2 Epidemiologic and demographic transition as drivers of NCDs

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Epidemiologic and demographic transition refers to changing disease and demographic patterns in populations along socio-economic development. The magnitude and speed of these changes over time are modulated by the changing exposures to risk factors and public health responses in populations.[1]

In brief, the following sequence is observed in populations: (i) a first phase where overall mortality is very high, the population is predominantly young (life expectancy [LE_0] ~30–40 years), and infectious diseases are the predominant cause of mortality; (ii) a later phase with larger proportions of older persons, LE_0 increases (~50–70 years) and the disease burden shifts from infectious diseases (largely owing to the public health response) to the four NCDs that are the topic of this compendium (e.g. cardiovascular disease [CVD] and cancer, as the prevalence of risk factors such as tobacco use and a diet high in saturated fats increases); and (iii) a final phase with a large proportion of older persons, longer LE_0 (~80+ years), and the disease burden shifting away from the four main NCDs (e.g. owing to tobacco control, healthier diet, treatment of hypertension) to lesser preventable/treatable NCDs (e.g. neurodegenerative conditions such as Alzheimer's disease).[2]

Trends in epidemiologic and demographic patterns explain why, for example, total numbers of deaths from NCDs such as CVD or lung cancer can markedly increase in a population (because of population growth and aging) while the age-standardized mortality rates (which express a risk irrespective of population growth and age structure) decrease, as is observed in high-income countries (HICs) and in an increasing number of low- and middle-income countries. Trends between 1990 and 2019 for both crude (total deaths) and age-standardized (risk) NCD mortality are shown in Table 1.1 in the chapter on the global burden of NCDs.

Demographic, epidemiologic and public health transition are described separately in this chapter, but they are strongly interrelated and also referred to as the 'health transition'.

Epidemiologic transition

Risks of diseases in populations change as exposures to risk factors and the public health response evolve. For example, the risk of infectious diseases is higher

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when sanitary conditions are poor and vaccines are unavailable, while the risk of some cancers and CVD increases when cigarettes become widely available, and the risk of CVD and lung cancer decreases when exposure to cigarettes is reduced as a result of tobacco control measures.

The paradigm of the epidemiologic transition has been widely described[3,4] and posits four stages (Box 2.1).

BOX 2.1 THE FOUR STAGES OF THE EPIDEMIOLOGIC TRANSITION

1. *Pre-transition.* The 'age of pestilence' dominated by famine, malnutrition, infectious diseases and high levels of infant and child mortality. Life expectancy at birth (LE_0) is typically <30 years.
2. *Early transition.* The 'age of receding epidemics', with urbanization and industrialization resulting in improved public health (more diverse diet, clean water and sewage systems, as well as interventions including immunization). Death rates begin to fall. As birth rates remain high, the population grows rapidly. LE_0 is typically 30–50 years.
3. *Late transition.* The 'age of degenerative or man-made diseases', with the four NCDs (CVD, cancer, chronic respiratory diseases, diabetes) and their risk factors becoming predominant. Birth rates decline and the rate of population growth decelerates. LE_0 is typically 50–70 years.
4. *Post-transition.* The 'age of delayed degenerative diseases', with a decline in some of the NCDs such as CVD as a consequence of reduced exposure to NCD risk factors (owing to prevention and treatment), but less preventable conditions (e.g. dementia, arthrosis) increase. Post-transitional populations are characterized by both low birth rates and low death rates. Population growth is negligible or declining. LE_0 is typically >70–80 years.

   More recently a fifth phase of the epidemiologic transition has been suggested, the 'age of obesity and inactivity', which is associated with several cardiometabolic diseases and threatens progress in postponing illness and death to later years in adult life spans.[5]

Figure 2.1 depicts mortality trends according to broad disease groups. Two main observations can be made. First, all-cause mortality declines markedly over time, largely owing to decreasing mortality from infectious diseases at young ages. Second, there is no uniform decline in mortality by cause of death but, rather, a sequence of causes of death that 'rise and fall'. The course of the sequence depends on exposures to risk/protective factors in the population at a certain

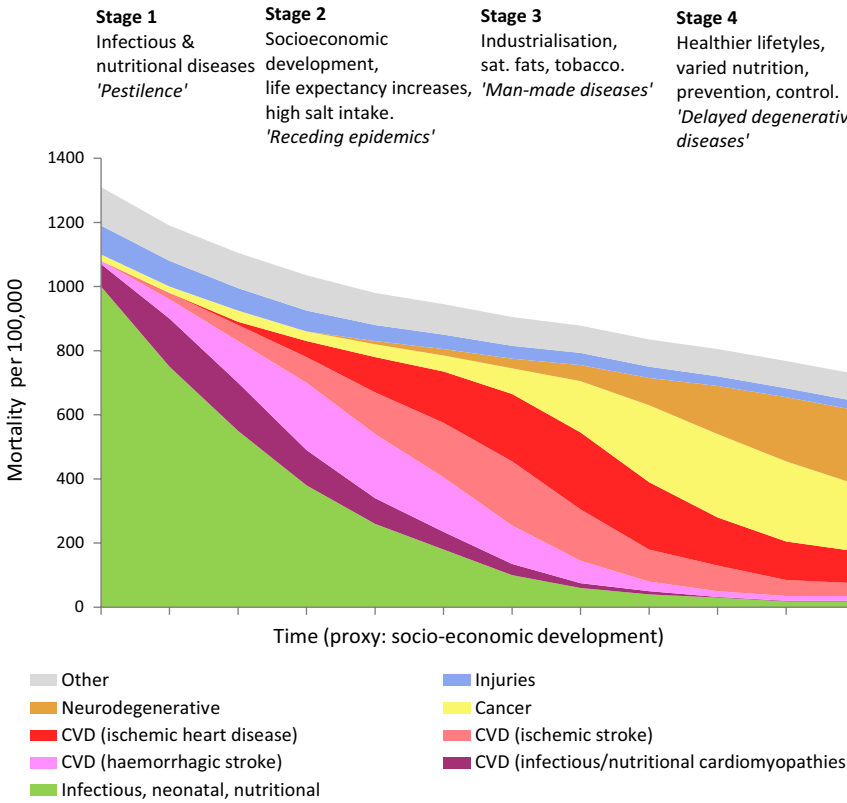

Figure 2.1 Decreasing all-cause mortality and changing broad-cause mortality patterns along the four stages of the epidemiologic transition. (adapted from Bovet P, Paccaud F. Cardiovascular disease and the changing face of global public health: a focus on low and middle income countries. *Public Health Rev* 2011;33:397–415).

period and the public health response. The 'rise and fall of diseases' may perhaps better be described as 'sequentially falling diseases'.[6]

A bell-shaped relationship between socio-economic development and CVD risk factors has been observed in many populations.[7] For example, mean blood cholesterol, blood pressure and (to a lesser extent) body mass index increase, plateau and then decrease along a country's socio-economic development as a consequence of the changing levels of their determinants in populations and the public health efforts to prevent and control them.[8] These changing levels of risk factors over time determine the 'rise and fall' (or 'sequential falls') of diseases. For example, the risk (age-standardized rate) of coronary heart disease peaked in HICs in the late 1960–1980s when the prevalence of several main modifiable CVD risk factors was highest (e.g. tobacco use and intake of saturated fats) but then declined over the next three decades by nearly 80%

owing to prevention and treatment, yet remaining a leading cause of death. This sequence is also increasingly observed in low- and middle-income countries along socio-economic development.[9] The epidemiologic transition model also predicts that the predominant disease burden will shift away from some NCDs (when they are prevented and controlled) to other lesser preventable and treatable NCDs, such as neurodegenerative diseases and diseases of the musculoskeletal system.

Demographic transition

Demographic transition is defined as the changes in population size and age structure over time that result from changes in mortality and birth rates. The population typically increases in size (growth) and age (with increasing LE_0) as a consequence of a time gap between the decline in all-cause mortality and the decline (decades later) in birth rates. The demographic transition is complete when both the mortality and birth rates reach low levels (as is already the case in a minority of high-income countries) and, at this stage, the population no longer increases in size and can even decline when birth rates fall below the population replacement ratio (e.g. fertility ratio of <2.1 children per woman). The causes of the decreasing birth rates and fertility rates are not fully understood but can be associated with societal changes in disease patterns, education, economic models (e.g. more women joining the workforce), societal values (e.g. a large number of children no longer considered as a necessary goal for families), and access to contraceptive means.

According to the UN, the global birth rate in 2019 was more than two times higher than mortality (1.85% vs 0.76%), meaning that the demographic transition was ongoing, with the world population size increasing by 1.1% per year.[10] The UN predicts that the world's population will stop growing in around 2100. According to IHME, the world population would peak in the 2060s at 10 billion and then decrease to 8.8 billion by 2100 (with 2.4 billion individuals aged >65 years).[11] Fertility rates would fall below the population replacement ratio in 151 countries by 2050, and in 183 by 2100. More than 20 countries (e.g. Japan, Thailand and Spain) are forecasted to have population declines greater than 50% between 2017 and 2100 (and a 48% decline from 1.4 billion to 768 million in China). Yet, fertility rates are expected to remain high in some countries, and sub-Saharan Africa is expected to become the most populated continent, with 3.0 billion individuals in 2100 and Nigeria would be the most populated country in the world with 790 million people (from 207 million in 2017).

UN estimates indicate that the percent of the world population aged >65 years (when most NCDs occur) was 9.3% in 2019 but is expected to reach 16% in 2050 (1.5 billion) – and some consider this figure may be an underestimate if different assumptions are made around maximal LE_0[12] and mortality compression during the few last years of life (the so-called 'rectangularization' of the survival curve).[13,14] Given that NCDs predominantly develop in middle-aged

and older individuals, these demographic predictions have important implications in terms of the expected numbers of persons with NCDs and the need for health care in the coming decades (including sufficient numbers of health workers and home carers).

Figure 2.2 illustrates how demographic and epidemiological previsions can be used to identify future public health needs.

Public health transition

The health transition is the set of interventions developed and implemented in response to demographic and epidemiological changes. This includes efforts for primary prevention through reducing the modifiable determinants in the whole population (to decrease the incidence of diseases) and for strengthening the healthcare system (to curb disease progression and reduce case fatality at the individual level).

Implications of demographic and epidemiologic transition for NCD policy and planning include:

- The need for robust health information systems, including surveillance to chart changes in levels of NCDs (as well as other diseases) over time (Chapters 4 and 5 on surveillance) to plan for health and healthcare services. NCD estimates should be presented using both age-standardized rates (to assess trends in NCD risk independently of size and age of populations, hence to evaluate the impact of prevention and treatment strategies) and total numbers (which largely depend, for NCDs, on changes in population size and age, and are useful to inform health care needs).
- Developing public health responses to meet the needs of people with NCDs, including the financing and delivery of preventive, treatment and care services, as well as other conditions such as neurodegenerative and musculoskeletal diseases, which are beyond the scope of this compendium.
- Recognition that the linkages and associations between infectious diseases and NCDs, and the ongoing double burden of disease (communicable diseases and NCDs) in many low- and middle-income countries, means that health systems need to have the capacity to address the full range of public health challenges in an integrated manner (Chapter 28 on infectious diseases and NCDs). As trends in the burden of different diseases can be partly predicted, health systems should anticipate and plan for future needs associated with these changes.
- Understanding that demographic transition will continue to evolve in the years ahead with direct and indirect impacts on incidence, health care and financing of NCDs. The *increasing* population size in many countries will also exert a significant impact on climate change and the environment as well as economic and geopolitical consequences, including food supply (which all have an impact on NCDs). Where populations are or will be, *declining*, future welfare will be increasingly threatened, including a

Demographic characteristics & predominant causes of deaths				
Population size	++	+++	+++	+ (-)
% young vs older	>>>	>	<	=
Mortality	+++	++	++	low
Birth rate	+++	++	+	low
Neurodegenerative diseases	-	(+)	+	+++
Cancers (less preventable*)	(+)	+	++	+++
Cancers (more preventable*)	(+)	+	++	+
Ischaemic heart disease	(+)	++	+++	+
Haemorrhagic stroke	+	++	+	(+)
Infectious diseases	+++	++	+	(+)

* In relation to relation to tobacco, alcohol or human papillomavirus infection

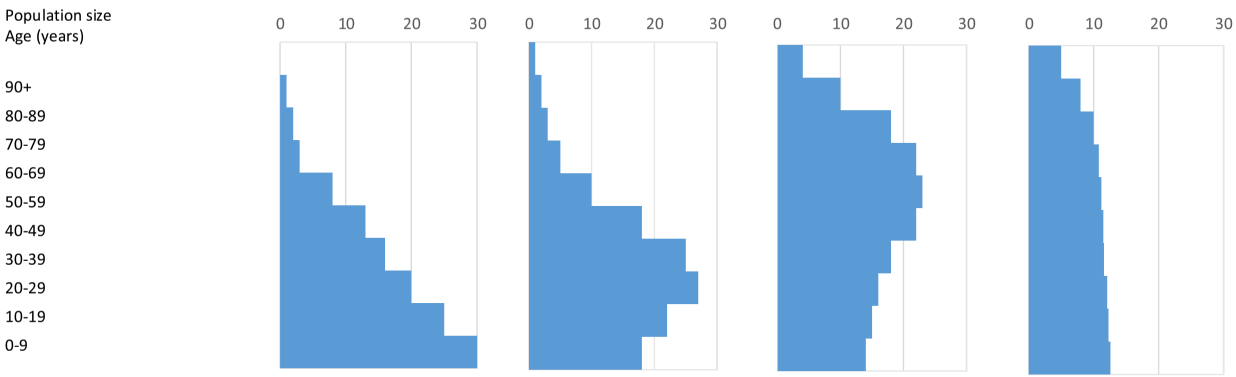

Figure 2.2 Demographic transition over time and associated predominant causes of deaths.

decreasing workforce able to respond to the increasing demand for health care for aging populations and individuals living with an NCD.[15] Planners therefore need to consider public health responses based on different scenarios.

Notes

1 Egger G. Health, "illth", and economic growth: medicine, environment, and economics at the crossroads. *Am J Prev Med* 2009;37:78–83.
2 Miranda JJ et al. Major review: on-communicable diseases in low- and middle-income countries: context, determinants and health policy. *Trop Med Int Health* 2008;13:125–34.
3 Omran AR. The epidemiologic transition: a theory of the epidemiology of population. *Milbank Q* 1971;49:509–538, 57.
4 Olshansky SJ et al. The fourth stage of the epidemiologic transition: the age of delayed degenerative diseases. *Milbank Q* 1986;64:355–91.
5 Gaziano JM. Fifth phase of the epidemiologic transition: the age of obesity and inactivity. *JAMA* 2010;303:275–76.
6 Mackenbach JP. The rise and fall if diseases: reflections on the history of population health in Europe since ca. 1700. *Eur J Epidemiol* 2021;36:1119–205.
7 Danaei G et al. The global cardiovascular risk transition: associations of four metabolic risk factors with national income, urbanization, and Western diet in 1980 and 2008. *Circulation* 2013;127:1493–502.
8 Ezzati E et al. Rethinking the 'diseases of affluence' paradigm: global patterns of nutritional risks in relation to economic development. *PLoS* 2005;2:e133.
9 Stringhini S et al. Declining stroke and myocardial infarction mortality between 1989 and 2010 in a country of the African region. *Stroke* 2012;43:2283–88.
10 https://population.un.org/wpp/Graphs/1_Demographic%20Profiles/World.pdf.
11 Vollset SE et al. Fertility, mortality, migration, and population scenarios for 195 countries and territories from 2017 to 2100: a forecasting analysis for the Global Burden of Disease Study. *Lancet* 2020;396:1285–306.
12 Oeppen J, Vaupel J. Broken limits to life expectancy. *Science* 2002;296:1029–31.
13 Anson J. The second dimension: a proposed measure of the rectangularity of mortality curves. *Genus* 1992;48:1–17.
14 Rousson V, Paccaud F. A set of indicators for decomposing the secular increase of life expectancy. *Pop Health Metrics* 2010;8:18.
15 Ezeh AC et al. Family planning 1: Global population trends and policy options. *Lancet* 2012;380:142–48.