Chapter 4

Mortality Projections in Norway

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4.1 A Brief Description of the Norwegian Population Projection Model

The official population projections for Norway are produced and published by Statistics Norway. As in Finland, though not in Denmark and Sweden, the national statistical agency makes regional projections as well. The smallest geographical units projected are the 435 municipalities (*kommuner*), which range in size from about 250 (Utsira) to about ½ million (Oslo) people.

Using the projection model BEFREG, the population by age and sex is projected 1 year at a time by the cohort-component method. The method employs a migrant pool approach for migration between the 90 economic regions of Norway (NUTS), with 1–19 municipalities in each region. The regional projection results are subsequently broken down into results for individual municipalities according to the size and historical growth rate of broad population age groups in each municipality. Thus, the cohort component method is generally not applied at the municipal level. The national population figures are found by aggregating the regional projections, *i.e.* the bottom-up principle.

The model has been virtually unchanged during the last 15–20 years; see Rideng et al. (1985) for a general description and Hetland (1998) for a technical description of the computer system.

After this paper was written, a new set of population projections for Norway for the period 2002–2050 was published in December 2002, see <http://www.ssb.no/folkfram/>. One important change compared to the 1999–2050 projections is that the assumed life expectancies up to 2050 are considerably higher than previously. The method for projecting the age-specific death probabilities is the same as that for the 1999–2050 projections.

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In the most recent projections, for the period 1999–2050 and with the registered population as of 1 January 1999 as the initial population, we assumed three variants for each of the following demographic components: fertility, mortality, net immigration and the degree of centralisation for internal migration (plus a variant with zero migration). This would yield 144 different population projections; however, only a few of these combinations have been computed and published. The populations of municipalities were projected until 2020, those of the counties were projected until 2050 (but published only for the years up to 2030), and the population for the entire country was computed until 2050.

All data for the projections come from registers through the population-statistics system BESYS, which is used to build up a structure of aggregate data for population, births, deaths, domestic and international migration, where the smallest unit is age*sex*municipality.

As mentioned above, BEFREG projects the population only by age, sex and region. Previously, Statistics Norway has also made national projections by age, sex and marital status (Brunborg et al. 1981; Kravdal 1986) and by age, sex and household status (Keilman and Brunborg 1995). The last two of these publications used mortality rates by formal marital status, whereas the first did not. Moreover, the stochastic microsimulation model MOSART projects a sample (from 1% to 10%) of Norway's population by age, sex, marital status, household status, educational activity and level, labour-market earnings and public-pension status/benefits (including disability and old-age). In this model the mortality probabilities have been estimated from 1993 data with sex, age, marital status, educational attainment and disability status as covariates (Fredriksen 1998). MOSART has a complicated data structure that is infrequently updated.

4.2 A Short History of Mortality Projections in Norway

Since 1969, thirteen sets of regional and national projections have been prepared and published, usually every 3 years.¹ In the first projections the mortality rates were kept constant for the entire projection period and set equal to the most recently observed rates, usually for a period ranging from two to five calendar years for national rates and 10-year periods or more for regional rates and time trends. The use of observations for several years is done to reduce random variations due to Norway's small population (about four million).

Gradually the projections of the age- and sex-specific mortality rates have become more sophisticated²:

¹See Texmon (1992) for a survey of Norwegian population projections for the period 1969–1990.

²For more detail, see the publication for each set of projections, with text in both Norwegian and English, the most recent being Statistics Norway (2002).

- In the projections of 1977 and 1979, the observed rates were reduced by 2% and 3%, respectively, and kept constant for the entire projection period (until 2010).
- Regional mortality rates (specific for each of the 19 counties) were introduced in the projections of 1979. This affects overall mortality if, for example, net migration flows go primarily from high to low-mortality areas.
- A declining trend in future mortality rates was assumed for the first time in the 1982 projection, when all rates were reduced by 1% per year for the first 10 years but kept constant for the rest of the projection period.
- The Brass logit life-table model was used for the projections of 1987 (but not later).
- A model with time- and age-specific death rates was used for the period 1990–2050 (but not later); see Statistics Norway (1991) and Gómez de Leon and Texmon (1992).
- Alternative mortality projections were introduced in the 1993 projections, when sets of rates yielding low, medium and high life expectancies were assumed (Statistics Norway 1994).
- Target life expectancies for the final projection year were also introduced in the 1993 projections (Statistics Norway 1994).
- Age- and sex-specific reductions in future death rates were used in the 1999–2050 projections.

Most of these changes were made because it was discovered that mortality had been persistently overestimated. It is perhaps surprising that it took so long to realise this, since Norway had experienced an almost uninterrupted mortality decline since the 1820s (though with some stagnation for men in the 1950s). The decline has been particularly rapid since the 1960s – see Fig. 4.1.

4.3 Current Methodology of Mortality Projections

In this section, we will describe the methodology and thinking behind the current mortality projections, focusing on a number of separate issues that need to be considered.

4.3.1 Target Life Expectancies

The assumed target life expectancies at birth for the final projection year, 2050, vary from 77 to 83 years for men and from 81.5 to 87.5 years for women (*i.e.* the same as for the previous projections, those of 1996) – see Fig. 4.1. There is no theory or profound thinking behind these assumptions, which have been based on the development in Norway and elsewhere:

Fig. 4.1 Life expectancy at birth for women and men. Registered 1825–1998 and projected 1999–2050: Low, medium and high assumptions of life expectancy

- The assumed future increase of e_0 –7.5 years for males and 6.3 years for women – in the most optimistic alternative from 1998 to 2050 is of the same magnitude as the *actual* increase during the previous 50-year period from about 1950 to 1998 (5.5 and 7.7 years, respectively).
- In the medium UN series, it is assumed that e_0 for Norway will increase to 80.5 years for men and 86.4 years for women in 2040–2050 (United Nations 1999), *i.e.* well within our range. The long-term UN projections to 2150 assume that e_0 will increase to 85.2 for men and 91.3 for women in Europe and to 87.1 and 92.5 in North America; these constitute the upper limits of the projections.
- The most recent Swedish projections assume life expectancies for 2050 that are slightly lower than in our high alternative, 82.6 for men and 86.5 for women (Statistics Sweden 2000).

We conclude that our assumptions about target life expectancies in 2050 are not extreme and perhaps even slightly conservative. In our next projections, we will consider assuming a wider range of life expectancies. It would be useful to base this range on probabilistic considerations, for example, the work done by Juha Alho and Nico Keilman – see *e.g.*, Keilman et al. 2001.

4.3.2 Difference in Target e_0 for Males and Females

We have assumed a continued gradual decline in the difference between female and male life expectancies, to $4\frac{1}{2}$ years in 2050. This is consistent with historical trends, where the difference increased from about $3\frac{1}{2}$ years around 1950 to almost 7 years in

the 1980s, declining later to 5.7 years in 1998. This decrease, which has been observed in most European countries, is usually explained as due to a narrowing of the gender differences in life style. A similar assumption has been made in Sweden, where the differential is reduced to 3.9 years for 2050.

The most specific manifestation, as well as the principal reason, for this tendency is probably the change in smoking behaviour. The proportion of daily smokers among men 16–76 in Norway has decreased from about $\frac{1}{2}$ in 1973 to $\frac{1}{3}$ in 2000, while it has remained constant at $\frac{1}{3}$ for women. In 2000, smoking had become more common for the first time among women than among men (32% vs. 31%) – see Fig. 4.2.

4.3.3 *Life Expectancies in the First Projection Year*

If we had assumed a smooth development of e_0 from the most recent observations to the target, there would have been practically no difference between the alternatives for the first years of the projection. We would like, however, to have a reasonably wide range of e_0 to cover the possibility of random year-to-year fluctuations in mortality. For this purpose, we chose, as described in Sect. 5.5, a parameter that yields a change in e_0 for the first projection year (*i.e.* from 1998 to 1999) that is similar to the largest observed annual change in e_0 during the period 1965–1998. In other words, we chose the largest annual *decrease* for the low alternative – about 0.4 years for men 0.2 years for women – and the largest annual *increase* for the high alternative – about 0.6 years for each sex (see Table 4.1). In 1996 a similar approach was taken to widen the mortality range in the first projection year, but then the standard deviation of the difference between observed and *projected* life expectancies was subtracted (or added) to yield the low (or high) values for the first projection year. Actual and assumed life expectancies for the first projection years are shown in Figs. 4.3 and 4.4. It can be seen that the observed values are close to the medium variant in both rounds of projections, with a slightly faster improvement for men than for women.

4.3.4 *Path of e_0 from the Initial Until the Target Year*

In Sect. 5.5, we describe the method used to project the mortality rates in the 1999–2050 population projections for Norway. The e_0 trajectory is found by interpolating between the life expectancies assumed for the initial and target years. This is done by assuming a dampening of the annual age- and sex specific rates of change in death rates. Figures 4.5 and 4.6 show e_0 for males and females for each of the three mortality alternatives in the two most recently completed projections, *i.e.* for 1996–2050 and 1999–2050.

Fig. 4.2 Proportion of daily smokers among men and women 16–74 Years of Age, 1973–2000. (Source: <http://www.ssb.no/emner/03/01/roy/>)

Table 4.1 Change factors and target life expectancies, population projections 1999–2050^a

Life expectancy variant	First projection year (1999)		Subsequent projection years (2000 . . . 2050)	
	Parameter α_s	Assumed life expectancy	Parameter β_s	Target life expectancy
Males				
L (low)	3.315	75.1	0.927	77.0
M (medium)	0.741	75.5	0.982	80.0
H (high)	−3.026	76.1	1.005	83.0
Females				
L (low)	1.417	81.0	0.791	81.5
M (medium)	−0.212	81.2	0.978	84.5
H (high)	−4.195	81.7	1.006	87.5

^aThe observed life expectancy at birth in 1998 was 75.5 years for males and 81.2 years for females

We notice that the 1999 projections generally assume a more linear development of e_0 than the 1996 projections, except for the low alternative. The main reason is that we did not impose the restriction of no mortality change in the target year, as discussed below. It is, however, not yet possible to determine whether the 1999 paths are more realistic than the 1996 paths – only time will tell!

4.3.5 Slope of e_0 in the Target Year

In the previous round of projections, for 1996–2050, it was assumed that life expectancy would cease to decline in 2050 due to high uncertainty about mortality

Fig. 4.3 Life expectancy at birth for men, registered 1994–2000 and projected to 2001

Fig. 4.4 Life expectancy at birth for women, registered 1994–2000 and projected to 2001

in such a distant future. In the most recent projections, however, we have not been concerned about the slope of e_0 in the target year. This is due partly to the high uncertainty, but also to the likelihood – in our opinion – that mortality will continue to decline, even after 2050.

4.3.6 *Alternative Mortality Assumptions*

As mentioned in the introduction, Statistics Norway did not begin to introduce alternative mortality assumptions before 1993. Although future fertility (and migration) may seem more uncertain than future mortality, there are a number of uncertainties related to the development of mortality. To mention briefly just a few:

Fig. 4.5 Life expectancy at birth for males, registered 1970–1999 and projected to 2050

Fig. 4.6 Life expectancy at birth for females, registered 1970–1999 and projected to 2050

technological breakthroughs in the diagnosis and treatment of diseases, new epidemics and other diseases, pollution and other environmental problems, increasingly unhealthy life styles, etc.

Thus, it seems wise to base population projections on several mortality alternatives. The alternatives should cover a realistic future range of variation. If the range is too small, there are in reality no alternatives; if it is too large, the projections may cease to be interesting. Ideally, the range should be based on a probability distribution.

The number of alternatives is another choice that needs to be considered. The number should be greater than one but not so large that it becomes confusing and

complicated to present and use the population projections. Thus, three seems to be a sensible number. In the last three rounds of projections, we have assumed one low, one medium and one high alternative for life expectancy. Note that “low”, “medium” and “high” do not refer to mortality levels as such but to life expectancies, for consistency with the assumptions about other demographic components; for example, “low” implies low population growth.

4.3.7 Age Groups

The current version of BEFREG has 100 age groups, 0,1,2,...,98 and 99+. We are considering including more single-year age groups, at least age 99, in the next version of the model for two reasons: First, there is an increasing number of (and interest in) centenarians. Second, the lack of a decline in mortality for the oldest of the old, as described in Sect. 4.4, may necessitate a more differentiated approach for this particular group.

4.3.8 Cohort Mortality

Cohort mortality is not directly considered in our mortality assumptions. However, we have calculated the implications of our assumptions for cohort mortality – see Fig. 4.7.³ We may note that projected cohort mortality approaches projected period mortality; this tendency may be expected in view of the assumptions made. We also see that the difference between cohort and period mortality is particularly high for the 1960s–1980s.

4.4 Age-Specific Trends in Mortality Rates

The future age pattern of mortality has been given little attention in previous Norwegian population projections. The reason may be that the past mortality decline was implicitly assumed to be about the same for all ages and perhaps also that the age pattern of mortality was not considered to matter so much for the population projections – the only important factor being the level of mortality as measured by life expectancy at birth.

It is clear, however, that the mortality decline has varied greatly by age and sex. It is well known that historically the decline was largest for infants and children. To

³The life expectancy for cohorts born in 1950 and later and having members still living in 2050 has been estimated from extrapolated death probabilities. For example, $q(101, c1950) = q(101, c1949)$.

Fig. 4.7 Life expectancy at birth for periods and cohorts, registered and projected

learn more about recent trends, we have studied the development of age- and sex-specific mortality rates for the past 30–40 years.

Let $q(x, t, s)$ be the probability of death at age x , time t and sex s . The annual relative rate of change during the period from t_1 to t_2 is

$$\check{r}(x, s) = \ln(q(x, s, t_2)/q(x, s, t_1))/(t_2 - t_1). \quad (4.1)$$

We estimated the rate of change for $x = 0, 1, \dots, 99$; $t_1 = 1965$ – 1968 , $t_2 = 1998$; and $s = \text{male, female}$.⁴ As these rates of change exhibit a rather ragged appearance we applied a smoothing procedure. The rate of change $\check{r}(x, s)$ is graduated using a 21-term weighted moving average, with coefficients from Hoem (1995). The smoothed rates of change for males and females are shown in Fig. 4.8.

As expected, the decline has been the most rapid for children, but it has also been very impressive for adolescents and for men and women between 40 and 80. On the other hand, it has been nearly zero for persons over 90. There is even a tendency of *increasing* mortality for the oldest individuals, especially men over age 95, see Figs. 4.9 and 4.10. Thus, mortality rates for the oldest in Norway may have stagnated or started to increase in recent years. This is contrary to the trends in most other countries, but similar to those in the Netherlands (Nusselder and Mackenbach 2000). There are also indications of stagnating old-age mortality trends in Denmark, especially for men (Danmarks Statistik 2000), and in the USA (Kranzler 1997).

⁴We experimented with different periods, finding similar patterns, and chose the oldest single-year age-specific death rates that were available to us when we performed this analysis, i.e. for 1965.

Fig. 4.8 Annual change in age-specific death probabilities, 1965–1998. Per cent. Men and women by age. Graduated by 21- term weighted moving average

Fig. 4.9 Expected remaining years of life for elderly men at selected ages

4.5 Projections of Age-Specific Mortality Rates

In the most recent projections, we assume that the age-specific mortality declines are consistent with the patterns shown in Fig. 4.8 and as estimated in (1). To project the mortality probabilities $q(x, t, s)$ by age x , time t and sex s , we multiply them by a factor depending on the rates of change $\dot{r}(x, t, s)$ estimated for the period 1965–1998, as shown in Fig. 4.8. These rates of change are also changed, however, 1 year at the time, through multiplication by the parameters α_s or β_s for each age.

Fig. 4.10 Expected remaining years of life for elderly women at selected ages

Thus, for the first projection year, 1999, we find

$$q(x, s, 1999) = q(x, s, 1997.5) * (1 + r(x, s, t)), \text{ where} \quad (4.2)$$

$$q(x, s, 1997.5) = (q(x, s, 1997) + q(x, s, 1998))/2 \quad (4.3)$$

and 1997.5 denotes the average of 1997 and 1998. For 1999 the change factors are

$$r(x, s, 1999) = \check{r}(x, s) * \alpha_s. \quad (4.4)$$

For the subsequent years we compute

$$q(x, s, t) = q(x, s, t - 1) * (1 + r(x, s, t)) \text{ for } t = 2000, \dots, 2050, \text{ where} \quad (4.5)$$

$$r(x, s, t) = \check{r}(x, s) * \beta_s \text{ for } t = 2000 \text{ and} \quad (4.6)$$

$$r(x, s, t) = r(x, s, t - 1) * \beta_s \text{ for } t = 2001, \dots, 2050. \quad (4.7)$$

Equation (4.7) determines the path of e_0 from the most recently observed values of q_x (the mean of 1997 and 1998) to the assumed target values for 2050 (see Table 4.1). The estimates of parameters α_s and β_s employed here imply a dampening of the annual rates of change of the age- and specific death probabilities, see Table 4.1. The parameters are determined in the following way, for each sex and mortality alternative (low, medium and high):

- The parameter for the first projection year, α_s , is chosen on the following assumptions about the *change* in life expectancy from 1998 to the first projection year (1999), to obtain a wide range of death probabilities rates for the first year:

- It is set equal to the largest *decline* in e_0 observed during 1965–1998 in alternative L
- It is set equal to zero in alternative M
- It is set equal to the largest *increase* in e_0 observed during 1965–1998 in alternative H
- The parameter for the rest of the projection years, β_s , is chosen such that the resulting life expectancy in 2050 is equal to our target life expectancy for that year – see Table 4.1. This is done through iteration. (The procedure is made easy by using an Excel spreadsheet function that lets the user set the target whereby the program estimates the value that yields the desired value of the target).

4.6 Projection Results

The two most recent sets of population projections for Norway, *i.e.* those for 1996–2050 and 1999–2050, are very similar with regard to most of the assumptions. The fertility and migration assumptions are almost the same, and the target life expectancies in 2050 are identical although the trajectories are slightly different. As mentioned above, the greatest difference is that we have assumed a different age-pattern of mortality change for the projection period. This difference, and in particular the slower mortality decline for the oldest, result in significantly lower numbers of old people than in the previous projections (Fig. 4.11).⁵ The results are very similar for the low alternatives, where only a very small mortality decline has been assumed. However, the *high* alternative of the 1999 projections yields about the same number of people 90+ as the *medium* alternative of the 1996 projections. For 2050, for example, the projected population 90+ varies from 50,000 to 150,000 in the previous projection to 50,000–100,000 in the most recent projections.

We conclude that the specification of the age-structure of mortality decline has significant effects on the projected number of old people. Thus, the analysis of mortality trends for the oldest members of the population is important for population projections.

⁵The three different projections from 1999 shown here differ only with regard to the mortality assumptions. The 1996-projections are also different with regard to fertility and migration, however, but for the age groups and period considered here, the effects of these differences are marginal. Fertility differences for 1996–2050 will obviously not affect the number of persons 90+ for this period. The youngest age in 1996 of persons to enter age group 90+ in the projection period 1996–2050 is 36 years. Since persons aged over 35 accounted for only 12% of net immigration in 1996–1999, differences in net immigration can only have marginal effects on the number of persons 90+ projected for the period 1996–2050.

Fig. 4.11 Number of persons 90+. Registered 1970–2001 and projected 1996–2050 and 1999–2050

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