Trends in mortality and the
evolution of the cause-of-death
pattern in the Netherlands:
1850-2000¹

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Abstract

In this paper we describe the contours of the mortality transition taking place in the Netherlands between the mid-nineteenth century and the end of the twentieth century. We first of all give an overview of the published statistical data that can be used to describe the mortality evolution. Next we present information on the development of our main mortality parameter, the expectation of life at birth, for males and females. We describe the changes in the age and sex patterns of mortality, making use of contour maps, and decomposition techniques. Then we describe the long-term trends in mortality by cause of death, focusing on the most relevant cause-of-death categories.

Introduction

The commonalities in the pattern of mortality decline in western industrialized countries has led to the formulation of the theory of the epidemiological transition (Omran 1971), a specification of the demographic transition theory. Omran described three stages in the mortality decline, each characterized by a differing cause-of-death pattern: the period in which pestilence and famine dominated the mortality regime, the age of receding pandemics and the age of degenerative and man-made diseases. The epidemiological transition theory gives a description of the basic characteristics of the mortality development in Europe between the middle of the nineteenth and the end of the twentieth centuries mostly based on French, English, Scandinavian and German studies. A key characteristic of the mortality pattern in traditional Europe was the wide regional differences that existed there until the end of the nineteenth century. Although mortality declined in all western industrialized countries, extreme diversity is visible in the dates at which the mortality decline began, the trend of the decline, the age-sex patterns of mortality and other characteristics of the mortality regime (Perrenoud 1999; Perrenoud & Bourdelais 1999). The Netherlands was among the forerunners in the epidemiological transition. Although compared to England and the Nordic countries death rates started to decline rather late, from the last quarter part of the nineteenth century on the Netherlands underwent such a fast decline in mortality that on the eve of the First World War the expectation of life was at the same level as that of the Scandinavian countries, England and Wales, Ireland, Belgium and Switzerland (Reher 2004; Riley 2001; Vallin 1991). The demographic characteristics of this secular mortality decline in the Netherlands will be described

1. The statistical data used here were published by the Central Bureau of Statistics and its predecessors. In the past decade a large part of this material has been entered in a database by researchers from NIDI. See Ewa Tabeau, Frans Willekens and Frans van Poppel, *Mortality in the Netherlands: The data base* (Den Haag 1994). Cause-of-death data for the period 1875-1992 were collected in a database by Judith Wolleswinkel-van den Bosch, at the Department of Public Health of the Erasmus University Rotterdam.

with a series of mortality parameters, all based on the standard sources of demographic information.

Death registration and mortality statistics

It comes as no surprise that the countries which were forerunners in the mortality transition were also the ones with the most advanced statistical systems of the time.

Death statistics are based on individual death certificates, which in their turn are based on the reporting of deaths to the Registrar of the municipality in which they occurred. Nation-wide complete death (and birth) registration was introduced in the Netherlands in 1811, at the time of the incorporation of the Netherlands into the French Empire. Although the registration started in most municipalities soon after, the quality of the data collected in the first years was poor: lack of experience of the registration officers, ignorance among the public and among registration officers of the official regulations, war, and other complications were responsible for this. Comparisons of the civil and the parish registers of births and baptisms and of deaths and burials have shown that during these first years a small proportion of births and deaths escaped registration (Kok 1991, 34; Noordam 1986, 219-220).

Statistical publications based on this death registration were until the 1840s almost absent and have many weaknesses. For example, information on the age and sex of the deceased was only published for the years 1827 and 1828 (Commissie voor de Statistiek 1828; 1829). Data for the Netherlands as a whole for the years before 1840 did not include data for the Dutch province of Limburg or referred to the Dutch and Belgium provinces of that name together. Death registration up to 1837 did not distinguish between children registered as still-born and children registered as live-born and deceased in their first year of life, leading to biased estimates of the level of infant mortality (Oomens 1989, 20-26). Calculating refined mortality parameters was also hindered by the absence of information on the population at risk, classified by sex and age; the first census containing this information was published only in 1830.

A continuous annual series of numbers of deaths by age and sex only became available from 1840 on. By combining this information with population data by age and sex from the decennial censuses and with annual data on live born children, the calculation of annual values of the most important mortality indicators becomes possible. Life tables were published on the basis of these data for the period 1840-51 and later. These published life tables however are not very well suited for more refined mortality analysis. The methods used for the construction of the life tables diverged considerably during the last century and a half: changes in the definition of live births and deaths in the first year of life cause serious problems when comparing life tables before and after 1917

(Tabeau 1994); life tables for the period 1941-1946 were never constructed; and in some periods, deaths due to accidental circumstances like floods and military activities were not included. The published life tables also stretch over intervals of varying length; especially before World War II, when they relate to ten-year periods (Van Poppel, Tabeau and Willekens 1996).

Information on differences in the level of mortality – for example by social class, region, marital status etc. – is even more scarce. Provincial level data on mortality started to become available at the same time as national data. On the municipal level data were for the first time published for the period 1841-1860 as a whole. More detailed data, for example on mortality of children in the first year of life according to the number of weeks lived or according to the marital status of the deceased, became available from the middle of the nineteenth century.

An essential element for our knowledge of the mortality transition is information on medical causes of death. The collection of this kind of information started already in the eighteenth century but for a long time this information is practically useless for the study of national trends. The registration of deaths by cause of death had developed from the second half of the eighteenth century on at a strictly local level. Physicians and local councils became to realize that prevention and control of diseases could only be based on detailed data on the causes of disease and death. The municipal council of The Hague was the first to establish a system of disease and death registration in 1755 on the basis of causes of death reported to the town clerk's office, by the person reporting the death. Other cities like Alkmaar, Rotterdam and Amsterdam followed this example and began to compile cause-of-death statistics in the 1770s. These kinds of local, lay and non-compulsory registration of causes of death remained the rule until the 1860s when after several decades of struggle a national, compulsory system of medical certification of causes of death was established (for the history of cause-death registration in the Netherlands see, Van Poppel and van Dijk 1997; Van Poppel and van Dijk 2002).

This nation-wide medically certified cause of death registration was introduced on 1 June 1865 by the Public Health Inspectorate Act and the Medical Practitioners Act. Upon the death of one of their patients, doctors were required to submit to the registrar a medical certificate, in which they were to state as accurately as possible, what was the cause of death but "with due regard to their oath of confidentiality." The *Burial Act* of 10 April 1869 finally made medical certification of cause of death a national, statutory requirement. Local registrars could not legally issue a burial permit without a reported cause of death. Municipal councils were required to send monthly reports to the Public Health Inspector, detailing the number of local deaths. This inventory was then to be processed by the Public Health Inspectorate. Between 1869 and 1899, 94-95% of all deaths in the Netherlands was reported by doctors.

The first statistical compilation of data on causes of death of the deceased related to 1866, and focused on just six diseases: smallpox, scarlet fever, measles, typhus, angina diphtheria, and cholera. Other diseases, including unknown causes, were grouped together. During the period 1867-1874, a more sophisticated system of classification grouped causes of death into eleven main headings, which in turn included 55 causes of death. Data were published by sex and age of the deceased and for provinces and larger cities. From 1875 on, a classification system was in use which included 35 causes of death and 10 subcategories. By 1900 the nomenclature was adjusted to meet internationally developed standards. Municipal data on cause of death by age and sex have been published continuously since 1875 but the publication has been interrupted several times due to budget cuts and for other reasons. In particular from 1931 on, only very restricted information on cause of death at the local level is available.

Trends and fluctuations in the expectation of life

Of all demographic indices of mortality, life expectancy at birth is by far the most widely used. The average number of years of life an individual of a given age is expected to live if current mortality rates continue to apply is a statistical abstraction based on a summary of age-specific death rates as given in a life table. It equals the arithmetic mean of the ages at death of individuals as given in the life table. As was mentioned above, published Dutch life tables with their values of the expectation of life at birth are not very well suited for a comparison of mortality over time. For that purpose, a cross-referenced, comparative series of life tables for each year of the period 1850-1991 was established, based on a precise inventory of the basic data compiled at the national level, on estimates of the population by sex and single years for each year and on standard methods for the construction of uniform life tables (Tabeau, Van Poppel & Willekens 1994).²

The first period for which data on death by age and sex at the national level were available are the years 1827 and 1828 (Commissie voor de Statistiek, 1828; 1829; Oomens, 1989, 21). By combining this information with data on population numbers by age and sex from the census of 1829, rather refined mortality parameters can be estimated for this period. For the period 1840-51 as a whole estimates are available but they cannot be distinguished by year. Only from 1850 on, annual values for the expectation of life at birth can be computed. They are given in figure 1.

2. Population numbers were estimated on the basis of the outcomes of the ten-year censuses, the annual numbers of live births and annual numbers of deaths classified by age, sex and year of birth. Numbers of migrants by sex and age were obtained as the difference between the populations recorded in the census and the population resulting from natural growth only and the migration balances were distributed equally between the years in the intercensal period.

In 1827-28 expectation of life at birth was equal to 36.6 years for males and 39.5 years for women; in 1840-1851 these values were respectively 36.1 and 38.5. From figure 1 it is clear that the pre-1850 values did not deviate much from those after 1850. Therefore, we can argue that the increase in life expectancy only started around the middle of the nineteenth century.

Turning points characterizing significant changes in the global movement of this indicator through time can be located in the 1870s when the annual fluctuations came to an end and the increase in life expectancy started, in the middle of the 1920s when the growth of life expectancy decreased, and after the mid 1950s when the increase slowed down further. Notwithstanding the reversal of the declining mortality trend in the 1950s, the expectation of life of men and women has doubled since 1850.

Fixed features of the old demographic regime – in the Netherlands and elsewhere in Europe – were mortality crises such as epidemics, subsistence crises and wars. They played an important role in the Netherlands as well. The largest fluctuations occurred in 1855, 1859, 1866, 1871, 1918 and 1945 (Ballot 1871). The outbreak of cholera observed in 1855 was combined with attacks of measles and typhus, and as a result the expectation of life fell to values of 33.2 (men) and 35.0 (women) respectively, compared with values in 1850 and 1851 of 38.5 for men and 40.5 for women. The situation became worse again in 1859 when smallpox and cholera took a heavy toll, leading to a fall in the expectation of life to 29.2 (males) and 31.4 years (females). After a few years, a new violent outbreak of cholera caused the expectation of life to plunge again in 1866 to 32.1 and 34.4 years. In 1871 expectation of life only reached 31.3 for males and 33.4 for females, due to an epidemic of smallpox. From then on fluctuations were very modest and overall a clear increase was visible. It was only the outbreak of the influenza epidemic in 1918 that for the first time since 1871 sent life expectancy down to much lower levels. While the expectation of life in 1913-1915 was circa 56.0 for males and 58.2 for females, in 1918 values of 46.5 and 48.5 were observed. This decrease brought the level of mortality back to levels which were found in the last decade of the nineteenth century.³

The worst crisis of the twentieth century came with the outbreak of World War II. Whereas for women the real crisis in mortality started only in 1944, men were already hit in 1940. Both sexes suffered most in 1945 but the decrease in

3. Mortality rates for the years 1915-19 are slightly overestimated due to an underestimation of the population at risk in these years. The refugees from Belgium who arrived in the period 1914-1918 were not yet included in the census of 1910 and had already returned to their country at the moment the census of 1920 took place. They thus were not included in the censuses which formed the basis for the calculation of the population at risk but were included among the deaths during that period.

Figure 1. Expectation of life at birth, by sex, period 1850-2003

mean length of life was much larger for men than for women. Compared to 1939, male length of life in 1945 had decreased by 16.3 years to 50.6; among females, the decrease was 7.6 years.⁴

Decreasing interindividual variation in mortality

Averages such as the life expectancy at birth are useful indexes when looking for a single figure to summarize a set of age-specific mortality rates (Wilson and Oeppen 2003). But often some indication of the variations about the average is relevant as even today variation in age at death still dominates. The average length of life does not do justice to this variation between individuals. Various authors have proposed measures for the heterogeneity of the length of life, making it possible to find out whether the increase in the expectation of life at birth has become equally accessible to the whole population. One of these measures is the Gini-coefficient, a measure which is widely used in econometrics as a standard measure of inter-individual inequality in income.

4. The figures for 1941-1945 seriously underestimate the mortality level. Of the estimated 210,000 direct civilian and military casualties of the war only 67,000 were recorded in the Dutch death statistics, either as military or civilian casualties or as deaths from executions, hunger and hardship in camps in the Netherlands. Not included in the national statistics are subjects formally removed from the local population registers on deportation to Germany. Because neither the year of death, nor the birth cohort of the deceased among the deported were known to the NCBS, these war victims were not included in the death records, leading to an underestimation of circa 27% of the mortality rates during 1941-45. (Those deported included 104,000 Jewish citizens, some 18,000 political prisoners and some 27,000 people who were forced to work in Germany).

Figure 2. Lorenz-curve for the Dutch life table for males 1850 and 2003

The Gini-coefficient is based on the Lorenz-curve. The Lorenz curve usually represents the cumulative income share (on the vertical axis) as a function of the cumulative population share (on the horizontal axis): if a population share is always exactly equal to the share in overall income then there is a situation of perfect equality. Applying this to the life table, that is to a schedule of survival by age, one can imagine the sum of person years lived from birth to death to be income and cumulative death numbers to be population. The number of years lived by all individuals (the life table function) is represented cumulatively on the vertical axis, starting with age 0. On the horizontal axis the cumulative number of deaths from age 0 to the highest age is represented.

The Lorenz-curve can be compared with the diagonal line which represents perfect equality between both quantities. In the example, the diagonal line indicates that the first 10 percent of all deaths has lived exactly 10 percent of the total number of years lived, the first 20 percent of all deaths 20 percent of the number of years lived, etc. The further away the Lorenz-curve is from the diagonal line, the higher the inequality in the numbers of years lived. The Gini-coefficient is defined as the area between the diagonal and this curve, divided by the whole area below the diagonal. The coefficient varies between 0 and 1. It is equal to zero if all people in a population (or in our case in the life table

Figure 3. Gini-coefficient of average length of life, Netherlands 1850-2003, by sex

describing the mortality of the population in a given year) die at the same age and equal to one if all people die at age 0 and one individual dies at an infinitely old age. Higher values of the Gini-coefficient thus show a greater magnitude of interindividual differences. In a number of studies Gini-coefficients have been applied to mortality schedules to analyse the time trends in the degree of people's inequality in the face of death (Shkolnikov, Andreev and Begun 2003).

Figure 2 shows the Lorenz-curve for Dutch males in 1850 and 2003, and the diagonal line. The figure makes clear that in 1850 there was no question of equality in the average length of life whereas in 2003 the interindividual variation in the length of life had decreased strongly. In 1850 the first 20 percent of all deaths lived less than 0.3 percent of the total number of years lived and the first 50 percent of all deaths only 12 percent. The corresponding Gini-coefficient was 0.46. In 2003 the first 20 percent of all deaths lived 15 percent of the total number of years lived and the first 50 percent 44 percent. The corresponding Gini-coefficient was 0.09. To a much stronger degree the average length of life has therefore become within reach of the average man and woman.

Figure 3 depicts for men and women the historical changes in the interindividual variability in the expectation of life. Since the middle of the nineteenth century the increase in the expectation of life has run parallel with the reduction of inequality in length of life. For men, after 1894 the values of the Gini-coefficient were never above 0.40 whereas for women this threshold was crossed in 1887. In the most recent period the Gini-coefficient reached values of around 0.10. As mortality now is more and more concentrated in higher ages and the mortality risks at low ages could not decline any further, the inequality in ages at death could not decrease any more. The strong reduction in the length

Figure 4. Percentage of deaths within a ten-years-range of the expectation of life at birth, by sex, 1850-2003

of life inequality can be compared with a process of income redistribution: just as poor people as a consequence of redistribution acquire a higher additional income than rich people do, in the process of the mortality decline infants acquired more additional years of life than adults and the elderly. In the last decades this process of redistribution has however been rather restricted.

The Gini-coefficient is not really a user-friendly measure of the variation in the length of life and cannot provide answers to questions about length of life which individuals ask themselves. A better measure of the interindividual variation in the length of life is possible by calculating which proportion of all life table deaths reached more or less the average age at death, (that is the expectation of life at birth) or by calculating which proportion of all births in the life table was still alive at the average age at death (Smith, 1996; Craig, 1998). Figure 4 presents information on the percentage of the life table deaths that died within a ten-year range of the expectation of life, that is died between five years below and five years above the average age at death.

Figure 4 shows that in the period till 1900 the expectation of life really is a statistical artifact; among men and women a poor 5 percent of births live till approximately the same age as the average length of life. Only after 1900 this percentage starts to increase but even after 2000 only about one third died at around the same age as the expectation of life at birth.

Changing age-profiles of mortality

The pattern of mortality change during the period 1850-2000 showed large variations from one age group to another. There exists a variety of methods to analyse and present this change in mortality by age. For example, methods have been developed to estimate the contribution of a change in mortality in a given age range to the change in life expectancy at birth. Finally, graphic methods have been used to depict the changing patterns of mortality over a wide age range.

We first of all make use of a method proposed by Arriaga (1984) in which the total change in life expectancy between year x and a reference year is decomposed into the fraction of that change brought about by a change in the mortality in a specific age group. The age intervals that we distinguish here are those between birth and age 1, between ages 1 and 5, between ages 5 and 20, 20 and 50, 50 and 65, 65 and 80 and 80 and over. The expectation of life in 1850 was used as a reference.

Figures 5 and 6 show that a large part (16.2 years for males and 14.7 for females) of the total increase in life expectancy since 1850 (37.6 for men, 40.3 years for women) was caused by the decrease in mortality between birth and age 1. Whereas infant mortality decrease alone could explain 43.1 percent of the change in life expectancy among males, among females only 36.5 percent of the increase could be ascribed to this age group. From the figures it is clear that mortality decrease in this age group only started to contribute to the increase in life expectancy from 1887 onwards. After 1896, infant mortality decrease was always responsible for more than 1.5 years increase in life expectancy at birth. From 1909 on, interrupted only by the temperature-related temporary increase in infant mortality of 1911, this contribution was 5 years or more. Infant mortality continued to decline after 1930 but at a smaller pace. Over the whole period 1850-2002, mortality decrease among 1-5 year old children contributed 7.4 years to the total increase in life expectancy at birth among men and 7.7 years among women. In relative terms, the age group was responsible for around 19 percent of the change in life expectancy among both men and women. For both sexes this age group started to contribute positively to the increase in life expectancy already in the beginning of the 1870s. Age groups 5-20 and 20-50 contributed respectively 3.8 (males) and 4.6 (females) and 6.9 (males) and 8.4 (females) years to the increase in life expectancy. In relative terms, these age groups were responsible for some 10 and 18 (for males) and 11 and 21 percent (females) of the change in life expectancy. In age group 20-50, the mortality decline started around 1867 and although this decline was temporarily interrupted in the early 1870s, it continued afterwards. Among men and women aged 50-65, mortality started to decline in the years 1867-1872 but mortality decline in this age group contributed only 2.0 years and 2.3 years to the increase in life expectancy among men and women respectively. Contributions for age groups 65-80 and 80 and over were negligible among males and females.

Figure 5. The contribution of various age groups to the total difference in expectation of life between 1850 and 2002, The Netherlands, men

Figure 6. The contribution of various age groups to the total difference in expectation of life between 1850 and 2002, The Netherlands, women

Measures such as the contribution to the increase in the expectation of life by the mortality decline in a given age group give a distorted picture of the changes in the age-sex pattern of mortality; by definition, mortality changes at younger ages contribute disproportionately to changes in expectation of life. Death rates for single years of age over a long period of time are however difficult to visualize. One option is to use so-called shaded contour maps. These maps, originally developed at the International Institute for Applied Systems Analysis (IIASA), permit a clear representation of a large number of two-dimensional data points (Vaupel, Zhenglian, Andreev, & Yashin 1997). In these maps, surfaces are shaded according to the height of the surface (the level of mortality). We use this method to show the evolution of age-specific mortality for the years 1850-2000. The level of mortality is represented by age-specific probabilities of death, that is the proportion of persons of a given age alive at January 1st who die before January 1st of the next year. The data set consists of probabilities of death for single years of age (ages 0 to 95) and time (years 1850-1998) by sex and contains some 14,000 death probabilities (149 years times 95 ages).

Figure 7 displays the evolution of death probabilities for Dutch males, and figure 8 does the same for females. The shading varies from light to dark as the surface rises from low to high levels of mortality, equalling an increase in probabilities of death from less than 1 per 1000 via 25 per 1000 to more than 200 per 1000.

The contour map shows the structural changes in mortality as well as the more temporary disturbances of the mortality pattern. Examples of period-effects are the epidemics of cholera in 1853, 1854 and 1855, in 1859, and in 1866 and 1867, the smallpox epidemics of 1858 and 1871, the Spanish influenza epidemic of 1918, and the devastation of the Hunger Winter in 1944-1945.

The general pattern over time is characterised by high mortality in infancy and among the elderly. As progress is made in the fight against mortality, surfaces with mortality risks of more than 200 per 1000 disappear, first among infants, later among the elderly. The age range characterised by death risks below 1 per 1000 becomes wider and wider, covering in the 1990s almost all ages below 40. Death risks between 1 and 5 per 1000, already visible around 1870 at ages around 10 years, extend and become common at all ages between 1 and 30 years. Relatively high death risks shift to the highest ages. Backlashes are visible for example among young male adults between the middle of the 1950s and the middle of the 1970s as a consequence of the rise in traffic accident mortality and from the early 1950s on, among elderly men. Starting with men aged between 55 and 65 and later extending to higher ages as well mortality rates increased as a consequence of increased tobacco consumption and changing diets, trends that both had their origin in changing consumption patterns in the middle of the 1920s, but showed an effect with a time lag of several decades. We come back to this issue later on.

Figure 7. Dutch male probabilities of death, 1850-2000

The growth and decline of male excess mortality

It is clear from the above that from the moment that national data became available, the average length of life of women was some two to three years higher than that for men. Yet there were clear differences over time in the level of that difference.

The period 1850-1898 can be characterized as one of increasing differences. Life expectancy at birth for males in the 1850s and early 1860s was between 1.6 and 2.3 years lower than that for females. Especially around 1865, male excess mortality started to increase, reaching values between 2.8 and 3.5 in the years 1893-1903. After 1903 this trend was reversed and female life expectancy was in the 1920s only 1.3-1.5 years higher than the value for males. A period characterized by a strong increase in excess mortality started in 1927 and lasted till 1975; on average the male/ female differences in life expectancy increased by 3.25% per year. The increase of male excess mortality was in fact rather modest till the beginning of the 1950s; whereas around 1950 women lived on average 2.4-2.6 years longer than men, in the middle of the 1970s the difference had increased to 6.7 years. From 1975 on, a decrease in excess mortality started.

Decomposition of the male-female difference in life expectancy at birth according to the method devised by Arriaga reveals some interesting findings (see figure 9a).

Male excess mortality was very low or did not even exist at higher ages till the end of the 1930s. Between ages 5 and 20, males had lower mortality than

Figure 8. Dutch female probabilities of death, 1850-2000

females till the beginning of the 1920s. Between ages 20 and 50, female excess mortality was characteristic till the mid-1880s. From that time on, males aged 20-50 had higher mortality than females.

As figure 9b shows, until the 1940s, the female advantage was almost completely due to much lower mortality in the first year of life. The difference between the infant mortality rates of males and females increased especially from the end of the 1860s. In 1880, male excess mortality in the first year of life had the highest impact on the difference between male and female life expectancy at birth, contributing 2.42 years to the total difference of 3.12 years. The *relative* contribution of this age group decreased somewhat from the same period on; that had to do with the fact that in other age intervals female mortality decreased somewhat faster. From 1880 on, the importance of the difference in mortality in the first year of life decreased nearly continuously; it was less than 0.20 years from 1985 on.

Between ages 1 and 5, male excess mortality was negligible till the 1870s; even after that time, mortality differences contributed only very marginally (maximally 0.40 years) to the difference in expectation of life at birth. Between age 50 and 65, male excess mortality started to increase from 1930 on, reaching a maximum in the 1970s. During the period 1962-1987, the contribution of this age group to the total difference in expectation of life was never below 1.0 years. Very remarkable was the development in age group 65-80. Whereas excess male mortality contributed less than 0.5 year to the total difference before 1940, a

Figure 9a. The contribution of various age groups in years to the total difference in expectation of life between men and women, Netherlands 1850-2002

Figure 9b. The contribution of various age groups in years to the total difference in expectation of life between men and women, Netherlands 1850-2002

steep increase in male mortality set in from the end of the 1940s on. As a consequence, this age group contributed in the beginning of the 1980s almost 4 years to the total difference in life expectancy, that is between 55 and 60%. Here too a decrease started in the mid-1980s. Finally, the mortality pattern above age 80, which hardly contributed to the total difference in life expectancy till 1900, showed a continuous increase in male excess mortality from the 1930s on, which accelerated from the mid-1970s on. During the most recent years, it almost contributed one year to the total difference in expectation of life at birth between males and females.

A more nuanced picture might be given by measuring for each separate age the level of male excess mortality. Figure 10 shows for each age and time combination the ratio of female to male death probabilities. Ratios above 1.0 (in light greys) indicate that males at the age concerned had a higher death risk than females, ratios below 1.0 (in dark grey) point to higher mortality of females.

In the past 150 years men had at most ages higher death risks than women. In the nineteenth century, for example, men in the age range between 45 and 70 years had death risks which were 10-30 percent higher than those of women. In the range between 70 and 90 years death risks varied in the same direction.

Four structural changes might be observed in the relation between male and female death risks (for a discussion of the causes see Van Poppel, 2000).

Of a relatively recent date is the strong increase in excess mortality among men aged between 16 and 26 years. This development started in the early 1950s, and showed itself as a peninsula of high excess mortality during a period of some thirty years. It was caused by a strong increase in mortality due to motor vehicle accidents, to other accidents and to suicide among men. As a consequence, male death risks in this age range in the 1960s and 1970s were two to three times higher than those of women.

The increase in male excess mortality at ages above 55 years also dates from the early 1950s. This increase started among men aged between 55 and 65 years and in the 1960s it had already resulted in male death risks which were at least two times higher than those of women. After 1960, this high level of male excess mortality shifted upwards until finally only at ages between 65 and 75 years large discrepancies between male and female mortality probabilities were observed. The very large diagonal blotch of light grey strongly suggests that male excess mortality followed a cohort pattern. It is the long-term effect of the increased consumption of cigarettes which is visible here. Among women cigarette smoking for a long time remained stigmatised and was considered quite definitely a male affair. As a consequence of the late adoption of smoking among women, the cohorts of women with the highest smoking prevalence

Figure 10. Dutch male probabilities of death divided by Dutch female probabilities of death, 1850-2000

entered only from the 1980s on the age range of highest smoking-related mortality. Death rates for lung cancer among women therefore lagged decades behind those of men.

Two other structural changes had their origin before the middle of the nineteenth century. In both cases it involved a situation in which women, in contrast to the usual pattern, had higher death risks than their male age peers. During a long period women aged between 25 and 45 years had higher death risks than men. This excess mortality still was at a level of between 5 and 30 per cent at the beginning of W.W. II and disappeared only after the war.

Higher female death risks were also observed at younger ages. Till around 1920 girls aged between eight and 16 years had higher death risks than boys. This excess mortality of girls gradually decreased and finally disappeared towards 1930.

Causes of death: From infectious to chronic diseases

Changes in the pattern of mortality by cause of death over time provide a first insight into the factors responsible for the mortality transition. They allow us to find at least indications regarding the factors behind the mortality decline: standards of living, public health, and medicine in a more narrow sense, behavioral changes, changing virulence etc.

During the period 1875-2003 eleven different cause-of-death classifications were in use. To study the trends in cause-specific mortality, use has to be made

of a nosologically continuous time series of cause of death. During the construction of this time-series the correspondence between the cause-of-death classifications of the various periods had to be determined, making it possible to link the codes of the successive classifications. In addition to that, causes had to be regrouped into meaningful categories, thereby avoiding the grouping together of diseases that were too different from each other anatomically or etiologically (Wolleswinkel-van den Bosch, van Poppel and Mackenbach 1996). The reclassification of the various cause of death categories in use since 1875 resulted in a system consisting of 27 causes of death for the whole period. For more recent periods in which more detailed classifications were in use more refined systems were constructed. We focus here only on the most rudimentary classification and present information on the most important causes of death. For these causes of death we present deaths rates by sex, standardized by age, per 100,000 person-years (for a sketch of the European context, see Caselli 1991).

The most important group of diseases in the nineteenth century were infectious diseases. Following McKeown (1976: 33-35), infectious diseases can be distinguished according to the modes of spread of the infection into the following groups: airborne-diseases, water-and food-borne diseases and other communicable diseases. This distinction is important since it determines in part the possibility in a given situation of preventing contagion and thus mortality. Airborne diseases are transmitted from one individual to another directly via saliva, or indirectly via dust in bed linen, clothing or carpets. To this group of infectious diseases belong bronchitis, pneumonia, and the typical childhood diseases such as whooping cough, croup, measles, scarlet fever, diphtheria, and smallpox. Lung-tuberculosis and puerperal fever also belong to this group but we will treat them separately, the last one together with other puerperal diseases. Water-and food-borne diseases such as cholera, diarrhea, dysentery, typhoid and typhus are spread by drinking or washing with water contaminated with infected human feces or urine, or with micro-organisms carried by animals. Bacterial and some viral and parasitic diseases can also be conveyed via food from contaminated livestock or from animals living in contaminated water or contaminated by infected individuals. Other diseases due to micro-organisms refer to conditions of infective origin which are not spread mainly by air, water or food for which certification of cause of death was unsatisfactory (as in the case of convulsions or teething).⁵ Among this group are malaria, anthrax, syphilis, appendicitis, and convulsions.

5. Death through convulsions was usually only the final and fatal effect of infection or some other condition, often (though not widely acknowledged at the time) including dehydration resulting from gastrointestinal disturbances. Contemporary experts considered convulsions and teething as causes of death following digestive sickness which could consequently be subsumed under the digestive disease category (Rombouts, 1902, 102).

Figure 11. Age-standardized death rates per 100,000 person-years by sex, 1875-2003, water- and foodborne infectious diseases

Figure 11 gives age-standardized mortality rates for water-and food-borne diseases for males and females. The figure shows the enormous decrease of diseases related to hygiene and food and thus make clear what tremendous effect improved public health facilities (sewage systems, water supply), improved personal hygiene, higher food quality, changes in breastfeeding and many other factors had. A very large proportion of all deaths amongst infants during the late nineteenth and early twentieth century were related to this cause of death. It is hard to see whether already before 1875 a decrease in this cause of death had taken place but it is clear that such a decrease was present in the last quarter of the nineteenth century and continued at much higher speed from 1900 on.

Mortality rates for diseases transmitted mainly by air and direct human contact were more or less stable during the last quarter of the nineteenth century. A clear decrease only took place after 1900. Mortality from the classic infectious diseases of childhood (scarlet fever, measles, diphtheria and croup, and in particular whooping cough) played only a minor role during the first year of life of the child. Yet there were years in which some of these diseases were epidemic and the number of deaths was relatively high. These causes of death gradually lost their importance only after 1900.

Other infectious diseases followed the same declining trend but at a much faster rate. The decline here was in full swing from the 1870s on.

Mortality due to lung tuberculosis followed more or less the same pattern, characterized by a decrease from the start of the observation period on. Thus, all

four categories of infectious diseases started at around the same level of between 180 and 250 deaths annually per 100,000 population, decreased very strongly from the beginning or from 1890-1900 on and had almost completely disappeared as causes of death of any importance after World War II. Whereas in 1875 969 males and 870 females per 100,000 person-years died as a consequence of one of these four groups of infectious diseases, those rates had decreased to 40 and 30 per 100,000 in 2003.

Puerperal fever and other diseases of pregnancy were responsible for only a small number of deaths compared to the aforementioned groups of infectious diseases. The decrease of this cause of death took place in two stages: till 1900 and after the middle of the 1930s.

External causes of death also played only a minor role. There was a decline until W.W. II, an increase after W.W. II till the middle of the 1960s, mainly caused by traffic accident mortality and a very strong decrease afterwards. Suicide mortality contributed only to a very small degree to the mortality transition. It showed a decreasing trend, from the 1970s followed again by a slight increase.

The present-day mortality pattern is characterized by the dominant role played by cardiovascular diseases and the various forms of cancer. Given the small degree of differentiation in the nineteenth- and early twentieth-century cause-of-death statistics it is not possible to distinguish within these groups between the various forms of cancer and between the various cardiovascular diseases. These various forms have all known their own dynamics and differences to which we cannot pay attention when we want to follow the mortality pattern from 1875 on.

Mortality due to cancer and due to cardiovascular diseases showed some parallel in their level at the start and in the trend it followed. Both causes of death showed a continuous increase from the start of the registration period onward. Cancer reached a peak in the 1980s, cardiovascular diseases in the 1970s. The most remarkable aspect however is the tremendous difference between men and women that became visible from the 1950s on. Whereas among men mortality rates kept on increasing, among women a stabilization or even decrease is visible. This is the main reason for the gender gap in mortality that was so characteristic for the 1960-1980 period.

Figure 12. Age-standardized death rates per 100,000 person-years by sex, 1875-2003, airborne infectious diseases

Figure 13. Age-standardized death rates per 100,000 person-years by sex, 1875-2003, other infectious diseases

Figure 14. Age-standardized death rates per 100,000 person-years by sex, 1875-2003, respiratory tuberculosis

Figure 15. Age-standardized death rates per 100,000 person-years, 1875-2003, maternal mortality

Figure 16. Age-standardized death rates per 100,000 person-years by sex, 1875-2003, external causes of death

Figure 17. Age-standardized death rates per 100,000 person-years by sex, 1875-2003, all forms of cancer

Figure 18. Age-standardized death rates per 100,000 person-years by sex, 1875-2003, cardiovascular diseases

Figure 19. Age-standardized death rates per 100,000 person-years by sex, 1875-2003, chronic respiratory diseases

Conclusion

The real start of the mortality decline in the Netherlands can be localized in the middle of the 1870s. Mortality had already been declining from the beginning of the nineteenth century on, as becomes clear from the development of the crude death rates, but the large swings in mortality masked this slow decline. What happened after 1880 was of a different order and meant the onset of a new mortality regime in which crisis mortality did not have an effect on the trend anymore (for a discussion of the causes behind the decline see for example Wolleswinkel-van den Bosch, 1998; Mackenbach 1992). The pace at which the expectation of life in the Netherlands increased was extraordinary: whereas around 1870, the average length of life in the Netherlands lagged some 10-12 years behind the Nordic countries, and some five years behind France and the United Kingdom, in 1910 the Netherlands were in a better position than most of these countries and only 2-3 years behind Sweden and Norway. After 1910 the Netherlands even reached levels comparable with those of the Scandinavian countries. Compared to 1850, the average length of life had doubled in 2003.

The by far largest part of the total increase in life expectancy (between 36 and 43 percent) was caused by the decrease in mortality between birth and age 1 that took place from 1887 onwards. Mortality among 1-5 year old children also contributed heavily to the increase in life expectancy at birth but the mortality decline in this age range started already in the beginning of the 1870s. In age groups 20-50 and 50-65, the mortality decline started around the middle of the 1860s.

We have to stress that until 1900 there was an enormous interindividual variation in the length of life and the average length of life was reached by only a very small part of the population.

This general overview of the historical mortality decline in the Netherlands might serve as a background to more refined and more local studies. Historians of mortality have increasingly begun to question the value of national-level mortality data for explanatory purposes. Various authors such as Johansson and Kasakoff (2000), Garrett et al. (2001), Imhoff (1990) and others have stressed that until the first decades of the twentieth century the 'disease environment' and economic circumstances varied enormously from place to place, from social class to social class, from men to women and from household to household. That could lead to large differences in the expectation of life at birth between regions, between the sexes, between social class and household categories, sometimes of the order of 10-15 years. A national value of the expectation of life is in such a situation not a measure that describes the experiences of the majority of the population but a statistical artifact. It also implies that it would be a mistake to assume that one factor (be it improved nutrition or better water supply or public health measures) was equally relevant to the mortality transition in all these groups and

categories, which each had their own specific type of disease environment. With Johannson (2000) we think that it is necessary to start identifying the different stories of the mortality transition. This has implications for the historical study of mortality and for the study of social history in general. It is urgently needed to identify forerunners and backwaters in the mortality transition and to look for the factors responsible for the mortality decline in various categories of the population. More detailed knowledge of the health situation of various groups, defined according to a variety of criteria will make it possible to reconstruct the living environment and the daily life of historical populations. After all, sickness, physical handicaps and death were essential and integral elements of life that had enormous consequences, not only for the person who became ill, injured or died, but also to persons in the household and the larger community. It brought about large changes in income and consumption; it reallocated labor within and outside the household, and caused the dissolution of households etc (Over, Ellis, Huber and Solon 1992). The region in which one lived, the class to which one belonged, the family situation in which one was in had a great bearing on when and how one died. By introducing this variation in mortality, our knowledge of the historical variation in living conditions can be increased considerably.