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Epidemiology: Populations, methods and theories

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Introduction

There is much that I disagree with in Miettinen's paper [1], including his focus on medicine rather than health, the related view that all epidemiologists should first train in clinical medicine, and his tortous terminology which often involves inventing new complicated terms for old simple concepts. However, these disagreements partly just reflect the fact that Miettinen sees epidemiology through the viewpoint of medicine, whereas I see it through the viewpoint of public health [2]. Bearing these complementary perspectives in mind, there are some key ideas that I agree with, and which I will focus on here.

Populations

The first key idea is that there is nothing special about "clinical epidemiology" and that this is simply epidemiology applied to a population "of patients and other clients of health care" rather than to the general population. This differs from other definitions of clinical epidemiology which focus on *who* does the research and essentially define clinical epidemiology as "epidemiology done by clinicians". This latter approach doesn't make any sense, since clinicians also do non-epidemiological research, whereas non-clinicians also conduct clinical epidemiology studies, e.g. on the safety of various forms of treatment (I've done a few myself). More generally, it doesn't make any sense to define a science according to who does it, even if this is politically useful for clinicians (what's next? welder's epidemiology?). Rather, sciences are defined in terms of a particular object of knowledge. Epidemiology focusses on factors that affect the *health* of *populations* [2, 3], and the first issue is therefore which populations are being studied (e.g. the general population, occupational populations, clinical populations). There is nothing particularly special about clinical epidemiology in this respect, although some special practical and methodological issues arise because it involves a clinical population, with clinical exposures (e.g. treatment), and clinical outcomes (e.g. survival after treatment).

More generally, and going beyond what Miettinen implied or intended, the focus on *populations* is a key strength of epidemiology, and the key area in which epidemiologists have been able to "add value" in the past [4]. For example, many of the recent discoveries on the causes of cancer have their origins, directly or indirectly, in the systematic international comparisons of cancer incidence conducted in the 1950s and 1960s [5]. These suggested hypotheses concerning the possible causes of the international patterns, which were investigated in more depth in further studies. In some instances these hypotheses were consistent with biological knowledge at the time, but in other instances they were new and striking, and might not have been proposed, or investigated further, if the population level analyses had not been done. Thus, even if one is focusing on individual "lifestyle" risk factors, there is good reason to conduct studies at the population level [6]. Moreover, every population has its own history, culture, and economic and social divisions which influence how and why people are exposed to specific risk factors, and how they respond to such exposures [2, 3]. This population context is not just "noise" which we need to remove (control for); rather it defines the field of study (the object of knowledge).

Methods

The second key idea is that epidemiological methods should be subordinate to the object of study. Too often, epidemiologists define the field in terms of the methods that are used rather than the object of knowledge (i.e. the populations, exposures and health outcomes that are being studied and the theories that are being tested). A current example of this is "molecular epidemiology" which attempts to constitute a whole field of epidemiology based on the techniques that are used [7]. This doesn't make any sense (why don't we also have "questionnaire epidemiology"?), and the focus on a particular technology severely limits the hypotheses that are tested, and diverts attention from the proper focus of epidemiology on *exposures* and *health outcomes* in

populations. This is an extreme case of the tail wagging the dog, and of letting the technology define the hypothesis, rather than starting with the hypothesis and using appropriate technology to address it.

Similar considerations apply to the study designs that are employed. As long ago as 1976 [8], Miettinen showed that cohort studies and case–control studies are not fundamentally different study designs. Rather, they are estimating the same effect measures (e.g. the incidence rate ratio which Miettinen terms the "empirical incidence density ratio") by different methods. A cohort study typically involves doing this by gaining information on exposures and outcomes in the entire source population over the entire risk period (what Miettinen terms the study base), whereas a case–control study typically involves studying all of the incident cases occurring in the source population over the risk period and comparing them to a random sample of the same source population over the same risk period [8, 9]. There is nothing in this approach which inherently entails "backwards causality", a greater tendency to bias, or which requires a rare disease assumption, and it is somewhat depressing to see that these misconceptions about case–control studies are still widely taught and widely believed. Thus, I completely agree that we should focus on the etiologic hypothesis under study, and that the study design we use in practice to test the hypothesis is a secondary issue. Epidemiologic teaching should therefore be problem-based rather than methods-based [3], i.e. we should start with public health problems (or clinical problems), develop hypotheses, and use appropriate technology to test them. Instead, most epidemiology courses involve a collection of apparently unrelated study designs (cohort studies, case–control studies, prevalence studies), and data collection methods (questionnaires, biomarkers), and students then proceed to ask the questions that can be answered with these particular methods. As attention moves "upstream" to the population level [10], "modern" epidemiologic methods will become increasingly inappropriate, and new methods will need to be developed [11]. There is nothing particularly unusual in this; all sciences develop new methods in response to new problems. As McMichael [11] notes "who had heard of a case-control study or a multivariate personalised risk score this time last century?" The appropriateness of any research methodology depends on the phenomenon under study: its magnitude, the setting, the current state of theory and knowledge, the availability of valid measurement tools, and the proposed uses of the information to be gathered, as well as the community resources and skills available and the prevailing norms and values at the national, regional or local level [12].

Theories

Finally, I agree that "statistics is to epidemiologic research as mathematics is to physics", and that "astronomy is about the cosmos and not about the telescope". I have made the same point previously, namely that "if epidemiology is merely a system of measurement, then it can never claim to be a science" [3]. Other macro-level sciences such as cosmology also involve a great deal of measurement, but they also involve the development and testing of *theories* about the phenomena they are studying. In this context, I have argued that epidemiology can be likened to physics before Newton, a period when physicists were able to give quite accurate predictions of the motions of the planets (in fact they were more accurate than Newton's theories initially were), without having any insight into why the planets moved in the way that they did. Miettinen's conception of epidemiology as going beyond simple measurement to providing the knowledge base for the theory of scientific medicine is analogous to the broader conception of epidemiology as providing the knowledge base for public health [2]. The key feature of science is not *measurement* (this is just a tool), but *understanding*. This requires the development and testing of theories.

However, theories do not arise in the abstract, despite the abstract nature of Miettinen's proposals. To understand the occurrence of disease in human populations we need to know something about biology, but also we often need to know something about the populations, including their history and culture, and the effects of current developments such as globalisation. In the clinical situation also, history and context are important; diseases such as HIV/AIDS and SARS have not arrived out of thin air, and the way that patients respond to treatment (and what treatment they receive) differs greatly between demographic groups and over time. To know where epidemiology should go, we need to know where it has been, and to learn from it's rich history [2, 3]. Furthermore, we need to consider the current context rather than only providing abstract arguments. How can we discuss where epidemiology should go without knowing its history, and without discussing current developments such as HIV/AIDS, SARS, globalisation, and developments in public health and clinical medicine?

Definitions

So how should we define epidemiology, and how should it develop? Just as astronomy is about the cosmos, epidemiology is about the health of populations. The concept of *populations* is therefore fundamental to epidemiology. This embraces all aspects of epidemiology, including studies in clinical

populations, occupational populations, and the general population. These populations experience *exposures* and *health outcomes* and to understand their etiologic relationships it is not sufficient to simply describe the occurrence (the *distribution*) of disease; we also need to develop and test etiologic theories (which may involve population-level, individual-level or micro-level exposures) about the causes (the *determinants*) of these population patterns. Bearing all of these considerations in mind, the most appropriate definition of epidemiology is that it is the study of the *distribution* and *determinants* of disease in human *populations* [13]. Sometimes the old ideas are the best.

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