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The Prevalence of Chronic Respiratory Disease in the Industrial Era
The United States, 1895–1910

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6.1 Introduction

A typical Union Army soldier returning home from the war in 1865 returned to a world that was still largely rural, agrarian, and unmechanized. Over three-quarters of the population lived either in sparsely populated areas or in towns and villages populated by fewer than 2,500 people. Those veterans who lived to old age were to see dramatic changes over the course of their lives. The modern world, with its new conveniences, crowded living conditions, and accelerated pace, descended rapidly as the twentieth century dawned in America. The growth of manufacturing and commerce in the several decades after the Civil War laid the economic foundations for tremendous improvements in standard of living over the twentieth century. These improvements included not only material gains, but also dramatic increases in life expectancy and general health at all points in the life course.[1]

A largely unresolved question, however, is what was happening to health during the period these changes were taking place. Most inferences on health in the nineteenth century come from trends in adult height, which is a comprehensive measure of the cumulative nutritional intake and disease environment present in childhood. In the mid-nineteenth century, a signifi-

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1. Life expectancy at birth (all races, both sexes) increased from 47.3 in 1900 to 76.5 in 1997 (NCHS 1999). Evidence is emerging, as well, that age-specific prevalence rates have fallen since the early-twentieth century for a variety of chronic illnesses (Fogel and Costa 1997; Costa 2000).

cant decline occurred in mean height, beginning with the cohorts born after 1830 and bottoming out with the cohorts born in the 1880s.[2] Height among birth cohorts born after the Civil War increased steadily, but did not fully recover until into the twentieth century. Fogel (1986) and Pope (1992) demonstrated a similar pattern in life expectancy. These trends together imply that although life expectancy rose over the latter part of the century and deaths from infectious diseases such as tuberculosis were falling (Leavitt and Numbers 1985), the elderly at the turn of the century had a particularly poor nutritional history and many of them had suffered the ravages of the Civil War, including the associated exposure to an infectious disease. Costa (2000) has shown recently that early life exposure to chronic illness had significant impacts on having a variety of chronic illnesses at the turn of the century.

Data on specific conditions and disabilities did not begin to be collected systematically in the United States until the 1950s, with the onset of the National Health Interview Surveys. However, new historical data have recently been collected from the pension records of Civil War veterans that can be used to perform epidemiological analyses of a rich variety of specific health conditions around the turn of the century. These data come from a randomly drawn sample of the Union Army that follows over 35,000 Union Army recruits from early childhood until death, by linking the recruits to census manuscripts and to the pension files that were maintained by the pension bureau. In these files are over 87,000 detailed medical examination certificates of board-certified physicians who determined the veteran's medical eligibility for pension assistance.[3]

One body system that may have been particularly sensitive to the demographic and economic trends in the latter nineteenth century is the respiratory system. In this paper, I provide a detailed (although by no means comprehensive) analysis of the medical data on the respiratory system covering the period from 1895 to 1910. I explore the variety of respiratory conditions that the examining physicians identified and how the distribution of conditions varied by age, occupation, population, and place of birth at four points in time: 1895, 1900, 1905, and 1910. A system-based approach is very practical when using the pension data, since the examining physicians typically recorded their observations system by system and recommended financial compensation by body system as well.

6.2 The Historical Setting

From 1870 to 1910, the United States experienced a dramatic continuation of the trend toward heavy industry and population concentration in

2. This trend was initially identified by Margo and Steckel (1983) and Steckel and Haurin in 1982 (but published only in 1994) and documented later by Fogel (1986), Komlos (1987), and Steckel (1992), among others.

3. All data used in this study come from Fogel (1999).

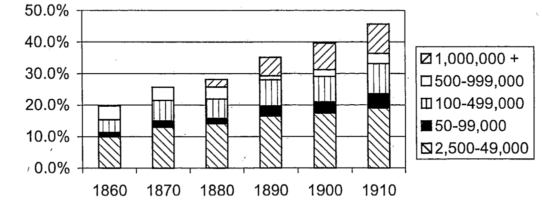

Fig. 6.1 Percent of U.S. population living in urban areas, 1860–1910
Source: U.S. Bureau of the Census (1976).

large cities. Since a primary reason for living in the large cities was access to manufacturing jobs, industry and population growth tended to go hand in hand. Figure 6.1 highlights growth in urbanization. From the end of the Civil War to 1910, the percentage of the population living in urban areas (over 2,500 residents) doubled. Even more striking is that most of this growth occurred in cities of over 50,000 residents.

Urbanization and industrialization both may have increased the odds of respiratory disease. Surely the filthy, crowded conditions of the large cities served to spread infectious agents, which may have contributed to the development of chronic respiratory problems. More likely still is that the tremendous growth of coal-burning industries led to dramatic declines in air quality. In 1870, the United States consumed about 21 million tons of dirty, bituminous coal and about 20 million tons of cleaner-burning anthracite coal. By 1910, consumption had increased to 81 million tons of anthracite coal and a whopping 406 million tons of bituminous coal.[4] Stradling (1999) documents that although some extolled the supposed virtues of smoke and soot, by the turn of the century vigorous antismoke efforts had begun, although it wouldn't be until the post–World War II period that significant gains in pollution control would be made.

Unfortunately, direct air quality measures from cities in this period are not available, although extensive descriptions of the heavy black clouds that hung over many cities have been given (Stradling 1999). Coal burning was a particular problem in cities such as Pittsburgh, where the surrounding hills worked to create air inversions that effectively trapped the smoke in the valleys, and most of the coal used was bituminous.

Industrial toxins affected urban residents not only through the air they breathed, but also on the factory floor. In modern times a wide variety of industrial pollutants affect respiratory health; these include coal dust, silica dust (from stone and other dry materials), asbestos, and other industrial chemicals in detergents, glues, paints, and other materials. In the 1920s, a public health report noted the high rates of respiratory disease (acute and chronic bronchitis, emphysema, asthma, and tuberculosis) in such indus-

4. Shurr and Netschert (1960), as cited in Stradling (1999).

tries as garment, cigar, and foundry where exposure to dust from fibers, vegetable materials, and metals was high (Britten and Thompson 1926). Of course, organic materials such as animal waste and dander, cotton dust, and dust from wheat and other grains are also sources of respiratory disease. Thus the nonfarmers, as a whole, are not necessarily at greater risk for respiratory illness than farmers.

Respiratory disease may have been rising at the turn of the century for another reason: the dramatic upturn in smoking during the latter part of the nineteenth century. In modern epidemiological studies, the dominant risk factor for respiratory diseases, such as emphysema and chronic bronchitis, is cigarette smoking. In the mid-nineteenth century, however, the cigarette in America was little more than a curio, although tobacco had long been consumed in other forms. But by the end of the century, the situation had changed. In 1839, the curing process for tobacco was revolutionized in North Carolina, giving birth to the "Bright Leaf" tobacco, which had the effect of making the smoke much easier to inhale than the dark leaf varieties found in cigar and pipe smoke. During the Civil War, tobacco use of all types spread among soldiers in America, just as it had earlier during the Crimean War in Europe. In 1884, Buck Duke, shortly to become the undisputed king of the tobacco industry, started to employ on a full-time basis the revolutionary machinery patented by James Bonsack in 1880. The Bonsack machine allowed, for the first time, the mass production of cigarettes at a fraction of the cost it took to hire North Carolina girls and women to roll them by hand.[5]

The new technology, coupled with vigorous marketing campaigns by Duke and his competitors, introduced to the modernizing country a stylish, clean, cheap, and very efficient method of delivering tobacco smoke deep into the lungs, where it could pass directly into the bloodstream. While there are no data that I know of that reveal specific consumption patterns of tobacco (who smoked it, when, and how often), from U.S. government statistics, we can calculate per capita production of cigarettes going back to 1870. Figure 6.2 displays the tenfold increase that occurred in per capita cigarette production between 1880 and the end of the century.[6] While the upward trend in cigarette production is striking, two features of figure 6.2 need to be noted. First, the rise in production after 1910, not shown in the figure, is even more profound, with per capita production rising from about 100 per year in 1910 to 1,000 by 1930 and 2,500 by the end of World War II. Though part of this growth can be attributed to increased exports, it is clear

5. This paragraph constitutes a much-condensed version of Kluger's (1997) fascinating history of the tobacco industry.

6. Tobacco production numbers are my calculations from the published government statistics (U.S. Bureau of the Census 1976). These numbers do not count for either exports or imports of cigarettes, nor changes in the composition of smokers, such as increases in the rate of smoking by women. Also, a large number of people still rolled their own cigarettes, but these numbers are not included in figure 6.1.

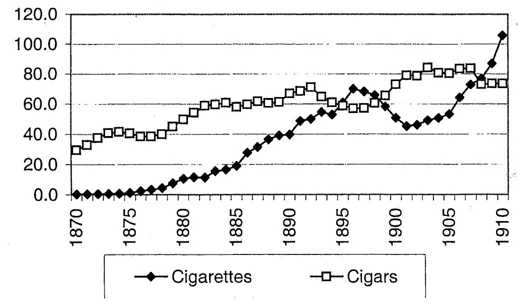

Fig. 6.2 Per capita U.S. production of cigarettes and cigars, 1870–1910
Source: U.S. Bureau of the Census (1976).

that post-1910 consumption was dramatically higher than pre-1910 levels. Second, there is a notable downswing that occurs in cigarette production between 1895 and 1905, although an upswing in cigar production compensates for this lull. This movement is likely due to the vigorous actions of social reformers who, convinced that cigarettes were either unhealthy, immoral, or both, successfully stigmatized cigarette smoking and succeeded in banning their sale in some states for a time (Kluger 1997).

Other public health reforms pushed ahead during the latter part of the century may have had significant impacts on chronic disease incidence and prevalence. Garbage was being picked up, water supplies began to be protected, and the general consciousness about the spread of disease increased. For instance, when Koch identified the bacteria responsible for tuberculosis in 1882, the annual death rate from tuberculosis was about 300 cases per 100,000 persons. By the time streptomycin (the first effective treatment) became available in the 1940s, the death rate had already fallen to below fifty cases, with about half the decline occurring before 1910. This decline illustrates dramatically the effectiveness of the public health movement.[7] (Leavitt and Numbers 1985)

In summary, although the years surrounding the turn of the century were characterized by important reforms in public health, it was still a time of rapid population movements to the big city, both from the countryside and from abroad, and it was a heyday of manufacturing, unhampered by modern pollution controls or workplace safety regulations. It was also a few years after the dawn of an extremely important new health risk: the mass-produced cigarette. Furthermore, the elderly people most at risk for chronic disease had a nutritional history which, as measured by their heights, declined across successive birth cohorts.[8] Thus, several factors were present

7. Other measures indicate the effectiveness of public health advances, such as the halving of the infant mortality rate between 1880 and 1910.

8. For example, the cohort aged sixty to sixty-five in 1890 had a better nutritional history, as measured by height, than cohorts entering the same age range in 1895, 1900, 1905, and 1910.

which could have caused the prevalence of respiratory disease to be either rising or falling at the turn of the century.

6.3 Classification of Respiratory Disease

6.3.1 The Modern Conception

Respiratory diseases are a diverse group of disorders. They are characterized by various symptoms, attributed to numerous causative factors—most poorly understood—and diagnosed with a variety of tools. It is convenient for the purpose at hand to make a distinction between upper respiratory (UR) conditions, including diseases of the nasal passages, sinuses, larynx, and pharynx, and lower respiratory (LR) conditions, which include diseases of the bronchi and the lungs. An additional useful classification is provided by the ninth version of the *International Classification of Disease* (ICD-9), which differentiates among the following major groupings:

1. Acute respiratory infections (460–69)[9]
2. Other diseases of the upper respiratory tract (470–78);
3. Pneumonia and influenza (480–87);
4. Chronic obstructive pulmonary disease and allied conditions (490–96);
5. Pneumoconiosis and other lung diseases due to external agents (500–08);
6. Other diseases of the respiratory system (510–19).

Although UR diseases are usually acute in nature and caused by bacterial or viral infection, chronic inflammation does occur. Indeed, the most commonly reported chronic condition in the National Health Interview Surveys is chronic sinusitis (sinus inflammation), with a prevalence of 13.6 percent among the general U.S. population in 1990 to 1992. Slightly less prominent is hay fever, or allergic rhinitis, which has a prevalence of 9.7 percent.[10] In addition to chronic sinusitis (473) and allergic rhinitis (477), chronic UR conditions include deviated nasal septum (470) and nasal polyps (471), as well as diseases of the nose and pharynx (472), tonsils and adenoids (474), and the larynx and trachea (476).

Upper respiratory conditions have a high degree of overlap. Oftentimes, for instance, inflammation of the nasal passages is associated with sinus inflammation. A common cause of UR inflammation is the presence of

9. In the ICD-9 classification system, the three-digit codes (indicated in parentheses) are usually further differentiated with fourth or even fifth digit classifications. For example, 493 refers to asthma, which is further differentiated as extrinsic asthma (493.0), intrinsic asthma (493.1), chronic obstructive asthma (493.2), and asthma, unspecified (493.9).

10. Prevalence rates are from Collins (1997).

allergens. Seasonal, regional, and climactic variation in allergens, as well as other organic and inorganic particles, is thought to influence the prevalence of chronic UR disease. In the late-twentieth-century United States, the regional variation in common UR conditions is readily apparent, especially in the case of chronic sinusitis. While the self-reported prevalence of chronic sinusitis is 17.5 percent in the South and 15.7 percent in the Midwest, in the Northeast it is only 9.4 percent, and in the West it is merely 8.8 percent (just over half the rate in the South). It is the West, however, that faces the highest rate of allergic rhinitis (11.7 percent), followed by the South (10.2 percent), the Northeast (8.5 percent) and the Midwest (8.2 percent). The South, therefore, has a relatively high prevalence for both sinusitis and rhinitis, while the Northeast has relatively low rates for both conditions. The West, probably because of its relatively arid climate, is prone to rhinitis but not sinusitis, while the situation is reversed in the Midwest.[11] In a recent important study, Ponikau et al. (1999) argue that the dominant cause of chronic sinusitis is not an allergic reaction at all, but an immune system response to fungus. Further study may attribute the importance of region to the presence of the fungus.

Table 6.1 below lists definitions of the most important chronic LR conditions. Goldring, James, and Anderson (1998) note that clinicians use a great variety of terms to define specific combinations of symptoms. Among the LR conditions, the most prominent are those conditions usually associated with obstruction of the airways. These include chronic bronchitis, emphysema, and asthma. Chronic obstructive pulmonary disease (COPD) is often used clinically as a nonspecific, catch-all term to describe chronic respiratory disease. Following the above authors, I will define the term COPD to include either chronic bronchitis or emphysema. A common classification is represented in the schema given in figure 6.3, which is adapted from Snider's characterization of the definitions put forward by the American Thoracic Society (1998). Diseases not allied with pulmonary obstruction include a variety of occupational lung diseases (pneumoconiosis) and other diseases, such as emphysema (510) and pleurisy (511).

The causes of lung disease are varied and not fully understood. COPD is generally believed to result from exposure of lung tissue to environmental agents, primarily tobacco smoke. According to the Surgeon General, almost 90 percent of COPD is attributable to cigarette smoking (U.S. Department of Health and Human Services 1994).[12] Asthma is typically classified as either allergic (extrinsic) or nonallergic (intrinsic). Allergic asthma

11. Prevalence rates cited here are from Collins (1997). Data come from self-reported conditions in the National Health Interview Surveys, 1990 to 1992. Rates are not adjusted for age or other factors.

12. A small number of persons with COPD have a genetically determined deficiency of the protein alpha 1-antitrypsin, a trait present in approximately 7 percent of the population (Snider 1998).

Table 6.1 **Definitions of Specific Chronic Lung Diseases**

Disease Group	ICD-9 Codes	Description
Cystic fibrosis	277.00, 277.01	Genetic disease with exocrine gland dysfunction resulting in pancreatic insufficiency, chronic progressive lung disease, and elevated sweat chloride concentration
Chronic bronchitis	490–491	Excessive tracheobronchial mucus production associated with narrowing of the bronchial airways and cough
Chronic obstructive bronchitis	491.2	Same as chronic bronchitis with involvement of smaller airways associated with airflow abnormalities
Emphysema	492	Alveolar destruction and associated airspace enlargement
Asthma	493	Reversible airway obstruction with airway inflammation and increased airways responsiveness to a variety of stimuli
Bronchiectasis	494	Destruction of bronchial wall
Allergic alveolitis	495	Immunologically induced inflammation of the lung parenchyma
Chronic airway obstruction	496	Generalized airway obstruction not classifiable as chronic bronchitis or chronic obstructive bronchitis
Other externally induced pneumoconioses	500–504, 506.4, 507.1, 507.8, 515, 516.3	Dust-, fume-, or mist-induced pneumoconioses or lung injury, nonimmunologically mediated
Sleep apnea	780.51, 780.53, 780.57	Repetitive cessation of breathing during sleep.

Source: Goldring, James, and Anderson (1998).

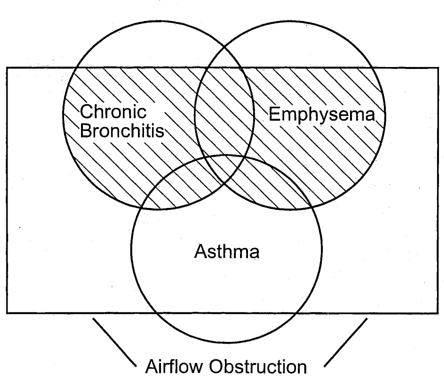

Fig. 6.3 Chronic lung diseases (COPD in shaded area)
Source: Adapted from Snider (1998).

is dominant in children, while adults have both allergic and nonallergic asthma in about equal numbers (Goldring, James, and Anderson 1998). Given that a family history of asthma is a significant risk factor, asthma may be, in part, genetically determined. In children, chronic exposure to allergens (primarily indoors) is associated with increased risk of asthma. The identified risk factors associated with adult onset of asthma are largely unknown, although occupational dust is a known cause (a condition usually classified as occupational asthma). Other occupational lung diseases, such as silicosis, asbestosis and coal-workers pneumoconiosis, are also the result of numerous environmental agents. Finally, interstitial lung diseases[13] have largely unidentified risk factors, though smoking and environmental agents are suspected causes.[14]

6.3.2 The Historical Record

A central concern in using the Union Army data, which cannot be fully resolved within the scope of this project, is whether or not the diagnoses of examining physicians in the late-nineteenth and early-twentieth centuries were valid and reliable. Physicians could visually observe UR conditions, but LR conditions would have been more challenging, although simple physical exam techniques can reveal much about the general conditions of the lung. Certainly the nineteenth-century physicians lacked a variety of modern diagnostic techniques, such as spirometry (which measures the expired volume as function of time), various tests for lung capacity, x-ray, biopsy of lung tissue, arterial blood gas measurements, and CT scanning of the chest (Snider 1998). However, patient-reported symptoms and history, which were available historically, still play a dominant role in diagnosing respiratory diseases today.

Although legitimate concerns remain about diagnostic competency and, in particular, the physicians' ability to differentiate between specific diagnoses, the historical classification of disease was not far removed from what exists today. In 1892, William Osler published what was quickly to become the most important medical text of the day. He classified both chronic and acute diseases of the UR system, including the nose, larynx, and pharynx. He also gave detailed discussions of diseases of the bronchi and lungs. Chronic bronchitis is characterized by a general inflammation of the bronchi indicated by chronic shortness of breath. Osler differentiates asthma from chronic bronchitis by the tendency of asthmatics to have severe attacks: "One of its most striking peculiarities is the bizarre and extraordinary variety of circumstances which at times induce a paroxysm"

13. Interstitial disease is that which occurs in the spaces between different tissues in the lung. These diseases are described generally as pulmonary fibrosis, alveolitis, and pneumonitis.
14. The preceding paragraph summarizes, again, the discussion of Goldring, James, and Anderson (1998).

(1892). Although emphysema could not have been confidently diagnosed prior to autopsy, Osler notes that the condition led to "enlargement of the lungs, due to distension of the cells and atrophy of their walls, and clinically by imperfect aeration of the blood and more or less marked dyspnoea" (1892).

The classification system used by Osler is remarkably similar in many respects to what we use today. Although autopsy allows a greater understanding of conditions than physicians could have been able to diagnose with living patients, the physicians of the day reported a wide variety of both upper- and lower-respiratory conditions that correlate closely with modern categories of respiratory diseases. The analysis that follows takes these physicians at their word. Since much more research is necessary to make confident comparisons between historical rates of respiratory disease, I will make such comparisons only in passing. The central intent here is to explore the variation in these physician-diagnosed conditions across important variables and across the period of study.

6.4 Methods

6.4.1 The Pension System and Surgeons' Certificates

The Civil War pension system began in 1862 as a means of providing financial support for soldiers disabled in battle. From this early date throughout the life of the system, applicants for assistance appeared before a board of examining physicians who conducted a detailed physical exam and forwarded their findings, noted on what was typically called a Surgeons' Certificate, to the pension board. These medical exams provide the essential data used in this study. Of the 35,570 Union Army veterans in the sample, 17,721 were examined at least once during their lives. A total of 87,271 examination records exist on these veterans, with an average of 4.9 exams (median = 4) per veteran.[15]

Changes in the pension laws fundamentally affected the number of medical exams available for analysis. For several years, the pension system was available only to people who could prove that their disability was somehow related to service in the military. This greatly limited the number of pensioners, although in practice, a wide variety of conditions, such as rheumatism or heart disease, were commonly ascribed to military service. In 1890, however, the system was changed dramatically, and any disabled veteran was eligible for coverage as long as he had served a period of at least ninety

15. The 35,570 recruits constitute 89 percent of the original random sample drawn from the Union Army regimental records. The original sample consisted of 331 randomly selected companies. To date, only 303 companies have been collected due to budgetary reasons. However, the uncollected companies come almost entirely from the Midwest, an area that was somewhat overrepresented in the original sample.

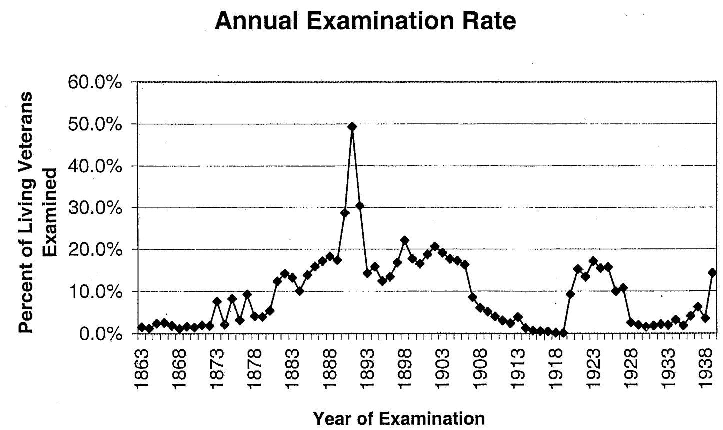

Fig. 6.4 Annual examination rate among current and future Civil War pensioners

days in the war. In 1904, Teddy Roosevelt issued an executive order that further expanded coverage, classifying old age as an infirmity, and Congress changed the law in 1907 making the pension system officially age-based. However, under the 1890 law, veterans who were aged sixty-five or older received a minimum pension unless they were "unusually vigorous." Thus any veteran over age sixty-two became eligible for a pension.[16]

These legal changes significantly affected the number of veterans getting a physical exam in any given year. Furthermore, as the veterans aged, they naturally acquired new conditions that made them eligible for new and increased support, which would often lead to a new examination. Figure 6.4 illustrates the annual rate of examination. The figure graphs the number of recruits examined in each year as a percentage of all veterans, who would at some point be in the system and who were known to be alive during the year indicated. The figure reveals the dramatic influx of exams following the implementation of the 1890 law. In 1891, half the veterans in the sample were examined.

Although the role of the physician was to provide a basis for granting or rejecting the claimant's petition, eligibility for the pension was not determined by the physician, but by the pension board. The physician's duty was to investigate the conditions made in the claimant's statement and to provide a systematic physical exam that was spelled out in a set of standardized instructions. The physician would typically go through the body systems one by one (usually starting with the cardiovascular system, followed by the respiratory system) and note any findings, whether positive or negative. Thus many conditions could be recorded, whether or not they were reported by the claimant, and whether or not they were pensionable.

16. See the discussion of the pension laws in Fogel (1999).

6.4.2 Disease Categories

The respiratory findings the physicians report are extensive, and the classification scheme used at the time was remarkably similar to the one we have today. The collection of this data into electronic form was designed to organize the data as much as possible without losing any of the detail present in the exams, thereby precluding future researchers from developing their own classification system. Consequently, in the data-inputting process, exam findings are entered chiefly in open-ended form. To facilitate the inputting process, the data collection team developed specially designed computer "screens," which correspond to each major body system.

This research exploits three central variables on the respiratory screen. First, a field exists for the description of any UR inflammation. Data are entered into this field essentially as written on the examination certificate. In all, there are over 18,000 unique phrases in the data that indicate the presence (or lack) of an UR inflammation, such as rhinitis, tonsilitis, or pharyngitis. Oftentimes, there are several UR comments on a given exam. Since the overwhelming majority of these inflammations are likely due to acute infections, UR inflammations are considered here only if the certificate explicitly states that the condition is chronic.

Second, specific LR conditions are also noted, although sometimes in very unspecific terms, such as "disease of the lung." There are, however, relatively frequent observations of the three main types of chronic lung diseases outlined above: emphysema, chronic bronchitis, and asthma. Tuberculosis is also present, but since tuberculosis is usually not classified with other respiratory conditions, it is not included here. Observations that are chronic in nature, but where no mention of the above specific conditions are made, are included in the "other" category. Other LR observations are considered acute unless they are specifically designated chronic by the physician.[17]

Third, as part of the examination process, physicians would often designate particular conditions as deserving of compensation. These physician ratings are an indicator of chronicity, since only chronic conditions were eligible for pension assistance. Oftentimes, the rating is the only piece of information present on a particular body system. Although the ratings sometimes lack specificity, they provide a valuable source of summary information on whether the physician viewed the claimant as having respiratory disease severe enough to warrant disability compensation.[18]

17. Findings assumed to be chronic include adhesion, allergy, anthracosis, atrophy, bronchiectasis, cavity, empyema, fibrosis, pleuritis, and pneumonitis. The findings assumed to be acute, unless specifically indicated to be chronic, are abscess, atelectasis, bronchitis, edema, effusion, hemoptysis, pneumonia, pneumothorax, tracheitis, and diseases of the lungs not further specified. The conditions mentioned here are actually standardizations of a wide variety of synonyms. The scheme for standardizing these synonyms was developed by Dr. Louis Nguyen, in consultation with the other physicians involved in the collection of the Surgeons' Certificates. Dr. Nguyen also recommended which findings to classify as chronic. I performed the actual coding of the data, and all mistakes are, consequently, my responsibility.

Other information related to the respiratory screen—such as dyspnea, respiratory sounds, cough descriptions, and indications of pulmonary dullness—may prove useful in making further diagnoses. I have confined this analysis, however, to specific diagnoses made by the examining physicians. Future research may be served by exploitation of these additional variables. Given the variable descriptions and caveats noted above, I present in the next section prevalence rates for chronic respiratory disease in six categories:

1. Chronic disease of the UR system
2. Chronic disease of the LR system
3. Chronic disease in either the UR or LR system
4. Any diagnosed or rated (DOR) respiratory disease
5. Asthma
6. COPD

These categories, therefore, represent both system-level classification of chronic illness as well as two important specific chronic diseases: asthma and COPD. The DOR category is the most general and indicates the presence of either a specifically designated chronic LR or UR condition or a physician rating. Due to the nonspecific nature of many of the exams, the DOR category is useful for measuring the prevalence of respiratory disease in general.

6.4.3 Prevalence Estimation

Strictly speaking, the estimates provided are not point prevalence rates for each disease category. Because of the irregular and sometimes infrequent examinations, the outcome to be measured is the percentage ever diagnosed. Given the chronicity of the conditions under study and the lack of effective treatment, this measure is a suitable proxy for the actual prevalence and has been used in other studies with the same data (Costa 2000). In order to minimize the underenumeration of conditions in those cases where a recent examination has not been conducted, only those individuals who have been examined in the five years prior to the prevalence date are included.

An examination of figure 6.3 reveals an obvious time period for examining the prevalence of disease in general, namely the period following the

18. Determining whether a rating was given is actually a rather involved process that requires sifting through the respiratory rating variables (p_rat*) as well as at the related diseases variables (p_rel*), which often contain indications that lung diseases are rated with another nonrespiratory condition.

rapid influx of veterans into the system after the liberalization of the law in 1890. For the next several years, a relatively high annual rate of examination exists which remains well over 15 percent through 1906. In 1907, the rate falls precipitously and examinations virtually disappear over the next decade.[19] Given the time pattern of examinations reflected in figure 6.4, I calculate prevalence at four dates: January 1 of 1895, 1900, 1905, and 1910. In each case, only those cases known to be alive[20] on that date and examined in the previous five years are included in the denominator. The decline in the examination rate from 1907 to 1909 will likely cause prevalence in 1910 to be underestimated relative to the other years.

This approach presents some potential biases. Because we must accumulate exams over a five-year period, there will be a tendency to understate prevalence because a portion of the population will have acquired respiratory conditions since their most recent exam. A potential bias in the other direction is that it may be that those applying for additional assistance are, in general, less healthy than those who do not get examined. Related to this second bias is potential variation in the health of the examined population during different time periods. As noted earlier there was a rush of examinees in 1890 and 1891, which might imply a healthier group of people got examined in those years. But many of these new examinees were severely ill people who were denied pension assistance prior to 1890 because their ailments could not be attributed to the war.

It is not clear, therefore, what the net effect of the 1890 liberalization would have been in terms of the health of a typical examinee. Increases in prevalence between 1900 and 1910 are even harder to attribute to changes in law. In fact, by the same reasoning assumed above, we would expect that as the de facto pension awards for age became more common, people who were eligible for pension due to age would be more likely to apply, thus successive cohorts of examinees would, on average, be increasingly healthier. This trend would cause disease rates to decline.

Finally, it is important to note that all the estimates presented here are for the population that lived long enough to be eligible for the pension after the liberalization of the pension system in 1890. Thus the prevalence rates presented in the next section are only valid, generally, for those fifty and older. There may be important features of the epidemiology of respiratory disease that would be uncovered by examining younger individuals, but the data at hand do not lend themselves to such an analysis.

19. On 6 February 1907 Congress passed the Service and Age Pension Act which introduced a new age-based system, although it is not clear if this was the reason why physical exams disappeared. In 1917, 1918, and 1920 further amendments were made to the laws (Sanders 2000). The administrative policies that may have been associated with these acts, including a reappearance of regular exams following 1920 (although by this time, all Civil War veterans qualified for age-based assistance) have not been investigated.

20. This is either from a death date recorded in the pension files (the majority of cases) or from the existence of a subsequent exam.

6.5 Results

This section presents an array of results concerning the distribution of respiratory disease in the population over the fifteen-year period under study. In order to simplify the presentation, confidence intervals are not reported for the descriptive statistics. As a general rule, the differences between years are statistically significant, while the differences across categories are not. Significance levels are reported for the probit regression results that follow the discussion of the descriptive statistics.

6.5.1 Age and Date

Table 6.2 below presents age breakdowns for each of the nonexclusive disease categories noted above. Sample sizes for each cell are given in the lower right corner of the table.[21] Note that changes from 1895 to 1910 in the age-specific rates can be observed by following the same age group horizontally across the columns. Within-cohort changes over time are seen by tracking the cohort diagonally in a southeasterly direction. The prevalence of disease among the oldest age groups, however, should be interpreted cautiously, given the small sample sizes in those cohorts.

Not surprisingly, the within-cohort prevalence increases for almost all cohorts and almost all categories.[22] More remarkable, however, is that age-specific disease rates are rising significantly over time for all categories. The biggest jump is generally between 1895 and 1900, but increases continue through 1910. Across the board categories of LR and UR disease, the prevalence rates double or triple in the period across age groups. Regarding specific conditions, asthma also rises significantly between 1900 and 1910 (except for the seventy-five to seventy-nine and eighty to eighty-four groups), while COPD increases are generally more modest, except for the sharp jump among the seventy-five- to seventy-nine-year-olds.

Table 6.2 also reveals important differences between the experiences of successive cohorts. If we look at the summary measure of all chronic respiratory conditions (which include physician ratings of disease that is not specifically identified as occurring in either the UR or LR system), we see that in 1895 the younger cohorts start out with significantly higher prevalence than older cohorts. This cross-sectional distribution may be due to two factors, both of which merit considerable further research. First, the overall force of mortality was high, which may have led to a declining preva-

21. Also, among those who were forty-five to forty-nine in 1895, most were in the forty-eight to forty-nine age group, since few people in the forty-five to forty-seven group were young enough to have served in the military.

22. The cohort that is age seventy to seventy-four in 1900 experiences a modest decline in prevalence between 1900 and 1905 for both LR and UR conditions as well as for asthma. The prevalence increases, however, for the category of COPD and the broad category of physician-rated respiratory disease.

Table 6.2 **Physician-Diagnosed Chronic Respiratory Conditions, by Age (percent of living pensioners ever diagnosed)**

Age	1895	1900	1905	1910
		Lower respiratory		
45–49	5.7			
50–54	6.4	8.1		
55–59	6.0	9.0	9.5	
60–64	6.0	9.3	10.7	11.3
65–69	5.4	7.9	10.6	12.2
70–74	5.4	8.8	11.6	14.3
75–79		7.1	7.7	18.1
80–84			10.9	4.2
		Upper respiratory		
45–49	8.0			
50–54	7.6	13.9		
55–59	6.4	12.6	16.3	
60–64	6.1	10.3	14.1	20.3
65–69	7.2	9.2	13.8	14.1
70–74	6.5	11.1	12.1	14.6
75–79		7.1	10.9	13.0
80–84			9.4	15.5
		Upper or lower		
45–49	12.6			
50–54	12.9	20.0		
55–59	11.7	19.4	23.6	
60–64	11.4	17.8	22.3	27.9
65–69	12.0	15.7	21.6	23.1
70–74	10.9	18.6	21.6	25.1
75–79		13.5	17.3	28.8
80–84			17.2	18.3
		Diagnosed or rated		
45–49	30.5			
50–54	30.4	40.7		
55–59	26.7	41.2	44.7	
60–64	25.1	37.8	45.1	47.4
65–69	24.9	34.9	42.7	46.2
70–74	21.4	37.6	41.5	46.7
75–79		34.0	40.1	49.2
80–84			34.4	45.1
		Asthma		
45–49	2.4			
50–54	2.4	3.9		
55–59	2.3	3.6	4.2	
60–64	2.3	3.8	4.2	5.0
65–69	2.7	2.5	4.5	4.7
70–74	3.6	4.1	4.9	6.6
75–79		2.8	3.2	2.8
80–84			6.3	0.0
		Chronic Obstructive Pulmonary Disorder		
45–49	1.4			
50–54	1.7	2.4		
55–59	1.8	2.6	2.0	
60–64	1.8	3.4	3.0	2.3
65–69	1.7	3.3	3.6	4.2
70–74	1.7	2.9	3.6	4.1
75–79		2.8	4.0	8.5
80–84			2.5	1.4
		Sample size		
45–49	1,821			
50–54	4,239	1,166		
55–59	2,625	2,531	990	
60–64	1,761	1,497	2,228	666
65–69	1,031	958	1,298	1,319
70–74	477	441	708	610
75–79		141	284	177
80–84			64	71

Notes: Percentages are calculated only for those cases where the veteran was examined in the five years prior to the date indicated. See text for definitions of disease categories. All years represent the percentage as of 1 January.

lence across age groups at a point in time. Second, recent research referred to earlier on the antebellum patterns in adult heights suggests that these younger cohorts were shorter than the older groups, indicating a harsher nutritional and disease history. Thus, the later occurrence of disease may be linked to the early nutritional experience of the recruits.

Even though the younger groups have higher rates of disease in 1895, it is the older groups who see the sharpest increase in disease rates over the next fifteen-year period, and by 1910 the age profile has flattened considerably. It is particularly notable that over this time period there is a sharp divergence between UR and LR conditions with respect to the age pattern. Whereas an inverse relationship between age and prevalence exists for UR conditions in 1910, there is a positive association between age and the prevalence of LR conditions. Further analysis may attribute this trend to other influences, but it may be the case that older cohorts are starting to see the effects of increased long-term exposure to environmental agents, such as cigarette smoke and industrial pollutants.[23]

23. The glaring exception to the trend in LR disease is the sharp decline in prevalence for the oldest group shown in table 6.2, although the small sample size at these old ages makes it hard to interpret this outcome.

6.5.2 Occupation

The most obvious potential link between occupation and respiratory disease is through the presence of pollutants and fine particulates associated with particular industries. Important occupation-specific diseases include pneumoconiosis (black lung), which strikes coal workers, and silicosis, which strikes workers who are exposed to concentrations of silica dust, such as stone cutters. In modern times more than 200 causative agents have been associated with occupational asthma. These agents include a variety of diverse sets of materials coming from plants and animals, grains, metals, chemicals, and drugs (Goldring, James, and Anderson 1998). In the nineteenth century we might posit an even greater role for industrial-based diseases, given the general lack of pollution control and worker protection that existed at the time.

Occupation is also associated with a number of other factors that may be associated with respiratory health. Low wages in some occupations may lead to poor nutrition and residency in crowded environments where exposure to infectious disease is more likely, as is exposure to pollution. Differences in the physical demands of labor across occupations may also play a role. Additionally, some have recently argued that relative position in the social hierarchy is associated with health.[24] Thus, individuals in lower-status occupations would be under more stress and, consequently, more prone to disease. Finally, in modern times, occupation is often a proxy for knowledge of health and access to medical care, although it is not clear that knowledge of health or health care were effective enough to have made a significant impact upon disease in the nineteenth century at the individual level.

The occupation of Union Army veterans is reported at several points during the recruit's lifetime. The recruit reported his occupation as part of the military enlistment record, and those who were linked to the 1850 and 1860 censuses may also have an occupation listed, if they were old enough to be employed at the time. Occupation was also reported as the recruit applied for a pension, either in the application or on the official certificate of the examining physician. Finally, occupation in later life is found on the census manuscripts for those recruits who were successfully linked to the 1900 and 1910 censuses. Although several reports of occupation are found in the data, a central weakness is that occupational information is seldom present between the end of the Civil War and the time when the recruit entered the pension system—usually several decades later.

Occupational categories are defined as follows. First, individuals are classified as high-risk if they ever report an occupation or industry where persistent exposure to smoke, dust, or fumes is likely. This includes occupations such as miners, masons, smiths, painters and finishers, printers, tenders of fires and furnaces, and workers at foundries and mills. Managers and clerks who worked in these industries are also reported at high-risk. General factory work is not reported as high-risk. Other occupational classifications are determined by either the occupation on the Surgeon's Certificate or the most recently reported occupation prior to the year under investigation. For those who are retired, their most recent known occupation is used. Additional occupational categories include farmers (including farm laborers); white-collar occupations, which include all types of professionals, proprietors, clerks, and salesmen; and skilled and unskilled labor.[25]

Table 6.3 reports prevalence of respiratory conditions according to the occupational classifications previously defined. In general, the occupational differences are not large. High risk occupations seem to have the greatest effect, as we would expect, on LR conditions, including COPD and asthma, to a lesser extent. Farmers have roughly equivalent rates with the high risk categories, while skilled workers have notably lower prevalence. White-collar and unskilled labor generally fall in the middle.

Patterns found in the descriptive statistics are suggestive of the importance of occupation, but they are not conclusive due to the limited scope of this analysis. The difference in prevalence between the high-risk group and skilled laborers gives some justification for the classification scheme used and shows the impact of occupation more than any other pattern in the data. Unskilled labor is also high, but this group has such a high percentage of workers where so little is known about the nature of their work that it is not meaningful to make direct comparisons to other groups. Farmers also have high rates of both LR and UR conditions. Of course farmers are exposed to a variety of organic materials that can lead to farmer's lung and other respiratory conditions, such as occupational asthma.[26] An additional explanation for the higher rate among farmers is that all-cause mortality was lower for farmers than for other groups. An unresolved puzzle is the high rate of respiratory illness amongst the white-collar group. Possibly, it is long periods of working indoors or the tendency to work in smoky and congested central cities that raises the prevalence among this group.

The classification scheme used in this analysis is, by necessity, crude and preliminary. It should be noted that thousands of individual occupational titles exist in the data, and collapsing these to five categories is sure to sacrifice important details. Further explorations of occupational health generally, and respiratory health specifically, are certainly warranted. The lack of

24. See Wilkinson (1996), for example.

25. Any type of trade or craft, such as carpentry or carriage making, was classified as skilled labor, as were those who reported the manufacture of specific items. Unskilled laborers were those who reported themselves as "laborer," "worker," or "helper" in any industry (other than those classified as high-risk).

26. Operators of threshing machines and grain elevators were classified as high-risk, although the harvesting and storing of grain would be a common activity for most farmers.

Table 6.3 **Physician-Diagnosed Chronic Respiratory Conditions, by Occupation (percent of living pensioners ever diagnosed)**

Occupation	1895	1900	1905	1910
		Lower respiratory		
Farmer	6.1	9.0	11.5	13.8
High-risk	7.0	8.7	10.1	12.8
White-collar	6.3	8.3	9.1	12.4
Skilled	4.7	7.8	8.5	8.3
Unskilled	5.9	8.7	9.8	11.9
		Upper respiratory		
Farmer	7.7	12.2	14.4	16.8
High-risk	6.5	12.0	13.6	15.4
White-collar	7.4	13.2	14.7	15.5
Skilled	5.9	10.4	12.3	13.3
Unskilled	6.1	9.2	13.7	14.2
		Upper or lower		
Farmer	12.8	19.3	23.3	26.6
High-risk	12.6	18.6	21.5	25.2
White-collar	12.2	19.0	20.3	23.8
Skilled	10.0	16.3	19.4	19.4
Unskilled	11.3	16.5	21.9	24.0
		Diagnosed or rated		
Farmer	30.5	41.4	46.0	48.2
High-risk	26.2	36.8	42.1	46.6
White-collar	28.1	38.2	41.9	45.5
Skilled	22.5	35.0	38.9	43.2
Unskilled	24.4	36.0	43.1	45.3
		Asthma		
Farmer	2.3	3.4	4.5	5.0
High-risk	3.0	3.6	4.7	5.4
White-collar	2.0	2.8	4.0	5.6
Skilled	2.5	3.2	3.2	2.5
Unskilled	2.9	4.6	4.5	5.6
		Chronic Obstructive Pulmonary Disorder		
Farmer	1.6	2.8	3.4	4.6
High-risk	2.0	3.6	3.0	5.2
White-collar	2.2	2.4	2.9	4.0
Skilled	1.7	3.4	2.7	1.9
Unskilled	1.3	2.5	2.7	2.1
		Sample size		
Farmer	6,626	3,650	2,561	1,315
High-risk	1,181	769	843	461
White-collar	907	532	627	323
Skilled	1,498	805	661	324
Unskilled	1,704	967	863	430

Notes: Percentages are calculated only for those cases where the veteran was examined in the five years prior to the date indicated. See text for definitions of disease categories. All years represent the percentage as of 1 January. The high-risk category includes workers of any type who have a history of employment in industries at risk for respiratory disease (see text). White-collar workers include professionals, proprietors, clerical workers, and salespersons. A small number of cases with no known occupational history are excluded.

complete occupational histories is also a potential source of bias, since no controls for time spent in specific occupations are undertaken here. Of particular concern is that some individuals may change occupations because of their health, which would cause overestimates of the prevalence rates in the occupations that unhealthy people transitioned to.

6.5.3 Region and Population

As is the case with other variables, such as occupation, place of residence is typically not known for the decades between the war and the initial pension application. However, when the veterans apply for a pension, their residency is known with great detail (street addresses, in many instances) and with a high rate of completion. As before, the convention is followed of assigning the last known place of residence if the residence is not given in the examination record. In all cases, cities are categorized using the population in 1900.

As noted earlier, the prevalence of UR conditions varies significantly by region in the modern United States. Regional variation for UR conditions is also apparent among the Union Army veterans. Table 6.4 reveals that in 1910 the rate of UR disease is about 10 percent in the New England and Mid-Atlantic regions, 16 to 18 percent in the North Central regions, 18.3 percent in the South and border states, and 20.3 percent in the West. Interestingly, these differences are much less pronounced in earlier years of the period, although the pattern exists in 1895 for respiratory conditions in general. Also notable is that LR conditions follow the same pattern (though the range is much smaller), with the striking exception of a dramatically low rate of LR disease in the South and border states.

Given the rapid shift of the nineteenth century population to the nation's large cities, which are widely viewed as teeming with filth and disease, we might expect that the large cities would be characterized by high rates of respiratory illness. The patterns present in table 6.5 reveal that no direct relationship between population and the prevalence of respiratory disease exists. On the contrary, the relationship is not monotonic at all. The largest cities and smaller cities between 25,000 and 99,000 have the lowest rates, while cities between 100,000 and 500,000 and locales under 25,000 have the highest rates of illness.

Numerous features of urbanization at the turn of the century need to be explored to make sense of these results. Here I make just brief mention of factors that may affect the variation in respiratory health across regions and population. First, public health programs that began in the late-nineteenth century had little impact outside of the cities, which may explain part of the high rates for the rural areas. Preston and Haines (1991, 91), for example, show that the child mortality rate in 1900 was lower in the 10 largest cities than it was in other cities 25,000 and over. However, Preston and Haines also note that most of the advances in public health were in the area of water and sewage, not air quality. Third, this analysis lumps together all locales under

Table 6.4 **Physician-Diagnosed Chronic Respiratory Conditions, by Region (percent of living pensioners ever diagnosed)**

Region	1895	1900	1905	1910
		Lower respiratory		
New England	5.3	6.7	7.2	10.2
Mid-Atlantic	4.8	7.5	10.2	10.7
East North Central	6.4	9.3	11.0	13.7
West North Central	7.1	9.9	10.0	13.2
South/border state	3.9	6.8	9.4	5.4
West	6.7	9.6	10.6	15.8
		Upper respiratory		
New England	6.0	7.9	9.3	10.2
Mid-Atlantic	6.1	9.1	10.9	10.3
East North Central	7.5	12.8	15.5	16.5
West North Central	7.7	12.9	14.9	18.1
South/border state	8.2	13.1	16.6	18.3
West	5.6	11.3	13.3	20.3
		Upper or lower respiratory		
New England	10.7	13.3	15.6	19.1
Mid-Atlantic	10.5	15.3	19.1	19.3
East North Central	12.8	19.9	23.7	26.2
West North Central	13.6	20.6	22.4	27.9
South/border state	11.9	18.2	24.1	22.0
West	10.7	18.7	21.5	29.7
		Diagnosed or rated		
New England	20.1	25.1	31.5	38.2
Mid-Atlantic	23.2	35.0	38.3	40.3
East North Central	31.4	42.5	47.2	49.5
West North Central	29.0	39.8	45.2	50.4
South/border state	31.3	43.6	49.9	45.2
West	23.0	36.7	37.6	43.0
		Asthma		
New England	2.1	3.0	3.3	4.5
Mid-Atlantic	2.2	3.6	5.3	5.6
East North Central	2.7	3.7	4.5	5.0
West North Central	2.4	3.5	3.7	4.8
South/border state	1.5	3.0	3.0	2.2
West	2.5	3.2	3.3	3.8
		Chronic Obstructive Pulmonary Disorder		
New England	1.2	2.7	2.4	3.2
Mid-Atlantic	1.1	2.6	2.5	2.4
East North Central	2.2	3.5	3.6	5.1
West North Central	1.7	2.6	2.5	3.2
South/border state	1.1	1.9	2.8	1.1
West	1.8	1.3	2.1	5.1

Table 6.4 (continued)

Region	1895	1900	1905	1910
		Sample size		
New England	768	406	333	157
Mid-Atlantic	2,493	1,403	1,141	534
East North Central	4,548	2,638	2,194	1,235
West North Central	2,593	1,377	1,085	524
South/border state	852	473	361	186
West	447	311	330	158

Notes: Percentages are calculated only for those cases where the veteran was examined in the five years prior to the date indicated. See text for definitions of disease categories. All years represent the percentage as of 1 January.

25,000 persons, although there is considerable heterogeneity within this group that needs to be further explored. Fourth, it is mostly UR conditions that have low prevalence in the great cities, with only relatively modest differences in LR conditions across city size. Fifth, the fact that the heavily industrial regions of New England and the Mid-Atlantic had much lower rates of UR disease would have reinforced the lack of UR conditions in the big cities. Sixth, the great cities of the East—New York, Boston, and Philadelphia—burned a much higher percentage of cleaner, anthracite coal and are believed to have much better air quality than many smaller industrial cities further west (Stradling 1999). Finally, and probably most importantly, the high all-cause mortality rates in cities may have suppressed prevalence rates. It is also conceivable that respiratory disease survival was shorter in the cities, thus driving prevalence downward relative to the rural areas.[27]

6.5.4 Probit Regression Results

This section further explores demographic patterns in chronic respiratory disease by simultaneously controlling for the variables outlined above in a regression context. Probit equations will be estimated, one for each of the four prevalence dates under examination: 1895, 1900, 1905, and 1910. It should be emphasized that this analysis is exploratory and not designed to confirm the causality of any factors involved. The occurrence of disease is a function of a variety of processes over the life cycle, while the regression equations account only for the variation in contemporaneous variables at a point in time. This exploratory analysis, however, is useful in that it allows us to gauge the relative importance of different factors and identify potentially important variables for future research.

Table 6.6 contains regression results from twelve probit regressions, while table 6.7 gives the relative frequency of the explanatory variables. Each of

27. Evidence that survival with respiratory disease is shorter in large cities is found in Costa (2003).

Table 6.5 Physician-Diagnosed Chronic Respiratory Conditions, by Population (percent of living pensioners ever diagnosed)

City Population (1900)	1895	1900	1905	1910
Lower respiratory				
500,000+	4.1	6.9	8.1	11.0
100–499,000	5.0	8.0	8.1	10.3
25–99,000	4.9	6.6	7.1	7.0
0–24,000 (nonfarmer)	6.2	8.7	10.0	12.6
0–24,000 (farmer)	6.3	9.2	11.8	13.9
Upper respiratory				
500,000+	2.2	5.2	9.1	7.7
100–499,000	7.3	12.0	14.4	15.1
25–99,000	6.0	9.3	12.3	17.1
0–24,000 (nonfarmer)	6.8	11.5	13.9	14.9
0–24,000 (farmer)	7.7	12.4	14.6	16.9
Upper or lower respiratory				
500,000+	6.1	11.3	15.7	16.5
100–499,000	12.2	18.0	20.4	22.6
25–99,000	10.4	14.5	16.8	19.8
0–24,000 (nonfarmer)	12.0	18.2	21.9	24.8
0–24,000 (farmer)	13.0	19.7	23.6	26.8
Diagnosed or rated				
500,000+	14.3	28.2	28.3	29.7
100–499,000	30.3	41.3	46.3	45.2
25–99,000	23.2	33.4	34.2	39.6
0–24,000 (nonfarmer)	26.1	37.1	43.3	47.8
0–24,000 (farmer)	30.8	41.8	46.4	48.5
Asthma				
500,000+	1.5	3.2	4.5	4.4
100–499,000	2.9	4.3	5.6	6.8
25–99,000	1.8	2.7	3.4	2.1
0–24,000 (nonfarmer)	2.6	3.7	4.1	5.0
0–24,000 (farmer)	2.4	3.5	4.6	5.2
Chronic Obstructive Pulmonary Disorder				
500,000+	1.5	3.2	2.5	2.2
100–499,000	1.4	3.0	1.1	2.1
25–99,000	1.5	2.7	0.9	2.1
0–24,000 (nonfarmer)	1.8	2.9	3.2	3.8
0–24,000 (farmer)	1.7	2.9	3.4	4.7
Sample size				
500,000+	413	248	198	91
100–499,000	558	300	270	146
25–99,000	715	407	351	187
1–24,000 (nonfarmer)	3,917	2,332	2,281	1,165
0–24,000 (farmer)	6,158	3,413	2,442	1,258

Notes: Percentages are calculated only for those cases where the veteran was examined in the five years prior to the date indicated. See text for definitions of disease categories. All years represent the percentage as of 1 January. The nonfarmer designation includes a small number of cases where occupational category is unknown. Cities are categorized based on their population in 1900.

Table 6.6 Sample Characteristics, by Year (percent)

	1895	1900	1905	1910
Age				
45–49	15.2			
50–54	35.5	17.3		
55–59	22.0	37.6	17.8	
60–64	14.7	22.2	40.0	23.3
65–69	8.6	14.2	23.3	46.2
70–74	4.0	6.5	12.7	21.3
75–79	100.0	2.1	5.1	6.2
80–84		100.0	1.1	2.5
85–89			100.0	0.5
				100.0
City population				
500,000+	3.5	3.7	3.6	3.2
100–499,000	4.7	4.5	4.8	5.1
25–100,000	6.0	6.0	6.3	6.5
0–24,000	84.3	85.3	84.8	84.8
Unknown	1.6	0.5	0.5	0.4
	100.0	100.0	100.0	100.0
Region				
New England	6.4	6.0	6.0	5.5
Mid-Atlantic	20.9	20.8	20.5	18.7
East North Central	38.0	39.2	39.4	43.2
West North Central	21.7	20.4	19.5	18.3
South/border state	7.1	7.0	6.5	6.5
West	3.7	4.6	5.9	5.5
Foreign/unknown	2.1	1.9	2.3	2.2
	100.0	100.0	100.0	100.0
Occupation				
Farmer	55.4	54.2	46.0	46.0
High-risk	9.9	11.4	15.1	16.1
White-collar	7.6	7.9	11.3	11.3
Artisans	12.5	12.0	11.9	11.3
Laborers	14.3	14.4	15.5	15.0
Unknown	0.3	0.2	0.3	0.2
	100.0	100.0	100.0	100.0
Wartime disease				
Tuberculosis	1.7	1.9	1.9	1.8
Pneumonia	4.4	4.3	4.7	4.6
Other respiratory	6.7	7.1	6.9	7.2
Measles	4.9	5.2	5.9	6.6
Typhoid	6.0	6.1	6.4	7.3
Malaria	3.6	3.8	3.6	4.1
Small Pox	1.2	1.3	1.3	1.4
Scurvy	1.8	2.0	1.8	2.1
Diarrhea	8.9	9.6	9.5	9.6
Fever	15.7	16.3	16.4	18.0
Enlistment height differential (inches)	0.17	0.17	0.18	0.27

Notes: Sample includes only cases where the veteran was examined in the five years prior to the date indicated. Height is measured as the deviation from age-specific averages at enlistment. Cities are categorized based on their populations in 1900. Individuals often have more than one wartime disease. The standard deviation of height is 2.50 inches.

the four years is investigated for three general categories: any diagnosed LR condition; any diagnosed UR condition; and any DOR condition. These are the same categories as used above, and the same definitions apply to both the dependent and independent variables. Regression coefficients are represented as changes in the estimated probability of disease, which occurs from changing the given explanatory variable from zero to one while holding all other variables constant at their mean values. Asterisks represent levels of statistical significance (see table 6.7 notes) based on robust, heteroskedasticity-consistent standard errors.

In addition to the variables previously discussed, I have included data on health-related variables from the veterans' early life and war time experience. From the medical records kept during the war, it is possible to identify the occurrence of important infectious diseases that the recruits had during their military service. Of primary importance are diseases affecting the respiratory system. These are tuberculosis, pneumonia, and other lung diseases, which include any illness of the lungs or bronchi (exclusive of tuberculosis and pneumonia). Measles is another infectious disease that can sometimes have serious respiratory consequences. Costa (2000) cites evidence that measles leads to pneumonia, bronchilar obstruction, distension of airways, and thickening of the peribronchial walls. Among soldiers in the Civil War, others have found that measles was often followed by chronic bronchitis, pneumonia, pleurisy, chronic diarrhea, and general debility (Cliff, Haggett, and Smallman-Raynor 1994, 105). Other common infectious diseases in the military records are typhoid, malaria, and small pox. Diarrhea and scurvy can also be indicators of nutritional deficiencies. Finally, any mention of fever that is exclusive of the above diseases is also included as a separate category.[28]

The final variable is the recruit's height at enlistment. This height is measured as the deviation from the age-specific mean height, since many recruits enlisted at young ages and grew several inches during the war. Height has been used widely as a measure that summarizes the health and nutritional history of an individual.

Among DOR conditions, a relatively strong age-pattern exists in all four years, whereby age is inversely related to the prevalence of disease, as expected. This same pattern was found in the descriptive statistics. The earlier time periods show a stronger relationship than later years, but the pattern persists. It would be interesting to know the composition of UR and LR conditions among the physician-rated conditions that are not further specified, since the age patterns prevalent in modern data show varying age profiles. In the early 1990s, the prevalence of allergic rhinitis peaks in early adulthood (11.7 percent among males aged eighteen to forty-four) and de-

28. These disease classifications are a modification and extension of those developed by Chulhee Lee.

Table 6.7 Marginal Effects for Probits

	Dependent Variable											
	Any Lower Respiratory Condition				Any Upper Respiratory Condition				Any Diagnosed or Rated Condition			
	1895	1900	1905	1910	1895	1900	1905	1910	1895	1900	1905	1910
Age												
45–49	–.004				.015*				0.29**			
50–54	.001	–.015			.010	.033**			.026**	.018		
55–59		–.006	–.013			.019*	0.21			.024	.016	
60–64	.000		–.002	–.030*	–.001		–.001	.057***	–.015		.021	.001
65–69	–.005	–.011		–.023	.012	–.011		–.007	–.014	–.026		–.012
70–74	–.001	–.007	.010		.006	.005	–.017		–.043	–.006	–.010	
75–79		–.011	–.032*	.025		–.034	–.031	–.024		–.026	–.031	.008
80–84			.010	–.095**			–.039	.007			–.083	–.036
85–89				.016				–.005				–.121
City population												
500,000+	–.011	–.009	–.016	.000	–.046***	–.061***	–.041	–.065	–.120***	–.098***	–.137***	–.159***
100–499,000	–.010	–.014	–.020	–.030	.002	–.008	–.002	–.013	.025	.011	.024	–.030
25–100,000	–.009	–.017	–.030*	–.053**	–.009	–.025	–.018	.023	–.039**	–.051	–.091***	–.067*
0–24,000												
Unknown	–.018	–.008	–.055		–.011	–.033	–.017		–.101***	–.117	–.159*	
Region												
New England	.005	–.011	–.031*	.005	–.005	–.024	–.029	–.014	–.047***	–.118***	–.081**	–.032
Mid-Atlantic												
East North Central	.015**	.014	.003	.024	.005	.029**	.041***	.056***	.053**	.045***	.070***	.069
West North Central	.020***	.022	–.010	.015	.007	.030**	.037**	.079***	.024*	.017	.046**	.080**
South/border state	–.012	–.013	–.017	–.061**	.015	.036*	.055	.084**	.064***	.051*	.098***	.042**
West	.016	.019	.001	.063	–.013	.011	.017	.099***	–.035	–.012	–.029	.009
Unknown	.050**	–.005	.065**	.132**	–.014	–.025	.014	.058	.061*	.042	.096*	.119*

Table 6.7 (continued)

	Dependent Variable											
	Any Lower Respiratory Condition				Any Upper Respiratory Condition				Any Diagnosed or Rated Condition			
	1895	1900	1905	1910	1895	1900	1905	1910	1895	1900	1905	1910
Occupation												
Farmer												
High-risk	.017**	.006	–.006	.001	–.001	.016	.005	.000	–.011	–.014	–.007	.011
White-collar	.012	–.001	–.012	.004	.010	.030*	.012	–.009	.018	.006	–.008	.014
Artisans	–.007	–.001	–.019	–.042**	–.006	.005	–.007	–.021	–.041***	–.021	–.034	–.014
Laborers	.008	.010	–.010	–.004	–.006	–.013	.002	–.009	–.026**	–.020	.004	.013
Unknown	.047	.339	.090	.334	–.002		–.069		–.014	–.043	–.078	.246
Wartime disease												
Tuberculosis	.045**	.115***	.141***	.160**	.021	.076*	.052	–.064	.168***	.226***	.177***	.207**
Pneumonia	.076***	.110***	.148***	.119***	.022*	.041*	–.003	.007	.165***	.168***	.135***	.164***
Other respiratory	.040**	.064**	.115***	.061	.015	.117**	.068	.003	.108***	.228***	.146**	.062
Measles	.030***	.025*	.030*	.044*	.057***	.051**	.051***	.080***	.144***	.158***	.128***	.198***
Typhoid	.003	–.002	.006	–.018	.007	.016	–.010	.017	.026	.047*	.033	.025
Malaria	–.001	.034*	–.011	.008	–.001	.030	–.036	–.007	–.020	–.003	–.015	.007
Small Pox	.002	.009	.015	.047	.023	.012	.068	.135**	.002	–.013	.065	.124
Scurvy	–0.21	–.004	–.014	–.063	.019	–.034	.015	.049	.053*	.029	.095*	.013
Diarrhea	.043**	.040	.007	.062	.026	–.019	.039	.112*	.108***	–.006	.047	.149*
Fever	.005	.008	–.002	.000	.005	.032**	.039***	.033*	.013	.043**	.027	.044*
Enlistment height (inches)	–.001	–.001	–.003*	–.006**	.001	.000	–.001	–.001	.000	.000	–.003	–.008**
Dependent variable mean	.060	.088	.104	.127	.071	.116	.139	.156	.280	.390	.436	.468
Sample size	11,877	6,693	5,553	2,839	11,877	6,693	5,553	2,839	11,877	6,693	5,553	2,839
Pseudo-R^2	.042	.039	.040	.059	.018	.024	.021	.033	.041	.031	.029	.037

Notes: The marginal effects are calculated as the change in probability resulting from a discrete change in the dummy variable from 0 to 1, holding all other variables constant at their sample means. *P*-values are based on robust standard errors.

***$P < .01$.

**$P < .05$.

clines thereafter (6.6 percent at age seventy-five and older). Sinusitis, on the other hand, peaks in the forty-five to sixty-four age group and then declines. LR conditions rise much more sharply with age, but COPD prevalence falls in the seventy-five plus age group, whereas asthma stays relatively flat across age groups (Collins 1997). What we see with the UR and LR categories is broadly consistent with the modern age-patterns, particularly the sharp decline in LR conditions in the latter ages in 1905 and 1910, and the generally negative relationship between age and UR disease prevalence.

Among the other covariates estimated, region is again the most pronounced, and the regional patterns highlighted earlier remain prominent when controlling for other factors. Relative to the Mid-Atlantic and Western states, the New England region has sharply lower prevalence, as measured with DOR, while the North Central and Southern regions have much higher prevalence. It is apparent that much of the regional variation is due to UR conditions. There is some variation in LR conditions, however. In 1895, LR condition prevalence is significantly higher in the North Central regions, though the magnitude of the differences are not large. The final region on table 6.7, which includes veterans living in foreign countries or cases where the residence is not available from the surgeons' certificates, has notably higher rates of respiratory disease, especially in the latter periods, although no obvious explanation exists for this occurrence.

Table 6.7 reiterates the patterns shown in the descriptive statistics for population. For DOR conditions, rural locations (the omitted group) have higher rates of illness than do either small cities or large cities. The only group comparable to the rural areas is the mid-size cities of 100,000 to 499,000. Again, the largest effects seem to be in terms of UR conditions. If we look only at cities, the prevalence of LR conditions rises with city size across all years.

The wartime disease variables, particularly diseases affecting the respiratory system, prove to be strong predictors of respiratory disease in later life, particularly LR conditions. As we might expect, tuberculosis, pneumonia, other lung conditions, and measles have very large and statistically significant positive impacts on the probability of having LR conditions (recall that tuberculosis is not included as a LR condition in this analysis). Indeed, these wartime conditions essentially double the probability of having LR disease diagnosed later in life. Interestingly, the wartime diseases have a much smaller and generally statistically insignificant impact on UR conditions (pneumonia has essentially no effect). The exception is measles, which has a powerful impact on both LR and UR disease. Other infectious diseases generally increase the odds of both LR and UR conditions, although often not at significant levels. In sum, the importance of infectious disease as a predictor of respiratory disease in later life is striking not only in the magnitude of their effects but also because we have the early life health history for only a narrow interval of time—the years they served in the war.

Furthermore, many of the conditions reported (such as other respiratory disease, diarrhea and fever) may have been relatively minor viruses that we would not expect to have long-term consequences, making their effects all the more surprising.

One hypothesis for why the disease prevalence rates may have been increasing with successive cohorts is long-term effects of childhood nutrition. The height variable is supposed to proxy for both childhood nutrition and health. Height does have a negative effect on LR disease, but this is only significant in later years. However, a 2–standard deviation increase in height would lower the probability of LR disease by 3 percentage points in 1910. This is nontrivial, given that the mean LR prevalence in that year was only 12.7 percent. Enlistment height has essentially no effect on UR disease.

Finally, all the covariates discussed in table 6.7 must be interpreted in light of the fact that data are available only for those who survived until at least 1895. Since we have little data on either the Union Army cohort prior to 1890, and no data on subsequent cohorts, the analysis can say nothing about the correlates of disease at younger ages.

6.6 Conclusions

This research explores demographic patterns associated with different categories of chronic respiratory disease for the period 1895 to 1910. A central finding is that the age-specific prevalence of respiratory disease (as measured by the percent of the sample ever diagnosed) among the veterans of the Civil War increased sharply between 1895 and 1910. This trend holds true both for UR and LR conditions and for the specific conditions of asthma and COPD. The sharpest period of increase was between 1895 and 1900, but steady increases occurred after 1900 as well. For instance, the prevalence of the most general category, DOR, increased over the 1900 to 1910 interval from 37.8 percent to 47.4 percent among the sixty- to sixty-four-year-old group, from 34.9 percent to 46.2 percent for those sixty-five to sixty-nine, from 37.6 percent to 46.7 percent for those seventy to seventy-four, and from 34.0 percent to 49.2 percent for the seventy-five- to seventy-nine-year-olds.

Earlier I identified four factors that suggest increasing prevalence of respiratory disease (in particular LR conditions) over this time period. These factors are (a) increased exposure to infectious disease due to rapid urbanization (though public health programs likely mitigated the effect of population growth); (b) decreased indoor and outdoor air quality rising from a booming and unregulated manufacturing sector; (c) the rise of mass-produced cigarettes in the 1880s; (d) a deterioration in childhood health and nutrition as reflected in the declining heights of successive cohorts within this study. The first three factors are, at this point, merely conjectures

since I do not have direct evidence on cigarette consumption or air quality. The final point finds some limited support, but only for LR conditions.

Exploratory analysis of the primary demographic variables present in the Surgeons' Certifications does reveal a few significant patterns. Regional variation in UR disease reflects roughly the same pattern as found today. New England states had significantly lower prevalence than other groups, while the Southern, Western, and Midwestern rates were significantly higher. This same general pattern was found for LR conditions as well, with the exception of the Southern and border states, where the rate was much lower.

The results for population and occupation suggest that we need to probe much deeper into the relationship between rapid urbanization/industrialization and the health of the population. The story is nowhere as simple as urban and industrial centers are unhealthy, and rural areas are healthy. Indeed, in the cross sections examined here, it is the rural residents, farmers in particular, who have the highest rates of respiratory disease—equally as high as high-risk occupations, such as coal mining and stonecutting. Residents of the largest cities actually have lower prevalence of respiratory conditions than any other population group.

Another way of interpreting these results is to conclude that neither population nor broad occupational categories adequately capture the effects of urbanization and industrialization during this period. A clear direction in future research is to conduct more city-specific analyses of respiratory disease. The development of estimates of air quality (as proxied by type and amount of coal consumption) and estimates of differences in the industrial mix of different cities may prove very fruitful. Similarly, more detailed analysis of respiratory disease among farmers might include incorporation of the geographical variation in climate, the types of crops grown in different areas, and trends in agricultural methods.[29] Agricultural differences may explain some of the strong regional effects that have been detected here.

As far as occupational classification goes, much more detail can be incorporated from the present data to study occupational health more generally, with respiratory health a particular focus. It is highly plausible that the lack of significant occupational variation in respiratory disease reflects not the lack of importance of occupation, but instead, the ubiquity of respiratory disease agents across a wide swath of occupations.

The strongest predictors of respiratory disease in this study are, perhaps surprisingly, the presence of respiratory diseases during the Civil War.[30] They had consistently stronger effects on respiratory health later in life than

29. Consumption of commercial fertilizer, for instance, increased from 164,000 tons in 1860 to 2,730,000 tons in 1900 (U.S. Bureau of the Census 1976).

30. Costa (2000), who examined a narrower set of respiratory indicators, also found strong effects of wartime infectious disease.

any other variable in the analysis (although, it should be noted, the overall fit of the probit equations is low). These results indicate the importance of looking at respiratory health in a life-cycle context. Although the data employed here have significant shortcomings, they are advantageous in that they contain data over the course of life—a feature that is frequently missing from modern data sets.

Although the patterns presented here are puzzling in many respects, it bears repeating that the estimates reported are for *prevalence.* A given prevalence rate can be consistent with a variety of incidence and mortality trends. Indeed, the uncertain impact of differential mortality across demographic subgroups is an example of the fact that this analysis raises far more questions than it answers. While there are some inherent data constraints, such as a lack of air quality measures, there is still an abundance of data in the massive Aging Veterans of the Union Army (AVUA) collection that remains to be exploited. The wartime disease variables suggest the importance of incorporating additional disease history in order to understand the etiology of respiratory disease. Clearly a next step is a detailed longitudinal analysis of all these potential risk factors for respiratory illness. The classifications of respiratory disease developed here should provide a useful starting point in this endeavor.

The results presented here will hopefully spur further research investigating the epidemiology of chronic illness during this critical time in American history. Recent research has highlighted the decline in chronic illnesses over the twentieth century. This study suggests that, at least in the case of respiratory disease, any decline in age-specific prevalence rates must have begun to occur some time after 1910, since the evidence presented here suggests a sharp rise in the years prior to 1910. Fogel's work in recent decades has emphasized the secular improvements in health over recent centuries. This study suggests the importance of reference points when making these long-term comparisons. Previous research on the decline in chronic illness over the past century has typically used 1910 as a reference point.[31] In the case of respiratory disease, the reported declines would be much more modest if an earlier reference point, say 1895 or 1900, had been used rather than 1910. And given the trends in smoking, urbanization, and industrialization discussed earlier, it is likely that the cohorts coming of age after the Civil War would have experienced even higher incidence and prevalence of respiratory disease than that experienced by the Union Army cohort in the 1895 to 1910 period.

At the very least, the research presented here reflects both the challenges and the importance of understanding the relationship between economic development and health. Respiratory disease, in both acute and chronic forms, remains a significant public health concern today. The past decade has seen a sharp rise in the prevalence of asthma, and epidemiological research has linked even minute particulates in the air to respiratory disease, causing a vigorous public debate over the Environmental Protection Agency's air pollution standards concerning fine particulates. Furthermore, researchers have still not completely disentangled the effects of smoking from the numerous social, economic, and environmental factors which also can lead to respiratory disease. Further investigation of respiratory illness in this dynamic period of American economic history promises to illuminate the relationships between health and economic activity.

31. See Fogel and Costa (1997), for example.

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7

The Significance of Lead Water Mains in American Cities
Some Historical Evidence

Werner Troesken and Patricia E. Beeson

7.1 Introduction

By the turn of the twentieth century, cities throughout the United States were using lead service mains to distribute water. For example, in 1900 the nation's five largest cities—New York, Chicago, Philadelphia, Saint Louis, and Boston—all used lead services to varying degrees (Baker 1897, 42, 89, 170, 373, 501). Despite the fact that many of these mains are still in use and that up to 20 percent of all lead exposure in young children comes from drinking water, the significance of lead service mains is poorly understood and there exists little scientific evidence that would allow us to precisely measure their effects on human health (U.S. Environmental Protection Agency 2000).

The dearth of information and scientific study on lead services is unfortunate. It is well known that ingesting even small amounts of lead can adversely affect health and mental development, particularly among children (Needleman and Belinger 1991). Moreover, the Centers for Disease Control (1997) estimate that as many as 5 percent of all American children suffer from subclinical lead poisoning. There are, as a result, numerous studies exploring the health effects of exposure to lead through soil (Xintaras 1992), paint and house dust (Lanphear and Rogham 1997), industrial pollution (Trepka et al. 1997), leaded gasoline (Charney, Sayre, and Coulter 1980), and work environments (Sata et al. 1998). The importance of lead dissolved

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