

INTERACTIONS OF ENVIRONMENTAL CHANGE AND HUMAN HEALTH

Neil Pearce

Massey University, Wellington, New Zealand

Anthony J. McMichael

London School of Hygiene and Tropical Medicine, United Kingdom

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Summary

History has always been uneven and contradictory, and there is a danger in proposing ideal models. Nevertheless, it is perhaps useful to consider the development of human society as involving three major revolutions. In this contribution we consider these three revolutions in turn with respect to their consequences for the environment and for human health. The *agricultural revolution* probably began in the “fertile crescent” of southwest Asia and involved major environmental changes, from the development of organized agriculture and the establishment of cities. These changes were initially reflected in a smaller human body size and, apparently, shorter life expectancy, but were followed by increased population growth. The *Industrial Revolution*, and the associated period of imperialism and colonialism, commenced in Great Britain in the late eighteenth century, and initially involved widespread social, environmental, and economic disruption; life expectancy initially fell before beginning to increase again in

the second half of the nineteenth century. We are currently undergoing an *information technology revolution* and an associated process of economic, social, and cultural globalization. The former has the potential to reduce the human impact on the biosphere, but it coincides with a time of increasing population size and major increases in consumption levels. Those increases are already having major environmental impacts, as did previous revolutions, with the positive and negative consequences being unequally distributed. However, unlike previous revolutions, current changes have the potential to endanger the sustainability of the biosphere's natural systems, thereby endangering the survival of the human species itself. This contribution discusses the potential benefits and potential hazards of these social and environmental changes for human health, and considers the changes in global thinking that are required to ensure human and environmental survival.

1. Introduction

In its broadest sense, the term "environmental health" refers to all nongenetic determinants of health, and includes aspects of individual lifestyle such as diet and exercise. Environmental health is often defined more narrowly to refer to the direct effects on health of specific environmental exposures, such as air pollution or toxic contamination of water supplies. In the current context, we adopt an inclusive definition which includes not only the physical environment, but also the built environment, social and economic relations, and the patterns of living that flow from these circumstances. This includes aspects of individual lifestyle, but we only consider these when they are reflections of more general "environmental" conditions.

History has always been uneven and contradictory, and there is a danger in proposing ideal "models." Nevertheless, in the context of this contribution it is useful to identify three major revolutions, each of which has had major consequences for the environment and for human health. The *agricultural revolution* involved major environmental changes from the development of organized agriculture and the establishment of settlements, whereas the *Industrial Revolution* involved major environmental and social changes from the development of machine tools and industrial production. The current *information technology revolution* and the process of globalization will also have major environmental health impacts. However, unlike previous revolutions, current changes have the potential to endanger the sustainability of the biosphere's natural systems, thereby endangering the survival of the human species itself. This contribution discusses the potential benefits and potential hazards of these social and environmental changes for human health, and considers the changes in global thinking that are required not only to ensure human and environmental survival, but also to maximize the benefits and minimize the hazards to human health.

2. The Agricultural Revolution

Prior to around 10 000 years ago, all people on Earth were hunter-gatherers. Since then, most parts of the world have seen an agricultural revolution which has had profound effects on human society and human health. This revolution appears to have only occurred independently in five areas of the world (southwest Asia, China, Mesoamerica, the Andes of South America, and the eastern United States), but may possibly have also

occurred in four others (Africa's Sahel zone, tropical West Africa, Ethiopia, and New Guinea) although the evidence for these latter four areas is uncertain. The reasons that agriculture arose in these areas, but not in others, are complex, but particularly include the availability of suitable indigenous plants (including wheat, barley, millet, rice, and corn) and animals (including sheep, goats, cattle, pigs, and horses) for domestication. Their use was probably prompted by the decline in the availability of wild foods, including the depletion of wild game, an increased availability of domesticable wild plants, in part due to climate change following the last ice age, which ended around 15 000 years ago, and also reflecting the development of suitable technologies for collecting, harvesting, and storing wild foods. Newly domesticated livestock also played a crucial role by providing meat, milk, and fertilizer and by pulling plows. The resulting food surpluses were the basis for the development of settled towns and cities with a systematic division of labor, and the creation of intellectuals, artisans, traders, soldiers, and ruling elites.

2.1 Health Effects

Although it may now appear obvious that an agricultural existence is preferable to that experienced by hunter-gatherers, this was probably not self-evident at the time. The reasons for the move from hunter-gathering to agriculture, as an alternative strategy, were complex and depended highly on local conditions. Most farmers spend more time "working" than do hunter-gatherers, and the first farmers in many areas were smaller and less well-nourished, suffered more disease, and died at a younger age than did hunter-gatherers. These health effects were distributed unevenly: for example, in the Chilean Maitas-Chirabaya agrarian culture, the priestly shamans were taller and had fewer bone lesions. Nevertheless, the agricultural revolution triumphed in most parts of the world, perhaps because the adoption of a "sedentary" existence means that more children could be produced with a shorter birth spacing. Although population densities rose faster than food production, and calorie intakes declined, the increased population both needed and could produce more food, enabling the displacement of neighboring hunter-gatherer populations. Thus the early stages of the agricultural revolution in some instances saw a paradoxical decrease in life expectancy accompanied by an increase in population size, because the increase in birth rate outweighed the accompanying increase in the death rate.

This increase in population size and density was accompanied by the rise of the major infectious diseases which remained the major "killers" until the twentieth century. The first evidence for the occurrence of these epidemic diseases is often surprisingly recent: 1600 BC for smallpox, 400 BC for mumps, 200 BC for leprosy, 1840 for epidemic polio and 1959 for AIDS. Hunter-gatherer populations did suffer from infectious diseases, but these were only of certain types, such as those that are carried by animals (e.g. the yellow fever virus carried by African wild monkeys) or chronic conditions that are nonfatal or only slowly fatal (e.g. leprosy). The major epidemic infectious diseases (including plague, measles, mumps, rubella, pertussis, and smallpox) require large populations and high population densities, and cannot survive in hunter-gatherer populations. For example, measles is likely to die out in any population fewer than half a million people. More importantly, these diseases apparently did not exist in humans before agrarianism. The major communicable diseases (including smallpox, flu,

tuberculosis, malaria, plague, measles, and cholera) all appear to have evolved from diseases of animals, and hence to have followed the adoption of agriculture, and the adoption of a sedentary existence in which people live amongst their own sewage and are surrounded by rodents and domesticated animals. The situation is worse in densely packed cities linked by world trade routes. For example, bubonic plague appeared in Europe in the sixth century, but the plague epidemics hit Europe in the fourteenth century following the establishment of the relatively rapid overland trade route with China. In fact, it was not until the beginning of the twentieth century that Europe's major cities became self-sustaining. Before then, constant migration from the countryside was necessary to make up for deaths from epidemic diseases.

Thus, the development of agriculture, domestication of animals, the adoption of a "sedentary" existence, and the accompanying rise in population size and density provided the conditions for the appearance and the epidemic nature of the major killer diseases. These did not occur in any major sense in populations that were too small or that retained a hunter-gatherer lifestyle. This became strikingly evident with the European colonization of the Pacific and the Americas after 1492, which saw the indigenous populations decimated by imported infectious diseases such as measles. However, it should be noted that these effects were not uniform and depended highly on local conditions. For example, the Pacific was colonized by Great Britain and France more than 150 years ago. It is commonly assumed that a major and widespread loss of life occurred due to the arrival of infectious diseases to which the indigenous people had no natural immunity. However, a more careful analysis of the history of colonization throughout the Pacific reveals that the indigenous people mainly suffered mortality epidemics from imported infectious diseases when their land was taken, thus disrupting their economic base, food supply, and social networks. In "countries" in which land was not taken in large amounts, the death rate from the imported infectious diseases was relatively low.

3. The Industrial Revolution

If the agricultural revolution can, albeit simplistically, be considered to have originated with the development of hand tools such as the scythe and the plow, the Industrial Revolution can be characterized by the development of machine tools, such as the steam engine, the spinning jenny, and the Cort's process in metallurgy. The origins of the Industrial Revolution can be traced back to the European Renaissance, but it is usually considered to have begun in Great Britain at the end of the eighteenth century. A second revolution can be considered to have occurred about 100 years later, characterized by the development of electricity and the internal combustion engine, and centered more on Germany and the United States. Although technology played a key role in both the agricultural and industrial revolutions, these developments occurred in a social and political context which also played a crucial role. For example, some historians consider that the scientific knowledge underpinning the first Industrial Revolution was available 100 years earlier, but awaited the appropriate social conditions for this knowledge to be translated into new industrial technologies. Furthermore, the Industrial Revolution was a revolution in agriculture as much as it was in industry, with the advent of large-scale farming spelling the end of feudalism, and forcing agricultural laborers to seek employment in the cities.

3.1 Health Effects

As with the agricultural revolution, the Industrial Revolution conferred economic advantages on those who adopted the new technology and the accompanying system of social relations, which meant that the new technological and socioeconomic paradigm eventually triumphed. However, these economic advantages were often accompanied initially by social and economic disadvantages for large sections of the population. The Industrial Revolution in Europe initially involved widespread social and economic disruption, unemployment, homelessness, pollution, and increased exposure to health hazards both at work and at home. In the late eighteenth century, it has been estimated that the poorest 20% of people in England and France suffered such severe malnutrition that they were unable to do laboring work. The conditions of factory workers in England during the height of the Industrial Revolution in the mid nineteenth century were vividly described by a number of contemporary observers, including Chadwick, Carlyle, and Engels. For example, a physician's report on conditions in Manchester in the 1840s noted that "the men wore out very early in consequence of the conditions under which they live and work and most of them are unfit for work at forty years."

As a result of such conditions, the death rate in the United Kingdom and other countries in the first half of the nineteenth century actually increased, before it eventually began to decline in those born after 1850. The modern agricultural revolution eventually resulted in improved nutrition. This together with improved housing quality, safe water supplies, better domestic hygiene, and improving literacy produced major improvements in health and marked declines in deaths from infectious diseases. Such improvements were indirect consequences of general improvements in the standard of living and were due partly to direct governmental and industrial policy. Disease and destitution, by injuring and killing workers, interfered with industrial production and put profit in jeopardy. Furthermore, infectious diseases were spreading from poor to rich districts.

The relative importance of these measures in reducing mortality has been subject to some debate. The decline occurred largely prior to the introduction of effective modern vaccines and treatments and was due in part to improvements in nutrition. However, specific public health interventions on factors such as urban congestion probably also played a major role. For example, in France major gains in life expectancy emerged first in Lyon (in the 1850s), then Paris (1860s–1870s) and then Marseilles (around 1890), in each instance following improvements in water supply and sanitation.

Although the later stages of the Industrial Revolution saw improvements in sanitation and reductions in "natural" infectious disease, they also saw increases in "artificial" environmental hazards such as air pollution, occupational hazards, and food contamination. The spread of industry, and particularly the automobile, in the twentieth century has greatly increased the environmental burden of human-made chemical exposures. However, it was primarily in the latter third of the twentieth century that concern arose concerning pervasive environmental contamination from human-made chemicals that not only affect human health directly, but also affect the health of the overall ecosystem (see below).

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Biographical Sketches

Neil Pearce has recently established, and been appointed director, of the Centre for Public Health Research at the Massey University Wellington Campus. Since the completion of his Ph.D. in epidemiology in 1985 he has been engaged in a wide range of public health research activities. During 1980–1988 his main research interest was in occupational epidemiology. Since 1988 he has also conducted a wide range of asthma research projects including the identification of the role of the asthma drug fenoterol in the New Zealand asthma mortality epidemic, studies of the management of asthma in the community, and more recently studies of the causes of the increases in asthma prevalence in New Zealand and worldwide. He has also published widely in other areas of public health research, including occupational cancer in developing countries, socioeconomic determinants of health, indigenous health research, and the philosophy of public health research.

Tony McMichael is professor of epidemiology at the London School of Hygiene and Tropical Medicine, UK. His research interests have encompassed the causes of occupational diseases, studies of diet and cancer, and various topics in environmental epidemiology. He has been an advisor to WHO, the World Meteorological Organization and the World Bank (Environment Division). During 1990–1992 he chaired the Scientific Council of the International Agency for Research on Cancer (WHO). In 1993 he published *Planetary Overload: Global Environmental Change and the Health of the Human Species* (Cambridge University Press). Since 1994 he has convened the second and third formal reviews by the UN's Intergovernmental Panel on Climate Change of the potential health impacts of climate change. He is a member of WHO's newly established Advisory Committee on Globalization and Health, a Council member of the newly formed World Health Policy Forum, coeditor of the newly launched journal *Global Change and Human Health*, and author of *Human Frontiers, Environments and Disease: Past Patterns, Uncertain Futures* (Cambridge University Press, 2001).