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Item 4 – Constructing assumptions for mortality: data, methods and analysis

Cohort and Period Mortality in Sweden in a very long perspective and projection strategies

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ABSTRACT

The present method for mortality projections in Sweden is a combination of the Lee-Carter method and argument-based adjustments. It is a two-factor model taking age and period into account. With long time series of mortality now available from year 1861 from both a period and a cohort perspective it is tempting to use more of the potential in the data to improve projections. One obvious strategy is to use the age and cohort information available and test the three-factor model expressing rates as a function of age, period and cohort. A project is under way to add cohort cause of death data for more recent years.

1. DATA

In preparation of a newly published report Cohort mortality in Sweden mortality data for the period 1861 to 2008 has been updated. Using the extinct cohort method, population size has been recalculated for ages 60 and up. The recalculation has been based on the most reliable statistics, the number of deaths by age. Age is available in one-year age classes and based on register information of date of birth and date of death. Age is calculated and we have no indications of any systematic errors. If in doubt about stated time of birth and death the parish registers were consulted.

The database starts with the calendar year 1861, the first year when very detailed population statistics became available. Keeping track of migrants is more problematic than keeping track of deaths. To get as reliable calculations as possible using the extinct cohort method the recalculations have been restricted to the ages 60 and up. In those ages migrants are very few, if any. For ages below 60 the official population size has been kept unchanged. Cohorts born after 1910 cannot be followed until the last person has died. For those cohorts the recalculation of the population size had to start with latest information available, the official population size at the end of year 2008.

2. PERIOD MORTALITY

From 1860 up to present time the composition of the Swedish population has changed a lot. In all, 1.5 million persons emigrated from Sweden during the 1861-1930 periods and some 0.4 million immigrated. This means a net loss of more than one million persons out of a total population of round four million. The largest excess of emigration can be observed for cohorts born in 1861-75. These cohorts were decimated by some 20 per cent for men and by some 16 per cent for women. The corresponding percentage for cohorts born in the 1890s is only nine for men and five for women. From 1930 onwards we have had a large net immigration. Between year 1860 and 2008 life expectancy nearly doubled from 47 to 81 years. The cause of death pattern has changed a lot during this period too. A decline in infectious diseases began after the middle of the eighteenth century. The victory over infectious diseases was the main reason for the increasing life expectancy. Living longer, the chronic degenerative diseases became the main cause of death during the

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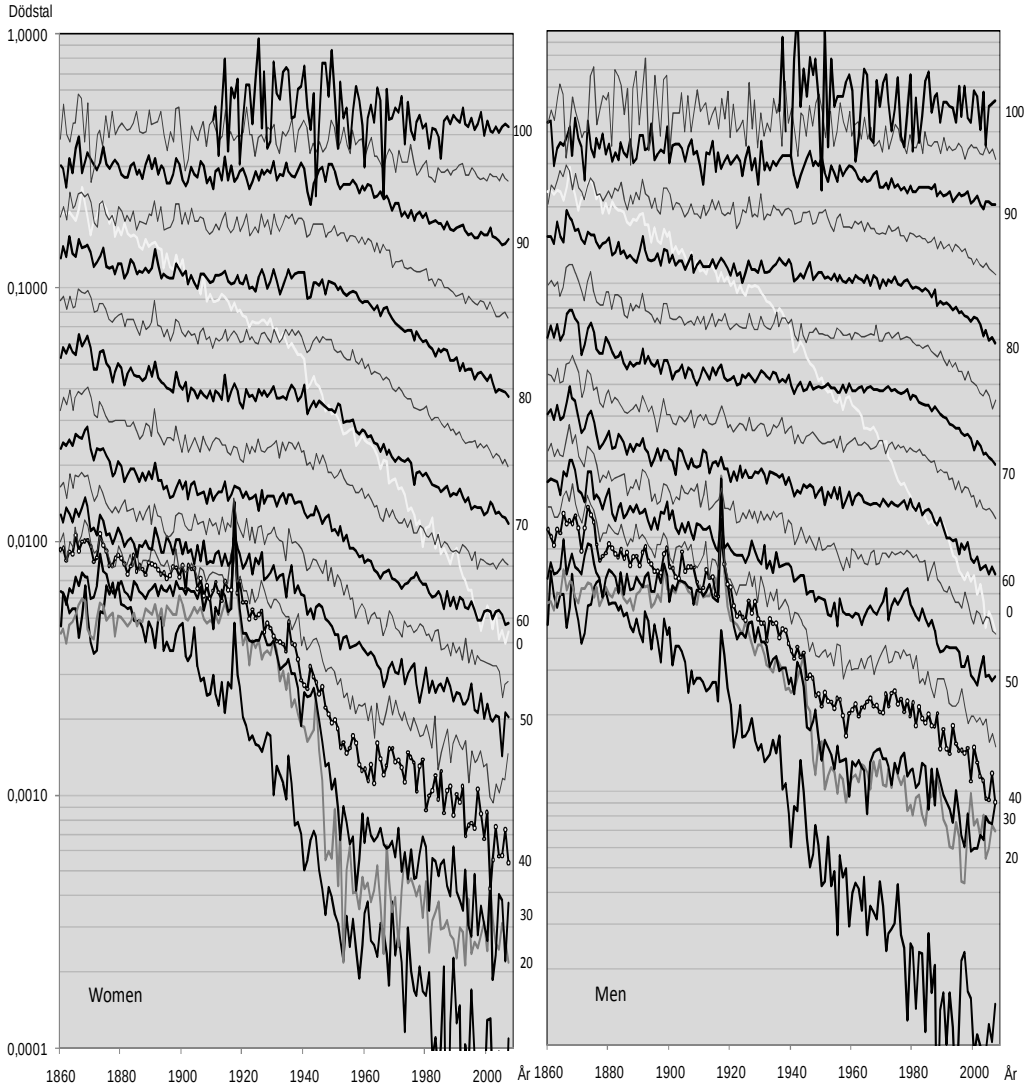
twentieth century. In spite of all these changes and many more, mortality rates show a smooth and gradual change over time and age. It was only the Spanish Flu in 1918 that temporarily broke that pattern.

We see random variations, of course, but the long-term trend has been relatively stable. This seems to be an ideal situation for projection and the use of for instance the Lee-Carter model. Some trend shifts make an extrapolation of mortality rates problematic however. In the 1940s female mortality started to decline at a faster rate than before. In the mid 1960s the decline slowed down for women and even turned into an increase for middle age men. At that time some persons believed we were close to the biological limit having reached a life expectancy of 75 for women and 71 for men. That turned out to be wrong. Mortality started to decline rapidly once more and it was mainly due to a decline in mortality from cardiovascular diseases.

The mortality decline since 1980 has been faster for men than for women. The trend shifts makes the choice of period over which the trends are to be determined crucial. The Lee-Carter method projects constant rates of improvements for a given age. This may lead to an implausible profile of mortality rates at successive ages if the projection extend a long time into the future. This problem can often be eliminated by choosing an optimal fitting period which in turn introduces other effects. The Lee-Carter method has an advantage in its simplicity and the possibility to produce measures of uncertainty. In figure 1 mortality rates for women and men can be followed for the period 1861 to 2008. To make it more readable selected ages are shown. Mortality rates show a smooth and gradual change over time for each age. The mortality pattern over time is very similar between ages too. The pattern of mortality change for let say age 70 is very similar to mortality change for those slightly younger and older than 70.

Figure 1. Mortality rates for Sweden 1861-2008 by sex and age. Logarithmic scale



3. COHORT MORTALITY

Cohort mortality gives another perspective of mortality decline compared to period data (Figure 2 and 3). Nearly 50 cohorts, born 1861 or later, can be followed from birth to the last person died. For the remaining cohorts information is lacking for the first or last part of the life cycle. Like period mortality rates the cohort approach show a relatively smooth pattern over cohorts. In the ages above 40 we see a more or less parallel downward shift of the curves from one cohort to the next. At first this shift in the mortality curve was not so pronounced. As from cohorts born around 1880 a more rapid decline of female mortality started. For men the mortality decline started some 20 years later with the cohorts born around 1900.

Figure 2. Mortality by year of birth for selected cohorts. Women, logarithmic scale

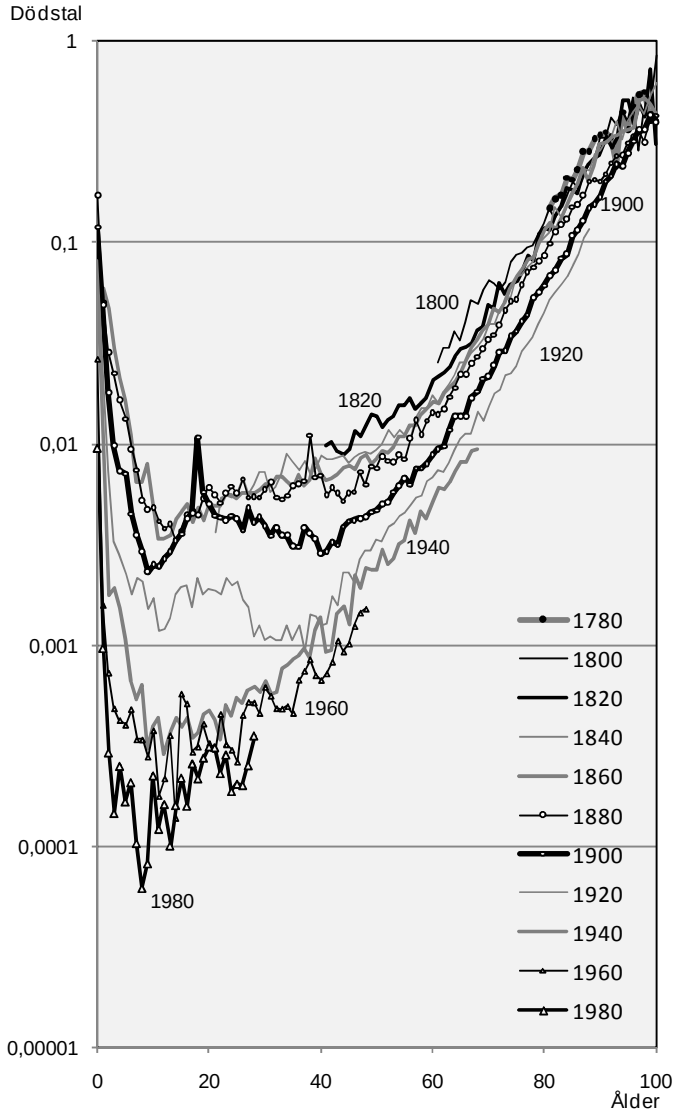
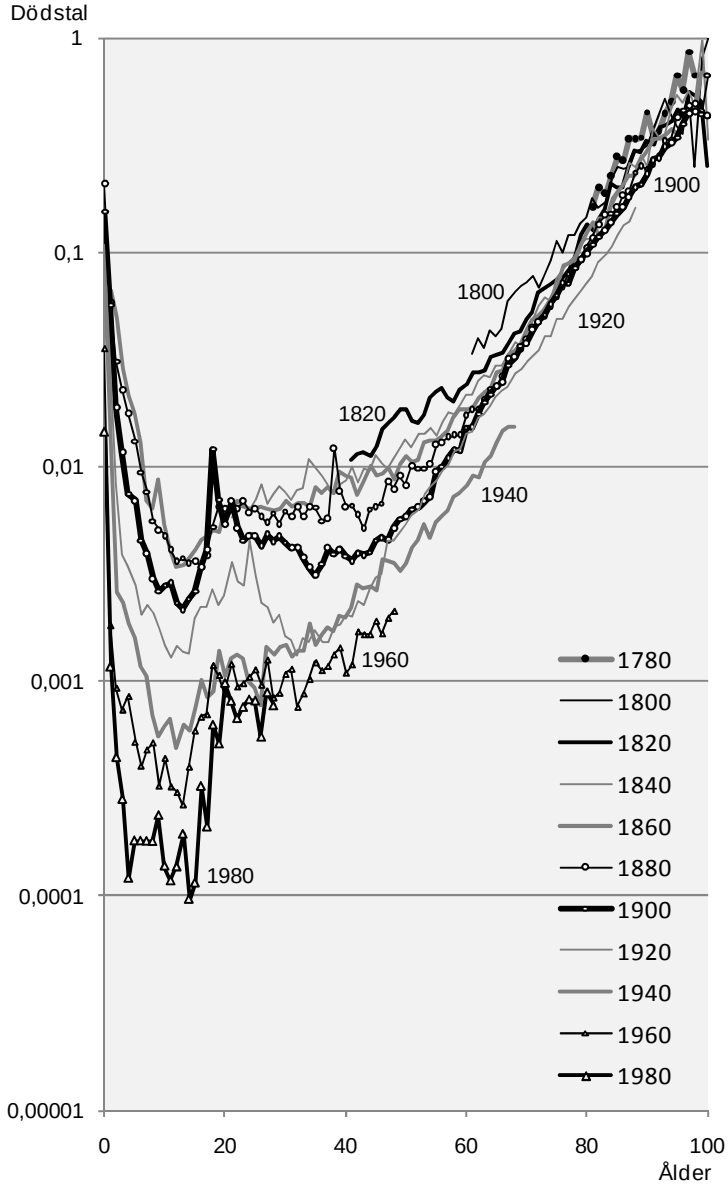


Figure 3. Mortality by year of birth for selected cohorts. Men, logarithmic scale



4. PRESENT MODEL FOR MORTALITY PROJECTIONS IN SWEDEN

The Lee-Carter method can be used on data that extends over very long time periods. We have however found that the age component in the Lee-Carter model is not stable for such long time series. At the beginning of the 20th century there was primarily a decline in mortality of young people and, at the end of the century, this decline related more to older people. The last 15-year period has been chosen as the base period.

When applying the Lee-Carter method, we have concentrated on estimations of the ages over 40. We have done so to make the structure of mortality as homogenous as possible, dominated by chronic diseases. The number of deaths in these ages is a determining factor for the forecast, as the majority of deaths occur in these ages. Calculations were made for all causes-of-death as well as for four groups (cancer, heart-lung disease, accidents/suicide and other illnesses).

In a final step information from the different Lee-Carter projections were put together to an assumption on future mortality development. In the long term, the drop in the mortality rate is expected to continue but to slow down as a result of changes in the cause of death panorama.

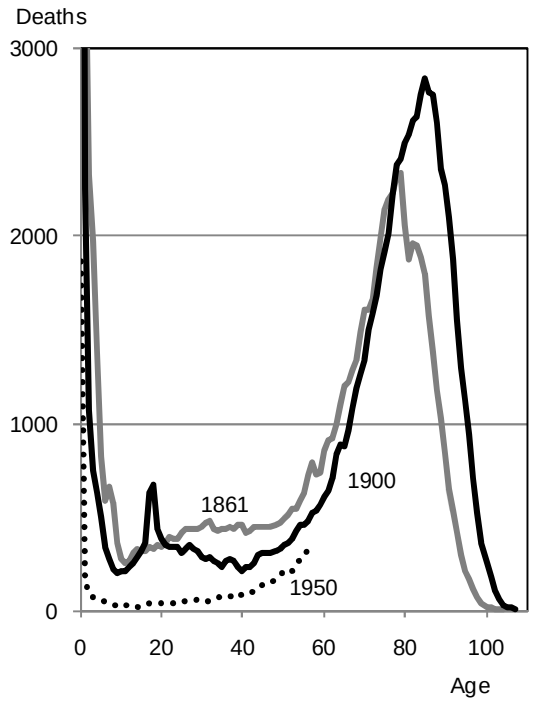
5. DISCUSSION

One way to improve mortality forecasts is to gain insight into the causes and predictors of mortality. To be able to do that we must know the "risk profile"of previous and current cohorts. Furthermore we must know the relationship between risk factors and mortality and be able to forecast changes in the risk factors. This seems to be an approach for the future. For present time other approaches are needed.

Short-term projections are often based on the general principle that the near future resembles the recent past. Long-term projections are a more difficult enterprise. Adding cause-of –death information may give some clues of what is to come. A much cited example of a successful cause of death projection appeared in a study by Pollard in 1949 indicating a rise in mortality in the 1960s. The projection turned out to be remarkably accurate (National Statistics Quality Review Series. Report No 8 2001).

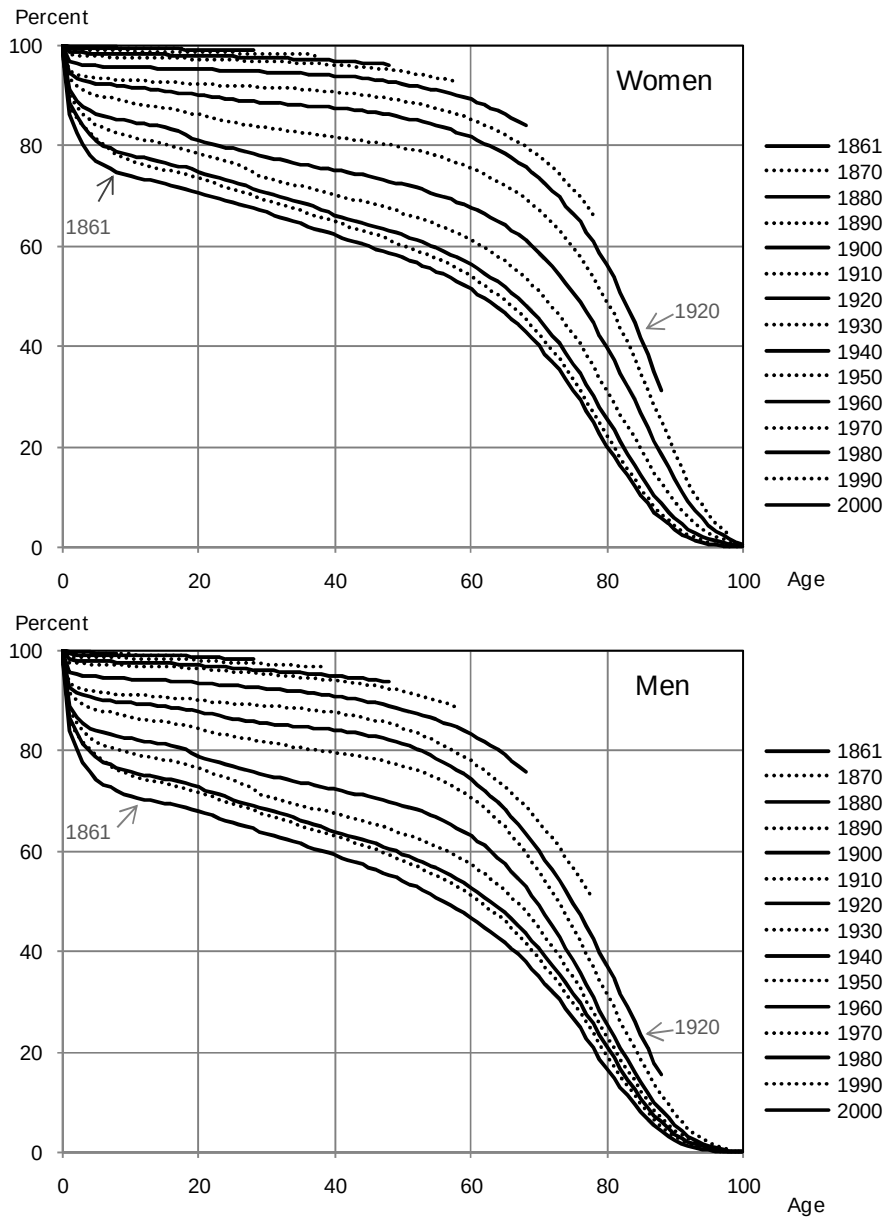
Adding cohort cause-of –death data will give some more insights into the factors behind the mortality decline. The approach is problematic however for at least two reasons. The reconstruction of consistent time series by cause of death is a challenging task. Different revisions of ICD classification, changes in coding practises, improved diagnostics over time and declining rates of autopsies are a few challenges. On top of that old-age mortality is one key component of any population projection model.

Figure 4. Cohort life table deaths out of 100 000 born. Three selected cohorts. Women



Declining mortality has resulted in an ageing population. Out of women born in 1920 over 50 percent is still alive at the age of 80 and for younger cohorts this age will most probably raise. Apart from high infant mortality the typical age at death nowadays is around the age of 80 to 90. Among the oldest-old the underlying cause of death cannot be easily identified. Booth and Tickles draw the conclusion that the perceived advantages of decomposition of mortality by cause of death are outweighed by the limitations involved (Booth 2008).

Figure 5. Proportion surviving by sex, age and year of birth



Primarily the two-factor model Age and Cohort and the three-factor model Age Period Cohort will be tested using the long time series available.

The Lee-Carter model has lately been extended to incorporate cohort effects and is worth a closer look (Renshaw 2006). In a later stage cause of death statistics by cohort may be added with cause of death specified in just a few broader groups.

6. REFERENCES

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