A COMPARATIVE STUDY OF TUBERCULOSIS MORTALITY RATES

By V. H. SPRINGETT, M.D.
Prophit Scholar, Royal College of Physicians of London

(With 20 Figures in the Text)

CONTENTS*

INTRODUCTION

The recorded mortality from tuberculosis has fallen greatly in England and Wales since the middle of the nineteenth century when records were first available. The fall in rate has not occurred uniformly in all age groups however, and one result of this is that the maximum mortality rate in males is now occurring at a much later period of life than formerly.

Brownlee (1917, 1920) made an extensive study of the mortality rates in England and Wales up to that time. He was led to the view that there were three types of phthisis causing peaks of mortality in childhood, young adult life and old age, and that the rates for the three types were not falling equally.

The occurrence of maximum mortality from tuberculosis at an earlier age and with a sharper peak in females than in males may be an innate characteristic of sex which is revealing itself in the mortality curves for England and Wales as environmental conditions improve, and as factors contributing to mortality, but not themselves sex characters, become less important. This would be adequate to explain the observed changes in England and Wales in recent years. One would, however, expect the sex-factor to be universal and that as mortality rates fell to equally low levels in various countries, the same tendency for the male and female peaks to diverge would appear. That this has not occurred in some other countries where rates have reached equally low levels throws doubt on the validity of the explanation.

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Stocks (1949) has recently reviewed the facts concerning the fall in rate in England and Wales. He draws attention to the much slower fall that has occurred in older males in recent years, so that the peak of mortality in males occurred at age 60 years in 1940. He points out that the female rates in 1891–1900 exhibited a peak at age 35–44 years and that the peak of the male curve has gradually moved from young adult life to age 60 years over a period of some 80 years. He attributes the present exceptionally high rate in older men to the fact that they form a group of individuals who have borne the brunt of two world wars.

This explanation of disproportionate strain due to war is adequate to explain the recent experience of England and Wales considered alone. Obviously the shift of the peak of the curve for each sex at the end of the last century cannot be explained in this way, nor did Stocks suggest that it could. Further, it is improbable that wartime influences can be held responsible for the even greater shift that has occurred in the peak of the curve for males of Massachusetts (*v. infra*), whose inhabitants were surely subjected to far less wartime strain. Taking into consideration these facts, it seems probable that wartime strains in England and Wales have exaggerated a tendency that had been operating for many years before 1940, and even before 1914.

Frost (1939) studied the tuberculosis mortality rates for Massachusetts for 10-year age groups of each sex, for every tenth year from 1880 to 1930. He showed that if the rates are plotted against age, the peak of the curve for males has moved to a comparatively late period of life. He then showed that if the rates are plotted for a group of individuals followed throughout life there is a remarkably constant pattern of curve with no shift of the peak from young adult life in either sex. This second method of presenting the results graphically is of fundamental importance; each curve on a graph of this type represents the mortality at various age periods of a group of individuals born in a given period of time, whereas on the conventional method of presentation each curve represents the rates experienced in the groups of various ages in the year under consideration. He stated in correspondence published posthumously that the data for England and Wales showed a similar constant pattern when studied by the same method. The method suggested by Frost does not appear to have been followed up by other workers except Picken (1940), though Frost himself declared his intention of 'getting together material for a somewhat more orderly study later', an intention thwarted by his death shortly afterwards. In the light of his paper, it is proposed to study all available rates by his method as well as on the more usual annual basis. Frost refers to the earlier work of Andvord (1930) on these lines, dealing with the tuberculosis mortality rates for the first 30 years of life in Norway, England and Wales, and Denmark.

Picken (1940) applied Frost's method to the rates for England and Wales for the period 1880–1930. He confirmed Frost's results, but added the observation that the peak of the curve in females had moved back to an earlier period of life on both methods of analysis.

Kermack, McKendrick & McKinlay (1934) examined the mortality rates from all causes combined for Scotland, England and Wales, and Sweden, and found a more constant age distribution in the 'generation' over the age of 15 years than in the annual rates. This led them to the conclusion that the mortality of a group in later life was largely determined by the conditions experienced up to adolescence.

The term 'cohort' is used in this paper in the sense in which it was used by Frost, that is, to indicate the survivors at any age of all persons born in a given year, or group of years. The term 'generation' has a rather different meaning, implying a time relationship with parents and children which is undesirable for the present purpose. While the term 'cohort' is not familiar, it is thought better to use an unfamiliar term which is clearly defined than to use a familiar term in a sense slightly different from that usually accepted.

THEORETICAL CONSIDERATIONS

By definition the age specific death-rate from any cause in a year is given by

$$\frac{\text{Number of deaths from given cause in age group}}{\text{Mid-year population of same age group}} \times 100{,}000.$$

Such rates are usually calculated for 5- or 10-year age groups, and the rates obtained for each age group may be averaged over 5 or 10 successive years provided that the population of the age group remains reasonably constant. By comparing rates for the various age groups in successive periods of time it is possible to observe whether rates for some ages are changing more rapidly than others.

If all age groups share equally in a fall in rate the relative age distribution of mortality is not disturbed; graphically, curves representing the age distribution of mortality will be similar but at lower levels. A fall in rate which is to be shared equally by all ages can occur if each age group of a cohort shows the same relative improvement in rate when compared with the corresponding age group of an earlier cohort. Then after a period of unchanging rates, a group born in one year shows definite improvement on its predecessors to an equal extent at all ages; those born in the next year show further improvement, again equally at all ages throughout their lives, and so on until groups born in successive years show no further change.

The changes due to declines in rate operating in various ways are now to be considered, using hypothetical age distributions of mortality. By using imaginary data and falls in rate conforming strictly to mathematical rules other possible variables are eliminated, and it is possible to study theoretically the characteristics of falls occurring in different ways on various patterns of mortality curve. The results obtained in this section are accordingly not confined to any one cause of death, and may be applicable to mortality rates from causes other than tuberculosis.

In a long period of unchanging rates the cohort and annual age distributions of mortality are the same; in a table, the rows of which are the same, reading diagonally gives the same series of figures as reading along a row.

Fall in rate occurring in equal relative amount at all ages of the same cohort

This type of fall has been briefly described above—after a period of unchanging rates, a group born in a given year shows a lower mortality than its predecessors at each age, while those born in a further year show a further improvement equally at all ages and so on.

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The results of tabulating on an annual basis mortality rates falling in this way may readily be deduced. Again assuming that the fall starts after a period of unchanging mortality, in the first year only the 0–1-year age group will benefit; in the second year the 0–1-year age group will show further improvement while the 1–2-year group will benefit to the same extent as the 0–1-year group did in the first year. The argument may be extended indefinitely; after 10 years the 0–1-year group will show most improvement, the 1–2-year group a little less improvement and so on to the 9–10-year group which will show only the improvement that the 0–1-year group showed in the first year of falling rates.

If in some subsequent cohort the fall is arrested, then the arrest of the fall will first become apparent in the youngest age groups on an annual basis, and only in later years become obvious in older age groups. The fall will continue in older age groups at a time when no further improvement is occurring at younger ages. Ultimately, however, when all ages have shown full benefit from the fall the relative age distribution of mortality will be that obtaining originally.

The characteristics of such a fall recorded on the usual annual basis are, then, that the relative age distribution of mortality is disturbed while the fall is occurring, but that the final distribution is the same as that obtaining originally. The first of these characteristics, a disturbance of the relative age distribution of mortality during the period of falling rates, may also be produced by a fall in rate occurring to a greater extent at some ages than others.

Some numerical examples of falls in rate occurring equally at all ages of cohorts are now given, so that the effects on graphical presentation may be studied. Three types of curve are considered—one rising steadily with age, one with a sharp peak and one with a rounded peak or plateau type. In each case it is assumed that there has been a period of unchanging rates before the fall began, and after it is complete. The imaginary 'mortality rates' in the first lines of Tables 1–4 are derived from successive terms of mathematical series.

Table 1. *Imaginary data. Mortality rates which increase with age undergoing a fall in rate of 20 % in each of three cohorts born at 10-year intervals*

Calendar year	Age (years) 0–	5–	15–	25–	35–	45–	55–	65–	75–
1901	**9**	18	35	64	109	171	248	329	400
1911	7	**18**	35	64	109	171	248	329	400
1921	6	14	**35**	64	109	171	248	329	400
1931	5	11	28	**64**	109	171	248	329	400
1941	5	9	23	51	**109**	171	248	329	400
1951	5	9	18	41	87	**171**	248	329	400
1961	5	9	18	33	70	137	**248**	329	400
1971	5	9	18	33	56	109	198	**329**	400
1981	5	9	18	33	56	87	159	263	**400**
1991	5	9	18	33	56	87	127	211	310
2001	5	9	18	33	56	87	127	169	256
2011	5	9	18	33	56	87	127	169	205

The rates for the cohort age 25–34 years in 1931 are in heavy type.

Table 2. *Imaginary data. Mortality rates which fall sharply from maximum rate in young adult life undergoing a fall in rate of* 20 % *in each of three cohorts born at* 10-*year intervals*

Calendar year	Age (years)								
	0–	5–	15–	25–	35–	45–	55–	65–	75–
1901	**202**	450	475	317	150	53	15	3	0
1911	162	**450**	475	317	150	53	15	3	0
1921	130	360	**475**	317	150	53	15	3	0
1931	104	288	380	**317**	150	53	15	3	0
1941	104	231	304	253	**150**	53	15	3	0
1951	104	231	243	202	120	**53**	15	3	0
1961	104	231	243	162	95	42	**15**	3	0
1971	104	231	243	162	77	34	12	**3**	0
1981	104	231	243	162	77	27	10	3	**0**
1991	104	231	243	162	77	27	8	3	0
2001	104	231	243	162	77	27	8	2	0
2011	104	231	243	162	77	27	8	2	0

The rates for the cohort age 25–34 years in 1931 are in heavy type.

Table 3. *Imaginary data. Mortality rates which fall slowly from a maximum in young adult life undergoing a fall in rate of* 20 % *in each of three cohorts born at* 10-*year intervals*

Calendar year	Age (years)								
	0–	5–	15–	25–	35–	45–	55–	65–	75–
1901	**248**	329	400	440	435	383	296	199	113
1911	198	**329**	400	440	435	383	296	199	113
1921	159	263	**400**	440	435	383	296	199	113
1931	127	211	320	**440**	435	383	296	199	113
1941	127	169	256	352	**435**	383	296	199	113
1951	127	169	205	281	348	**383**	296	199	113
1961	127	169	205	225	278	306	**296**	199	113
1971	127	169	205	225	223	245	237	**199**	113
1981	127	169	205	225	223	196	190	159	**113**
1991	127	169	205	225	223	196	152	127	90
2001	127	169	205	225	223	196	152	102	72
2011	127	169	205	225	223	196	152	102	58

The rates for the cohort age 25–34 years in 1931 are in heavy type.

Table 4. *Imaginary data. Mortality rates which fall slowly from a maximum in young adult life undergoing a fall in rate of* 20 % *in each of three successive* 10-*year periods of time*

Calendar year	Age (years)								
	0–	5–	15–	25–	35–	45–	55–	65–	75–
1901	248	329	400	440	435	383	296	199	113
1911	198	263	320	352	348	306	237	159	90
1921	159	211	256	281	278	245	190	127	72
1931	127	169	205	225	223	196	152	102	58

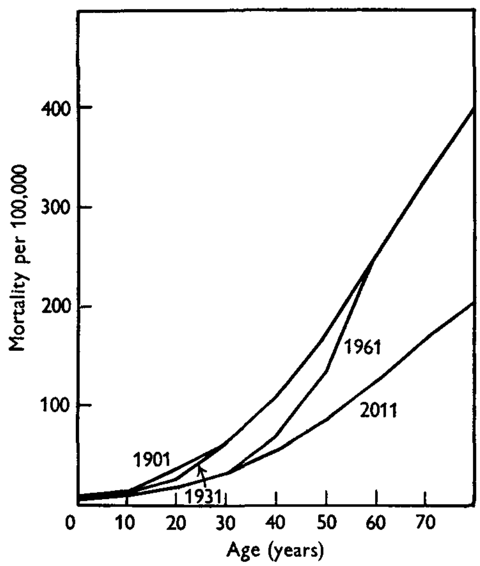

Fig. 1.

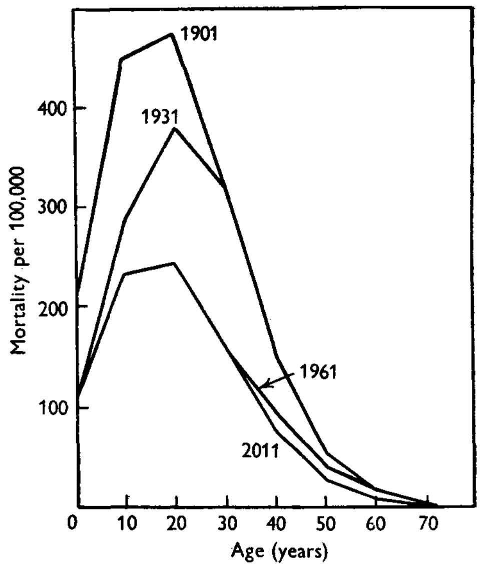

Fig. 2.

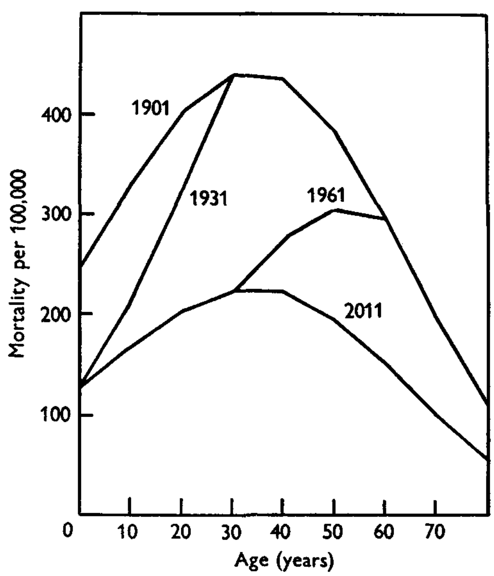

Fig. 3.

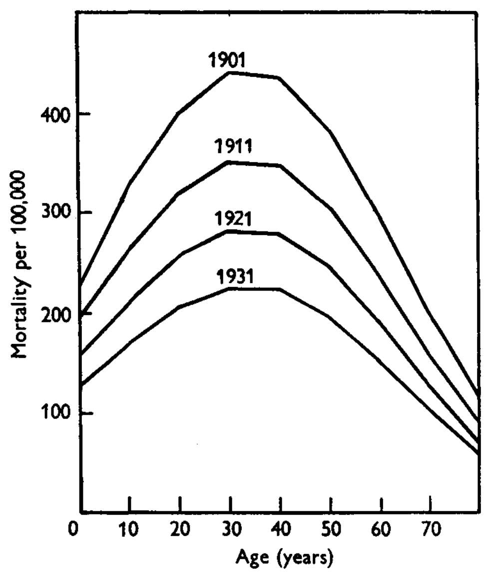

Fig. 4.

Figs. 1–4. The age group 0–5 is plotted at 0, and the remaining age groups are plotted centrally.

Fig. 1. Mortality at various ages before, during and after a fall in rate occurring equally at all ages of cohorts. Imaginary data of Table 1: rates before the fall increase with age.

Fig. 2. Mortality at various ages before, during and after a fall in rate occurring equally at all ages of cohorts. Imaginary data of Table 2: rates before the fall rise to and fall steeply from a peak.

Fig. 3. Mortality at various ages before, during and after a fall in rate occurring equally at all ages of cohorts. Imaginary data of Table 3: rates before the fall rise to and fall gradually from a peak.

Fig. 4. Mortality at various ages before, during and after a fall in rate occurring equally at all ages in the same period of time. Imaginary data of Table 4: rates before the fall rise to and fall gradually from a peak.

Example 1. The first line of Table 1 gives a series of numbers assumed to represent mortality rates at successive ages in the year 1901. These rates are plotted against age in Fig. 1 and give a curve rising progressively from childhood to old age. It is then assumed that those born in 1906–15 suffer throughout their lives a 20% lower mortality than their predecessors, while the cohort of 1916–25 shows a 20% improvement on that of 1906–15, and the 1926–35 cohort a 20% improvement on that of the 1916–25 group. Cohorts born subsequent to 1935 are assumed to show no further improvement. The resulting rates for each age group for every tenth calendar year from 1901 to 2011 are given in Table 1. The mortality curves in the years 1901, 1931, 1961 and 2011 are shown in Fig. 1. There is no great disturbance of the general pattern of the curve in this example: the general appearance of the curves for each of the years is similar, with a steady rise from infancy to old age.

Example 2. The first line of Table 2 gives imaginary mortality rates for the year 1901 which, when plotted in Fig. 2, give a curve rising to a peak at age 15-24 years and then falling rapidly. The same assumptions as to the nature of the fall in rate are made as in Example 1. In this case, there is slight disturbance of the pattern of the curve, in that for the years 1931, 1941 and 1951 the fall from the peak at age 15–24 years is less steep than before or after that period.

Example 3. The first line of Table 3 gives rates for the year 1901 which, when plotted against age, give a curve with a gradual rise to, and a gradual fall from, a rounded peak at age 25–34 years. The same assumptions as to the nature and magnitude of the fall in rate are made as in the two preceding examples, and the curves for the years 1901, 1931, 1961 and 2011 are again plotted in Fig. 3. It is at once apparent from the figure that a considerable change in the curve occurs during the period of falling rates. In particular, the peak moves from age 25–34 years in 1901 and 1931 to age 45–54 years in 1961; but the peak has returned to age 25–34 years in 2011. Indeed, if the course of events subsequent to 1961 were not shown in this example, it could hardly be expected that all ages were in fact to share equally in the fall in rate.

Several points of interest arise from these numerical examples:

(1) For a fall affecting cohorts born over a 30-year period of time, the full effects are not seen for a century, assuming a life span of 70 years.

(2) In each case, the recording of rates for any chronological year whilst a fall is occurring equally at all ages of cohorts leads to a distortion of the annual mortality curves. This effect is most obvious with the plateau type of curve, less obvious with a sharply peaked curve, and least obvious with a steadily rising curve.

(3) It is possible, by working in general terms, to define the conditions in which the peak of a peaked curve will move to an older age group. It can be shown that the peak will shift if the original maximum rate falls by a greater amount than the difference between this original maximum rate and the rate for the next older age group (assuming that the fall in rate is calculated over the same number of years that separates age groups). If the fall in rate in 10 years is greater than the difference in rate between the 25–34 and 35–44 years age groups, then the peak shifts from 25–34 to 35–44 years. If the fall in 20 years is greater than the difference between

the 25–34 years rate and the 45–54 years rate, the peak will shift 20 years and so on. Even more generally, it is apparent that the magnitude of the shift depends on two factors—the original age distribution of mortality and the magnitude of the fall in rate. The more rapid the fall, the greater the shift of the peak.

(4) The shift of the peak occurs only as part of the fall: when the fall is complete at all ages, the curve assumes its original form at a lower level.

Fall in rate occurring in equal relative amount at all ages in the same period of time

This is the type of fall that is generally expected to occur, all ages sharing more or less equally in the fall at the same time. An example is given in Table 4, demonstrated in Fig. 4. A fall of 20% in each of three 10-year periods from 1901 is assumed, using the same original age distribution of mortality as in Example 3 above. Fig. 4 shows that for each year a similar curve is obtained and that the fall in rate is complete within a period of 30 years. This type of fall is ultimately reached in all schemes of the kind so far illustrated, if a constant rate of fall goes on long enough. It is reached when there are no survivors left from the time before the fall commenced.

The effect of compiling such changes for all ages of cohorts may briefly be stated for subsequent reference. In the example given, individuals born about 1850 would benefit from age 50 years and older, those born in 1860 would benefit from age 40 years, while those born in 1910 would benefit at all ages. Thus, the earliest born cohorts benefit only in the older age groups, while those born more recently benefit at successively younger ages. Graphically, this effect would be shown by a depression of the rates for older ages of earlier cohorts, the sudden change affecting progressively earlier ages in later-born cohorts. This result is stated so that when in subsequent analysis of actual mortality rates a fall occurring equally at all ages in the same period of time is studied for all ages of cohorts, this characteristic change may be recognized. Here again the final age distribution of mortality, whether for years or for cohorts, is the same as that obtaining originally.

Fall in rate affecting some ages to a greater extent than others

It is not unreasonable to expect that a preventive or curative measure might be more effective at some ages than others, e.g. a drug may well be more successful in saving affected individuals in the prime of life than affected individuals at the extremes of life. The Registrar-General's *Statistical Review* notes such effects with regard to the insulin treatment of diabetes and the introduction of sulphonamide therapy for the pneumonias.

It is obvious that a fall in rate of this type, whether occurring on an annual or cohort basis, will affect the age distribution of mortality. The effect will be noticed not only during the period of falling rates, but also when the fall is complete and a new equilibrium is reached, provided that the preventive or curative measure continues to be applied. The important distinction is that the final age distribution of mortality is different from that obtaining originally before the fall began. It is apparent that with rates recorded on an annual basis the distinction between the

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unequal fall and a fall occurring equally at all ages of cohorts can in some cases be made only retrospectively when the fall has been in progress for a considerable period of time.

Discussion

It is hardly to be expected in practice that any fall in rate would occur with the mathematical regularity of the examples quoted. Many complications are possible which make recognition of characteristic types of fall difficult in practice: decision as to the nature of a fall in rate should not be made until the fall has been in progress long enough for its characteristics to be recognized.

From a medical standpoint it would seem highly improbable that mortality from some diseases could fall equally at all ages of cohorts; e.g. the mortality of an acute epidemic disease will depend primarily on the prevalence of the disease in any given year. For such a disease it is almost inconceivable that the mortality at, say, age 50 years could be directly related to the mortality at age 20 years, 30 years earlier. On the other hand, it is conceivable that with a disease that may run either a short course or a prolonged one, mortality at age 20 years might be an index of prevalence in the cohort at that age and that more chronic forms of the disease would exert their toll in an almost constant proportion up to age 50 years or older.

If improvement in mortality occurs mainly by a reduction of morbidity while the case fatality remains unaltered, and if most cases of tuberculosis originate in young adult life, it follows that the mortality at ages above young adult life will depend directly on the morbidity of the group in young adult life. An approximate measure of this will be given by the mortality in young adult life.

Other workers have made this suggestion that the fall in tuberculosis mortality is due mainly to a reduction of morbidity with no change in the prognosis of the individual case. In this country, Stocks & Lewis-Faning (1944) studied the deaths from tuberculosis in relation to the notifications from which they were drawn and found no evidence to suggest any change in the case fatality of respiratory tuberculosis in the period 1923–40. Using a similar method of analysis for figures from Australia, Lewis (1948) came to a similar conclusion. Berg (1939), from an analysis of clinical material in Sweden, stated '...we may assert that the decreased mortality from tuberculosis should essentially be ascribed to a decrease in the frequency of open pulmonary phthisis'.

The attitude that a cohort method of analysis of tuberculosis mortality is valueless or is a 'trick' is equivalent to stating that events in young adult life of a group cannot have any significant bearing on the mortality of the group when older. In other words, it is equivalent to stating that the mortality is solely determined by the conditions, presumably environmental, of the period in which the mortality occurs. It is certainly not the intention here to suggest that tuberculosis mortality in later life is solely dependent on the conditions experienced by the group when young, but that mortality in later life is influenced by conditions of environment, infection and disease when young as well as by the conditions obtaining in later life.

METHODS

Mortality rates from all forms of tuberculosis constitute the material on which this study is based. Rates for 10-year age groups of each sex have been obtained or calculated for England and Wales, Scotland, Ireland, Norway, towns of Denmark, Sweden, city of Paris, and the State of Massachusetts.

The rates are expressed per 100,000 living in the same age group, whatever the unit used in the source. The age grouping used is in some cases 15–24, 25–34, 35–44, etc., years; in some cases 10–19, 20–29, 30–39, etc., years, according to the grouping used in the source. The rates for the 0–4 years age group are always shown separately, but are not used in the main analysis nor shown in the figures. To facilitate the reading of both annual and cohort rates from one table, the rates are given for every tenth calendar year, or for alternate quinquennia, or for successive decennia.

In the theoretical discussion above, cohorts were identified by the year of birth. When using grouped data this method is unsatisfactory, so cohorts are specified by the period in which they are aged 25–34 years or 20–29 years, according to the method of grouping used.

The earliest dates at which sufficiently detailed records became available varied from 1850 to 1911, so that the length of the period of study varies from country to country. The analysis is in general not taken beyond 1940, though some comment is introduced parenthetically on the more recent rates for England and Wales.

Tables giving the basic data for age groups of each sex in each country are shown in the text. From each of these tables three further tables have been derived, but are given only for males of England and Wales. These three tables show:

(i) The percentage decline in rate in 10-year periods in each age group.

(ii) The relative age distribution of mortality in years, quinquennia or decennia (rate at age 25–34 or 20–29 taken as 100).

(iii) The relative age distribution of mortality in cohorts, using the same point of reference as for (ii).

It is obviously desirable for such an analysis that the rates should be comparable from one period of time to another, and from one age group to another. In this respect, the rates for the towns of Denmark, the city of Paris, and the State of Massachusetts are less satisfactory than those for whole countries, as the rates for the smaller units are more likely to be affected by movements of population.

Doubt has also been expressed on the validity of a cohort method of analysis for a single cause of death such as tuberculosis. It is obviously true that if considerable changes occur over a period of time in the accuracy with which tuberculous deaths are certified, then a cohort method of analysis is meaningless; but under these conditions the comparison of annual rates separated by any appreciable number of years is also meaningless. In fact, whatever the variation in accuracy may be, it would appear that, if comparison of annual rates over a considerable period is justified, then analysis by the cohort method over the same period is subject to no greater error.

TUBERCULOSIS MORTALITY RATES IN VARIOUS AREAS

England and Wales, 1851–60 *to* 1931–40 (*males*)

Table 5 gives the mean annual mortality from tuberculosis in 10-year age groups of males in England and Wales for decennia from 1851–60 to 1931–40 inclusive. The maximum rate in adult life in 1851–60 was 416 per 100,000 at age 25–34, but ages up to 54 years had rates very near to 400. In 1931–40 the maximum rate was 139 per 100,000 at age 45–54 years, while the rate at age 25–34 years was 91 per 100,000.

Table 6 shows the percentage decline in rate in each age group between one decennium and the next. The main fall in rate began betweeen 1861–70 and 1871–80, at which time the fall was practically confined to ages under 35 years. In subsequent decennia the fall spread to involve older age groups until, in the 10 years to 1911–20, there was approximately 20 % fall in ages over 34 years, but only very slight improvement at ages 5–24 years. Since the first World War there have been considerable falls at all ages. The last line of Table 6 shows that for the whole period 1851–60 to 1931–40 the greatest fall has occurred at ages up to 14 years

Table 5. *England and Wales. Males. Tuberculosis, all forms. Mean annual mortality per* 100,000 *living at various ages in decennial periods* 1851–1940

	Age (years)								
Decennium	0–	5–	15–	25–	35–	45–	55–	65–	75–
1851–60	**632**	119	344	416	412	396	348	257	106
1861–70	602	**109**	321	421	424	397	343	217	74
1871–80	580	83	**254**	378	420	393	328	202	65
1881–90	500	72	201	**316**	368	361	303	191	73
1891–1900	435	61	162	254	**325**	330	277	171	63
1901–10	313	55	137	216	262	**293**	257	169	67
1911–20	188	54	131	184	220	234	**214**	139	58
1921–30	105	32	111	140	164	173	146	**96**	39
1931–40	61	18	80	91	114	139	129	81	**35**

Rates for the cohort age 25–34 years in 1881–90 are in heavy type.

Table 6. *England and Wales. Males. Percentage improvement in* 10-*year periods* 1851–60 *to* 1931–40, *and in the whole period, for* 10-*year age groups*

	Age (years)								
Percentage fall in 10 years to	0–	5–	15–	25–	35–	45–	55–	65–	75–
1861–70	5	8	7	+11*	+3*	0	1	16	30
1871–80	4	24	21	10	1	1	4	7	12
1881–90	14	13	21	16	12	8	8	5	+12*
1891–1900	13	15	19	20	12	9	9	10	14
1901–10	28	10	15	15	19	11	7	1	+6*
1911–20	40	2	4	15	16	20	17	18	13
1921–30	44	41	15	24	25	26	32	31	33
1931–40	42	44	28	35	30	20	12	16	10
1851–60 to 1931–40	90	85	77	78	72	65	63	69	67

* Denotes an increase in rate.

(90 and 85 %), while falls between 70 and 80 % have occurred at ages 15–44, and between 60 and 70 % over that age.

Age distribution of mortality in decennia

It follows from this uneven fall in rate that the age distribution of mortality has changed, and the nature of the change may be followed in Fig. 5 or in Table 7, which show the mortality experienced at various ages as a percentage of that at age 25–34 years in the same decennium. There has been a steady shift of the maximum rate to older age groups. In 1851–60 the peak occurred at age 25–34 years, but the rate for age 45–54 years was only 5 % less. The peak moved to age 35–44 years in 1861–70, 1871–80 and 1881–90; to age 45–54 years in 1891–1900 and subsequent decennia up to 1931–40. (For each year 1939–47 inclusive the maximum rate occurs at age 55–64 years.) Even during the periods when the actual peak is at a given age, e.g. 35–44 years for 30 years at the end of the last century, the progressive nature of the change may be seen from the fact that in 1861–70 the rate for age 25–34 years practically equals the maximum, while that for age 45–54 years is appreciably less; in 1871–80 the rates for both ages 25–34 and 45–54 years are appreciably below the maximum; while in 1881–90 the rate for age 45–54 years practically equals it while that for the younger age group is much less.

Table 7. *England and Wales. Males. Mortality rates at various ages as a percentage of that at age* 25–34 *years in the same decennium*

Decennium	Age (years) 0–	5–	15–	25–	35–	45–	55–	65–	75–
1851–60	152	29	83	100	99	95	84	62	25
1861–70	143	26	76	100	101	94	81	52	18
1871–80	153	22	67	100	111	104	87	53	17
1881–90	158	23	64	100	116	114	96	60	23
1891–1900	171	24	64	100	128	130	109	67	25
1901–10	145	25	63	100	121	136	119	78	31
1911–20	102	29	71	100	120	127	116	76	32
1921–30	75	23	79	100	117	124	104	69	28
1931–40	67	20	88	100	125	153	142	89	38

Table 8. *England and Wales. Males. Mortality rates at various ages as a percentage of that at age* 25–34 *years in the same cohort*

Cohort age 25–34 years in	Age (years) 0–	5–	15–	25–	35–	45–	55–	65–	75–
1851–60	—	—	—	100	102	94	73	41	16
1861–70	—	—	82	100	100	86	66	40	14
1871–80	—	31	85	100	97	87	68	37	10
1881–90	200	34	80	100	103	93	68	30	11
1891–1900	237	33	79	100	103	92	57	32	—
1901–10	269	33	75	100	102	80	60	—	—
1911–20	272	33	74	100	89	76	—	—	—
1921–30	311	39	94	100	81	—	—	—	—
1931–40	344	59	122	100	—	—	—	—	—

Percentages below the line are wholly or partly dependent on rates since 1920.

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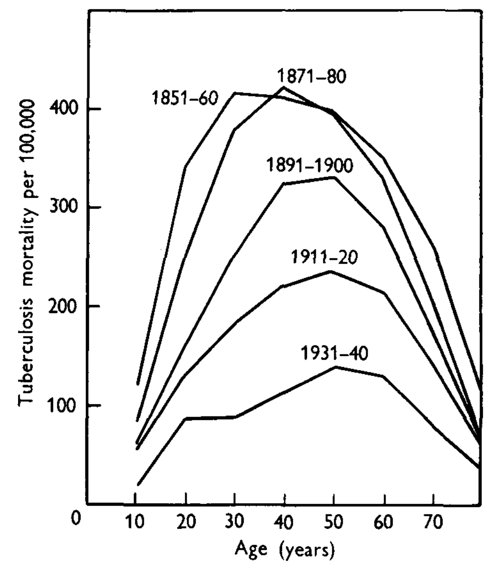

Fig. 5.

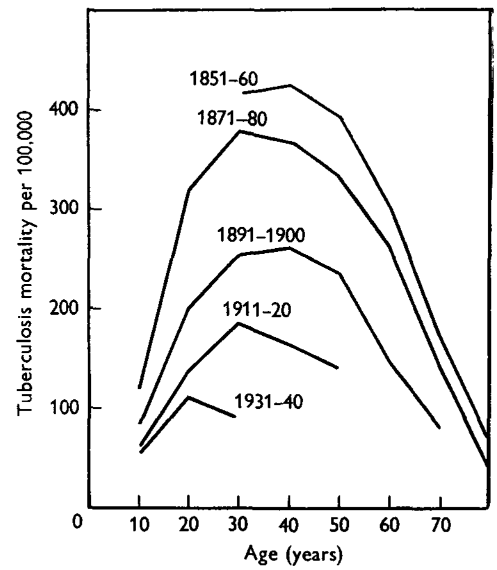

Fig. 6.

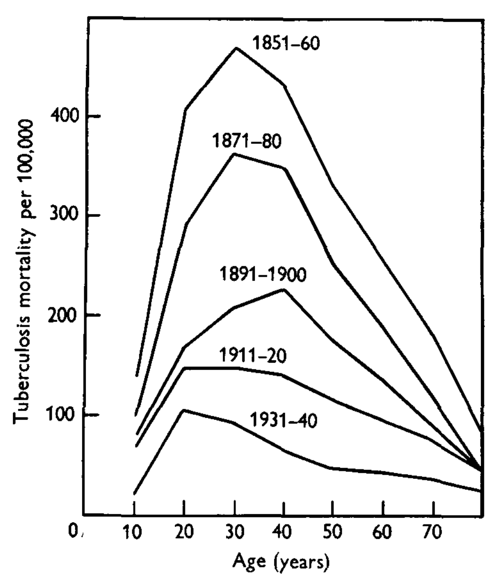

Fig. 7.

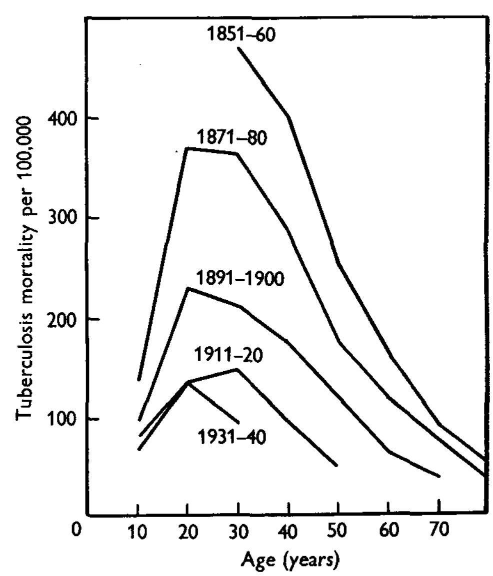

Fig. 8.

Fig. 5. England and Wales (males). Tuberculosis mortality at various ages in the decennia 1851–60, 1871–80, 1891–1900, 1911–20 and 1931–40.

Fig. 6. England and Wales (males). Tuberculosis mortality at various ages of the cohorts age 25–34 years in 1851–60, 1871–80, 1891–1900, 1911–20 and 1931–40.

Fig. 7. England and Wales (females). Tuberculosis mortality at various ages in the decennia 1851–60, 1871–80, 1891–1900, 1911–20 and 1931–40.

Fig. 8. England and Wales (females). Tuberculosis mortality at various ages of the cohorts age 25–34 years in 1851–60, 1871–80, 1891–1900, 1911–20 and 1931–40.

Age distribution of mortality in cohorts

In Fig. 6 and Table 8 the age distribution of mortality for cohorts is analysed. Comparison of Figs. 5 and 6 can leave little doubt that the latter, for cohorts, gives a much more constant form of curve. In Table 8 the rates for the various age groups are expressed as percentages of that at age 25–34 years in the same cohort. For cohorts up to that at age 25–34 years in 1901–10 the maximum rate generally occurred at age 35–44 years, with the rate at age 25–34 within 3 % of this rate. For two cohorts since that one, the rate at age 25–34 years has been 11 and 19 % greater than that at age 35–44 years; for the most recent cohort, the highest rate so far recorded has been at age 15–24, with a rate 22 % above that at age 25–34 years.

Table 8 shows that this constant relationship was shown also by older age groups of the first five cohorts. At age 45–54 years the rates were about 90 % of those at age 25–34 years. At age 55–64 years the rates were about 70 % of the young adult rate, and at age 65–74 years about 40 % of the young adult rate. The figures below the line drawn diagonally through Table 8 do not conform to this regular pattern. These percentages below the line are partly dependent on rates experienced since 1920, suggesting that some factor has come into play since that time to break the previously constant cohort pattern.

England and Wales, 1851–60 *to* 1931–40 (*females*)

Table 9 gives the corresponding mortality rates for females in England and Wales.

Table 9. *England and Wales. Females. Tuberculosis, all forms. Mean annual mortality per* 100,000 *living at various ages in decennial periods* 1851–1940

	Age (years)								
Decennium	0–	5–	15–	25–	35–	45–	55–	65–	75–
185–601	**523**	135	408	469	429	324	252	178	83
1861–70	492	**112**	369	448	399	295	218	135	53
1871–80	466	96	**291**	363	347	253	187	119	45
1881–90	399	95	227	**293**	285	215	160	106	45
1891–1900	352	78	167	209	**226**	175	134	91	43
1901–10	264	70	134	165	171	**145**	119	89	49
1911–20	161	68	147	148	140	116	**95**	75	44
1921–30	87	40	135	123	94	74	63	**50**	32
1931–40	52	21	106	93	66	48	43	36	**24**

The rates for the cohort age 25–34 years in 1881–90 are in heavy type.

In females in 1851–60 the maximum rate in adult life was 469 per 100,000 at age 25–34 years; the rates for older age groups were much lower. At age 45–54 years the rate was only 69 % of the maximum. There is a real difference between this distribution and the much more gradual fall observed in males at the same time. In 1931–40 the maximum rate was 106 per 100,000 at age 15–24 years, and the rates in older age groups were proportionately lower than in 1851–60.

The fall in rate showed some similarity to that in males, but also some differences. Thus the fall was at first greatest in young adults (at least 20 % between decennia from 1861–70 to 1901–10 at age 15–24), but some falls did occur in all older age groups throughout this period, falls of about 12–18 %. As is well known, the fall in young adults was arrested in the early years of this century and there was an actual increase at age 15–24 years for the decennium including the war: this increase was only just made good in 1921–30, but since then the rates in young adult females have fallen only a little less rapidly than those of older females. The decline in rate in older females has continued in this century showing only a slight check during the first World War. For the whole period 1851–60 to 1931–40 a fall in rate of 90 % has occurred at ages under 5, of 84 % at age 5–14 years, but only 74 % at age 15–24 years. From age 25–74 years the rates have fallen by percentages varying from 80 to 85 %.

Age distribution of mortality in decennia

Fig. 7 shows that the maximum rate occurred at age 25–34 years in 1851–60; the maximum, in fact, occurred at this age for each decennium up to 1881–90, though the rate at age 35–44 was approaching it during this period. For the decennia 1891–1900 and 1901–10 the highest rate occurred at age 35–44 years, while in 1911–20 the rates for all ages 15–44 were very similar. Since then the maximum rate has occurred at age 15–24 years.

Age distribution of mortality in cohorts

In Fig. 8 the age distribution of mortality in cohorts is shown. The maximum rate has never occurred at a greater age than 25–34 years, and even in some of the earlier cohorts the maximum occurred at age 15–24. For the most recent cohorts the maximum has very definitely occurred at age 15–24 years. Rates for older age groups at first tended to show a more constant relationship with the young adult rates of the same cohort than of the same decennium, but this regularity is not true for rates experienced since the first World War. Since then the rates for older age groups have been falling more rapidly than would have been expected from the experience of previous cohorts.

The fact, noted by Picken (1940), that the peak of the curve has moved back from age 25–34 years to age 15–24 years by both methods of analysis is strong evidence that there has been a fundamental change in the age distribution of mortality, to the disadvantage of the young adult female. It is possible that a similar change may be occurring in males, for the maximum rate of mortality in recent cohorts of males occurs also at age 15–24 years.

Scotland, 1861–1941

The tuberculosis mortality rates for age groups of each sex in every tenth calendar year from 1861 to 1941 are shown for males in Table 10 and for females in Table 11. For most age groups, except the oldest, the rates increased between 1861 and 1871 in each sex. In 1871 the maximum rate occurred at age 25–34 years in each sex, the rate being 487 per 100,000 in females and 456 per 100,000 in males. Up to, and including, age 35–44 years the female rates are somewhat the greater, while over the age of 44 years the male rates are the greater.

Table 10. *Scotland. Males. Tuberculosis mortality per* 100,000 *living at various ages every tenth year from* 1861 *to* 1941

Year	Age (years) 0–	5–	15–	25–	35–	45–	55–	65–	75–
1861	**694**	180	413	401	314	279	242	271	74
1871	779	**196**	419	456	341	340	269	212	95
1881	577	160	**318**	354	280	262	223	133	81
1891	431	117	279	**316**	300	265	225	173	58
1901	439	87	218	284	**251**	256	210	160	64
1911	352	81	174	209	207	**208**	187	128	47
1921	190	51	124	163	154	144	**122**	95	39
1931	147	36	100	108	122	124	101	**62**	31
1941	104	30	125	144	144	125	104	61	**31**

Rates for the cohort age 25–34 years in 1891 are in heavy type.

Table 11. *Scotland. Females. Tuberculosis mortality per* 100,000 *living at various ages in every tenth year from* 1861 *to* 1941

Year	Age (years) 0–	5–	15–	25–	35–	45–	55–	65–	75–
1861	**599**	177	380	406	352	269	236	183	103
1871	888	**225**	460	487	440	282	209	150	94
1881	501	204	**391**	395	317	199	133	92	46
1891	375	155	309	**348**	319	166	136	77	49
1901	335	136	265	269	**256**	175	103	76	37
1911	277	98	195	216	191	**145**	110	61	48
1921	156	**61**	153	149	116	103	**79**	57	32
1931	135	38	133	102	81	59	53	**38**	18
1941	93	32	173	105	61	44	35	23	**13**

Rates for the cohort age 25–34 years in 1891 are in heavy type.

After 1871 the rates fell in each sex and all ages shared in the fall in rates. Between 1871 and 1881 all ages of males shared more or less equally in the fall in rate; but between 1881 and 1891 the rates fell by about 10 % at ages 15–34 years, while over that age some increase in rate occurred in this period. In the 10 years to 1901, also, the fall was greater in young adults than in older persons. From 1901 to 1931 the rates fell at all ages, and it is difficult to pick out any particular age group at which the fall in rate was especially rapid or slow. The figures for females show somewhat the same tendency—between 1881 and 1901 the percentage fall in rate was a little greater in young adults than in older persons, but after 1901 all ages shared in the fall in rate. Between 1921 and 1931, however, the fall in rate at age 15–24 years was only 13 %, while the rates for all older ages fell by at least 30 %.

Age distribution of mortality in calendar years

The age distribution of mortality is shown graphically for years at 20-year intervals in Fig. 9 for males and Fig. 11 for females. In each sex in 1871 there was a peak at age 25–34 years with a fairly sharp rise to and fall from this peak; the rate for males age 55–64 was then 59 % of the maximum rate. As a result of the

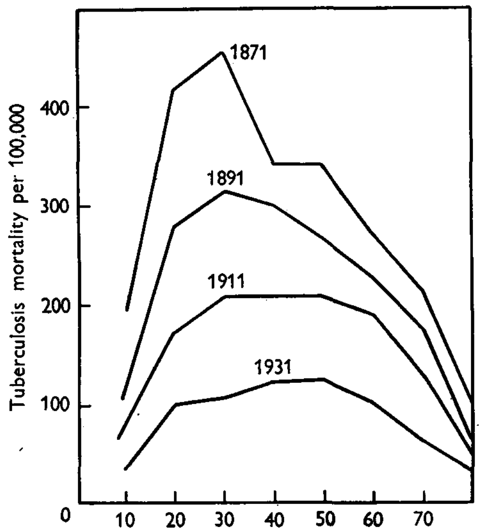

Fig. 9.

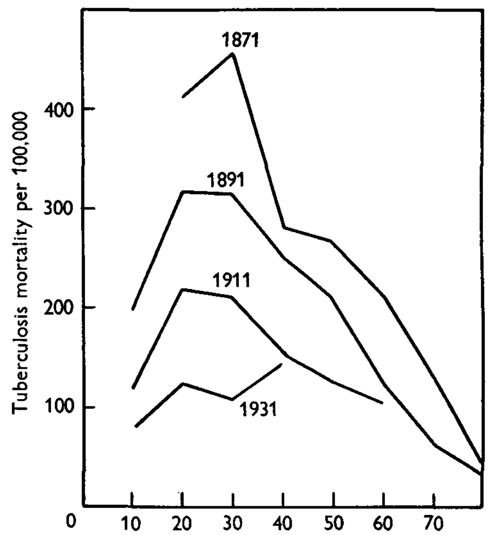

Fig. 10.

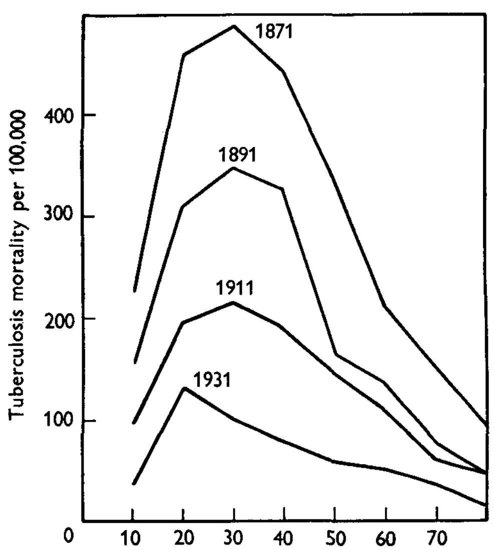

Fig. 11.

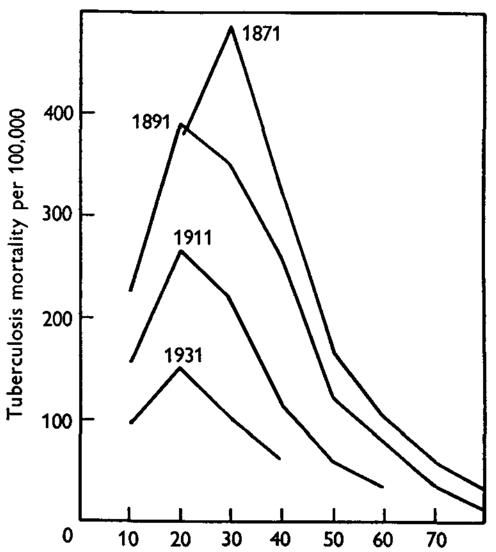

Fig. 12.

Fig. 9. Scotland (males). Tuberculosis mortality at various ages in the years 1871, 1891, 1911 and 1931.

Fig. 10. Scotland (males). Tuberculosis mortality at various ages of the cohorts age 25–34 years in 1871, 1891, 1911 and 1931.

Fig. 11. Scotland (females). Tuberculosis mortality at various ages in the years 1871, 1891, 1911 and 1931.

Fig. 12. Scotland (females). Tuberculosis mortality at various ages of the cohorts age 25–34 years in 1871, 1891, 1911 and 1931.

greater fall in rate in young men than in older men the shape of the curve was somewhat modified by 1891. The peak remained at age 25–34 years, but the fall from this peak was less rapid: the rate at age 55–64 years was now 71 % of that at age 25–34 years. The curve for 1911 continues this tendency, the rates for all ages from 25 to 54 years being practically the same, and even at age 55–64 years the rate was 89 % of that at age 25–34 years. By 1931 the peak of the curve had shifted to age 45–54 years, and the rate at age 55–64 years had increased, relatively, to 94 % of that at age 25–34 years.

The course of events in females was different. The fall from the peak at age 25–34 years was originally more steep than in males, the rate at age 55–64 years being only 43 % of the maximum in 1871. Little change has occurred in the relative age distribution of mortality. In 1911 the highest rate remained at age 25–34 years, but there was some tendency for the rates for the immediately older age groups to approximate more closely to this maximum—the rate at age 45–54 years was 67 % of that at age 25–34 years instead of 58 % in 1871. By 1931 the peak of the curve had passed back to age 15–24 years owing to the considerably less favourable fall in rate at this age. Over the age of 25–34 years the age distribution of mortality relative to that at age 25–34 years remained much as before.

Age distribution of mortality in cohorts

This is shown graphically in Fig. 10 for males and Fig. 12 for females. In each sex the cohort age 25–34 years in 1871 shows a peak at age 25–34 years, while for subsequent cohorts the peak occurs generally at age 15–24 years. In females this peak at age 15–24 years is quite definite, the rates being 12–31 % greater than those at age 25–34 years of the same cohort up to that aged 25–34 years in 1921; for the cohort age 25–34 years in 1931 the rate at age 15–24 years was 50 % greater than that at age 25–34 years. For males, the rates at age 15–24 years have been more nearly equalled by the rates at age 25–34 years of the same cohort; for two cohorts the rates at age 25–34 years are the greater. Over the age of 25–34 years the rates fall rapidly with increasing age, with the single exception of the rate at age 35–44 years for the most recent cohort shown in Fig. 10, age 25–34 in 1931. This discrepancy is no doubt to be attributed to the high rates experienced in the earliest years of the war, and shows how easily the cohort distribution is disturbed by sudden changes in rate.

By this cohort method of analysis there is no consistent tendency for any shift of the peak rate of mortality to occur in either sex: since 1881 the peak of the cohort curve has been at age 15–24 years in females; for males also the peak has, with one exception, occurred at age 15–24 years since 1881, though the rate at age 25–34 years has been only slightly less.

Ireland, 1871–1941

The tuberculosis mortality rates at various ages are given in Table 12 for males and Table 13 for females, for years at 10-year intervals from 1871 to 1941. Between 1871 and 1901 the rates for most ages either showed no great change or a tendency to increase; from 1901 to 1931 the rates improved as a whole, with falls of up to

40 % in 10-year periods. There was a check to the fall between 1931 and 1941 with considerable increase in rates at some ages.

Table 12. *Ireland. Males. Tuberculosis mortality per* 100,000 *living at various ages in every tenth year from* 1871 *to* 1941

Year	Age (years) 0–	5–	15–	25–	35–	45–	55–	65–	75–
1871	**347**	99	334	420	280	232	258	190	68
1881	339	**112**	323	403	263	213	220	159	57
1891	347	112	**346**	450	340	229	196	116	36
1901	353	104	345	**466**	353	276	193	131	26
1911	222	79	263	375	**300**	223	196	103	23
1921*	158	68	232	290	239	**179**	162	82	20
1931*	93	37	161	206	178	134	**129**	62	18
1941*	83	30	137	201	178	157	123	**61**	19

* The rates for these years must be regarded as approximate, especially 1921. The rates for the cohort age 25–34 years in 1901 are in heavy type.

Table 13. *Ireland. Females. Tuberculosis mortality per* 100,000 *living at various ages in every tenth year from* 1871 *to* 1941

Year	Age (years) 0–	5–	15–	25–	35–	45–	55–	65–	75–
1871	**361**	128	330	335	283	226	234	160	45
1881	307	**155**	361	388	283	215	175	70	18
1891	320	160	**420**	447	308	218	159	68	29
1901	306	167	385	**415**	331	211	124	79	19
1911	198	129	334	345	**291**	196	144	62	35
1921*	140	93	280	295	225	**163**	121	52	23
1931*	81	57	226	245	160	129	**98**	43	10
1941*	80	40	226	214	153	101	77	**54**	16

* The rates for these years, especially 1921, must be regarded as approximate. The rates for the cohort aged 25–34 years in 1901 are in heavy type.

In 1901 the maximum rate occurred at age 25–34 years in each sex, the rates being 466 per 100,000 for males, 415 per 100,000 for females. At ages 5–24 years the female rates were greater than the male rates, but at age 25–34 years and over the male rates were the greater.

All ages of both sexes shared in the fall in rate beginning after 1901. Between 1901 and 1911 the rates for males up to age 34 years fell by 20 % or more, the rates for females by rather less. Over the age of 54 years the changes are irregular with no consistent tendency for the rates to improve. Between 1911 and 1921 improvements of the order of 15–20 % occurred at most ages of each sex, while between 1921 and 1931 the rates for adult males fell by 20–30 %, those for females by about 20 %. The fall in rate was therefore first apparent in young adults between 1901 and 1911, when the rates for some older ages were increasing; but between 1911 and 1931 there was no consistent tendency for the fall in rate to occur at one age rather than another.

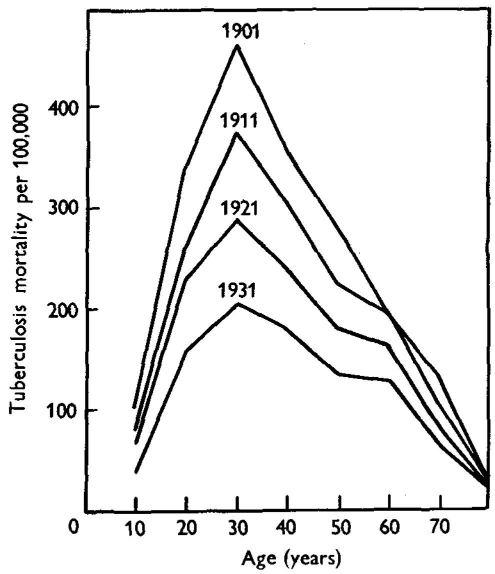

Fig. 13.

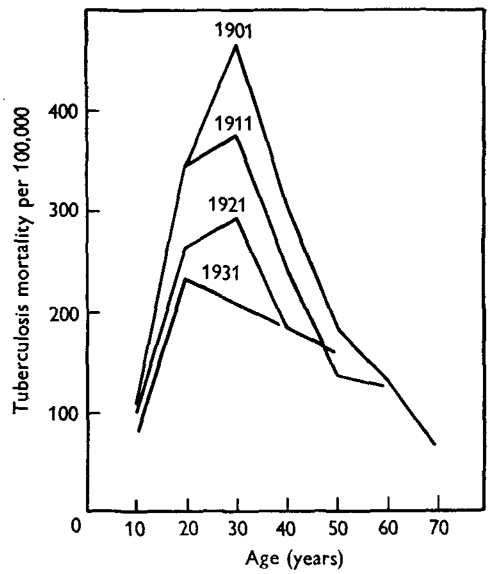

Fig. 14.

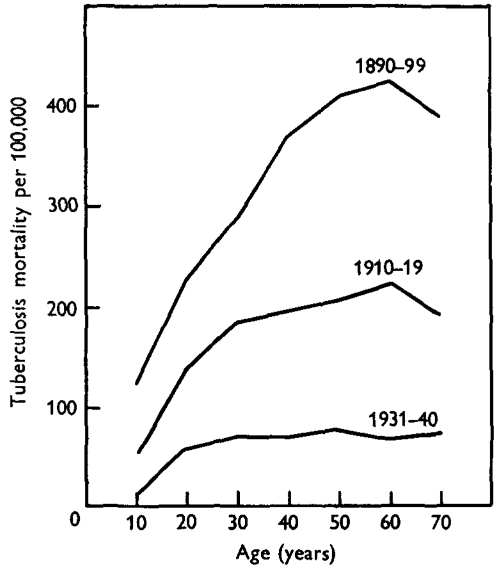

Fig. 15.

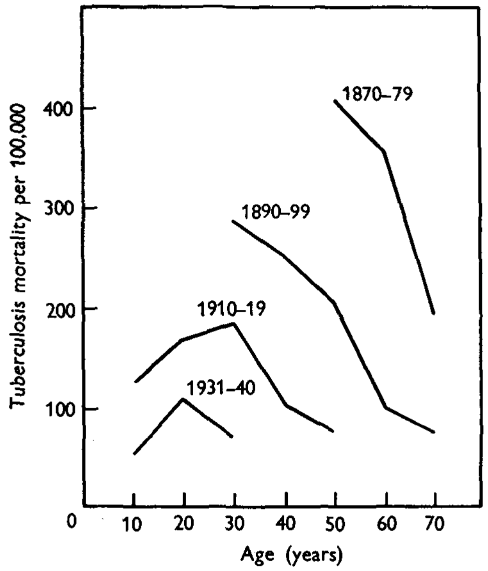

Fig. 16.

Fig. 13. Ireland (males). Tuberculosis mortality at various ages in the years 1901, 1911, 1921 and 1931.

Fig. 14. Ireland (males). Tuberculosis mortality at various ages of the cohorts age 25–34 years in 1901, 1911, 1921 and 1931.

Fig. 15. Towns of Denmark (males). Tuberculosis mortality at various ages in the decennia 1890–99, 1910–19 and 1931–40.

Fig. 16. Towns of Denmark (males). Tuberculosis mortality at various ages of the cohorts age 25–34 years in 1870–79, 1890–99, 1910–19 and 1931–40.

Age distribution of mortality in calendar years

This is shown graphically in Fig. 13 for males. The distribution for females is very similar, the only consistent difference being that the rates for females age 15–24 years are much closer to the peak. In each sex in each year up to 1931 the peak occurs at age 25–34 years, and the fall from this peak is steep in each sex. In the older age groups the male rates fall a little less rapidly with age; thus, at age 55–64 years the male rates are about 40–60 % of the maximum rate, while for females the corresponding percentages are from 30 to 40 %.

There is no shift of the peak for either sex, nor any marked tendency for a change in shape of the curves with the passage of time. There is a small increase of the rates for older age groups of males relative to those at age 25–34 years.

Age distribution of mortality in cohorts

This is shown graphically in Fig. 14 for males. Again no graph is shown for females, as it would give essentially the same result except that the peak occurs at age 15–24 years in each cohort from that age 25–34 years in 1901. From Fig. 14 it can be seen that even in males the peak of the curve for cohorts passed to age 15–24 years in the cohort age 25–34 years in 1931, and this was only the culmination of a process in which the rates at age 15–24 years and 25–34 years had been approaching each other.

In the more recent cohorts the rates for older age groups fall in relation to those at age 25–34 years. Thus in females for the cohort age 25–34 years in 1901 the rate at age 35–44 years was 70 % of that at age 25–34 years; the corresponding percentage for the cohort age 25–34 years in 1931 was 54 %. This tendency for the mortality rates of older age groups to decrease relative to that of younger age groups was noted earlier as a feature of a fall in rate occurring to an equal extent in all ages in the same period of time, and there can be little doubt that the rates for each sex in Ireland do, in fact, fall mainly in this way between 1901 and 1931.

Norway, 1896–1900 *to* 1936–40

The tuberculosis mortality rates are given for alternate quinquennia from 1896–1900 to 1936–40 in Table 14 (males) and Table 15 (females). With only three exceptions the rates have fallen in each age group in each 10-year interval.

Table 14. *Norway. Males. Mean annual mortality from tuberculosis per* 100,000 *living at various ages in alternate quinquennia* 1896–1940

	Age (years)								
Period	0–4	10–	20–	30–	40–	50–	60–	70–	80–
1896–1900	345	**232**	504	360	270	281	296	228	102
1906–10	219	202	**458**	312	232	234	240	190	75
1916–20	140	176	452	**284**	211	186	196	154	58
1926–30	94	98	320	221	**156**	137	150	133	105
1936–40	38	46	149	147	116	**94**	105	102	70

Rates for the cohort age 20–29 years in 1906–10 are in heavy type.

Table 15. *Norway. Females. Mean annual mortality from tuberculosis per 100,000 living at various ages in alternate quinquennia* 1896–1940

Period	Age (years) 0–4	10–	20–	30–	40–	50–	60–	70–	80–
1896–1900	339	**299**	419	411	318	289	293	248	92
1906–10	188	273	**439**	385	279	238	224	199	81
1916–20	138	230	391	**318**	229	189	169	144	68
1926–30	88	142	310	216	**145**	126	135	134	94
1936–40	37	54	150	125	76	**68**	76	87	81

Rates for the cohort age 20–29 years in 1906–10 are in heavy type.

In 1896–1900 the maximum rate occurred at age 20–29 years in each sex, the rate for males being 504 per 100,000, for females 419 per 100,000. For ages 30–49 years the female rates were greater than the male rates and this unusual feature persisted until 1930, when there was hardly any difference between the sexes in their rates at these ages. In 1936–40 the maximum rates still occurred at age 20–29 years in each sex, the rates being 149 for males and 150 for females.

Between 1896–1900 and 1906–10 the rates for males age 10–49 years fell by about 10 %, while the rates for older ages up to 79 years fell by 17–19 %. In the next 10 years also, a smaller fall occurred amongst males aged 10–49 years than in older age groups. The rates for females behaved similarly in this period—only comparatively small falls occurred in young adults, but the rates for older adults fell more rapidly. After 1916 the position was reversed in each sex, very large falls in rate occurring at all ages, of the order of 50 % in 10-year periods, but being if anything rather greater in young adults than in older adults.

Age distribution of mortality in quinquennia

In each sex the maximum rate occurs at age 20–29 years in each quinquennium; both the rise to and fall from the maximum were originally very steep in males, but the fall from the peak was at first less steep in females. In both sexes the fall in rate with increasing age is broken between ages 40–49 and 60–69 years, this break being more marked in females. In neither sex does any shift of the peak occur, though for males in 1936–40 the rate at age 30–39 years practically equalled the maximum at age 20–29 years.

Age distribution of mortality in cohorts

The data do not cover a long enough period of time to be entirely satisfactory. In each sex the peak of mortality has occurred at age 20–29 years in each cohort, and the rise to, and fall from, this peak has been very steep. Further, the fall from this peak with age has become steeper in successive cohorts. Thus, the rate for males age 40–49 years was 42 % of the maximum for the cohort age 20–29 years in 1896–1900, but only 26 % of the maximum for the cohort age 20–29 years in 1916–20. As in the case of Ireland, the rates for older ages of cohorts are falling more rapidly than those for the younger ages and this suggests that the main fall in rate is occurring equally at all ages in the same period of time, as was suggested by the age distribution of mortality in quinquennia.

Towns of Denmark, 1890–99 *to* 1931–40

Tables 16 and 17 show the tuberculosis mortality rates for males and females respectively for the towns of Denmark in the decennia 1890–99, 1900–09, 1910–19, 1921–30 and 1931–40. The rates have fallen in each age group in each 10-year period of time.

Table 16. *Towns of Denmark. Males. Mortality from tuberculosis (all forms) at various ages per* 100,000 *living in decennial periods* 1890–1940

	Age (years)							
Period	0–	5–	15–	25–	35–	45–	55–	65–
1890–99	383	124	**228**	288	369	408	423	385
1900–09	254	81	168	**225**	251	299	342	270
1910–19	149	54	163	186	**195**	206	221	189
1921–30	105	29	111	113	104	**97**	98	107
1931–40	59	13	58	71	68	75	**66**	72

Rates for the cohort age 25–34 years in 1900–09 are in heavy type.

Table 17. *Towns of Denmark. Females. Mortality from tuberculosis (all forms) at various ages per* 100,000 *living in decennial periods* 1890–1940

	Age (years)							
Period	0–	5–	15–	25–	35–	45–	55–	65–
1890–99	355	162	**192**	232	237	204	206	213
1900–09	228	132	184	**203**	176	158	153	161
1910–19	137	68	169	184	**151**	117	118	114
1921–30	88	36	143	122	81	**70**	70	81
1931–40	48	12	71	84	46	36	**44**	62

Rates for the cohort age 25–34 years in 1900–09 are in heavy type.

In 1890–99 there was a great difference between the sexes in the age distribution of mortality. For males the maximum rate of 423 per 100,000 occurred at age 55–64 years, while for females the maximum rate of 237 per 100,000 occurred at age 35–44 years: the male rates were greater than the female rates at age 15 years and over, but the difference was greatest in the older age groups.

Between 1890–99 and 1900–09 the rates for males fell by at least 19 %, with the fall shared more or less equally by all ages. For females age 15–24 years a fall of only 4 % occurred, and of 13 % at age 25–34 years, while for all older age groups the rates fell by 23 % or more. For the next period also, to 1910–19, there was in females a smaller fall at ages 15–44 years than at other ages and this tendency was seen in males also during this period up to 1910–19. This tendency for the fall in young adult life to be less than in older life persisted in the interval 1921–30, but by 1931–40 very large falls in rate were occurring at all ages, larger indeed in young adults than in older persons.

Age distribution of mortality in decennia

A fall in rate occurring at first more rapidly in older age groups has naturally altered the age distribution of mortality. As a result of the more rapid fall in older age groups the peak of the curve passed back to age 25–34 years for females in 1909–19 and to age 15–24 years in 1921–30; in 1931–40 the peak was again at age 25–34 years. For males the peak remained at age 55–64 years until 1910–19, when the rates for ages 25 years and over varied by less than 20%. In 1921–30 the highest rate occurred at age 25–34 years with the rates for older ages within 14%: in 1931–40 the peak was at age 45–54 years and again the rates for all adult ages were at about the same level. These changes in the rates for males are represented graphically in Fig. 15.

It is suggested that, as in England and Wales at the same time, these comparatively late peaks of mortality may be due to a fall in rate which began some years previously and which occurred at first more rapidly in young adults than in older age groups.

Age distribution of mortality in cohorts

This is shown graphically in Fig. 16 for males. In each sex the maximum rate for each cohort occurs in young adult life at either age 15–24 or 25–34 years. The decrease in rate with increasing age over the age of 34 years is rapid and becomes even more rapid in the more recent cohorts. Thus for females the rate at age 45–54 years was 50% of the rate at age 25–34 years for the cohort age 25–34 years in 1890–99, but for the cohort age 25–34 years in 1910–19 the corresponding percentage was only 20%. It would appear that since 1920 the rates have been falling rapidly at all ages in the same period of time, but there is some evidence that prior to this the rates were falling predominantly to an equal extent at all ages of cohorts.

Sweden, 1911–41

The mortality rates given in Tables 18 and 19 for males and females respectively cover only the comparatively short period from 1911 to 1941. The rates for 1911 are based on deaths recorded in a single year; those for the three subsequent periods are based on 3-year averages. There has been a fall in rate in each age group of each sex during this period, greater in children and young adults than in older persons.

In 1911 the highest rate occurred at age 20–29 years in each sex, being 299 per 100,000 for males and 352 per 100,000 for females. The female rates were greater than the male rates at all ages from 5 to 49 years. The rates for older age groups were appreciably less than those for young adults, the rate at age 50–59 years being 67% of the maximum for males, 55% for females.

Table 18. *Sweden. Males. Mortality from tuberculosis (all forms) per* 100,000 *living at various ages in groups of years at* 10-*year intervals*, 1911–40

	Age (years)								
Period	0–	5–	10–	20–	30–	40–	50–	60–	70–
1911	202	64	**128**	299	233	190	199	195	153
1919–21	146	62	106	**281**	205	155	161	167	101
1929–31	81	36	88	193	**163**	124	119	138	93
1939–41	36	12	46	110	87	**86**	84	98	73

Rates for the cohort age 20–29 years in 1919–21 are in heavy type.

Table 19. *Sweden. Females. Mortality from tuberculosis (all forms) per* 100,000 *living at various ages in groups of years at* 10-*year intervals* 1911–40

Period	0–	5–	10–	20–	30–	40–	50–	60–	70–
	Age (years)								
1911	155	89	**178**	352	312	228	195	206	200
1919–21	116	69	145	**249**	212	168	141	142	96
1929–31	79	40	122	233	**164**	116	98	121	94
1939–41	27	13	53	110	84	**68**	75	78	93

Rates for the cohort age 20–29 years in 1919–21 are in heavy type.

Age distribution of mortality in calendar years

In each period the maximum rate of mortality has occurred at age 20–29 years. There has been no consistent change in the age distribution of mortality, the rates for males at age 50–59 years being 67% of the maximum in 1911, 76% of the maximum in 1939–41, after falling to 57 and 62% in the intervening periods.

Age distribution of mortality in cohorts

The data cover an insufficient period of time to give satisfactory results, but so far as analysis is possible there does not seem to be any constant pattern, though the distribution is consistent with a fall occurring equally at all ages in the same period of time.

City of Paris, 1889–93 *to* 1929–33

The rates for alternate quinquennia from 1889–93 to 1929–33 are given in Table 20 for males and Table 21 for females. There has been a general tendency for the rates to fall throughout this period.

Table 20. *Paris. Males. Tuberculosis mortality per* 100,000 *living at various ages in alternate quinquennia* 1889–33

Years	0–	5–	15–	25–	35–	45–	55–	65–	75–
	Age (years)								
1889–93	744	152	**452**	646	931	902	680	436	185
1899–1903	625	129	403	**540**	859	917	735	508	285
1909–13	482	132	307	454	**727**	842	706	506	275
1919–23	392	104	281	273	403	**490**	510	405	233
1929–33	190	61	178	274	385	458	**448**	301	184

Rates for the cohort age 25–34 years in 1899–1903 are in heavy type.

Table 21. *Paris. Females. Tuberculosis mortality per* 100,000 *living at various ages in alternate quinquennia* 1889–1933

Years	0–	5–	15–	25–	35–	45–	55–	65–	75–
	Age (years)								
1889–93	657	174	**330**	467	451	323	268	194	133
1899–1903	557	160	335	**433**	449	346	270	229	155
1909–13	451	169	277	352	**372**	309	260	224	133
1919–23	319	131	286	271	265	**220**	203	169	135
1929–33	161	75	200	173	157	141	**142**	150	110

Rates for the cohort age 25–34 years in 1899–1903 are in heavy type.

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The rates for males in 1889–93 were very high, reaching a maximum of 931 per 100,000 at age 35–44 years: the rates for females were lower, the maximum being 467 per 100,000 at age 25–34 years. The rates for males are greater than the rates for females throughout adult life, the differences being very great in the older age groups.

Between 1889–93 and 1899–1903 the rates for males aged 5–44 years fell by 8–16 %; the rates actually increased in the older age groups. For females there was little change in the rates during this period, though some increase occurred in the rates for the oldest age group. Between 1899–1903 and 1909–13 quite large falls in rate occurred in young adults of both sexes with little or no improvement in the rates for older adults. In the next period, to 1919–23, very little improvement occurred at age 15–24 years, while quite large falls occurred in older persons. The fall was particularly large for males aged 25–54 years with falls of over 40 % in the 10-year period. However, this large fall in males was offset in the next period to 1929–33, when little improvement occurred in the rates for males age 25–44 years though appreciable improvement occurred at other ages of males and all ages of females.

Age distribution of mortality in quinquennia

It can be seen from Fig. 17 that the maximum mortality for males in 1889–93 occurred at age 35–44 years. In 1899–1903 and 1909–13 a peak occurred at age 45–54 years, while in 1919–23 the maximum was at age 55–64 years, passing back to age 45–54 years in 1929–33, though the rate for age 55–64 years was only a little less. From Fig. 19 it can be seen that the maximum rate of mortality for females occurred at age 25–34 years in 1889–93, but at age 35–44 years in 1909–13. After that the peak passed back to a younger age period, 15–24 years in 1919–23 and 1929–33. In both sexes it can be seen that these movements of the peak rates are not chance variations of the position of the maximum rates but are part of a general pattern; in males, for the rates in older age groups to fall less rapidly than in younger age groups in the period under review; in females, for the rates for older age groups to fall only slowly up to 1909–13, and then for the rates in these older age groups to fall quite as rapidly as those in younger life.

Age distribution of mortality in cohorts

The analysis by cohorts is given in Fig. 18 for males. The results seem to be completely irregular, with no consistent pattern, and they are shown partly for this reason, to demonstrate how greatly the cohort distribution is disturbed if large changes occur in a short space of time. It was noted above that the rates for ages 25–44 years in 1919–23 were remarkably low in relation to those for 1909–13, and indeed low in relation to those for 1929–33. Moine & Oudet, from whose paper these figures are taken, suggest that the low figures for 1919–23 are due to excessive mortality during the war years 1914–18, a large part of the mortality being deaths which, under more normal conditions, would have occurred in 1919–23. If for the recorded 1919–23 rates are substituted the means of the 1909–13 and 1929–33 rates, the apparent irregularities in the cohort rates are almost completely eliminated,

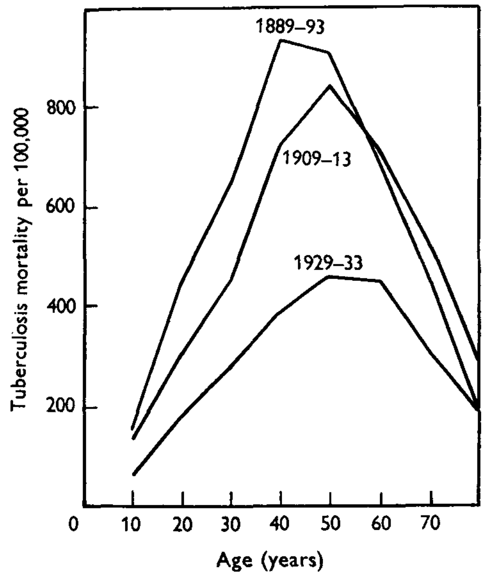

Fig. 17.

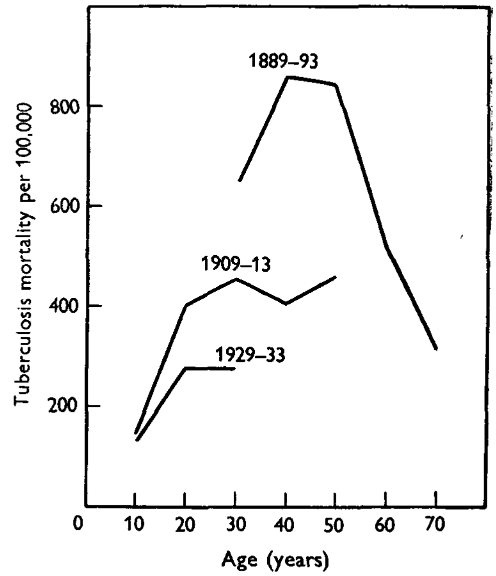

Fig. 18.

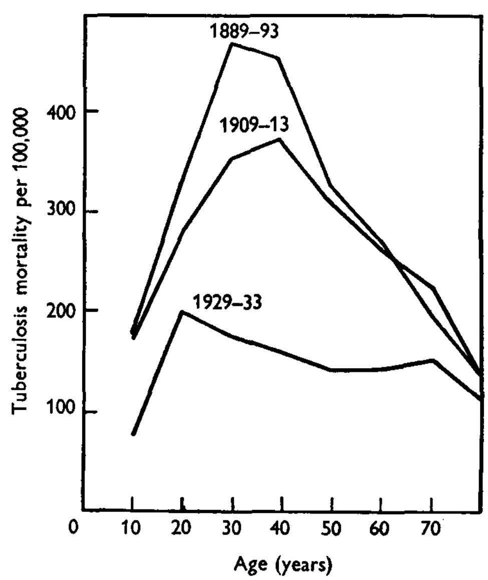

Fig. 19.

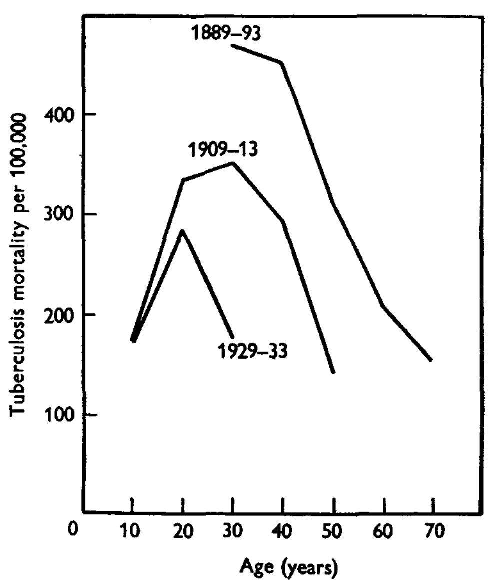

Fig. 20.

Fig. 17. Paris (males). Tuberculosis mortality at various ages in the quinquennia 1889–93, 1909–13 and 1929–33. *Note*: the vertical scale of this and Fig. 18 is half that of the other figures.

Fig. 18. Paris (males). Tuberculosis mortality at various ages of the cohorts age 25–34 years in 1889–93, 1909–13 and 1929–33. *Note*: the vertical scale of this and Fig. 17 is half that of the other figures.

Fig. 19. Paris (females). Tuberculosis mortality at various ages in the quinquennia 1889–93, 1909–13 and 1929–33.

Fig. 20. Paris (females). Tuberculosis mortality at various ages of the cohorts age 25–34 years in 1889–93, 1909–13 and 1929–33.

with the peak rate occurring at age 35–44 years for each of the five cohorts. Even without this rather artificial adjustment it can be seen that there is no tendency for the peak of the curve for cohorts to pass to an older age group. (Stocks & Lewis-Faning have shown that in England and Wales in the early years of the second World War there was evidence of a smaller but similar acceleration of deaths that would normally have been expected to occur later.) For females, the analysis by cohorts is given in Fig. 20. For each cohort up to that aged 25–34 years in 1909–13 the peak occurred at age 25–34 years: for the two more recent cohorts the rate at age 15–24 years has been greater than that at age 25–34 years; that is, there is no tendency for the peak of the curve to pass to an older age group, and more recently the peak has passed to a younger age group. Coupled with the similar recent change in the rates for quinquennia this suggests that there has been a real change in the pattern with the peak passing to a younger age.

Massachusetts, 1880–1940

The data originally analysed by Frost are reproduced in Table 22 for males and Table 23 for females, with rates for the year 1940 added. Between 1880 and 1940 there has been a general tendency for the rates to fall in each age group of each sex.

Table 22. *Massachusetts. Males. Tuberculosis mortality per* 100,000 *living at various ages in every tenth year from* 1880 *to* 1940

	Age (years)								
Year	0–	5–	10–	20–	30–	40–	50–	60–	70–
1880	760	43	**126**	444	378	364	366	475	672
1890	578	49	115	**361**	368	336	325	346	396
1900	309	31	90	288	**296**	253	267	304	343
1910	209	21	63	207	253	**253**	252	246	163
1920	108	24	49	149	164	175	**171**	172	127
1930	41	11	21	81	115	118	127	**95**	95
1940	10	3	7	34	60	85	98	99	**90**

Rates for the cohort age 20–29 years in 1890 are in heavy type.

Table 23. *Massachusetts. Females. Tuberculosis mortality per* 100,000 *living at various ages in every tenth year from* 1880 *to* 1940

	Age (years)								
Year	0–	5–	10–	20–	30–	40–	50–	60–	70–
1880	658	71	**265**	537	422	307	334	434	584
1890	595	82	213	**393**	372	307	234	295	375
1900	354	49	145	290	**260**	211	173	172	296
1910	162	45	92	207	189	**153**	130	118	126
1920	101	24	78	167	135	108	**83**	83	68
1930	27	13	37	92	73	53	47	**56**	40
1940	10	1	11	39	36	26	29	33	**35**

Rates for the cohort age 20–29 years in 1890 are in heavy type.

In 1880 peaks of mortality occurred at age 20–29 years, with rates of 444 and 537 per 100,000 in males and females respectively. In each sex the rates decrease with

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age up to age 40–60 years, with rates 20–40 % below the young adult peak, but there was then in older ages an increase to even higher levels than in young adult life. Female rates were greater than the male rates at ages up to age 39 years, but from that age the male rates were the greater.

Between 1880 and 1890 very large falls occurred from the high rates that had been recorded in the older age groups. Little improvement occurred in middle life, but some improvement occurred in young adults. After 1890 considerable falls occurred at all ages, but in males the falls were at first much greater in young adults than in older life. Between 1910 and 1920 there was some slowing of the fall in young adults, but since 1920 remarkably large falls in rate have occurred in young adults with falls of over 50 % in 10-year periods; while considerable, if slightly smaller, falls have continued in the rates for older age-groups.

Age distribution of mortality in calendar years

As Frost pointed out, there has in males been a progressive shift of the peak of the curve from age 20–29 years in 1880; the peak occurred at age 30–39 years in 1890 and 1900; in 1910 the rates at ages 30–59 years were all 22 % above that at age 20–29 years, while the rate at age 60–69 years was 19 % above that at age 20–29 years. In 1920 a peak occurred at age 40–49 years, in 1930 at age 50–59 years and in 1940 at age 60–69 years. In females the peak of the curve has throughout remained at age 20–29 years, with a tendency for the rates for older ages to approach those for young adults with the passage of time.

Age distribution of mortality in cohorts

For females the peak again occurs at age 20–29 years throughout, with, however, the rate for older ages becoming progressively lower in relation to the peak rates. For males also the peak remains at age 20–29 years of each cohort with no tendency for the rates for older ages to increase relatively, but rather the reverse. From the figures given in Frost's paper there can be little doubt that the cohort method of analysis gives much the more consistent result in males.

COMPARISON OF TUBERCULOSIS MORTALITY IN VARIOUS AREAS

Males of England and Wales and of Massachusetts show the most marked shift of the peak rate, from young adult life to an age about the end of working life. In both countries the shift has been a slowly progressive one over a long period of time and it is by no means certain that the limit has yet been reached. Males of Paris show only a slightly less marked shift of the peak, partly because the peak rate was already at age 35–44 years at the time when rates were first available: it is possible that if rates were available for a still earlier period a peak in even younger life would have been shown. In males of Danish towns the peak occurred late in life in 1890–99, the earliest period for which rates are available. More recently, the peak has passed back to a younger age period. It is suggested that the fall began some years before 1890, in a similar way to that in England and Wales, and that the 1890–99 rates show the maximum shift of the peak. Males of Scotland have shown a shift of the peak more recently than males of England and Wales, and so far not to the same degree, but it is probable that the movement is not yet complete. Females of England and Wales and of Paris show a small shift of the peak rate to an older age period, followed by a greater movement back to an even younger age period than originally. Females of Denmark show the shift back to a younger age period from a peak at 35–44 years. In the same way as for the males, it is suggested that this comparatively late peak for Danish females is the result of a change starting before 1890.

Of at least equal importance for the purpose of this analysis are the groups which have shown no shift of the peak rate in the period for which rates are available. They are females of Scotland and Massachusetts, and both sexes of Ireland, Norway and Sweden.

Sex

The shift of the peak has occurred more often and to a greater extent in males than in females. Five male groups have shown such a shift, four to a marked degree, while only three female groups have shown this change and none to the same extent as the male groups.

Density of population

The shift of the peak has occurred in both sexes of the most densely populated communities studied, viz. in the entirely urban districts of Paris and towns of Denmark, and in England and Wales which together have a density of 742 persons per square mile. In Massachusetts (514 persons per square mile) and Scotland (308 persons per square mile) a shift of the peak has occurred in males but not in females. No shift of the peak has occurred in either sex in Ireland, Norway or Sweden which have densities of 130, 23 and 35 persons per square mile respectively. (These densities of population are derived from areas and populations given in Philips's *Handy Gazetteer of the World.*)

Rates before the fall began

In nearly every region studied, and in each sex, a rate in excess of 400 per 100,000 was recorded in some age groups: the sole exception is Sweden, for which the earliest rates available are those for 1911. The upper limit of the rates was, in general, not above 500; with the exception of males of Paris with a rate of nearly 1000. Other groups show a peak rate, at the time rates were first available, between 400 and 500. Of greater interest is the different pattern of curve obtained by plotting mortality rates against age. Males of England and Wales, Massachusetts and Paris show rounded curves, or even a plateau type in the case of England and Wales. On the other hand, both sexes of Ireland, Norway and Sweden show sharply peaked curves, the peak occurring in young adult life; each of these does, however, show a definite 'step' in the falling curve at about age 40–60 years. This step is even more marked in the case of Scotland. The original curve for the towns of Denmark with a peak in older life is regarded as being already distorted by previous falls in rate. This listing according to the form of curve tallies very closely with that given earlier for the presence or absence of a shift of the peak. Table 24 gives the analysis numerically by expressing the rate in middle life as

Table 24. *Ratio of mortality in middle age to that in young adult life related to the occurrence or otherwise of a shift of the peak of a mortality curve to an older age period in various countries*

Country	Period	$\frac{\text{Rate at age 45–54}}{\text{Rate at age 25–34}} \times 100$ M.	F.	Shift of peak M.	F.
England and Wales	1851–60	95	69	+ +	+
Scotland	1861	70	66	+	0
Ireland	1871	55	67	0	0
Towns of Denmark	1890–9	142	88	+ +	+
Paris	1889–93	140	69	+ +	+
		$\frac{\text{Rate at age 40–49}}{\text{Rate at age 20–29}} \times 100$ M.	F.		
Massachusetts	1880	82	57	+ +	0
Norway	1896–1900	54	76	0	0
Sweden	1911	64	65	0	0

a percentage of the rate in young adult life and showing in another column the presence or absence of a shift of the peak. On this numerical basis the association between shift of the peak and a relatively high rate in middle life is shown especially by the males. For the four male groups showing a marked shift of the peak, the rate in middle age is 80 % or more of the rate in young adult life, whereas for the three groups showing no shift at all the percentages are 54, 55 and 64. Scottish males occupy an intermediate position with a percentage of 70 %. The rates for females do not show such a relationship and the total range of the percentages is appreciably less, 6 of the 8 figures lying between 65 and 76 %: it has already been noted that a shift of the peak is less common in females.

Rapidity of the fall in rate

It is of little value to compare the overall percentage falls in rate, as they deal with such varying periods of time. If, however, the percentage fall in successive 10-year periods is considered, it is found that in all groups falls of at least 20 % in 10 years have occurred at some stage. The fall has varied greatly in time, place and age group; it has rarely been more than 35 % in a 10-year period and once a fall in rate was well under way, a fall of less than 10 % in 10 years was also exceptional. There does not appear to be any difference in this respect between groups in which a shift of the peak has occurred, and those in which it has not occurred.

It was noted earlier that the peak rates were originally in most cases above 400: in the most recent period considered here, 1930–40, the peak rates were, with few exceptions, below 150, and in some cases below 100. Again the shift of the peak does not appear to be associated with any particular level of mortality. For males Ireland has shown no shift and has a peak rate of 206 at age 25–34 years in 1931, Norway no shift, peak rate of 149 at age 20–29 years in 1936–40; on the other hand, England and Wales, with a marked shift, shows a peak rate of 139 at age 45–54 years in 1931–40 when the rate at age 25–34 years was 91; but in 1901–10 the peak rate was 293 at age 45–54 years, and the rate at age 25–34 years was 216.

The rates in successive cohorts

It was found in studying the rates for each area that the relative age distribution of mortality for cohorts of males in England and Wales and of Massachusetts remained remarkably constant. It seemed probable that the same was true for males of Danish towns and of Paris, after certain allowances and assumptions had been made. For females of England and Wales and Paris, and males of Scotland, the relative age distribution of mortality in cohorts did not remain constant; nor did the relative age distribution in years; it would appear that in these cases the fall was occurring partly equally at all ages of cohorts, partly equally at all ages in the same period of time. For other groups, that is, both sexes of Ireland, Norway and Sweden, and females of Scotland and Massachusetts, the relative age distribution of mortality was much more constant in the annual rates than in the rates for cohorts: in these groups the cohort rates give rates falling very rapidly indeed with increasing age.

DISCUSSION

From the above, the following general conclusions appear to be justified:

(1) The shift of the peak rate of mortality to an older age group occurs more often and to a greater extent in males than in females.

(2) The shift of the peak rate occurs more readily in densely populated communities and not at all in sparsely populated communities.

(3) The shift of the peak is related to the form of the mortality curve before the fall commences: with a rounded or plateau type of curve a shift occurs, with a sharply peaked curve, no shift occurs. This is consistent with Observations 1 and 2 above, as the mortality curve is more sharply peaked in females than in males, and in the 'sparsely populated' communities than in the 'densely populated' communities.

(4) The shift has been observed only in association with rates falling fairly rapidly; but in other groups showing equally rapid falls in rate there has been no shift of the peak. The shift is not associated with any one period of time or level of mortality.

Consideration of these results in association with the theoretical discussion given earlier suggests that one assumption will explain most of the observed results, viz. that the relative age distribution of mortality is constant in cohorts rather than in years.

When this assumption is tested against the rates actually recorded, it is found to hold reasonably well for those groups which have in fact shown a shift of the peak: the implications of this as to types of disease were considered in the theoretical discussion earlier. In that discussion it was noted also that unless the percentage fall in rate per unit of time was greater than the percentage difference in rate between age groups, no shift of the peak could occur: this observation would be adequate to explain the absence of any shift of the peak in groups with a sharply peaked age distribution of mortality.

The relative age distribution of mortality is not, however, constant in cohorts in those groups with a sharply peaked mortality curve. During the period of falling rates there has been some relative increase in the rates for middle-aged groups, but the increase is much less than would be expected if the rates were falling strictly equally at ages of cohorts. A mortality curve with a sharp peak in young adult life necessarily implies a high incidence of acute, rapidly fatal disease at this period of life. With a great preponderance of such cases it is unlikely that the mortality rates of the group in later life, due to a small proportion of chronic cases or late developing cases, would bear any constant relationship to these young adult rates.

No explanation is offered for the earlier and sharper peak of mortality from tuberculosis in young adult females than in young adult males. Some factor (? endocrine) of fundamental importance must be responsible for a fact which is shown by the records of so many countries over so long a period of time. While this analysis offers no explanation of this basic difference, it does give an explanation for the apparently increasing discrepancy between the rates for older males and older females in some countries, but not in others.

To explain the differences in age distribution observed between the communities studied, it would be necessary to determine why some should have a preponderance of acute disease, while others have a greater proportion of more chronic cases. This cannot be done with certainty, but there are at least the three following ways in which such differences could arise:

(1) *Genetic racial differences.* It is possible that the populations of Ireland, Norway and Sweden are on the whole less resistant than those of England and Wales, Massachusetts and Paris. The fact that the towns of Denmark give the more rounded type of curve, however, makes it difficult to believe that any racial difference is playing a major part, as genetically Denmark would be expected to belong rather to the Scandinavian group of countries. There is another reason for doubting whether racial factors are of major importance as between the populations studied. It has been noted that, for females of England and Wales, Paris and Danish towns, there has been a change from a rounded peaked mortality curve to a sharply peaked curve, with the peak occurring earlier in life. A change of this type would suggest that the community concerned was becoming more susceptible to acute forms of the disease, which is hardly to be expected on a genetic basis in a short period of time.

(2) *Environmental conditions.* The less satisfactory living and working conditions of urban life may lead to the occurrence of tuberculosis in individuals who would not have developed the disease under more favourable rural conditions, or to the death of cases that would otherwise have survived. Either of these factors would tend to give a mortality rate remaining at a high level over a large part of adult life in urban communities. It has frequently been observed that the mortality at all ages is greater in towns than country: the difference may well be due to the occurrence of disease leading to death in a group who, under slightly more favourable conditions, would survive, and such groups would be the more resistant ones in whom the disease might take longer to develop and progress.

(3) *Age of Mantoux-conversion.* It has been assumed until comparatively recently that all town dwellers undergo primary infection at an early age, and even that a high proportion of rural dwellers were infected before reaching adult life. Studies since 1930 in many countries have shown that in fact large and increasing numbers of individuals are reaching young adult life, even in towns, without acquiring sensitivity to tuberculin. The surveys suggest that the proportion of negatives is greater in Ireland, Sweden and Norway than in England and Scotland. It is now generally accepted that a group not previously infected is more susceptible to tuberculosis than a group which has survived primary infection: the greater susceptibility is shown both by higher morbidity and mortality, and by more acute type of disease. If in fact there is, and has for decades been, a considerable proportion of the population of Ireland, Norway and Sweden reaching young adult life without being infected, there is here sufficient reason for the sharply peaked mortality curves of these countries as compared with the more rounded curves occurring in England and Wales in earlier decades. If a considerable proportion of primary infections are now occurring in young adult life in England and Wales, there is here also an explanation for the observed change in age distribution in mortality of females of this country towards an earlier and sharper peak.

CONCLUSIONS

1. The age distribution of mortality from tuberculosis is different in the two sexes. The female mortality rises more sharply to, and falls more rapidly from, a peak at a rather younger age than does the male mortality.

2. The age distribution of mortality from tuberculosis is different in various countries: the more thinly populated countries tend to have a more rapid rise to, and fall from, a peak at a rather earlier period of life than do more densely populated communities.

3. If a fall in mortality rate occurs equally at all ages of cohorts the peak of a peaked curve may shift to an older age period when the rates are studied on an annual basis. For any given rapidity of fall in rate the peak of a roundly peaked curve will shift more readily and to an older age period than that of a more sharply peaked curve.

4. Given 1 and 2 above as factual observations, and that tuberculosis mortality may fall equally at all ages of cohorts, then the result stated in 3 is adequate to explain why in some sex and geographical groups the maximum tuberculosis mortality rate has moved to an older age period when analysed on an annual basis, while this phenomenon has not been observed in other groups.

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