

## Historical declines in tuberculosis in England and Wales: improving social conditions or natural selection?

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### SUMMARY

**OBJECTIVES:** A reinvestigation of the relationship between the decline of tuberculosis and improvement in social conditions in England and Wales during Victorian times.

**DESIGN:** A retrospective study using data published in the annual reports of the Registrar General from 1853 to 1910.

**MEASURES ASSESSED:** The diseases studied, in addition to tuberculosis were dysentery and cholera, including their total and infant mortality. Social conditions were evaluated from earnings and population density per house.

**RESULTS:** Tuberculosis mortality declined at an annual average rate of 1.71% (95% confidence interval [CI]

0.77–2.63), whereas total mortality, infant mortality and mortality from cholera and dysentery and house population density showed no statistically significant decline over the same period. Real earnings increased by 1.05% (95% CI 0.29–1.81).

**CONCLUSION:** Improving social conditions do not provide the total explanation for the decline in tuberculosis during Victorian times. Other factors, principally natural selection, probably played a role. Part of the current increase in tuberculosis may be caused by effective drug therapy eliminating natural selection.

**KEY WORDS:** tuberculosis; mortality; social conditions; historical

WITH THE EXCEPTION of the years during the World Wars, mortality from tuberculosis has steadily declined since records began in 1850. Because of the close association between tuberculosis, poverty and crowding, an association still found to be present today, most observers assumed that improving social conditions alone were responsible for improved mortality, an improvement that continued up to the time specific chemotherapy and immunisation became available in the 1950s.<sup>1–4</sup>

However, the possible effects of immunity acquired by successive generations in a process of natural selection, and selective mortality of susceptible individuals or families on the pattern of disease, are generally overlooked in studies of historical tuberculosis rates.<sup>5</sup> (D'Arcy Hart, personal communication).

If natural selection had played a part in the improvement of tuberculosis mortality before chemotherapy, the current increase in tuberculosis being ex-

perienced by many countries<sup>6–8</sup> may be partially due to the absence of natural selection caused by the new and beneficial chemotherapy era.

The aim of this study is to reinvestigate the association between changes in mortality from tuberculosis on the one hand, and mortality from other poverty-related diseases and socio-economic conditions and measures in Victorian England on the other.

### METHODS

Mortality statistics for England and Wales from 1853 to 1910, after which date World War I disrupted the steady downward trend, were obtained from the Registrar Generals Annual Reports.<sup>9</sup> These publications include data on tuberculosis, cholera and dysentery. Infant mortality and total mortality rates were taken from the same source. Data on other diseases over the same period of time were not as complete.

Socio-economic measures for the same period were also obtained from the Registrar General's Reports. Measures of overcrowding were calculated using the decennial census data from statistics on the number of habitable houses and the size of the resident popu-

**Editor's note:** Dr Davies and colleagues present an analysis of tuberculosis morbidity and mortality data which suggests a biological component to the declining TB rates independent of socio-economic factors. We hope it will provoke on-going efforts at distinguishing the various elements that influence tuberculosis epidemiology.

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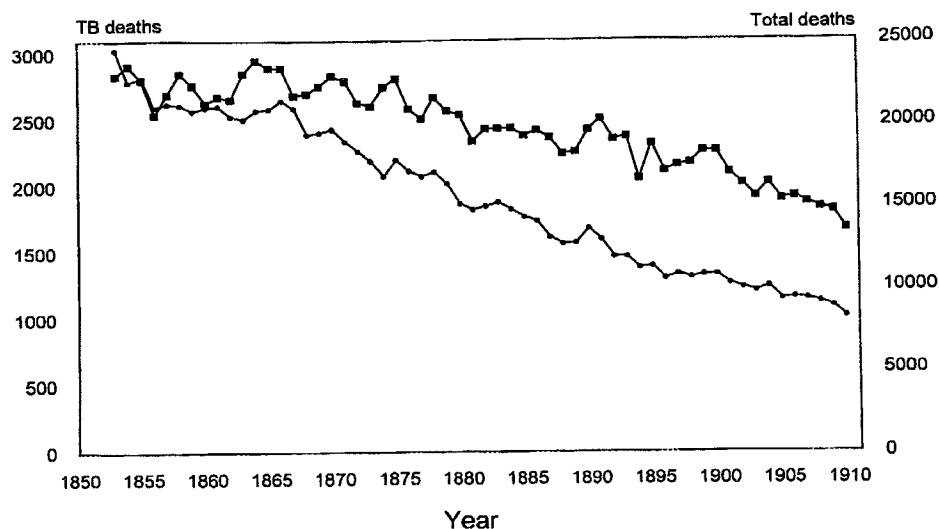


Figure 1 Death rates for tuberculosis per million per annum, left hand scale (●), and all causes per million, right hand scale (■), for England and Wales.

lation. Statistics on average real earnings, also available from the Reports, were used.

The rates of change of each of these variables were calculated as the average percentage change per year, and are given together with the 95% confidence intervals (95%CI).

## RESULTS

The crude annual death rates for both sexes, for all causes and age groups combined, and for tuberculosis for all age groups and both sexes combined are shown in Figure 1. The mean annual change for each measure is shown in the Table. Total mortality rates declined by 0.80 per year (95%CI -2.13 to 0.54), whereas tuberculosis mortality declined by 1.71 (95%CI -2.63 to -0.77). The average annual decline for tuberculosis was therefore twice that for all causes. In fact decline in mortality for all causes, calculated on an annual basis, did not achieve statistical significance.

Infant mortality, which might be expected to be a closer indicator of improvement in social deprivation

than mortality for all age groups combined, declined even more slowly, by 0.58 per year (95%CI -2.62 to 1.15), again not achieving statistical significance (Figure 2 and Table). Secondly, whereas tuberculosis deaths showed a steadily improving trend over the 60 years studied, infant mortality apparently only improved from approximately 1900.

Dysentery mortality fluctuated widely, and showed no evidence of decline at all during the period. In fact there was a marginal increase of 0.009 (95%CI -38.9 to 38.9, Table). Fluctuations were marked, as the disease tended to occur in epidemics. Cholera mortality decline was present, but fluctuations were also marked and statistical significance in decline was not achieved (-1.07; 95%CI -14.1 to 11.95, Figure 2, Table).

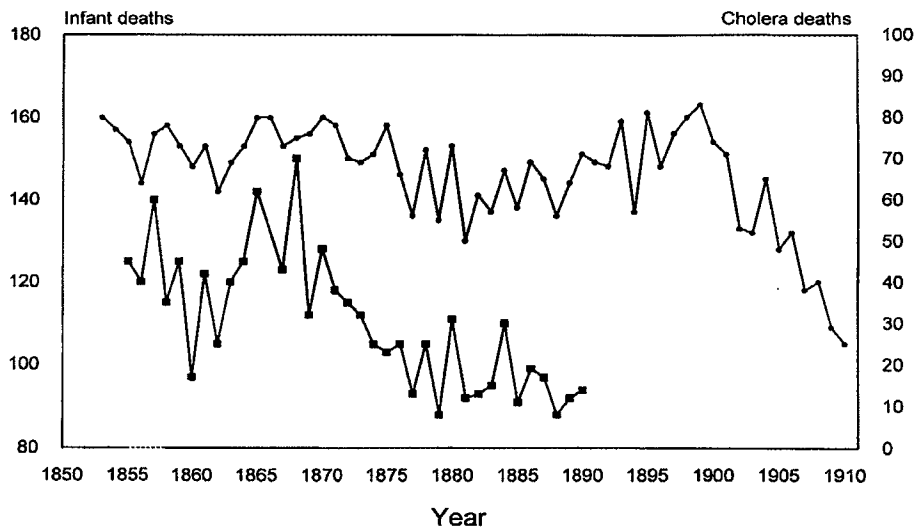
Overcrowding showed a trend towards improvement (-0.05; 95%CI -0.41 to 0.03), but surprisingly did not achieve statistical significance on an annualised basis. Real earnings were the only factor studied, other than tuberculosis, to show a statistically significant change over the period, rising by an average annual rate of 1.05 (95%CI 0.29 to 1.81, Table). This was in contrast to a decline in tuberculosis mortality of 1.71 per year. The decline in tuberculosis mortality exceeded by 63% the increase in real earnings on an annual basis.

Table Relative changes of death rates and socio-economic factors

	Mean change/year	95%CI
Total mortality	-0.80%	-2.13-0.54
Infant mortality	-0.58%	-2.62-1.15
Tuberculosis mortality	-1.71%	-2.63--0.77
Cholera mortality	-1.07%	-14.1-11.95
Dysentery mortality	0.009	-38.9-38.9
Real earnings	1.05%	0.29-1.81
Overcrowding	-0.05%	-0.41-0.30

## DISCUSSION

The study has shown that tuberculosis mortality declined at a very much faster rate than any indicator of social deprivation improved for the period 1853 to 1910. In particular, mortality rates, both for infants and all age groups, declined by less than half the tuberculosis mortality rates. It is therefore unlikely that so-



**Figure 2** Death rates for infants per 1000 live births, left hand scale (●), and cholera (■) per million, right hand scale.

cial improvements alone were responsible for the remarkably steady decline in tuberculosis mortality.

Other diseases thought to be poverty related, such as diphtheria and cholera, showed no similar decline. Simple measures of social improvements such as overcrowding showed no relationship to tuberculosis mortality improvement. Though real earnings were one factor that did show steady improvement, the average annual improvement was considerably less, by approximately two thirds, than the rate of the decline in tuberculosis mortality.

Had the mortality of tuberculosis been closely related to poverty during this period, the steady improvement of 1.71% a year, which showed a remarkable consistency (Figure 1), would have been most unlikely to have occurred. That tuberculosis is associated with poverty there can be no doubt, as both early and later studies have shown.<sup>1,3,4,10</sup> What this study has shown is that the decline in tuberculosis mortality far exceeded improvements in social conditions and other disease markers of poverty over the period studied. Some other factors are likely therefore to have been playing a part, of which the most important is probably the process of natural selection.

Historical studies have shown that in any age cohort tuberculosis rates are highest in the young adult group.<sup>11</sup> Individuals susceptible to tuberculosis are therefore most likely to develop disease around the child bearing and child rearing age. Morbidity and mortality due to tuberculosis at this time of life would therefore tend to restrict the number of children born to sufferers, or by depriving children of their parents in infancy and early childhood lead to greater mortality in children of tuberculosis sufferers. In either event, fewer children of tuberculosis sufferers would reach child bearing age than those of parents who remained

free from disease. Thus a process of reduced fertility of tuberculosis-susceptible families would occur, leaving those that were naturally resistant to produce children.

If this were the case, then the introduction of chemotherapy in industrialised countries over the past 50 years might well have resulted in the natural selection process being removed so that a new generation of children with a higher proportion of susceptible individuals, perhaps possessing a phenotype with a weaker ability to acquire immunity, would have been born. Tuberculosis rates might then cease declining, or even increase in younger age groups exposed to infection. The fact that tuberculosis rates have shown no decline among the white population of England and Wales between the national notification surveys carried out in 1988 and 1993,<sup>12,13</sup> either for all ages combined, or more significantly in males aged 15–24 years, lends some support to this theory.

The concept that natural selection might have had a major part to play in the decline of tuberculosis during Victorian times, and that its absence due to chemotherapy is currently contributing to the present increase, is essentially a hypothesis of default, as the data shown here suggest that improvement of social conditions alone was not sufficient to account for the decline in tuberculosis mortality.

Previous researchers investigating the decline of tuberculosis in England during Victorian times have tended to dismiss natural selection in favour of other theories such as improved nutrition or isolation of cases in workhouses.<sup>14,15</sup> Although data are not complete on these aspects of social improvement, there is no doubt that social improvement varied widely in England over the 60 years studied, in both time and place. None of these theories can fully explain such a steady decline in tuberculosis.

The fact that a hypothesis of natural selection is sustainable on the present evidence reinforces the need to continue protection of uninfected individuals by BCG until tuberculosis poses far less of a threat internationally than it does now.<sup>16</sup>

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#### RÉSUMÉ

**OBJECTIFS :** Réinvestigation des relations entre le déclin de la tuberculose et l'amélioration des conditions sociales en Angleterre et au Pays de Galles à la période victorienne.

**SCHEMA :** Etude rétrospective utilisant des données publiées dans les rapports annuels du conservateur des Actes de l'Etat Civil entre 1853 et 1910.

**DONNEES EVALUEES :** Les maladies étudiées comportaient, outre la tuberculose, la dysenterie et le choléra, y compris leur mortalité totale et celle concernant le nourrisson. Les conditions sociales ont été appréciées à partir des salaires et de la densité de population par habitation.

**RÉSULTATS :** La mortalité par tuberculose a décliné à un taux moyen annuel de 1,71% (IC 95% 0,77 à 2,63)

alors que la mortalité totale, la mortalité des nourrissons et la mortalité par choléra et dysenterie ainsi que la densité de population des habitations n'ont révélé aucun déclin statistiquement significatif pendant la même période. Les salaires réels ont augmenté de 1,05% (IC 0,29 à 1,81).

**CONCLUSION :** L'amélioration des conditions sociales ne fournit pas l'ensemble de l'explication du déclin de la tuberculose pendant la période victorienne. D'autres facteurs, et principalement la sélection naturelle, ont probablement joué un rôle. Une partie de l'augmentation actuelle de la tuberculose peut être causée par l'élimination de la sélection naturelle par suite de l'intervention d'un traitement médicamenteux efficace.

#### RESUMEN

**OBJETIVOS :** Una nueva investigación sobre la relación entre la disminución de la tuberculosis y la mejoría de las condiciones sociales en Inglaterra y Gales durante la era Victoriana.

**MÉTODO :** Un estudio retrospectivo de los datos publicados en el informe anual del Registro General desde 1853 hasta 1910.

**MEDIDAS EVALUADAS :** Las enfermedades estudiadas, además de la tuberculosis, fueron la disentería y el cólera, incluyendo la mortalidad total e infantil. Se evaluaron las condiciones sociales a partir de los ingresos y la densidad de población por cada hogar.

**RESULTADOS :** La mortalidad por tuberculosis disminuyó a un tasa anual promedio de 1,71% (IC 95%

0,77 a 2,63), mientras que la mortalidad total e infantil por cólera y disentería, así como la densidad de la población por cada hogar, no mostraron una disminución estadísticamente significativa en el mismo período. Los ingresos reales aumentaron en 1,05% (IC 95% 0,29 a 1,81).

**CONCLUSIÓN :** La mejoría de las condiciones sociales no explican por sí la declinación de la tuberculosis en la era Victoriana. Otros factores, principalmente la selección natural, desempeñan probablemente un papel. Una parte del actual aumento de la tuberculosis puede ser causada por la terapéutica efectiva con drogas que eliminan la selección natural.