

EDITORIAL

The eco- in eco-epidemiology

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In 1996, Susser and Susser proposed breaking the constraints of the risk factor paradigm. They envisioned for the future an 'eco-epidemiology' that would explicitly recognize multilevel causation and emphasize the ties that bind epidemiology to public health.^{1–3} Others also advocated for a transition in epidemiology and articulated various perspectives on what it should be.^{4–8} Since then, these perspectives have begun to merge into a common vision of a broad and integrative epidemiology, in which studies designed to identify risk factors would be balanced by studies designed to answer other questions equally vital to public health. These would include studies of trajectories of health and disease over the life course, the effects of social contexts broad and narrow, the spread of communicable diseases and behaviours through populations, genetic causes, and historical trends. By fully incorporating these elements, epidemiology would be rooted in the investigation of the pathways by which biological and social experiences generate health and disease, and would be equipped to identify the impact of biological and social changes on the health of populations.

Developments in epidemiology over the ensuing decade attest to the movement in this direction.⁹ In the *International Journal of Epidemiology*, these elements are represented and embraced as being integral to the discipline.^{10,11} The trend is also evident, to varying degrees, in other journals, conferences, and research underway. It is quite apparent that the identification of risk factors will not be sufficient for epidemiologists to confront some of the most pressing public health challenges of our time, such as those emanating from the AIDS pandemic, social inequalities, and movements of and changes in populations. Other strategies are being applied and refined, reminiscent of the progress in previous decades during which the designs for studying risk factors were honed.

With the aim of nurturing this transition, we offer an historical perspective on the 'eco-' in eco-epidemiology, and on the recent resurgence of interest in the elements encompassed by it. We suggest that this rubric carries forward a line of thinking that has deep roots in previous eras and is well suited to the challenges of the present era in epidemiology. It is our hope that, ultimately, the 'eco-' in eco-epidemiology, still embryonic in form, will no longer be required for the sake of differentiation from the dominant paradigm.

Transitions in epidemiological thinking

Thomas Kuhn's notion of the scientific paradigm is widely known and useful for recognizing how certain ideas have achieved dominance in successive eras of epidemiology.¹² Kuhn focuses on the normative constraints of scientific cognition and activity, which he terms 'paradigms'. Although he analyzes the conditions under which scientific paradigms change, he does not explain how science moves from one paradigm to the next. In contrast, Ludwik Fleck, who preceded and anticipated Kuhn, illuminates the underlying intellectual and social processes that provoke scientists to change their thinking.¹³ In this sense, his work addresses more directly the way in which paradigms shift in epidemiology.

For Fleck, all scientific facts develop within the context of 'thought collectives'. These exist 'wherever two or more people are actually exchanging thoughts... [which] creates a condition in which each utters thoughts he would not have been able to produce by himself or in different company'. [Ref. 13 (p. 44)] The broader scientific culture represents a 'thought style'. Thought styles both shape and are shaped by thought collectives.

Fleck illustrates the process by which ideas develop within a given thought style. He analyzes the discovery of the biological agent responsible for syphilis and the development of the Wasserman reaction. Both resulted from the confluence of several lines of collective thought, and thus cannot be attributed to a single individual. In the words of Fleck:

[A]n interaction exists between that which is known and the act of cognition. What is already known influences the particular method of cognition; and cognition, in turn,

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enlarges, renews, and gives fresh meaning to what is already known. Cognition is therefore not an individual process of any theoretical “particular consciousness.” Rather it is the result of a social activity, since the existing stock of knowledge exceeds the range available to any one individual. [Ref. 13 (p. 38)]

We propose that the ideas of Fleck and Kuhn can be meaningfully integrated to offer a perspective on transitions in epidemiological thinking. Thought styles in epidemiology can be seen as emerging from a critical concentration of collective thought, and a paradigm as crystallizing a given thought style. From this vantage point, thought collectives peripheral to the mainstream of the discipline in one era may establish a thread for a new paradigm in a subsequent era. Indeed, the concepts of eco-epidemiology originated in a thought collective that coalesced in the decades after World War II, and its roots can be traced to even earlier antecedents.

The conceptual origins of eco-epidemiology

The intellectual foundation of eco-epidemiology was cemented, for the most part, in the same years as the risk factor paradigm. Jerry Morris and Mervyn Susser contributed significantly to an epidemiological understanding of multiple causation and other concepts central to the risk factor approach. However, they situated these ideas within a broader rubric.

In *Uses of Epidemiology*, first published in 1957, Morris advanced the notion that populations have unique properties representing more than just the amalgamation of their constituent properties.^{14,15} He also recognized the individual as a dynamic system in which small changes might have large consequences for health, and in which intervention might have unintended consequences in the context of ‘multiple causality’:

[I]f the causes are related in a dynamic way to each other, and if one or more perform a homeostatic function, it must not be assumed that simple interference will have simple results. Thus it is supposed to be a common experience that men who give up smoking may put on weight. [Ref. 14 (p. 71)]

Nearly two decades later, Susser formally introduced levels of organization into epidemiology. He emphasized that the determinants of health on the individual level differ from those on the population level, despite the fact that populations comprise individuals, and that there are difficulties inherent to analytical movement between them. He gave equal weight to the hazards of the ‘ecological fallacy’ (inferring causation at the individual level from population level comparisons) and the ‘atomistic fallacy’ (inferring causation at the population level from individual level comparisons).¹⁶

Thus, Morris and Susser viewed health in terms of dynamic states influenced by factors on multiple levels, such as the cellular, the individual, the community, and the population. As intimated by Morris and explicitly articulated by Susser, this constituted an ‘ecological’ perspective. According to Susser, ‘[E]cology embraces the interrelations of all living things. Epidemiology could be described as human ecology, or that

large part of human ecology relating to states of health’. [Ref. 16 (p. 30)] (To avoid confusion, we note that the terms ecologic and eco-epidemiology have been used in different ways by other epidemiologists.¹⁷)

Morris and Susser participated in a thought collective that considered the elements central to eco-epidemiology: multiple levels of organization; the individual life course, as reflected by consideration of early antecedents and concepts of embodiment; equal consideration of communicable and non-communicable diseases, which entailed understanding infectious causes of chronic diseases, as well as risk factors for infectious diseases; the imprint of historical time; and, the dynamic relationship between macro causes (e.g. societal change) and micro causes (e.g. genetic mutations). This thought collective was situated in an ecological thought style, evident in the work of many other epidemiologists, including John Gordon,¹⁸ Gunnar Inghel,¹⁹ Thomas Francis, Jr.,²⁰ Alexander Leighton,²¹ Manfred Pflanz,²² René Dubos,²³ and John Cassel.²⁴ An ecological thought style was also apparent in other disciplines during this era.

Although this was perhaps the first thought collective to articulate the perspective we identify as eco-epidemiology, one can find examples of multilevel thinking in each of the previous eras of epidemiology.⁹ The best known are John Snow’s work on cholera during the Sanitary era,^{25,26} and Joseph Goldberger’s work on pellagra during the Infectious Disease era.^{27,28} Each challenged the dominant ideas of the time by considering the changes in social and biological context that gave rise to an epidemic, the individual behaviors that increased the risk of disease or its transmission, and the cellular and molecular processes underlying the pathophysiology. As early as the 1930s, Goldberger’s co-worker, social scientist Edgar Sydenstricker, came close to outlining an ecological perspective on public health, if not specifically epidemiology.²⁹

The risk factor storm and the shoring of ecology

An approach like that of eco-epidemiology has the ability to conceptually subsume various branches of epidemiology within a more capacious rubric. However, such an approach did not, at the time, gain traction in the discipline.

By the mid-twentieth century, the decline in infectious disease mortality in developed countries and the rapid discoveries of effective antibiotics and vaccines seemed to herald an imminent triumph over diseases caused by microorganisms. The thought style that crystallized into the dominant paradigm in epidemiology largely relegated communicable diseases to the discipline’s periphery, signaled in 1964 by the declaration of the US Surgeon General that ‘the time has come to close the book on infectious diseases’.³⁰

Indeed, the time was ripe for the risk factor paradigm, tailored to non-communicable diseases, which were referred to as ‘chronic’ diseases. Risk factor studies aimed specifically at estimating the effect of an exposure on the disease risk of individuals within a given population. In these studies, the broad social context was held constant and was not within the frame of the investigation.³¹ In the cohort, case-control, and other study designs crafted during this era, it proved possible

in some instances to infer a causal relationship and draw implications for prevention without understanding the biological processes that linked the exposure to the disease and without understanding the social context that gave rise to them.³² By the mid-1980s, an armamentarium of elegant and readily applicable study designs and analytical methods had been significantly developed.³³⁻³⁵

Thus, in a particular socio-historical moment characterized by concern with chronic diseases, the risk factor framework achieved the status of a paradigm, forming what Kuhn would term the normal science of modern epidemiology. The ecologically informed ideas of Morris and Susser and others like them became, in essence, background noise to the overture of risk factor epidemiology. Nonetheless, at the periphery of the discipline, the theoretical germ line for eco-epidemiology continued to develop, evident in the work of Geoffrey Rose,³⁶ Richard Levins,³⁷ and James Koopman,³⁸ among others.

Turning tides

Despite the continuing dominance of risk factor methods and their successes with chronic diseases, critiques of this approach began to proliferate in the 1990s. Among the public health problems driving that intellectual discourse were AIDS and social inequalities in health. The limited utility of the dominant risk factor methods to explain and address both began to be seen as handicapping the field.

In the subsequent decade, the discipline has witnessed remarkable developments. A particularly salient example is the response to the AIDS pandemic. The 2000 International AIDS Conference, held in Durban, South Africa—the first international AIDS conference organized in the developing world—was emblematic of the transition taking place in epidemiology.

First, the conference made explicit that AIDS was a global public health emergency that would necessarily drive much of the development of epidemiology and public health. This countered a notion in risk factor epidemiology that the scientific endeavor should be separated from public health advocacy.³⁴ The conference and the social movement connected to it legitimated and invigorated what soon became a landmark in public health history—the global effort to provide treatment to AIDS patients in resource poor countries. Women's rights and family relationships were made central to prevention and treatment strategies. To their credit, epidemiologists played a major role in both of these epic changes.

Second, the conference captured what is meant by eco-epidemiology. An overarching theme of the conference was to recognize causes on multiple levels and advance both the qualitative and quantitative methods required to investigate them. Ecological concepts of illness were evident in discussions of mutations in the virus, host resistance, and social phenomena, and the interactions among them. Indeed, the conference reflected the transmission of the ecological perspective across generations of epidemiologists. The successful bid to host the 2000 conference in Durban was led by the Head of South Africa's AIDS Control Programme at the time, Quarraisha Abdool Karim; the scientific chair of the conference was Salim Abdool Karim. Both had studied epidemiology with Mervyn

Susser and Zena Stein. Susser and Stein originated in South Africa and had been strongly influenced by Sidney Kark,³⁹ who applied multilevel thinking in a classic analysis of the forced migratory labor system as an underlying cause of epidemic syphilis in Natal (now Kwazulu/Natal) in the 1940s.^{40,41} Among many other manifestations of this continuity, parallel sessions were organized to ensure that affected communities and individuals were represented and engaged, an approach advocated by Kark, Susser, and Stein.

Third, analyses of the dynamics of HIV transmission inserted an innovative quantitative strand. In the keynote speech, Roy Anderson drew attention to the notion of the reproductive rate and its relevance to the AIDS pandemic. Thus, nonlinear quantitative means of examining ecological phenomena and ecological concepts of illness shared a high profile platform in public health. The implicit challenge for the coming era was to move from the juxtaposition to the integration of these two threads.

The quantitative strand reflected other intellectual continuities. Anderson had developed this concept with Robert May, a mathematician who entered the realm of epidemiology in the late 1970s by examining the dynamic behavior of several diseases, both chronic and infectious.⁴² May's work grew out of a thought collective of mathematicians concerned with complex systems.^{43,44} May had partly propelled the development of the chaos paradigm in mathematics, which seeks to understand patterns of stability and complexity of large systems.⁴⁵ Thus, he was equipped to provide the quantitative companion to Anderson's expertise in parasitology. While their initial work addressed the regulation of populations by infections and diseases, it increasingly focused on the movement of infectious diseases through populations. They published on the transmission dynamics of AIDS,⁴⁶⁻⁴⁸ and a groundbreaking textbook on infectious disease epidemiology.⁴⁹

Their ideas, too, had earlier antecedents: epidemiologists and physical scientists concerned with the dynamics of disease, beginning some six decades prior, had laid the foundation for their modeling efforts. At the beginning of the 20th century, Sir Ronald Ross, an epidemiologist with a keen interest in mathematical modeling, began to characterize the transmission dynamics of malaria,⁵⁰⁻⁵² though at the time, epidemiologists largely eschewed this work.⁵³ On the heels of Ross, in the 1920s, William Ogilvy Kermack and Anderson McKendrick examined epidemic transmission and, like Ross, championed mathematical epidemiology.^{54,55}

Other developments

In the same year that the AIDS conference took place in the southern hemisphere, the first draft of the human genome was completed largely in the northern hemisphere. Advances in genomics make it easier to see that the ecological perspective is relevant to understanding processes at the cellular and molecular level.⁵⁶ Conceptual and methodological developments allow epidemiologists to study more thoroughly genetic and non-genetic causes alike.⁵⁷

Other developments over the past decade also suggest an important transition in epidemiology. Consideration of the life course is increasingly well developed and defined as an approach,⁵⁸ building upon early studies of the fetal origins

of adult disease and health trajectories over the life span.^{59–61} Psychiatric epidemiology, with its rich ecological tradition—Morris addressed in *Uses of Epidemiology* what he termed an ‘ecology of mental disorders’¹⁴—is being integrated into mainstream epidemiology.⁶² Moreover, social epidemiology continues to develop in order to better address the implications of inequalities—rife within high and low income societies alike—for health;^{63,64} examination of contextual factors by means of multilevel analyses is central to such endeavors.⁶⁵ In addition, the field is rediscovering the central importance of analyzing historical trends,⁶⁶ and of improving the methods for doing so, such as age-period cohort analyses.⁶⁷

New depths

There is no turning back towards a more circumscribed epidemiological science that is less connected to public health applications. These advances represent what Kuhn would call ‘scientific achievements...supplying the foundation for... further practice’. [Ref. 12 (p. 10)]

Still, the risk factor paradigm is the dominant if not exclusive focus of training in epidemiology, especially in the United States, as reflected in textbooks and curricula. Thus, the training of new epidemiologists lags somewhat behind the development of the field. It is true that the study of risk factors remains the most elaborated and widely applied strategy. Other approaches have not yet achieved the discipline-defining salience of the successes of risk factor epidemiology in the height of the chronic disease era. It is also true, however, that without advancing and integrating these other elements, epidemiology will diminish in importance as a central science of public health in the current era.

We envision for the future an epidemiology that—informed by its rich history—adopts, develops, and teaches methods to understand both biological and social complexities, thereby extending its range of application. The charge of the next generation of epidemiologists is to bring about these changes—in the words of Fleck, to enlarge, renew, and give fresh meaning to what is already known. For those already established in the field, a priority is to provide this next generation with the conceptual and methodological tools that will enable them to do so. Engendering awareness of the historical roots from which they can grow and develop, essentially creating an intergenerational and international thought collective, is at once a continuation and a beginning.

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