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MORTALITY

Women's death in Scandinavia – what makes Denmark different?

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Abstract. *Objective*: To compare the mortality for women in Sweden, Norway and Denmark in order to search for clues for the low life expectancy of Danish women. *Methods*: Prospective age-period-cohort study covering 40 years for all Swedish, Norwegian and Danish women aged 40–84 during the period 1960–2000, and born 1900–1950. *Outcome measures*: Relative risks and 95% confidence intervals for deaths. *Results*: The high risk of dying among Danish women was associated with being born between the two World Wars, and that a similar pattern was not found for women in Norway and Sweden. A tendency of a cohort effect was observed for Swedish women born around 1940. *Conclusions*: The currently low life expectancy of Danish women compared with that of women in Norway and Sweden is partly a transitional phenomenon caused by excessive death rates for women born between the two World Wars. Data on smoking prevalence by birth cohort and age indicate that a high percentage of Danish women in these cohorts were smokers throughout their adult life.

Key words: Age-period-cohort modelling, Denmark, Life expectancy, Mortality, Norway, Sweden

Background and objectives

The life expectancy of Danish women now ranks 28 in the world [1] and is lower than that of women in other countries in Western Europe, USA, Canada, Australia, and comparable to countries as Costa Rica and Slovenia. The life expectancy is an index reflecting the mortality across all ages at a given point in time. In a previous study to disentangle the long term mortality changes behind the currently low life expectancy of Danish women we showed that the low life expectancy was associated more with birth cohort then with calendar period. This suggests aetiology associated with the life of certain generations rather than with risk factors affecting all women in the population at a certain point in time [2].

The life expectancy of women in Sweden and Norway is at present 3 years above that of Danish women [1]. We therefore made a comparative analysis of the mortality for women in Sweden, Norway and Denmark using age-period-cohort modelling. If a cohort effect similar to the one found in Denmark was found also for women in Sweden and Norway, then this cohort effect may not explain why Danish women have a low life expectancy. However, if the cohort effect was not found in Sweden and Norway, then the identified cohort effect for women in Denmark might provide a clue for the low life expectancy of Danish women.

Methods

The number of deaths and mid-year population, stratified by 5-year groups, for all Swedish, Norwegian and Danish women aged 40–84 in the period 1960–2000 and born 1900–1950 were obtained from publications of Statistics Sweden, Statistics Norway and Statistics Denmark [3–7]. The data were organised in a two-way table with rows as 5-year age groups and columns as 5-year periods and synthetic birth cohorts represented by the diagonals of the table. Within 5-year age and period groups, the women contributing to such a cohort are born within a 10-year period, the same women contributing to two adjacent synthetic birth cohorts.

The data were analysed using age-period-cohort modelling. This technique aims to solve the problem that the age, period and cohort effects cannot be simply estimated in the same model as they are linearly dependent on each other [8]. To meet this problem the linear components of age, period and cohort and parameters associated with deviation of the effects of each of these factors from linearity can be examined [8, 9]. Preliminarily we examined the effects of the age, calendar period and birth cohort for each country separately:

$$\log(\text{rate}_{ij}) = \mu_k + \alpha_{ik} + \beta_{jk} + \varepsilon_{ck}, \tag{1}$$

where for country k, μ_k represents the mean effect (intercept), α_{ik} the effect of age group i, β_{jk} the effect of the jth period, and ε_{ck} the effect of the cth cohort, where it is well known that only one linear component in each pair (β_{jk}, ε_{ck}) is identifiable. Under the assumption of a common age effect the period and birth cohort estimates are directly comparable for the three countries:

$$\log(\text{rate}_{kij}) = \mu_k + \alpha_i + \beta_{jk} + \varepsilon_{ck}, \qquad (2)$$

where μ_k represents the mean effect (intercept), α_i the common effect of age group i, β_{jk} the effect of the jth period for country k, ε_{ck} the effect of cth cohort for country k. Again only one linear component in each pair (β_{jk}, ε_{ck}) is identifiable. At conventional statistical significance levels, the age effects differ between countries (Equation 2). The estimates for the common age effect model in the present paper are therefore primarily intended as a descriptive representation. The reference group was selected as the risk of death for Danish women born in 1915–1919 and aged 50–54 in 1965–1969. To validate the 'common age effect'-model (Equation 2) we calculated the expected rates based on the model and compared them visually with the observed rates.

The parameters of the age-period-cohort models were estimated using multiplicative Poisson regression models [10], and all statistical analyses were done using the SAS 6.12 package [11].

Information on percentages of smokers at given ages for birth cohorts of Danish women, was estimated on self reported smoking history from population surveys undertaken in 1953 [12], 1987 [13], 1991 and 1994 [14]. Data on percentage smokers at given ages for birth cohorts of women in Sweden and Norway was obtained from previous publications, with population based data on smoking prevalence for women born 1900–1949 (data available on request) [15, 16].

Results

The separate model deviances for Sweden, Norway and Denmark were 4.2, 9.6 and 1.9 times the relevant degrees of freedom (36), respectively. When assuming a common age effect for the three countries, the deviance for the model was 17.8 times the relevant degrees of freedom (36) (output of regression results available on request). Due to the poor statistical fit of the model, significance levels for uncertainty measures of the estimates were not reliable. As is well known when working with data of demographic size such as the present one, standard significance levels almost lose their definitive power as a criterion for goodness of fit. We therefore put considerable weight on a careful examination of the structure of the unavoidable deviation from perfect fit of the model. As an attempt to validate the model we fitted the age-period-cohort models and calculated the expected mortality rates for women in the three countries. These expected rates were close to the observed mortality rates (Figure 1), and we concluded therefore, that the age-period-cohort model with the

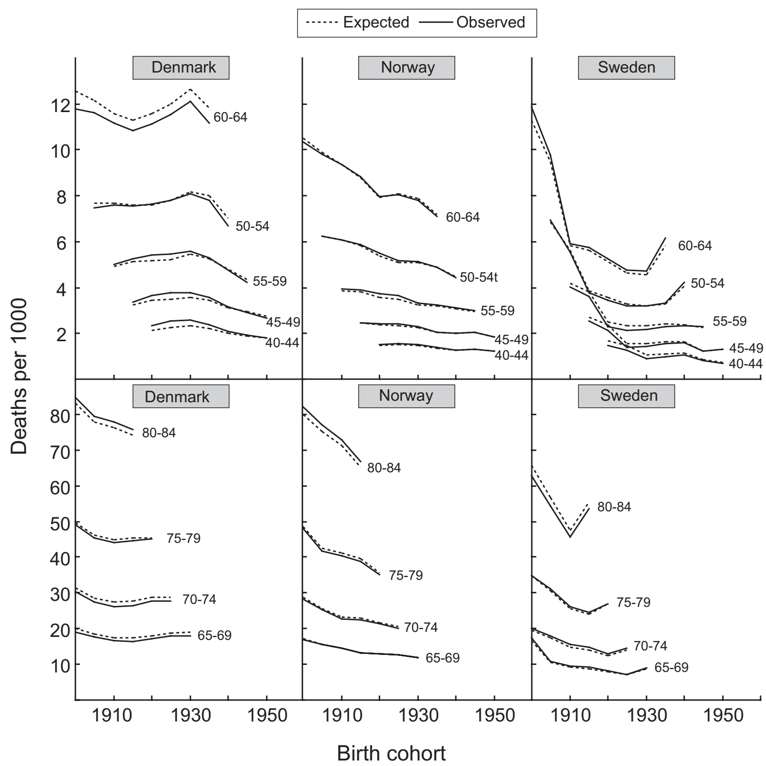

Figure 1. Observed and expected mortality rates for women in Denmark, Norway and Sweden 1960–2000.

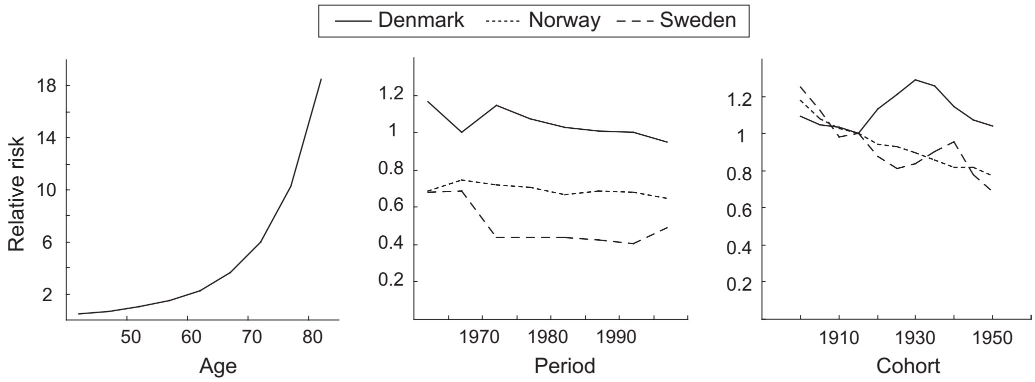

Figure 2. Relative risk of death for women in each age, period, cohort and country, when compared with a Danish women born in 1915–1919 and aged 50–54 in 1965–1969.

common age effect captured well the structure in the mortality rates.

The risk of death for women in each age, period and cohort was compared with the risk for women born in 1915–1919 and aged 50–54 in 1965–1969 (Figure 2). The non-linear period effects were strongest for the Swedish women with a decrease from 1960 to 1970 followed by a stagnation until around 1990 where the risk increased again. For both Danish and Norwegian women, the non-linear period effects were negligible. The non-linear cohort effects were clearly more pronounced for Danish women than for Norwegian and Swedish women. There was a high relative risk of dying for Danish women born between 1920 and 1940. There was a less marked increased risk of dying for Swedish women born around 1940. No non-linear birth cohort effect was present for the Norwegian women.

The percent smokers among Danish, Norwegian and Swedish women by birth cohort is shown in Figure 3. The general level of female smokers by birth cohort in Norway and Sweden was lower than in Denmark. Sweden had the lowest smoking percent. The percentage of smokers increase for consecutive birth cohorts in Norway and Sweden, whereas the highest percentage of smokers was found for Danish women born 1920–1929.

Discussion

The present study confirms previous findings of a strong birth cohort effect in the mortality rates for Danish women [2]. The pronounced birth cohort effect seen for Danish women born between the two World Wars was not found for women in Norway and Sweden. A small and maybe upcoming cohort effect was seen for Swedish women born around 1940. In order to explain the observed pattern it is important to remember that a cohort effect means that we should look for etiological factors affecting the high risk cohort, and not affecting the cohorts born before and after the high risk cohort. This means that we here have to look for risk factors affecting Danish women born from around 1920 to around 1940 and not affecting women born before 1920 and after 1940 to the same extent. The standard interpretation of a cohort effect on mortality in adult life is the influence from conditions in foetal life. However, Danish men have not shown a cohort effect similar to the one found for Danish women [2]. This suggests that the causal factor(s) for a high mortality of Danish women born 1920–1940 must occur later in life. Relevant risk factors later in life include smoking [17], risks associated with being mothers of the babyboomers [18], sexually transmitted diseases in the

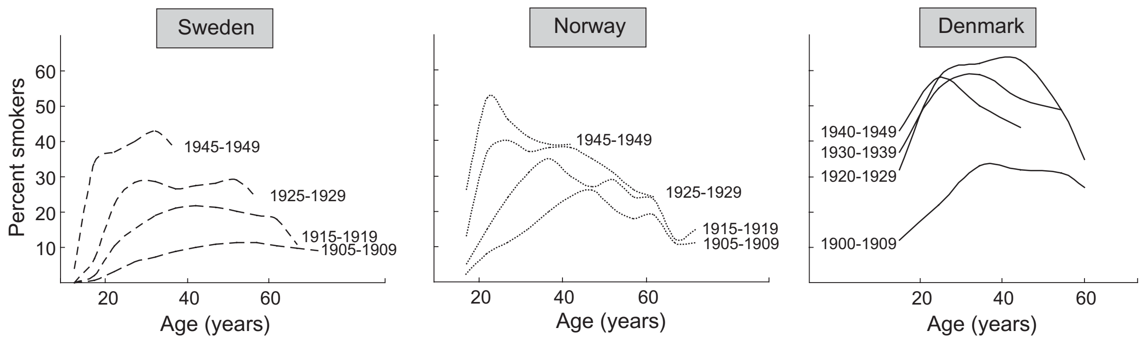

Figure 3. Percent smokers for different birth cohorts of women in Norway, Sweden and Denmark.

mid 1940s [19], and introduction to the Danish labour market in massive numbers in the 1960s [20].

If smoking is the major causal factor for the observed cohort mortality pattern among Danish women, then we would expect the smoking prevalence to be higher for women born 1920–1940 than for women before 1920 or born after 1940. Such a pattern was actually supported by the estimates of smokers by birth cohort and age group among Danish women (Figure 3). This suggests that smoking may indeed be a major reason for the birth cohort effect observed among Danish women. The analysis furthermore shows that it is primarily in the cumulated smoking prevalence from age 25 to age 60 that the birth cohorts vary. Women born 1900–1909 and 1920–1929 have almost the same percentages of smokers at age 60, and women born 1920–1929 and 1940–1949 have almost the same percentages of smokers at age 25. The cumulative smoking prevalence throughout adult life is however much higher for women born 1920–1929 than for the other cohorts. Also, it is clear that the smoking prevalence of Norwegian and Swedish women has been below that of Danish women for each birth cohort and age group. The tendency for a cohort effect for Swedish women born around 1940 could also be smoking-related, as both smoking prevalence and lung cancer incidence are the highest for these generations [21]. One may speculate that the future life expectancy of Swedish women will be unfavourably affected by the higher mortality of these birth cohorts. The clear period effect observed for Swedish women from 1960 to 1970 is explained by a rapid decrease in the mortality from cardio-vascular diseases [22]. Why the death rates for women dropped so dramatically in Sweden at this time has been subject to speculation. A similar development was not seen for Swedish men. A rapid change among women to a healthier diet during this period has been put forward as a possible explanation [22].

The currently low life expectancy of Danish women compared with that of women in Norway and Sweden seems to be mostly a transitional phenomenon caused by excessive death rates for Danish women born between the two World Wars. With the dying out of the generations born between 1920 and 1940 a relatively rapid increase is expected in the life expectancy of Danish women compared with the life expectancy of both Swedish and Norwegian women. This is supported by the fact that the difference in life expectancy between Swedish and Danish women reached a maximum of 3.45 years in 1995, a difference which had declined to 2.83 years in 2000. The life expectancy of Swedish women is expected in the near future to be adversely affected by the high mortality of women born around 1940.

The life expectancy is the most common used measure in the overall health status of a population [1]. The data presented here underline that we should be cautious in attributing recently observed differences to recent exposure patterns. Our analysis has illustrated that the age-period-cohort modelling can show additional light on the underlying structure in mortality rates observed at a given point in time.

In conclusion, the low life expectancy of Danish women compared with that of women in Norway and Sweden is caused by excessive death rates for women born between the two World Wars. Data on smoking prevalence by birth cohort and age show that a high percentage of Danish women in these birth cohorts were smokers throughout their adult life. A heavy burden of tobacco smoking in women born between the two World Wars therefore seems to be the key explanatory factor behind the low life expectancy experienced by Danish women in the 1990s.

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