Objectives: To estimate the prevalence of major eye diseases and low vision or blindness in a national sample of male US Union Army veterans from 1890 to 1910 and to compare these prevalence rates with contemporary rates for the same diseases and visual status.

Design: Longitudinal histories of 16,022 white Union Army veterans receiving disability pensions from 1890 to 1910 were developed from pension board examination records. Prevalence rates of trachoma, corneal opacities, cataract, diseases of the retina and optic nerve, and low vision or blindness were calculated in 1895 and 1910. Changes in prevalence by age were examined.

Results: By 1910, 11.9% of veterans had low vision or were blind in both eyes. Prevalence of cataract increased with age, resulting in 13.1% of veterans having had cataract in one or both eyes. Rates of trachoma were 3.2% in 1895 and 4.8% in 1910. Rates of corneal opacity were 3.0% and 5.1%, respectively. Glaucoma was rarely diagnosed from 1890 to 1910, but diseases of the optic nerve were reported in 2.0% of veterans in 1895 and 3.6% in 1910.

Conclusions: This study documents substantial reductions in the prevalence of low vision or blindness and changes in the composition of eye diseases from an era in which there were few effective therapies for eye diseases to the present.

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tion); therefore there were multiple medical records for some veterans. Surgeons’ certificates data were classified by the Center for Population Economics into 21 (primarily) organ system–based health screenings.

The total surgeons’ certificates sample includes 87 224 examinations of 17 721 veterans. The veterans sample was reduced to 16 022 because of missing information on birth or death dates. Once a veteran’s condition was diagnosed, we assumed that the veteran had that condition until death. In any year, the number of veterans in the sample was well below 16 022, because either the veteran had not yet been examined or had died by then. Our analysis focused on 1895 and 1910. The year 1895 was long enough after the statutory change of 1890 that allowed many veterans with non–service-related disabilities to be examined and added to the pension roles. By 1910, 3 years had passed since the statutory change of 1907, an eligibility expansion that classified old age (≥ 62 years) as a disability. Also, by 1910, most surviving veterans were aged 65 years or older. The death rate was high enough that sample sizes were too small to calculate reliable estimates of prevalence a decade or a decade and a half later.

We identified veterans with a visual disability who had diagnosed amblyopia or blindness in both eyes. We examined 5 categories of eye disease: trachoma, corneal opacity, cataract, disease of the retina, and disease of the optic nerve. Trachoma, corneal opacity, and cataract were all easily identified then by basic visual inspection. All were well-known causes of blindness and were considered when determining cause of impairment. Diseases of the retina and of the optic nerve, rather than being specific diagnoses, refer to findings from an examination with an ophthalmoscope. Ophthalmoscopes were reasonably well distributed by the 1890s.

Trachoma was identified by searching responses for trachoma within a category dealing with the conjunctiva. We identified cases of corneal opacity by searching for items pertaining to the cornea. Cataract was identified from variables for cataract and cataract extraction and was indicated as specific to the left, right, or both eyes. Diseases of the retina and optic nerve were identified by codes for infection or inflammation of the eye. Few cases were explicitly classified as glaucoma, but glaucoma was also plausibly included in a separate category, diseases of the optic nerve. We included both in the category disease of the optic nerve.

The sample increased by 50% between 1890 and 1895 (Table 1), reflecting the increase in veterans obtaining examinations after the statutory change in pension law in 1890. In 1895, of the 12 144 veterans in the sample, 84.8% were aged younger than 65 years. By 1910, of the 7782 remaining veterans in the sample, only 17.8% were aged younger than 65 years. Most veterans were aged 65 through 74 years in 1910 (66.2%).

Cataract was by far the most common of the study diseases, with prevalence ranging from 4.5% for those younger than 55 years to 15.6% for those aged 75 years and older in 1895 (Table 2). In 1910, prevalence of cataract among those aged 75 years and older had risen to 17.1%. For those aged 65 through 74 years, prevalence of cataract was 8.4% in 1895 and 13.0% in 1910. Corneal opacity affected 3.8% and 4.8% of this age group in 1895 and 1910, respectively. Prevalence of trachoma was similar; that for diseases of the retina and optic nerve was much lower, ranging from just under 1% to 2% in 1895.

Prevalence of diseases of the retina increased between 1895 and 1910, even on an age-adjusted basis, possibly reflecting better detection in the latter year. However, in data for either year, rates of documented retinal disease did not increase with age, as is now typical in elderly populations. Prevalence of disease of the optic nerve did not change appreciably between 1895 and 1910 on an age-adjusted basis, and the patterns of prevalence rates with respect to age are irregular in both years.

In 1895 and 1910, respectively, 7.1% and 11.9% of the white male veteran population had low vision or blindness. The prevalence of low vision/blindness increased substantially with age. In 1895, 6.0% of veterans younger than 55 years and 11.0% aged 75 years or older had this diagnosis. In 1910, 14.1% of veterans aged 75 years or older were recorded as having low vision or being blind in both eyes. Of those veterans with low vision or blindness, most had diagnosed cataract (Table 3). Corneal opacity and trachoma were present in one-quarter or more of these individuals. Diseases of the retina and optic nerve were documented in 13% to 15% and 8% to 10% of these cases, respectively.

Several major eye diseases and low vision/blindness were highly prevalent at the turn of the 20th century. Prevalence of some major eye diseases, especially cataract, increased substantially with age.

Owing to increased longevity and improved medical knowledge and diagnostic techniques, reported prevalence increased for many eye diseases. Current rates of cataract surgery, a reasonable proxy for cataract prevalence in high-income countries, are well above those for cataract and cataract surgery combined in the Union Army data, especially for populations aged 70 years or older. Data from populations aged 65 years or older in the 1990s indicate a prevalence rate of about 5% for age-related macular degeneration, about 7% for diabetic retinopathy, and close to 8% for glaucoma. The combined rates of 5% and 7% for the retinal diseases are far above the corresponding rates in the Union Army data (considering joint prevalence of both diseases), even allowing for a somewhat higher mean age of the more recent population. Diabetes prevalence among white veterans in 1895 was about 2% and was about 4% in 1910. Judging from recent data, far fewer than half of veterans

### Table 1. Age Distribution of a Sample of US Civil War Veterans for 1895 and 1910

<table>
<thead>
<tr>
<th>Age, y</th>
<th>1895 (n=12 144)</th>
<th>1910 (n=7782)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 55</td>
<td>47.4</td>
<td>0.1</td>
</tr>
<tr>
<td>55-64</td>
<td>37.4</td>
<td>17.7</td>
</tr>
<tr>
<td>65-74</td>
<td>13.2</td>
<td>66.2</td>
</tr>
<tr>
<td>≥ 75</td>
<td>1.9</td>
<td>16.0</td>
</tr>
</tbody>
</table>

*a Samples in other years: 1890 (n=8020); 1891 (n=8693); 1900 (n=11 291); and 1905 (n=9849).
with diagnosed diabetes would have had retinal disease (≤ 1% in 1895 and ≤ 2% in 1910). Urinalysis was used during this period to diagnose diabetes. Recent prevalence of glaucoma is also much higher than the rates diagnosed in the Union Army veteran population, even accounting for some differences in age between the comparison and Union Army data.

However, trachoma, which was highly prevalent in the United States around 1900, is now virtually nonexistent in the developed world, which is largely a result of better sanitation, improved personal hygiene, and antibiotics. The disease now exists almost exclusively in low-income countries, where sanitation and hygiene may be more like that of the United States in the early 20th century. According to the World Health Organization, prevalence of blindness in Africa among individuals aged 50 years or older was 9% in 2002. In Southeast Asia, including Indonesia, Malaysia, the Philippines, and Thailand, prevalence in 2002 was 6.3%. Combined prevalence of blindness and low vision (best-corrected visual acuity ≤ 20/60 OU and > 20/200 OU) among adults in Pakistan and Bangladesh is around 10%. Rates for persons aged 60 to 69 years have been reported at 13% in Malaysia and 8% in Nepal.

Access to affordable, safe, and effective cataract surgery is of primary importance in decreasing prevalence of blindness in the developed world. Cataract is the leading cause of blindness globally, accounting for 47.8% of adult-onset blindness. The EDPRG estimated that among white Americans, cataract caused less than 9% of blindness, even though the US population is proportionally much older than the world as a whole; 7.4% of the global population is aged 65 years or older compared with more than 12% of the US population.

Causes of low vision or blindness cannot be ascertained from the Union Army data; however, prevalence of eye diseases among those with low vision or blindness provide an approximation. These data assign a major role to cataract as causing low vision or blindness. Even with better technology, contemporary estimates of the causes of the 2 conditions in the United States differ appreciably. Acc-

### Table 2. Prevalence of Major Eye Disease Among US Civil War Veterans in 1895 and 1910 by Age

<table>
<thead>
<tr>
<th>Disease</th>
<th>1895 (n=5753)</th>
<th>1910 (n=1378)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trachoma</td>
<td>2.2 (55 y)</td>
<td>4.3 (55-64 y)</td>
</tr>
<tr>
<td>Corneal opacity</td>
<td>2.7 (65-74 y)</td>
<td>3.4 (65-74 y)</td>
</tr>
<tr>
<td>Cataract</td>
<td>4.5 (75 y)</td>
<td>10.0 (75 y)</td>
</tr>
<tr>
<td>Disease of retina</td>
<td>1.9 (n=1604)</td>
<td>3.8 (n=1604)</td>
</tr>
<tr>
<td>Disease of optic nerve</td>
<td>0.8 (n=1604)</td>
<td>1.0 (n=1604)</td>
</tr>
<tr>
<td>Low vision/blindness</td>
<td>6.0 (n=1604)</td>
<td>9.7 (n=1604)</td>
</tr>
</tbody>
</table>

* Seven persons had reported birthdates of 1856 or later. These birthdates are implausible; these persons were excluded from this table.

### Table 3. Prevalence of Major Eye Diseases Among US Civil War Veterans With Low Vision/Blindness

<table>
<thead>
<tr>
<th>Year</th>
<th>No. of Veterans</th>
<th>Veterans With Low Vision/Blindness, %</th>
<th>Disease Prevalence in Veterans With Low Vision/Blindness, %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Trachoma</td>
</tr>
<tr>
<td>1890</td>
<td>8020</td>
<td>5.4</td>
<td>31.0</td>
</tr>
<tr>
<td>1891</td>
<td>8693</td>
<td>7.5</td>
<td>27.6</td>
</tr>
<tr>
<td>1895</td>
<td>12144</td>
<td>7.1</td>
<td>23.8</td>
</tr>
<tr>
<td>1900</td>
<td>11291</td>
<td>9.4</td>
<td>24.5</td>
</tr>
<tr>
<td>1905</td>
<td>9849</td>
<td>11.6</td>
<td>24.1</td>
</tr>
<tr>
<td>1910a</td>
<td>7782</td>
<td>11.9</td>
<td>24.8</td>
</tr>
</tbody>
</table>

* Includes the 7 persons with birthdates of 1856 or later excluded from Table 2.
According to EDPRG’s meta-analysis, cataract, for example, accounts for 59.9% of low vision and only 8.7% of blindness among white Americans. Rates are 3.3% and 6.4% for glaucoma and 22.9% and 54.4% for age-related macular degeneration among white individuals with low vision and blindness, respectively.23 Age-related macular degeneration’s prominence in the EDPRG meta-analysis relative to that in the Union Army data (even considering that some diabetic retinopathy would have also been included in diseases of the retina) primarily reflects current knowledge compared with that of a century ago as well as the higher fraction of younger elderly in the veterans’ analysis.

Unlike cataract, age-related macular degeneration, and glaucoma, corneal opacities were much more common among those with low vision or blindness in the Union Army sample compared with contemporary populations in both the United States or low-income countries. Corneal opacities accounted for 3% of blindness in the United States and 8% to 12% of blindness in Africa in 2002.24 Higher prevalence of trachoma, the most important infectious cause of corneal opacity,33 cannot fully explain this effect. While rates of trachoma in Africa (6%-8%)24 are higher than those in our data, the reported effect of corneal opacity on vision is substantially lower. Corneal scarring from war-related trauma is the likeliest explanation for the high rates of corneal opacity among those with visual impairments in the veterans’ sample. This explanation is supported by the decline in the prevalence of corneal opacity among those with serious visual impairment as the sample aged and other eye diseases become more common.

A strength of the veterans data is that they are fairly representative of middle-aged and elderly white men who were alive around 1900. About half of adult white men in the North fought in the Civil War.35 Many men whose poor health precluded fighting in the Civil War, owing to, eg, congenital heart disease, probably did not survive to 1895. The pension program covered 85% of all Union Army veterans by 1900 and more than 90% by 1910.4,5 Because of the pension program covered 85% of all Union Army veterans by 1900 and more than 90% by 1910.4,5 Because of the relaxation of regulations in 1890 that allowed pensions to be granted to almost all veterans older than 65 years and the formalization of this policy in 1907, there was a substantial incentive for even veterans without disabilities to apply for pensions. Fogel36 conducted analyses comparing the examined soldiers with other men of this period, concluding that the veterans sample was representative of the Northern white male population according to geographic distribution, wealth, and cause of death.

We acknowledge several study limitations. Our data only pertain to adult white men and exclude men in states not held by the Union Army until the end of the Civil War. Second, methods of diagnosing and classifying disease and depth of understanding of disease processes differed substantially between the beginning and the end of the 20th century. Diagnostic techniques around 1900 were very limited, the field of ophthalmology was comparatively young, and the physicians performing the examinations were not likely to be familiar with any ocular pathologies besides the very most common. Consequently, misdiagnosis and underdiagnosis were likely to have been more common relative to more recent data. For example, around 1900, the presence of cataracts was typically based on observing a “white pupil” rather than by methods used more recently. Vision loss at the time of cataract surgery today is comparatively mild. Thus, using contemporary criteria, prevalence of cataract in 1895 and 1910 reported in our study is likely to be understated.

However, visual and functional status was observable. Graeff,37 in his book Das Menschliche Auge published in 1933, urged those rating severe visual impairment and blindness to classify them based on the conditions’ effects on patients’ ability to function in their usual activities.

Classification, terminology, and knowledge of disease processes also differed. For example, the 1898 English edition of Fuchs’ Text-Book of Ophthalmology,38 a widely respected reference at the time, defines amblyopia as weak sight or low vision that cannot be corrected by eyeglasses. Similar definitions are found in Alt’s 1884 A Treatise on Ophthalmology for the General Practitioner39 and Higges’ 1888 Ophthalmic Practice.40 Complete blindness is referred to in these 3 texts as amaurosis. Our analysis considered a diagnosis of amblyopia in both eyes as functional blindness.

There is good support for supposing that a diagnosis of amblyopia, as the term was used then, was associated with severe functional impairment. Wood,41 writing on the army pension program, stated that “No pension is given for a partial loss of sight or for the partial or complete loss of the field of vision or the muscular functions of the eyes.” Graeff,37 writing more than 3 decades after Fuchs,38 Alt,39 and Higges,40 characterized amblyopia as a historical scientific term for severe visual impairment. He argued that if the criterion of amaurosis had been strictly applied as a basis for admission, 80% to 90% of all residents of institutions for the blind would have been there inappropriately.

Glaucoma provides an example of the lack of understanding of disease processes in the early 20th century. The term glaucoma appeared in ophthalmologic reference books of the period, and it was one of the listed diagnoses the board of surgeons could apply following their examinations of pension applicants; but the consequences of glaucoma were not understood then. There are 2 chief reasons for the rarity of reported glaucoma: (1) The disease was thought to be very uncommon and (2) the relationship between glaucoma and the optic nerve was not well understood. Fuchs40 wrote in 1898 that glaucoma accounted for less than 1% of all eye diseases. In 1900, Deyl and Sattlers42 chapter “Diseases of the Optic Nerve” in Norris and Oliver’s System of Diseases of the Eye made no reference to glaucoma, though some connection with the optic disc was mentioned in Smith’s43 chapter on glaucoma in the same volume. Fuchs40 identified excavation of the optic nerve as the cause of blindness in advanced glaucoma but went no further. Both Alt39 and Higges40 discussed glaucoma and the optic nerve separately. However, by the time Graeff’s37 text was published in 1933, examination of the optic nerve was used to diagnose glaucoma. Although tonometers existed in the late 1800s,44 in our data, there were more findings of disease of the optic nerve than there were of diagnoses labeled glaucoma. Thus, in our analysis, the latter was combined with the former group.

This study documents substantial reductions in the prevalence of low vision/blindness and changes in the composition of eye diseases from an era in which there were few effective therapies for eye diseases to the present.
Comparisons of major eye diseases over the course of 100 years reveal substantial improvements in visual function. The appreciable reductions in the prevalence of low vision/blindness reflect such technological changes as innovations in the treatment of cataract and glaucoma and economic growth, which provided funds for developing capacity and financing provision of services. Other improvements, such as a reduction in the prevalence of trachoma, reflect improvements in environmental and public health, which is largely a byproduct of a country’s level of economic development.

The burden of chronic eye disease is substantial3,4 and is reflected by (1) the resources devoted to its diagnosis and treatment and (2) the losses in productivity and quality of life it can cause. Both are important components of the total burden. Around 1900, when therapeutic options were limited, the burden of such disease and disability was largely borne outside the health care system. But nevertheless, particularly as reflected in high rates of low vision/blindness, this burden was substantial and much greater than is now.

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REFERENCES

19. Bejiga A, Almekaye W. Prevalence of trachoma and its determinants in Dalo- choma, reflect improvements in environmental and public health, which is largely a byproduct of a country’s level of economic development.

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