English summary of
Dr. med. Wilhelm WEINBERG

DIE KINDER DER TUBERKULÖSEN

[The children of the tuberculous]

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Prepared by Regina Guthold (gutholdr@who.int) and Alfredo Morabia (alfredo.morabia@qc.cuny.edu) with the assistance of Ronda Ali

Cite as

Address for correspondence:
Center for the Biology of Natural Systems
School of Earth and Environmental Sciences
Queens College - City University of New York
163-03 Horace Harding Expressway
Flushing NY 11365
USA
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Begleitwort
[Preface]

From Obermedizinalrat Prof. Dr. Max von GRUBER, Munich,
chairman of Deutsche Gesellschaft für Rassenhygiene [German Society for Racial Hygiene]

Historically, the use and appreciation of statistics in medical research has had considerable fluctuations. After being widely accepted as a method in other sciences, it will hopefully soon gain favor in medicine, too.

Reasons why statistics in medical research were not as much appreciated as they had been in other areas include their misuse by people who did not understand them well. Basic principles such as clear definitions of populations, completeness of populations / samples, need of comparison of two or more populations, awareness of biases / co-variables, need of calculation of correlation coefficients, etc. were often not well understood. Therefore, it would be important that medical doctors learn to differentiate between good and bad statistics.

I am very happy about this work of a marvelous statistician from Stuttgart, and I am convinced that it will, just as his other works, contribute to a greater appreciation of statistics in medical research. Particularly in research that includes human beings and therefore leaves little freedom for experiments, statistics are a very valuable and helpful method / tool.

The results of this work are of great value, furthermore from a racial hygienic point of view, and include the proof of lower fertility of tuberculous people and higher mortality of children of the tuberculous during their childhood and adolescence. Weinberg's results also indicate that for the spread of tuberculosis, infection plays a great role, but genetic factors are rather non-relevant.

Statistics, however, still can't deliver facts about the etiology of diseases if they are used as the only method, but are very valuable in testing / corroborating hypotheses. Weinberg's work proves this, and I hope he will be given credit for his huge amount of labor.
The subject of this study is the destiny of children up to age 20, born from parents who died from tuberculosis in Stuttgart between 1873 and 1902. The study is based on the family register of Stuttgart combined with diagnoses of deaths from medical doctors. The material includes 200,000 years of life.

Estimated costs for special cards for counting, administrative work, and postage are 2,500 Mark, excluding costs for the time I spent on analysing the material which stretched over approximately ten years. Overall costs should average 6 pennies per analysed year of life, and are only that low due to the excellent family register of Stuttgart.

For financial support, I acknowledge the administration of Stuttgart city, the Stuttgart club of medical doctors, Stuttgart health insurance company, as well as the Robert-Koch foundation who also supported the work although some management members were against supporting any kind of statistical work. I also acknowledge the many persons who gave me access to registries and information, or helped in following up studied persons who moved, including Mayor von GAUSS, Dr. RÖSSGER, Mister HEIM, and Prof. Dr. RIFFEL.

Stuttgart, 24th April 1913.
Wilhelm WEINBERG
Einleitung
[Introduction]

Robert KOCH has often criticized the use of statistical methods, which is, taking his frequent misuse into account, not surprising. His last publication in the journal “Hygiene”, however, proves that he didn’t fully refuse their use.

Statistics, along with experiments, are very important methods for receiving valuable results, particularly in sciences involving human beings such as social medicine. In research on tuberculosis, they play an important role and bring up the idea that this disease is influenced by social factors and might be infectious.

Recent research, including KOCH’s identification of the human type of the tuberculosis bacterium, and BEHRING’s finding that baby age plays an important role for getting infected with tuberculosis, brought attention with regards to the spread of tuberculosis more and more towards sick individuals as well as their closest family.

The interest in families of tuberculous individuals has always been remarkable among another branch of research on tuberculosis, too, which sees genetics as the main influential factor for generation of tuberculosis. The main interest of this branch, however, is the mortality of children of the tuberculous along with the number of their children, as many people think tuberculous individuals might be over-fertile.

In addition, life insurance companies have a practical interest in mortality of children of tuberculous due to financial reasons.

Therefore, the questions which need to be answered using statistical methods are:
1. Do relatives (in particular: children) from tuberculous individuals have a higher morbidity / mortality from all causes / from tuberculosis?
2. What are the influence factors?
3. Do tuberculous individuals have a higher fertility?

(1) With respect to the first question, a lot of research, mainly looking into frequencies of tuberculous individuals within families, has already been conducted. Regarding mortality of children from the tuberculous, three main studies (from KIRCHNER, WESTERGAARD, and REICHE) have proved that they have a higher mortality from tuberculosis, each of them having, however, their limitations. All three only looked into the mortality from tuberculosis, not from all causes, and none of them could prove either the theory that tuberculosis is an infectious disease, nor that it is a genetic disease.

(2) But now that the tuberculosis bacterium has been identified, a theory purely based on genetics is old-fashioned anyway. Therefore, the question has to be what other factors, along with infection, influence mortality from tuberculosis. Methods for finding potential influence factors include elimination of social influence factors, e. g. by comparing families with similar social background, dividing the material in children born before / after parent’s infection with tuberculosis, looking into the order of children, as well as into the age of children at parent’s death from tuberculosis.
(3) To find an answer to question three is important, and not only from a racial hygienic point of view. We also need to know about the fertility of tuberculous individuals given the danger that they might infect their children. Only by looking into the mortality of children of the tuberculous, we can find out the net fertility, meaning the number of children reaching reproductive age, of the tuberculous.

Methods for answering these types of questions are always based on comparison of mortality rates, meaning comparison of deaths in different groups with living individuals or life years, and include four different ways:

- Comparison of families from persons who died at the same time,
- Comparison of children from tuberculous with children in the whole population living at the same time,
- Comparison of children from individuals born at the same time,
- Comparison of children from persons who were born and lived at the same time.

In this work, however, only the first two ways could be conducted, due to the material given. In addition, I calculated correlations, a method which has not been used very often in statistical medicine.
1. Allgemeiner Teil [General part]

1. Kapitel [Chapter 1]

Das Material der Untersuchung, seine Quellen und Aufbereitung [Material, sources and methods of the study]

Material of the study were children of tuberculous individuals dying in Stuttgart between 1873-1902 from tuberculosis, including:
3,246 families with 11,141 children from tuberculous fathers,
2,022 families with 6,911 children from tuberculous mothers, adding up to 18,052 children (children with tuberculous father and mother were counted twice).

Children whose mother or father died before 1889 could be followed up until their 20\textsuperscript{th} year of life, others had shorter follow-up time.

The study is based on two main sources of information: death certificates from medical doctors in Stuttgart, and the Stuttgart family register. The information was put together in special cards for counting, called family cards (example on page 13). Both sources of information were very reliable. Death certificates from all married persons who died in Stuttgart between 1873 and 1902 include only 5.6\% of deaths for which the cause tuberculosis was not fully confirmed, mainly concerning persons older than 60 years. Death certificates give information on cause of death, name, marital status, profession, age, date of birth / death, as well as place of residence.
The family register displays information on names of family members, place and date of births / deaths of family members, dates of marriage / divorce, name of husband / wife of children with corresponding (new) place of residence, illegitimate children of mother / daughters. Illegitimate children, however, have not been taken into account due to financial reasons.

The following methodological decisions were made:
- Deaths from tuberculosis which had not been fully confirmed were treated as cases in order to avoid selection bias as those cases may have been poor individuals not being able to afford treatment. Including them, however, did not change the results.
- Persons with no permanent residence in Stuttgart were excluded.
- Tuberculous individuals from Stuttgart who were treated and died elsewhere were excluded. Looking into a sub-sample of those revealed that there were only very few who also died elsewhere.
- With regards to children from to Stuttgart immigrated tuberculous persons, registry offices from former places of residence were contacted, leaving only 23 children whose exact age at death was unknown (0.27\% of total children deaths). As it was known that they all died very young, and given that most children died in their first year of life, these were counted as cases who died within the first year of life.
- Due to financial and organizational reasons, persons who emigrated from Stuttgart could not be included. Hence, their age at emigration was noted and two categories were set up. Category one included children emigrating without their family (females leaving for elsewhere before reaching age 20 due to marriage), category two included children emigrating with their whole family (mainly males).
The table on page 12 gives information, where available, on emigrated children which were excluded: age of parents, time of death of parents, number of children in the family, ranking number of child who died in order of siblings, age of child who died at emigration/death. Weinberg notes that it is very important to closely look into the characteristics of these emigrated children in order to know / prevent bias.

Finding causes of death other than / distinct from tuberculosis turned out to be very difficult and time consuming, and included consulting autopsy books, death certificates, and registry offices for emigrated children. For a total of 10 cases of children who died in Stuttgart, and 81 cases (4.31%) aged 1 year or older and dying elsewhere, exact causes of death could not be determined.
Limitations of the study are:

- Exclusion of illegitimate children,
- Limitation of follow-up to 20 years,
- No separation of the material by gender.

An advantage of the study, however, is that children from all marriages of a tuberculous individual were taken into account.
3. Kapitel [Chapter 3]

Die Auszählung des Materials
[Enumeration of the material]

In order to answer questions on the mortality of children from the tuberculous, such as deaths in total, deaths by age-group, deaths during specified time periods, it has been necessary to count every single child’s death and emigration, as well as the number of children in total. Therefore, using the information from the death certificates and the family register, which was put together in family cards, a variety of tables were made, depending on the question posed.

As a starting point of the work, using the family cards, 60 Grundtabellen [basic tables] were created, one for each year of death (1873-1902) and gender of parents, including all relevant information for the objectives (for example, a tuberculous mother who died in 1879 on page19, Abbildung B). Each row of these tables represents a year of birth of children. The rows are subdivided into the categories birthday of child before (α) or after (β) date of death of mother. Hence, adding values of the two rows of a specific year, e.g. 1876, gives numbers / deaths / emigrations of children who were three (or four) years old when their tuberculous mother died. Columns contain information on timely distance of death / emigration of child to death of parents, for example, a, c, g, and l mean emigration / death of child more than 5 years before parents died. Specific meanings of letters / signs in the table are:

T = dead born child,
0 = child died at age 0,
24 = child died at age 24,
19T = child died at age 19 from tuberculosis,
(11) = child emigrated at age 11,
[23] = child died elsewhere at age 23,
l = child still alive in 1909.

These basic tables were also used for counting numbers / deaths / emigrations of children for the whole time period 1873-1902, as well as for the three decades 1873-1882, 1883-1892, and 1893-1902.

Transforming these basic tables as well as counting their contents in different ways helped to create 26 Urtabellen [origin tables] which were used for further calculations to achieve the actual results. These Urtabellen [origin tables] mainly contained information on deaths, emigrations, and population sizes at different points of time or different occasions.

However, for creation of the Urtabellen [origin tables], intermediate steps had to be conducted, presented as Hilfstabellen [backup tables]. The table on page 21 (Abbildung C) gives an example, and includes information on number, deaths and emigrations of children born three years before their tuberculous mother died. These tables were produced for every timely distance of birth of children from death of parents, as well as for each gender of parents, and led to Urtabellen [origin tables] XI and XII, presented in chapter 12.

For being able to look into other factors which might influence mortality of children from the tuberculous, methods were more complicated. The tables on pages 23, 25, 27 (Abbildung D, E, F) were created for getting information on the numbers of children living 5 years before tuberculous mother / father died, of those living at parent’s death, and those living 5 years after tuberculous mother / father died. This exercise was undertaken in order to find out if
timely distance / closeness to parent’s death from tuberculosis influenced the mortality of their children.

Abbildung D, page 23, shows total numbers of children for those who lived at death of the father, using numbers from Grundtabellen [basic tables]. According tables were made for being alive 5 years before tuberculous father died, and 5 years after tuberculous father died, as well as for mothers.

Abbildung E, page 25 is another Hilfstabelle [backup table] which shows numbers of children living 5 years after death of tuberculous mother (information from Grundtabellen [basic tables]), as well as deaths and emigrations during this period (information from Hilfstabellen [backup tables]).

The table on page 27, Abbildung F, also a Hilfstabelle [backup table] shows numbers of children living 5 years before their tuberculous father died as well as numbers of children born less than 5 years before their tuberculous father died. These numbers were used later on as the denominator for calculation of mortality of children who lived 5 years before their tuberculous father died.
4. Kapitel [Chapter 4]

Die weitere rechnerische Bearbeitung des Materials
[Further calculations with the material]

a) Calculation of total number of observations in general, if not already available.

As shown in Urtabellen [source tables] II A, II B and III on pages 40-42, what is known so far
is the number of families with different numbers of children. The number of observed
children can be calculated by multiplying and then adding the values. These results were used
in chapters 6-8, 10, 11, 13, 14.

b) Calculation of total number of observations for specified time periods.

There are two approaches:

- Calculation of observations at the start of a time period:
  Example: number of observations at start of 2\textsuperscript{nd} year of life = number of observations at
  start of 1\textsuperscript{st} year of life – emigrations – deaths.
  However, comparing deaths occurring during a specific year with the number of
  observations at the beginning of this year doesn’t give an accurate measure of mortality,
  due to emigrations. Therefore, lifetime of emigrated observations should only be counted
  by half as much:
  Number of observed years of life = number of observations at start of year of observation
  – number of emigrations during year of observation / 2.

- Average number of observations at the mid-point of a time period:
  Average number of observations at mid-point of a specified time period = observed years
  of life during this period – deaths within this period / 2.

c) Calculation of ratios, including creation of life tables and calculation of correlation
coefficients.

- The “likelihood” of an individual at start of a specified year of life to die within this
  year of life = deaths at this specified age / number of observed years at this age.
- Another measure for comparison of mortality is the “intensity of mortality”, which
  equals deaths within this period / average number of observations at the mid-point of a
  time period.

For comparison of mortality of different groups during one specified time period, it doesn’t
matter which method is chosen, but the two measures should never be compared against each
other, as the “intensity of mortality” is always bigger than the “likelihood”.

For determining the likelihood of dying during consecutive time periods, however, the first
method should be used, and this calculation is based on the likelihood of surviving (likelihood
of dying + likelihood of surviving = 1). For construction of a life table, values of consecutive
time periods have to be multiplied.

These calculations are complicated, mainly due to emigrations, which could not be omitted in
this analysis in order to know the exact number of observed years of life.
In general, calculation of the “likelihood” of dying is not the most accurate measure, as, e.g., the result always equals 1 if we look at the likelihood of a baby to die before it reaches 100 years. Hence, the most accurate measure of mortality is the comparison of number of observed years of life with number of deaths, though it can be quite complicated to calculate (formulas on page 32).

For determining the influence of a specific factor, we can now compare the observed and expected values of different groups, using the same ratios. Doing so, it is very important to only compare groups which are comparable, and to be aware of potential biases. As for example, when comparing mortality of different professions, age could be a bias, and therefore numbers for comparison should be age-standardized.

Another possible bias stems from the fact that comparing two mortality numbers that are low, or comparing two numbers that are high with one another, leads to very different results. This is also a problem when either comparing changes in mortality, or changes in survival. Therefore, in cases like that, we should calculate correlation coefficients, e.g. BRAVAIS, which take both mortality and survival into account (formula on page 33). The only problem with this method is that the maximum value of 1 (strongest correlation) will only be the result if, when looking into two different factors (e.g. tuberculous parents – non tuberculous parents and death – no death), frequencies are exactly the same.

Formulas for another possible calculation of correlation, for which only differences between observed and expected values, but not frequencies matter, are shown at the bottom of page 33. If the result is 0, there is no difference between observed and expected mortality. Two examples using this method are given at the bottom of page 34 and on page 35.

The method used in chapter 14, calculation of contingency coefficient C is different again. The formula is shown on page 34, and the exact explanation of this method is given in another book, GROTJAHN’S “Handwörterbuch der sozialen Hygiene” [Dictionary of social hygiene].
5. Kapitel [Chapter 5]
Übersicht über den Umfang und die Zuverlässigkeit des Materials
[Overview of amount and reliability of the material]

The material includes data from 5,309 families. Data from 4 families could not be used due to inaccurate information (Urtabelle [source table] I on page 36 gives information on these four families). Therefore, data from 5,305 families with father, mother, or both dying from tuberculosis could be used, including 18,206 children (some are counted double if mother and father died from tuberculosis), and specifically:

6,322 children from 1,897 tuberculous fathers who died 1873-1889,
4,016 children from 1,168 tuberculous mothers who died 1873-1889,
4,916 children from 1,375 tuberculous fathers who died 1890-1902,
2,958 children from 865 tuberculous mothers who died 1890-1902.

Due to limitation of follow-up until 1909, only for the families with mother or father dying from tuberculosis between 1873-1889, all children could be followed up until age 20. Having not yet reached 20 years old in the year 1909 were 436 children of tuberculous fathers and 341 children of tuberculous mothers.

Looking into the deaths (including deaths after emigration) and emigrations of children, there were:
2,932 deaths and 359 emigrations in families with father dying from tuberculosis 1873-1889,
1,916 deaths and 227 emigrations in families with mother dying from tuberculosis 1873-1889,
2,213 deaths and 260 emigrations in families with father dying from tuberculosis 1873-1889,
1,425 deaths and 135 emigrations in families with mother dying from tuberculosis 1873-1889,

adding up to 8,486 deaths in total.

Observed years of life of children are:
70,862.5 in families with father dying from tuberculosis 1873-1889,
44,446.5 in families with mother dying from tuberculosis 1873-1889,
54,906.5 in families with father dying from tuberculosis 1890-1902,
31,258 in families with mother dying from tuberculosis 1890-1902,

adding up to 201,475.5 years of life in total.

Assuming that approximately 22% of parents within a city of 2.5 million inhabitants suffered from tuberculosis, this amount of observed years would cover one observed year for all children from tuberculous parents in this city.

The “average error” of this study (in percent of observed deaths) is 1.07. Formulas for its calculation are shown at the bottom of page 37 and on page 38.
6. Kapitel [Chapter 6]

Die Bruttofruchtbarkeit der Tuberkulösen
[Gross fertility of the tuberculous]

We have to distinguish between gross fertility and net fertility. Here, gross fertility means the total number of children from tuberculous individuals; net fertility means the number of children who reached the 20\textsuperscript{th} year of life.

Urtabellen [source tables] II A and II B on pages 40 and 41 show frequencies of tuberculous fathers/mothers by age at death and number of children in the family.

In total, the 5,305 tuberculous individuals had 18,212 children, including double counted, and an average equivalent of:

- 3.435 children per tuberculous father dying 1873-1902,
- 3.33 children per tuberculous father dying 1873-1889,
- 3.430 children per tuberculous mother dying 1873-1902,
- 3.44 children per tuberculous mother dying 1873-1889.

Looking into the number of marriages reveals that per marriage, averages were
- 3.16 children per tuberculous individual,
- 3.08 children per tuberculous father,
- 3.31 children per tuberculous mother.

Excluding the families with both father and mother suffering from tuberculosis (286 families with 911 children) gives the following results:
- 3.07 children per tuberculous father,
- 3.33 children per tuberculous mother.

Urtabelle III on page 42 shows those tuberculous individuals who were married more than once by age and age at death.

In conclusion, tuberculous women have a higher fertility than tuberculous men.

The fact that women marry at a younger age than men, however, doesn’t fully explain this difference in fertility, as looking into the age distribution of the sample (table on top of page 43) reveals that women were a lot younger than men when they died.

The best method for determining whether or not tuberculous individuals have a higher fertility than the non-tuberculous would be a direct comparison of both populations.

This was only possible with a sample of living non-tuberculous females in Berlin in 1885. The table at the bottom of page 43 shows that women with many children among the tuberculous are more frequent than expected:

<table>
<thead>
<tr>
<th>Observed nr. of women</th>
<th>Expected nr. of women</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Stuttgart)</td>
<td>(based on Berlin data)</td>
</tr>
<tr>
<td>0 children</td>
<td>80.5</td>
</tr>
<tr>
<td>1 child</td>
<td>96.3</td>
</tr>
<tr>
<td>2-3 children</td>
<td>103.9</td>
</tr>
<tr>
<td>4-6 children</td>
<td>103</td>
</tr>
</tbody>
</table>
Possible explanations may be that women who were already suffering from tuberculosis may not have married at all, or that in Stuttgart, not only among the tuberculous but in general, women tended to have more children than those in Berlin.

In order to compare the fertility in tuberculous with non-tuberculous, non-tuberculous individuals dying in Stuttgart from causes other than tuberculosis have been identified for the years 1876, 1879, and 1886, using the same methods used for the tuberculous. These years have been chosen as being representative for the period of 1873-1889.

Urtabelle [source table] IV on page 44 shows non-tuberculous individuals dying 1876, 1879, and 1886 by age of death and number of children.

The comparison gave an average number of children of
3.33 for tuberculous men,
3.44 for tuberculous women,
4.41 for non-tuberculous men,
3.87 for non-tuberculous women,

and a percentage of individuals whom had no children of
21.7 for tuberculous men,
17 for tuberculous women,
16.1 for non-tuberculous men,
20.4 for non-tuberculous women.

These results clearly show a decreased fertility of the tuberculous which is, however, mainly due to a younger age at death of the tuberculous as compared to the non-tuberculous.

Therefore, a comparison of the average number of children by age-group is necessary:

<table>
<thead>
<tr>
<th>Died at age</th>
<th>TB Males</th>
<th>TB Females</th>
<th>non TB Males</th>
<th>non TB Females</th>
</tr>
</thead>
<tbody>
<tr>
<td>20-30</td>
<td>1.34</td>
<td>1.73</td>
<td>1.06</td>
<td>1.62</td>
</tr>
<tr>
<td>31-40</td>
<td>2.7</td>
<td>3.58</td>
<td>2.66</td>
<td>3.33</td>
</tr>
<tr>
<td>41-50</td>
<td>3.65</td>
<td>4.53</td>
<td>3.92</td>
<td>3.49</td>
</tr>
<tr>
<td>51-60</td>
<td>4.05</td>
<td>3.56</td>
<td>4.07</td>
<td>3.64</td>
</tr>
<tr>
<td>61-70</td>
<td>4.64</td>
<td>4.21</td>
<td>4.87</td>
<td>4.51</td>
</tr>
<tr>
<td>71-x</td>
<td>5.60</td>
<td>4.48</td>
<td>5.48</td>
<td>4.37</td>
</tr>
</tbody>
</table>

Overall, taking into account that within the 10-year age-groups, tuberculous individuals may die earlier, and that there might be selection bias with regard to social class, we can conclude that fertility is relatively lower for the tuberculous as compared to the non-tuberculous.

In addition, I looked into the fertility of tuberculous individuals during their last year of life. This analysis showed an over-fertility of tuberculous women and a very low fertility of tuberculous men during their final year of living.
Determining the frequency of children born of tuberculous individuals is complicated due to the differences in fertility of tuberculous and non-tuberculous persons, and because some children have both tuberculous mothers and fathers. For giving exact frequencies, we would need to know fertility as well as causes of death for a whole generation, which is not possible in this work. Here, we can only compare those dying from tuberculosis with those dying from other causes in 1876, 1879, and 1886.

Among those dying in these three years, there were
367 men dying from tuberculous having 1,149 children (3.13 per individual),
912 men dying from other causes having 4,019 children (4.41 per individual),
200 women dying from tuberculous having 736 children (3.68 per individual),
918 women dying from other causes having 3,555 children (3.87 per individual).

Hence, 28.5% of males and 17.9% of females died from tuberculosis during these three years. 22.24% of children were born from tuberculous males, and 17.15% from tuberculous females, adding up to 39.39%. This percentage is too big as we have to take families with both tuberculous mothers and fathers into account.

From my earlier work, we know that observed compared to expected frequencies of tuberculous women being married to a tuberculous man are 175 : 100, and those for tuberculous men being married to a tuberculous woman 253 : 100.

Therefore, we estimate that 28.5% * 0.179 * 2.53 = 12 % of tuberculous men who are married to tuberculous women, and 17.9% - 12% = 5.9% of non tuberculous men are who married to tuberculous women.

Hence, taking the fertility of tuberculous men into account, there would be
1,149 + (367+912) * 0.050 * 3.13 = 1,349 children from men who died from tuberculosis, which equals 1,349 / 5,168 = 26% of children born from all men dying in 1876, 1879, or 1886.

The same calculations for women give a percentage of 36% of children born from women dying from tuberculosis out of those born from all women dying in 1876, 1879, or 1886.

However, two other factors should be taken into account which lower the frequency of children from tuberculous parents:

- Tuberculous individuals die at a younger age than the non tuberculous, and therefore the number of tuberculous couples is probably an underestimation of their true frequency, and
- Decrease in frequency of tuberculosis.

In conclusion, we can estimate that approximately a fifth to a sixth of all children living from 1873-1902 were born from parents who died from tuberculosis.
8. Kapitel [Chapter 8]

Allgemeine Ergebnisse über die Sterblichkeit der Kinder der Tuberkulösen bis zum 20. Lebensjahr
[General results on the mortality of children from tuberculous parents until their 20th year of life]

1. Total mortality

Using values from Urtabellen [source tables] II, IV, VII, VIII, three mortality tables were made for the years 1873-1902, 1873-1889, 1890-1902. Only the first mortality table exclusively includes children who have been followed up for 20 years, so this one is the most important (table 1 on page 53).

According to this table, the likelihood of dying within the first 20 years of life is:
- 0.4682 for children with tuberculous father,
- 0.4811 for children with tuberculous mother,
both of them including cases with both tuberculous father and mother, and taking emigrations into account.

We should now look into questioning whether it would have made any difference had emigrations not been taken into account. By trying to answer this question, we can also find out the number of unknown deaths of emigrants. However, assuming the same mortality for emigrants would probably lead to an overestimation of deaths among the emigrated, as it is likely that emigrants are relatively healthy.

Comparison of results with and without taking emigrants into account:

<table>
<thead>
<tr>
<th></th>
<th>with</th>
<th>without</th>
<th>difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mortality of children with tuberculous father:</td>
<td>46.57%</td>
<td>46.82%</td>
<td>0.25%</td>
</tr>
<tr>
<td>Mortality of children with tuberculous mother:</td>
<td>47.78%</td>
<td>48.11%</td>
<td>0.32%</td>
</tr>
</tbody>
</table>

To find out the number of unknown deaths of emigrants:

6,322 children of tuberculous fathers (total from 1873-1889) * 0.4682 = 2,960 estimated deaths in total (while 2,943 have been observed for non-emigrants) → 17 estimated deaths among emigrants.

4,016 children of tuberculous mothers (total from 1873-1889) * 0.4820 = 1,936 estimated deaths in total (while 1,919 have been observed for non-emigrants) → 17 estimated deaths among emigrants.

Out of the 17 estimated deaths for emigrated children from tuberculous fathers, 11 could actually be determined after children emigrated.
Out of the 17 estimated deaths for emigrated children from tuberculous mothers, only 2 could be determined after children emigrated.

Overall, results would not have been very different if emigrations were left unaccounted for. As we will see in the following chapters, the difference is mainly caused by children still being very young when their parents emigrated.
The next question has to address whether or not the estimations for the mortality are too high. For answering this question, the best method would have been to look into the mortality of the total population between 1873-1889, but as there was no data available, conducting this method was not possible.

Therefore, individuals dying from causes other than tuberculosis in the years 1876, 1879 and 1886 were taken as a group for comparison again, also taking emigrations into account.

Results of this comparison with regards to the likelihood of dying in their first 20 years of life:

For children from tuberculous father: 46.82%
For children from non tuberculous father: 40.27%
For children from tuberculous mother: 48.11%
For children from non tuberculous mother: 40.17%

We can clearly see a higher mortality for children from tuberculous parents.
Looking into a mortality table of an urban population (Stuttgart, years 1873 / 82), out of 100 children born, 43.57 died before reaching their 20th year of life.

The following “mortality intensities” (i) have been calculated (risk divided by survived years):

For children from tuberculous father:  \( i = \frac{0.4682}{11.56} = 0.0407 \) / yr
For children from non tuberculous father:  \( i = \frac{0.4027}{12.73} = 0.0317 \) / yr
For children from tuberculous mother:  \( i = \frac{0.4811}{11.40} = 0.0424 \) / yr
For children from non tuberculous mother:  \( i = \frac{0.4017}{12.76} = 0.0315 \) / yr

We can see that the difference in mortality is even higher when looking into mortality intensities.

Looking into the duration of life also shows a big difference between children from tuberculous parents and those from non tuberculous parents.
When assuming a further duration of life of 40 years, average duration of life would be:
For children from tuberculous father:  \( 11.5 + (1-0.4682) \times 40 = 32.8 \) years
For children from non tuberculous father:  \( 12.73 + (1-0.4027) \times 40 = 36.6 \) years
For children from tuberculous mother:  \( 11.36 + (1-0.4811) \times 40 = 32.1 \) years
For children from non tuberculous mother:  \( 12.76 + (1-0.4017) \times 40 = 36.7 \) years

This difference (3.8 years for children from tuberculous fathers and 4.6 years for children from tuberculous mothers) is probably an underestimation, because mortality of children from the tuberculous is still higher after reaching their 20th year of life.

The causes and possible influence factors of these differences in mortality such as age of parents, order of children, date of birth of children, and social class will be examined in the following chapters.

The question of whether mortality is lower for the children born from tuberculous parents dying between 1890-1902 also needs to be answered.
Results of this comparison are per 100 children for:
Children with tuberculous father who died 1873-1889: 46.83 deaths,
Children with tuberculous father who died 1890-1902: 45.50 deaths,
Children with tuberculous father who died 1873-1902: 46.08 deaths,
Children with tuberculous mother who died 1873-1889: 48.20 deaths,
Children with tuberculous mother who died 1890-1902: 48.87 deaths,

However, the values for the years 1890-1902 have to be interpreted with caution due to potential selection bias (by only taking children with complete 20 year follow-up into account).

Seeing no decrease in mortality should not be taken too seriously: mortality from tuberculosis in the total population has been decreasing since 1873, while average population numbers increased:
1873-1889: 118,037
1890-1902: 160,211.

Therefore, the number of children (per 1,000) losing either mother or father dying from tuberculosis were on average per age group, 5 for the years 1873-1889, and 4 for the years 1890-1902. So, the relative number of exposed children decreased.

2. Mortality by age-group

The table at the bottom on page 56 and the top of page 57 shows mortality of children born from tuberculous father and mother who died 1873-1889 by 1-year age-groups.

In spite of the large amount of material, we can see differences in mortality for different age-groups, and for most ages, a higher mortality for children born from tuberculous mothers, an exception being mortality at birth. This exception will be explained in chapter 16.

Looking into higher age-groups doesn’t change these results (table at the bottom of page 57), and comparing them with the mortality in Stuttgart, Germany and Württemberg (table on top of page 58) shows that mortality of children from the tuberculous is particularly high for ages 1-5 and 16-20.

The comparison of children born from tuberculous parents dying 1873-1889, with children who were born from non tuberculous parents dying in 1876, 1879, 1886 shows the following mortality (in % of total observations):

<table>
<thead>
<tr>
<th>Child died</th>
<th>father died from TB</th>
<th>father died not from TB</th>
<th>mother died from TB</th>
<th>mother died not from TB</th>
</tr>
</thead>
<tbody>
<tr>
<td>At birth</td>
<td>4.13</td>
<td>4.8</td>
<td>3.81</td>
<td>5.46</td>
</tr>
<tr>
<td>1st year of life</td>
<td>29.88</td>
<td>23.77</td>
<td>30.52</td>
<td>23.28</td>
</tr>
<tr>
<td>2nd - 5th year of life</td>
<td>3.85</td>
<td>3.17</td>
<td>4.03</td>
<td>2.92</td>
</tr>
<tr>
<td>6th - 10th year of life</td>
<td>0.67</td>
<td>0.63</td>
<td>0.66</td>
<td>0.57</td>
</tr>
<tr>
<td>11th - 15th year of life</td>
<td>0.32</td>
<td>0.3</td>
<td>0.36</td>
<td>0.31</td>
</tr>
<tr>
<td>16th - 20th year of life</td>
<td>0.63</td>
<td>0.37</td>
<td>0.81</td>
<td>0.47</td>
</tr>
</tbody>
</table>

Table 2 on page 59 shows emigrations, number of children alive after follow-up, deaths, observed years of life by 1 year age-groups for children born from parents who died from tuberculosis between 1890-1902, while table 3 on page 60 shows similar elements for all children.
Table 4, page 61, gives groups for years of death of parents, number of observations, number of deaths, and distribution of deaths by larger age-groups.

Table 5 at page 62 gives the mortality table including emigrations, deaths, observed years of life by 1 year age-groups for children of parents who died in 1876, 1879, and 1886 from causes other than tuberculosis.
2. Spezieller Teil [Specific part]

9. Kapitel [Chapter 9]

Die Sterblichkeit der Kinder zweier tuberkulös er Eltern
[Mortality of children having both tuberculous father and mother]

The problem about this topic is that so far, we don’t know the total amount of children with both tuberculous mother and father because:

- Some of the husbands / wives of the individuals who died from tuberculosis are still alive,
- Difficulty of knowing deaths and reasons of deaths for the emigrants who died,
- Difficulty of knowing deaths and reasons of deaths for those who died before 1873.

Thus, it’s not possible to compare children from families with either mother or father dying from tuberculosis with children from families with both mother and father dying from tuberculosis, but it is possible to only look into those children with both parents dying from tuberculosis between 1873 and 1902, and compare them to the rest. 911 children from 286 marriages could be identified of which both tuberculous mother and father died from tuberculosis. Urtabelle [source table] V on page 64 gives information on amount, emigrations, deaths, and observed years of life for these children.

According to this table,
52.44% of the children with both parents dying from tuberculosis died during their first 20 years of life, compared to
46.73% of the children from father dying from tuberculosis, and 48.21% of the children from mother dying from tuberculosis.

This demonstrates that children with both parents dying from tuberculosis had a very high mortality.

The mortality by age-groups was (also shown in table 6 on page 64):

<table>
<thead>
<tr>
<th></th>
<th>Both mother and father died from tuberculosis</th>
<th>Father died from tuberculosis</th>
<th>Mother died from tuberculosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>At birth</td>
<td>4.06%</td>
<td>3.88%</td>
<td>3.54%</td>
</tr>
<tr>
<td>In the 1st year of life</td>
<td>31.92%</td>
<td>29.51%</td>
<td>30.89%</td>
</tr>
<tr>
<td>In the 2nd – 5th year of life</td>
<td>5.93%</td>
<td>3.78%</td>
<td>3.86%</td>
</tr>
<tr>
<td>In the 6th – 10th year of life</td>
<td>0.72%</td>
<td>0.64%</td>
<td>0.66%</td>
</tr>
<tr>
<td>In the 11th – 15th year of life</td>
<td>0.30%</td>
<td>0.29%</td>
<td>0.37%</td>
</tr>
<tr>
<td>In the 16th – 20th year of life</td>
<td>1.14%</td>
<td>0.69%</td>
<td>0.85%</td>
</tr>
</tbody>
</table>

The mortality is particularly high during the 1st – 5th and 16th – 20th years of life.
Looking into the mortality of children whose parents both died within a five-year time period shows that for them, mortality is even higher. 490 of these children could be identified. Their mortality was 54.42% (see Urtabelle [source table] VI and table 7 on page 65).

Mortality by age-groups of the children with mother and father dying from tuberculosis within a five-year time period:

- At birth: 5.31%
- In the 1st year of life: 34.27%
- In the 2nd – 5th year of life: 4.53%
- In the 6th – 10th year of life: 1.21%
- In the 11th – 15th year of life: 0.42%
- In the 16th – 20th year of life: 1.01%

Compared to other children with both mother and father dying from tuberculosis, the mortality of these children is particularly high during their 1st and 6th – 15th years of life.

This high mortality of children with both mother and father dying from tuberculosis can explain part of the difference in the mortality between children from tuberculous fathers and those from tuberculous mothers, because the cases with both tuberculous parents have a high percentage in the marriages of tuberculous mothers. Removing all children with tuberculous mother and father from the analysis would probably lead to a similar mortality of children from tuberculous mothers and those from tuberculous fathers.

However, the influence of having both tuberculous mother and father on mortality should not be overestimated.

If we assume that the number of couples having both mother and father suffering from tuberculosis, and do the calculations without them, we would still get high mortality for children from tuberculous parents (using fathers as a start point: 44.7%, using mothers as a start point: 46.8%).
10. Kapitel [Chapter 10]

Die Sterblichkeit der Kinder nach dem Todesalter der tuberkulösen Eltern
[Mortality of the children by age at death of their tuberculous parents]

Information shown in Urtabellen [source tables] II (page 40-41) and IV (page 44) was used to create Urtabellen [source tables] VII and VIII (pages 68-73), as well as Tabellen 8 and 9 (pages 74 and 75). Urtabellen [source tables] VII and VIII show number of deaths, emigrations and observed life years of children born from father, mother dying from tuberculosis 1873-1889, father, mother dying from tuberculosis 1890-1902, and father, mother dying from other causes in 1876,1879, and 1886, for one-year age groups, and by age at death of parents.

Using information from Urtabellen [source tables] VII and VIII, logarithms of the likelihood of surviving were calculated (shown in Tabelle 8 and 9, pages 74 and 75). Using the numbers from Urtabelle VII and VIII, he summed the logarithms to get the number of children who survived their 20th year of life. For these calculations, only years of death of parents 1873-89 were used.

During the first 20 years of their life, children who died per 100 births were:

<table>
<thead>
<tr>
<th>Age of tuberculous parents:</th>
<th>Children born from tuberculous father</th>
<th>Children born from tuberculous mother</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;30</td>
<td>53.22%</td>
<td>54.63%</td>
</tr>
<tr>
<td>30-40</td>
<td>48.45%</td>
<td>49.44%</td>
</tr>
<tr>
<td>40-50</td>
<td>48.94%</td>
<td>49.90%</td>
</tr>
<tr>
<td>50-60</td>
<td>45.50%</td>
<td>42.96%</td>
</tr>
<tr>
<td>60-70</td>
<td>41.85%</td>
<td>35.78%</td>
</tr>
<tr>
<td>&gt;70</td>
<td>44.40%</td>
<td>47.30%</td>
</tr>
</tbody>
</table>

We see that the mortality of children decreases with increasing age of their tuberculous parents. The same is true for children from non-tuberculous parents. According to the years of death 1879 and 1886, the following percentages of children from non tuberculous parents died before reaching age 20:

<table>
<thead>
<tr>
<th>Age of non tuberculous parents:</th>
<th>Children born from non tub. father</th>
<th>Children born from non tuberculous mother</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;20</td>
<td>47.73%</td>
<td>43.41%</td>
</tr>
<tr>
<td>20-30</td>
<td>55.03%</td>
<td>54.02%</td>
</tr>
<tr>
<td>40-50</td>
<td>39.88%</td>
<td>45.58%</td>
</tr>
<tr>
<td>50-60</td>
<td>40.07%</td>
<td>39.16%</td>
</tr>
<tr>
<td>60-70</td>
<td>39.32%</td>
<td>41.17%</td>
</tr>
<tr>
<td>&gt;70</td>
<td>38.45%</td>
<td>37.20%</td>
</tr>
</tbody>
</table>

[Note: in the original document, age-group 30-40 is missing in this table]

The mortality pattern according to age of parents at death is similar for children born from tuberculous and those born from non tuberculous parents. Differences in mortality however, can partly be explained by tuberculous parents dying at a younger age as compared to non tuberculous parents. But the mortality of children from tuberculous parents is higher for almost all ages of parents when compared to the mortality of children from non tuberculous parents.

According to WESTERGAARD, PÖLZ found a similar trend regarding the mortality of children from parents who died at different ages (without looking into the reasons of death).
PRINZIG explained this trend with the decrease in frequency of tuberculous individuals with increasing age. However, the results here show that this explanation is not correct.

The table at page 76 shows the mortality of children by age-group and by age at death of parents. T means tuberculous parents, N means non tuberculous parents. In this table, all years of death of tuberculous parents (1873-1902) are included, as opposed to only 1873-1889. Being that the time of observation was about 7 years earlier for children from non tuberculous parents as compared to children from tuberculous parents, the difference in mortality is probably underestimated.
Die Nettofruchtbarkeit der Tuberkulösen
[Net fertility of the tuberculous]

The number of children surviving the first 20 years of life per father / mother (net fertility) can be calculated by multiplying the number of children born with the likelihood of surviving:

For tuberculous fathers (who died 1873-1889): 3.33 * 0.5318 = 1.77,
For tuberculous mothers (who died 1873-1889): 3.44 * 0.5180 = 1.78,
For non tuberculous fathers (who died 1876, 1879, 1886): 4.41 * 0.5973 = 2.63,
For non tuberculous mothers (who died 1876, 1879, 1886): 3.81 * 0.5983 = 2.31.

The net fertility by age of parent’s death (in 10-year age groups) is shown at the bottom of page 77 for tuberculous parents and at the top of page 78 for non tuberculous parents. It shows that the net fertility is increasing with increasing age at death of parents for both tuberculous and non tuberculous individuals.

We can now calculate the expected net fertility of the tuberculous by combining the net fertility of the non tuberculous with the age structure of the tuberculous. Results for the expected compared to the observed net fertility are:
For tuberculous fathers 1.90 (expected) : 1.77 (observed),
For tuberculous mothers 1.67 (expected) : 1.78 (observed).

Hence, tuberculous fathers seem to be subfertile, while tuberculous mothers seem to be overfertile. However, we should be aware of the fact that non-tuberculous individuals die at an older age than the tuberculous. It would be best to compare the fertility of the tuberculous to the total population who lived as long, which isn’t however, possible with this material.
12. Kapitel [Chapter 12]

Der Einfluss des Abstands der Geburtszeit der Kinder von dem Tode der tuberkulösen Eltern auf ihre Sterblichkeit
[Influence of the delay between children’s birth and death of tuberculous parents on the mortality of the children]

Urtabellen [source tables] IX, X, XI (pages 85-87, 93-94) give information on number of children, deaths, and emigrations by age of children and delay to parent’s death. Tabellen 10, 11 and 12 (pages 88-90) give, using these numbers, observed years of life of children by age-groups of children and timely distance to death of parents. Tabellen 13 and 14 (on pages 91 and 92) show logarithms of the likelihood of survival.

We can assume that the closer the birth of the child to the death of the parents, the greater the effect on the mortality of the child. For determining the exact number of children born from parents who were already suffering from tuberculosis at the time of birth of their children, we have to take the estimated average duration of tuberculosis, which is approximately 7 years, into account. Therefore, this exact number must be between 4,047 and 7,947, 4,047 being the number of children in the sample born less than 5 years before their tuberculous father / mother died, and 7,947 being the number of children in the sample born less than 10 years before their tuberculous father / mother died. The average of these two numbers is 5,998, approximately a third of all children of the tuberculous, and approximately 7% of all children (assuming that 20% of all children have tuberculous mother or father). This finding is against BAUMGARTEN, as his hypothesis is that tuberculosis is transmitted to the embryo at very early stages.

The table at the bottom of page 80 shows that mortality increases as delay between birth of child and death of parents decreases, especially for children born from a tuberculous mother. The mortality is extremely high among children born during the last month before their mother’s death.

As the mortality of children in Stuttgart changed over the years, it would have been ideal to compare the mortality of the children from the tuberculous to the mortality of those in the total population who were born at the same time and at the same timely distance from the death of their father / mother.

According to the increase in mortality for those born in the last year of life of their tuberculous parents, their average life expectancy is very low: 23.3 years for children who were born in the year before their tuberculous father died and 17.5 years for children who were born in the year before their tuberculous mother died (assuming an additional 40 years of life for those who reached their 20th year of life).

The decrease in mortality of children born after their tuberculous father died supports the theory that tuberculous is purely an infectious disease. The table in the middle of page 82 gives an overview on the mortality of children during their first year of life, and during their first six years of life by timely distance of their birth to death of their tuberculous father / mother.

The table on top of page 83 shows that, especially during the first four years of life, mortality of children is highest during the last year of their parents’ life. For the older age groups of
children, this is not as clear as it is for the young age groups. This might however, be due to less contact with parents among the older age groups of children, especially those being 16-20 years old. This shows that infection does not only play a role at baby age or strictly during the first two years of life, but later on as well.

Another reason for the high mortality of children during the last year of life of their parents may also be the deterioration of living conditions (e.g., missing salary, worse diet, missing breast-feedings, etc.).

Looking into the mortality of children from non tuberculous parents during the last five years of life of parents shows a mortality of 52% for children from non tuberculous fathers, 55.11% for children from tuberculous fathers, 57.33% for children from non tuberculous mothers, 58.01% for children from tuberculous mothers. However, among the 300 children from non-tuberculous mothers in this category, 42 (=14%) were stillborn due to a difficult birth from which the mother died, leading to high mortality numbers.

When looking into mortality for the first 20 years of life of children, born less than five years before the death of their tuberculous parents, by age of parents, there is no bearing of the age of parents at their death on the mortality of the children:

<table>
<thead>
<tr>
<th>Died at age</th>
<th>Tuberculous father</th>
<th>Tuberculous mother</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;30 years</td>
<td>53.2%</td>
<td>57.5%</td>
</tr>
<tr>
<td>30-40</td>
<td>56.4%</td>
<td>54.4%</td>
</tr>
<tr>
<td>40-50</td>
<td>54%</td>
<td>60.3%</td>
</tr>
<tr>
<td>50-60</td>
<td>62%</td>
<td></td>
</tr>
<tr>
<td>60-70</td>
<td>28.6%</td>
<td></td>
</tr>
</tbody>
</table>

We conclude that the factor that increases the mortality for children of tuberculous parents is not the age at death of their parents, but the difference in exposure to infectious parents.

In addition, we can assume that miscarriages among women during the last stages of tuberculosis were also very frequent, and if we were to take them into account for calculation of the likelihood of survival, low as it is, it would be even lower. However, it would be wrong to take this low likelihood of survival as a reason to demand abortions for all women suffering from tuberculosis.
13. Kapitel [Chapter 13]

Der Einfluss der Kinderzahl der Familie auf die Sterblichkeit der Kinder
[The effect of the number of children in a family on their mortality]

In this chapter, only children born from tuberculous parents dying between 1873-1889 are taken into account.
Tables used for determining the effect of the number of children in a family on their mortality include Urtabellen [source tables] II, XII, XVI (pages 40, 41, 102, 103, 117). Results are presented in an overview on page 97.
We can see an increase in mortality of children from tuberculous parents with increasing number of siblings, with the lowest mortality among children with no siblings from tuberculous mothers, and those with 2 siblings from tuberculous fathers. Results for children from non-tuberculous parents are similar; for almost all numbers of children in a family, we can see a higher mortality in families with tuberculous parents as compared to families with non-tuberculous parents.

While emigrations have not been taken into account for these calculations, but were not equally distributed (mainly families with few children emigrated as shown on page 95) results may be slightly biased.
Only for calculation of mortality of children having no siblings, have emigrations been taken into account. Results are presented in Table 16 on page 100 for single children from tuberculous parents, and in Table 17 on page 101 for single children from non-tuberculous parents.

The three tables on page 98 show (1) numbers of children born in families with different numbers of children for tuberculous and non-tuberculous mothers and fathers, (2) numbers of children who died in families with different numbers of children for tuberculous and non-tuberculous mothers and fathers, and (3) mortality of children in families with different numbers of children for tuberculous and non-tuberculous mothers and fathers.
For children from tuberculous and non-tuberculous fathers, we can see increasing mortality with increasing number of children in the family. The same is true for children from tuberculous and non-tuberculous mothers, except for the families with only 1-3 children. Their high mortality may be due to closer contact between mother and children in families with few children.
Higher mortality for children living in families with many children may be due to increased risk of infection by tuberculous siblings.
14. Kapitel [Chapter 14]

Der Einfluss der Geburtenfolge auf die Sterblichkeit der Kinder der Tuberkulösen
[The effect of the order of children on the mortality of children of the tuberculous]

Looking into the effect of the order of children in a family on their mortality helps determine how important external influence factors are. If their mortality were only influenced by genetic factors, children in one family should have, given a big enough number of observations and controls for biases, the same mortality.

Urtabelle [source table] XIII (pages 112-113) gives numbers of emigrations and deaths for children of tuberculous parents dying 1873-1889 by age of children and number in order of children in the family.

Urtabellen [source tables] XIV and XV (pages 114-115) give numbers of emigrations and deaths for children of tuberculous parents dying 1873-1889 and non-tuberculous parents dying 1876, 1879, and 1886, by number of children in the family and number of child in order of children in the family.

There are three possible ways of looking into the effect of birth rank on child mortality:

- **Method A**: Comparison of the relation between number of deaths and number of children in total for first born children with that of second born children, that of third born children, etc.
  This method is valid if the material consists of families which all have the same number of children. It is not valid if the material consists of families with different numbers of children, as it gives a higher weight for families with few children, and doesn’t account for differences in mortality of children in families with different numbers of children. Therefore, we need to find a method which avoids these biases.

- **Method B**: calculation of expected values (using the frequency of families with a specific number of children and the according mortality, assuming no effect of the order of children on their mortality), and then comparing these to observed values.
  Results using this method are shown in Tabellen 18 (for children from tuberculous) and 19 (for children from non-tuberculous) on pages 106 and 107. The second to last column in these tables also show results when using method A.

- **Method C**: comparison of first and last born children, based on the assumption that, if the order of children has no effect on their mortality, the first and last born should have the same mortality. Results using this method are shown in Tabellen 20 and 21 (pages 108 and 109).

Results for all three methods are based on children from tuberculous parents dying 1873-1889, and those from non-tuberculous parents dying 1876, 1879, and 1886.

Using method C without taking emigrations into account, the relation between mortality of the last and first born is:
- 122 : 100 for children from tuberculous fathers,
- 111 : 100 for children from non-tuberculous fathers,
- 134 : 100 for children from tuberculous mothers,
- 108 : 100 for children from non-tuberculous mothers.

Taking emigrations into account didn’t make a big difference (shown at the bottom of page 110).

For the calculation of the correlation between order of children and their mortality, the material was divided into two groups: first and second half in order of children.
For children from tuberculous fathers, the following table was made:

<table>
<thead>
<tr>
<th></th>
<th>Died in first 20 years of life</th>
<th>Survived first 20 years of life</th>
</tr>
</thead>
<tbody>
<tr>
<td>First half in order of children</td>
<td>A=1,788.5</td>
<td>B=1,372.5</td>
</tr>
<tr>
<td>Second half in order of children</td>
<td>C=1,590.5</td>
<td>D=1,570.5</td>
</tr>
<tr>
<td></td>
<td>4,379</td>
<td>2,943</td>
</tr>
</tbody>
</table>

\[ R = \sin \left( \frac{\pi}{2} \right) \times \frac{(4abcd)/(b-d)^2 (a+d)(b+c))}{(a+d)(b+c)} = 0.0987. \]

We conclude that we see a slight increase in mortality with ascending order of children. This result is the opposite of what PEARSON, RIVERS et al. say. According to them, firstborn children have the highest risk of getting tuberculosis. Their results however, are based on data from hospitals, and they mainly included adults in their analysis.
15. Kapitel [Chapter 15]

Die Sterblichkeit der Kinder nach der sozialen Stellung der tuberkulösen Eltern
[The mortality of children according to social class of their tuberculous parents]

For looking into the effect of social class of tuberculous parents on the mortality of their children, the material (including years of death 1873-1889) has been categorized into social class A, B and C, according to origin, profession and property. Category A (self-employed persons, upper officer) has been subdivided into Aα and Aβ, Aα being the highest social class. Category B includes vine dresser, innkeeper, and officer, while category C includes manual worker, day-labourer, and lower officer.

Urtabelle [source table] XVI shows an increasing mortality of children with decreasing social class of their tuberculous parents, children from parents belonging to category Aα clearly having the lowest mortality.
Children from vine dressers and innkeepers show a relatively high mortality, probably due to the unfavourable effect of alcohol.
16. Kapitel [Chapter 16]

Die allgemeine und spezifische Sterblichkeit der Kinder der Tuberkulösen im Zeitraum von 1873-1902 und in Perioden verschiedener Abstände der Beobachtung vom Tode der Eltern im Vergleich zur Gesamtbevölkerung

[The mortality of children from the tuberculous from all and from specific causes from 1873-1902 and by timely distance of observation from death of parents, compared to the general population]

In this chapter, mortality of children from the tuberculous will be compared to mortality of children in the general population. As mortality varies with time, the period 1873-1902 has been divided into three smaller time periods.

It will also be determined if mortality from tuberculosis accounts for the difference in mortality between children from tuberculous parents and those in the general population, and if living with tuberculous parents at different timely distances from their death has an effect on the mortality of their children from tuberculosis and from other causes. For this purpose, 4 periods were set up: living with tuberculous parents 10-5 years before their death, less than 5 years before death, less than 5 years after death, and 5-10 years after death.

The method used in this chapter was again the comparison of expected (using mortality from tuberculosis and from other causes of the general population and combining it with frequency of children from tuberculous parents) to observed values. The methodological difference to the other chapters is that here, “mortality intensities” had to be used (see chapter 4).

For being able to conduct these calculations, we need to know mortality in different age-groups as well as frequency of tuberculosis in the general population.

The two sources for getting this information were the annual statistical reports of the city of Stuttgart and the notifications of statistical agency of the state Württemberg.

Tabelle 23 on top of page 122 shows “mortality intensity” (in 0 / 0000) of the 0-20 year old population of Stuttgart, in total and from tuberculosis for three different time periods, and is based on numbers shown in Urtabelle [source table] XXI on page 153. Numbers at birth and for the first year of life don’t include illegitimate children. For ages 2-20, deaths of immigrants are not taken into account.

The table at the bottom of page 122 shows the comparison of expected and observed children deaths, by age of children, for children from tuberculous fathers and mothers. For the creation of this table, information shown in Tabelle 23 (page 122), 24, 25 and 26 (pages 124, 125 and 126) has been used. The information given in Tabelle 24 (page 124) includes average numbers of children from tuberculous parents for the years 1873-1902, by age and timely distance to death of tuberculous parents. Tabelle 25 displays expected deaths for children from tuberculous parents from all causes for the years 1873-1902, also by age and timely distance to death of tuberculous parents. Tabelle 26 gives the same information, but for expected children deaths from tuberculosis.

Observed / expected values (in %) for deaths of children:

<table>
<thead>
<tr>
<th></th>
<th>from tuberculous father</th>
<th>from tuberculous mother</th>
</tr>
</thead>
<tbody>
<tr>
<td>At birth</td>
<td>87</td>
<td>84</td>
</tr>
<tr>
<td>In the 1st year of life</td>
<td>123</td>
<td>136</td>
</tr>
<tr>
<td>In the 2nd - 5th year of life</td>
<td>117</td>
<td>138</td>
</tr>
<tr>
<td>In the 6th - 10th year of life</td>
<td>101</td>
<td>103</td>
</tr>
</tbody>
</table>
In the 11th - 15th year of life 115 125
In the 16th - 20th year of life 197 277
In total 118 133
In the 1st - 20th year of life 122 138

This shows, just as the results shown in chapter 8, that mortality of the children of the tuberculous is high, and extremely high for the ages 1-5 and 16-20.

We can also see that, again consistent with results from chapter 8, mortality of children is higher for those with tuberculous mother as compared to those with tuberculous father.

Observed numbers of stillborn are lower than expected. Dead births often happen for firstborn children, and also for children that are highest in the order of children. Both are underrepresented in the material, as births before 1873 were not taken into account, and as in general, tuberculous individuals don’t have as many children as other persons, and therefore, children with a very high number in the order of children are rare.

It is very important to be careful when interpreting these values. Given the values above, one could think that ages 16-20 are doing worst. However, it has to be taken into account that, as explained in chapter 4, the same increase in percent can have a very different meaning. Given “mortality intensities” of 29.41% for the first year of life, and 3.31% for ages 16-20, an increase of 3.31% would result, when comparing observed with expected values, in 111% for the first year of life, and in 200% for the 16th-20th year of life.

Therefore, comparing observed with expected values is not always the most exact method when looking into factors influencing mortality, and it is necessary to calculate correlation coefficients. When using this method, we can see that the influence of tuberculosis of the parents on mortality of the children is still highest among 16-20 year olds, and higher for those in the 1st year of life as compared to 2-5 year old children.

For answering the question if mortality of children from the tuberculous is higher due to higher mortality from tuberculosis, basically the same methods as described above were used. As not all causes of death could be determined, numbers had to be corrected slightly.

Observed / expected values (in %) for deaths from tuberculosis of children:

<table>
<thead>
<tr>
<th></th>
<th>from tuberculous father</th>
<th>from tuberculous mother</th>
</tr>
</thead>
<tbody>
<tr>
<td>In the 1st year of life</td>
<td>222</td>
<td>229</td>
</tr>
<tr>
<td>In the 2nd - 5th year of life</td>
<td>203</td>
<td>229</td>
</tr>
<tr>
<td>In the 6th - 10th year of life</td>
<td>109</td>
<td>193</td>
</tr>
<tr>
<td>In the 11th - 15th year of life</td>
<td>168</td>
<td>203</td>
</tr>
<tr>
<td>In the 16th - 20th year of life</td>
<td>264</td>
<td>382</td>
</tr>
<tr>
<td>In total</td>
<td>198</td>
<td>246</td>
</tr>
</tbody>
</table>

Observed are a lot higher than expected values for all age groups, and again, mortality from tuberculosis of children is higher for those with tuberculous mother as compared to those with tuberculous father.

When calculating correlation coefficients, we recurrently see that the correlation between mortality from tuberculosis of children with tuberculosis of parents is strong for the first years of life, and strongest for ages 16-20.

The table on page 130 shows differences in absolute numbers of deaths from all causes and from tuberculosis.
Overall, for the first year of life, we should assume higher observed values for deaths from tuberculosis as reported, as about 50% of causes of death for this age group could not be determined, which would probably lead to the highest correlation coefficient for this age group. As diagnoses for older age groups are more accurate, we can assume that the high mortality of children from the tuberculous is due to higher mortality from tuberculosis.

When looking into the influence of living with tuberculous parents at different timely distance to their death, we see that observed : expected values are

for living more than five years before death of tuberculous parents 115:100
for living less than five years before death of tuberculous parents 142:100
for living less than five years after death of tuberculous parents 187:100
for living more than five years after death of tuberculous parents 142:100.

Children living with their tuberculous parents close to parent’s death have a higher mortality.

The table on top of page 132 shows the same calculations, but by age group. For almost all age groups, mortality increases with decrease in timely distance of living close to parent's death. The degree of increase, however, varies with age groups. Mortality is again highest for ages 1-5 and 16-20.

The same calculations have also been undertaken for death of children from tuberculosis. Observed : expected values for all age groups are

for living more than five years before death of tuberculous parents 121:100
for living less than five years before death of tuberculous parents 267:100
for living less than five years after death of tuberculous parents 333:100
for living more than five years after death of tuberculous parents 227:100.

A clear increase in mortality from tuberculosis for children living with parents close to their death can be seen.

Looking into causes of children’s deaths other than tuberculosis shows the following observed : expected values:

for living more than five years before death of tuberculous parents 114:100
for living less than five years before death of tuberculous parents 133:100
for living less than five years after death of tuberculous parents 156:100
for living more than five years after death of tuberculous parents 82:100.

These findings indicate that the increase in mortality of children who live close to their parent's death from tuberculosis is not only due to an increase in mortality from tuberculosis, but also in other causes.

The tables on page 133 show observed: expected values for mortality from tuberculosis and mortality from causes other than tuberculosis by age groups of children and timely distance to death of parents. Results are consistent to the ones shown above.

We can conclude that this analysis shows a very high risk for children in their first years who live together with, and are therefore close to their tuberculous parents, particularly with the tuberculous mother, but also for older age groups, we can see this high risk.
Future studies that look closer into the older age groups, especially ages 16-20, are desirable, as the number of observations in these age groups are relatively low in this study.

The overall results of the study may be biased by the influence of the social status. Families of the tuberculous usually have a lower social status as compared to the average of the population. Unfortunately, we don't have enough information on the influence of the social status on the mortality of children.

One possibility of being able to determine the influence of the social status is to look into the mortality of the wives / husbands of the tuberculous (using information from my former work), assume a similar social status, and compare this mortality to the mortality of their children.

Observed vs. expected values for the mortality from tuberculosis of the wives / husbands of the tuberculous are 206:100, while these values for the children of the tuberculous are 251:100.

Observed vs. expected values for the mortality from tuberculosis of the wives / husbands of the tuberculous during the first five years after their death are 238:100, while these values for the children of the tuberculous are 277:100, and for the children during their first year of life 618:100. This clearly indicates that, when eliminating the influence of the social status, mortality is still excessive for the children of the tuberculous.

The results of this study suggest that the tuberculous individual is a source of infection for persons living in close proximity to this individual.

In another work which also has been published recently, I looked into numbers of children who had ever been infected with tuberculosis and into newly infected children by age groups. The results of this work suggest that numbers of new infections don't decrease a lot with age, and hence, getting tuberculosis at a higher age cannot solely be due to re-infection. Also, getting infected with tuberculosis as a child does not protect a person from getting infected again as an adolescent, which is the case for other infectious diseases.

The high mortality for ages 16-20 may be explained by the influence of the profession, which is often the same for parents and children, or by specific genetic factors that only play a role in adolescence.

The contribution of causes of death of the children other than tuberculosis to their excessive mortality was slightly problematic, as the recording has not been consistent over the years, and, e.g., the handling of cases with more than one disease was not standardized. I didn't count those cases as death incidents of tuberculosis, even if one of the diseases was tuberculosis, however, as they were not many, it didn't make a big difference.

Urtabellen [source table] XXII and XXIII (pages 153 and 154) show all causes of death for children from Stuttgart and for the children from the tuberculous, by age groups. Tabelle 28 on page 140 gives deaths per 100,000 observations for the children from Stuttgart, also by age group. Tabelle 29 (page 141) shows, based on information from Tabelle 24 (page 124) and Urtabelle [source table] XXII expected numbers of deaths for different causes for children from tuberculous parents.

For comparison of the observed vs. expected values, as shown in the table on page 139, numbers have been slightly corrected to adjust for incomplete recording.

These numbers clearly show that observed vs. expected values are highest for death from tuberculosis. Numbers for typhus are also very high, but as this disease is quite rare, this could just be coincidental.
Another cause of death for which values are high is cachexy, but here however, we can assume that this includes "hidden" cases of tuberculosis. Values for scrofula, meningitis, other respiratory and gastro-intestinal diseases, and other infectious diseases are slightly higher.

As we are assuming physical inferiority for children of the tuberculous, and also higher mortality from infectious diseases other than tuberculosis in lower social classes, it is surprising that, for these other infectious diseases, observed values are, except for pertussis and typhus, not that much higher than the expected values (observed : expected):

Diphtheria: 91
Scarlet fever: 105
Measles: 101
Pertussis: 146
Typhus: 221

Possible explanations for this finding include the idea that physical inferiority only plays a role for diseases that have a long duration such as pertussis or typhus. Another factor that may have influenced these results is the age distribution in the sample, because the mortality for some of these diseases varies with age. It is also important to take into account that mortality is a product of morbidity and lethality. According to REICHE (table on page 144), lower social classes have a lower morbidity, but a higher lethality. Therefore, the relatively low mortality of children from the tuberculous from some other infectious diseases could be due to their lower morbidity from these diseases. Causes for the lower morbidity of children from the tuberculous from other infectious diseases are probably due to their lower number of siblings as compared to other children. This means that we can also assume that mortality from tuberculosis of children from the tuberculous would have been even higher if they had more siblings.

In conclusion, these results suggest that tuberculosis is the disease which accounts most for the excessive mortality of children from the tuberculous.
**Schlusswort**  
[Closing words]

This work doesn’t answer all of the questions we have with regards to children from tuberculous parents. More material would be needed to look closer into this topic. I hope that the publication of the results that have been achieved so far will increase interest in the subject.

Results of this work clearly show strong effects of living with tuberculous family members. We see that the mortality of children from the tuberculous is influenced by:

- Order of children in the family,
- Timely distance of birth of child to death of parents,
- Social class of parents.

Tuberculosis of the parents is highly correlated with tuberculosis of the child in the first year of life, but also during adolescence.

Deaths from tuberculosis account for most, but not all of the excessive mortality of children from the tuberculous. Mortality from other causes is also high for children from the tuberculous, particularly during their first year of life. Deaths from other infectious diseases are only slightly higher than expected. This may be due to a lower number of siblings among children from the tuberculous.

Overall, we can’t conclude that the physical constitution doesn’t influence mortality of children of the tuberculous, as there is a relation between mortality of the children and the age at death of the parents, as mortality is very high for children from tuberculous parents whose professions deal with alcohol, and as mortality is also very high for children from the tuberculous at the ages 16-20.

Unfortunately, this study could not look into mortality of children from the tuberculous at ages older than 20, however, we can assume that mortality for these age groups is lower than it is for the younger ones.

Fertility of the tuberculous is lower as compared to the non-tuberculous, which is an important finding from a racial hygienic point of view.

Results also suggest that living with tuberculous individuals is not only dangerous for the poverty-stricken, but for the total population at large. This increases the need of fighting against tuberculosis. This fight will be expensive, but it needs to take as many aspects as possible into account.

It is important to avoid infections among the children, but also among the adults, as they are the main source of infection for the children.