The Environment in Health and Well-Being FREE

George Morris, European Centre for Environment and Human Health, University of Exeter Medical School, Truro, United Kingdom and Patrick Saunders, University of Staffordshire, University of Birmingham, and WHO Collaborating Centre

https://doi.org/10.1093/acrefore/9780199389414.013.101
Published online: 29 March 2017

Summary

Most people today readily accept that their health and disease are products of personal characteristics such as their age, gender, and genetic inheritance; the choices they make; and, of course, a complex array of factors operating at the level of society. Individuals frequently have little or no control over the cultural, economic, and social influences that shape their lives and their health and well-being. The environment that forms the physical context for their lives is one such influence and comprises the places where people live, learn work, play, and socialize, the air they breathe, and the food and water they consume. Interest in the physical environment as a component of human health goes back many thousands of years and when, around two and a half millennia ago, humans started to write down ideas about health, disease, and their determinants, many of these ideas centered on the physical environment.

The modern public health movement came into existence in the 19th century as a response to the dreadful unsanitary conditions endured by the urban poor of the Industrial Revolution. These conditions nurtured disease, dramatically shortening life. Thus, a public health movement that was ultimately to change the health and prosperity of millions of people across the world was launched on an “environmental conceptualization” of health. Yet, although the physical environment, especially in towns and cities, has changed dramatically in the 200 years since the Industrial Revolution, so too has our understanding of the relationship between the environment and human health and the importance we attach to it.

The decades immediately following World War II were distinguished by declining influence for public health as a discipline. Health and disease were increasingly “individualized”—a trend that served to further diminish interest in the environment, which was no longer seen as an important component in the health concerns of the day. Yet, as the 20th century wore on, a range of factors emerged to r-establish a belief in the environment as a key issue in the health of Western society. These included new toxic and infectious threats acting at the population level but also the renaissance of a “socioecological model” of public health that demanded a much richer and often more subtle understanding of how local surroundings might act to both improve and damage human health and well-being.

Yet, just as society has begun to shape a much more sophisticated response to reunite health with place and, with this, shape new policies to address complex contemporary challenges, such as obesity, diminished mental health, and well-being and inequities, a new challenge has emerged. In its simplest terms, human activity now seriously threatens the planetary processes and systems on which humankind depends for health and well-being and, ultimately, survival. Ecological public health—the need to build health and well-being, henceforth on ecological principles—may be seen as the society’s greatest 21st-century imperative. Success will involve nothing less than a fundamental rethink of the interplay between society, the economy, and the environment. Importantly, it will

demand an environmental conceptualization of the public health as no less radical than the environmental conceptualization that launched modern public health in the 19th century, only now the challenge presents on a vastly extended temporal and spatial scale.

Keywords: environmental and human health, environment, environmental epidemiology, environmental health inequalities, ecological public health

Subjects: Environment and Human Health

Introduction

This article traces the development of ideas about the environment in human health and well-being over time. Our primary focus is the period since the early 19th century, sometimes termed the "modern public health era." This has been not only a time of unprecedented scientific, technological, and societal transition but also a time during which perspectives on the relationship of humans to their environment, and its implications for their health and well-being, have undergone significant change.

Curiosity about the environment as a factor in human health and well-being, and indeed health-motivated interventions to manage the physical context for life, substantially predate the modern public health era. The archaeological record provides evidence of sewer lines, primitive toilets, and water-supply arrangements in settlements in Asia, the Middle East, South America, and Southern Europe, dating back many thousands of years (Rosen, 1993). Some religious traditions also imply recognition of the importance of environmental factors in health. For example, restrictions on the consumption of certain foods probably derive from a belief that these foods carried risks to health; a passage in the book of Leviticus conveys the existence of a belief in the relationship between the internal state of a house and the health of its occupants (Leviticus [14:33–45], quoted in Frumkin, 2005).

The sixty-two books of the "Hippocratic Corpus" dating from 430–330 BC are the accepted bedrock of Western medicine (Lloyd, 1983), not least because they departed from the purely supernatural explanations for health and disease which hitherto held sway. For the first time, ideas about medicine, diseases, and their causes were being written down. Among these were ideas about the environment and its relationship to mental and physical health (Lloyd, 1983; Rosen, 1993; Kessel, 2006). While scarcely a template for how societies would come to think about environment and health in the modern era, one Hippocratic text in particular, *On Airs, Waters and Places*, introduces several ideas that do retain currency. For example, the simple message that good health is unlikely to be achieved and maintained in poor environmental conditions is enduring. Also, through specific reference to the health relevance of changes in water, soil, vegetation, sunlight, winds, climate, and seasonality, *On Airs, Waters and Places* conceives an environment made up of distinct compartments and spatial scales from local to global, recognizing that perturbations in these compartments, and on these scales, may result in disease. Such thinking remains conceptually and operationally relevant today. Hazardous agents are still frequently addressed in "environmental compartments" such as water, soil, air, and food

or by developing and applying environmental standards for the different categories of place where people work, live, learn, and socialize. In parts, the Hippocratic Corpus also presages the ecological perspectives now coloring 21st-century public health thinking. These include an understanding of the potential for human activity to impact negatively on the natural world and the importance of viewing the body within its environment as a composite whole.

Environment and Health in the Modern Public Health Era

Epidemiology is the basic science of public health and is concerned with the distribution of health and disease in populations across time and spaces, together with the determinants of that distribution. Environmental epidemiology is a subspecialty dealing with the effects of environmental exposures on health and disease, again, in populations. Since the early 19th century, the outputs of epidemiology have been key components of a "mixed economy of evidence" that has shaped and reshaped priorities and informed the decisions society takes to protect and improve population health (Petticrew et al., 2004; Baker & Nieuwenhuijsen, 2008).

In a classic paper from the 1990s, the respected epidemiologists, Mervyn and Ezra Susser, helpfully described different "epidemiological eras" in modern public health, each driven by a dominant paradigm concerning the causes of disease and supported by a particular analytical approach (Susser & Susser, 1996). This differentiation offers a useful framework within which to consider changing perspectives on the role of environment in health since the early 1900s.

The Environment in an "Era of Sanitary Statistics"

The Industrial Revolution came first to 19th-century Britain driven by technological innovation, abundant coal supplies, and supportive political/economic conditions. Also influential was a post-Reformation philosophy that extolled the work ethic and self-sufficiency. The events were to resonate throughout the world, bringing great prosperity to some, but others, especially the urban poor, endured poor housing, severe overcrowding, and an absence of wholesome water or sanitation. The growing industrial cities became crucibles of squalor, disease, and severely reduced life expectancy as their citizens suffered the ravages of typhus, tuberculosis, and successive cholera epidemics. Unhealthy working conditions and grossly polluted air also damaged health and compounded the misery of urban life at this time. Such challenges were common to all locations touched by the Industrial Revolution and became the catalyst for a new public health movement across Europe and North America (Rayner & Lang, 2012; Rosen, 1993).

Using the new science of medical statistics, investigators quickly established the locations with the poorest living conditions to be also those where disease and early death were most prevalent (Chadwick, 1842), fueling an ultimately transformational societal response—a "sanitary revolution" (Rosen, 1993). Such was the impact of this mix of slum clearance with the introduction of waterborne sewerage and piped water supplies that readers of the *British Medical Journal*, voting almost two centuries later, still chose it, from a shortlist of 15, as the most

important medical milestone since the Journal was first published in 1840. The 11,300 readers who voted even placed it above the discovery of antibiotics and the development of anaesthesia (Ferriman, 2007).

Despite its impact, the "sanitary revolution" was famously initiated and sustained on a biologically flawed paradigm regarding the mechanistic causes of disease. Yet "miasma" (the transmission of disease through noxious vapors), because it served as a metaphor for squalid insanitary conditions, still drove effective intervention (Morris et al., 2006; Nash, 2006). During this time, however, the emergence of epidemiology as the primary mode of inquiry of public health was also pivotal to success. Endorsing this view, Susser and Susser labeled the first half of the 19th century an "Era of Sanitary Statistics," citing the frequent use of district-level data to link disease to, for example: filthy and degraded urban environments; overcrowding and poor housing and working conditions; and social factors like infant care (Susser & Susser, 1996)).

Thus, recognition that the environment (physical and social) mattered for health and notions of a "permeable" human body in close connection with other organisms and the abiotic environment were embedded at the launch of the 19th-century public health movement. It is notable that the perspective of the reformers was quite properly "proximal," that is, rooted in an acceptance of the importance of the local environment, physical and social. While the term "ecology" would not be coined until 1866 (Haekel, 1866) and "social ecology" much later still (Bookchin, 1990), the public health pioneers embraced what, in today's terms, we would understand as a broadly socioecological perspective and discerned no conflict in this with their efforts to understand the immediate causes of disease and intervene in a focused way to prevent it (Nash, 2006).

Especially through the efforts to stop cholera, the sanitarians affirmed the pathogenic potential of unsanitary conditions and pioneered the epidemiological approach, initially as "environmental epidemiology" (Baker & Nieuwenhuijsen, 2008). Other legacies of the Era of Sanitary Statistics have been less enduring. Despite recent advocacy of a "precautionary principle" (see, e.g., Martuzzi, 2007; European Environment Agency, 2013), the willingness to act on the basis of strong suspicion of a societal-level environmental threat to population health has diminished, perhaps an inevitable casualty of increasing sophistication and "evidence-based" approaches in medicine and policy (Kessel, 2006; Brownson et al., 2009). Many of public health's greatest triumphs have flowed from interventions that would have struggled to satisfy today's evidential criteria. Also, despite a recent reconnection with such arguments, the inherent logic of seeing and tackling disease in its social and environmental context, so obvious to the pioneers of public health, has periodically been less visible in the rhetoric and actions of their successors.

It is appropriate at this point to emphasize the international character of the 19th-century public health movement. This movement can all too easily be presented as a British phenomenon, with seminal contributions from John Snow (1813–1858) on the investigation of cholera (Vinten-Johansen et al., 2003); William Farr (1807–1883), also on cholera but more widely on medical statistics (Susser & Adelstein,, 1975); Edward Jenner (1749–1823) on vaccination (Baxby, 2004), and Edwin Chadwick (1800–1890) on the assembly of data relating disease to the filth and squalor that came with poverty (Chadwick, 1842). In reality, public health, then as now, advanced through the contribution of many individuals in many nations. For example, the German pioneer of

cellular biology, Rudolf Virchow (1821–1902), and his fellow countryman, the hygienist Johan Peter Frank (1745–1821), were hugely important (Rather, 1985). In France, Louis-Rene Vilerme (1782–1863), the doctor and pioneer of social epidemiology, highlighted links between poverty and death rates (Rosen, 1993) and, in the United States, the meticulous work of Lemuel Shattuck (1793–1859) bears direct comparison with that of Chadwick (Rayner & Lang, 2012).

It might be supposed that the consolidated outputs of European laboratories, especially in the decades between 1830 and 1870, would have quickly expunged the miasmic paradigm from 19th-century medicine and public health. Yet, the concept of miasma was so inculcated in Western thought that, for many, it retained significant explanatory power. Thus, for much of the 19th century there was not a single settled view on disease contagion (e.g., see Kokayeff, 2013). Indeed, as late as 1869 some distinguished Medical Officers of Health in England still attributed diseases such as typhoid to "the insidious miasma of sewer gases" and dismissed germs as "pure nonsense."

The Environment in an "Era of Infectious Disease Epidemiology"

Increasingly contested, the miasmic theory of disease was effectively supplanted in the 1880s by broad acceptance of the germ theory, ushering a new "Era of Infectious Disease Epidemiology" (Susser & Susser, 1996). In 1882, Louis Pasteur's techniques for growing organisms made it possible for Robert Koch (1843–1910) to demonstrate that a mycobacterium was the cause of tuberculosis and, shortly thereafter, to provide scientific proof that cholera was waterborne (Foster, 1970; Collard, 1976; Brock, 1999). In so doing, Koch established, what had been hypothesized by his teacher, Jacob Henle (1809–1885), some 40 years earlier that disease was microbial. Henle, Snow, Koch, and the biologist Ferdinand Cohn (1828–1898) are rightly seen as fathers of the science of medical microbiology that for a time would come to dominate thinking in medicine and public health (Rayner & Lang, 2012).

Initially at least, the germ theory did little to diminish interest in the environment as a determinant of health. Indeed, by revealing causal linkages between organisms isolated from their environmental carriers and specific diseases, it conferred scientific coherence on the established sanitary model and vindicated efforts to secure hygienic water, food, and housing. As Lesley Nash has observed, the germ theorists were initially content to meld the insights of bacteriology with longstanding environmental beliefs. Notions of a body in constant interaction with, and closely dependent on, its local social and physical context (in today's terms a socioecological perspective) did not conflict with the narrower perspectives of laboratory science (Nash, 2006).

While relative contributions may be debated, over a short timeframe medical microbiology, isolation, immunization, and improving social/environmental conditions combined to sharply reduce the burden of infectious disease for Western society. Yet, by the early years of the 20th century, the capacity to examine disease at the microscopic level, which was the engine of diagnostics and therapeutics, was beginning to act on the very foundations that support public health. Medical science gradually made its focus the pathogenic agents of disease, moving attention away from the environment and eroding socioecological perspectives. Doctors seemed

quite content to express health as an absence of disease, and medical science to project its role as the maintenance and reinforcement of "self-contained" human bodies (Nash, 2006). Through a growing tendency to see health, disease, and their determinants as attributes of individuals rather than characteristics of communities, wider society seemed almost complicit in an 'individualization' of health status. One implication of this blunting of a social/environmental thrust of public health was to divorce health from place, a development that would have profound implications in the very different epidemiological context that emerged following World War II.

The Environment in an Era of Chronic Disease Epidemiology

The dramatic reduction in infectious disease was certainly one reason why the epidemiological climate in Western society changed substantially in the mid-20th century. But just as important was the emergence of a quite disparate set of pathologies believed to be of noncommunicable etiology. Coronary heart disease, cancers, and peptic ulcers, which became the targets in a new "Era of Chronic Disease Epidemiology" (Susser & Susser, 1996), were thought rather unlikely to have origins in exposure to what was an increasingly regulated and ostensibly improving physical environment. While the outputs of much postwar epidemiology seemed to endorse this view, it is useful, with hindsight, to recognize the influence of what might be seen as "fashions" in epidemiological inquiry. These fashions would influence how medical science and the wider society would come to regard diseases and their causes for a generation.

The response of the public health community to the new and alarming "noncommunicable" threats was, logically, to deploy descriptive epidemiology to reveal those most likely to be affected. Perhaps surprisingly, those who traditionally were most vulnerable to disease (the young, the old, the immunocompromised, etc.) did not appear to be at increased risk. Rather, the new epidemics disproportionately affected men in their middle years (Nabel & Braunwald, 2012). Supported by enhanced computing power and methodological advance (Susser & Susser, 1996), researchers began to converge on specific risk factors that correlated with diseases of greatest concern. Many, it seemed, were aspects of individual lifestyle and behaviors, ostensibly freely chosen. A particular attraction for the proponents of what was to become known as "risk factor epidemiology" was its capacity to represent, mathematically, the "relative risk" of contracting a disease between people exposed to a putative risk and those who were not. Some have dubbed this epidemiological approach to noncommunicable or chronic disease "black box epidemiology" because it can relate exposure to outcomes "without any necessary obligation to interpolate either intervening factors or even pathogenesis" (Susser & Susser, 1996). Another unfortunate characteristic of this approach to epidemiology is that, despite its laudable intent to understand and address disease in *populations*, its focus is on *individuals* within those populations. As a result, it fails to elucidate the societal forces whose influence and interplay shape the health and health-relevant choices of those individuals. When viewed through a policy lens, this mitigates in favor of simplistic solutions that target individuals divorced from context and that lack the traction to produce meaningful change.

In summary, the desire to create a mathematical measure of relative risk for a specific factor is understandable. However, risk factor epidemiology uses an approach that is much more flexible than material reality. In the real world, many different factors coexist and interact to create and destroy health. This is not, however, to deny risk factor epidemiology's capacity, particularly in synergy with laboratory-based research, to break new ground. Notably, these methodologically driven approaches were key to elucidating links between smoking and lung cancer, heart disease and serum cholesterol, and between levels of prenatal folic acid intake and neural tube defects (Susser & Susser, 1996; Kessel, 2006; Perry, 1997).

The same basic criticism is voiced where similar "black box" epidemiological approaches are used to explore the contribution of a specific environmental agent, as in the case of much recent air pollution epidemiology (see below) (Kessel, 2006). Any specific pollutant under epidemiological investigation inevitably coexists with other pollutants and in a specific exposure context (e.g., prevailing climatic conditions). These coexisting factors may be critical in determining the health outcomes from exposure to the pollutant under investigation. Because the outputs of black box epidemiology are abstractions, the relative risk calculation represents an abstraction that can be limited in its capacity to inform policy.

The decades following World War II were a time of declining influence for public health and population perspectives, largely for reasons we have outlined. Yet, in its rhetoric and activities, the discipline of public health seemed at times almost complicit. Even its defining science of epidemiology seemed for a time more concerned to reinforce the insights of clinical medicine than to play the exploratory role on which its reputation had been founded (Susser & Susser, 1996). On the face of it, academic public health and the wider public health discipline had little to say about environment, no longer presenting it as an active component in the then current health challenges for Western society. As Nash has observed, physical environments were "recast as homogenous spaces which were traversed by pathogenic agents." Nevertheless, divorced from the prevailing rhetoric, in many locations there was a parallel narrative depicting a workforce that continued to work at a local level, within established legal and administrative frameworks, to protect and maintain health-relevant environmental quality standards. However, the environmental health function was often set in the narrow, hazard-focused, and compartmentalized terms framed for it by laboratory science. The task was largely confined to identifying, monitoring, and controlling a limited set of toxic or infectious threats in their environmental carriers. Only when pathogenic organisms or toxic agents demonstrably escaped their industrial, agricultural, or marine confines to damage health and reinforce the porosity of the human body did environment briefly assume a higher profile.

Against this backdrop, it was not necessarily predictable or inevitable that environment would regain a central place in public health. Yet, by the end of the 20th century, a much richer understanding of the environmental contribution to human health and well-being had indeed emerged. This change cannot be attributed to a single factor in isolation. Some point to the key influence of Rachel Carson's *Silent Spring* in 1962 (Carson, 1962), which expressed grave concern for the ecosystem effects of DDT, the linkage to potential human health effects, and the implications of a growing disconnect between humankind and nature. We do not deny the status of Carson's work as a seminal text of a modern "environmentalism" that would rapidly gather

pace and influence (Nash, 2006). However, we submit that it is only now, in the 21st century, when the reality of unprecedented anthropogenic damage to global processes and systems and its health implications is self-evident, that the health sector has fully made common cause with the environmentalist movement (e.g., see Butler et al., 2005; Butler & Harley, 2010) (We discuss this development later in this article under Ecological Public Health.

However, for reasons that are distinct from a mounting concern over anthropogenic threats to global environmental systems and processes, we argue that the closing decades of the 20th century and the early years of this century did see a rekindling of public health and societal interest in the local or proximal environment. This interest has continued into the 21st century. Developing interest in well-being as a concept, the belief that it is important and that it might be enhanced through the organized efforts of society, continues to engage the attention of academics and policymakers. Although well-being demonstrably impacts health and vice versa, well-being is about much more than health. Rather, it is a measure of what matters to people in every sphere of their lives. Despite its importance, well-being has proved a challenging target for policy. Some of its components are beyond the reach of policy. However, others, including aspects of the built and natural environment and people's connection to it, are amenable to manipulation. Accordingly, research has been especially concerned to identify the qualities of their environment that are important for different people's well-being, quality of life, and health at various life stages (Royal College of Physicians, 2016). Also, on a practical level, integrating the various well-being frameworks and indices that continue to emerge is an ongoing challenge. However, it is sufficient at this point simply to recognize that elevated concern for well-being and its connection to environment can only broaden and deepen concern for the environment in public health. It will continue to drive renewed interest in matters such as landscape, natural beauty and scenery; crime free, clean places; green, blue, and natural environments; and so on.

Reconnecting Health with Place

Five issues/developments merit particular mention for their role in reestablishing the local environment as a mainstream consideration in health in the developed world in the late 20th century. While recognizing that there is an interrelationship among some of the factors discussed, for simplicity, we discuss them separately here.

Air Pollution

In citing air pollution as a key factor in a late-20th-century resurgence of interest in the environment, we recognize its much longer history as a contributor to ill health (Evelyn, 1661; Lloyd, 1983). We acknowledge, too, that accounts of the modern public health era since its inception have been suffused with references to air pollution events, their health implications, and the political and professional campaigns that have sought to mitigate risk (Kessel, 2006). However, despite a compelling case for action, the need for urgent intervention was only fully accepted after a number of high-profile air pollution episodes in the 20th century. In 1930, a severe smog incident in Belgium's Meuse Valley resulted in the death of sixty people.

Prophetically, investigators were quick to highlight the potential for many more deaths, were such an incident to be repeated in a more highly populated area (Bell & Samet, 2005). In 1948, a further twenty people were to die and many more suffer injury after an industrial pollution incident in Donora, Pennsylvania (Hamil, 2008), but the tipping point came four years later, with the London Smog of 1952.

Between December 5 and December 9, a dense fog descended on London where it mixed with air, polluted by domestic and industrial emissions. The resulting thick smog was familiar to many urban dwellers, but in this case, a combination of cold weather and stagnant atmospheric conditions caused sulfur dioxide and smoke concentrations to reach and maintain extremely high levels for a sustained period. The smog had a paralyzing effect on the city's transport system, and many other aspects of daily life were severely disrupted. But the most dramatic effects were on health. Death rates were to reach three times the normal level for the time of year, and demand for hospital beds far exceeded supply (Baker & Nieuwenhuijsen, 2008). While the smog dissipated after a few days, deaths rates remained high for several months thereafter. Subsequent analysis has revealed that, rather than the 3,000–4,000 deaths linked to the episode in at the time, a figure of 10,000–12,000 deaths is more probable (Bell et al., 2004).

The London smog is historically important, obviously because of the distressing toll in morbidity and mortality and because it catalyzed long-overdue legislative intervention in the UK in the form of the Clean Air Act of 1956 and the U.S. Clean Air Act 1963. Critically, however, it reminded the public and politicians of the reality that, given the right conditions, population-level environmental exposures were still entirely capable of producing significant morbidity and mortality.

In combination with other factors, the clean air legislation that emerged in the wake of the smog reduced domestic and industrial fossil fuel emissions, and helped to secure significant reductions in background concentrations of smoke and sulfur dioxide (Royal College of Physicians, 2016). However, by the late 1980s, a new, more insidious, urban air pollution threat had begun to emerge. This pollution had its origins not in fixed-point emissions, but in the rapidly increasing numbers of motor vehicles and other fossil fuel-driven forms of transport in towns and cities. The pollutants of concern here, which lacked the visibility of the earlier sulfurous smogs, were fine particles, oxides of nitrogen, and ozone. So-called time-series analyses, using data on the temporal variation in environmental exposure and in health, aggregated over the same time period, were now applied to explore the issue of urban air pollution and health (e.g., see Pope et al., 1995; Dockery & Pope, 1996; Kessel, 2006). The studies revealed the cardiopulmonary effects of long-term exposure to much lower levels of ambient air pollution and, later, following further investigation, the absence of a threshold level for causing health effects. Recent outputs of 'life-course' epidemiology have also shown that air pollution affects health, not only through the exacerbation of symptoms in the elderly, but through various processes that have impacts from the womb, through childhood to adolescence, early adulthood, and on into middle and older age (Royal College of Physicians, 2016). Also, appreciation that air pollutants can be resident in the air for days or even weeks makes air pollution not simply a local problem, but one that demands

source control at city, regional, and international levels. In the UK, for example, the equivalent of around 40,000 deaths every year can be attributed to fine particulates and NO_2 exposure from outdoor air (Royal College of Physicians, 2016).

Air pollution is probably the most thoroughly investigated of all environmental threats to health and well-being. Revelations about the true extent of its impact on health keep the issue in the headlines and emphasize the centrality of the physical environment within the public health project. Despite being a focus for academic interest and research fundings, the problem of urban air pollution is a very long way from resolution and is one factor that demands a fundamental reappraisal of how, as a species, we live, consume, and travel. (We discuss a wider, global dimension of the air pollution challenge later in this article.)

Everything Matters: The Environment as an Ingredient in Social Complexity

Another important and often overlooked reason for the late-20th-century rekindling of interest in the environment and human health can be traced to developments within the wider discipline of public health. Ironically, the thinking behind what, by the 1990s, was being termed the "new public health" had its origins in much older ideas that gave prominence to the social structures in which health is created and destroyed (Baum, 1998; Awefeso, 2004). If we accept that health, disease, and social patterning in these matters are products of a complex interaction of influences at the level of society with the characteristics of individuals, then such complexity ought to be reflected in the policies and partnerships formed to address them. A growing number of analyses, beginning in the 1970s, would turn a spotlight on this complexity and fundamentally challenge the dominance of the biomedical/health care model and its capacity to solve the problems that beset public. These problems included the intractable burden of noncommunicable disease; growing levels of obesity; diminished psychological well-being; and, not least, stubborn and widening inequalities in the health and well-being of different social groups. Concern also mounted over containing rising, and potentially bankrupting, health care costs.

"A New Perspective on the Health of Canadians," more commonly referred to as the Lalonde Report, after Canada's then health minister Marc Lalonde, was published in 1974 (Lalonde, 1974). Despite its national focus, the report assumed wider relevance because of its analysis of one of public health's greatest generic challenges, that of navigating among the many complex and interacting determinants of health to identify effective policies and actions. Implicitly offering a socioecological perspective, the Lalonde Report spoke of a "Health Field," which included all matters that affect health and comprised four core elements: human biology, environment, lifestyle, and health care organization. Any issue, it was proposed, could be traced to one, or a combination, of these elements, allowing the creation of a "map of the health territory" for any problem (Lalonde, 1974). In this way, the contribution and interaction of the elements could be assessed. The analysis affirmed the health relevance of a complex environment comprising interacting physical and social dimensions in interaction with the human body. Lalonde's message was logical and important, yet more than just an echo of an earlier, more inclusive, understanding of the determinants of health and disease. It recast these largely abandoned perspectives for a more scientific and sophisticated era. The proposal that thousands of "pieces"

relevant to health and its determinants could be organized in "an orderly pattern" was alluring and progressive, as was the notion that the exercise alone would allow all contributors to more fully appreciate their roles and influence (Morris et al., 2006). In the ensuing years, Lalonde's proposals for understanding and addressing complexity in the determinants of health have been refined and given greater policy relevance by others. In part, this has been through the development of conceptual models of the socioecological determinants of health. These models have been promoted as tools for presenting evidence that can make their implications more apparent (Evans & Stoddart, 1990; Dahlgren & Whitehead, 1991). In most of these representations, the local environment is accepted as a key driver of health and well-being (Morris et al., 2006).

Despite its inherent logic, the socioecological perspectives that emerged in the closing decades of the 20th century created scientific and policy challenges for all constituencies concerned with public health. There were obvious generic challenges, for example, around which of the models (each, necessarily, a gross simplification of a complex reality) might point to solutions (Morris et al., 2006; Evans & Stoddart, 1990; Reis et al., 2015); around the nature of evidence and its interpretation (Petticrew et al., 2004; Tannahill, 2008); and how, in practice, to traverse professional and policy silos to produce the interdisciplinary approaches that are inevitably required. In this connection, the task of motivating, supporting, and delivering effective intersectoral working, an abiding challenge for public health policy and practice, assumed a much higher profile in the late 20th century with the emergence of the socioecological model of health.

We emphasize that the continuing failure to adequately confront this challenge has the gravest implications for global public health. As Prüss-Üstün et al. recently observed, "Tackling environmental risks requires intersectoral collaboration. After nearly 50 years of actively promoting this concept, whether referred to as intersectoral action, breaking down silos or the nexus approach, it remains elusive as ever. The statement 'intersectoral collaboration: loved by all, funded by no-one' points to obstacles, mainly vested interests, that have burdened this approach ever since it was included as part of the WHO/UNICEF Alma Ata Declaration on Primary Health Care in 1978. Environmental health, quintessentially intersectoral, has suffered most from this lack of progress" (Prüss-Üstün et al., 2016a).

With specific reference to the role of the local environment, the recognition of socioecological complexity as the determinant of health meant that strict adherence to narrow hazard-focused and compartmentalized approaches became intellectually unsustainable. Yet, acceptance of the dynamic interaction of environment with other determinants of health demands a richer understanding of the environmental contribution than can be provided by toxicology or microbiology in isolation.

The Role of the Environment in Health Inequalities

The fact that the poorest, most degraded urban neighborhoods were those most blighted by disease and reduced life expectancy was clear even to the public health pioneers of the 19th century. Indeed, throughout much of the modern public health era, an acceptance of the

importance of the environment for health and well-being has been accompanied by a recognition of the interplay between sociodemographic, economic, and physical factors in creating and sustaining health inequalities.

The term "health inequalities" refers to general differences in health, however caused. Where the differences in health are unfair, unjust, and avoidable, as they often are when linked to social variables, they should more properly be termed "health inequities." However, in the extensive literature on the topic and in common usage, inequities are termed inequalities, and we adopt this convention here. Despite their importance, the emphasis on tackling health inequalities has varied considerably over time and according to place.

In 2008, the final report of the Commission on the Social Determinants of Health (CSDH, 2008) elevated the global profile of health inequalities and emphasized the interplay of many societal-level factors in their creation in the 21st century. The significant achievements in public health across the world over nearly two centuries have not been shared equally between countries or by all social groups within countries. An important component has been the health-relevant differences in the physical context for people's lives—the quality of the physical environment. Sometimes expressed in terms of environmental justice *<https://www.epa.gov/environmentaljustice>*, or elsewhere as environmental health inequalities, attention to this area is key to tackling health inequalities across the world (CSDH, 2008; Morris & Braubach, 2012).

Estimates of the impact of environmental quality on health and well-being vary widely, depending on the definition of environment used. However, that impact is undeniable. Over a billion people in developing countries, for example, have inadequate access to water, and 2.6 billion lack basic sanitation *<http://www.who.int/water_sanitation_health/>*. The World Health Organization estimates that environmental factors were responsible for 12.6 million deaths worldwide in 2012, 23 percent of all deaths, and 22 percent of the total burden of disease. Addressing environmental risks could prevent 26 percent of all deaths of children under the age of 5 (Prüss-Üstün et al., 2016b).

In addition, there is clear evidence that a "good" environment empowers health through access to environmental assets such as green spaces, access to a healthy diet, and safe environments in which to walk, cycle, play, and socialize. However, as these data suggest, there is also a fundamental equity dimension to the distribution of both the cause and distribution of environmental stressors, the susceptibility to exposure, and the adverse effects of those exposures. Deprived communities almost invariably live in poorer quality environments, with higher levels of indoor and outdoor air pollution, contaminated land, polluting industrial processes, overcrowded and poor quality housing, and lower levels of environmental assets (Prüss-Üstün et al., 2016a; 2016b; Royal College of Physicians, 2016; The Marmot Review Team, 2010). Populations in developed countries, including the former communist states of eastern Europe living in areas of high air pollution, are disproportionately deprived, for example (Kriger et al, 2014; Bell & Ebisu, 2012; Branis & Linhartova, 2012; Goodman et al., 2011). Poor indoor air quality is associated with unfit or inadequate housing standards, conditions that overwhelmingly affect the deprived (The Marmot Review Team, 2010). There is evidence that deprived communities are not only more exposed to environmental hazards but are also more *susceptible* to

the effects of those exposures (Goodman et al., 2011; Carder et al., 2008; Richardson et al., 2011; 2013; Vinikoor-Imler et al., 2012). There are also concerns that stress, at both the individual and community level, can weaken the body's defenses against external insult and influence the internal dose of toxicants (Gee & Payne-Sturges, 2004).

This effect is also seen in social and physical environments. An adequate and nutritious diet is essential to a healthy, productive, and fulfilling life, and it is a fundamental right predicated by a range of factors including personal knowledge, choice, convenience, availability, quality, cost, and social norms. The evidence is clear that deprivation compounds all these factors, with poorer people buying more unhealthy foods with fewer healthy components while being exposed to circumstances that make such "choices" inevitable (Rudge et al., 2013). The proportion of adults considered overweight or obese in 2008 in the 19 EU member states for which data were available ranged between 37 and 57 percent for women and between 51 and 69 percent for men (EUROSTAT *<http://ec.europa.eu/eurostat/statistics-explained/index.php/Overweight_and_obesity_-_BMI_statistics>*). English children from deprived areas are almost twice as likely to be obese than those in affluent areas, and adult obesity is also associated with deprivation, particularly in women (Public Health England, 2016; National Obesity Observatory, 2013).

The poor in developed countries are adept at sourcing cheap calories and are exposed to a large numbers of local outlets selling cheap, calorie-dense takeaway food (Saunders et al., 2015). These meals are often super-sized and contain high levels of fats, sugar, and salt. At the same time, many of these areas provide limited access to healthy food options, creating a highly compromised public health environment (Saunders et al., 2015).

In addition, environmental stressors seem to have a cumulative impact, exacerbating this inequality. It is evident that poorer people have multiple health, social, and environmental stressors. It is entirely plausible that these stressors modify the effect of exposure to pollutants, as is reflected in the increased vulnerability of obese people to the effects of exposure to air pollutants, including increased risk of diseases such as cardiovascular events and respiratory symptoms (WHO, 2013; Jung et al., 2014). Long-term exposure to airborne pollutants has also been reported to increase the risk of obesity, and being overweight or obese is associated with an increased susceptibility to indoor air pollution in urban children with asthma (Lu et al., 2013).

The responsibility for, and relative benefits and costs of, environmental contamination are also important components of inequality. Environmental contamination may be tolerated by communities living in the vicinity of dirty industrial processes if they perceive a benefit in terms of local employment, although that trade-off has largely broken down in developed countries as those industries have declined in the 20th and 21st centuries. On a wider scale, the environmental consequences of contemporary affluent nations' fuel economies are borne by those populations least able to bear them and with little or no responsibility for their causation (Patz et al., 2005). UNICEF has projected that 75–250 million Africans will be exposed to increased water stress due to climate change by 2020 (UNICEF, 2008), a phenomenon overwhelmingly caused by the First World. This is a gross injustice. These are also the same people with limited powers to prevent the dumping of rich countries' waste in their communities. One appalling example is that of the "disposal" of 500 tons of toxic waste in and around Abidjan, the capital of Cote D'Ivoire, in 2006.

This poisonous cocktail of waste oil and contaminants was the result of the trading in, and processing of, hydrocarbon fuels by multinational commodity and shipping companies, criminal levels of cost cutting, and local political corruption, which led to 17 deaths and over 30,000 injuries in one of the poorest communities in the world (Bohand et al., 2007) There are many other examples, including the export, often illegally, of hundreds of thousands of tons of e-waste from Western countries to Africa, China, and Asia for recycling or disposal—transferring the costs and dangerous consequences of exposure to workers, including children, and local communities in these countries that do not have the technical or regulatory systems to deal safely with these toxic materials (ILO, 2012). Inuit mothers in northern Canada have elevated levels of chemicals such as PCBs—generated many hundreds, if not thousands, of miles away—in their breast milk (Johansen, 2002).

The redistribution of the environmental injustices historically endured by the poor also perversely appears to be affecting more affluent communities in the West. The huge expansion of "fracking" in North America, for example, may be leading to an export of risks from traditional "national sacrifice zones" to areas with no previous experience of such industry, creating "profound social, cultural, and economic shocks for middle class communities losing control over their environments" (Lave & Lutz, 2014). Despite their relative affluence, this would nonetheless be an injustice given the constraints on local democratic input *<http://www.theguardian.com/environment/2015/nov/27/lancashire-fracking-shale-gas-drilling-cuadrilla-greg-clark>* and highly questionable direct economic benefits to those communities (Kinnaman, 2011; Lave & Lutz, 2014; Sovacool, 2014).

During a period when environmental catalysts for distress migrations are becoming more frequent (Thomas-Hope, 2011), there is a moral as well as a professional duty for the Environmental Health community to tackle these inequalities, which otherwise are likely to both widen and deepen.

The Health-Promoting Environment: Green, Blue, and Natural Spaces

While human communities have long valued access to natural resources such as green spaces, the industrialization of the 19th and early 20th centuries saw millions of people deprived of this access. This era did witness some far-sighted philanthropic gifting of areas of open recreational space for the working classes driven by a moral rather than evidence-based imperative. Though welcome, the distribution of, and access to, such resources was limited, inconsistent, unplanned, and vulnerable to the insecurities of voluntary funding. Subsequent local municipal development of parks and other open spaces increased access, and a greater understanding of the benefits of such access blossomed during the late 20th century as research demonstrated and quantified the public health dividends. Access to good-quality green spaces not only makes the places in which we live, work, and play more attractive, but also has a demonstrable effect on improving health and well-being. Green space is linked to lower levels of several diseases and conditions, including lower rates of mortality (Villeneuve et al., 2012), increased longevity in older people (Faculty of Public Health, 2011), improved mental health (Faculty of Public Health, 2011), better outcomes in disease treatment, and reduced medication (Faculty of Public Health, 2011), and it also helps

reduce health inequalities (Mitchell & Popham, 2008; CABE, 2010). Plausible mechanisms for these benefits include the provision of a venue for physical activity, promotion of social contact, and the direct impacts of green spaces <http://www.hutton.ac.uk/sites/default/files/files/projects/GreenHealth-Final-Report.pdf> on psychological and physical health. Natural spaces also promote greater community cohesion and reduce social isolation, providing a platform for community activities, social interaction, physical activity, and recreation (Public Health England, 2014). Research from the United States has identified powerful associations between green space and major reductions in aggressive behavior, domestic abuse, and other crime in deprived urban areas (Kuo et al., 2001a, 2001b).

And yet, there remain great inequalities in the distribution, use, and quality of this empowering resource. People living in the most deprived areas are less likely to live in the greenest areas and therefore have less opportunity to gain the health benefits of green space compared with people living in the least deprived areas (Public Health England, 2014). Children living in poor areas, for example, are nine times less likely than those living in affluent areas to have access to green space and places to play (National Children's Bureau, 2013). It is entirely plausible that that this contributes to the sobering reality that children from deprived communities are up to three times as likely to be obese than those children growing up in affluent areas (National Children's Bureau, 2013).

Accessibility, however, is not the same as availability or utility, nor is it simply a function of proximity. It is strongly impacted by the cost of access, whether it is *actually* physically available, opening times, and the ease of being able to get to it, for example, walking and good public transport. Deprived communities in particular appreciate the value of such spaces, but they tend to underuse them due to concerns about the safety and quality of the spaces (CABE, 2010). Experience has shown that quality of the green space is just as important, if not more so, than its size. Post-World War II urban developments in many countries have included large grassy areas, and substantially derelict former industrial sites have often been entirely grassed over. The sterility and sheer size of these sites, the cost of maintenance, and the lack of facilities have often led to misuse and subsequent abandonment by both communities and local municipalities.

The provision, maintenance, and promotion of *good-quality* and *safe*, publicly available spaces is not a subsidy; it is an investment delivering economic, health, and regeneration benefits <http://www.fph.org.uk/uploads/bs_great_outdoors.pdf>. Research on Philadelphia estimated that maintaining city parks could achieve huge annual savings in health care costs, stormwater management, air pollution mitigation, and social cohesion benefits (The Trust for Public Land, 2008). The improved social cohesion associated with natural spaces also has economic benefits. A 2009 Scottish study estimated a £7.36 dividend for every £1 invested in conservation volunteering projects (Greenspace Scotland, 2009). It is clear from the evidence that increasing the use of good-quality green space for all social groups is likely to improve health outcomes and reduce health inequalities.

The Reemergence of the Infectious Threat

Among the developments that, for Western societies, consigned environment to the periphery of medical and public health interest in the post–World War II era, we highlighted the epidemiological transition in the mid-20th century. Indeed, for a period in the 1960s and 1970s it seemed that infectious disease in the developed world had effectively been conquered (Fauci, 2001). It was even tempting to suggest that the developing world might eventually follow suit. Yet, within a relatively few years, the twin threats of emerging infectious disease and antibiotic resistance would shatter the earlier confidence and reestablish infection as a live threat to individuals, communities, and populations and one that presented, increasingly, on a global scale.

The term "emerging infectious disease" (EID) denotes an infectious disease, newly recognized as occurring in humans; one that has been previously recognized but is appearing for the first time in a new population or a different geographic area; one that now affects many more people; and/or one that is displaying new attributes, for example, in terms of its resistance or virulence (*adapted from The US Government & Global Emerging Infectious Disease Preparedness and Response <http://kff.org/global-health-policy/fact-sheet/the-u-s-government-global-emerging-infectious-disease-preparedness-and-response/>*). Although the return of infection was not necessarily anticipated by a confident global community, many predisposing factors were clearly present. Changes in land use, growth and movement of populations, contacts between people and animals, international trade and travel, and, often, an absence of a public health infrastructure all played a part. Where such influences coincided, as in sub-Saharan Africa or parts of Asia, hotspots were created that were conducive to the emergence of infectious disease. Several hundred new infectious diseases appeared across the globe in the period between 1940 and 2004, with the greatest number emerging in the 1980s (Jones et al., 2008). The 1980s was also the decade that notoriously witnessed the late 20th century's most sentinel infection event, the first reported cases of Human Immunodeficiency Virus/Acquired Immune Deficiency Syndrome (HIV/AIDS). By 2014, AIDS alone would result in approximately 78 million cases worldwide *<http://www.who.int/gho/hiv/en>*. Although HIV/AIDS engendered particular alarm, the list of late-20th-century EIDs of medical and public health significance is extensive. Variant Creutzfeldt-Jacob disease (vCJD), H5N1 Influenza and Ebola Virus Disease, the Northern Hemisphere debut of the mosquito-borne zoonotic viral disease, and West Nile Fever in New York City in 1999 were all public health and media events. The process continues unabated in the 21st century with the arrival of Severe Acute Respiratory Syndrome (SARS), H1N1 Influenza ("swine flu"), H7N9 Influenza ("bird flu"), and, despite having surfaced some 40 years earlier, Ebola revealed its potential as a global threat with the West African Outbreak of 2014–2015. More recently still, the distressing incidence of microcephaly in South America putatively linked to the Zika virus simply emphasizes the abiding challenge posed by infection for public health and global economics (European Centre for Disease Control, 2016).

Antibiotic resistance has been a developing public health horror story over, perhaps, 50 years. The therapeutic use of antimicrobials and especially antibiotics was a key factor in slashing the burden of illness from infection in Western countries in the latter half of the 20th century. Yet all classes of organisms—fungi, protozoa, viruses, and bacteria—can develop antimicrobial

resistance. Through their genetic processes, bacteria have derived multiple resistance mechanisms to antibiotics used in medicine and agriculture. The threat renders humankind vulnerable to a host of infections, notably in hospital settings where treatment options for many infections are now severely limited. As a consequence, even at the dawn of the 21st century, drug resistance was already being perceived as an increasing threat to global public health, involving all major microbial pathogens and antimicrobial drugs (Levy & Marshall, 2004)

The challenges of EIDs and antimicrobial resistance are, unquestionably, game changers for medicine and public health in the 21st century. Importantly, they are among the factors that have revealed the true limitations of the biomedical model of health and disease in the 20th century and rekindled interest in the socioeconomic and environmental determinants of disease. HIV/AIDS merits special mention in this regard. Although it is believed to have origins in nonhuman primates in West Africa, it is not an environmental disease in the sense that there is a specific environmental reservoir. Medical sciences and epidemiology have shown transmission of the virus via unprotected sex, contaminated blood transfusions, hypodermic needles, and mother to child transmission during pregnancy, delivery, and breastfeeding. HIV (the infection) and AIDS (the disease) have shown the capacity to extend beyond the initially identified high-risk groups, potentially placing whole populations at risk. In some areas of sub-Saharan Africa where the infection is widespread, it impacts negatively on almost every aspect of society and the economy.

Over 30 years after it first emerged and despite concerted efforts, there is still no cure. In addition to banishing complacency, the infection and the disease call for a much wider perspective than that which took root in the postwar era of scientific positivism and medical paternalism. The failure to manage the threat stems in part from an incapacity to understand where to intervene to change behaviors and to see the disease in its social and environmental context.

Ecological Public Health

Earlier in this article, we identified five issues that helped reestablish awareness of the environment as a key component in the production of human health and well-being in the late 20th century. These issues, and our understanding of them, continue to evolve to challenge the public health community and wider society in the 21st century. In the most general terms, progress seems most likely where issues and challenges are framed with reference to a much wider range of pertinent factors by developing new approaches to evidence and its synthesis; by aligning institutional, physical, and educational infrastructures to the task; and by building governance structures in which all players are accountable and yet are encouraged to unite in common cause.

However, society must now embrace an additional and potentially more devastating threat to health and well-being. Human activity, including economic activity, is now directly and indirectly driving changes to the ecosystems and planetary processes on which we rely for health, well-being, and existence. For too long, human beings have lived, moved, consumed, and pursued health and well-being as if humankind is distinct and separate from nature rather than integral to it. The consequences of this disconnect for the natural world were graphically expressed by

Rachel Carson in the 1960s and many others in the ensuing years (e.g., see Rockström et al., 2009; Steffen et al., 2015). However, developments in science and technology now reveal the true extent of the crisis, its accelerating nature, and its consequences both now and in the medium and longer term.

The term "ecological public health" is increasingly being used to encapsulate a need to build health and well-being, henceforth, on ecological principles. Rayner and Lang (2012) observe that, despite appearing difficult and complex, Ecological public health "is now the 21st century's unavoidable task." Thus, the already complex challenge of navigating human social complexity to deliver health, well-being, and greater equity, which has defined public health in Western society for several decades, is made more challenging still. The relationship of the environment and human health and well-being must be understood and addressed on vastly extended temporal and spatial scales.

The notion that the planet is a finite resource on which human activity can place intolerable pressure and that the consequences of doing so are potentially catastrophic has been around for some time (e.g., see Carson, 1962; Meadows et al., 1972). A contemporary evolution of this thinking is expressed by Rockstrom and colleagues. Their sentinel paper, first published in 2009 (Rockström et al., 2009) and updated in 2015 (Steffen et al., 2015), lists the large earth system processes that are urgently in need of stewardship if humanity is to remain safe into the future. Where applicable, it proposes thresholds beyond which nonlinear, abrupt, and potentially catastrophic changes in these systems might be expected. This thinking is used as a basis for defining a "safe operating space for humanity." The authors propose nine "planetary boundaries." Three of these—climate change, ocean acidification, and stratospheric ozone depletion—are major planetary systems where evidence exists of large-scale thresholds in the history of the planet history of the planet. Also included are systems of a rather different sort. These are the slow variables that buffer and regulate planetary resilience. These slow variables comprise interference with the nitrogen and phosphorus cycles; land-use change; rate of biodiversity loss; and freshwater use. Two parameters, air pollution and chemical pollution, are especially difficult to quantify, meaning that thresholds cannot yet be defined. It is emphasized that, while for understandable reasons, the nine systems are often discussed independently, they are interrelated in ways meaning that changes in one system have profound implications for the others. Rockstrom and colleagues observe that in the preindustrial era, all nine parameters were within the safe operating boundaries, and yet by the 1950s, change was underway, most evidently in the nitrogen cycle. By 2009, according to their analysis, three planetary boundaries had been transgressed: climate change; rate of biodiversity loss; and the nitrogen cycle.

An implicit challenge in limiting global ecosystem damage and its multiple implications is how to achieve recognition among the public and policymakers that the choices they make either directly or indirectly cause ecosystem damage and related environmental change (Morris et al., 2015). Climate change is simply the most striking example, but comparable challenges over communication exist in relation to other planetary process and systems. The fundamental rethink of society, the economy, and the environment, which is necessary if health and well-being are to be built on ecological principles, will happen only if the true implications for health and well-being of a "business as usual" approach are understood, communicated, and

challenged. For any population, the environmental changes that may ultimately have profound implications may take place in countries and regions well beyond their borders or may not occur for some time, conferring a temporal and/or spatial remoteness that diminishes the sense of urgency. Appreciating the importance of these "distal" pathways of ecosystem damage to human health and well-being demands a greater understanding of ecosystem services (the benefits human beings get from the natural environment) and of why they matter. It also demands a much fuller appreciation of the global connectivity of social, economic, and ecological systems (Morris et al., 2015; Adger et al., 2009).

When initiating our discussion of the role of environment in health, we observed that the modern public health era was built on an environmental conceptualization of public health. It is now inconceivable that health, well-being, health care, and equity in any of these domains can be delivered without rediscovering an environmental conceptualization of public health for the 21st century.

For Western society, ecological public health is likely to require a rethink of society, the economy, and our stewardship of the natural environment (Rayner & Lang, 2012). At the very least, it will demand pursuit, through policy and action, of outcomes that recognize a 'quadruple bottom line' measured in health and well-being, environmental quality, equity, and sustainability. The extent to which we embrace ecological principles will be evidenced in policies that address how we live (for example, the energy efficiency of our homes), how we move (particularly our reluctance to substitute travel in fossil-fueled cars with more active forms of travel); how we consume (notably how we source and produce food) and, of course how we obtain and conserve energy.

Taking Stock

Despite being necessarily selective, this article has sought to illustrate how perspectives on the role of the environment in human health and well-being have evolved over the course of the modern public health era. Perspectives can be seen to shift owing to changes in the nature of environmental hazards and risks that are themselves products of the evolution of how societies live, move around, consume, source their energy, and so on. Our understanding of the health relevance of the built and natural environments is also shaped by advances in scientific understanding and technology and a much wider economic, social, cultural, and even political context. In structuring our account, we have adopted a loose framework based on the "epidemiological eras," elegantly articulated by two of the 20th century's leading epidemiologists (Susser & Susser, 1996). These eras are differentiated according to the dominant paradigm of the time concerning the causes of disease, each underpinned by analytical approaches to understand and prioritize risk.

The importance accorded to the environment as a mainstream public health issue arguably reached its lowest point in the decades following World War II when the tendency to regard health and disease as characteristics of individuals, rather than communities or populations, gained prominence. This approach diverted attention from social and environmental factors, divorcing health from place. Notions that humans are self-contained and impervious to context have now

been largely swept away, not least because denial of a socioecological perspective hugely undermined attempts to address the most serious contemporary health challenges. Also instrumental in challenging the notion of the self-contained body has been an environmentalist movement with a particular interest in pesticide and other chemical contamination of the biosphere. The toxic effects of chemical contamination reinforce the reality of a body that is permeable and invariably in a state of intimate exchange with its surroundings. As Nash (2006) has observed, "the singular and self-contained body of the early 20th century came, by the end of that century to seem distressingly porous and vulnerable to the modern landscape" (p. 13). We would simply add that humans exhibit comparable porosity and vulnerability to the social and economic context in which they exist.

We recognize that our account contains only limited reference to the regulatory context that has been so central to controlling the environment for public health. We consider it appropriate to sound a warning in this regard. The processes through which environment is monitored and regulated to protect human health and well-being are sometimes taken for granted. Yet, since the 1980s, pressures have mounted in most Western nations to 'deregulate' markets to maximize profit. These pressures have led to environmental and public health regulation being increasingly perceived by governments and markets as "red tape" and a barrier to economic enterprise. Pressure to loosen or even abandon aspects of environmental regulation has weakened formal controls, leaving society vulnerable to corporate excess and irresponsibility, with often serious impacts on public health (Oldenkamp et al., 2016). This is not to argue that regulation should be static. Rather, it should adapt to changing technological, social, and economic circumstances and should be appropriately funded whether it relates to the quality of the air we breathe, the water we drink, the buildings we live, learn, and work in, or the nutritional aspects of the food we eat. Neither do we deny the potential to exploit citizen science and the power of new technology *<https://www.epa.gov/sciencematters/epas-next-generation-air-measuring-research>* to supplement conventional regulation (e.g., enabling vulnerable individuals to avoid hazardous exposures and the opportunities for personal pollution monitoring to improve research).

Mainly anthropogenic damage to planetary resources and ecosystems demands that, wherever we are in the world, public health agencies must understand not just the proximal threats to health and well-being that have been the targets of public health intervention throughout the modern public health era. They must also understand and move to prevent, counteract, and contain more distal threats to health and well-being. The distal threats derive from changes to environments that appear remote in space or time or involve a complex interaction of social, environmental, and economic influences. These are no longer abstract considerations. The unprecedented global connectivity of economic and social systems and the growing understanding of ecosystem interdependencies demand that the implications of human activity for health and well-being be recognized, understood, and addressed on a vastly extended temporal and spatial scale.

Only by build health and well-being on ecological principles (Ecological Public Health) will society effectively address the more distal threats to health and well-being from global ecosystem damage; the socioecological complexity of the proximal environment and the interconnections between these.

Conclusions

In this necessarily brief and artificially linear account, our intention has been to reinforce the enduring importance of the environment for health and well-being. Along the way, we have identified three factors that have marginalized the environment as a component of health and disease. We suggest that they continue to represent clear and present threats, undermining public health and, in the case of the latter, an existential threat to humankind.

The Threat from Medical Reductionism

This tendency to think of disease almost exclusively in terms of pathogenic agents and organic dysfunction marginalizes any influence outside the crucible of the laboratory. This trend was most evident in the decades following World War II but remains an ever-present threat.

The Separation of Health from Place

Closely related to medical reductionism is the tendency to downplay the importance of local context for life. The idea that if local environment matters, it does not matter much and, that when it comes to health and disease, the real action is not out there in the neighborhood and among the community but "over here" in the laboratory and at the level of the individual. Such perspectives are divisive. They create artificial barriers between many academic disciplines, including some medical specialties, and those working to manage and improve the local social and environmental context within which "permeable" human beings live out their lives.

The Denial of Ecology

Science now permits humans to understand the true extent to which their activities are plundering natural resources and harming the planetary systems and processes on which they depend. The pace of change is such that health, well-being, heath care, or anything approaching equity in these things will not be sustained in the medium to longer term without radically rethinking society, the environment, and the economy. The global connectivity of social, economic, and environmental systems means, ultimately, that no one is insulated from the threat whether by distance or socioeconomic circumstance. Ecological public health, the pursuit of health and well-being on ecological principles, has been described as the 21st century's unavoidable task. It demands recognition of the dynamic interconnections between people and their environment. Manifestly, we depend on the environment we inhabit, and we powerfully affect it. Among the clearest impediments to delivering ecological public health and preserving a viable environment for future generations are the belief that we can manipulate and conquer the natural environment without consequence, and the irresponsible capitalist imperative that subverts regulatory standards and damages and exploits the environment for profit. Both are revealed as transparent absurdities by an ecological understanding and analysis.

References

Adger, W. N., Eakin, H., & Winkels, A. (2009). Nested and teleconnected vulnerabilities to environmental change <https://dx.doi.org/10.1890/070148>. *Frontiers in Ecology and the Environment*, *7*(3), 150–157.

Awefeso, N. (2004). What's new about the new public health? *American Journal of Public Health*, *94*, 705–709.

Baker, D., & Nieuwenhuijsen, M. J. (Eds.). (2008). *Environmental epidemiology: Study methods and application*. New York: Oxford University Press.

Baum, F. (1998). *The new public health: An Australian perspective*. Oxford: Oxford University Press.

Baxby, D. (2004). Jenner, Edward (1749–1823). In *Oxford Dictionary of National Biography*. Oxford: Oxford University Press. Retrieved from http://www.oxforddnb.com/view/article/14749 <http://www.oxforddnb.com/view/article/14749>.

Bell, M. L., & Davis D. L. (2001). Reassessment of the lethal London fog of 1952: Novel indicators of acute and chronic consequences of acute exposure to air pollution. *Environmental Health Perspectives*, *109* (Suppl. 3), 389–394.

Bell, M. L., Davis, D. L., & Fletcher, T. (2004). A retrospective assessment of mortality from the London smog episode of 1952: The role of influenza and pollution. *Environmental Health Perspectives*, *112*, 6–8.

Bell, M. L., & Ebisu, K. (2012). Environmental inequality in exposures to airborne particulate matter components in the United States. *Environmental Health Perspectives*, *120*, 1699–1704.

Bell, M. L., & Samet, M. J. (2005). Air pollution in environmental health. In H. Frumkin (Ed.), *From Global to Local* (pp. 387–415). San Francisco: Jossey-Bass.

Bohand, X., Monpeurt, C., Bohand, S., et al. (2007). Toxic waste and health effects in Abidjan City, Ivory Coast. *Medecine Tropicale*, *67*, 620–624.

Bookchin, M. (1990). The *philosophy of social ecology: Essays on dialectical naturalism*. Montreal: Black Rose Books.

Branis, M., & Linhartova, M. (2012). Association between unemployment, income, education level, population size and air pollution in Czech cities: evidence for environmental inequality? A pilot national scale analysis. *Health and Place*, *18*, 1110–1114.

Brock, T. D. (1999). *Robert Koch: A life in medicine and bacteriology*. Washington, DC: ASM Press.

Brownson, R. C, Fielding, J. E., & Maylahn, C. M. (2009). Evidence-based public health: A fundamental concept for public health practice. *Annual Review of Public Health*, *30*, 175–201.

Butler, C. D., Corvalán, C. F., & Koren, H. S. (2005): Human health and well-being in global ecological scenarios <http://link.springer.com/article/10.1007/s10021-004-0076-0>. *Ecosystems*, *8*(2), 153–164.

Butler, C. D., & Harley, D. (2010) Primary, secondary and tertiary effects of eco-climatic change: The medical response <http://pmj.bmj.com/content/86/1014/230.full.pdf>. *Postgraduate Medical Journal*, *86*: 230–234.

CABE. (2010). *Community green: Using local spaces to tackle inequality and improve health*. London: CABE.

Carder, M., McNamee, R., Beverland, I., et al. (2008). Does deprivation index modify the acute effect of black smoke on cardiorespiratory mortality? *Occupational and Environmental Medicine*, *67*, 104–110.

Carson, R. (1962). *Silent spring*. Boston: Houghton Mifflin.

Chadwick, E. (1842). Report to her majesty's principal secretary of state for the Home Department from the Poor Law commissioners on an inquiry into the sanitary conditions of the labouring classes of Great Britain. London: HMSO.

Collard, P. (1976). *The development of microbiology*. Cambridge: Cambridge University Press.

Commission on Social Determinants of Health. (2008). Closing the gap in a generation: health equity through action on the social determinants of health. Final Report of the Commission on Social Determinants of Health. Retrieved from http://whqlibdoc.who.int/publications/2008/9789241563703_eng.pdf *<http://whqlibdoc.who.int/publications/2008/9789241563703_eng.pdf>*.

Dahlgren, G., & Whitehead, M. (1991). *Policies and strategies to promote social equity in health*. Institute of Futures Studies. Department for Education and Skills, Stockholm.

Dockery, D., & Pope, A. (1996). Epidemiology of acute health effects: Summary of time-series studies. In R. Wilson & J. D. Spengler (Eds.), *Particles in our air. Concentration and health effects* (pp. 123–147). Cambridge, MA: Harvard University Press.

EPA. *Environmental justice*. (2016). Retrieved from https://www.epa.gov/environmentaljustice *<https://www.epa.gov/environmentaljustice>*.

EPA. *Next generation air measuring research*. (2016). Retrieved from https://www.epa.gov/sciencematters/epas-next-generation-air-measuring-research *<https://www.epa.gov/sciencematters/epas-next-generation-air-measuring-research>*.

European Centre for Disease Control. (2016). *Zika outbreak in the Americas and the Pacific*. Retrieved from http://ecdc.europa.eu/en/healthtopics/zika_virus_infection/zika-outbreak/Pages/zika-outbreak.aspx *<http://ecdc.europa.eu/en/healthtopics/zika_virus_infection/zika-outbreak/Pages/zika-outbreak.aspx>*.

European Environment Agency. (2013). *Late lessons from early warnings: Science, precaution, innovation*. Copenhagen: EEA.

Eurostat. *Overweight and obesity BMI statistics*. Retrieved from http://ec.europa.eu/eurostat/statistics-explained/index.php/Overweight_and_obesity_-_BMI_statistics *<http://ec.europa.eu/eurostat/statistics-explained/index.php/Overweight_and_obesity_-_BMI_statistics>*.

Evans, R., & Stoddart, G. (1990). Producing health, consuming health care. *Social Science and Medicine*, *31*, 1347–1363.

Evelyn, J. (1661). *Fumifugium, or the inconvenience of aer or the smoake of London dissipated*. London: Dorset Press for the National Society of Clean Air.

Faculty of Public Health and Natural England. (2011). *Great outdoors: How our natural health service uses green space to improve wellbeing briefing statement*. London: FPH.

Fauci A. S. (2001). Infectious diseases: considerations for the 21st century. *Clinical Infectious Diseases*, *32*, 675–685.

Ferriman, A. (2007). BMJ readers choose the “sanitary revolution” as greatest medical advance since 1840. *British Medical Journal*, *334*, 111.

Foster, W. D. (1970). *A history of medical bacteriology and immunology*. London: Heinemann.

Frumkin, H. (Ed.). (2005). *Environmental health: From global to local*. San Francisco: Jossey-Bass.

Gee, G. C., & Payne-Sturges, D. C. (2004). Environmental health disparities: A framework integrating psychosocial and environmental concepts. *Environmental Health Perspectives*, *112*, 1645–1653.

Goodman, A., Wilkinson, P., Stafford, M., & Tonne, C. (2011). Characterising socio-economic inequalities in exposure to air pollution: a comparison of socio-economic markers and scales of measurement. *Health and Place*, *17*, 767–774.

Greenspace Scotland. (2009). Social return on investment (SROI) analysis of the Greenlink, A partnership project managed by the Central Scotland Forest Trust (CSFT). Retrieved from http://1068899683.n263075.test.prositehosting.co.uk/wp-content/uploads/2013/04/Greenlink-SROI-Final-report-5-October-2009.pdf *<http://1068899683.n263075.test.prositehosting.co.uk/wp-content/uploads/2013/04/Greenlink-SROI-Final-report-5-October-2009.pdf>*.

Haekel, E. (1866). *Generelle morphologie der organismen*. Berlin: Georg Reimer.

Hamil, S. D. (2008, November 1). Unveiling a museum, A Pennsylvania town remembers the smog that killed 20. *New York Times*. Retrieved from http://www.nytimes.com/2008/11/02/us/02smog.html?_r=0 *<http://www.nytimes.com/2008/11/02/us/02smog.html?_r=0>*.

International Labour Office. (2012). *The global impact of e-waste: Addressing the challenge*. Geneva: ILO.

James Hutton Institute. Greenhealth. Contribution of green and open space to public health and wellbeing. Retrieved from http://www.hutton.ac.uk/sites/default/files/files/projects/GreenHealth-Final-Report.pdf *<http://www.hutton.ac.uk/sites/default/files/files/projects/GreenHealth-Final-Report.pdf>*.

Johansen, B. E. (2002). The Inuit’s struggle with dioxins and other organic pollutants. *American Indian Quarterly*, *26*, 479–490.

Jones, K. E., Patel, G. N., Levy, M. A., et al. (2008). Global trends in emerging infectious diseases. *Nature*, *451*, 990–993.

Levy, S. B., & Marshall, B. (2004). Antimicrobial resistance worldwide: Cause. Challenges and responses. *Natural Medicine*, *12*(Suppl.), S122–S129).

Lloyd, G. E. R. (Ed.). (1983). *Hippocratic writings* (trans. J. Chadwick. & W. N. Mann). London: Penguin.

Jung, K. H., Perzanowski, M., Rundle, A., et al. (2014). Polycyclic aromatic hydrocarbon exposure, obesity and childhood asthma in an urban cohort. *Environmental Research*, *128*, 35–41.

Kessel, A. (2006). Air, the environment and public health. Cambridge: Cambridge University Press.

Kinnaman, T. C. (2011). The economic impact of shale gas extraction: A review of existing studies. *Ecological Economics*, *70*, 1243–1249.

Kokayeff, N. (2013). Dying to be discovered: Miasma vs germ theory. *ESSAI*, 10: Article 24. Retrieved from http://dc.cod.edu/cgi/viewcontent.cgi?article=1416&context=essai *<http://dc.cod.edu/cgi/viewcontent.cgi?article=1416&context=essai>*.

Kriger, N., Waterman, P. D., Gryparis, A., et al. (2014). Black carbon exposure more strongly associated with census tract poverty compared to household income among US black, white, and Latino working class adults in Boston, MA (2003–2010). *Environmental Pollution*, *190*, 36–42.

Kuo, F., & Sullivan, W. C. (2001a). Environment and crime in the inner city: Does vegetation reduce crime. *Environmental Behavior*, *33*, 343–367.

Kuo, F. E., & Sullivan, W. C. (2001b). Aggression and violence in the inner city: Effects of environment via mental fatigue. *Environmental Behavior*, *33*, 543–571.

Lalonde, M. (1974). A new perspective on the health of Canadians. Ministry of Supply and Services Canada. Retrieved from http://www.phac-aspc.gc.ca/ph-sp/pube-pubf/perintrod-eng.php *<http://www.phac-aspc.gc.ca/ph-sp/pube-pubf/perintrod-eng.php>*.

Lave, R., & Lutz, B. (2014). Hydraulic fracturing: A critical physical geography review. *Geography Compass*, *8*, 739–754.

Leviticus [14:33–45] quoted in Frumkin, 2005.

Lu, K. D., Breysse, P. N., Diette, G. B., et al. (2013). Being overweight increases susceptibility to indoor pollutants among urban children with asthma. *Journal of Allergy and Clinical Immunology*, *131*, 1017–1023.

Martuzzi, M. (2007). The precautionary principle: in action for public health. *Occupational and Environmental Medicine*, *64*, 569–570.

Meadows, D. H., Meadows, D. L., Randers, J., et al. (1972). *The limits to growth: A report for the Club of Rome's project on the predicament of mankind*. New York: Universe Books.

Mitchell, R., & Popham, F. (2008). Effect of exposure to natural environment on health inequalities: An observational population study. *The Lancet*; *372*, 1655–1660.

Morris, G. P., Beck, S. A., Hanlon, P, et al. (2006). Getting strategic about the environment and health. *Public Health*, *120*, 889–907.

Morris, G. P., & Braubach, M. (2012). Environmental health inequalities in Europe. Geneva: World Health Organization. Retrieved from http://whqlibdoc.who.int/publications/2008/9789241563703_eng.pdf *<http://whqlibdoc.who.int/publications/2008/9789241563703_eng.pdf>*.

Morris, G. P., Reis, S., Beck, S., Fleming, L. E., Adger, W. D., Benton, T. G., & Depledge, M. H. (2015). Climate change and health in the UK. Scoping and communicating the longer-term "distal" dimensions. In S. Kovats (Eds.), *Health Climate Change Impacts Summary Report Card, Living With Environmental Change*. Retrieved from http://www.nerc.ac.uk/research/partnerships/ride/lwec/report-cards/health-source10/ *<http://www.nerc.ac.uk/research/partnerships/ride/lwec/report-cards/health-source10/>*.

Nabel, E. G., & Braunwald, E. M. (2012). A tale of coronary heart disease and myocardial infarction. *New England Journal of Medicine*, *366*, 54–63.

Nash, L. (2006). *Inescapable ecologies: A history of environment, disease and knowledge*. Berkeley, CA: California University Press.

National Children's Bureau. (2013). *Greater expectations: Raising aspirations for our children*. London: NCB.

National Obesity Observatory. (2013). National Child Measurement Programme changes in children's body mass index between 2006/07 and 2011/12. Retrieved from http://www.noo.org.uk/uploads/doc/vid_17929_NCMP_Changes_children.pdf *<http://www.noo.org.uk/uploads/doc/vid_17929_NCMP_Changes_children.pdf>*.

Oldenkamp, R., van Zelm, R., & Huijbregts, A. J. (2016). Valuing the human health damage caused by the fraud of Volkswagen. *Environmental Pollution*, *212*, 121–127.

Patz, J. A., Campbell-Lendrum, D., Holloway, T., et al. (2005). Impact of regional climate change on human health. *Nature*, *438*, 310–317.

Perry, I. J. (1997). Risk factor epidemiology. *The Lancet*, *350*, 1256.

Petticrew, M., Whitehead, M., Macintyre, S., et al. (2004). Evidence for public health policy on inequalities: 1: The reality according to policymakers. *Journal of Epidemiology and Community Health*, *58*, 811–816.

Pope, C. A., Dockery, D. W., & Schwartz, J. (1995). Review of epidemiological evidence of health effects of particulate air pollution. *Inhalation Toxicology*, *47*, 1–18.

Prüss-Üstün, A., Wolf, J., Corvalan, C., Neville, T., Bos, R., & Neira, M. (2016a). Diseases due to unhealthy environments: An updated estimate of the global burden of disease attributable to environmental determinants of health *<https://dx.doi.org/10.1093/pubmed/fdw085>*. *Journal of Public Health*. Retrieved from http://jpubhealth.oxfordjournals.org/content/early/2016/09/12/pubmed.fdw085.full *<http://jpubhealth.oxfordjournals.org/content/early/2016/09/12/pubmed.fdw085.full>*.

Prüss-Üstün, A., et al. (2016b). *Preventing disease through healthy environments: A global assessment of the burden of disease from environmental risks*. Geneva: World Health Organization.

Public Health England. (2016). Health Inequalities. Retrieved from http://www.noo.org.uk/NOO_about_obesity/inequalities *<http://www.noo.org.uk/NOO_about_obesity/inequalities>*.

Public Health England and UCL Institute of Health Equity. (2014). *Local action on health inequalities: Improving access to green spaces*. London: PHE.

Rather, L. J. (1985). *Rudolf Virchow: Collected essays on public health and epidemiology*. Canton, MA: Science History Publications.

Rayner, G., & Lang, T. (2012). *Ecological public health: Reshaping the conditions for good health*. Oxford: Routledge.

Reis, S., Morris, G., Fleming, L. E., et al. (2015). "Integrating Health and Environmental Impact Analysis." *Public Health*, *129*, 1383–1389.

Richardson, E. A., Pearce, J., & Kingham, S. (2011). Is particulate air pollution associated with health and health inequalities in New Zealand? *Health and Place*, *17*, 1137–1143.

Richardson, E. A., Pearce, J., Tunstall, H., et al. (2013). Particulate air pollution and health inequalities: A Europe-wide ecological analysis. *International Journal of Health Geographics*, *12*, 34.

Rockström, J., Steffen, W., Noone, K., et al. (2009). Planetary boundaries: Exploring the Safe Operating Space for Humanity. *Ecology and Society 14*, 32.

Rosen, G. A. (1993). *History of public health* (Expanded ed.). Baltimore, MD: Johns Hopkins University Press. Originally published 1958.

Royal College of Physicians. (2016). *Every breath we take: The lifelong impact of air pollution*. Report of a working party. London: RCP.

Rudge, G., Suglani, N., Jenkinson, D., et al. (2013). Are fast food outlets concentrated in more deprived areas? A geo-statistical analysis of an urban area in central England. *Journal of Epidemiology and Community Health*, *67* (Suppl. 1), A14.

Saunders, P., Saunders, A., & Middleton, J. (2015). Living in a 'fat swamp': exposure to multiple sources of accessible, cheap, energy-dense fast foods in a deprived community. *British Journal of Nutrition*, *113*, 1828–1834.

Sovacool, B. K. (2014). Cornucopia or curse? Reviewing the costs and benefits of shale gas hydraulic fracturing (fracking). *Renewable and Sustainable Energy Reviews*, *37*, 249–264.

Steffen, W., et al. (2015). Planetary boundaries: Guiding human development on a changing planet. *Science*, *349*, 1286–1287.

Susser, M., & Adelstein, A. (1975). An introduction to the work of William Farr. *American Journal of Epidemiology*, *101*, 469–476.

Susser, M., & Susser, E. (1996). Choosing a future for epidemiology: I. Eras and paradigms. *American Journal of Public Health*, *86*, 668–673.

Tannahill, A. (2008). Beyond evidence to ethics: A decision-making framework for health promotion, public health and health improvement. *Health Promotion International*, *23*, 380–390.

The Marmot Review Team. (2010). *Fair society, healthy lives: Strategic review of health inequalities in England post-2010*. Marmot Review Team, London.

The Trust for Public Land. (2008). How much value does the city of Philadelphia receive from its park and recreation system? Retrieved from http://cloud.tpl.org/pubs/ccpe_PhilaParkValueReport.pdf *<http://cloud.tpl.org/pubs/ccpe_PhilaParkValueReport.pdf>*.

Thomas-Hope E. (2011). *People on the move. Managing migration in today's commonwealth*. The second report of the Ramphal Commission on Migration and Development.

UNICEF. (2008). *Our climate, our children, our responsibility. The implications of climate change for the world's children*. Retrieved from https://www.crin.org/en/docs/climate-change.pdf *<https://www.crin.org/en/docs/climate-change.pdf>*.

Villeneuve, P. J., Jerrett, M., Su, J. G., et al. (2012). A cohort study relating urban green space with mortality in Ontario, Canada. *Environmental Research*, *115*, 51–58.

Vinikoor-Imler, L C., Gray, S. C., Edwards, S. E., et al. (2012). The effects of exposure to particulate matter and neighbourhood deprivation on gestational hypertension. *Paediatric and Perinatal Epidemiology*, *26*, 91–100.

Vinten-Johansen, P., Brody, H., Paneth, N., et al. (2003). *Cholera, chloroform and the science of medicine: A life of John Snow*. New York: Oxford University Press.

World Health Organization. (2013). *Review of evidence on health aspects of air pollution—REVIHAAP Project*. Bonn: World Health Organization. Retrieved from http://www.euro.who.int/__data/assets/pdf_file/0004/193108/REVIHAAP-Final-technical-report-final-version.pdf *<http://www.euro.who.int/__data/assets/pdf_file/0004/193108/REVIHAAP-Final-technical-report-final-version.pdf>*.

World Health Organization. (2016). *Water sanitation and health*. Retrieved from http://www.who.int/water_sanitation_health/en/ *<http://www.who.int/water_sanitation_health/en/>*.

World Health Organization. (2016). *Global Health Observatory (GHO) data: HIV/AIDS*. Retrieved from http://www.who.int/gho/hiv/en *<http://www.who.int/gho/hiv/en>*.

World Health Organization Regional Office for Europe. (2012). *Environmental health inequalities in Europe Assessment Report*. Copenhagen: WHO.