SECTION III

MULTI-STATE MODELLING
CHAPTER 4

DETERMINANTS OF MORTALITY DECLINE

4.1. SUMMARY

Introduction The importance of the contribution to the mortality decline of improvements in nutritional status, safe water supply, sanitation, income and literacy status, and health services is subject to recurrent and heated debates. The chapter examines how multi-state modelling can synthesise the results from epidemiologic and demographic studies to estimate the effect of each health determinant to changes in differential mortality in India, Mexico, and The Netherlands.

Methods The applications use the generic model framework. Input data on health risks are based on historical figures. The input figures for these three parameters are selected from studies on comparable sub-populations. The calculations reproduce the historical demographical figures of the three countries on population size, crude death rates, crude birth rates and life expectancy at birth. Model outputs have been tested for their validity and consistency. Calculated excess total age- and sex-specific mortality risks by health determinant are similar to those reported in the literature. Calculated annual disease-mortality rates, however, were not always consistent with historical time series.

Results Adding official future scenarios, the generic model framework shows that it can account for competing, multiple health determinants and multiple diseases, describing historical mortality declines in the three countries.

In the Netherlands, literacy and increases in SES lead to considerable high health level even without modern health care. With the introduction of modern care, life expectancy increased even more, but with diminishing returns. In Mexico, simultaneous increases in SES and access to modern health care lead to a fast increase in health levels. In India all improvements in health determinants seem to be there but increase at a slower rate. Two model experiments show the net estimates of the contribution of safe water supply and health services as a function of the level of other health determinants.

Conclusion The outcomes and model testing show that improvements in health determinants have three distinct origins: 1) the substitution and competition of health risks and diseases causing a certain inertia in the improvement of health 2) the prevention of cohorts becoming ill and, 3) increased survival after entering disease states. There are no unique solutions in the quantification of the role of health determinants in the mortality transition for specified populations. The contribution of each determinant is always depending on the level of other health determinants. Each population is bound to follow its own path in the transition by the country-specific pattern of determinants. Time series of historical disease-specific mortality rates should be used for further calibration and validation of model outcomes. This will result in a reduction of uncertainties in parameter values. Many more applications are possible, especially for the design of optimal strategies in the improvement of health determinants.
4.2. INTRODUCTION

This chapter describes the use of the generic modelling framework to analyse the historical decline in mortality in three countries i.e. India, Mexico and the Netherlands. These case studies have been part of a larger programme at the Dutch National Institute (Swart et al., 1995; UNEP, 1997; Niessen and Hilderink, 1997). The countries were selected by four criteria: (1) each population presently living in a different stage of mortality decline, (2) the availability of demographic data, (3) different population sizes, and (4) their relevance for the UN’s international reporting (Swart et al., 1995). The case studies were selected to test our methodological postulate regarding the generic use of the framework. In addition, the assessment results of the case studies are given and compared. It shows the contribution of health determinants in mortality decline.

After an introduction, the scenario methodology for the health determinants is described and the sources given. Next the estimates of their contribution to mortality decline are given and compared. Then two model experiments are reported to show the dynamics of disease substitution and competition. Last, a number of conclusions are drawn on the relationship of health determinants and disease occurrence.

Table 4.1 shows the specific demographic pattern in the three countries. India shows the demographic pattern of a late first transitional stage (chapter 2) with still a high level of fertility and mortality. Mexico finds itself in the second stage. Death rates have been declining for many decades but the changes in fertility are lagging behind for relatively long time i.e. some 30 years. The Netherlands, in the next stage, have seen an early decrease in mortality levels and a relatively slow decline in births rates to below replacement level. The crude death rate rises in the Dutch population as it is ageing.
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In each case the modelling framework is used to analyse mortality changes for the populations from the first stage of the health transition onwards starting in 1900 for two countries. It explores the possible futures for India and Mexico based on scenarios. In case of the Netherlands we tested only a historical simulation, from 1860 to 1990, as this country has completed the last known stage of fertility and mortality change. We used historical input scenarios for population health determinants and the related future scenarios internationally available.

The chapter describes first the methodology regarding the health determinants scenarios followed by the associated results regarding population change and disease burden. It is discussed for each case how the health transition pathway can be mapped out. Last, it arrives at a synthesis and conclusions regarding the general applicability of the modelling framework.

4.3. SCENARIO METHODOLOGY

Here, we describe first the general methodology of scenario development. The next section gives the details by country. As said, these scenarios are based on internationally available data and estimates. Each scenario parameter is consistent with the levels of the other parameters. This means that the GNP scenarios are taken as the basis for the changes in literacy, health services, water supply, and food availability. As the World Bank GNP scenarios are all optimistic the projected changes in the parameters are also optimistic. They are based on scenarios that haven been part of the Global Environmental Outlook reports by the UN Environmental Programme (Swart, 1996). The same methodology has been applied uniformly to the three case studies (see tables in the next section for the country scenarios). These are historical and future input assumptions regarding the changes in water availability, food security and socio-economic changes as expressed in literacy, gross national product, and changes in total health service expenditure level. We describe them by input scenario parameter.

Gross national product projections The economic scenarios are based on projections available from the World Bank (1993). They are expressed in percent growth of the gross national product in US$ 1990.

Changes in the number of people below the poverty line The (future) changes in the number of absolute poor are estimated using the fitted function of GNP and percentage of people below the poverty line (chapter 3). We used the GNP figures expressed in 1990 prices. The poverty threshold at this price level amounts to an annual 420 US$ on a purchasing power parity basis. The population below the poverty line is estimated using a function of poverty distribution and GNP for low-income countries categories (chapter 3).

Food availability The food scenario is associated with the GNP scenario for developing countries. It is expressed in terms of number of available kilocalories per person per day. It is calculated using a general increasing function between GNP and food demand in kilocalories i.e. the “Engel” curve (Alcamo et al. 1994) and the Agrostat data (FAO, 1992, Rosengrant, 1995).
Water supply. The water supply scenario is calculated assuming a full water and sanitation coverage by the year 2050. This is set as a policy as this is usually the case in the implementation of this type of infrastructure. Full coverage seems to be economically feasible given 1) the favorable economic scenarios used of an average 2.3% growth per capita until 2025 in the low- and middle-income countries combined (World Bank, 1994), 2) a constant total percentage of investments in water and sanitation of 0.4% of the GNPs, and 3) the demographic scenarios as given in the tables (UN, 1992). For these scenarios we had to make a number of separate, not included, costs assumptions. They are based on:
- the costs of a technologies mix for urban populations (50% of the population for 200US$ per capita, 25% of the population for 100 US$ and 25% 20 US$ per capita, and low-cost technology for rural populations (=30% of the population).
- the water access scenarios by UNEP (1997). Here, about 120 million people, worldwide, are assumed to receive access to safe water annually. This is below the 135 million people that were reached annually during the Water Decade (Scheitenleib, 1993; UNDP, 1994).
- the assumption that urbanisation rates will be constant after 2010. This is important for the costed technology mix.
- an extrapolation of the historical time series based on the review by Cleighs (1993) and the international reports (World Bank, 1993; WHO, 1995).

Service development. The estimates for the scenarios on total health service expenditure are based on a logarithmic function of GNP per capita and the percentage of GNP devoted to the health service per capita (chapter 3).

Human development index. An overall index of the general socio-economic level is the human development index (HDI), which we computed to summarize some of the input scenarios. This is done as described by the UNDP in the Human Development Report for 1994. This index combines health risk parameters (GNP, literacy) with an impact parameter (life expectancy) without accounting for the "input-output" relationship. Limitations of this index are that it is relative insensitive and it only slowly changes over time because of the contribution of three factors. An income level below $200 is used in the scaling as a cut-off point: below it the GNP contribution to the index becomes zero.

4.4. SCENARIOS FOR INDIA, MEXICO & THE NETHERLANDS

The case studies show each a characteristic pattern of health determinants in the past and in the future. This pattern determines, as postulated, the largest part of the changes in disease occurrence and related mortality decline. To be able to do this, we had to make a number of model adaptations of the generic structure. The first adaptation was related to the start values of population, determinants and disease states. For each of the cases the initial values have been adapted based on the above presented historical input scenarios and available additional data. If not available, they were estimated by an initialization run for eight hundred years to calculate the equilibrium values, typically for the early transition phase. Next, some adaptations were made in
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the disease model, although less extensive. We had to include a malnourished fraction among those born to fit the number of perinatal deaths to the empirical figures. The consequence was an overestimation of the simulated number of life births as compared to the empirical figures. This is very likely due to an underreporting of perinatal deaths. The fraction malnourished disappears later in the scenarios as malnutrition disappears and perinatal mortality lowers as a consequence of economic growth. The timing of technology was adapted to reflect the observed onset of medical technology by changing the effectiveness function.

We have included some structural model adaptations in the generic model. The other adaptations are basically value adaptations, including the timing of the introduction of technology and modern family planning. These do not influence our postulate on the generic nature of modelling disease occurrence in stages of the health transition and the modelling framework.

<table>
<thead>
<tr>
<th>Health determinant</th>
<th>input scenario by calendar year</th>
<th>annual change (%)</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>a. India</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GNP (10^12 US$1990)</td>
<td>1990 0.3 0.7 3.7 4.3 3.8</td>
<td>WB, 1991</td>
<td></td>
</tr>
<tr>
<td>GNP per capita (10^3 US$1990)</td>
<td>0.3 1.0 1.8 3.0 3.0</td>
<td>ibid</td>
<td></td>
</tr>
<tr>
<td>Percentage in poverty</td>
<td>43 28 14 -1.2 -2.7</td>
<td>function estimate</td>
<td></td>
</tr>
<tr>
<td>Population in poverty (10^6)</td>
<td>365 400 270 3.0 1.5</td>
<td>ibid</td>
<td></td>
</tr>
<tr>
<td>Health expenditure (% GNP)</td>
<td>3.7 3.8 3.9 0.0 0.1</td>
<td>OECD, 1995</td>
<td></td>
</tr>
<tr>
<td>Food per capita (10^3 kcal/day)</td>
<td>2.2 2.6 2.9 0.5 0.5</td>
<td>Rosegrant, 1995</td>
<td></td>
</tr>
<tr>
<td>Safe water and sanitation (%)</td>
<td>56 100 100 1.6 1.5</td>
<td>Majumdar, 1994</td>
<td></td>
</tr>
<tr>
<td>Population (10^6)</td>
<td>840 1,400 1,900 1.3 1.3</td>
<td>UN, 1993</td>
<td></td>
</tr>
<tr>
<td><strong>b. México</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GNP (10^12 US$1990)</td>
<td>1990 0.2 0.8 2.0 3.2 2.8</td>
<td>WB, 1991</td>
<td></td>
</tr>
<tr>
<td>GNP per capita (10^3 US$1990)</td>
<td>3.0 5.5 11 1.7 2.2</td>
<td>ibid</td>
<td></td>
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<tr>
<td>Percentage in poverty</td>
<td>17 5.0 0.1 -0.4 -0.1</td>
<td>function estimate</td>
<td></td>
</tr>
<tr>
<td>Population in poverty (10^6)</td>
<td>15 6.5 0.2 -0.3 -0.4</td>
<td>ibid</td>
<td></td>
</tr>
<tr>
<td>Health expenditure (% GNP)</td>
<td>4.0 5.8 7.1 0.2 0.4</td>
<td>OECD, 1995</td>
<td></td>
</tr>
<tr>
<td>Food per capita (10^3 kcal/day)</td>
<td>2.7 3.2 3.5 0.4 0.4</td>
<td>Rosegrant, 1995</td>
<td></td>
</tr>
<tr>
<td>Safe water and sanitation (%)</td>
<td>71 100 100 1.0 1.0</td>
<td>Majumdar, 1994</td>
<td></td>
</tr>
<tr>
<td>Population (10^6)</td>
<td>83 122 160 1.1 1.1</td>
<td>UN, 1991</td>
<td></td>
</tr>
<tr>
<td><strong>c. The Netherlands</strong></td>
<td>1860 1900 1950 1990 1990 1900</td>
<td>Stuijvenberg, 1970</td>
<td></td>
</tr>
<tr>
<td>GNP (10^12 US$1990)</td>
<td>0.0005 0.001 0.01 0.3 3.3 9.0</td>
<td>Stuijvenberg, 1970</td>
<td></td>
</tr>
<tr>
<td>GNP per capita (10^3 US$1990)</td>
<td>0.15 0.2 0.9 19 2.0 8.0</td>
<td>ibid</td>
<td></td>
</tr>
<tr>
<td>Percentage in poverty</td>
<td>49 48 0.1 0.0 -2.4 -2.0</td>
<td>function estimate</td>
<td></td>
</tr>
<tr>
<td>Population in poverty (10^6)</td>
<td>1.5 2.4 0.1 0.0 -5.1 -0.1</td>
<td>ibid</td>
<td></td>
</tr>
<tr>
<td>Health expenditure (% GNP)</td>
<td>0.1 0.1 3.9 8.2 4.0 1.8</td>
<td>OECD, 1995</td>
<td></td>
</tr>
<tr>
<td>Food per capita (10^3 kcal/day)</td>
<td>2.2 3.0 3.2 3.5 0.2 0.2</td>
<td>Jobse-Putten, 1995</td>
<td></td>
</tr>
<tr>
<td>Safe water and sanitation (%)</td>
<td>8.0 42 95 100 2.5 0.1</td>
<td>Zon, 1986</td>
<td></td>
</tr>
<tr>
<td>Population (10^6)</td>
<td>3.0 5.1 10 15 1.3 1.0</td>
<td>CBS, 1990</td>
<td></td>
</tr>
</tbody>
</table>

Table 4.2. Health determinant input scenarios by calendar year for India, Mexico and The Netherlands. Other sources on India: Hutter et al. 1995; Arnold, 1993; Resource Analysis, 1994; TARU, 1993; on Mexico: Kunitz, 1993; Bobadilla, 1993; Vianen et al., 1996; Nicholas et al, 1993; on the historical Dutch scenarios are van Deursen (1994) on literacy and Houwaart (1991) on health care development.
The scenarios on the health determinants for the three countries are listed in the Table 4.2 below. The estimated changes in poverty level are shown in Figure 4.4. In spite of the optimistic economic scenarios one can observe that the absolute number of poor in India tend to remain at the same level for some time. In the Mexican case, one can observe an early economic growth and general human development.

![Figure 4.2](image1.png)

**Figure 4.2.** GNP per capita (PPPS) change in The Netherlands (Stuijverberg, 1970; CBS, 1990).

![Figure 4.3](image2.png)

**Figure 4.3.** Food availability per capita in The Netherlands. (Jobse-van Putten, 1995)

The scenario set for the Netherlands is based on estimated historical figures. The historic time series for GNP is based on a Dutch publication (Stuijvenberg, 1970) and the literacy data on a report by van Deursen (1994). *Figure 4.2* shows the changes in GNP, calculated in US$ on a purchasing power parity basis (World Bank, 1992). The number of poor decreases faster than in the Mexican and Indian scenario as the result of the speedy economic development and the slower increase in population. *Figure 4.3* shows the time series on food availability by Jobse (1995). The average diet by the middle of the last century consisted of potatoes and some bread. During the so-called dark European decades of 1840-1860, there were a number of famines in Europe and in the Netherlands. The Netherlands show a slow overall increase in food availability after that period but diversity is lacking. The calculation of available
kilocalories per day has been made in a standard manner: This means that 1 kilogram of meat is taken as the equivalent of 7 kg of vegetables and 1 kilogram vegetable as the equivalent of 3500 kilocalories (FAO, 1992). The outcome of the calculation for the 1840-1960 period is comparable to those found for England (2000-2200 kcal/cap/day).

Figure 4.4. Population below poverty level in relative figures (rectangles) and absolute numbers (triangles).
as calculated by Fogel in a Swedish Academy of Science paper (Kiessling and Landberg, 1994). The complete food scenario (Figure 4.5) includes a shortage of food during the end of the Second World War. This situation is comparable to the levels of one century earlier for both kilocalories per capita available as the reached level of life expectancy at birth (CBS, 1990; Tabeau, 1995). The estimations of water access and sanitation coverage are based on van Zon (1986) and Houwaart (1991). In 1860, only Amsterdam had a drinking water supply and suggestively lower mortality rates (van Loghum, 1953). In most towns there was a door-to-door bucket collection system. During the second half of the 19th century the Commission on Drinking Water (1875) succeeded to mobilise policy makers to make relatively huge investments in the water and sanitation infrastructure. By the year 1890 there was coverage of 51 municipalities. The historical scenarios for India and Mexico are based on empirical national estimates based on local literature and reports. The future scenarios for the countries are mostly based on World Bank scenarios (WB, 1993). The food scenarios are by the Food and Agriculture Organisation. One can see that the optimistic scenario for Mexico after 2000 leads to a rapid decline of people living below the poverty line. The moderate scenario for India results in a very slow decline of poverty with a persistent absolute number of more than 300 millions of people still under the poverty line. First, the historical demographic figures, such as crude death rate and life expectancy have been calibrated. In the case of Mexico the figures in Basch (1994) on the change in mortality causes between 1950 and 1990 have been used (see also Fundacion, 1994). For India, only a limited calibration was possible, as disease-specific figures were available for only a decade.

4.5. RESULTS

Figure 4.5 shows the overall results for three case studies, under the health determinant scenarios based on assumptions regarding water availability, food security and human development and health services. The Human Development Index (HDI) is a combined figure for life expectancy, GNP and literacy levels. Looking closer at the changes in the human development index one can observe the interplay between population changes and socio-economic development. The HDI for Mexico shows an early rise as the consequence of economic growth and increase in literacy. Despite of optimistic economic scenarios for India potential changes in HDI are lower as a result of population increase. Still there is a rise in HDI as the result of increases in literacy and life expectancy. The early rise in HDI for the Netherlands is mainly caused by an increase in literacy and an increase in life expectancy as the result of better nutritional status and improved sanitary conditions. Economic growth in Mexico and in the Netherlands allows for considerable growth in service expenditure per capita, while, again this is much lower for India.
4.5.1. CHANGES IN LIFE EXPECTANCY AND POPULATION

In the Figure 4.6 the calibrated results for all three case studies are depicted for life expectancy and population size. They show the different patterns of population change and the different pathways through the health transition. Changes for India are huge and include a gradual fertility decline and life expectancy increase. Mexico shows a very rapid increase in population size, also historically (already a 700% in 1990). This is a result of a late onset of the fertility decline (since 1972) in spite of an early economic growth (since 1940) combined with an early rise in life expectancy at the start of this century. Population policy has been absent most of the time and, if present, rather pro-natalist for socio-cultural reasons, until recently (Vianen et al., 1995). In the long run, as the result of a speeded-up fertility transition the projected total number of people at the end of the last century is lower than projected by trend extrapolation. Another additional factor is that the present model has not been corrected for the annual net migration figures. This would make the empirical figures go up or down to a limited
extend. The entry of the health transition is due to the already moderate levels of social development reflected in literacy rates in general and for women and the higher economic status of a large proportion of the population (Figure 4.4). The empirical fertility level for the Netherlands remains, nevertheless, rather high as compared to other European countries and as compared to the projected increase for India. In the case of Mexico, the decrease in mortality combined with the high fertility leads to population increase that is twice the increase in the Netherlands and India.

4.5.2. BURDEN OF DISEASE BY HEALTH DETERMINANTS

*Figure 4.7.* depicts the computed health expectancies (DALE) for the three case populations. Here, the disease burden is expressed in lost years in disability-weighted life expectancy, by the main health determinant clusters as outlined in the previous chapter. The three clusters used in the figure are 1. life-style i.e. smoking and
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hypertension, 2. environment-related causes (lack of safe water, lack of sufficient food, malaria presence, and other environmental conditions) combined with conditions of low SES status, and 3. low SES status, or poverty, only.

Disease burden for India. The changes in health expectancy depicted in Figure 4.7 are computed in comparison to an assumed upper limit of 81 years. Early in the present century the lost life years reflect the level of life expectancy as the total lost DALYs are determined by perinatal and early childhood mortality. Years lost because of low quality environmental conditions in combination with low SES status are many. India's transition is starting only in the 1950s at the onset of the economic growth (in relative figures) but also, slightly later, the onset of the Green Revolution. As food and water supply improve, the lost life years among persons living in low SES conditions only increase as a result of substitution of health risks. The loss of life years attributable to life style only slowly increases as these appear at older ages. One can observe (Figure 4.7. and 4.10) that the modelled transition for India is protracted and results in a double burden of disease: both from infections and chronic diseases. Presently there are still a substantial number of deaths related to the environment-low SES status-infections complex (Resource Analysis, 1994; Hutter, 1995).

Disease burden for Mexico. The scenarios are optimistic regarding the improvements in sanitary conditions and food availability. Hence, the model demonstrates the shift from health loss because of lack of hygiene, malnutrition combined with low SES status to a low SES status only. There is an additional shift to health loss due to life style factors as the consequence of increased economic development and higher income status. This excess of life years lost is not countered by effects of modern curative services, as, in contrast, has been the case in the Netherlands. Here, typically for Mexico, one can observe (Figure 4.7.) that the modelled transition results in a double burden of disease: both from infections and chronic diseases. Throughout the 20th century, as is shown in other studies on Mexico, there is still a 15-25 years of life lost that can be shown in the computed life expectancy and also expressed as DALYs lost per thousand.

Disease burden for The Netherlands. At the impact level the model demonstrates health loss due to lack of hygiene, malnutrition combined with low SES status during the 19th century. This improvement resulted in the onset of the second stage of the health transition in a population growth. Low SES estimations remain high and loss of life years in this group remains high, also at total population level. There is a considerable gain in life years during the beginning of the present century (RIVM, 1995). After the Second World War the loss due to life-style factors dominates but flattens. Inevitably, the figures after this period are less precise but comparable to results from others (Ginneken, 1994). For a better analysis of this period more detailed models are needed.
Figure 4.7. Health expectancy and loss by health determinant category for India, Mexico, and The Netherlands (UNEP, 1997).
4.5.3. THE CONTRIBUTION OF HEALTH SERVICES

We explored the increased disease survival attributable to health services, both curative and preventive, only for the Netherlands. In this country the level of expenditure and the quality of the services are assumed to be sufficient enough to have a health impact at the population level (Mackenbach, 1988). By 1950 the two broad health determinants, malnutrition and low SES, are not contributing to health loss anymore. It is explored how the health gain since 1950 can be attributed to health services development (Treurniet, 1994). Figure 4.8 shows the effect of total health service expenditure, both prevention and cure (over 90% of the budget) on life expectancy. In this run a zero health expenditure scenario is simulated. This results in a change to the worst values for all the remaining health risks, including those for disease survival. As a result life expectancy is reduced considerably (about 12-15 years) and is even decreasing as the effect of another health determinant i.e. the increase in smoking prevalence among men and women.

![Figure 4.8. Modelled life expectancy based on historical time series and in a scenario without health services (The Netherlands version).](image)

4.6. DISCUSSION: MULTIPLE ROADS TO HEALTH

A different pattern of health determinants and disease leads to a different pattern of disease and mortality in populations. Below this ‘phenotype’ other health risks may or may not be present and play a role. Figure 4.9 shows a model experiment to illustrate competition and substitution of health risks, using the input and output data for The Netherlands. The figure on top shows two hypothetical safe water interventions and the figure below the changes in health expectancy and attributable losses due to health determinants (see 4.5.2). The input scenario for access to safe water has been changed dramatically, twice, during the period of mortality decline. The early intervention with a
large increase in safe water access results in corresponding increase in weighted life expectancy. At the same time there is a shift in health risks that causes loss of life years. In the presence of safe water supply, the socio-economic status of the same sub population involved remains unchanged.

Figure 4.9. Upper graph shows two hypothetical scenarios for water-access campaigns and lower graph shows the shifting effect of, competing, health risks (Dutch model version).

Consequently, for this population group this will have two effects shown in the figure: 1) inadequate water handling is still causing loss of health and 2) there is a no loss of healthy years due to life style related determinants. Next, the second simulated sudden complete increase in safe water access shows less increase in weighted life expectancy,
as there is less to be gained. The concomitant increase in food availability limits also environment-related loss of years.

The summary output for the three case studies are shown in Figure 4.10. It shows a comparison of the changes in socio-economic development, summarized by the human development index (HDI) and the changes at impact level (population size and life expectancy) for the three countries. One observes differences in timing and speed of the changes for each of the figures. Changes in HDI and life expectancy in the first stage of the transition run parallel for Mexico and India while for The Netherlands the HDI lags behind the increase in life expectancy. India and Mexico show a slowly
increasing HDI and life expectancy and a huge increase in population. In India this continues and the population is expected to increase even more. In Mexico, the huge population growth slows down as the HDI improves further. In The Netherlands, changes in life expectancy and population increase have been observed while the HDI remains low due to low economic growth. In the second stage, when population growth is not paralleled with an increase in HDI, life expectancy improvement may nevertheless lag behind (see India). A later rise in HDI does have less effect (Mexico and the Netherlands). In the case of Mexico, one can observe slowly converging tendencies and a stabilization of the population. A similar pattern one has observed for the Netherlands. In the latter, health gain has been achieved mainly because of factors not related to the HDI. The general level of this index remains low for a long time but still there is stabilization.

Studying the changes in the various health determinants for the three countries (Figure 43.7), again one can observe that different health determinants lead to additional health gains. For life expectancy, Mexico and The Netherlands show a gradual increase starting at the beginning of this century and even earlier. Socio-economic and environmental improvements run parallel for Mexico (Table 4.2b). In the Netherlands environmental improvements dominate early on, while low SES status in the Netherlands disappears rapidly by the end of the war due to economic growth. For both countries lifestyle factors become a leading cause of loss of health. Only for the Netherlands there is a further increase due to the effect of preventive and curative services. For India our calculations show a rapid retrieval of life years lost from environmental causes and slow improvement in SES early last century. In the seventies and eighties there is an improved availability of food per capita that contributes during this period to the increase in life expectancy. There is a projected continuous loss of life years by people living in low economic status from 1950 onwards and also in future. Lifestyle factors initially play a lesser role.

4.7. CONCLUSIONS

Based on official scenarios, the generic model framework shows that it can account for competing, multiple health determinants and multiple disease describing historical mortality declines in the three countries. In the Netherlands, literacy and increases in socio-economic status lead to considerable high health levels even without the interventions related to modern health care. With the introduction of modern care, life expectancy increased even more, but with diminishing returns. In Mexico, simultaneous increases in SES and access to modern health care lead to a fast increase in health levels. In India all improvements in health determinants seem to be there but increases are at a slower rate. The two model experiments show the net estimates of the contribution of health services as a function of the level of other health determinants.

The improvements in health determinants have three distinct features: 1) the substitution and competition of health risks and diseases causing a certain inertia in the improvement of health, 2) the prevention of cohorts becoming ill and, 3) increased survival after entering disease states. There are no unique solutions in the
quantification of the role of health determinants in the mortality transition for specified populations. The contribution of each determinant is always depending on the level of other health determinants. Each population is bound to follow its own path in the transition defined by the country-specific pattern of health determinants. Time series of historical disease-specific mortality rates should be used for further calibration and validation of model outcomes. This will result in a reduction of uncertainties in parameter values. Historical national data series in a number of European countries will be suitable. More recent time series for Sub-Saharan countries might also be suitable for additional model applications. Many more applications are possible, especially for the design of optimal strategies in the improvement of health determinants.
REFERENCES

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