Introduction to the Symposium: Causal Inference and Public Health

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Abstract

Assessing the extent to which public health research findings can be causally interpreted continues to be a critical endeavor. In this symposium, we invited several researchers to review issues related to causal inference in social epidemiology and environmental science and to discuss the importance of external validity in public health. Together, this set of articles provides an integral overview of the strengths and limitations of applying causal inference frameworks and related approaches to a variety of public health problems, for both internal and external validity.

INTRODUCTION TO THE SYMPOSIUM

The editors of the *Annual Review of Public Health* deemed the application of causal inference in public health as an area warranting further review and comment. Two major critiques of how researchers utilize causal inference frameworks have emerged: one from the public and one from health practitioners, program planners, or policy makers. The public complains that their journalistic channels of health science news seem never to come to any conclusion on health advice without caveats, qualifications, hedges, and "more research is needed" bottom lines. The hope of lay consumers of health news for definitive guidance on diet, exercise, household cleaning products, threats to their water supply, clean air, food supply, and waste disposal all seem to have a "yes, but" conclusion. The "but" is usually a qualification, sometimes but not always, placed by science journalists (9), given their reading beyond the "breaking news" press releases.

Professionals and the scientists themselves continue to debate the role of the potential outcome approach to causal inference (6, 11, 15, 16, 18). By focusing research questions that are conceptualized as treatments/interventions and approaching design through an appropriate counterfactual (or potential outcomes approach), one can estimate outcomes that justify measures imbued with a causal interpretation (10, 12). This is a laudable goal because it supports the idea that research results provide clarity and therefore direct policy recommendations, with less equivocation on the underlying assumptions. Moreover, the appeal of applying a potential outcomes approach goes straight to the foundation of the scientific approach: It requires a refutable hypothesis and clear definition of how one tests these hypotheses in a controlled scenario. How can one therefore debate the need for rigorous adherence to the potential outcomes approach in research? Arguments to the contrary appear absurd to any well-trained scientist. However, others have pointed out that the goal of conceptualizing all exposures as treatments begins to fall apart when we are forced to acknowledge exposures that are complex in their counterfactual conceptualization, such as exposures that depend on combinations of historic and current exposures [for example, the effects of racism (7, 19)]. Moreover, uninformed adherence to causal inference approaches may dissuade mechanism-generating research in the future because the assumption that an exposure is truly intervenable makes mechanistic studies a moot point. Why would public health researchers and practitioners need to understand the causal mechanisms if one has already accurately identified the intervenable lever? For these reasons, questions remain around the intense focus on causal inference in public health and how this doctrine will influence the formulation of future research questions, especially for social and environmental determinants, where mechanistic studies may be highly informative for presenting additional avenues of intervention or for adding to the weight of existing evidence for a causal link between exposure and disease. These tough questions continue to be worthy of debate and discussion.

In this symposium, Kaufman (14) argues that social epidemiologists should continue to better define exposures as treatments, with the goal of translating their findings to policy, and, presumably by extension, to programs and professional practice guidelines that involve policy changes. Kaufman provides key suggestions on how social epidemiologists can ask questions that allow investigators to conceptualize social exposures as treatments so that they can test well-defined social treatment regimens that may influence health outcomes. Kaufman also discusses the ways in which the causal inference paradigm has faced criticism, primarily because broadening the definition of a social exposure in some situations may be needed. As Kaufman states, "To know something about our real world is hard enough, involving complexities of definition and measurement that can challenge our abilities and require substantial resources. But to aspire to know something about counterfactual worlds is even more audacious" (14). Whether the audacity is actually larger in social epidemiology remains debatable, but clearly many researchers argue this is not the case (5, 7,

17, 19), regardless of how some social determinants have been treated as immutable in the past. Kaufman concludes that we may need to take a broader view of causal inference in social epidemiology and allow for the loosening of exposure definitions at the expense of some vagary in our causal parameters of interest. The question remains whether this debate should be occurring in social epidemiology or all epidemiology. Kaufman's article highlights that we must be vigilant about how causal inference methods influence the questions asked in social epidemiology. If we are unable to find the right balance between encouraging testing of exposures with a strict treatment interpretation and the need to sometimes broaden our definitions of exposures for social determinants, we may risk missing opportunities to address some of the most impactful problems in public health.

Bind contributes to this symposium by describing the issues in causal inference facing researchers who study environmental exposures (2). Using both a historical framework and a current context, Bind provides integral guidance on methods for enhancing causal inference focusing on air pollution. As it pertains to this symposium, some of the barriers Bind describes parallel those discussed for social epidemiology, including unethical treatment regimens and vagaries in defining environmental exposures. Bind argues that environmental scientists should ask the questions, How would I proceed if I could conduct a randomized experiment in the population of interest? and How can the nonrandomized data be described as collected from a randomized experiment (2)? Bind argues that these types of thought exercises will help researchers better utilize the potential outcomes approach to enhance work in environmental science. Bind also provides several examples of statistical approaches in air pollution research to assess exposures more rigorously. As in social epidemiology research, there are many examples in air pollution research where the question of interest is mechanistic. Bind highlights this mechanistic goal through a discussion of mediation methods, including those directly developed by Bind et al. (3), to assess the environmental-biologically mediated pathways to poor health outcomes among those exposed to air pollution. Finally, the impacts of future approaches, including big data and computational approaches, are discussed. Whether these novel methods will result in better causal inference for environmental exposures in the future remains to be seen.

Related to causal inference, one debate that has been especially relevant to the field of public health has been that of external validity. External validity can be divided into generalizability (study sample comes from the target population) and transportability (study was outside the target population but has sufficient similarities to warrant viewing it as equally receptive to, or susceptible to, the influence of the study interventions) (1, 21). The "public" that interfaces with public health professionals are the users of systematic reviews of research, in search of evidence-based practices. To the extent that most of the health research has been funded by the National Institutes of Health, the criteria of adequate research proposals have centered especially on their provisions for guards against threats to internal validity that would make causal inference more dubious. However, causal inference tools and conceptual thinking have also been applied to the issues of external validity (4, 20, 21). A growing concern for public health has been the degree to which the single-minded pursuit of internal validity threatens the ability to apply inferences externally. For that reason, we sought a companion review by Huebschmann, Leavitt, and Glasgow (13).

The specific problems of external validity posed by the emphasis on internal validity of studies is how much the tipping of the balance toward favoring controls on internal validity makes the controlled research environment less generalizable in communities, populations, and circumstances unlike that of the experimental interventions. These generalizability issues raise questions in the minds of public health practitioners and policy makers of whether evidence-based practices based too heavily on recommendations from systematic reviews that favor evidence from the most

rigorously controlled studies might need to be supplemented with field trials in representative, free-living populations and communities. This source of evidence versus intended application dilemma has called for complementing evidence-based practice with practice-based evidence (8).

In summary, we hope this symposium will continue to generate discussion around many of the parallel debates in social epidemiology, environmental health, and the translation of research findings into actionable public health interventions.

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