Soz.- Präventivmed. 43 (1998) 162–166
0303-8408/98/030162-05 $ 1.50 + 0.20/0

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Mortality from respiratory tuberculosis in Switzerland

Summary

Since 1901, the Swiss Federal Office of Statistics has published at least each decade detailed mortality statistics from tuberculosis. These cross-sectional data on deaths from respiratory tuberculosis from 1901 to 1991 were utilized to analyse retrospectively tuberculosis death experience within each birth cohort. The cross-sectional data indicate that tuberculosis mortality increases with age in each successive decade. Nevertheless, the cohort-contour approach indicates that this phenomenon is the result of a much higher mortality that each cohort experienced in their early adulthood, and that mortality form respiratory tuberculosis in Switzerland always preferentially affected the young. The data also indicate that tuberculosis mortality in Switzerland has been decreasing for at least 160 years, and perhaps peaked as early as in the eighteenth century.

The epidemiologic situation regarding tuberculosis in Switzerland has improved remarkably in this century. Since 1945, the average annual risk of infection with *Mycobacterium tuberculosis* has decreased each year by an estimated average of 11.4%, and tuberculosis notifications by 4.9% from 1945 to 1973, and by 5.7% from 1975 to 1988. Tuberculosis mortality decreased on average 7.5% per year from 1952 to 1986[1].

Before the introduction of systematic tuberculosis case notification systems, mortality data on tuberculosis were usually more readily available than morbidity data. They also provided a reasonably reliable measurement of the extent of the tuberculosis epidemic in a community, because the natural history of tuberculosis without intervention resulted in a morbidity-to-mortality ratio that was fairly constant[2]. To ascertain the course of the tuberculosis epidemic in Switzerland using records of mortality, published data on deaths from respiratory tuberculosis were scrutinized to portray more precisely how tuberculosis has receded.

Materials and methods

The Federal Office of Statistics publishes health statistics for Switzerland. Since 1901 this institution has regularly published tuberculosis mortality data by age and sex, separately for respiratory and other forms of tuberculosis. For the present analysis, only data on mortality from respiratory tuberculosis were utilized. The analysis was limited to respiratory tuberculosis because of the generally more reliable diagnostic accuracy, and because overall tuberculosis mortality is largely determined by deaths from respiratory rather than extra-respiratory tuberculosis, as the incidence of the former considerably exceeds that of the latter[3]. Deaths among persons aged 80 years and older were omitted from the analyses of rates, because the small numbers and the resulting large variation in mortality rates in the 80- to 89-year-old and 90- to 99-year-old age groups precluded meaningful evaluation. Mortality rates were used as published, or recalculated from numerator and denominator data. Mortality rates in children less than 10 years of age had to be aggregated for easier presentation. Utilizing information on tuberculosis mortality for the seven 10-year age groups from age 0 through 79 years and the ten cross-sectional reports from 1901 to 1991 allowed the evaluation of deaths from respiratory tuberculosis for birth cohorts from 1836

through 1986. With the available data it was possible to follow the three cohorts born in 1896, 1906, and 1916 through their potential life span from birth to the age of 80 years.

Results

From 1901 to 1991, the number of reported deaths from respiratory tuberculosis in Switzerland decreased from 6'261 to 47 per year, a reduction of 99.2% (Tables 1 and 2). In the same period, the reported crude mortality rate from respiratory tuberculosis decreased from 187.5 to 0.7 per 100'000 population in 1991, a reduction of 99.6%, with an average annual decline of 6.0%.

Mortality from respiratory tuberculosis among males

Mortality from respiratory tuberculosis reported for the years 1901 through 1991 among males decreased in each successive decade (Fig. 1, dotted lines). The highest mortality rate was recorded in 1901 in the 60 to 69 year-old age group (353 per 100'000 population). At every cross-sectional point of observation, mortality rates increased with increasing age up to the oldest age group, with the exception of the years 1901 through 1941, when mortality peaked at age 60 to 69 years. In 1991, the mortality rate was highest in the age group of the 70–79 year-olds (5.8 per 100'000 population). In 1981 and 1991, no deaths from respiratory tuberculosis were reported in males below age 40 years.
Analysis by birth cohort shows, however, that in each cohort tuberculosis mortality was highest in young age groups (Fig. 1, solid lines). For the cohorts of 1886 to 1926, respiratory tuberculosis mortality always peaked in the 20–29 year old group.

Mortality from respiratory tuberculosis among females

Mortality from respiratory tuberculosis among females differed from that reported among males in that the cross-sections showed a bimodal distribution, with a nadir in the 40–49 year-old group (Fig. 2,

Year	0–9	10–19	20–29	30–39	40–49	50–59	60–69	70–79	80+	Total
1901	162	217	690	658	527	442	322	91	9	3118
1911	101	184	601	624	523	408	271	101	8	2821
1921	67	160	471	407	456	384	259	103	10	2317
1931	33	89	361	348	330	342	229	81	12	1825
1941	20	44	226	239	247	233	221	101	13	1344
1951	9	11	67	91	129	156	146	112	23	744
1961	8	3	11	13	33	94	81	75	36	354
1971	1	0	1	3	16	43	83	64	31	242
1981	0	0	0	0	2	10	18	35	23	88
1991	0	0	0	0	1	2	6	10	7	27

Table 1. *Number of deaths from respiratory tuberculosis by age, males, Switzerland, 1901–1991.*

Year	0–9	10–19	20–29	30–39	40–49	50–59	60–69	70–79	80+	Total
1901	196	451	868	598	363	306	267	89	5	3143
1911	145	398	854	608	379	263	250	117	12	3026
1921	82	345	744	514	363	282	251	130	19	2730
1931	42	220	603	349	202	214	202	119	16	1967
1941	19	79	262	238	149	125	161	133	22	1188
1951	7	12	62	71	71	62	88	96	39	508
1961	1	1	5	15	28	24	45	73	38	230
1971	2	0	3	3	6	12	30	46	36	138
1981	0	0	0	0	2	2	16	21	17	58
1991	0	0	0	0	1	0	2	6	11	20

Table 2. *Number of deaths from respiratory tuberculosis by age, females, Switzerland, 1901–1991.*

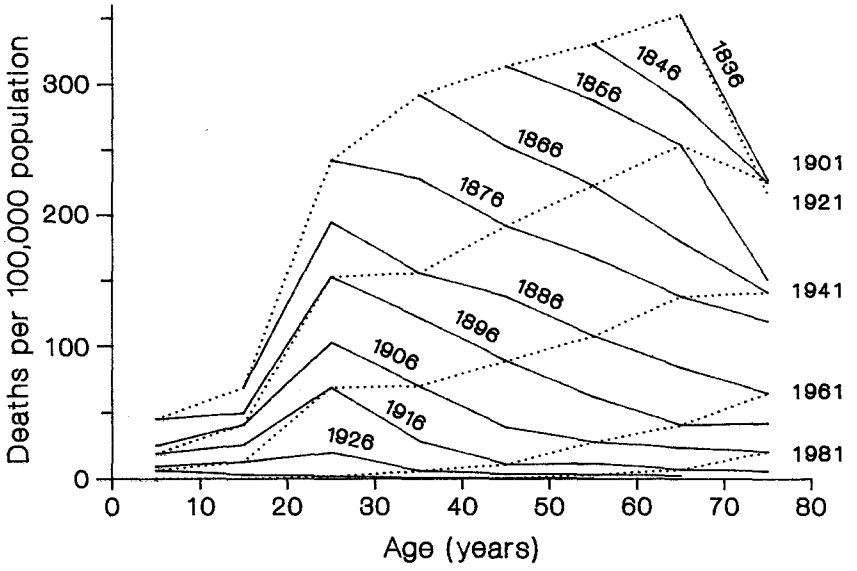

Figure 1. *Mortality rates (per 100'000 population) from respiratory tuberculosis among males, cross-sectional reports (dotted lines, alternating decades, 1901–1981) and presentation by cohort (solid lines, every decade, 1836–1926).*

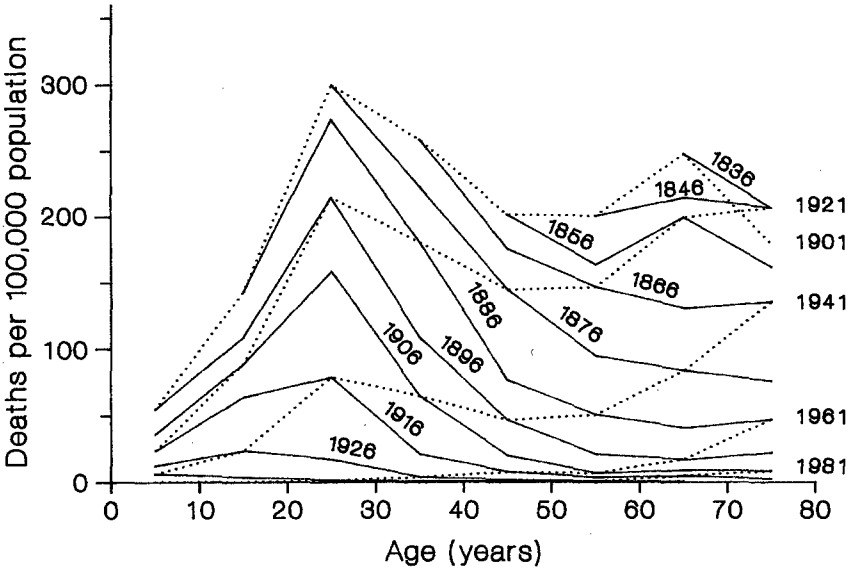

Figure 2. *Mortality rates (per 100'000 population) from respiratory tuberculosis among females, cross-sectional reports (dotted lines, alternating decades, 1901–1981) and presentation by cohort (solid lines, every decade, 1836–1926).*

dotted line). In each decade mortality showed two peaks, one in the 20–29 year-old age group, and a second in persons 60 years old and older. Over the entire observation period mortality decreased in each successive decade. The highest mortality rate among females was recorded in 1901 in the 20–29 year-old age group (300 per 100'000 population.) Analysis by birth cohort shows that in females, as in males, in each cohort tuberculosis mortality was highest in young age groups (Fig. 2, solid line). In the cohorts born between 1886 and 1926, respiratory tuberculosis mortality always peaked in the 20–29 year-old age group.

Discussion

In all industrialized countries which have recorded such data, it has been shown that tuberculosis mortality decreased long before the advent of effective intervention strategies[4–6]. It appears from the available data that the current epidemic in most European countries lasted for several centuries, peaking in London, for example, as early as 1750 or even earlier. Since that time tuberculosis mortality has gradually declined. In other European countries a similar picture emerges, although the peaks of mortality in various places occurred at somewhat different times. The time at which mortality reached its peak is later the further one moves from west to east[4]. Reliable, suitably detailed tuberculosis mortality data have only been available in Switzerland since the beginning of this century.

Mortality data are reliable only to the extent that death certificates, which provide the basis for mortality statistics, are properly completed, a requirement that is often wanting[7]. In particular, it is also not known to what extent deaths attributed to tuberculosis were actually bacteriologically confirmed. Lack of bacteriological confirmation was perhaps particularly likely in the early part of this century when bacteriological tests had just recently been introduced, but failure to do such examinations continues until today[8,9]. Nevertheless, because the slope, i.e., the trend over time, is less liable to bias than the intercept, i.e., the absolute level of mortality, the overall validity of the conclusions presented here is unlikely to have been affected importantly.

As Andvord[10,11] and Frost[12] recognized more than half a century ago, a description of the decline in tuberculosis mortality based only on cross-sections does not tell the whole story. Analyses of other data sets[13–18], similar to that presented here, have repeatedly revealed the same phenomenon. In each successive cohort, with few exceptions, tuberculosis mortality peaked in young adults. What is seen in cross-sectional analysis, i.e., that mortality is highest in the oldest age group, is a mere residual of a much higher mortality that its respective cohort experienced when it was much younger. Three factors have been identified that shape tuberculosis mortality; an age effect, a cohort effect, and a period effect[19]. These three components are not easy to disentangle, because detailed enough information is not always available and both interactions and multicollinearity complicate mathematical modeling[19]. The cohort contour approach applied here to the data from Switzerland shows mainly two components. An age effect is demonstrated by the different magnitude of mortality in different age groups within each cohort. The cohort effect is demonstrated by the distance between the lines and shows how tuberculosis has rapidly decreased between successive birth decades. Period effects would reveal themselves by a departure from simple parallelism of the lines in each successive decade. Such distortions are present, especially in the past 50 years. In the earlier periods the individual lines appear to be fairly parallel, indicating that at that time period effects played a minor role compared with cohort and age effects. A large period effect on tuberculosis mortality would be expected if, for example, wars like the First and Second World Wars greatly affected mortality or if medical interventions such as the introduction of chemotherapy in the 1950s rapidly changed the natural history of the disease. In the data from Switzerland, such effects are difficult to identify, largely because by 1945 the epidemic had already reached relatively low levels.

The difference in the mortality between males and females is striking. Until very recently, mortality in cohorts of young women always exceeded that of young men. It is not entirely clear why this is the case. The gender difference might be explained by differences in the risk of becoming infected, a difference in the risk of developing tuberculosis once infected, a difference in risk of death from tuberculosis among those with the disease, or a combination of these factors. It is conceivable that the risk of becoming infected is different among males and females, and it has been shown that the risk of tuberculosis following infection is higher among young women than among males of the same age[20,21]. While there is no solid evidence that pregnancy increases the risk of tuberculosis[22,23], the post-partum period may incur an increased risk[24], which may partially explain the gender difference in tuberculosis risk and thus fatality in the reproductive age groups. In contrast, after age 44, the risk of tuberculosis once infection has occurred seems to be higher among males than among females[20].

That tuberculosis mortality is highest among young adults in each of the cohorts is best explained by the fact that whenever risk of infection is declining, the majority of persons who ever become infected are infected by age 20 years. Because a short period since infection is one of the most potent risk factors for tuberculosis[25], and cavitary tuberculosis, the most frequent lethal form of tuberculosis, tends to develop in adults rather than in children[2], case fatality is of necessity highest in young adults. For those who survive this period without falling ill from tuberculosis the risk of developing, and succumbing to, tuberculosis decreases constantly as the period since infection increases. Furthermore, the risk of infection with *Mycobaterium tuberculosis* has been decreasing rapidly with the passage of time and the aging of each cohort.

The cohort contour approach to the analysis of Swiss tuberculosis mortality data has also allowed a glimpse much further into the past than the cross-sectional reports can portray. The available data suggest that tuberculosis mortality started to decrease at least since the birth of the 1836 cohort. The pattern further suggests that the latest epidemic wave of tuberculosis in Switzerland may well have peaked in the 18th century.

Zusammenfassung

Mortalität an Tuberkulose der Atmungsorgane in der Schweiz

Das Bundesamt für Statistik publiziert seit 1901 mindestens alle 10 Jahre detaillierte Mortalitätsstatistiken zur Tuberkulose in der Schweiz. Diese Querschnittsdaten zur Mortalität an Tuberkulose der Atemwege wurden benutzt, um die Tuberkulosemortalität innerhalb jeder Geburtskohorte zu untersuchen. Die Analyse zeigt, dass auf Grund der im Querschnitt publizierten Daten die Mortalität mit dem Alter ansteigt, und zwar in jeder sich folgenden Dekade. Werden jedoch die Daten nach Geburtskohorte analysiert, so zeigt sich, dass dieses Phänomen ein Residuum einer sehr viel höheren Mortalität innerhalb der Geburtskohorte darstellt als diese im jungen Erwachsenenalter stand. Die hier vorgestellten Daten weisen auch darauf hin, dass die Tuberkulosemortalität in der Schweiz seit mindestens 160 Jahren abgenommen hat und ihren Höhepunkt vielleicht im 18. Jahrhundert erreicht hatte.

Résumé

Mortalité due à la tuberculose des voies respiratoires en Suisse

Depuis 1901, l'Office fédéral de la statistique publie, au moins une fois par décennie, les statistiques de mortalité de la tuberculose. Les données de mortalité par tuberculose des voies respiratoires de 1901 à 1991 ont été analysées rétrospectivement afin de déterminer le taux de décès pour chaque cohorte de naissance. L'analyse des données transversales (telles qu'elles sont publiées) montre une augmentation de la mortalité avec l'âge dans chaque décade. En revanche, l'analyse par cohorte de naissance montre que cette observation résulte d'une mortalité beaucoup plus élevée parmi les jeunes adultes de chaque cohorte et que la mortalité par tuberculose pulmonaire a toujours touché surtout les jeunes adultes en Suisse. Les données indiquent également que la mortalité due à la tuberculose en Suisse est en diminution depuis au moins 160 ans et qu'elle avait probablement déjà atteint son maximum au cours du 18e siècle.

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Acknowledgement

The authors greatly appreciate the contribution of Dr. R. Kammerlander for his comments on the manuscript and for providing the French version of the abstract.

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