

Choosing a Future for Epidemiology

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THE PRESENT ERA OF

epidemiology is coming to a close. The focus on risk factors at the individual level—the hallmark of this era—will no longer serve. We need to be concerned equally with causal pathways at the societal level and with pathogenesis and causality at the molecular level. . . .

[C]hoices have to be made about the future of epidemiology. To look forward, we do well to look backward for guidance. [The first part] of this article sketches in brief outline the evolution of modern epidemiology in 3 successive eras. Following Kuhn, we set the bounds of these eras in terms of dominant paradigms. In [the second part] of this article, we advocate a paradigm for a fourth emergent era of "eco-epidemiology." . . .

THE EVOLUTION OF MODERN EPIDEMIOLOGY

[I]n the face of the miseries of 19th-century England . . . modern epidemiology gradually took shape and then burst into activity with the Sanitary Movement. Thereafter, one can discern at least 3 eras in epidemiology, each with its own dominant paradigm: (1) the era of *sanitary statistics* with its paradigm, *miasma*; (2) the era of *infectious disease epidemiology* with its paradigm, the *germ theory*; and (3) the era of *chronic disease epidemiology* with its paradigm, the *black box*. . . .

SANITARY STATISTICS AND MIASMA

Sanitary statistics made plain the toll of sickness and death in the city slums. . . . For the conditions in these slums, the Sanitarian hypothesis of miasma impugned poisoning by foul emanations from the soil, water, and enviroing air. The environmental causes were thought to have broad and multiple manifestations in morbidity and mortality, and the sanitary statistics that were collected . . . were related more to overall morbidity and mortality than to specific diseases. . . .

Closed drainage and sewage systems, supplemented by garbage collection, public baths, and housing, were the remedies that would disperse miasma, reduce mortality and morbidity (as indeed they did), and dispel the poverty of the new urban poor (as indeed they did not). . . .

Young physicians were excited by the challenge of emergent patterns of disease that seemed rooted in a horrendous environment of urban misery. . . . These epidemiologists mapped excess mortality across the country by district . . .; studied a wide range of industries and occupations; [and] detected many hazards from dusts, heavy metals, and general working conditions. . . .

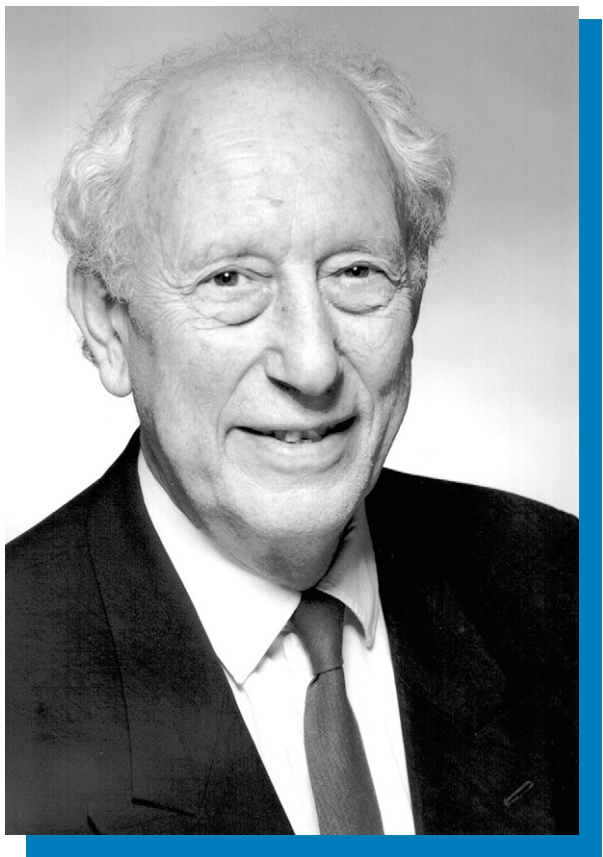
An irony of the history of public health is that, while the sanitarians were mistaken in their causal theory of foul emanations, they nonetheless demonstrated how and where to conduct the

search for causes in terms of the clustering of morbidity and mortality. The reforms they helped to achieve in drainage, sewage, water supplies, and sanitation generally brought major improvements in health. . . .

INFECTIOUS DISEASE EPIDEMIOLOGY AND THE GERM THEORY

Louis Pasteur's demonstration of a living organism as the agent in an epidemic afflicting silkworms culminated in 1865. Studies of infection and contagion in human disease—for instance, tuberculosis, anthrax, and leprosy—followed. . . . [T]he new paradigm of disease that followed from their work, the *germ theory*, led in the end to the narrow laboratory perspective of a specific cause model—namely, single agents relating one to one to specific diseases.

The germ theory . . . dominated medical and public health sciences from the last quarter of the 19th century through at least the mid-20th century. Single agents of disease were sought by the isolation and culture of microorganisms from disease sites, the experimental transmission of these microorganisms, and the reproduction of lesions. The appropriate responses were to limit transmission . . . , to isolate those affected, and, ultimately, to cure with chemotherapy and antibiotics. Laboratory-based diagnosis, immunization, and treatment gained precision with



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Source. Photo by Charles Manley.

every new advance. The miasma theory was relegated to the same oblivion as phlogiston. . . .

CHRONIC DISEASE EPIDEMIOLOGY AND THE BLACK BOX

World War II serves as a convenient watershed for the beginning of the Chronic Disease Era and the black box paradigm. Shortly after the war ended in 1945, it was clear that, in the developed world, rising chronic disease mortality had overtaken mortality from infectious disease. . . . By this time . . . chemotherapy and antibiotics had been added to the medical armamentarium. Their overwhelming therapeutic effects seemed to give tangible evidence that the major infectious diseases had been conquered. . . .

Chronic disease epidemiology took firm hold with the first undeniable successes in this endeavor. British epidemiologists Richard Doll, Austin Bradford Hill, Jeremy Morris, Thomas McKeown, and others were key figures. The case-control and cohort studies on smoking and lung cancer, and the early cohort studies on coronary heart disease that established serum cholesterol and smoking as risk factors, demonstrated the power of the observational method and established its credentials.

These studies carried the invisible imprimatur of the black box paradigm. . . . This paradigm related exposure to outcome without any necessary obligation to interpolate either intervening factors or even pathogenesis. . . .

Epidemiologists were obliged to depart from the specific-cause model of the germ theory. The metaphor of a “web of causation” characterized the multicausal nature of public health problems, particularly those of chronic disease. . . .

MOMENTUM FOR A NEW ERA

The climax and, in all likelihood, the culmination of the black box as dominant paradigm is already upon us. Two forces, characteristic of our time and much written about, are blunting the black box paradigm: (1) a transformation in global health patterns and (2) new technology.

With regard to health patterns, none has had more impact than the human immunodeficiency virus (HIV) epidemic. Although epidemiology has made some notable contributions to understanding the epidemic, black box epidemiology is ill equipped to

address epidemic control. . . . [T]he HIV epidemic has demonstrated that both developing and developed countries remain vulnerable to devastation by infectious disease. . . .

For the majority of the world’s population, chronic infections—tuberculosis, syphilis, malaria, and many others—were never under control. As with HIV infection, the immediate causes and the risk factors were known, but this knowledge could not be translated into protection of the public health.

Similarly, our confidence in our ability to control chronic non-communicable diseases themselves by modifying behavior that carries risk has been shaken.

Again, knowledge of risk factors and interventions directed solely at changing the behavior of individuals, even across several communities, have proven insufficient.

Health problems driven by societal problems point to the location of the underlying difficulties. The black box paradigm alone does not elucidate societal forces or their relation to health. The focus on populations is generally directed at the individuals within them. Prevention at the societal level, conceptualized as intervening with individuals en masse, is often nullified when the target is a social entity with its own laws and dynamics. . . .

TECHNOLOGY

Biological techniques such as genetic recombination and imaging have transformed the ability of epidemiologists to comprehend human disease at the micro level. . . . Learning from the new technology has only begun. Once unimaginable possibilities follow from the mapping of the human genome for specifying the role of

heredity in disease, and no less from the visualization of physiological processes for interpreting human function. . . .

In parallel, technology at the societal level in the form of the global communication network has opened new possibilities for understanding and controlling disease. Information networks can provide instant access to—and enable the continuous assemblage of—existing stores of vital statistics and other relevant health and social data across the world, . . . the overall surveillance of health states, the detection of nascent epidemics and new diseases, the response to disasters, and the evaluation of interventions. . . .

When research under the current black box paradigm in its pure form relies on risk ratios that relate exposure to outcome with no elaboration of intervening pathways, it forfeits the depth offered by our new biological knowledge. In addition, because of an implicit and sometimes explicit commitment to analyzing disease solely at the individual level, research under this paradigm also dispenses with the potential breadth offered by new information systems in placing exposure, outcome, and risk in societal context. . . .

As happened with previous paradigms, the black box, strained beyond its limits, is soon likely to be subsumed if not superseded entirely by another paradigm. . . . In our view, we stand at the verge of a new era. . . .

FROM BLACK BOX TO CHINESE BOXES AND ECO-EPIDEMIOLOGY

[O]n the choices before epidemiology, we advocate a paradigm for an emergent era of

eco-epidemiology. To connote the inclusion of systems at different levels, we term the paradigm *Chinese boxes*. This paradigm stems from a particular distinction between the “universalism” of the physical sciences and the “ecologism” of the biological sciences. It places epidemiology on the track of ecologism. . . .

The practical implication of a localizing ecological paradigm for the design of epidemiological research is that an exclusive focus on risk factors at the individual level . . . will not serve. We need to be equally concerned with causal pathways at the societal level and with pathogenesis and causality at the molecular level. . . .

Our concept envisages interactive systems. . . . [A] system is an abstraction that allows a set of related factors to be described in terms of a coherent structure or coherent function. . . . Systems also relate to one another; they do not exist in isolation. A metaphor may serve to illuminate this ecological perspective. We liken it to Chinese boxes—a conjurer’s nest of boxes, each containing a succession of smaller ones. Thus, within localized structures, we envisage successive levels of organization, each of which encompasses the next and simpler level, all with intimate links between them. . . .

The paradigm represented by the metaphor of Chinese boxes could be suited to a new eco-epidemiology. . . . This paradigm treats relations within and between localized structures that are bounded socially, biologically, or topographically. The appropriate epidemiological approach is to analyze determinants and outcomes at different levels of organization. Such contextual analysis would draw on new information systems both

within and across levels to achieve breadth. It would draw on new biomedical techniques to achieve depth. . . .

The metaphor of Chinese boxes is perhaps not apt in every dimension, in that levels exist in a hierarchy not only of scale but also of complexity, with multiple interactions between and within levels. The outer box might be the overarching physical environment, which, in turn, contains societies and populations (the epidemiological terrain), single individuals, and individual physiological systems, tissues and cells. . . .

CHOOSING THE FUTURE

Although we hear stirrings, we have yet to adopt, develop, and apply this type of paradigm in epidemiology. What we present here is no more than a skeletal framework. . . . The paradigm is bound to evolve and change as the constraints of existing thought are broken, and one can expect it to confer new power on epidemiology. Such a paradigm will require a slew of sophisticated methods . . . that enable epidemiologists to test models at levels from the molecular to the social. . . .

[O]ne must recognize that a molecular paradigm taken on its own is hugely attractive because of its explanatory power. . . . [W]ith the sacrifice of conceptual and analytic breadth, epidemiology could again be reduced to a derivative pursuit of laboratory science, and the mainstream of our subject could be lost to creative science. A countervailing force, which at the same time restores public health to epidemiology, resides in a developed version of the Chinese boxes paradigm.