Op-Ed

Criteria for Action in Population Health: The Hill Criteria a Half Century Later

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All scientific work is incomplete—whether it be observational or experimental. All scientific work is liable to be upset or modified by advancing knowledge. That does not confer upon us a freedom to ignore the knowledge we already have, or to postpone the action that it appears to demand at a given time.

Bradford Hill¹(p300)

IN JANUARY 1965, SIR BRADFORD HILL STOOD BEFORE THE Section of Occupational Medicine of the Royal Society of Medicine in London and delivered his famous speech “The Environment and Disease: Association or Causation?”¹ He outlined 9 points for evaluating causal relationships between “sickness, injury and conditions of work.” Referred to as the Hill “criteria,” although Hill never used that word, these concepts have often been repeated. Generations of public health students have memorized his 9 points: “strength,” “consistency,” “specificity,” “temporality,” “biological gradient,” “plausibility,” “coherence,” “experiment,” and “analogy.” While few, if any, well-trained epidemiologists or statisticians today would hold fast to what Hill called his 9 “viewpoints,”² some, especially in the legal arena, do use these criteria and rigid statistical probability levels as the means of literally “judging” the “scientific” legitimacy of experimental or epidemiological evidence. In liability cases where experts are challenged in what are called “Daubert” hearings, lawyers sometimes invoke Hill’s tests for causation in efforts to persuade judges to disqualify opposing experts as witnesses.³

It is worth recalling the world of public health in which Hill was working when he proposed his “viewpoints.” What is remarkable about his 1965 speech was its subtlety and humility, in which he warned that knowledge took many forms and invited others to challenge a too rigid application of his points.

The examples that Hill presented 50 years ago were largely drawn from contemporary worries about the impact of industries on the health of Britain's working people. Hill, after all, was living through one of the most tumultuous periods in history, having experienced the ravaging effects on the health and well-being of the British population during a decade of depression, a destructive world war, and the slow, uneven redevelopment of the industrial economy. The epidemiological transition from infectious diseases to chronic noncommunicable diseases such as cancer, heart disease, and stroke was on the minds of colleagues and policymakers alike. When Hill gave his talk, Thomas McKeown, Margot Jeffries, Mervyn Susser, and Zena Stein were emerging as central figures in epidemiology. They all came of age during the vibrant social medicine movements of the 1930s and 1940s and were deeply concerned about social and economic factors that were affecting population health.

Throughout his speech, Hill referred to the upheavals that were undermining British health in the postwar era. For example, he began by explaining that he wanted to enable an understanding of "the relationship between sickness and injury and conditions of work . . . [and to] make available information about the physical, chemical and psychological hazards of occupation."¹(p295) "How do we determine what are physical, chemical and psychological hazards of occupation?"¹(p295) he asked. How could public health workers identify the cause of subtle chemical toxins that were now emerging as concerns to workers and communities alike?

Tobacco was clearly on his mind. A year earlier the US surgeon general had praised Hill's and Sir Richard Doll's early studies of tobacco and lung cancer. Hill also drew on other historical examples of occupational and environmental causes of disease, from scrotal cancers in chimney sweeps, to industrial dust diseases such as silicosis, byssinosis, and asbestosis, and even water-borne cholera. The "strength" of an association was his first criterion, and here he described the strong relationship between the rise of lung cancer and smoking. He illustrated "consistency" by describing peptic ulcers and their relationship to domestic crises. For other criteria, he used examples from exposures to lubricating oils, cotton mills, horse tanning, other trades and industrial products, and new drugs, including thalidomide. Diet, as well as arsenic and coal exposure, also bolstered his argument.

Hill cautioned against strictly relying on statistical testing, and he worried that we were prioritizing rigid probability testing for clinical observations, no matter how obvious or historically grounded they might

be. He even wondered whether his older studies, which did not include statistical tests, would be published in the current climate.

While very critical of the informal, almost anecdotal, information that formed much of the practice and that had earlier passed as the “science” of medicine, he also “wonder[ed] if the pendulum has not swung too far” in the opposite direction, asking, “To decline to draw conclusions without standard errors can surely be just as silly?”^{1(p299)} He was particularly worried about his “friends in the USA where . . . some editors of journals will return an article because tests of significance have not been applied,” even though there are “innumerable situations in which they are totally unnecessary.”^{1(p299)} Most remarkable about Hill’s paper is how much space he devoted to qualifying the very turn to methodology for which he is often remembered.^{4,5}

While good epidemiological data and well-designed studies could certainly be a benchmark, Hill argued that we had to balance our approaches to understanding disease causation and that public health had to take action in the face of uncertainty when the stakes were either clear or high. Accordingly, it was proper for public health “on relatively slight evidence . . . [to] decide to restrict the use of a drug for early-morning sickness in pregnant women,”^{1(p300)} he contended, undoubtedly referring to the recent thalidomide disaster in Europe and the United States. After all, even if the chance is slight, the risk is great. Likewise, “on fair evidence we might take action on what appears to be an occupational hazard, e.g. we might change from a probably carcinogenic oil to a non-carcinogenic oil . . . without too much injustice if we are wrong.”^{1(p300)}

Clearly, the emerging world of occupational and environmental health, along with the recognition of chronic diseases with nonspecific or possibly multiple origins, presented new challenges that the older model of specific etiologies for specific diseases, such as those seen with infectious diseases, could not explain.

What remains extraordinary at this late date was the humility with which Hill proposed his methodology and his points for evaluating causation. He understood that “all scientific work is incomplete,” even his own. But that did not give us or the legal system the right “to postpone the action that it appears to demand at a given time.”^{1(p300)}

References

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