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An argument for renewed focus on epidemiology for public health

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Abstract

Purpose—While epidemiology has an indispensable role in serving public health, the relative emphasis of applications of epidemiology often tend toward individual-level medicine over public health in terms of resources and impact.

Methods—We make distinctions between public health and medical applications of epidemiology to raise awareness among epidemiologists, many of whom came to the field with public health in mind. We discuss reasons for the overemphasis on medical epidemiology and suggest ways to counteract these incentives.

Results—Public health epidemiology informs interventions that are applied to populations or that confer benefits beyond the individual, while medical epidemiology informs interventions that improve the health of treated individuals. Available resources, new biomedical technologies, and existing epidemiologic methods favor medical applications of epidemiology. Focus on public health impact and methods suited to answer public health questions can create better balance and promote population-level improvements in public health.

Conclusions—By deliberately reflecting on research motivations and long-term goals, we hope the distinctions presented here will facilitate critical discussion and a greater consciousness of our potential impact on both individual and population-level health. Renewed intentions towards public health can help epidemiologists navigate potential projects and ultimately contribute to an epidemiology of consequence.

As new students of epidemiology, many of us are drawn to the field with the ideal of improving the public's health *en masse*. We seek greater impact by informing health interventions at the population level to prevent disease, in contrast to medicine, which treats sick patients or minimizes disease risk in one individual at a time. Yet during our technical training in the methodological challenges of epidemiology, it is easy to lose sight of the public health we came to improve. We often work on projects based on availability and

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funding, and while we recognize these factors are difficult to ignore, we call on epidemiology students to think critically about how to navigate potential projects with their larger goals in mind. Epidemiology is not always geared towards public health, and we have a responsibility to continuously reflect on our work if we are to achieve the goals that originally brought us to this field.

Perhaps surprising to some, much of the work in epidemiology furthers the goals of medicine – to identify high-risk populations for medical interventions and to improve patient outcomes. Only a minority of this medically-relevant work informs population-level interventions, sometimes termed community medicine. Broad subfields of epidemiology, such as genetic epidemiology (research of necessarily individual risk factors) and pharmacoepidemiology (research of drugs and medical interventions), produce research that is primarily applied at the individual healthcare level.

We would like to emphasize that epidemiology has an important role in both public health and medicine; we do not attempt to suggest right or wrong applications for epidemiology or discourage epidemiologists with medical backgrounds. Furthermore, we appreciate the symbiotic relationship between public health and medicine. However, given that public health is the driving motivation for many epidemiologists, we wish to make a distinction between public health epidemiology and individual-level medical epidemiology that can be assessed thoughtfully among those beginning a career in epidemiology. We suggest that it is deconstructive to conflate medicine focused on individuals with public health because it allows medicine to overshadow public health – in terms of securing resources and, by extension, impact. Furthermore, failure to clearly distinguish the two is a disservice to public health because it avoids consideration of critical questions about how the public and not just individual patients may benefit from interventions. In an effort to prevent the neglect of public health, we promote the part of epidemiology that is not medical and the indispensable role of epidemiology in serving public health. We hope that new epidemiologists will be better able to make their work consequential [1] by deliberately reflecting on these motivations and long-term goals.

Distinction between public health and medicine

Discussions over the distinction between public health and medicine have been present in the epidemiology and public health literature since the mid-19th century [2]. While epidemiology is often called the basic science of public health, and definitions of epidemiology generally focus on the health of populations [3–6], epidemiologists have not always agreed on the appropriate role for epidemiology with respect to public health and medicine. This lack of clarity may have roots in the fact that until very recently (in the last 50 years or so), nearly all epidemiologists were physicians. The first doctoral degrees in epidemiology at the University of North Carolina-Chapel Hill, for example, were not awarded until 1963 [7], and before 1980, 93% of officers of the Epidemic Intelligence Service, the premier training program for applied epidemiology at the CDC, were physicians [8]. While many physicians have championed public health and helped drive the development of epidemiology with an orientation towards public health, this history of

epidemiology as within the physicians' domain is likely partially responsible for the unclear delineation between the disciplines.

The major distinction between epidemiology for public health and individual-based medicine was highlighted in a seminal paper by Geoffrey Rose who explained the differences between causes of incidence and causes of individual cases, showing that populations are not simply sums of their individuals [9]. Epidemiologic studies must therefore investigate appropriate disease causes and contexts depending on the focus—populations or individuals. For example, he notes that genetic factors may "dominate individual susceptibility," but "explain rather little of population differences in incidence" [9]. Because the causes of cases may differ from the causes of incidence [9], narrow focus on individual causes can lead to a "biomedical fallacy, that is, the error in inferring that risk factors for diseases in individuals can be summed to understand the causes of disease in populations, or that the health of a population can be explained entirely in terms of the characteristics of individuals" [6].

Beverly Rockhill built on this work to argue that the study of individual risk factors and related interventions will not be effective in modifying population incidence and therefore improving public health [10]. There are many supporting examples in which results from epidemiologic studies targeting individual risk factors did not translate to successful public health interventions. For example, the Stanford Five-City Project, Minnesota Heart Health Program, and the Pawtucket Heart Health Program were ineffective at reducing the risk of cardiovascular disease at a population level, even with a combination of individual- and community-level interventions [11]. Similarly, the trials of sexually transmitted disease treatment to prevent HIV transmission in Mwanza, Tanzania and Rakai and Masaka, Uganda produced conflicting results suggesting that time, place, and other population level factors are critical modifiers of the impact of individual-level interventions and must be understood and targeted appropriately [12]. The importance of public health interventions is also supported by evidence that improvements in population health in the 20th century were largely the result of changes in social and environmental factors rather than in medical services [13–15].

Where does epidemiology fit in?

While there are substantial areas of overlap between epidemiology with public health and medical applications, we suggest the distinction between them is useful to highlight their unique merits and to understand the potential impact of our epidemiologic work. We distinguish them broadly from an interventions perspective: public health epidemiology informs interventions that are applied to populations rather than individuals (such as seatbelt or food safety laws) or that confer benefits beyond the individual (such as herd immunity from vaccines). Conversely, medical epidemiology informs interventions that improve the health of the treated individual, often as part of clinical care or within the traditional healthcare system. The majority of these interventions are applied to and impact individuals rather than populations.

Because epidemiologic investigations almost always involve the study of groups of people (populations), one might assume they will necessarily translate to an impact on population health. However, classic population-based study designs do not ensure public health impact. Often, individual risk factors may be identified in a population only to be applied to interventions at the individual level (i.e. through clinical care). Similarly, in the study of individual risk factors, one might assume results can be translated to public health through large-scale targeting of interventions. Yet, epidemiologic studies that identify high-risk subgroups do not always inform public health interventions since targeting of interventions often occur when individuals present to the healthcare system.

Traditionally, subfields of epidemiology including environmental, occupational, and social epidemiology have contributed directly to public health. For example, environmental epidemiology focuses on exposures such as air pollution and radiation from telecommunication wires that are external to individuals and can generally be modified at the community or population level. Similarly, occupational epidemiologists study workers' health to identify work-related exposures that can be modified to reduce morbidity and mortality incidence in the workforce. Social epidemiologists study broad social structures and determinants of health that are defined by the social environment of populations and can generally only be modified at the population level.

In contrast, pharmacoepidemiology, clinical, and genetic epidemiology have tended towards medical epidemiology. Pharmacoepidemiology, which largely focuses on the study of drugs, is directly translatable to medicine, where these drugs are dispensed and monitored. Similarly, clinical epidemiology focuses on hospital and healthcare-related topics. Genetic epidemiology aims to identify genes as causes of disease, which are individual, unmodifiable characteristics. Genes cannot change at the population level in the relatively short timescale to account for recent disease trends (e.g. the obesity epidemic), and evidence of genetic causes are generally translated to interventions on a case-by-case basis. While this work is important from an individual therapeutic perspective, and there are exceptions, applications to population-level health are more difficult to realize.

The challenges of promoting public health epidemiology

Without a maintained intention towards improving public health, the tendency will likely be to drift towards medical applications of epidemiology. Apprehension over the distancing of epidemiology from public health has a long history [4]. The prevention paradox, such that population interventions provide little benefit to individuals, as described by Geoffrey Rose, continues to contribute to low motivations for public health interventions [9]. In contrast to the highly visible gains in medicine which are easily lauded to donors and the public, the benefits of public health are difficult to communicate since success is often measured by the absence of disease.

As a result, available resources for epidemiology largely favor biomedical research and interventions. The National Institutes of Health (NIH), which funds the majority of epidemiology researchers, is advertised as "the leading supporter of *biomedical* research in the world" (emphasis added) [16]. Epidemiologists are encouraged to pursue NIH grants,

which are a primary funding mechanism for conducting independent research and often viewed as the ticket to a successful career [17, 18]. In aiming to please study sections composed of basic scientists and physicians, it is often easiest to highlight the medical significance of our work and impact on patients.

The disparities in resources between public health and medicine have grown with recent advances in biomedical technologies. Some suggest that the technologies associated with molecular epidemiology promise a new direction for the field [19–21]. High expectations for the impact of whole genome sequencing, for example, have attracted scientists and research dollars. However, these techniques are often used to study characteristics of individual cases and can shift focus away from interventions that benefit the public.

The recent attention on personalized medicine has further shifted interest and resources to medical epidemiology. Personalized medicine seeks to leverage genetic and other molecular factors specific to an individual to develop tailored treatment strategies [22–24]. By focusing on individuals, personalized medicine could be considered the diametric opposite of public health. Personalized medicine can necessarily only be applied to individuals in a healthcare setting. Further, individual-level data is becoming increasingly available and cheap to collect with the advent of social media and smartphone-optimized health-tracking software. Analysis methods have been developed to handle the challenges associated with this “big data” [25]. As epidemiologists, we are always in search of data and may be attracted to this type of individual-focused health information that may increasingly present opportunities for research.

Many standard epidemiologic methods are also often more easily applied to questions relevant for medicine rather than public health. Cohort studies are considered the gold standard design for observational studies, and are optimal for measuring and studying exposures at the individual level. Upstream factors that may lead to population level interventions are more difficult to measure [26]. The magnitude of effects of upstream determinants will likely be smaller given the many mediating causes between them and the effects of interest. Alternative study designs, including ecological studies, are often dismissed as inferior and to be avoided when possible. The cultural anxiety over the ecologic fallacy discourages population level studies [6], while the assumption of independence in individual-level analyses is often accepted without question.

More recently, the growing interest in causal inference as a modern approach to causality in epidemiology may also unwittingly push the field towards medical applications. Causal inference methods were largely developed in the clinical context of understanding the effects of antiretroviral treatment on HIV outcomes using time-varying information on CD4 cell counts [27]. As a result, these methods are most easily translated and applied to other similar medically-relevant questions with high-resolution, longitudinal patient-level data.

Not only is the history of causal inference based in the clinical realm, but the required assumptions of the methods also favor clinical applications. A pre-requisite for making causal inference is to identify a well-defined intervention that could result in the observed exposure distribution [28]. While no restrictions are made on what type of intervention that

might be, it is easier to precisely define individual-level interventions than population-level interventions. The assumption of treatment-variation irrelevance, which requires that differences in versions of the treatment are irrelevant for the outcome [29, 30], will often be more tenable for medical interventions, such as taking one aspirin per day, compared to public health interventions, such as a policy change to prohibit smoking in the work place. For example, there would be fewer variants of a medical intervention to take one aspirin per day, compared to a public health intervention involving a policy change to prohibit smoking in the work place [31]. Studies of medical exposures and interventions may be lauded as more scientifically valid or unbiased since they are better able to meet this and other assumptions needed for causal inference [31].

Finally, medicine is often seen as apolitical—cases of disease can be considered either idiosyncratic happenings or due to individual shortcomings. Public health approaches necessarily involve messier questions about power, social policy, resource distribution, public investment, and economic inequity. In the 1840s for example, arguments for a greater focus on biomedical causes of death were made as “an attempt to steer medicine away from a political critique of the industrial revolution” [2]. Biomedical explanations provide an opportunity to side-step public health goals involving social justice, human rights, and reduction of health disparities.

The need for public health epidemiology

Despite incentives that promote medical applications of epidemiology, epidemiology has a critical role in serving public health. Over-emphasis on medical interventions may result in missed opportunities for greater impact through population-level improvements in public health. For example, focus on genetic determinants for an individual-level response to obesity will not address the underlying causes of the epidemic, and therefore will not likely affect change at the population level. Imagine an alternative response to one of the greatest epidemiologic findings of the 20th century—that smoking causes lung cancer. If we had attacked the lung cancer epidemic by providing personalized drugs to those who were at high risk for cancer rather than introducing smoking bans and large-scale health education campaigns, it is unlikely that the substantial reductions would have been achieved in lung cancer incidence, and more importantly in smoking prevalence, which increases risk for numerous other health outcomes as well.

Public health also has a unique ability to address health equity, which was identified as a high priority for action at the 2009 World Health Assembly [32]. Interventions implemented through medical care often reach only those who have access and financial capabilities. While public health interventions may also inadvertently discriminate by failing to reach all populations [15], interventions that are structured towards a population (e.g. regulations and policies applied to an entire community) rather than specific individuals will have a better chance at improving health for all.

Further, prevention is often less costly than medical care, and reduces suffering by promoting health and reducing the incidence of illness. Public health interventions can also have spillover benefits by addressing multiple health issues at once. For example,

restrictions on smoking in public areas not only protect smokers themselves, but others who are subject to second-hand smoke. These measures might also reduce the incidence of many poor health outcomes attributed to smoking, instead of just one condition, as is often tackled in medical care. This ability to address more than one condition at a time contributes to the cost-effectiveness of prevention.

Finally, if public health is enabled to work effectively, then medicine wins, too. Fewer patients present to care with preventable diseases, and therapeutic focus can be redirected to conditions for which medical intervention is the best option.

Potential cross-over

The fields of public health and medicine are inherently connected, and a subset of topics in medicine fall within public health. Examples include the estimation of the population-level impact of screening for medical conditions and epidemiologic studies that inform medical care policies. Even genetic epidemiology can have public health implications. If a genetic variant is found to be a modifier of a health effect, information on the population-level distribution of the variant is crucial for estimating the effect of interventions in target populations with different distributions of that variant.

In some instances, individual-level medical applications of epidemiology may also serve public health. For example, the case management and treatment of infectious diseases through clinical care can also benefit population health by reducing transmission of infection to others—a public health goal. Improved diagnostics (rapid diagnostic tests) and drugs (artemisinin-based combination therapy and primaquine) for malaria case management are important components of strategies to reduce malaria transmission in endemic areas [33–35]. Similarly, HIV treatment as prevention is a promising individual-level intervention to reduce HIV incidence by reducing the infectiousness of HIV-positive individuals [36]. This same logic could be applied to other areas where clinical and pharmacoepidemiology, traditionally more medically-oriented, link well with the goals of public health. While these areas of overlap exist, the question is one of emphasis. Individual-level medicine dominates the field, and we suggest a more equal balance is needed that promotes public health applications.

Navigating the distinction

With the distinction between public health and individual-level medical epidemiology in mind, how do students and young investigators navigate choices of potential areas of research? The first step is to be conscious of personal goals and develop an outline of the ideal impact you would like to make. For some, this may be to promote advances in medicine. For others, improvements in population-level health, health disparities, or other public health goals may be more important. With a defined perspective, it will be easier to assess potential opportunities that arise. Periodic reflection on our work in relation to those goals will help maintain intentions towards public health.

Available opportunities may not always match ideals, and students may feel torn between following their heart or the money and the promise of a more successful career. Because

projects with non-public health goals may be better funded, it may not be possible to work only on public health-related issues. The epidemiology student should not despair. Opportunities to learn and gain new skills outside of your interest area are worthwhile, and public health work can be pursued in other ways. For example, if it is not possible to take a job with public health goals, service opportunities can be pursued that promote public health more directly. Moreover, students may be able to incorporate a public health focus into projects that are more medically oriented by highlighting areas of potential cross-over like those described above. This might take the form of pursuing how associated interventions could be applied more broadly or how the results could be translated to health policy. Public-health oriented epidemiologists could further consider it their responsibility to be advocates for the public health perspective among classmates and colleagues. This includes encouraging discussion in academic courses about how a given topic or method impacts population-level health. During opportunities to influence resource allocation, such as when sitting on NIH study sections, epidemiologists could champion proposals for population-oriented research that will have high public health impact.

Another avenue to promote public health-oriented epidemiology is to develop and implement epidemiologic methods that are better suited to answer public health questions. These methods may address causality in situations that do not meet the restrictive assumptions required by modern causal inference, as may often be the case in public health-focused projects. We need to acknowledge that randomized controlled trials (RCTs) are not necessarily the gold standard for answering questions of public health importance and may not generate the most valid evidence for developing public health interventions. Alternative study designs and methods focused on issues of causality unique to public health are critically needed. Towards this aim, a causal impact framework has recently been developed to encourage epidemiologists to make their scientific results more relevant to public health by formally assessing external validity and estimating population intervention effects in addition to ensuring internal validity [37]. The further development and broader implementation of these and other methods will contribute to the dissemination of evidence from epidemiologic studies that is more directly relevant to public health goals.

Conclusion

While distinctions between public health and medical applications of epidemiology are not new, they are rarely an appreciated focus during standard epidemiology training. To maximize our effectiveness as epidemiologists with public health goals, we must understand the differences and our unique skills that set us apart from individualized medicine. While there may be resistance to making boundaries for our field in terms of type of work, application, and purpose, we hope the distinctions presented here will promote critical discussion and a greater consciousness of our potential impact. In addition, acknowledgement of the distinctions will hopefully drive the development and implementation of study designs and analysis methods that are better suited to tackle public health-relevant questions. These discussions are especially critical early in the training of epidemiology students. Students who are drawn to epidemiology with the goal of informing interventions to improve public health should be conscious of these issues when navigating the many factors that determine what projects they pursue. We hope the discussion and

resulting renewed intentions towards public health will help epidemiologists determine how they can best contribute to an epidemiology of consequence.

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List of Abbreviations

NIH	National Institutes of Health
HIV	human immunodeficiency virus

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