic conditions observed among veterans age sixty-five or older between 1910 and the present. BMI is also related to more objective measures of ill health. The prevalence of hypertension, heart disease, and other circulatory disorders and of diabetes and chronic neck pain rises with obesity. Chronic respiratory disorders show a U-shaped relation to BMI (Makela et al. 1991; Negri et al. 1988; Roman Diaz 1992). The incidence of pulmonary tuberculosis is greater at lower BMI levels (Tverdal 1988). BMI is also related to the number of chronic conditions, bed days, hospitalizations, and doctors' visits (see fig. 4.6).[4]

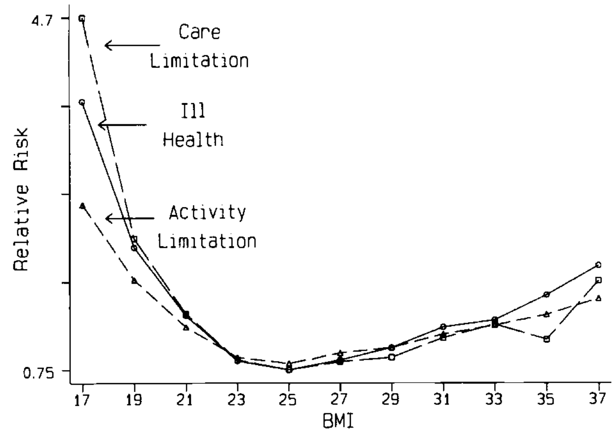


**Fig. 4.5 BMI and relative risk of ill health, as measured by presence of self-reported activity or care limitation or of self-reported ill health among white men aged fifty to sixty-four**

*Source:* Costa (1996).

*Note:* An individual with an activity or care limitation indicated that he could not perform certain basic activities of daily living or needed help with personal care, respectively. Individuals were also asked whether they were in poor, fair, good, or excellent health. An individual who answered poor or fair is considered to be in ill health. All observations are centered at the marks.

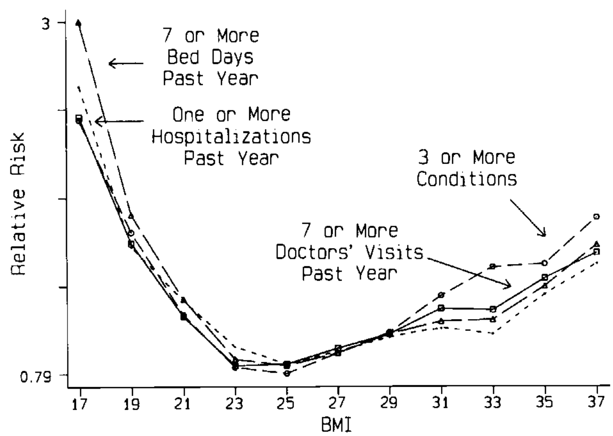


**Fig. 4.6 BMI and relative risk of chronic conditions, bed days, hospitalizations, and doctors' visits among white males aged fifty to sixty-four**

*Source:* Costa (1996).

*Note:* All observations are centered at the marks.

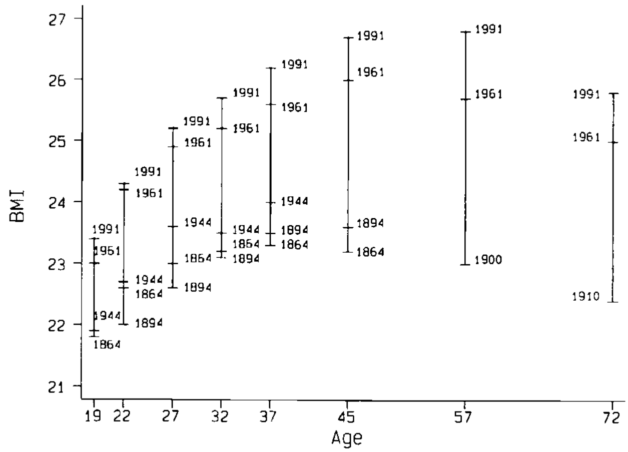


**Fig. 4.7 Mean BMI by age group and year, 1863–1991**

*Source:* Costa and Steckel (1997).

*Note:* The age groups are centered at the marks and are ages eighteen to nineteen, twenty to twenty-four, twenty-five to twenty-nine, thirty to thirty-four, thirty-five to thirty-nine, forty to forty-nine, fifty to sixty-four, and sixty-five to seventy-nine. For some years BMI is not available for a specific age group.

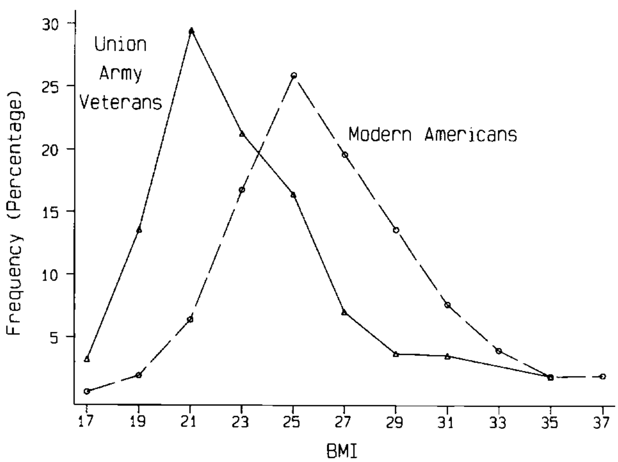


**Fig. 4.8 BMI distribution among Union army veterans and modern, white American males, aged fifty to sixty-four**

*Source:* Costa (1996).

*Note:* All observations are centered at the marks.

Not only were men born in the nineteenth century stunted by today's standards, but their BMIs at adult ages were also about 13 percent lower than current U.S. levels (see figs. 4.7 and 4.8). Mean BMI for modern Americans aged fifty to sixty-four is 26.4, while that for Union army veterans was 23.0. This was not necessarily because Americans today are more obese; they also have greater muscle and bone mass (Costa and Steckel 1997). Men in the past were thin by today's standards, perhaps because chronic disease rates were so high, nutritional intakes lower, physical activity greater, and exposure to occupational hazards higher. The corrosive effects of occupation were well recognized by contemporaries: "Castin'? No I never did that. It's a hell of a job. The fires burn a man out. Lots of them get burnt out. That heat is no good for a man. You know Charley Buckland? He's burnt out. That man used to be as fleshy as I am, but look at him now. Skinny as a rail" (WPA Life Histories Collection, interview with Robert White). Differences in BMI between men today and men in the past widened with age, perhaps because chronic disease rates increased more rapidly with age in the past or because differences in nutritional intakes, physical activity, and exposure to occupational hazards have cumulative effects. Insufficiency of contemporaneous income was probably not the major determinant of BMI. Mean BMI at older ages did not differ among farmers, artisans, and laborers. At younger ages, it did not differ among professionals and proprietors, artisans, and laborers.

The next section uses BMI as a health proxy to examine the relation between health and labor force participation. BMI is used as a proxy, rather than height or specific chronic conditions, because the relation between labor force participation and either height or specific chronic conditions among Union army veterans is relatively weak.

## 4.2 Health and Labor Force Participation

Despite the large health differential between Union army veterans and recent populations, the relation between BMI and labor force participation is similar among Union army veterans and modern American men found in successive years of the 1985–91 National Health Interview Survey (NHIS).[5] Figure 4.9 shows that the relative risk that a man aged fifty to sixty-four would be out of the labor force in 1985–91 falls precipitously from a BMI level of 17, levels off at 22–28, and then rises gradually. Among Union army veterans in 1900 for whom BMI was measured at ages fifty to sixty-four, the probability of participating was also at its peak at a BMI of 22–28 (see fig. 4.10). Although sampling error warrants some caution, among Union army veterans the probability of nonparticipation increased sharply, not just at low BMIs, but also at high BMIs.

The relation between BMI and labor force participation is weaker at older ages among both modern Americans and Union army veterans in 1910, even though there is still a strong relation between BMI and other health proxies,

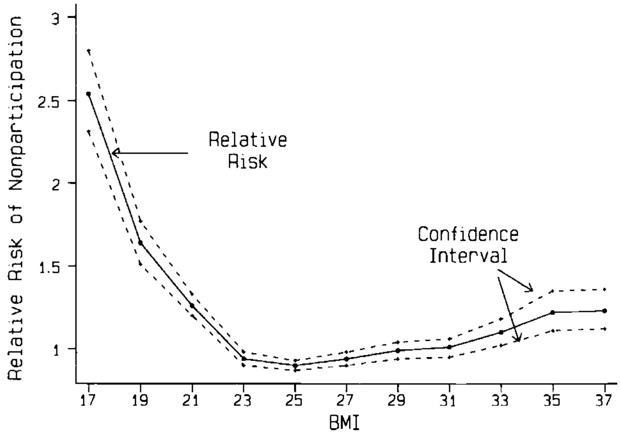


**Fig. 4.9 Relation BMI and relative risk of nonparticipation, white, modern, American men, aged fifty to sixty-four, 1985–91**
*Source:* Costa (1996).
*Note:* All observations are centered at the marks.

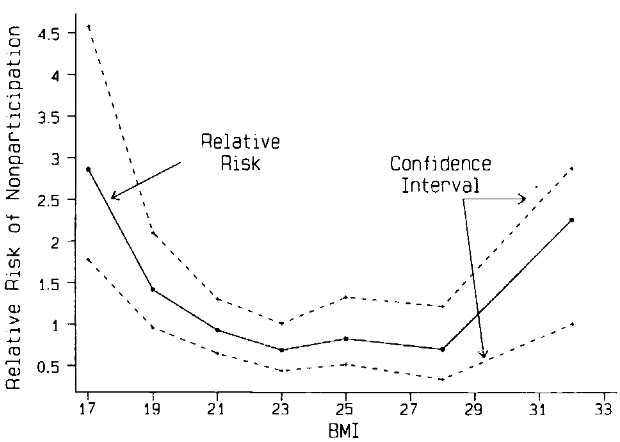


**Fig. 4.10 Relation BMI and relative risk of nonparticipation, Union army veterans, 1900**
*Source:* Costa (1996).
*Note:* All observations are centered at the marks.

such as the relative risk of self-reported ill health or of seven or more bed days within a year (see fig. 4.11). Among modern Americans, the relation between BMI and labor force participation is flatter at ages sixty-five to seventy-nine than at ages fifty to sixty-four, and the relative risk that the lean are not in the labor force is lower. Among Union army veterans, the distinctive U-shaped

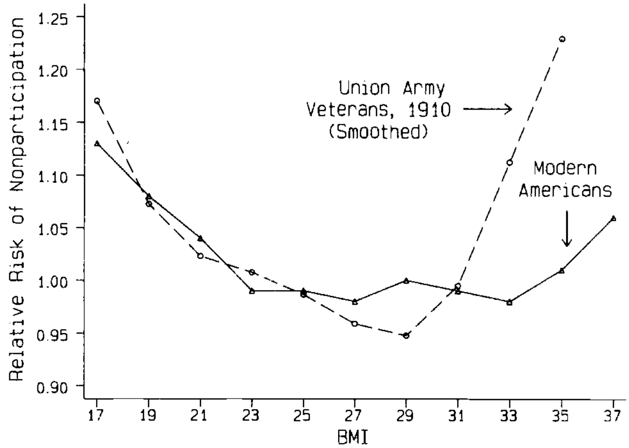


**Fig. 4.11 Relation BMI at ages sixty-five to seventy-nine and relative risk of nonparticipation, modern American males, 1987–92, and Union army veterans, 1910**

*Note:* Calculated from the 1987–92 NHIS and the Union army sample.

relation between BMI and labor force participation persists, but the U shape is less deep and the relative risk of being out of the labor force lower both for the lean and for the obese. Health appears to have less of an effect on the labor supply decision at older ages. This conclusion is tentative because sampling error problems are even more acute among older Union army veterans. To avoid working with excessively small samples, I will focus on men aged fifty to sixty-four.

In investigating the relation between BMI and labor force participation, it is necessary to control for socioeconomic and demographic characteristics because these variables are correlated with BMI. Among Union army veterans, wage income, as proxied by occupation, and BMI were positively correlated, while pensions and BMI were negatively related. Among modern Americans, the correlation between wage income and BMI is slightly negative, while that between disability benefits and BMI is likely to be strongly negative. Provided that I control for socioeconomic and demographic conditions, I can derive estimates of the BMI levels that maximize the probability of participation among both modern Americans and Union army veterans. Once I derive these BMI levels, I can then determine whether the BMI level that maximizes the probability of labor force participation has changed over the last ninety years. I can also derive estimates of the elasticity of labor force nonparticipation with respect to BMI for the two groups of men. Changes in this elasticity provide some indication of whether health, as proxied by BMI, is now more or less important to the retirement decision than in the past.

The BMI level that maximizes the probability of participation can be derived using a regression framework similar to that employed in the previous chapter. There is an additional complication in the estimation of the participation-maximizing BMI level among modern Americans. Recall that an individual's decision to retire depends on both the income he expects to receive when working and the income he expects to receive when not working. In the case of Union army veterans, pensions did not depend on labor force status, and unobserved income flows were proxied by occupation. For modern Americans, income flows are observed, but the income flows under either the retirement or the participation option are observed only if the respective choice was made. If an individual is in the labor force, then we do not know how much in Social Security disability payments he would receive were he to withdraw from the labor force. Alternatively, if an individual is out of the labor force, then we do not know how much in income he would receive were he to enter the labor force. These income flows can be estimated, provided that a correction is made that accounts for differences in characteristics between those who choose work and those who choose nonparticipation. First, a participation probit is estimated where the explanatory variables are BMI, age, education, veteran and marital status, year of survey, extent of urbanization, geographic region, foreign birth, and the presence of a care limitation (i.e., whether the individual reported needing help with personal care). Then income is estimated for both participants and nonparticipants using the same explanatory variables, with the exception of the presence of a care limitation, and the inverse Mill's ratio to account for selection (see table 4.3).[6] Estimated nonparticipation income will therefore include income from disability programs as well as from family members. In the final step, the probability of labor force nonparticipation is then estimated by means of a probit in which the dependent variable is a dummy equal to one if the individual is not participating, and the independent variables are estimated family income when working, estimated family income when not working, BMI, marital status, age, and survey year (see table 4.4).[7]

The effect of BMI on the probability of participation is fairly large and significant.[8] The elasticity of nonparticipation with respect to BMI is 0.28. The BMI level that maximizes the probability of participation is 25.4—statistically indistinguishable from the BMI level that at the sample mean height of 1.78 meters minimizes mortality risk. When dummies are used for BMI levels, the risk of nonparticipation is minimized at BMI levels of 23–26, and the risk of nonparticipation is much greater at lower BMI levels, as in figure 4.9 above.

The regression specification includes no interactions between BMI and income. But it is certainly plausible to assume that the effect of health on the probability of participation varies by income. The poor cannot always afford to withdraw from the labor force even when they are ill. When BMI is interacted with a dummy for household income of less than $20,000 per year when not participating in the labor force, the BMI level that maximizes the probability of participation of men in households where this income is less than $20,000 per year is 25.9, compared to 24.7 among men in households where

Table 4.3 **Participation Probit and Earnings Equations Used to Estimate Income in and out of the Labor Force, NHIS, Men Aged 50–64**

| | | Participation Probit | | Participant Income | | Nonparticipant Income | |
|---|---|---|---|---|---|---|---|
| Variable | Mean | Parameter | S.E. | Parameter | S.E. | Parameter | S.E. |
| Probability of participation | .23 | | | | | | |
| Log of participant income | 10.41 | | | | | | |
| Log of nonparticipant income | 9.83 | | | | | | |
| Intercept | | 22.713‡ | 1.856 | 8.792‡ | .949 | 3.804* | 1.936 |
| BMI | 26.4 | −.894‡ | .112 | .189† | .055 | .119 | .088 |
| $BMI^2$ | 712.24 | .029‡ | .004 | −.006‡ | .002 | −.003 | .003 |
| $BMI^4/10$ | 1,959.45 | .003‡ | .000 | .001† | .000 | .000 | .000 |
| Age | 56.86 | −.628‡ | .054 | −.036 | .027 | .107* | .060 |
| Age squared | 3,233.06 | .007‡ | .000 | .000 | .000 | −.001 | .001 |
| Dummy = 1 if: | | | | | | | |
| Care limitation | .03 | 1.780‡ | .044 | | | | |
| Less than high school | .39 | | | | | | |
| High school graduate | .36 | −.121‡ | .018 | .047‡ | .008 | .177‡ | .018 |
| Some college | .14 | −.200‡ | .024 | .143‡ | .010 | .366‡ | .026 |
| Graduate school | .11 | −.468‡ | .029 | .328‡ | .011 | .651‡ | .034 |
| Married | .86 | −.397‡ | .021 | .372‡ | .011 | .587‡ | .020 |
| Veteran | .65 | .020 | .017 | .098‡ | .007 | .135‡ | .019 |
| Foreign born | .03 | −.045 | .047 | −.104‡ | .019 | −.306‡ | .049 |
| Non-MSA | .27 | | | | | | |
| MSA 1 million or more | .38 | −.097‡ | .020 | .276‡ | .008 | .242‡ | .021 |
| MSA ≤ 1 million | .35 | −.033* | .020 | .182‡ | .008 | .151‡ | .020 |
| Northeast | .22 | | | | | | |
| Midwest | .27 | −.045† | .023 | −.060‡ | .009 | −.009 | .024 |
| South | .31 | .119‡ | .022 | −.078‡ | .009 | −.083‡ | .023 |
| West | .20 | .100‡ | .100 | −.028† | .010 | −.020 | .025 |
| 1985 | .14 | | | | | | |
| 1986 | .09 | .009 | .034 | .009 | .014 | .080† | .034 |
| 1987 | .16 | .031 | .029 | .070‡ | .012 | .088‡ | .029 |
| 1988 | .16 | .022 | .029 | .111‡ | .012 | .112‡ | .029 |
| 1989 | .15 | .047 | .029 | .156‡ | .012 | .219‡ | .030 |
| 1990 | .15 | .040 | .030 | .196‡ | .012 | .249‡ | .030 |
| 1991 | .15 | .065† | .029 | .214‡ | .012 | .286‡ | .030 |
| Inverse Mills ratio | | | | −.221‡ | .032 | −.121‡ | .020 |

*Source:* Costa (1996).

*Note:* The symbols *, †, and ‡ indicate significance at the 10 percent, 5 percent, and 1 percent levels, respectively. The participation probit was run on 39,923 observations. The likelihood ratio test for all coefficients except the intercept being different from zero is 9,062. The participant income regression was run on 25,665 observations, adjusted $R^2$ = .19. The nonparticipant income regression was run on 7,517 observations, adjusted $R^2$ = .25. The standard errors in the income regressions are unadjusted, but, since the equations are used only for prediction, this is unimportant to interpretation.

**Table 4.4 Probit of Determinants of Probability Nonparticipation with Nonparticipation as the Dependent Variable, NHIS 1985–91**

| Variable | Mean | Parameter | S.E. | Mean Derivative |
|---|---|---|---|---|
| Nonparticipating | .23 | | | |
| Intercept | | 20.230‡ | 1.811 | |
| Family income/10,000: | | | | |
| If nonparticipant | 2.15 | .292‡ | .031 | .033 |
| If participant | 3.33 | −.595‡ | .031 | −.111 |
| Age | 56.86 | −.537‡ | .522 | −.133 |
| Age squared | 3,251.86 | .005‡ | .000 | .001 |
| Dummy = 1 if married | .86 | −.052† | −.024 | −.015 |
| Dummy = 1 if year is: | | | | |
| 1985 | .12 | | | |
| 1986 | .09 | −.019 | .033 | .000 |
| 1987 | .17 | .082‡ | .028 | .020 |
| 1988 | .16 | .133‡ | .029 | .030 |
| 1989 | .15 | .161‡ | .029 | .041 |
| 1990 | .15 | .209‡ | .030 | .050 |
| 1991 | .16 | .233‡ | .030 | .057 |
| BMI | 26.43 | −.733‡ | .108 | −.208 |
| $BMI^2$ | 712.36 | .024‡ | .004 | .007 |
| $BMI^4/10$ | 1,959.90 | −.003‡ | .000 | −.001 |
| 39,923 observations | | | | |

*Source:* Costa (1996).

*Note:* The symbols *, †, and ‡ indicate significance at the 10 percent, 5 percent, and 1 percent levels, respectively. The likelihood ratio for the test that the coefficients on all variables except for the intercept are equal to zero is 6,773. Family income was estimated by means of the Heckman two-step selection correction. Additional variables that were included in the income and participation regressions were the extent of urbanization, education, geographic region, foreign birth, and the presence of a care limitation.

this income is more than $20,000. But recall that, to minimize their mortality risk, the shorter should be heavier and the taller leaner (Fogel 1994). Those in high-income households are taller, and the difference in BMI levels that maximize the probability of participation is accounted for by differences in height. When dummies for a low BMI (under 22) and a high BMI (over 30) are included in the regression and interacted with income both in and out of the labor force, the resulting coefficients are small and insignificant. The evidence thus suggests that the effect of health on the probability of participation does not vary by income.

The retirement problem of Union army veterans in 1900 is investigated using the same econometric specification as in the previous chapter, with the exception that BMI replaces the health dummies on the basis of the ratings of the examining surgeons. Because figure 4.10 above indicated that the risk of labor force nonparticipation was strongly U shaped in BMI levels, a quadratic rather than a cubic specification was employed.[9]

**Table 4.5 Probit of Determinants of Probability of Nonparticipation with Nonparticipation as the Dependent Variable, Union Army Sample**

| Variable | Mean | Parameter | S.E. | Mean Derivative |
|---|---|---|---|---|
| Nonparticipating | .16 | | | |
| Intercept | | −6.257* | 3.337 | |
| BMI | 22.97 | −.551‡ | .160 | −.107 |
| $BMI^2$ | 540.56 | .011‡ | .003 | .002 |
| Age | 61.32 | .054‡ | .012 | .011 |
| Monthly pension | 12.73 | .030‡ | .010 | .006 |
| State unemployment | 3.62 | 2.168‡ | .708 | .419 |
| Dummy = 1 if farmer | .46 | | | |
| Professional or proprietor | .17 | −.552† | −.107 | −.119 |
| Laborer | .22 | −.083 | .227 | −.016 |
| Artisan | .15 | .135 | .234 | .026 |
| Does not own residence | .31 | .319* | .178 | .062 |
| Atlantic seaboard | .20 | | | |
| Midwest | .74 | .583† | .279 | .113 |
| Other region | .06 | −.146 | .547 | −.028 |
| Urban county | .36 | .363* | .177 | .070 |
| 4 or more dependents | .14 | −.538 | .314 | −.104 |
| Servant present | .02 | −.747 | .663 | −.144 |
| Boarder present | .04 | −.034 | .421 | −.007 |
| Illiterate | .06 | .079 | .330 | .015 |
| Foreign born | .10 | −.065 | .272 | −.012 |
| 471 observations | | | | |

*Source:* Costa (1996).

*Note:* The symbols *, †, and ‡ indicate significance at the 10 percent, 5 percent, and 1 percent levels, respectively. The likelihood ratio for the test that all coefficients except for the intercept are equal to zero is 96.11. Mean duration of unemployment in months for manufacturing workers is from table A.13 in Keyssar (1986, 340–41).

Once again the effect of BMI on retirement is substantial and significant (see table 4.5). The elasticity of nonparticipation with respect to BMI was 1.07. The BMI level that maximizes labor force participation is 25.2—well within the range that maximizes labor force participation in figure 4.10. This BMI level is statistically indistinguishable from that which for the sample mean height of 1.73 meters minimizes mortality risk. Coefficients on the interactions of BMI dummies with pension amount were small and insignificant. The BMI level that maximizes the probability of participation remains unchanged when an instrumented probit is estimated using whether a disability could be traced to the war as an instrumental variable.

In contrast to modern American males the body build of Union army veterans placed them at relatively high risk of nonparticipation. The mean BMI of modern Americans is 26.4, within half a standard deviation of the level that maximizes the probability of participation within the sample of modern Americans. However, the mean BMI in the Union army sample is 23.0, not within half a standard deviation of the level that maximizes the probability of participation within the Union army sample.[10]

Figures 4.9 and 4.10 above showed that low BMI levels have a large effect on the nonparticipation probability of both Union army veterans and modern American men. It is therefore not surprising that, among Union army veterans, for whom mean BMI is low, the elasticity of nonparticipation with respect to BMI is larger than it is for modern Americans. Some adjustment to the elasticities can be made by evaluating the Union army elasticity at the mean BMI of modern Americans. This calculation yields an elasticity of 0.88, still much larger than the elasticity of 0.28 found among modern Americans. The regressions produce results similar to those of figures 4.9 and 4.10, which show that, in 1900, the excessively lean and the excessively obese were at relatively greater risk of being out of the labor force compared to their present-day counterparts.

The regressions have shown that, in both 1900 and 1985–91, the BMI that maximizes the probability of participation was about 25 and that the relative risk of nonparticipation first fell with increasing BMI and then rose. But the elasticity of nonparticipation with respect to BMI has fallen since 1900, implying that the retirement decision is now less dependent on health.

## 4.3 Interpreting BMI

BMI depends on individual characteristics such as smoking status, exercise habits, and illness. If we do not control for these characteristics in estimating the effect of BMI on retirement, then we may confound the effect of BMI with that of other factors. The problem may be particularly acute when we try to estimate whether the BMI level that maximizes the probability of being in the labor force has remained constant throughout the shifts in the work and disease environment and in health habits that occurred over the century. The occupational structure has shifted from one in which physically strenuous occupations are common to one in which sedentary occupations are. The percentage of muscle mass may therefore differ across the two samples. Cigarette smoking became a widespread practice after World War II. The higher risk of nonparticipation among thin, modern Americans could arise from the thinner being smokers and therefore in worse health.[11] As smoking rates fall, the BMI level that maximizes participation rates could change. Among Union army veterans, a group of men suffering from much higher rates of respiratory disorders and diarrhea than men today, the BMI levels that maximize participation rates may have been high because infectious diseases were so prevalent.

Although information on muscle mass is unavailable, the 1985, 1990, and 1991 National Health Interview Surveys provide information on exercise habits. Figure 4.12 shows the relation between labor force participation and BMI in the entire sample when the sample is divided into those who exercise regularly and those who do not. Note that the relation between labor force partici-

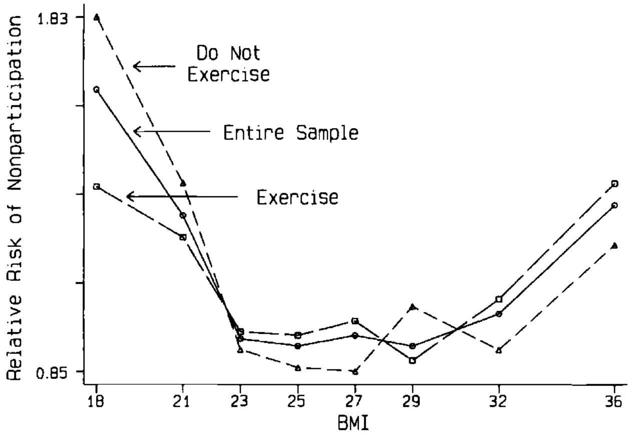


**Fig. 4.12 BMI and relative risk labor force nonparticipation by exercise habits among modern white Americans, 1985, 1990, and 1991**

*Source:* Costa (1996).

*Note:* All observations are centered at the marks.

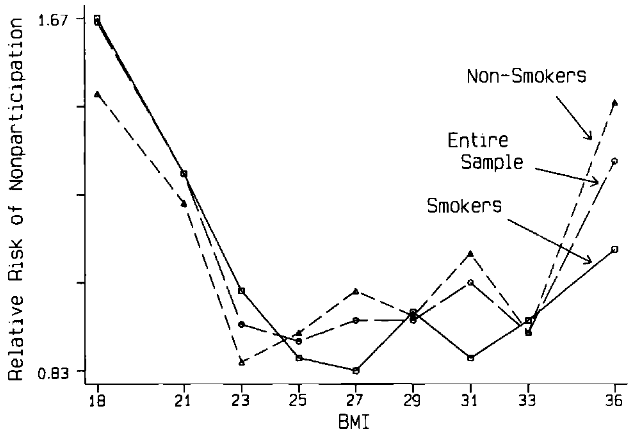


**Fig. 4.13 BMI and relative risk labor force nonparticipation by smoking status among modern white Americans, 1985, 1987, 1990, and 1991**

*Source:* Costa (1996).

*Note:* All observations are centered at the marks.

pation and BMI does not change by that much, suggesting that the estimated relation is not confounded by differences in muscle mass.[12]

Nor does the relation between labor force participation and BMI change when a sample consisting of the NHIS in the years 1985, 1987, 1990, and 1991 is divided into smokers and nonsmokers (see fig. 4.13). Furthermore,

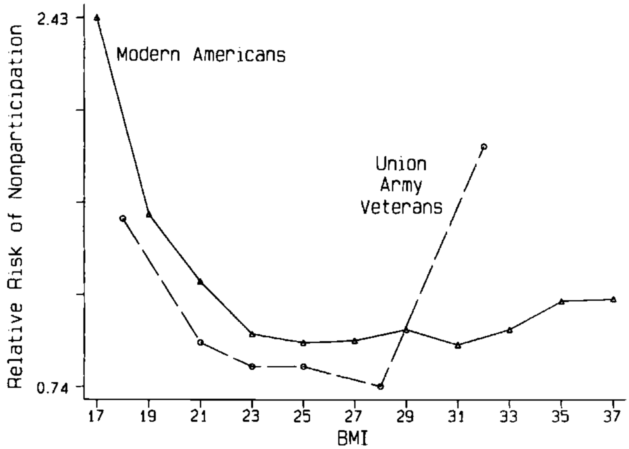


**Fig. 4.14 BMI and relative risk labor force nonparticipation, Union army veterans and modern white American males, deleting the very ill**
*Source:* Costa (1996).
*Note:* All observations are centered at the marks.

controlling for other characteristics, the addition of smoking status as an explanatory variable in predictions of labor force participation does not change the coefficients on dummies for BMI levels or the coefficients on the cubic specification for BMI.[13]

The relation between BMI and labor force participation among modern American men and Union army veterans is unchanged when the very sick are deleted from the sample, suggesting that the relation between BMI and labor force participation does not arise from current illness alone (see fig. 4.14).[14] Rather, BMI measures the stock of health. When men who reported at least one condition are deleted from the sample of modern Americans, the obese are no longer at greater risk of nonparticipation than those of average weight for height, suggesting that BMI partially reflects chronic conditions.[15]

Changes in relative chronic disease rates may have changed the relation between BMI and retirement. The effect of chronic conditions on labor force participation differs greatly by chronic condition (Bartel and Taubman 1979). If chronic conditions that are now correlated with a high BMI do not have as large an effect on labor force participation as conditions that in the past were correlated with high BMI, then high BMI levels will no longer have as large an effect on participation rates. Most of the heart disease observed among Union army veterans was valvular rather than arteriosclerotic, and among these men prevalence of heart disease decreased with increasing BMI. Today prevalence increases with BMI.

The constancy of the BMI level that maximizes the probability of being in the labor force, even when personal characteristics such as smoking, exercise habits, and the extent of chronic conditions are controlled for, suggests that the lessened effect of BMI on retirement rates cannot be accounted for by changes in personal characteristics. Although we cannot say with certainty, perhaps the changing nature of chronic conditions, technological advances in the control of chronic conditions, and improvements in the workplace that now enable those in poor health to participate in the labor force more actively may explain the reduced role of health in the retirement decision.

## 4.4 Implications

One of the most significant findings of this chapter has been that rates of chronic disease among the elderly in the first half of this century were extremely high. Heart disease was almost three times as prevalent, musculoskeletal and respiratory diseases were one and a half times as prevalent, and digestive diseases were more than four times as prevalent among veterans aged sixty-five or over in 1910 as in 1985–88. The elderly also suffered from high rates of blindness and from occupational injuries. Their risk of specific forms of heart disease relative to the general population was much greater than that of the elderly today.

The findings suggest that chronic conditions were far more prevalent throughout the life cycle for those born in the nineteenth century than is suggested by the theory of the epidemiological transition. This theory has characterized the past as a period when chronic conditions were relatively rare because the predominance of acute conditions ensured that those individuals susceptible to them would not survive. Support for this characterization of the past has come from cause-of-death data, which indicate that in the past few individuals died of chronic disease, whereas today chronic diseases are the most common causes of death. But reliance on cause-of-death information to characterize the epidemiology of the past may have led to a significant misrepresentation of the distribution of health conditions among the living. Only 61 percent of Union army veterans observed at age sixty-five died of one of the causes listed in a surgeons' exam. The chronic disease rates of Union army veterans suggest that any genetic advantage to having survived the deadly infectious diseases of childhood and adolescence was offset by a lifetime of socioeconomic and biomedical stress that left health in old age badly impaired and that sharply curtailed the life expectations of the elderly.

The trend in prevalence rates of chronic conditions, in the relative risk of chronic conditions at older ages, and in anthropometric measures suggests that the secular rise in retirement cannot be attributed to an increase in chronic disorders, as implied by the work of Riley (1989) and Verbrugge (1984). Retirement rates increased despite, not because of, improving health. Furthermore, because the average sixty-five-year-old today is much healthier than a sixty-five-year-old at the beginning of the century or even at the middle of the century, a retirement age first established by Bismarck and later enshrined in the Social Security Act may no longer be an appropriate demarcation of old age. What is more, health now appears to be less important to the labor force decision. Although the relation between BMI and the risk of labor force nonparticipation in 1900 was remarkably similar to that in 1985–91, men in 1900 were much more responsive to changes in health than they are now, perhaps because of changes in the relation between chronic conditions and BMI, improved control of chronic conditions, and reduced job requirements brought about by the rise of the clerical sector, the increased mechanization of manufacturing, greater safety in the workplace, and the shortening of the workday.

Had the distribution of BMI in the Union army sample been the same as that in the NHIS, the probability of nonparticipation among men age forty-five to sixty-four would have fallen by 6 percent, thereby increasing the total output of all male workers by 1 percent.[16] But how could such a shift in BMI have been achieved? Advances in medical care, public health investments in sanitation, improved working conditions, and rising incomes have ameliorated both early childhood and adult environmental conditions. The mounting body of evidence of a relation between chronic conditions at late adult ages and early childhood environmental factors suggests that better early life conditions have improved adult health (Barker 1992, 1994). However, these improvements may have changed the relation between BMI and the relative risk of nonparticipation. If the increase in BMI was accompanied by a shift in the relation between BMI and the relative risk of labor force nonparticipation, then, because the effect of high BMI on retirement is relatively small in recent data, if the distribution of BMI in the Union army sample had been the same as that in the NHIS, the probability of nonparticipation would have fallen by 10 percent (rather than 6 percent), and the total output of male workers would have increased by 1.7 percent.[17]

The findings do not necessarily imply that, as the population grows increasingly healthier, jobs become less physically demanding, control over chronic conditions improves, and greater efforts are made to increase the incorporation of the old and disabled into the labor force, labor force participation rates among older men will rise. Secularly rising incomes lower participation rates and, according to chapter 3, explain up to 60 percent of the fall in labor force participation rates among men sixty-five years of age or older. Moreover, because it affects wage levels, improved health may lower labor force participation rates. Recent cross-sectional evidence indicates that the male labor supply curve is gently backward sloping (Killingsworth 1983, 12–13). In the nineteenth century, the labor supply curve for working men was strongly backward bending (Whaples 1990). If BMI were a strong predictor of wages in the nineteenth century, the strongly backward-bending labor supply curve implies that early improvements in health may have produced a substantial rise in retirement.[18] The findings thus suggest that, although health is now less important to the retirement decision than in the past, and although there have been improvements in the health of the elderly population, these factors might not induce greater labor force participation.

## 4.5 Summary

At the beginning of the century the health of men older than sixty-four was very poor compared with that of men today, who have benefited from advances in medical technology, lessened occupational hazards, and better early life conditions. Despite improvements in average health, and despite the decreasing importance of health to the retirement decision, retirement rates rose. An individual today looks forward to a long retirement, much of which is spent in good health. Age sixty-five may therefore no longer be as appropriate a demarcation of old age as it was in the first half of the century, when the health of a typical sixty-five-year-old was very poor.

# Notes

1. For a review, see Quinn and Burkhauser (1990).

2. For example, in the 1928–31 survey no attempt was made in the published results to distinguish between acute and chronic conditions, thus limiting the set of conditions that could be examined. Not only were conditions in that survey self-reported and therefore dependent on health awareness (probably much higher in 1992); a condition is enumerated in the survey only if it resulted in illness during the survey year. More than one illness from the same cause within the year was rare, suggesting the undernumeration rather than overnumeration is the more likely problem.

3. Height differentials at adult ages have disappeared in Scandinavia and the Netherlands (Eveleth and Tanner 1990, 199).

4. When height and weight are jointly related to the presence of an activity, work, or care limitation or to the number of chronic conditions, bed days, hospitalizations, and doctors' visits, once again the resulting surface is similar to the mortality surface. However, in the case of the chronic conditions, bed days, hospitalizations, and doctors' visits, the relation with height is greatly diminished.

5. I examine the relative risk of nonparticipation, $R_i$, which at BMI level $i$ is defined as

$$R_i = L_i/\left(\sum N_i L_i/N\right) = L_i/\bar{L},$$

where $L_i$ is the probability of nonparticipation at BMI level $i$, $N_i$ is the number of individuals of age $i$, $N = \sum N_i$, and $\bar{L}$ is the probability of nonparticipation over all BMI levels.

6. The inverse Mill's ratio is $\phi(\gamma w)/\Phi(\gamma w)$, where $\Phi(\ )$ is a standard normal cumulative distribution function, $\phi(\ )$ is a standard normal density function, $\gamma$ is the vector of coefficients from the participation probit, and $w$ is the vector of variables used in the participation probit. When the presence of a care limitation and BMI are included in the income equations, the coefficient on the presence of a care limitation is insignificant. The presence of a care limitation is therefore used to ensure statistical identifiability.

7. Provided that not all the variables used in the two-step selection correction are included in the final probit, the model will be identified. The covariance matrix is approximated as if estimated family income were the exact exogenous variable.

8. Tests revealed that a quadratic specification for age and a cubic specification for BMI fit the data. The use of dummy variables for age and BMI indicated that interactions between age and BMI were small and insignificant. The use of a spline indicated that retirement did not rise abruptly at age sixty-two, perhaps because the effect of Social Security benefits is captured by income when out of the labor force. I also tested whether height had any effect on retirement by including the log of height as an explanatory variable. The coefficient on height was insignificant, perhaps because height is correlated with income.

9. When either a cubic or a dummy variable specification is used, the coefficients on BMI are no longer significant. Work with the NHIS indicates that the significance of coefficients on BMI is more sensitive to sample size when a dummy variable rather than a continuous specification is used.

10. The standard deviation of BMI in the Union army sample is 3.6, whereas that in the sample of modern Americans is 3.7. The observed relation between BMI and labor force participation is not an artifact of distance of the mean from the level that maximizes the probability of participation. When the sample of modern Americans is randomly restricted to have the same fraction of men in BMI categories as the Union army sample, the relation between health and participation remains unchanged.

11. Lee et al. (1993) argue that the influence of cigarette smoking can skew weight recommendations that are optimal in terms of subsequent mortality.

12. In both fig. 4.12 and fig. 4.13 below, the relative risk of nonparticipation is lower than in fig. 4.9 above. Because of missing information, few men in the sample had a BMI of less than 18.

13. When smoking is interacted with BMI, the coefficient on the resulting variable is insignificant. Once again, the coefficients on BMI remain unchanged.

14. Among men who are in the labor force, the relation between BMI and sick days is U shaped and similar to that between BMI and labor force participation.

15. However, the thin still face a greater risk of nonparticipation, perhaps because the strong focus in the medical literature on the problems of obesity means that the obese are more likely to be diagnosed as having a chronic condition.

16. The increase in labor force participation rates would have added 31,806 male workers in the labor force in 1900. Assuming that each of these workers would produce the average annual output per employee in 1900, the increase in the total output of male workers forty-five to sixty-four would have been 0.6 percent. Assuming that the probability of nonparticipation among all men in 1900 would have fallen by 6 percent had they had modern BMIs, 226,674 more workers would have been added to the labor force, increasing the total output of male workers by 1 percent (estimated from the nonparticipation graph and Series D 29-41 in U.S. Bureau of the Census 1975, 131–32). This calculation abstacts from any complications caused by the substitutability of healthy and unhealthy workers and the impact of increases in labor force participation among older men on the employment prospects of the young.

17. Repeating the previous calculation, the total output of male workers age forty-five to sixty-four would have increased by 0.8 percent. Again assuming that the probability of nonparticipation among all men would have fallen by 10 percent, the total output of male workers would have increased by 1.7 percent.

18. In the NHIS the effect of BMI on income was substantial among low-income families and declined as family income rose. Estimates from quantile regressions indicate that the elasticity of family income with respect to BMI ranges from 0.50 for the tenth income decile, to 0.11 for the fiftieth, and to 0 for the eightieth.