Human frontiers, environments and disease

This compelling account charts the relentless trajectory of humankind and its changing survival patterns across time and landscape, from when our ancestors roamed the African savannah to today's populous, industrialised, globalising world. This expansion of human frontiers – geographic, climatic, cultural and technological – has entailed many setbacks from disease, famine and depleted resources. The changes in human ecology due to agrarianism, industrialisation, fertility control, social modernisation, urbanisation and modern lifestyles have profoundly affected patterns of health and disease. Today, while life expectancies rise, Earth's ecosystems are being disrupted by the combined weight of population size and intensive consumption. The resultant climate change, stratospheric ozone depletion, loss of biodiversity and other environmental changes pose risks to human health, perhaps survival. Recognising how population health, long term, depends on environmental conditions, can we achieve a transition to sustainability?

Whilst the canvas that Tony McMichael covers is vast, the detail he brings to bear on this immense subject is both illuminating and dramatic. This account succeeds on many levels: as a chronicle of human colonisation and environmental impact; as a description of how recent technological changes have induced mismatches between our biological needs and our ways of living; and as an analysis of our rapidly changing demographic and social profile and its environmental and health consequences. As Tony McMichael argues in the Preface, 'Humankind is now treading heavily upon the Earth. We have greatly increased the size of our "ecological footprint". As we perturb Earth's life-support systems, so we endanger the prospects for human population health and survival. The trail cannot continue much longer with footprints like these.'

Tony (A.J.) McMichael is Professor of Epidemiology, London School of Hygiene and Tropical Medicine. He has held positions in Australia, USA and UK, and has taught widely in Asia, Africa and Europe. He has advised WHO, UNEP, the World Bank and Intergovernmental Panel on Climate Change on dietary, environmental and climatic influences on health. He has enthusiasms for palaeoanthropology and social history. His previous book published by Cambridge University Press in 1993 was *Planetary Overload* (ISBN 0 521 55871 9), a widely acclaimed and influential account of global environmental change and health of the human species.

Human frontiers, environments and disease

Past patterns, uncertain futures

Tony McMichael

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Central theme

Humankind's long evolutionary and historical experience shows how the social and natural environments affect patterns of disease and survival. Appreciating this ecological perspective on human population health – at a time when large-scale stresses are appearing in our world – is a prerequisite to achieving a sustainable future.

Some comments on *Human frontiers, environments and disease*

'This impressive book by an eminent public health scientist explores our most important relationship: our interaction with the environment. It is essential reading for all concerned with assuring future human health – and our very survival.'

Robert Beaglehole *Professor of Community Health, University of Auckland*

'This book achieves an unusual and important synthesis of the large-scale evolutionary, social and environmental influences on human health and survival. This ecological perspective, highlighting the history of disease and wellness, the state of our epidemiological environment, and the general impacts of recent cultural trends on well-being, is essential if we are to achieve a sustainable future.'

Paul R. Ehrlich *Bing Professor of Population Studies, Stanford University, and author of 'Human Natures'*

'Human Frontiers, Environments and Disease is an innovative and constructive analysis of a problem fundamental to mankind, past, present and future. No one concerned with the bio-medical prospects of the human race could fail to find Professor McMichael's accomplished account thought-provoking and eye-opening.'

Roy Porter *The Wellcome Trust Centre for the History of Medicine at University College London*

'This is a splendidly written book – a revelation about human health over the millennia. From yellow fever to hypertension it underscores the larger framework of environment-health links. We will be better able to handle the future if more people read this insightful book.'

Thomas E. Lovejoy *Smithsonian Institution, Washington, DC*

'Today, worldwide, most people live longer and are better fed than ever before. These benefits, however, have environmental and other costs. Tony McMichael's book gives a well organised and wide ranging account of this human story and of its ecological underpinnings. The book concludes with a clear-eyed analysis of current threats to sustainability.'

Sir Robert May *President, The Royal Society*

To Judith

for lives shared

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Preface

Human life expectancy, in the space of a mere century or so, has become much longer than ever before. This primarily reflects the improved social and physical conditions of living, along with the strengthening of civil institutions; circumstances which, in particular, have greatly diminished childhood deaths from infection and malnutrition. We have thus partially reined in two of the four biblical Horsemen of the Apocalypse: *Famine* and *Pestilence* on their black and pale horses, respectively.[1] Meanwhile, the other two Horsemen, *War* and *Conquest*, still roam menacingly on their red and white steeds.

Warfare continues. The recent conflicts in Kosovo, Chechnya and Sierra Leone testify to the destructiveness of modern firepower and the attendant toll in civilian casualties. Conquest persists, albeit mostly in modern commercial guise, reflecting aspects of economic globalisation and deregulated trade. The ascendancy of free markets, while conferring some health gains via material improvements and the restoration of dietary diversity, adversely affects the health of many vulnerable populations. Our modern economic system has widened the rich–poor gap and, in many settings, has weakened social institutions, eroded environmental conditions, fostered exploitative labour practices and displaced peasant farmers onto more marginal land. Meanwhile, in the world's expanding cities, commercial pressures promote cigarette smoking, automobile dependency and the consumption of energy-dense processed foods.

The profile of human health remains mixed.[2] The health of the wealthy and fortunate continues to exceed that of the poor and disadvantaged, both between and within countries. New diseases emerge alongside the old as societies change, as urbanisation proceeds, and as life expectancy rises. Further, we face various unfamiliar large-scale risks to health.[3] Changes in human demography and mobility, and heightened environmental disruption, have contributed to increases in both new and resurgent infectious diseases. Meanwhile, nature's food-producing resources and fresh-water supplies, now under great pressure, must somehow suffice for a world population that has rising material expectations and is likely to increase from 6 billion to 9 billion

by 2050. More generally, the increasing impact of human economic activity on Earth's atmosphere, oceans, topsoil and biodiversity is weakening the planet's life-support systems, changing the climate, and thereby casting a long shadow over humankind's future prospects.

Even so, our health indices are generally improving. Infant mortality has fallen markedly in most populations in response to gains in nutrition, female literacy, family planning, sanitation and vaccination. Modern medicine is increasingly able to defer death, if not always to maintain or restore good health. Epidemiologists continue to whittle away at identifying the factors that contribute to the causation of each specific disease, thereby facilitating its prevention. Meanwhile, on the horizon looms the prospect of disease prevention or alleviation by genetic engineering.

How can we explain this seeming paradox of extended life expectancy in an increasingly environmentally stressed world? Optimists might argue that our improved social institutions and technological capacities can more than compensate for this 'external' environmental decline. Meanwhile, ecologically attuned scientists suspect that we have achieved better population health substantially via material advances that have eroded natural environmental capital – that, in Tim Flannery's words, we have been 'future eaters'.[4] In all other species, sustained population health depends on the continuation of natural processes that yield energy, nutrients and fresh water. This life-supporting 'dividend' from nature is consumed on a recurrent basis, leaving nature's capital stock essentially intact. Human populations, however, have become increasingly dependent upon consuming that natural capital, a process that has now culminated in unprecedented global environmental changes. Those changes pose risks to the health of future generations.

We can understand the significance of these emerging large-scale influences on human health best within an ecological framework. Such a framework elucidates the evolutionary, historical and cultural dimensions of the patterns of human health, disease and survival. We forfeit much understanding of the determinants of health and disease *unless* we can stand back and consider how the changing conditions of life, the collective experiences of whole populations over time, shape the larger patterns of health and survival. This means extending beyond the recent focus of epidemiologists on an individual-based 'biographical' account of disease risk – that is, a risk that is the product of itemised personal behaviours, exposures and biomedical characteristics. Rather, we should apply a more integrative approach of a kind that, during the twentieth century, was largely overshadowed by the reductionist ideas inherent in the classic germ

theory and the ensuing biomedical model; an approach which must now engage with the often naive determinism of 'post-genome' molecular genetics.

THERE ARE THREE distinctive, yet inter-related, features in this long history of the changing patterns of human ecology and disease. They are: (i) the encountering by human societies, over time, of many new environmental hazards; (ii) the recurring tensions between changes in living conditions and the needs and capacities of human biology; and (iii) in recent times, the impacts upon patterns of health and disease of population ageing and urban living. These important transitions each deserve a few more introductory words. They encapsulate the unusual, evolving experiences of health and disease in a uniquely dominant, environmentally invasive, species.

First, human populations have colonised, adapted to and ultimately changed many of the world's regional environments. As our *Homo sapiens* forebears dispersed out of Africa from around 80,000 years ago, they encountered unfamiliar types of infections, foods and physical hazards. The particularities of those environments induced cultural and, in some cases, genetic adaptations. Social and technological adaptation has been the real key to global colonisation, enabling humans to increase the 'carrying capacity' of local environments. These changes in human ecology and living conditions also changed the spectrum of diseases. Agriculture and settled living, originating a brief 10,000 years ago, increased the local food yield. As staples came to predominate, agrarianism reduced the range of dietary nutrients and incurred risks of occasional famines. Settled human living, in close proximity with livestock, created unprecedented new ecological opportunities for microbes to adapt to and colonise humans. Hence the emergence of measles, smallpox, tuberculosis and so on. Subsequently, military, commercial and colonial contacts amplified the spread of these infectious diseases. Much later, industrialisation brought new material wealth, various localised environmental hazards, occupational diseases, and the health impacts of modern transport systems. The subsequent generalisation of more 'affluent' ways of living within developed countries consolidated the health gains that had followed the retreat of infectious epidemics – but at the price of acquiring various chronic noncommunicable diseases of late adulthood, particularly those associated with dietary imbalances, physical inactivity and tobacco. Heart disease, peaking in late twentieth century, became the hallmark of modern Western societies, even as infectious disease continued to account for almost half the deaths in the world's poorest populations.

Second, the increasing rapidity and intensity of technological change, urbanisation, material consumption and migration in recent centuries has heightened various mismatches between the biological attributes of humans and their living environment. Some of these mismatches influence the occurrence of particular diseases. For example, the advent of abundant energy-dense foods in increasingly physically inactive urban populations, and the resultant obesity, is causing a worldwide surge in diabetes. The sickle-cell trait in African Americans no longer confers benefit in the absence of malaria, but it does cause pain and suffering. Skin cancer rates are greatly elevated in fair-skinned people of northern European ancestry living now at more sun-exposed latitudes in Australia, New Zealand and the southern USA.

Third, the human demographic profile is now changing dramatically as numbers increase, as urbanisation gathers pace, and as life expectancy extends well beyond our reproductive years. We will thus incur considerably more chronic disability and disease than occurs in other animal species, most of whose members do not survive beyond middle adulthood. We face a social future in which a much greater proportion of the population is elderly, and in which patterns of community and family support differ markedly from historical traditions.

On the horizon, meanwhile, are two other momentous developments. Each has far-reaching consequences for human population health. At the micro-scale we are revealing, intentionally, nature's molecular secrets; we are learning about our genetic code and beginning to rearrange genetic structures. At the macro-scale, as mentioned above, we are unintentionally overloading Earth's life-supporting systems. We have already modified the social, material and environmental foundations of human health over the past two centuries, much of it for the good. Today, as human intervention in the global environment and its life processes intensifies, we need better understanding of the potential consequences of these ecological disruptions for health and disease. These insights should then guide our search for sustainable ways of living.

IN THIS BOOK I explore the story of how changes in human biology, culture and the surrounding environment have influenced patterns of health and disease over many millennia. I offer a narrative account of the evolution of human biology, society, environmental impact and ways of living and how those have affected patterns of health. The *message* is that the health of populations is primarily a product of ecological circumstance: a product of the interaction of human societies with the wider environment, its various ecosystems

and other life-support processes. Within the larger scheme of things, human health and survival depends on our maintaining a functional ecosphere that can continue to support human biological and social needs.

A *metaphor* that illuminates the ecological dimension of human population health is that of our species' 'footprints': our footprints along the trail of biohistory. Four types of footprints lead from our distant past into today's world, and then on into an uncertain future.

First, we have a wonderful reminder of the evolutionary trajectory of our hominid ancestors in the mud-preserved Laetoli footprints. These were the footprints, from 3.5 million years ago, of a little band of three upright-walking australopithecines in the African savannah of Laetoli Gorge, Tanzania. The height of these australopithecines was two-thirds that of modern humans; their brain capacity was one-third of ours. Their toes were still a little curved; they were predominantly vegetarians; their communications probably lacked syntax; and adult sexual pair-bonding may have been tentative and temporary. But here, in these footprints, were pointers to the eventual physical, cognitive and emotional attributes of the hominines, the successors to the australopithecines. These, in retrospect, were footprints wandering into the human future.

Second, as these early hominids responded to local environmental changes and the pressures of competition for food within their African environment, so their biology evolved. The brain enlarged; the anatomy of the gut changed; the metabolic handling of altered diets adapted; and skin, hair, stature and blood-vessel tone were all modulated in response to climatic shifts. Similar genetic adaptation occurred in response to regional diets and, later, the adoption of agrarianism. Successful biological adaptations were preserved in genes, to be passed to future generations. Today, various of those genetic adaptations affect our susceptibility to certain diseases, especially in situations of markedly altered ways of living. Those genetic adaptations are molecular footprints that reach from our past into the present and future.

Third, the capacity for cumulative culture enabled humans to leave their primordial evolutionary patch. From around 80,000 years ago, the modern human species, *Homo sapiens*, spread from Africa to West Asia, then South-Central Asia, Australia, East Asia, Europe, North America and so on. The footprints of this global diaspora remain in many forms: stone tools, fire-hearths and permanently modified local environments. Those are our species' palaeoanthropological footprints across the landscape of time and place.

And what of that future? Humankind is now treading very heavily upon the Earth. We have greatly increased the size of our 'ecological footprint'.[5] We used

ten times more energy in the twentieth century than our ancestors used in the previous thousand years.[6] As we perturb Earth's life-support systems, such as the climate system and the stocks of biodiversity, so we endanger the prospects for human population health and survival. The trail cannot continue much longer with footprints like these. Yet we cannot reverse, and need not apologise for, human dominance over other species and the environment at large. Humans, after all, are a part of nature. We are a species that, by evolutionary happenstance, has the unique capacity to transform and control the natural world. But we must find a way of living within the limits of this essentially closed biophysical system, Planet Earth. To this end we must now redirect our wonderfully inventive and versatile brains – to date, the most distinctive product of hominoid evolution. Otherwise the hominid chapter in life's grand evolutionary narrative may end unhappily.

MEANWHILE, and on a happier note, I must acknowledge the many and diverse persons who have directly and indirectly assisted me in writing this book. Various colleagues at the London School of Hygiene and Tropical Medicine have been a rich source of ideas and critical comment. These include in particular Dave Leon, Simon Strickland, Astrid Fletcher, David Bradley, Paul McKeigue, John Cleland, Prakash Shetty, Sari Kovats, Andrew Haines, Virginia Berridge, Andy Hall, Emily Grundy, Pat Doyle, Lucy Pembrey, Chris Curtis and Paul Fine. Other colleagues from outside the School whose ideas and suggestions I have appreciated include John Powles, Kirk Smith, Bill Rees, George Davey Smith, Nancy Krieger, Alistair Woodward, Tord Kjellstrom, Jack Caldwell, Robert Beaglehole, Kris Ebi, Philip McMichael, Neil Pearce, Peter Newman, Ruth Bonita, David Waltner-Toews, Leslie Aiello, Laura Westra, Norman Myers, Paul Ehrlich, David Rapport, Paul Epstein, Steve Kunitz, Paolo Vineis, Jonathan Patz, Pim Martens, Maurice King, Tim White and Colin Butler. My thanks to Phillip Raponi for typing the rather arduous final round of revisions, and to Peter Silver my editor at Cambridge University Press – both for his encouragement and for his understanding that a busy academic life does not permit books to be written by the agreed date, or even soon thereafter. My wife, Judith, immersed in her own writing commitments, has known that it meant much to me to finish this book. We will find more weekend time in future to tread lightly on the countryside.