Demographers and the Study of Mortality

Scope, Perspectives, and Theory

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ABSTRACT: Demographers have for a long time adopted an empirical approach to the study of the levels and trends of mortality, fertility, and population size. They depend for their analyses on data, usually collected until recent times by government and often for other purposes. Modern demography had its origins in Britain in the second half of the seventeenth century. The major focus of demographers has usually been on mortality, although fertility studies predominated in the 1960s and 1970s. Mortality decline in the West only became certain in the late nineteenth century. Until the 1960s the fastest mortality declines were for the young, but an unheralded mortality decline among the old thereafter became important. The world, especially in economically advanced countries, is faced with an increasingly high proportion of old people, explained largely, not by mortality decline, but by fertility decline. Explanations for the mortality transition place different emphases on the role of modern medicine, better nutrition, and behavioral and social change, particularly rising levels of education. Even among the old, at least until 85 years of age, there are wide differentials in mortality by educational level. Analysts have divided the mortality transition into stages: (1) high, pretransitional mortality, (2) early transitional mortality with the decline explained by the conquest of infectious disease, and (3) late transitional mortality largely attributable to degenerative disease. Some have now added stage (4), the reduction or delay in death from degenerative causes. Attempts have been made to effect the convergence of demographic and epidemiological approaches to the analysis of mortality, and they have been more successful in the case of medical demographic than in social demographic approaches.

KEYWORDS: aged; causes of death; demographic empiricism; demography; epidemiology; health transition; mortality; mortality transition; old age mortality; population; wealth flows theory

INTRODUCTION

Interest in the size and growth of populations is as old as the first formation of states in the ancient Middle East, and some attempts to count or estimate populations go back for millennia. State strength was dependent on population numbers, especially those of males of military age, and a good government was one under which the numbers increased because of the suppression of violence and success in averting

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famine. There have long been attempts to place a figure on the number of deaths during severe epidemics. Censuses and the recording of deaths were carried out in some of the city states of Renaissance Italy. Birth rates were treated as either constant or meaningless and little attempt was made to measure them until shortly before the recent fertility transition.

Modern demography had to await the development of a scientific outlook and population counts and vital events that were reasonably complete. These conditions began to be realized during the second half of the seventeenth century in Britain, where the Royal Society was founded in 1660 with two of the fathers of demography, John Graunt (1620–1674) and William Petty (1623–1687) as members. Graunt was a merchant and used bookkeeping principles to construct the first life table, drawing mortality data from the records of deaths in London that had been compiled since the previous century. Petty described this activity as "political arithmetic",[1] a term regarded as being so appropriate by Lancelot Hogben that in 1938 he published a book under that title on the demography of contemporary Britain.[2] Edmond Halley (1656–1742) in 1693 constructed a life table much closer to the modern model with more complete data on the deaths and population of the German city, Breslau. Kreager[3] identifies Graunt, Petty, and Halley as the first to apply scientific principles to the study of society. All were consciously influenced by the work and scientific principles of Francis Bacon (1561–1626) and were well aware of the value of scientific laws, as evidenced by the work of their fellow Royal Society member, Isaac Newton (1642–1727) in his *Principia Mathematica* (1687) (edited by and published with the cost borne by Halley).

THE DEMOGRAPHIC APPROACH

The demographic pioneers' work bore much the same characteristics as those of their successors today.

1. The work depended on data having come into existence at the whim of others, usually governments, often for other purposes (e.g., the London Bills of Mortality were a means of detecting epidemics, principally plague). This is admittedly less true today.
2. Much of the labor was spent, not on making immediate deductions from the numbers, but on suspiciously testing the data and trying to improve them. This central assumption, that the raw data are almost certainly imperfect, sets demographers apart from most social, medical, and statistical scientists.
3. Demographers were deeply sensitive to the fact that crude numbers or measures may be misleading, owing to such factors as the age and sex structure of the population, and they were given to devising measures that overcame the distortions to allow valid comparisons.
4. There was a concept of a population, a large body of people constituting some kind of definable unit to which the measurements pertain.
5. Attention to large populations, often national ones, explained why demographic "arithmetic" is political. Often, indeed, its practitioners wanted to gauge the health of the body politic and even to point the direction for

improvement. Such policy involvement did not become controversial until the twentieth century when controversy arose, first over focusses on migrants and differential fertility in response to the eugenics movement, and later over research appearing to support the call for a curb on Third World fertility.[4,5]

6. Demographers were suspicious of the study of individuals and small groups, feeling that such persons are significant only when it can be shown what fraction of a larger population they constitute and even then that the fraction is of a considerable size.
7. Demographers looked for regularities in populations or subpopulations and for contrasts between subpopulations: Graunt showed urban-rural differentials in mortality, as well as male–female differentials in both numbers born and subsequent mortality.
8. From the beginning there was an interest in causation (Graunt examined the causes of death), but there was, at the same time, a suspicion that measures of causes were more likely to be in error than measures of population or death.
9. Until the nineteenth century in France and the twentieth century elsewhere mortality and population growth dominated demographers' interests; fertility became of interest only when birth rates began to decline, and the major concern only during the 1960s–1980s, when interest focussed on the beginning of fertility decline in developing countries.[6]
10. Demography has always been an empirical discipline maintaining almost uniquely nineteenth-century positivist attitudes throughout the twentieth century. Most demographers have been happy to carry out analyses within a minimalist theoretical framework and have been deeply suspicious of disciplines that built theoretical structures upon unproven, theoretical bases.[6] They have preferred intermediate or short-range theory to grand theory.
11. Nevertheless, the population field also gave birth to grand theory, associated with such names as Thomas Robert Malthus, Arsène Dumont, Frank W. Notestein, Thomas McKeown, Ester Boserup, and Philippe Ariès. Frameworks were established that consciously or unconsciously generated much of the shorter range research, and have made the subject known beyond its practitioners.
12. Once demographers had established the usual levels of mortality and fertility they became interested in change, especially once the demographic transition was under way. Modern demography has not only a population base, but also a time dimension. There is hardly a major demographic study in the twentieth century in which change over a period (usually of years) is not important.
13. Demographers, in contrast to epidemiologists, are usually concerned with total mortality decline, and are suspicious of approaches singling out advances in treating specific diseases, and of any attempt to treat total mortality decline as the sum of individual medical breakthroughs. When they

do trace mortality changes from one cause, they usually want to see what has also happened to mortality from other causes.

On the empirical side, demography made only limited progress during the eighteenth century. The reason was the failure of national censuses or vital registration systems to appear. The foremost demographic thinker of the age was Johann Peter Süssmilch (1707–1767), who, in his search for the divine order (not very different from later concepts of the natural order, or from ideas embedded in the work of Adam Smith and Malthus), examined masses of demographic data searching for regularities, discerned the balance of births and deaths (later to be termed "homeostasis"), and produced a life table that was used for actuarial purposes well into the nineteenth century.[7,8]

Sweden set up a system of population registers in the mid-eighteenth century, mandated by a 1748 Act. This allowed Per Wargentin to produce the first data-based national life table in the world for the years 1755–1757.[9] The United States decennial census, necessitated by its constitution for electoral purposes, was first taken in 1790. Britain followed in 1801, and in 1837 the registration of births and deaths was made compulsory in England and Wales.

The stage was being set for the rapid growth of demographic studies in Britain and other parts of Northern Europe in the second half of the nineteenth century. The most important single body of research was that on differential mortality by socioeconomic class inaugurated by William Farr (1807–1883) in a supplementary report on the 1851 census and continued over six decennial censuses. Such work was not paralleled in the United States because of State responsibility for vital registration, with the result that the US Death Registration Area, covering those states with satisfactory complete registration, expanded from 1880 until national coverage was achieved in 1933 for both births and deaths. Population registers, or, more commonly, the combination of censuses and registration systems, have remained the central mechanisms for studying demographic change. For contemporary studies they have been supplemented by sample surveys, facilitated by the computer revolution, and for historical studies by the painstaking examination and linking of parish church records, especially in France and Britain. In France and Geneva, village studies have yielded data from as far back as the seventeenth century, and E.A. Wrigley and R.S. Schofield (1981) have reconstructed English population history from 1541 to 1871.

Demography has maintained its primary focus on population, births, and deaths. All are definable within a fairly high degree of precision, a criterion about which demographers feel strongly. Interest has swung from mortality to fertility largely in accord with how the levels of each are changing. There has not been the same attention to health or morbidity. In fact, when demographers purport to write on health, most of their output is usually on mortality change. One reason is that these conditions cannot be defined exactly, a situation that has been worsened by WHO's all-inclusive definition of *good health*. Another reason is the source of data. If demographers work alone through censuses or surveys, they must depend upon self diagnosis or the reporting of symptoms by respondents, and such reporting is often inaccurate and varies in terms of such characteristics of the respondents as education. Surveys can sometimes coopt medically trained individuals but diagnosis in the field is difficult and the employment of pathology testing usually limits the size of the survey. The alternative of using data from hospitals or doctors' surgeries goes far

toward destroying the concept of a *population*, which is basic to the way demographers see the world. Similarly, migration has remained a specialist, and somewhat marginal, concern, even though, in an open population, it is the additional process, along with fertility and mortality, that explains population change. There is no simple measurement, and indices of migration are affected by definitions of the number of movements to count and the distance and timing of movements. Marriage, too, has not been enthusiastically embraced, partly because definitions can be questionable. It has been employed mostly in the explanation of fertility levels, as in the Princeton European Fertility Project and in John Bongaarts' formulæ. These procedures are simplest when nearly all fertility occurs within marriage, as in the Princeton Project's work on historic Europe or in contemporary studies of much of Asia and North Africa.

This paper discusses the contribution of demographers to understanding demographic change and propounding theory based on those changes, mostly in terms of mortality, but there is also passing reference to fertility.

DEMOGRAPHIC CHANGE

Demographers' interests and theories are dependent not only on data but on clear patterns or changes revealed by the data. Mortality data revealed two different kinds of phenomena. The first was a pattern of mortality differentials that existed long before mortality transition and was assumed to be stable. The British seventeenth-century investigators found differences in death rates by age, sex, and urban–rural residence. During the eighteenth century, observers became increasingly convinced that there were also socioeconomic differentials: the poor, especially during early childhood, being more likely to die than the rich. It had also always been known that mortality evidenced periodic surges, as epidemics or famines ravaged populations. Indeed, that was the original reason for attempting to collect death statistics. It was also known that these factors interacted: the fourteenth-century story-tellers in Boccaccio's *Decameron* had left Florence to lessen their chance of being infected by the plague.

Wrigley and Schofield[10] show that in England the great mortality peaks did not recur after the middle of the eighteenth century. This is not synonymous with mortality decline, and it was to be generations before there was certainty about the existence of a secular trend toward lower mortality and higher life expectancy. In England life expectancy was fairly constant from 1826 to 1871, at just over 40 years, around 1.5 years above the level during the first quarter of the century or the level in the late sixteenth century. There was no proof here of major change.[10] Greater change did come during the last three decades of the nineteenth century so that by the end of that century life expectancy was 47 years and there was a realization that mortality was falling and an expectation that it would continue to do so. Neither Tom Paine, writing toward the end of the eighteenth century, nor Karl Marx, writing until the early 1880s, saw a major mortality decline as an aspect of mankind's future experience. In contrast, Alfred Marshall's *Principles of Economics,* published in 1890, took the decline very seriously.[11]

The mortality transition had, at least until two-thirds of the way through the twentieth century, certain striking characteristics. In Sweden, for which there is the longest series of reliable statistics, the marked declines occurred among the younger population, although they were by no means confined to infancy. By 1965 age-specific death rates among infants were six percent of the level in 1780, one percent among 1–4-year-olds, three percent among both 5–9 and 10–14-year-olds, ten percent among 30–34-year-olds, but exceeding 40 percent among those over 60 years of age.[12] During this 185-year period both male and female life expectancies doubled, female expectancies remaining 6–7 percent greater than for males, although, in absolute terms, increasing from 2.5 to 4.4 years greater than male expectancies. Alter and Riley[13] claimed that in England morbidity rose as mortality fell, and offered a "frailty" explanation.

Mortality transition is classically pictured as occurring decisively before fertility transition begins. In the West the picture is less clear. Except in France, and possibly the United States, marital fertility decline began in the last third of the nineteenth century. In England and Wales mortality fell by about one-sixth between 1870 and 1900 and so did the total fertility rate. Other Western countries were not dissimilar. It is clearer that fertility transition theory was to achieve a robustness that mortality transition theory did not attain. Part of the explanation is that the fertility decline was seen as a solely behavioral phenomenon.

By the 1970s a new stage in the mortality transition was becoming evident. It was clear that significant gains against mortality among older populations were being achieved.[14] In 1982 Lopez and Hanada[15] looked at mortality change among populations over 60 years of age in developed countries, and, dividing each country into separate male and female groups, showed that in almost one-third of the groups, the 25 years, 1950 to 1975, had witnessed greater mortality decline than the 50 years from 1900 to 1950. In Australia, Canada, and Sweden a decline in mortality from heart disease was mainly responsible, but in Japan and France a greater decline was attributed to stroke. The two diseases explained around 80 percent of the decline in old-age mortality. Explanations were slow in coming, as were quantitative descriptions of what exactly was happening; Myers[14] commented: "Whether this prolongation [of life] results from delayed onset of diseases or postponed case fatality is a major research issue facing demographers, epidemiologists, and health scientists." Attempts to gather demographic and other data on aging were quicker to start; the Duke, Seattle, and Baltimore longitudinal studies began recording cohort experience in 1955, 1956, and 1958, respectively.[16]

The final success of the mortality transition has aggravated but not caused the problem of high aged-dependency levels. The main engine in increasing the proportion of the aged has been the fertility decline. If we take the case of a representative English-speaking overseas-settlement country attaining a stable population structure at 1870 levels of vital rates and again at present-day rates, we get the following picture (calculations from the Coale and Demeny, West Model[17]). In 1870 with a gross reproduction rate of 3.0 and life expectancy at birth of 47.5 years, then only 2.8 percent of the population would exceed 65 years of age. If stable population structure were to be achieved at present levels, a gross reproduction rate of 1.0 and life expectancy of 77.5 years, 19.0 percent of the population would exceed 65 years. Four-fifths of the rise in the proportion of old population is explained by the fertility decline and

only one-fifth by the mortality decline. If fertility had remained constant over those 130 years but the same conquest of death had been achieved, the proportion of the population exceeding 65 years of age would have risen only from 2.8 to 5.2 percent.

It might also be noted that demographers are very good at working with defined categories. However, they tend to regard such categories as equating with reality, and they are usually poor at discerning underlying reality. They can accept Otto von Bismarck's 1889 definition (for pension purposes) of *old* meaning at least 65 years of age, without worrying that the same definition today might not mean the same socially, physiologically, or actuarially. They know (but often do not appreciate that their readers do not understand) that life expectancy is a cross-sectional annual measure, a good index but saying little about actual life experience. Dublin *et al.*[18] calculated that the life expectancy of persons born in Massachusetts in 1890, according to the usual way of computing life expectancy from 1890 vital rates, was 42.5 years for males and 44.5 years for females, but, in the real world, with improving health during subsequent years, males actually averaged 46.7 years and females 50.3 years.

What explanations, then, do demographic theorists have to offer for this stupendous event, a doubling of life expectancy in the West since the beginning of the nineteenth century? How does the theory relate to the analytical work performed by most demographers?

THE THEORY OF MORTALITY TRANSITION

For most of human history the chief explanation for mortality decline has been good government in the sense of strong governments that kept the peace, suppressed internal disorder and violence, avoided or mitigated famine, and attempted to mitigate the worst excesses of epidemics. In much of the world this explanation is even now not completely redundant. Early attempts to record mortality were aimed partly at providing an index of good government.

Much of the world believes that the entire mortality transition is little more than the victory of modern medicine, a view seemingly receiving support from spectacular mortality declines in developing countries during the second half of the twentieth century. Colin Clark maintained this view as late as 1967: "the significant decline in mortality…clearly began about 1759 [and] was due to medical improvements, due to better knowledge and application of medical science."[19] There is a gray area in the arguments of Clark and others, and that is an ambiguity about the extent to which they include sanitary engineering in their definition of modern medicine.

In contrast most demographic and social theory attributes a good deal to economic and social change, often down playing the role of modern medicine even in recent decades. Most demographic theory of mortality decline can be separated into two camps: those emphasizing rises in living standards, especially nutrition, and those placing a significant emphasis on social and behavioral change. The latter group can again be subdivided according to the extent that a key factor in behavioral change is thought to be cooperation with modern medicine.

Resource Theory

Malthus,[20] in his 1798 *Essay,* and its subsequent editions, succinctly stated the resource hypothesis. Population tends to grow faster than additional food can be supplied for it, and hence, unless reproduction is held down to the rate of growth of food by late or forgone marriage, some members of society will have lives shortened by starvation or more commonly by maladies arising from malnutrition. In a class society this will occur mostly among the children of the poorest class that is inclined to aggravate the situation by imprudent marriage.[20] Malthus's theory as first postulated was an explanation not of mortality decline but of long term population homeostasis, and the concepts of a Malthusian ceiling and a Malthusian equilibrium have been valuable to historical demographers. However, Malthusian theory can be turned into an explanation of secular mortality decline in two ways toward which Malthus moved in later editions of the *Essay,* either by food supplies outstripping population growth (because of an agricultural revolution or the large scale import of food) or by even the lowest class exercising greater prudence over marriage as a result of increasing civilization (perhaps one can include education here). Three further points are important. The first is that Malthus appeared to hold that mortality as a result of malnutrition tended to rise only among the very poor, but not that better nutrition could cause a mortality decline across most of society. The second is that, no matter how much Malthus detested the practice of contraception, his theory provided an excellent framework for arguing that the poor could reduce their children's mortality by marrying and deliberately thereafter limiting family size. The third is that Malthus's theory is also one of behavioral change in that deliberate decisions about marriage and reproduction could reduce the population pressure on food supplies with the consequence of declining mortality.

Thomas McKeown's theory[21] is a direct descendant of that of Malthus. In a series of papers from the 1950s to the 1970s he argued that modern medicine had little potential for reducing mortality until the mid-1930s and, hence, that the earlier mortality decline must have been the result of rising living standards, mainly nutritional standards. He argued that mortality had declined most in the case of tuberculosis and other airborne diseases and, hence, that water purification must have played only a small role. Most demographers writing on McKeown's ideas have done so critically, arguing that his method of emphasizing nutrition as the residual category was unscientific, that his grouping of causes of death was faulty, and that he underemphasized the impact of sanitary interventions and of housing and fresh-air legislation.[22] A.R. Omran's 1971 paper, "The epidemiologic transition: a theory of the epidemiology of population change", completely adopted McKeown's explanation for the decline in "pandemics of infection".

Somewhat surprisingly, at least to demographers, the improved nutrition explanation for the mortality transition received a powerful boost during the 1990s from the work of R.W. Fogel and his colleagues. Fogel,[23] drawing heavily on Wrigley and Schofield,[10] and amassing statistical data as he did for *Time on the Cross,* argues that the mortality decline was a product, not of the elimination of the great mortality crises, which explained only six percent of all historic mortality, but of general mortality. He uses food consumption figures starting with France in 1785 and England in 1790 to compute average calorie consumption in an approach called "energy cost accounting". This approach supports Malthus by showing that in both countries the

per capita calorie consumption of the lowest decile of the population was a little over one-third of that of the highest decile. He points out that the average French intake in the late eighteenth century (about 85 percent of that of the English) was above that of contemporary Pakistan (and, he could have added, Sri Lanka), Rwanda, and Algeria. He concludes that "Improvements in the average nutritional status (as indicated by stature and body mass indexes) appear to explain about 90 percent of the decline in the mortality rates in England and France between the last quarter of the eighteenth century and the third quarter of the nineteenth century, but only about half of the mortality decline between the third quarter of the nineteenth century and the third quarter of the twentieth century."[23] He argues further that much of the impact of malnutrition has occurred by three years of age with the result of higher mortality over the rest of the lifetime and concludes that the better infant and toddler feeding that the baby boom generation received in the 1950s and 1960s, compared with the cohorts born during two world wars and the economic depression of the 1930s, means that we can project future old-age mortality to fall sharply.[23]

Demographers have not yet had time to dissect Fogel's work, and indeed most of his detailed research is not yet published. The findings do give cause for some misgivings. They imply for England that of the 6.5 years gain in life expectancy between 1787 and 1887 only two-thirds of a year can be attributed to vaccination, better clothing and housing, improved sanitation, and rise in educational levels. They imply that Pakistan's and Sri Lanka's contemporary diets would warrant them a life expectancy of only 35 years and that the additional 23 and 37 years respectively are almost entirely a product of modern medicine. They imply that in 1962 English life expectancy would have only been 57 years but for the development of sulfa drugs, penicillin, and other medical advances, and that, without them, it probably would now be 60 instead of 77 years of age.

The complete negation of Malthus's views is provided by Ester Boserup.[24] She argues in her *Conditions of Agricultural Growth* that the Malthusian collision between population and food did not exist. Population burst through every food-imposed ceiling by adapting the means of food production to a more intensive system of cultivation. She regarded mortality levels as being capriciously determined by the accidental presence of disease or epidemics. A much more likely scenario would seem to be that populations were usually at the Malthusian ceiling, with malnutrition keeping up mortality levels, but that occasionally, and in some places, innovations in cultivation allowed a breakthrough in population numbers to a higher ceiling.

Social and Behavioral Theory

The idea that human beings do not merely play a passive role in determining their own and others' health and survival has a long history. The Mother and Child movements of the beginning of the twentieth century were based upon that belief. Classic demographic transition theory, as epitomized by the writings of Notestein[25,26] regarded fertility choice as being impossible until the fatalism and control structures of the traditional family were eroded, and much the same postulate can be made about health or mortality choice. This field has come to be called *health transition*.[27,28]

In traditional agrarian families the psychological and social context of decision-making is radically different from that found in the modern market economy. The

family was so structured that emotional and economic flows went upward from the young to the old, as described in *wealth flows theory.*[29–31] During the mortality transition, child mortality fell much more rapidly than did old-age mortality, doubtless chiefly the result of the conquest of childhood infectious disease, but probably owing something to the priorities in family attention changing from the old to the young (compare this with the change in fertility as described by Ariès[32]). The traditional agrarian family was organized like a firm so as to maximize production and stability. The daughter-in-law was discouraged from giving too much attention to the health of her children (although she was blamed if they died) and forbidden from harnessing her husband into a dyad to focus on their children.[33]

Simons[34] has argued that, as modern individualistic and secular society developed, two health-relevant processes intensified. The first was a conviction that death was qualitatively different from all other experience, and should be avoided at all cost. The second was the growth of a commitment to survival: a belief in personal responsibility for taking all possible action to ensure the survival of one's children, one's spouse, and oneself. In traditional families it was presumptuous for the younger generation to take such actions even with regard to themselves or their own children. Such theory developed from findings that societies fashioned parents to have very different levels of child mortality, even when they had equal access to health facilities. The first discovery was that child mortality in developing countries fell steeply as the education of parents, especially mothers, rose. This finding proved to be true in practically every society in which World Fertility Surveys and Demographic and Health Surveys had been conducted.[35–42] The second discovery was that the different cultures in plural societies had very different levels of child mortality even when income, parental education, and access to health services were controlled.[43] Clearly there were strong social and behavioral influences on survival. The picture was rendered more complex by Preston and Haines[44] establishing that maternal education in the United States around the end of the nineteenth century had only one-quarter to one-half the impact on child mortality that it does in the contemporary Third World. One reason may be that medicine had less to offer a century ago, but another reason may well be that modern medicine works best when the patients or their parents cooperate most fully with it. Such cooperation needs a belief in the science and modern medicine that was part of turn-of-the-century America, but is imparted to Third World populations in proportion to their exposure to imported Western education.[45]

These findings have been extended in two ways. The first is the demonstration that an individual's own survival in both developing and developed countries is strongly influenced by his or her education. Adequate data sources are not easy to find, but the International Centre for Diarrhoeal Disease Control, Bangladesh has at Matlab a demographic surveillance system suited to the task. Employing these data, Duffy and Menken[46] showed that there were three significant factors determining the survival of females over a 20-year period: their age, health status, and education at the beginning of the period. We also now know, for a range of countries in Europe and for America, that mortality falls as education rises.[47–50] This is particularly the case with respect to deaths by violence, but is also marked with respect to circulatory ailments (which contribute most of the decline on a population basis) and respiratory disease. However, even in the case of cancer, and even in Norway with its national

health service, mortality is 15 percent lower among those with post-secondary education than among those with incomplete secondary schooling.[51] The second is the argument that female education was merely the most easily measured aspect of a larger concept, female empowerment, and that it was the relative position of women that allowed mothers to reduce the mortality of their children.[52]

Modifying the Attack on Health Interventions

Razzell[53] argued that McKeown had underestimated the impact on eighteenth-century mortality of the introduction of smallpox immunization, long used in the Ottoman Empire. He also believed that a richer, more sophisticated, and more individualistic society had become cleaner and perhaps more hygiene-conscious, and he related increasing per capita soap consumption in the period 1800–1840 to a decline in mortality from "dirt diseases": gastroenteritis, typhoid fever, dysentery, relapsing and trench fever, and typhus.

McKeown had not always been clear whether he treated the sanitary revolution as part of medical intervention or as important in its own right, but, if not, it certainly had a claim to be treated as a rival to nutrition for explaining late nineteenth-century mortality decline. The problem was that perhaps 60 percent of the nineteenth-century Western European mortality decline had occurred during its final three decades, 1870–1900. By 1870 the treatment of water supplies was well under way and there were improvements in sewage disposal. Preston and van de Walle[54] showed that the advent of treatment for water supplies in French urban areas was associated with decreases in the death rate. Szreter[22] argued that in Britain the contribution of housing and crowding laws, building regulations, and municipal water and sewerage programs had been greatly underestimated. He concluded that "the decline in mortality, which began to be noticeable in the national aggregate statistics in the 1870s, was due more to the politically and ideologically negotiated movement for public health than to any other positively identifiable factor."[22] Johansson and Mosk[55] showed that Japan, during the last decades of the nineteenth century, made the policy decision to import the new Western public health policies and technology with the result that by 1900 its life expectancy had almost caught up with that of Britain and Italy. They argued that the Japanese had demonstrated that "above a certain minimum standard of living threshold, the 'right' to live to old age can be secured for the average citizen, even in low-income developing countries, if the government is dedicated to the efficient exploitation of existing public health technology and the population is educated and cooperative."[55]

McKeown had made it clear that he was addressing the period before sulfa drugs and antibiotics. Nevertheless, there have been those who saw the thesis as relevant to the contemporary Third World, arguing that modern medicine was too unsuited to conditions in those countries to have had much of an impact on mortality. Caldwell[52] examined three "great-leaps-forward" in health: 1946–1953 when life expectancy in Sir Lanka rose by 12 years over seven elapsed years; 1956–1971 when it rose 12 years in Kerala over 15 years; and 1970–1980 in Costa Rica when it rose seven years over 10 years. The three experiences had much in common. At the beginning of the period women as well as men were, by Third World standards, well educated. Nevertheless, the previous rise in life expectancies ranged only between 0.24 and 0.58 years per elapsed year, not particularly fast in comparison with other developing

countries. The marked advances occurred after sulfa drugs, antibiotics, DDT, and new malaria prophylactics became available, and probably could not have occurred without them. The mass vaccination programs had not yet begun. However, the advances did coincide with periods of radicalism when universal democratic health systems were established, even in urban slums and remote rural regions, with free or cheap services. Those involved gave great credit for the success to the eager, cooperative, educated clients. The paper showed that in countries like some of the oil producers, where much money had been spent on health facilities but where women were neither educated nor independent, similar health advances had not been made. In Sri Lanka, Kerala, and Costa Rica, the universal health services were based on health centers or small hospitals. There was little in the way of high-technology medical services, but the services were not strictly primary health care in that they were centered on doctors and were largely curative. The conclusion was that the fastest mortality declines in contemporary conditions were achieved by a collaboration between the democratic provision of modern medicine and a populace that was educated and where women enjoyed considerable independence. A similar conclusion had earlier been drawn from a comparison of two areas in Nigeria.[56] Later studies showed how more-educated women could gain for their children greater benefits from the health system than could less-educated women.[57]

The Stages of Mortality Transition

Demographers had found it useful to separate the demographic transition into stages.[25,58,59] Omran[60] did the same for mortality transition, separating it into three stages: (1) the age of pestilence and famine, prior to the transition; (2) the age of receding pandemics, as mortality fell consistently with the reduction of death from infectious disease; and (3) the age of degenerative and man-made diseases, when mortality was dominated by heart disease, stroke, and cancer. Although he wrote of the degenerative diseases replacing the infectious ones as if they were a new arrival, the central theme of his paper was really the conquest of infectious disease, with the result that most people lived longer with little else ultimately to kill them than degenerative disease. Fifteen years later, Olshansky and Ault,[61] followed by Rogers and Hackenberg (1987), furnished with new American mortality data, added a fourth stage, that of delayed mortality from degenerative disease.

THEORY AND ANALYSIS

The foregoing discussion outlines some of the major demographic frameworks within which demographers work. Some of the theorists would not describe themselves as demographers, but all approach demographic change in an essentially demographic way, and not in a medical or epidemiological way. High demographic theory employs a broad population base and is usually concerned with changes in mortality and/or fertility over time. It usually starts with at least some empirical data but often then soars far beyond them. Nevertheless, demographers—in contrast with many anthropologists, sociologists, or even economists—are usually apprehensive of building further pyramids of theory on existing theory. Their instincts are to substantiate at least part of the high theory by developing intermediate-range theories

that can be tested empirically. Few empirical demographers do not somewhere in their papers make reference to theoretical postulates.

Some demographic analysis is so broad that it inevitably implies theoretical constructs. In the mortality area there are studies such as Stolnitz's,[62,63] "A century of international mortality trends"; Preston and Nelson's,[64] "Structure and change in the causes of death: an international summary"; and Preston's[65] paper, "The changing relationship between mortality and level of economic development". What distinguishes these from most epidemiological papers is first that they usually deal with all mortality, even if they later subdivide by individual causes. Indeed, demographers often draw attention to parallel movements in the reduction of mortality from a variety of causes (e.g., Preston and Taubman[66]), thus throwing doubt on the epidemiological analyses of the efficacy of interventions affecting a single disease. Second, demographic analysis tends to seek background or fundamental influences—using social and economic data—not on the individual but on entire societies. Third, their population base is frequently the entire society. Finally, demographic and epidemiological papers tend to orient themselves to different audiences, as any glance at their respective journals shows. Demographic studies are usually written by social scientists for social scientists, whereas the authors of most epidemiological papers have medical training. Epidemiological studies are the most population-based of all medical research, but nevertheless, they are not usually embedded in whole populations seen over long periods of time in their social and economic context.

Attempts have been made to meld the demographic and epidemiological approaches. Perhaps the most successful was that by Mosley and Chen,[67] which they accomplished by using *social science* and *medical* measures as different levels of explanation, the former as "background variables" and the latter as "intermediate variables". Preston[68] has pointed out that demographers use *quasibiological material*, such as duration of birth-spacing, parity, and age, but "analyses with more biological data are not likely to be undertaken by demographers, nor published in demographic journals."

Finally, does demographic theory have anything to say about the recent decline in old-age mortality? The fact that heart disease and stroke account for about 80 percent of mortality decline, whereas the contribution of cancer is negligible (Myers[14]), suggests that medical interventions should receive most credit. Yet the greater importance of a decline in stroke mortality in Japan and France, in contrast to the predominant significance of lowered heart disease in Australia, Canada, and Sweden, suggests that cultural and behavioral factors should not be ignored. Certainly the rising levels of education among the old, reflecting advances in schooling from the 1920s onward, must have had an impact. Preston and Taubman[66] reported that between 1960 and 1971–1984 in the United States large educational differentials in mortality opened up among 65–84-year-olds (with differentials being negligible above 85 years). Males with the most education exhibited mortality levels only 58 percent of those with the least education whereas the figure among females was 66 percent. Furthermore, the differentials were similar for all causes of death.[66] Fogel's[23] work on nutrition among the very young may also be part of the explanation. He believes that the greatest old-age mortality declines are yet to come as the baby boom generation, which in developed countries suffered no malnutrition during childhood, begins to reach old age in the second decade of the twenty-first century.

Treas[69] argued that there would be continuing decreases in old-age mortality because of younger people becoming increasingly conscious of the need for healthier lifestyles and the dangers associated with smoking, obesity, high blood pressure, and high levels of cholesterol.

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