1

Disease patterns in human biohistory

We are living through an unprecedented transformation in the pattern of human health, disease and death. There have been many great episodes of pestilence and famine in local populations over the ages, but there has been nothing as global and rapid as the change in the profile of human disease and longevity over the past century or so. For hundreds of thousands of years as hunter-gatherers, and subsequently in agrarian societies, our predecessors had an average life expectancy of approximately 25–30 years. Most of them died from infectious disease, and many died of malnutrition, starvation or physical trauma. A large proportion died in early childhood. Today, for the world as a whole, average life expectancy is approaching the biblical 'three score years and ten', and in some rich countries it has reached 80 years.

Two immediate questions arise. What has caused this radical shift in health profile? Can future health gains be shared more evenly around the world? During the 1990s, the combined burden of premature death and chronic or disabling disease was about four times greater, per 1,000 persons, in sub-Saharan Africa than in the Western world.[1] An even more important question looms in a world that is undergoing rapid social and environmental change: can those gains in population health be sustained? To answer the second and third questions we will need to answer the first question.

Over the past two centuries human ecology has been transformed, albeit very unevenly between rich and poor regions. Little more than a century ago, in Manchester, England, half of all young children died before age five. Subsequently, in much of the world, food supplies, housing, water quality and sanitation have improved; ideas of personal and domestic hygiene and of family planning have spread; and workplaces have become safer. Literacy has increased and social modernisation has occurred. Various public health and medical interventions have arisen: anaesthesia and antiseptic surgery in the second half of the nineteenth century, followed by vaccination, contraception, antibiotics, pesticides and oral rehydration therapy for diarrhoeal disease. Death rates in early childhood, particularly from infectious diseases, have

declined markedly, first in Western countries from around mid-nineteenth century and then in low-income countries from the 1920s onwards. Maternal deaths in childbirth have declined. Deaths from adult infectious disease, particularly from tuberculosis, have receded.

As more people survive to older age, and as patterns of living, consuming and environmental exposures change, so noncommunicable diseases such as coronary heart disease, diabetes and cancer have come to dominate. Low-income countries are following in the footsteps of the rich countries (Figure 1.1). An epidemic of obesity now looms in rich countries and in urban middle-class populations elsewhere – even as a similar proportion of the world population continues to be underfed and hungry. The world's three leading causes of disease burden (comprising premature death and disabling disease) in the early 1990s, as assessed by the World Health Organization in 1996, were pneumonia, diarrhoeal disease and perinatal disorders.[1] The three conditions projected to take their place by 2020 were coronary heart disease, mental depression and road traffic accidents. Even so, the human immune-deficiency disease, HIV/AIDS, had moved rapidly into second position by 1999, after pneumonia.

Most of this transformation in population health has resulted from broad social changes, from radical shifts in human ecology. Even so, most health-related research continues to focus on specific behavioural, clinical and technological interventions. That, of course, is the style of mainstream science, which deals with discrete, measurable and manipulable units. It also reflects the difficulty we have in seeing the larger picture, in recognising that a population's profile of health and disease is essentially an expression of its social and physical environments. That is, it is an 'ecological' characteristic that reflects the population's collective experiences and way of life. In early 2000, Britain's Labour government announced a national initiative for the *prevention* of heart disease deaths. Along with a familiar 'quit smoking' campaign came an ill-conceived strategy that gave precedence to quicker treatment of heart attack cases (including placing life-saving defibrillators in public venues), training more heart surgeons and more effective prescribing of drugs. Little attention was given to modifying the nation's heart-unfriendly diet, or to changing transport systems and physical activity patterns in order to counter the rise in obesity and its associated metabolic disorders and high blood pressure. The 'Mediterranean diet' keeps heart disease rates low in Greece and Italy. The greater reliance on public transport, cycling and walking has slowed the rise of obesity in the Netherlands. British surgeons at the ready will achieve little in the way of actual prevention (but may, of course, win votes).

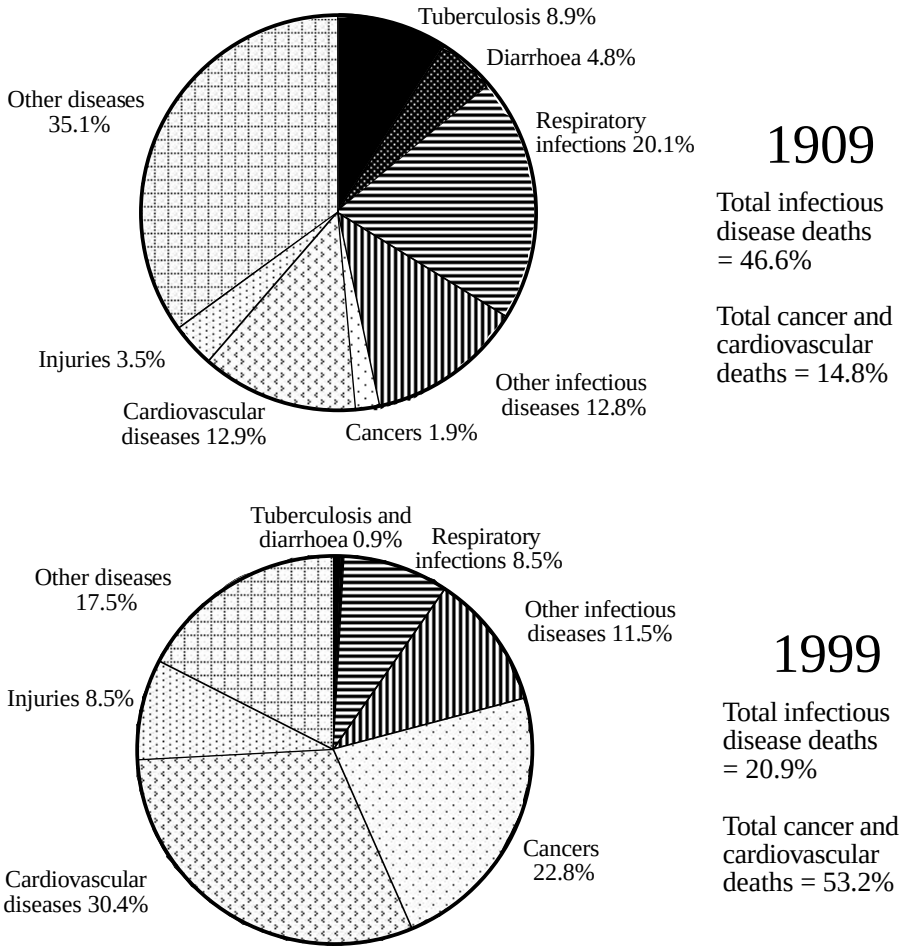

Figure 1.1 Change in the profile of causes of death in Chile between 1909 and 1999. Note the marked reduction in deaths from infectious diseases, and the rise in noncommunicable diseases, especially cardiovascular disease.

Our awareness of these larger influences on health and disease, reflecting the population's relationships with both the natural world and other populations and its own history and internal social structures, ought to have increased in recent years. Various recent developments have underscored this ecological dimension – including, for example, evidence of the health hazards of intensified food production, of the adverse impacts of increased climatic instability attributable to global warming, and of the many social and environmental influences on the emergence and spread of infectious diseases.

A grim reminder of the power of social change to alter patterns of population health comes from HIV/AIDS. Both the origins and the spread of this infectious disease, first identified in the early 1980s, reflect aspects of human ecology. These include: the initial contact with chimpanzee or monkey sources of a human-compatible strain of the ancestral simian virus, the amplified local spread in humans via rural–urban migration in Africa, long-distance dissemination via movements of tourists and military mercenaries, patterns of sexuality and intravenous drug use, and (especially in Africa) the roles of poverty, political denial and the subordination of women. HIV/AIDS may well become numerically the greatest epidemic scourge in human history. Currently there are 40 million infected persons; two-thirds of them are in Africa.

MEANWHILE, NEW large-scale influences on population health are emerging. The future patterns of disease will be much affected by the rapid increase in the proportion of older people, the worldwide process of urbanisation, gains (unequally shared) in affluence and its associated patterns of consumption, and new genetic technologies. The advent of unprecedented global environmental changes, especially human-induced climate change, stratospheric ozone depletion, biodiversity loss and the depletion of fertile soils and fresh water supplies, will have a range of adverse effects on human health. The prospects for human health are being further affected by the processes of globalisation, especially the liberalisation of production, trade and investment with its often inadvertent collateral damage to economic equity, social wellbeing, labour standards, environmental resources and human health.

Patterns of health and disease in the twenty-first century will differ greatly from those of previous centuries. In Western societies, deaths from infectious disease dominated in 1900 and those from heart disease and cancer dominated in 2000. What will dominate in 2100? We are entering a new phase of human ecology as we restructure our relationships with the natural world, convert the global village into a global supermarket, and accelerate the through-traffic of materials, money, people, microbes, information and ideas. The 1.5 billion humans of 1900 will have become 8–9 billion by 2050. We may yet face adversity and crisis as a result of unconstrained climate change and deterioration in the vitality of the planet. There is great uncertainty about these unfamiliar 'futures' – and, as yet, little experience in seeking effective international solutions.

Over the next few decades, life expectancies will probably continue their historically unprecedented rise, especially in low-income countries. However,

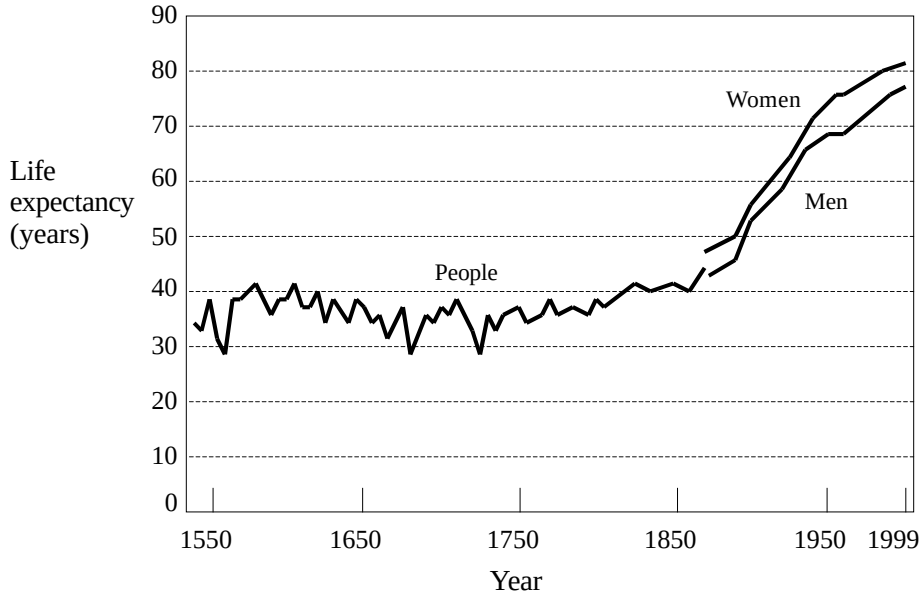

Figure 1.2 Gains in life expectancy in England and Wales over the past two centuries. Social, economic and climatic conditions deteriorated during the seventeenth century. From around 1750 there was a gradual rise in average life expectancy, accelerating after 1850. Much of that rise reflected the decline in infant and child deaths.

if the HIV/AIDS pandemic intensifies, then life expectancies will decline in afflicted countries as they have already done in many sub-Saharan African countries. Globally, the proportion of deaths from infectious diseases will halve from around one-third to one-sixth of total deaths, whereas the proportion due to coronary heart diseases, stroke, cancer and other noncommunicable adult diseases will rise from around one-half to three-quarters.[1] The proportion of deaths from injuries, too, will increase. Malnutrition and unsafe drinking water in the less-developed countries, along with indoor air pollution from cooking and heating in poor households, will remain major killers – even as cigarette smoking, alcohol consumption and dietary excesses cause increasing rates of adult disease and premature death. The burgeoning global tobacco epidemic killed at least 4 million people in 2000. By 2020 it will be killing 10 million per year – that is, about one in every three adult deaths.[1] Diabetes, currently afflicting around 4% of the world's adults, is becoming more prevalent as urban populations everywhere get older and fatter. The widespread decline in traditional family and social supports may contribute

to mental depression becoming a major source of chronic health impairment within several decades.

In this changeable world surprising shifts in disease patterns may become more frequent. Life expectancy plummeted in Russia in the early 1990s as social structures and controls dissolved following the collapse of communism. Elsewhere during the 1990s, adult life expectancy fell by at least two years in around 10 other (non-African) countries, including Haiti, Ukraine, Moldova, North Korea and several countries of Central Asia. The newly named variant Creutzfeld-Jakob disease (human 'mad cow disease') appeared unexpectedly in Britain in the mid-1990s, and its future course remains ominously uncertain. For much of the past half-century we imagined that humankind's ancient foe, infectious disease, was in terminal retreat: antibiotics, pesticides, vaccinations, modern sanitation and environmental controls seemed like a winning hand. But then HIV/AIDS emerged and, by the year 2000, was killing over 2 million people annually. Cholera has extended its dominion over the past quarter-century, having embarked on its longest-ever pandemic. Tuberculosis, assisted by HIV, has rebounded. During that same period, the mosquito-borne diseases, malaria and dengue fever, have become resurgent.

So, it is appropriate to stand back from the details and ask big questions about the determinants of population health – and about the sustainability of human health across future generations. The great theme permeating that long-running story is the intimate relationship between environmental circumstances, social conditions, human biology and the occurrence of disease. It is an *ecological* story that reflects the shaping of both human biology and society by environment. It reflects the dependence of human population health upon stocks of natural resources, the functioning of ecosystems, and cohesive social relations.

Disease in history: seeking patterns

The historical record contains many spectacular one-off disease events. One thinks of the great killing epidemics of classical Athens and of Justinian Constantinople; the fourteenth-century Black Death; the Irish potato famine in the 1840s; and the 'Spanish influenza' pandemic that killed around 25 million people in 1918–19. The history of human disease is replete with anecdote and intrigue. Perhaps the Fall of Rome was hastened by lead-induced dementia in the ruling class who stored their wine in lead-lined vessels. The

porphyria and resultant intermittent madness of Britain's King George III in the late eighteenth century helped precipitate the fiscal feud that caused the American War of Independence. Smallpox in the seventeenth and eighteenth centuries killed emperors in Japan and Burma and kings and queens in Europe. Beethoven's deafness may have been caused by a markedly raised blood lead concentration (as evidenced in preserved samples of his hair). The Battle of Waterloo may have turned upon Napoleon's haemorrhoids and his resultant sleeplessness.

But those are merely history's eye-catching headlines. The story runs much deeper. It is embedded in the long biological and social evolution of humans and their australopithecine ancestors over the past 5 million years. It is a story of genetic adaptations acquired by globally dispersing hunter-gatherer populations when confronted by unfamiliar local environments. Some of those genetically based traits affect the health of today's populations even though they may now live in environments free of the original hazard. Sickle-cell anaemia in African Americans who are no longer threatened by malaria, and skin cancer in fair-skinned Australians who no longer live under clouded northern European skies are two simple examples. The story is also embedded in human cultural evolution, particularly over the past 10,000 years since agriculture emerged, entailing changes in diet, patterns of infectious diseases, urban living, workplace hazards, and social inequalities. As the scale of human intervention in the natural environment has increased, depleting resources and disrupting ecosystems, so the plot has thickened further.

The scale of real interest, then, is not that of personal haemorrhoids or porphyria. Rather, it lies in the ebb and flow of diseases in whole populations. These are the deeper currents that signify changes in the ecological circumstances of human populations, and which have often affected the course of history. Consider how the warming and climatic instability that followed the end of the last ice age, around 15,000 years ago, induced landscape changes, species dispersals and regional food scarcity that eventually pressed many human groups into growing their own food and herding animals. Consider how the subsequent crowded early villages and towns acted as incubators for novel infectious diseases able to enter human populations from cohabiting animal sources. During the first millennium AD, the repeated ravaging of the Roman Empire and the vast Chinese Han Empire by imported epidemic diseases affected the political map of Eurasia. Later, following the devastating Black Death in Europe, the loss of faith in church and politics contributed to a new social fluidity, scepticism and individualism that potentiated the

Renaissance in Europe and the rise of post-Aristotelian empirical science. With Europe becoming expansionary in trade and conquest, the unwitting reinforcement of adventurous bands of Spanish conquistadors by deadly legions of measles, influenza and smallpox viruses facilitated the conquest of the vast and opulent civilisations of Central and South America. And so the story continues. During the past century, the profile of disease has changed radically, first in Western countries and now in the rest of the world.

We are transient participants in this great, unfinished adventure. Hominids have processed from humble australopithecine origins on the margins of the African savannah several million years ago to today's world, in which modern humans stand, mightily, centre-stage. Central to this unfinished story is the ever-changeable pattern of human health and disease, reflecting the shifts in human ecology and the extent to which our way of life is materially provident, socially equitable and ecologically sustainable. Historical anecdotes make fascinating reading, of course, but it is the larger story at the population level that will assist us to find a sustainable path to the future.

OUR PERCEPTIONS of the causes of disease have evolved rapidly over the past century. Earlier longstanding ideas of divine wrath, astrological conjunctions and non-specific miasmas were replaced in the late nineteenth century by the idea of specific casual agents. That idea arose particularly from the influential germ theory as propounded by Louis Pasteur and Robert Koch. It was reinforced by the elucidation of vitamin deficiency disorders and the identification of particular disease-inducing exposures in the workplace. As the science of genetics evolved; as neo-Darwinism arose in the early twentieth century from the blending of Darwin's theory of evolution with Mendel's theory of inheritance; and as Erwin Schrodinger and others plumbed the mysteries of the nature and origins of life itself, so by mid-twentieth century deeper questions were being asked about human biology and disease. These included questions about the biological ancestry of the human species, about human susceptibility or resistance to agents of disease, and about the social and environmental modulation of disease occurrence.

By the 1960s it became clear that high-income, urbanising populations in the West and Japan had substantially exchanged the ancient burden of infectious diseases for a new set of noncommunicable diseases of later adulthood. The overly simplistic assumption emerged that health and disease were mainly determined by personal behaviours and local environments.[2] With infectious disease seemingly under control and with modern energy-intensive agriculture

yielding larger harvests, any sense of dependence on the wider environment had receded. Western epidemiologists led the way in demonstrating the health hazards to individuals of cigarette smoking, of excessive alcohol consumption, of diminished physical activity, and of acquiring high levels of blood pressure and blood cholesterol. Even so, there were other stirrings: there was new talk of 'human ecology', a growing awareness of the insidious hazards to species and ecosystems from DDT and other human-made organic chemicals,[3] accruing evidence of adverse respiratory effects from exposure to a range of urban air pollutants, and, in the 1970s, discussion about the 'limits to growth'.[4] During the 1980s, concerns over human-induced stratospheric ozone depletion and impending global climate change grew stronger. By century's end we could see more clearly that the sheer weight of the human enterprise was increasingly overloading, disrupting and depleting many of Earth's great biophysical systems. Here was a new, potentially serious dimension of risk to human well-being and health.

From this narrative we see that there are probable risks to population health whenever we exceed the capacity of the natural environment to stabilise, absorb, replenish or recycle. Intensifying the production of British beef by feeding cows recycled scraps of other cows, and thus violating nature's food chains, opened up a niche for an infectious agent. If global climate change intensifies the El Niño system, then droughts, tropical hurricanes and floods will increase in many regions. We can gain some perspective on likely future problems by considering some of the large-scale ecological experiences of past civilisations.

A polar bear for a bishop: carrying capacity and survival

The tragic story of Easter Island, one of the world's most remote specks of land in the south-east Pacific, encapsulates the dire consequences for humans of exceeding the natural environmental carrying capacity of a closed system.[5] Having settled the island in about 900 AD, the once thriving Polynesian population, the Rapanui, eventually denuded the island of forest. The trees were needed as rollers for transporting massive stone statues, the poker-faced *moai*, to their ocean lookout posts. Massive soil erosion ensued. Hence wooden canoes for fishing could no longer be built. From an estimated peak population of around 7,000 in the fifteenth century, numbers dwindled, conditions deteriorated, and warfare and cannibalism broke out. When Dutch explorers landed in 1722, there were fewer than 2,000 inhabitants – plus

several hundred *moai*. By the nineteenth century, the survivors had dwindled to several hundreds.

A similar but less well known story comes from the other side of the world. The mysterious demise of the West Viking settlement in Greenland in the fourteenth century attests to the vulnerability of human societies to small shifts in environmental conditions if they are already living on the margins of viability. Which of the Four Horsemen of the Apocalypse bore down upon that remote settlement at the limits of European colonialism? Regional climate change, leading to malnutrition and culminating in acute famine, is the most likely.

Global temperatures began rising in the ninth century AD as the Medieval Warm period arrived. The Norse began to expand their settlements around the North Atlantic: from northern Scotland, to the Faroe, Shetland and Orkney Islands, to Iceland and, a hundred years later, to Greenland. The Norse colonisation of Greenland, established around 985 AD and eventually totalling about 4,000 persons, lasted for five centuries. The eastern settlement was initiated by the renegade viking Erik the Red.[6] With a real estate developer's flair and considerable poetic licence, Erik called the great ice-bound continent 'Greenland', to entice further settlers. There were indeed several grassy but treeless fjord-like havens around the south-western coastline. The eastern settlement was towards the southern tip of Greenland, four days sailing westwards from Iceland. The western settlement was 500 kilometres further up the west coast of Greenland, at Godthabsfjord. Each location had sufficient pasture for grazing and for the production of fodder for winter. It was difficult to grow cereals: the climate was cold and the soil was thin. The settlers got by with cows and sheep, along with some goats and pigs. The diet was supplemented with caribou, fish, seal, snow hare and some seasonal berries. Walrus ivory and polar bear skins were exported. Timber, iron nails and corn were imported.

Contemptuous of the primitive Inuit 'skraelings', whom they considered akin to trolls, the colonists learnt little about the wider possibilities for acquiring local foods. Had they, for example, adopted the Inuits' toggling harpoons, they could have hunted harp and ring seals all year round rather than just the harp seals during the warmer months. Indeed, compared to other contemporary Norse settlements in varied environments around Europe, the Greenland settlers displayed an unusual rigidity. They struggled to recreate a little Norseland with unchanged styles of clothing, housing and diet. Later, both the east and west settlements became more fervent in their religious practices. Christianity had only recently arrived in the Scandinavian region, after struggling northwards in Europe during the Dark Ages. The settlements paid their