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Commentary

Causal identification: a charge of epidemiology in danger of marginalization

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ABSTRACT

The requirement for framing all causal questions as well-defined interventions is being promoted in the causal inference literature within epidemiology. One can consider this perspective as an intervention on the field which requires a refocusing of epidemiologic questions and retooling of epidemiologic methods. Although this intervention has produced many positive results, we think that its underlying assumptions and the possibilities of unintended consequences warrant examination. In so doing, we argue that this approach can lead to the neglect of causal identification as a useful link between associations and the estimation of intervention effects.

Counterfactual approaches to causal inference have permeated academic epidemiology to great benefit. Counterfactual thinking sharpens the framing of causal questions and facilitates clear articulation of study goals. It clarifies many basic concepts in epidemiology and has been the basis for numerous methodological advances, particularly methods for dealing with noncomparability. Within this frame, the requirement of a well-defined and practicable intervention for estimating causal effects is currently promoted as the standard for all causal questions in epidemiology [1–7]. Causal effects are interpreted as intervention effects with the attending gold standard of the randomized controlled trial (RCT). Even when an RCT is not actually conducted, the causal question must be posed in terms of a hypothetical trial [4,5]—what would be the effect of treating individuals with exposure A versus treating the same individuals at the same time with exposure B? If such a formulation is not possible, the question is relegated to one of description or surveillance but not causation [1,6,7].

This seems contrary to traditional definitions of epidemiology as "the study of the distribution and determinants of health-related states or events in specified populations, and the application of this study to control of health problems" [8]. In our reading of this definition, in addition to surveillance (a study of distribution), there are two causal goals of epidemiology, not one. The "application of this study to control of health problems" is aligned with an intervention perspective, and therefore, the goal of estimating the effects of causes. However, the other causal goal, the identification of the causes of effects (the determinants of health-related states), is marginalized in an intervention perspective.

For example, Kaufman et al. [7] delineate two goals of epidemiology—surveillance and etiologic inference. "In surveillance we merely seek to accurately describe what the world looks like … the second class of epidemiologic activity is etiologic. This activity is designed not to describe the world as it exists, but rather how it would change under some defined, generally hypothetical, intervention … [E]pidemiologists are firmly committed to this activity by virtue of the field being situated within the larger domain of public health. This disciplinary identity fixes intervention as the primary focus of epidemiologic research" (p. 2397–2398).

The application of counterfactual approaches to understanding the world through the identification of realized causal effects is bypassed in this perspective. Causal inference is reserved for exposures that can be conceptualized as "well-defined interventions" or manipulable treatments in an experiment. Well-defined interventions meet Rubin's Stable Unit Treatment Value assumptions of no unrepresented versions of treatment and no interference between units [9,10]. If exposures are not well defined, they are dismissed as "fishy causal concepts," yielding estimates that do not provide precise predictions about what would happen if actual interventions were carried out [1]. For example, Hernán and Taubman [2] argue that it does not make sense to talk about the causal effect of obesity on mortality since any effect estimate would depend on how obesity was removed (e.g., diet, exercise).

We might consider the well-defined intervention requirement itself an intervention on the field of epidemiology as this approach

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requires refocusing epidemiologic questions and retooling epidemiologic methods [11]. As appreciative consumers of these advances, we support the use of explicit causal frameworks in epidemiology and think that counterfactual thinking should be encouraged. But as with the dissemination and scale-up of any intervention, underlying assumptions warrant examination and the possibilities of unintended consequences and over-reach deserve reflection.

The underlying assumption of the interventionist approach is that framing all our causal questions in terms of well-defined interventions is the surest route to useful public health policies. Hernán [1] is direct in stating this assumption—"causal questions not posed in this manner are of no use to either scientists or policy makers" (p. 619). We think that the goal of predicting the effect of the manipulation of a cause is an important type of causal question. However, it is not the only one for which counterfactuals are useful, and not the only one that has value for science and practice. Can counterfactual frames play a legitimate role in identifying causes, in addition to estimating intervention effects? By identifying causes, we mean documenting that an exposure actually caused a particular outcome in some people in the population. Is it possible, in fact, that causal identification may provide a better interpretation of effect estimates even for many questions posed as "well-defined interventions"? Can the use of counterfactual thinking for causal identification provide another, sometimes more effective and efficient route, to sound public policy? To support an argument for a "yes" response, we discuss (1) the problem of limiting the types of questions eligible for causal analysis, (2) limitations of strategies from within an interventionist frame for dealing with these types of questions, (3) some unintended consequences of the well-defined intervention requirement, and (4) counterfactual approaches to identifying causes.

What types of questions are eligible for causal analysis?

The requirement for framing all causal questions as intervention questions has developed over time, as authors have issued an increasingly emphatic call for well-defined interventions that are potentially practicable (e.g., [1,6,12]). A practicable interventionist perspective fits well when the causal question and the intervention question align naturally, such as estimating the causal effect of some assignable protective factor. There may be logistic barriers to actually carrying out this intervention (e.g., compliance), but there is no barrier to imagining it.

A common example is the effect of zudovudine (AZT) on AIDS mortality (e.g., [13,14]). One can imagine an intervention where everyone infected with HIV is given the same specific dose of AZT versus not given AZT—the causal question and intervention question are aligned. Indeed, the exposure in the study is the actual treatment that we want to implement and the causal effect estimated represents the goal of an actual intervention. Although the study effect might not reflect the actual effect of the intervention, we may get an estimate of some reasonably short-term intervention effect in the population in which the study was conducted.

However, for questions about causes hypothesized to be harmful, the fit is less optimal. For example, the classic epidemiologic question about the effects of cigarette smoking on lung cancer does not align naturally with this approach. Although one could, in some very theoretical way, imagine an RCT where individuals were assigned to smoke a certain number of cigarettes a day or not smoke at all (e.g., [1]), this is certainly not a practicable intervention and is not even a well-defined hypothetical intervention. First, the mechanism through which we assign smoking (e.g., forcing people to smoke 10 unfiltered cigarettes a day under observation) would almost certainly influence the causal effect. But more importantly, it is not an intervention that would be of any practicable interest. The intervention question of real interest would be "what would be the effect of preventing people from smoking" or "what would be the effect of having smokers quit smoking"? One may be tempted to say that the effect of prevention would be the reverse of the effect of smoking, but potential outcomes approaches have taught us that this is not the case [15,16]. The intervention effect would be highly dependent on the details of the treatment—here, how we intend to prevent people from smoking (e.g., public health advertisements, cigarette taxes). Yet questions posed in terms of identifying harmful exposures, questions which are not aligned with practicable well-defined interventions, are of central concern in epidemiology. Several approaches have been suggested from within the interventionist frame to handle these situations.

Interventionist approaches to dealing with questions ineligible for causal analysis

From the interventionist perspective, two general solutions are proposed to handle epidemiologic questions that are not directly conceptualizable as well-defined interventions: (1) relegate them to questions of surveillance or (2) redefine the exposure [7,15,17–19].

Relegate to surveillance

A simple solution is to categorize, and interpret, questions that do not meet the well-defined intervention criterion as descriptive. For some questions this solution is certainly apt, particularly when the goal is to simply measure the frequency of some health outcome and document its variation across specific subgroups.

But an entire class of epidemiologic inquiry is neither about description nor about the effects of causes—questions about the identification of causes of effects. Relegating these questions to the realm of description risks losing all the methodological and conceptual clarity won from counterfactual thinking. For example, if a question is merely descriptive, confounding, and other sources of nonexchangeability have no explicit meaning. But, if the goal is to identify causes of a particular disease outcome, exchangeability is essential. It may be more difficult to achieve exchangeability in such circumstances, but the conceptual and methodological tools derived from counterfactual thinking would still be beneficial [20,21].

Redefine the exposure

Some constructs do not fit an interventionist frame because they are too broad—different contingencies of the exposure may have different effects even for the same individual and interference between units is likely. Many constructs central to social epidemiology, such as neighborhood poverty, are examples. Even researchers who are convinced that neighborhoods can have profound effects on health [22] note the difficulty this construct poses for effect estimation. One solution is to change the construct so that it can be imagined as an intervention. This approach has been used, for example, in the Moving to Opportunity experiment designed to provide evidence for the causal effect of neighborhood socioeconomic characteristics on health [23]. Because it is difficult to imagine an intervention to change these neighborhood characteristics under well-defined intervention requirements, the exposure in this study was redefined as the random distribution of a voucher that allowed individuals to move to a neighborhood with a higher socioeconomic status.

Although this design enabled the development of an actual RCT, its ability to address the question of whether neighborhood