Health expectancy and the problem of substitute morbidity

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SUMMARY

During the past century, the developed world has not only witnessed a dramatic increase in life expectancy (ageing), but also a concomitant rise in chronic disease and disability. Consequently, the tension between 'living longer' on the one hand and health-related 'quality of life' on the other has become an increasingly important health policy problem. The paper deals with two consequences of this so-called epidemiological transition in population health. The first one concerns the question of how—given the impressive changes—population health can be measured in an adequate and policy relevant present-day fashion. The second one is the so-called phenomenon of 'substitute morbidity and mortality': more and more acute fatal diseases are replaced by non-fatal delayed degenerative diseases like dementia and arthritis.

How the phenomenon of substitute morbidity and mortality affects the development of population health is illustrated with the epidemiological transitions, worldwide shifts in the main causes of death, assumptions used in models, adverse consequences of medical technologies and some results from intervention trials. Substitute morbidity and mortality may thwart our disease-specific expectations of interventions and asks for a shift to a 'total population health' perspective when judging potential health gains of interventions. Better understanding of the dynamics that underly the changes in population health is necessary. Implications for data collections are more emphasis on morbidity data and their relation with mortality, more longitudinal studies, stricter requirements for intervention trials and more use of modelling as a tool. A final recommendation is the promotion of integrative measures of population health. For the latter several results are presented suggesting that, although the amount of morbidity and disability is growing with an increasing life expectancy, this is mild unhealthiness in particular. This finding supports the 'dynamic equilibrium' theory. In absolute numbers, however, the burden of disease will continue to increase with further ageing of the population.

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1. INTRODUCTION

Ageing of the population is one of the most remarkable advances of modern times. Especially in the course of this century, developed countries have witnessed a dramatic increase in life expectancy: from around 40–50 years at the beginning of this age to 70–80 years in recent years. Human life expectancy has never been as high as it is today. However, the drawback of this 'improvement' has gradually become clear. Greying of populations goes hand in hand with an increase in chronic disease and disabilities. Consequently the question has arisen whether additional years gained in life expectancy are to be spent in good health or in a prolonged state of illness and dependency. Since about 1980 this question has formed the nucleus of a debate on the relationship between the evolution of mortality and the evolution of morbidity. Some consider it unavoidable that morbidity will expand (Gruenberg 1977; Kramer 1980). Others take the view that it will be possible to postpone chronic illness and disability to the 'evening of human life' by achieving what is called 'compression of morbidity' (Fries 1980, 1989). A third theory, that of the so-called 'dynamic equilibrium', postulates that although increasing life expectancy does indeed lead to more disease and disability, they will gradually become less serious in nature as each successive generation becomes healthier (Manton 1982).

The ongoing ageing process confronts society with the challenge of finding the right balance between living longer, on the one hand, and improving the health-related quality of life, on the other. However, despite significant research in the past few decades we still do not seem to have even started to meet this challenge. In many countries the burden of disease continues to increase, in particular due to the contribution of the elderly. Therefore, for health policy-makers ageing gives rise to many troubling questions. The main questions are: how can the burden of disease be diminished? How can we best deal with the unavoidable consequences of ageing? Important prerequisite conditions to finding the answers to these questions are:

1. an insight into the dynamics that underlie the process of population ageing;

2. the availability of a proper yardstick to be able to assess the problem in an adequate way.

The organizers of the meeting asked me to discuss these two conditions in my presentation. Therefore the paper contains two parts.

1. To start with, the phenomenon of 'substitute morbidity and mortality', an important aspect of the dynamics of population health, will be discussed.
2. Then a relatively new health indicator 'health expectancy' will be described. Most examples given come from The Netherlands, but similar results can be found in other countries.

At the end of the paper the relationship between the two issues will be touched upon.

2. SUBSTITUTE MORBIDITY AND MORTALITY

Substitute morbidity and mortality (SMM) has been defined as 'that disease and mortality which results from a decrease in another specific disease' (Van de Water *et al.* 1995). The philosophy behind this definition is a simple aspect of the dynamics of population health. If health is gained on the one hand, due to elimination or reduction of one particular disease, this gain may be lost again on the other hand because other diseases may sooner or later replace that disease. Hence, SMM is about competition among diseases.

As will be demonstrated in subsequent paragraphs, SMM is not a new mechanism. As long as the gains in health exceeded the losses, however, there was no reason to worry about this phenomenon. The fact that SMM now has become more relevant for health policy considerations can be explained by the disturbed balance between gains and losses, as described in the introduction. In this paper the occurrence and effects of SMM will be illustrated with the epidemiological transitions in population health that also comes to expression in worldwide shifts in the main causes of death. Furthermore, it will be discussed how attempts are made to deal with the phenomenon in models and how far the issue is covered in intervention trials. Finally, an example will be given of how medical interventions may play a role in the process of substituting mortality and morbidity. Obviously, in view of their ready availability, there is more data on mortality than on morbidity to illustrate how SMM affects health policies. However, it also will become clear that changes in mortality patterns are so closely related to changes in morbidity in the population, that the two should be considered as mutually dependent phenomena.

(*a*) *Epidemiological transitions*

Life expectancy of man has increased dramatically in the course of the past centuries, especially the present century. The ever-increasing survival rates are attribuable to measures that resulted in a reduction in mortality. Examples are better food, hygiene, proper housing and better health care. For example, the dramatic decrease in infant mortality is due mainly to improved obstetric and infant care. The major causes of death have changed in the course of time. These historical changes in mortality, however, were also accompanied by underlying changes in morbidity patterns. In the historical development of population health several eras can be distinguished.

Like demographers, who use their concept of 'demographic transitions' to explain worldwide population growth by changes in birth rates and mortality rates, epidemiologists have developed the concept of the so-called 'epidemiological transitions' (Omran 1971; Olshansky & Ault 1986). In this approach four eras are distinguished in the development of populations health from the middle ages up to the present time. The first era is a phase of 'pestilence and famine', with a life expectancy of 20 to 40 years. This period was followed by the phase of 'receding pandemics', such as cholera, with a life expectancy of about 50 years at the turn of the century. The next era, extending in The Netherlands from approximately 1930 to 1970, was that of 'man-made and degenerative diseases' (Mackenbach 1992). In this period, characterized by an increase in diseases related to human lifestyle (e.g. cardiovascular disease, cancer and accidents) life expectancy increased to over 70 years. At present we are in the phase of 'delayed degenerative diseases' and life expectancy is growing to 80 years. In this phase, mortality due to cardiovascular disease and accidents has decreased but the occurrence of non-fatal diseases, such as dementia and arthritis, has increased.

(*b*) *Worldwide shifts in the main causes of death*

Historically, registration of morbidity data has been less extensive than that of mortality data. However, since we can consider mortality patterns to be the outcome of underlying disease patterns, death registries may provide interesting information about the SMM phenomenon. In The Netherlands, although the same applies in many other developed countries, cardiovascular diseases have been the major cause of death for many decades (Hoogenboezem 1993*a*). This has not always been the case, however. Moreover, the question is whether cardiovascular disease will remain killer number one. Since the top of the epidemic around 1972, the role of cardiovascular death (expressed as a proportion of total mortality) has been decreasing. Cancer, however, has shown a steady increase for many years (Hoogenboezem 1993*b*). Extrapolations made some years ago even predicted that in The Netherlands cancer would become the 'main cause of death' before the year 2000 (Schaapveld *et al.* 1992). Since about 1990, however, both the decrease in cardiovascular mortality and the increase in cancer mortality have levelled off and a significant rise in deaths due to diseases of the respiratory system has occurred. Whether cancer will occupy the first position in the long run remains to be seen, but the fact remains that these shifts in the causes of death can be seen as part of the underlying dynamics of population health. On the other hand, such mortality data only disclose to a limited extent changes in the incidence and prevalence of these diseases. The fact that the prevalence of cardiovascular disease has increased, for example, because more patients are kept alive due to successful medical treatment, is not apparent from such data sources.

Evidence for significant changes in mortality patterns can be found worldwide. Moreover, in support of the concept of epidemiological transitions, it has been illustrated that these worldwide shifts are systematic. Figure 1 shows three main causes of death, as a proportion of total mortality, for eight regions of the world. The regions are ranked according to income per capita, which can be seen as a rough approximation of industrial development. For the regions situated lowest on the *x*-axis, the situation seems to be a little confusing; this may be due to the quality of the data for these areas. It appears that there is a relationship between developmental status and rank order of mortality causes. As industrial development increases communicable diseases are replaced by cardiovascular diseases; when the latter have reached the apex cancer is still on the way up.

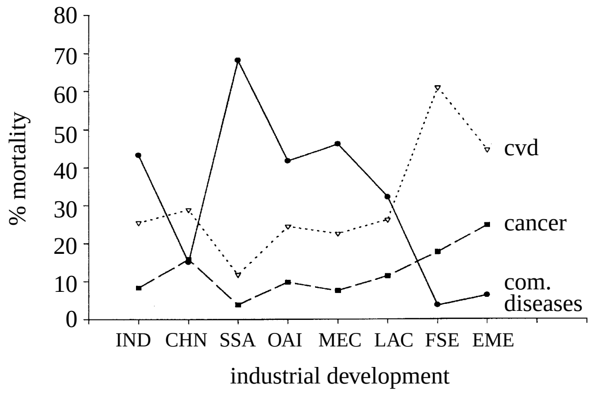

Figure 1. Main causes of mortality (as a proportion of total mortality) in eight regions of the world, ranked by industrial developmental status (estimated by income per capita). Source: Murray & Lopez (1994). IND, India; CHN, China; SSA, sub-Saharan Africa; OAI, other Asia and islands; MEC, middle eastern crescent; LAC, Latin America and the Caribbean; FSE, former socialist economies; EME, established market economies. cvd, cardiovascular disease; com. diseases, communicable diseases.

(*c*) *Assumptions used in models*

Probably because it is intuitively felt to be a plausible approach, the SMM phenomenon has often already been taken into account in mathematical models used to support health policy decisions. Demographers in many countries have calculated the potential gain in life expectancy under the hypothetical condition that one is able to eliminate mortality due to a disease completely (Cornfield 1957; Chiang 1978; Pollard *et al.* 1981). For example, in The Netherlands in the early eighties cardiovascular disease accounted for 44% of all deaths; expressed in potential life years it caused 36% of all years lost. The potential gain in life expectancy, however, is no more than 6.4 years (Van Ginneken *et al.* 1989). This is explained by the fact that the applied mathematical model assumes (albeit under the simple assumption of independence) that all individuals saved from a cardiovascular death are subsequently exposed to other risks, e.g. cancer, an accident or other diseases.

Another example is provided by PREVENT, a model developed to calculate the potential health gain of preventive interventions (Gunning-Schepers 1988). PREVENT can be used to estimate potential health gain over time, for example a projection of what would happen in the future if one were able to reduce smoking in the male population by 50%. Since the risk factor smoking is related to several diseases, the model gives both the total gain in avoided mortality (while taking competing risks of death into account) and the disease-specific gains (for lung cancer, chronic obstructive pulmonary diseases and cardiovascular diseases). The fact that the sum of the calculated disease-specific gains by far exceeds the calculated gain in total mortality is very instructive for those who want to consider particular interventions from a broader perspective.

(*d*) *Coverage in intervention trials*

The concept of epidemiological transitions and the use of competitive risks in models illustrate that the idea of substitution is gaining acceptance, albeit illustrated from health statistics almost exclusively for mortality. Some years ago we therefore studied the intriguing question of how SMM is taken into account in intervention trials (Van de Water *et al.* 1995). Our survey covered trials on smoking cessation, screening for breast cancer, lowering the cholesterol level and medical treatment for hypertension. The goal was to see whether and to what extent information relevant to the SMM issue was reported in the main articles.

The results showed that total mortality is reported in most studies (see table 1). Specific substitute mortality, that is death due to other specified diseases, is often reported for cholesterol-lowering trials and trials on hypertension treatment but seldom in the other types of intervention studies. Total morbidity and specific substitute morbidity are rarely reported, and if so information is given only to a limited extent. More recent intervention trials tend to provide more information, however.

Insofar as data on mortality are given, it appears that almost all cholesterol trials showed an increase in mortality due to diseases other than cardiovascular diseases, which can be seen as an illustration of substitute mortality. There is not much, however, that we can learn from these trials about substitution of morbidity.

The conclusion of this survey is that, although there is even some evidence of SMM in the results, the phenomenon unfortunately is only covered to a limited extent in intervention trials. Hence, expensive as such studies are, they (as yet) provide less information than one would hope to obtain. Not even all authors consider what the intervention means for total or other mortality; only in several exceptional cases is the effect of the intervention on the occurrence of other diseases discussed.

Theoretically, intervention studies could be a rich source of better understanding of the SMM phenomenon. Therefore, it appears necessary to improve the

Table 1. *Reporting of data relevant to understanding substitute morbidity and mortality, in four groups of intervention trials* (Source: Van de Water *et al*. (1995).)

	percentage coverage in the groups of trials			
issues	smoking cessation ($n = 5$)	breast cancer screening ($n = 7$)	cholesterol-lowering ($n = 26$)	hypertension treatment ($n = 13$)
total mortality	100	29	88	100
specified substitute mortality	40	14	73	77
total morbidity	20	0	0	8
specified substitute morbidity	20	0	35	38

informative value of intervention trials, which could be achieved by standardization of trial reports. For example, one could require that the effects on mortality and morbidity of diseases other than the disease under study should be reported in the main publication on the trial. On the other hand we must keep the practical limitations of intervention trials in mind. The focus of such studies, which directly influences the length of the follow-up period and the sample size required for adequate statistical power, is mainly the intended effect of the intervention. Side effects are neglected, partly because the nature of possible side effects is not yet known and partly because the study period is too short to 'discover' them. Longer longitudinal studies therefore are recommended.

(*e*) *Medical interventions*

Health care is a process that in its application focuses on individuals, and maybe therefore it is sometimes forgotten that medical interventions may also have a significant impact on the development of population health. Many examples can be given of how medical technologies change the occurrence of death and disease. Here the induction of ovulation is used as an example. Not only may this intervention lead to the intended 'fertility' effect, but also to changes in the future mortality and morbidity of the mother. When this happens there is clear substitution. However, it may also affect the future health of the child. There are some indications that, compared with children born without this intervention, children born after induction of ovulation may experience a slightly different mortality and morbidity pattern due to substitutions of risks.

In the western world the introduction of ovulation-inducing drugs and the development of *in vitro* fertilization have broadened the possibilities of treatment of infertility. Since the early eighties there has been a marked increase in the use of ovulation-inducing preparations such as clomiphene and gonadotrophins. In 1989 approximately 2.5% of all pregnancies in The Netherlands occurred after induced ovulation (De Jong-Van den Berg *et al.* 1992); the sales of gonadotrophins increased from 60 000 ampoules per year in 1984 to almost 400 000 in 1990.

The iatrogenic damage which can occur as a result of the use of ovulation-inducing drugs is not insignificant. In approximately 1% of the women who undergo stimulation with gonadotrophins the 'ovarian hyperstimulation syndrome' can occur—a potentially life-threatening condition (Schenker & Weinstein 1978; Varma & Patel 1988). Furthermore the induction of ovulation often leads to a multiple pregnancy (Bonaventura 1989; Medical Research International 1991) which in turn can result in premature birth and an increased risk of infant mortality (Hoffman & Bennett 1990; Seoud *et al.* 1992). There are indications that there is an increased risk of neural tube defects in children born after induced ovulation (Vollset 1989; Cornel *et al.* 1991), and an increased risk of ovarian cancer in women who have undergone this treatment (Whittmore *et al.* 1992; Harris *et al.* 1992), although both associations must be studied in more detail. Little is known about the later physical and psychological consequences for mother and/or child.

In vitro fertilization is just one example of present medical technologies. People opt for such medical interventions because of the expected benefits. However, negative consequences connected with medical technologies, in particular large-scale applications, may in the long run affect population health significantly.

(*f*) *Conclusions on SMM*

Although intuitively SMM is already a plausible concept, the examples above support the view that the phenomenon really exists. As a phenomenon it is closely related to population ageing; prolonged survival in particular is associated with the increasing burden of disease. Over time, the balance between death and disease on the one hand and health and quality of life on the other appears to shift continuously toward a longer life but with proportionally more suffering and disabilities. Because the survival curve has shifted far up to higher ages in the course of time, many more individuals than in the past enter into the phase of increased chronic suffering before their death.

The significance for public health policy is that SMM may thwart our disease-specific expectations of various interventions. SMM confronts us with such questions as 'Is it really progress to exchange less cardiovascular disease for more cancer, or less cancer for more dementia?' The phenomenon of SMM in fact forces us to ask critical questions before decisions about the introduction of medical interventions are taken. Not all medical technologies will in the long run yield the benefit that we hope for at the time of their discovery.

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To cope with SMM one must therefore become aware of it. Furthermore, the phenomenon requires an important change in the conceptual framework with which public health policy decisions are taken: less from the traditional disease-specific perspective and more from the point of view of 'total population health'. Such a change in orientation can only be achieved effectively if adequate information becomes available. The necessary information could be divided into two main types: descriptive and explanatory. The first consists of data collections which describe and monitor population health, the second regards data which help to explain the underlying dynamics of changing population health. It goes beyond the scope of this paper to discuss in detail the implications of this need for different collection methods and study designs. However, some important issues worth mentioning here are: there should be more emphasis on morbidity data; stricter requirements should be formulated for reporting on intervention trials; more should be invested in longitudinal studies; modelling should be promoted as a useful tool for getting a grip on the issue of SMM, hence more studies should be attuned to delivering data that can be used in models. A last important issue is that, given the mutual relationship between mortality and morbidity patterns, ways must be found to integrate information on mortality with information on morbidity. This issue will be dealt with in the following paragraphs.

3. HEALTH EXPECTANCY

Health expectancy is a relatively new indicator for population health, taking into account both mortality and morbidity and/or disability. This integral measure is in fact based on the simple idea of subtracting the number of years that may be expected to be spent in ill health from the total life expectancy. For the United Kingdom an extensive overview of 'health expectancy and its uses' is available (Bone *et al*. 1995).

In The Netherlands the most extensive results have been presented for disability-free life expectancy and healthy life expectancy. In the first approach estimation of the healthy part of life expectancy is based on questions on disability in the representative Health Interview Survey of the Dutch Central Bureau of Statistics. In the latter type, to which the examples here will be restricted, health is assessed by one health interview question about self-perceived health (Van de Water *et al*. 1996*a*).

(*a*) *Integrated measures of population health, a logical development*

With the greying of the population, understanding changes in population health and the impact of medical interventions has become more complicated. Scientific research has unravelled many relevant and interesting parts of this problem, but how should policy-makers retain an oversight of the complex picture of health? Taking the epidemiological transitions into account, it is not chance but a logical consequence of developments in recent years that new indicators of population health have been developed (Van de Water 1993).

A common feature of such indicators is the effort to provide an overall picture of population health by integrating mortality and morbidity data. The example that will be discussed here is the indicator 'health expectancy', the principle of which was first described in 1964 (Sanders 1964), while the first operational calculation method was ready in 1971 (Sullivan 1971). Since the start of REVES, the international Network on Health Expectancy and the Disability Process in 1989, the number of countries that have produced health expectancy calculations has grown quickly (Bone 1992; Robine & Ritchie 1991; Robine *et al* 1995). Also the Euro-REVES project, a concerted action in the framework of the BIOMED-programme of the European Commission, is contributing to such progress (Van de Water *et al*. 1996*b*). Results for the first calculations for England and Wales were already published in 1988 (Bebbington 1988).

Another example of an integrated measure of population health is the DALY (Disability-Adjusted Life Years), an indicator for the total burden of disease which was developed for a project of the World Bank (World Bank 1993).

(*b*) *Types of health expectancy*

'Health expectancy' is a general term referring to an entire class of indicators that are expressed in terms of life expectancy in a given state of health. Examples are disease-free life expectancy (e.g. dementia-free life expectancy), disability-free life expectancy and healthy life expectancy. The latter is based on perceived health as reported, mainly through a Health Interview Survey, by a representative group from a population. Recently a provisional classification system to group the different types of health expectancy and their terminology (see table 2) has been proposed (Boshuizen & Van de Water 1994; Robine *et al*. 1995; Van de Water *et al*. 1996*b*). The proposed classification is reasonably compatible with WHO's classifications of diseases, respectively impairments, disabilities and handicaps (WHO 1980, 1992).

Originally many different terms were proposed by different authors to cover more or less the same idea. For example, the indicator 'active life expectancy', proposed by Katz and subsequent authors to measure independence by calculation of the average number of years an individual is expected to live without being restricted in a number of activities of daily living or instrumental activities of daily living (Katz *et al*. 1983). Its place in the classification system would be as an indicator of handicap-free life expectancy. The same would apply for the Healthy Active Life Expectancy (HALE), an indicator proposed to measure the effectiveness of health and social services for elderly people (Grimley Evans 1993).

(*c*) *Some examples from The Netherlands*

For a first understanding of how the results of health expectancy calculations can be presented, table 3 shows

Table 2. *Provisional classification system for types of health expectancy*

(Source: based on Boshuizen & Van de Water (1994).)

types of health expectancy
based on ICD
—disease-free life expectancy (example: dementia-free life expectancy, DemFLE)
based on ICIDH
—impairment-free life expectancy (IFLE)
—disability-free life expectancy (DFLE)
—handicap-free life expectancy (HFLE)
based on self-perceived health
—healthy life expectancy (HLE)
combined with severity weights
—health-adjusted life year equivalents (HALYE)

Table 3. *Total life expectancy, life expectancy in poor health and healthy life expectancy in The Netherlands 1994 (in years), for men and women at birth*

(Source: Perenboom *et al.* (1997).)

categories	men	women
total life expectancy	74.6	80.3
life expectancy in poor health	14.5	20.0
composed of:		
—mildly unhealthy	9.0	12.0
—moderately unhealthy	3.0	4.9
—severely unhealthy	2.5	3.2
(of which in long-term institutions)	(0.6)	(1.0)
healthy life expectancy (good perceived health)	60.1	60.3
healthy life percentage	80.5	75.1

some data on newborns in The Netherlands in 1994. Males can expect to live 74.6 years, women 80.3 years. Of this period men will spend 14.5 years in poor health, while this is 20.0 years for females. Hence, although the life expectancy at birth of females exceeds that of males by almost six years, this lead is almost entirely cancelled out by the greater number of years which females spend in poor health. Males thus spend a higher proportion of their life in good perceived health than females (80.5 versus 75.1%).

More interesting than the results for just one year is the development of trends over time. Figure 2 presents the trends from 1983–1994. In this period, the life expectancy (not shown) has increased for both sexes, albeit more for males (from 72.9 to 74.6 years) than for females (from 79.5 to 80.3 years). To take account of these changes in total life expectancy, the trend results in figure 2 have been expressed as healthy life percentages, that is their proportion of total life expectancy.

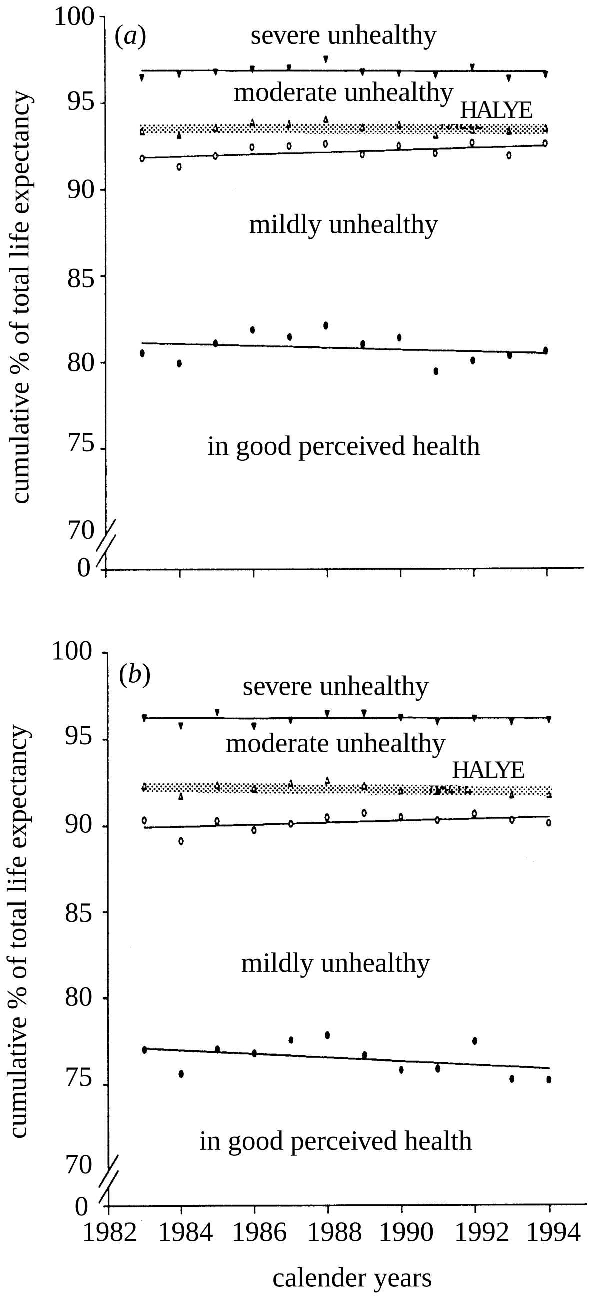

Figure 2. Trends in healthy life percentage, levels of unhealthiness and health-adjusted life year equivalents, for men (*a*) and women (*b*) at birth, 1983–1994. Source: Perenboom *et al.* (1997); Perenboom & Van de Water (1997).

The percentage of life spent in good perceived health, together with the percentages for the different levels of severity in poor health, sum up to 100%.

From figure 2 it appears that there is a slight (not significant) decline in the proportion of life spent in good perceived health. The proportion of life spent in a severe unhealthy state seems to be more or less stable, that for moderate unhealthiness is decreasing, while the proportion with mild unhealthiness is increasing significantly. Women spend a smaller proportion of their lives in good health than men. They spend relatively more time in all states of severity, in particular in mild unhealthiness.

(*d*) *Taking account of severity and other interesting findings*

If different weights are given to different levels of severity then it becomes possible to calculate how much difference there is between the two sexes in 'health-adjusted life year equivalents' (HALYEs). Also these trends are given in figure 2. For the calculations as severity weights we used the answers on questions about self-reported severity from the same Health Interview Surveys as the other data used to calculate these health expectancies (Perenboom & Van de Water 1997)

Over the period 1983–1994 the health-adjusted life year equivalents show a more favourable trend than health expectancy as such. The absolute number of health-adjusted life year equivalents increases for males and remains stable for females (not shown). Figure 2 reveals that the ratios of health-adjusted life year equivalents to total life expectancy remain fairly constant. After weighting for severity, the original difference between the two sexes, as inferred from the results in table 3, has almost disappeared. If severity is taken into account; males and females spend almost the same proportion of their life in good perceived health. In addition, there seem to be no change over the years studied. Results for The Netherlands therefore give no indication of either an expansion, or a compression of morbidity. The explanation seems to be that an increase in unhealthy years is balanced out by, on average, less severe states of unhealthiness. This idea finds support in a cohort study among elderly, which shows a change towards less dependence in activities of daily living (ADL) but worse perceived health, which is likely due to an increase in less severe disabilities not picked up by ADL questions (Spiers *et al.* 1996).

Comparable results have recently been found in Sweden (H. Petterson, personal communication) and similar conclusions can be drawn from a comparison of trend studies in other countries (Robine *et al.* 1995). These findings not only support the 'dynamic equilibrium' theory. They also illustrate how the application of an overall health indicator can serve the health policy debate. One should realize that the absolute burden of disease cannot be directly estimated from the health expectancy indicator, because this measure is independent from the composition of the population. By combining age-specific health expectancy results with demographic data, however, it is very well possible to produce meaningful estimates and projections of the burden of disease.

Other interesting findings of health expectancy calculations in The Netherlands show that rheumatism, back disorders and chronic obstructive pulmonary disease are the greatest contributors to the years in poor health (Boshuizen *et al. 1997*). Furthermore, analysis of health expectancies according to socioeconomic class revealed an impressive difference of more than 10% between high and low economic status (Boshuizen *et al.* 1994; Van Herten *et al.* 1997), which tallies with findings in Great Britain (Bebbington 1993). A study on dementia-free life expectancy (DemFLE) showed that an important part of the years that on average will be spend with this disease, will be years outside institutions and largely dependent of informal care givers (Perenboom *et al.* 1996).

(*e*) *Methods of calculation*

The results presented above were calculated with Sullivan's method (Sullivan 1971). In principle three different methods of calculation of health expectancies exist: the observed prevalence life table or Sullivan's method, the double decrement life table method and the multistate life table method (Robine *et al.* 1995).

The advantages of the Sullivan method are the separate collection of mortality and morbidity data, and the ready availability of the data needed for the calculation. Mortality statistics and cross-sectional surveys are sufficient to determine the mortality data, respectively prevalence data, needed. Problems with this method can occur with the approximation of the period prevalence. For example, results of trend studies obtained with this method tend to be less realistic when there is a sharp change in morbidity incidence. Such a change will only after some delay come to expression in a change in prevalence data used as input for the method.

The double decrement life table method is based on the occurrence of two possible outcomes: mortality and morbidity. These outcomes are considered as being irreversible. The advantage is that this method provides a good period indicator. A problem, however, is the non-separated collection of mortality and morbidity data in one study. For example, the accuracy of the mortality data largely depends on the follow-up period, which is too short for collecting information on all mortality risks in the sample (which would imply waiting until everybody had died).

The multistate life table method also takes account of the recovery of lost function and return to a state of good health (Rogers *et al.* 1989). It covers reversibility by observing transitions between states of health, and as such gives the best reflection of the dynamics that underlie changes in health. A disadvantage is that data requirements are considerable; only a few countries have adequate national data available. Another problem with this method can occur when the gaps between waves of the study are too long; part of the flow between health states during the inter-survey period then may be missed.

The Sullivan method uses cross-sectional morbidity and mortality data, whereas the double decrement and multistate life table methods depend upon longitudinal data sets. The financial and political implications of the choice between two such data collection strategies are enormous. Because they are relatively cheap, so far most countries rely on cross-sectional rather than on longitudinal surveys. However, longitudinal data and multistate methods are essential for projecting the health of populations. Despite the fact that the Sullivan method is simple and that its methodological limitations are very well understood, there is one very important practical drawback to cross-sectional studies. They do not contribute to our understanding of the dynamics that underlie population health. As such, this fact is a strong argument for the organization of more longitudinal studies.

(*f*) *Conclusions on health expectancy*

Health expectancy is a relatively new health indicator, emanated as a logical reaction to changes in population health, the so-called epidemiological transitions. As one of the new integrated measures of population health, it aims to provide an overall picture of population health by combining mortality with morbidity data. Health expectancy is a general term for several types of indicators of this kind.

With health expectancy calculations it is possible to present comprehensive but very policy relevant information on the consequences of ageing. For example, trend studies of health expectancies suggest that, although the total amount of morbidity is increasing with ageing, there is a shift towards less severe disabilities. Findings like this support the 'dynamic equilibrium' theory, which claims that an increase in disability due to greying of the population will be balanced out by the fact that younger generations tend to be healthier. There are no indications for a compression or an expansion of morbidity.

Presently most health expectancy calculations are based on the cross-sectional Sullivan's method. For methodological reasons, but in particular also because this may yield insight into the dynamics underlying changes in population health, the multistate method is to be preferred. Longitudinal studies on ageing are therefore recommended.

4. FINAL REMARKS

The phenomenon of SMM exists. It is a mechanism inherent in epidemiological transitions in population health and such transitions are taking place continuously. SMM is closely related to population ageing. Ageing as such should be considered as a positive development, in spite of the fact that prolonged survival in particular is associated with an increasing burden of disease.

The significance for public health policy is that SMM may thwart our disease-specific expectations of interventions. The phenomenon of SMM in fact forces us to ask critical questions which could influence decisions about the introduction of medical interventions. Not all medical technologies will yield in the long run the benefit that we hope for at the time of their discovery. Furthermore, SMM has important ethical implications for the process of priority setting in health policy, but they go beyond the scope of this paper.

To cope with SMM one must first acknowledge the phenomenon. Furthermore, the focus of public health policy considerations should be changed from the traditional disease-specific perspective to a more 'total population health' approach. Such a change in orientation can only be made if adequate information is available and that is the relationship between SMM and the health expectancy indicator. For descriptive purposes the indicator 'health expectancy' has already proved to be a promising tool. Until now most health expectancy calculations are based on cross-sectional studies. Much more should be invested, however, in longitudinal studies because they are an indispensable source of understanding the dynamics of the ageing process, the occurrence of connected diseases and potential ideas for interventions.

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