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Social Epidemiology: Past, Present, and Future

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Abstract

In a context where epidemiologic research has been heavily influenced by a biomedical and individualistic approach, the naming of "social epidemiology" allowed explicit emphasis on the social production of disease as a powerful explanatory paradigm and as critically important for interventions to improve population health. This review briefly highlights key substantive areas of focus in social epidemiology over the past 30 years, reflects on major advances and insights, and identifies challenges and possible future directions. Future opportunities for social epidemiology include grounding research in theoretically based and systemic conceptual models of the fundamental social drivers of health; implementing a scientifically rigorous yet realistic approach to drawing conclusions about social causes; using complementary methods to generate valid explanations and identify effective actions; leveraging the power of harmonization, replication, and big data; extending interdisciplinarity and diversity; advancing emerging critical approaches to understanding the health impacts of systemic racism and its policy implications; going global; and embracing a broad approach to generating socially useful research.

INTRODUCTION

Over the past 30 years, the term social epidemiology has been increasingly used to refer to a subfield within epidemiology that focuses on understanding how social organization shapes the distribution of health and disease. Social organization encompasses a range of structures and systems, including social and economic relationships, rules and policies, and norms. It includes a broad set of factors such as social structure and levels of inequality, the economy, distribution of resources and organization of work, social hierarchies and relations between racial and ethnic groups, as well as cultural factors and social norms. In contrast with other areas within epidemiology that are defined by the health outcome, social epidemiology is defined by its focus on the broad set of social conditions that affect many health-related outcomes (59, 67).

Although one could argue that all epidemiology necessitates consideration of the social world, in a context where epidemiologic research has been heavily influenced by a biomedical and individualistic approach, the naming of "social epidemiology" allowed explicit emphasis on the social production of disease as a powerful explanatory paradigm and as critical to identifying the policies needed to improve population health. The complexity of the social and biological worlds and how they interact to affect health has made this line of inquiry particularly challenging, but has also made it fertile ground for critical thinking and innovation in epidemiology and population health research more generally. In this review, I briefly highlight key substantive areas of focus in social epidemiology over the past 30 years, reflect on major advances and insights, and identify challenges and possible future directions.

MAJOR SUBSTANTIVE AREAS OF FOCUS

The substantive areas of focus in social epidemiology over the past 30 years have been broad and varied. A significant portion of the work has focused on generating the evidence base for the argument that social conditions play a major role in the generation of ill-health. A related body of work has focused on identifying the specific processes through which this social causation operates in order to both lend support for causal claims and improve causal understanding of biological processes themselves (as they often cannot be fully understood without reference to the social context in which they operate). In more recent years, there has been growing interest in investigating the health impacts of interventions or policies that focus specifically on social determinants.

The Social Patterning of Health: Describing and Inferring Social Causation Writ Large

Description of the social patterning of health has been key to the demonstration that social organization has profound impacts on health. The simple quantification of differences in health by social class, race and ethnicity, or place of residence immediately suggests that social processes linked to economic systems and inequality, systemic racism, and residential segregation play a major role in shaping population health. Significant work in social epidemiology has focused on describing and quantifying this social patterning as a way to motivate more in-depth inquiry into causation, but also as a way to buttress the argument that there are significant health inequities by class, race, and neighborhood that need to be addressed, whatever the underlying processes driving these differences may be.

Research on social stratification and health has conceptualized social position in various ways. Although constructs such as socioeconomic status, socioeconomic position, or social class are sometimes used interchangeably, they have specific meanings based on the underlying theory of social stratification (71). Using measures such as income, education, or occupation as proxy

measures of social status, socioeconomic position, or class, research has quantified the size of social differences, explored the shape of the relationship between social position and health, and investigated heterogeneity in social patterning over time and place (3, 15, 36, 56, 85). Other work has attempted to isolate the relative importance of specific dimensions such as schooling, income, or wealth (60). The examination of the links between social stratification and health has also extended over the life course, illustrating how social position at different points in time can have independent or interacting effects (11, 25, 58).

Another major area of emphasis has been the documentation of differences in health by race and ethnicity. The terms race and ethnicity are used to capture socially constructed population categories linked to perceived ancestry or geographic origin, physical features, or shared culture and language (12) that capture differential access to power and resources in society (129). Social epidemiologic inquiry has highlighted the contributions of social organization to race differences, moving beyond scientifically unsound attributions of race/ethnic differences to biological or genetic differences. A large body of work has demonstrated race differences in social, economic, and environmental conditions (e.g., education, income, wealth, work conditions, neighborhoods) that may affect health (130). These race and ethnic differences are, in turn, driven by historical and social processes of systemic racism and structural inequality (7). The individual experience of racism or discrimination has also been documented as a health determinant (75, 98). Social epidemiologists have argued that race differences in health emerge from a system that structures opportunity, resources, and exposures by race (8, 127). A related area of social epidemiologic inquiry has focused on the health consequences of immigration and acculturation. This work has shown how the process of adopting the norms and lifestyle of a new country (sometimes referred to as acculturation or assimilation) can have important and varying health implications (1, 109). Because immigrants are often members of minoritized groups in their new country, the effects of migration history and acculturation on health are closely linked to the health effects of inequality and racism.

Whether formal causal inference methods need to be used to draw broad conclusions about social causes of health has been the subject of spirited debate (51, 114). Because the social processes leading to differences in health by social position, race, or immigration history involve the functioning of systems with multiple interacting pathways and long causal chains, the broad causal questions that are of interest in social epidemiology are often not easily amenable to causal inference methods designed to quantify the short-term causal impact of changes in very specifically defined factors, with all other factors held constant. And yet it would be difficult to argue that social causation cannot be inferred from the persistent documentation of pronounced differences in health (across many health outcomes) associated with social stratification and race in the context of unequal and racist systems. These descriptive analyses are fundamental to making the case that social organization shapes the distribution of health and disease, even in the absence of precise counterfactual comparisons. We return to the topic of causal inquiry in social epidemiology later in this review.

Beyond Individuals: From Multilevel Determinants to Systems Approaches

Another important area of emphasis in social epidemiology has been the incorporation of factors at different levels of organization in conceptual models and in empirical analyses. This emphasis on multiple levels has stimulated formalization of the notion that epidemiology needs to look beyond individual-level factors in understanding health and has ushered in extensive discussion within epidemiology on the implications of this multilevel approach for study design and analytical methods. The broadening of epidemiologic inquiry to explicitly encompass factors defined at

levels above individuals has major implications for the types of interventions and policies that may be identified as relevant to health. Levels of organization of interest in social epidemiology have included neighborhoods, workplaces, schools, and states among many others. Three examples of substantive areas that have pioneered this multilevel approach include investigations of the health impacts of income inequality, social capital, and neighborhood features.

Income inequality has received significant attention because of the pervasiveness of income inequality across the world and because it is amenable to policy. There is little doubt that countries with more income inequality tend to have worse health outcomes even after adjusting for gross domestic product or summary measures of income, as demonstrated by a long history of ecologic analyses (111, 126). These associations may reflect, at least in part, the dual facts that more unequal countries generally have more individuals who live in poverty (or at lower levels of income generally) and that income is strongly related to health (sometimes nonlinearly) across the income continuum (53). In the early 2000s, a rich discussion emerged as to whether individuals who live in more unequal societies have worse health regardless of their own level of income (82, 118, 119). Some hypothesized that these associations would be mediated primarily through the psychosocial consequences of relative deprivation (62). Others suggested that any contextual effect of income inequality was likely due to differences in policies and social investments associated with income inequality (82). Debates about whether income inequality itself (over and above any effects of individual-level income) affected health led to a surge in multilevel studies that attempted to isolate the contextual effects of income inequality from individual-level social position (103). Debates ensued regarding the appropriate level of measurement of income inequality (e.g., countries, states, neighborhoods), the time lags likely to be involved, the extent to which studies appropriately controlled for confounders, and the mechanisms linking population levels of income inequality to health (22, 24, 50, 103). In many ways, the story of income inequality and health illustrates the challenges inherent in identifying the health impacts of a policy-relevant, population-level attribute, which itself is correlated with many other population attributes, may act through many interrelated mechanisms (including the effects of individual-level income itself), and may operate over very long time periods.

The construct of social capital also received significant attention. Social capital has been defined as "the resources—for example, the exchange of favors, the maintenance of group norms, the presence of trust, and the exercise of sanctions—available to members of social groups" (124, p. 105). Social capital encompasses social cohesion (solidarity and trust, norms, and the ability to engage in collective action) and social connections as captured by the formal analysis of social networks (63). There has been substantial discussion on the definition of social capital and how it should be measured (61, 63). Research has documented associations of higher levels of social capital with better health (64), suggesting that social capital may be a source of resilience. But research has also documented adverse health impacts of social capital via social contagion of unhealthy behaviors and adverse effects in some individuals, potentially as a result of exclusion (104, 124).

A third and major area of focus for the multilevel approach has been the study of neighborhood effects on health. This field has encompassed a broad set of neighborhood-level constructs ranging from features of physical environments (such as access to resources and walkability) to social variables, including measures of neighborhood deprivation, segregation, and violence as well as constructs such as social cohesion or collective efficacy (33). Neighborhood health effects have received special attention because of their implications for so-called place-based interventions. Important challenges in this field of study have included the definition of the neighborhood (or, more precisely, the spatial context relevant to the process being studied), the measurement of neighborhood attributes, the appropriate time frame for expected effects, and causal inference challenges, especially challenges related to properly accounting for individual-level

confounders (29). The field has evolved from initially simplistic approaches that attempted to isolate a contextual effect of neighborhood disadvantage to sophisticated longitudinal studies, including direct measurement of a broad range of neighborhood attributes and the use of improved analytical approaches to strengthen causal inferences (18, 28, 34). Work in this area has also expanded to policy evaluation (20), randomized trials (20), and the use of systems modeling (6).

Over time, consideration of factors at multiple levels of organization has become the norm rather than the exception in population health research, stimulated by the focus on this approach in social epidemiology. The use of multilevel approaches has expanded to encompass a broad range of questions, including the health impacts of gender equality (96) and residential segregation (e.g., 65), among others. But social epidemiologists have also recognized the need not only to include factors at multiple levels of organization but also to capture the dynamics of the systems that underlie the social patterning of health. Social epidemiology has been at the forefront of efforts to bring systems thinking and the tools of complex systems approaches to population health (30, 43, 47). The systems approach is quite different from traditional approaches to causal inference in that it explicitly accounts for feedbacks, dependencies generated via social networks or other processes, nonlinearities, and conditional effects. Systems approaches include a large set of approaches and tools ranging from qualitative and participatory methods to social network analyses to sophisticated mathematical modeling using agent-based models or systems dynamics models (e.g., 5, 19, 72). A number of applications of systems approaches to social epidemiology questions have emerged (e.g., 6, 21, 38, 43, 131), illustrating the potential but also the challenges involved (19). Multilevel and systems thinking are two important ways in which social epidemiology has broadened conceptualization as well as empirical analyses in population health more generally.

Processes and Mechanisms: Tracing the Specific Pathways Through Which Social Organization Impacts Biology

Another area of focus within social epidemiology has been the characterization of specific mechanisms through which social factors affect health. Understanding of mechanisms can yield important scientific insight into the causes of disease more generally. In addition, it contributes to strengthening causal inferences in social epidemiology by explicating the specific ways through which the hypothesized social causation operates.

A large body of work has examined the extent to which behavioral factors mediate social differences in health (e.g., 73), the underlying hypothesis being that environmental and resource constraints and social influences shape the distribution of behavioral risk factors that then impact health (97). Debate ensued about what might explain social differences that persisted after behavioral factors were accounted for. Psychosocial factors were hypothesized to contribute to associations that remained after adjustment for behavioral risk factors. The set of psychosocial factors hypothesized as mediators of social differences include some that are more psychological in nature (e.g., depression, anxiety, anger, status perceptions) and others that are more social (social support) and encompass a broad set of domains, including stressors, emotional responses, and resources (86). Perceived discrimination has also been proposed as an important stressor in racist societies (75) and posited to contribute to race and ethnic differences in health.

The work environment, including job status, psychosocial factors, and physical and chemical hazards at work, has also been posited to contribute to social differences in health (23). Sophisticated models of work-related psychosocial dimensions, including demands at work, control over the work process, effort–reward imbalance, and social support at work, were conceptualized and empirically examined in relation to health outcomes (23). This work made a strong case

for the impact of work organization on health. Although less commonly investigated by social epidemiologists, differences in access to and quality of health care services have also been posited to contribute to social differences in health (e.g., 97).

A growing body of work also examined the links between social factors and specific biological processes. Early work focused on biomedical conditions and measures such as blood pressure, weight, and diabetes, with interest subsequently shifting to markers of inflammation and related biological domains (88, 93). Interest in stress biomarkers and in measures of cumulative biological dysregulation, such as allostatic load, as a way to capture how repeated exposure to stressors results in wear and tear on the body, also grew (37, 89, 115). In recent years, researchers advocated for expanding gene-by-environment interaction studies to include social factors (107) and have investigated how social factors relate to epigenetic markers and gene expression (40). In other work, researchers explored the links between social conditions and biological markers of aging, such as telomere length (94).

The quantification of how different types of factors (or sets of factors) contribute to or mediate social differences (e.g., percentage of effects mediated through different factors) has been challenging, owing to the rudimentary nature of many of the mediation analyses used, often simple comparisons of associations before and after adjustment, many times using cross-sectional data. Even when longitudinal data are available and when more sophisticated approaches are used, the quantification of mediation is rendered very complex because of the presence of confounders, the multiple mediators likely involved, and the possible interactions between mediators and between mediators and social antecedents (39). Perhaps the main contribution of mediation studies has been the demonstration of how pervasive the social patterning is of many behavioral, psychosocial, and biological factors linked to health. The fact that all these factors are consistently and strongly socially patterned has buttressed the argument that the social world is a major determinant of health. This patterning demonstrates the notion of embodiment, i.e., the process by which the social world has specific and measurable impacts on biological structure and function (69).

Policies and Interventions: Intervening on Individuals, Community, and Society

As has been noted elsewhere (9, 55), social epidemiology has focused much more on description of the social patterning of health and on etiologic and mechanistic research than on policy and intervention research. Yet the study of the health effects of specific policies or interventions is important not only to build the evidence base for specific actions but also to strengthen causal inference in social epidemiology more generally (32). The range of interventions and policies that can be investigated, the hypothesized health impacts, and the time frames over which they can be expected to occur are varied and broad, making this area of research challenging in terms of study design, data availability, and analytical methods.

The policies or interventions of greatest interest in social epidemiology are those that impact the social determinants of health directly. Interventions can range from very specific and narrowly focused (e.g., housing remediation programs or initiatives to increase access to fresh fruits and vegetables in neighborhoods) to much broader and upstream (e.g., reducing income inequality through taxation and redistribution). Other policies or interventions may not act directly on the social determinants of health but can contribute to reducing social inequities by targeting or modifying individual targeted behavioral or medical interventions so that they are more effective in certain social groups. These types of interventions can reduce inequities by blocking the mechanisms through which social causes operate. **Figure 1** presents selected examples of policies and interventions classified according to the level of intervention and the place along the social causation continuum at which the intervention primarily operates.

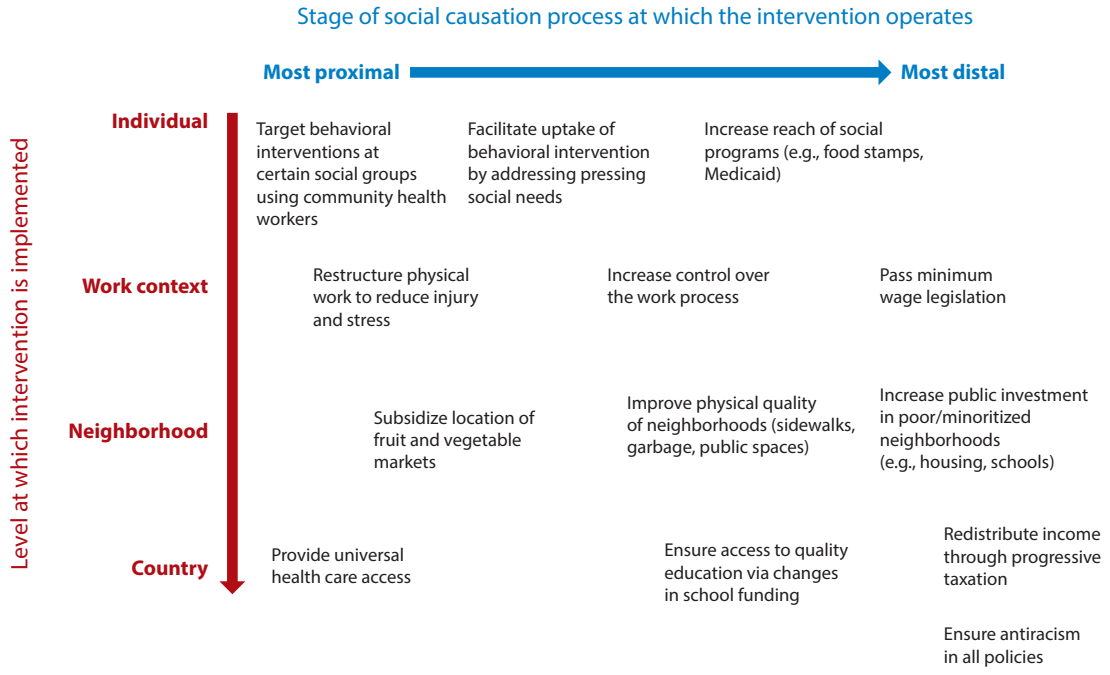

Figure 1

Schematic typology of policies and interventions that address social determinants of health.

A growing body of work in social epidemiology has leveraged experiments to identify intervention or policy effects. An often-cited example is the Moving to Opportunity trial. Originally designed to assess the impact of a housing voucher program on economic outcomes, it was extended to also examine health impacts of residential relocation to nonpoor neighborhoods (81). Another example is the Oportunidades trial, a randomized study of a conditional cash transfer program implemented in Mexico (42). Although these studies have shed light on the impact of the specific interventions tested, neither of them focused on broader policy strategies to address neighborhood or income differences in health. Such strategies would include things like investment in segregated or poor neighborhoods or the use of taxation to reduce poverty and income inequality. These kinds of policies are much more difficult if not impossible to study in randomized trials.

Because of the challenges in performing true experiments, many researchers have called for greater use of "natural experiments" (26). A number of efforts have been made to use natural experiments to gain insight into the health consequences of policies that target social determinants of health. Many focus on interventions on neighborhood or community features. Examples include the opening of new food stores (49), a new public transportation system (20), vacant lot greening (14), neighborhood revitalization initiatives (123), and interventions to improve social capital (57). Other studies have attempted to estimate the effects of policies that address broader elements of social and economic policy by capitalizing on heterogeneity across geographies or over time in specific policies. For example, Dahl & van der Wel (27) leveraged heterogeneity in social spending across 18 European countries to examine whether more social spending is associated with better health. Ludwig & Miller (80) capitalized on the way in which the Head Start program was implemented in US counties over time to assess the program's impact on child health. Montez et al. (90) used heterogeneity in state policies to estimate effects on differential life expectancy trends

by state. Systematic reviews across study designs have also been used to synthesize the impact of policies or interventions focused on the social determinants of health (121).

It is important to note that policies intended to improve population health may have unintended adverse health consequences (e.g., 41, 95) and can simultaneously increase health inequities as a result of how the policies interact with existing social structures and systems (79, 122). Assessment of all health or public health policies for their impact on health equity (be it racial, socioeconomic, geographic or based on other characteristics) is an important yet neglected area of research in social epidemiology.

CHALLENGES AND OPPORTUNITIES

The field of social epidemiology has been extraordinarily vibrant and has acted as an engine of innovation and motivated debate on the nature of epidemiology itself and its societal implications. In this section, I highlight some challenges as well as some opportunities for the future.

Grounding Research in Theoretically Based and Systemic Conceptual Models of the Fundamental Social Drivers of Health

Conceptual models are fundamental to any field because they make explicit theory and assumptions, facilitate the framing of research questions, and allow researchers to identify analytical implications. Conceptual models are embedded in underlying theories that make explicit the structures, processes, and dynamics that are posited to underlie the empirical regularities that we observe. This theory (which must itself be subject to empirical verification or refutation) is fundamental to the questions that we ask, the data that we collect and analyze, and the conclusions that we draw (68). In its quest to become more methodologically rigorous and empirically grounded, social epidemiology must not forget the fundamental role of concepts and theories in developing valid and socially useful explanations (91).

A myriad of different conceptual models for the social determinants of health have been proposed. One key challenge has been to expand these models so that they reflect levels of organization, time, dynamics (including feedbacks and dependencies), and pathways but still remain parsimonious enough to be useful (i.e., generate insight into fundamental drivers or guide specific empirical analyses). In some ways, the proliferation of many all-encompassing models has detracted from the generation of significant scientific consensus about what the fundamental factors, dynamics, and processes linking social organization to health are. Given the complexity of the links between social organization and health, it may be more useful to develop more focused models that aim to explain specific phenomena rather than models that attempt to very simply capture a very broad set of social influences on health. These more focused models may allow a better understanding of dynamic relations, something that many existing conceptual models tend to ignore (30). One example of a focused approach has been the fundamental social cause model proposed by Link et al. (78). Their model proposes a fundamental dynamic and generates testable predictions. Examples of other areas where the development of focused approaches with attention to dynamics would be useful (and are emerging) include the impact of systemic racism on health and the role of environmental factors in generating health inequities.

Implementing a Scientifically Rigorous Yet Realistic Approach to Drawing Conclusions About Social Causes

In recent years, social epidemiology has benefited from a more thoughtful consideration of causal inference from observational studies. Recommendations have included a greater use of tools

such as directed acyclic graphs to provide insight into identifiability of causal effects and the assumptions and analytical approaches required; greater formalization of the assumptions needed to draw causal inferences from observational studies; the appropriate use of state-of-the-art statistical approaches; and a greater focus on the study of the health impacts of policies or interventions using experiments or natural experiments (51, 55, 63).

One important methodological debate of particular relevance to social epidemiology has centered around defining which causal questions can be answered in the context of the potential outcomes approach to causality. The increased interest in formalizing causal inference based on the potential outcomes approach has led to debate about which factors should be the focus of causal inquiry in social epidemiology, and some scholars have argued that causal inference should be focused on exposures that can be explicitly defined as "realistic" or "practicable" interventions (52, 70, 114). Specifying the causal factor of interest as an intervention has many benefits. By specifying the causal question in a very precise way, it improves understanding of the data needed, the best analytical approach, and the assumptions involved. An added benefit is that the answer to the causal question also directly addresses the impact of a hypothesized intervention that could be realized in the real world.

However, in social epidemiology, we are also interested in understanding social causation broadly because this etiologic understanding is fundamental to identifying possible avenues for actions to improve health. The social production of health involves structures and systems. Hence fully understanding social causation requires comprehending how the systems work, something that cannot be fully done by reducing and narrowing the study of social causation (only) to identifying the effects of practicable interventions. As noted by Schwartz et al. (114), the exclusive focus on "well-defined interventions" in causal inquiry in social epidemiology tends to prioritize "interventions that are less social, less upstream, less system changing" (p. 255).

A challenge for social epidemiology in coming years is therefore to embrace both the advances of quantitative causal inference and the emphasis on policies and interventions without abandoning a broader focus on understanding the social structure and systems that give rise to health (110). Because the object of study of social epidemiology is how social organization affects health, social epidemiologists focus on a range of "causes" from broadly defined structural and very distal determinants that could operate in many different and interacting ways to specific factors, to definable interventions, and to definable interventions under very specific circumstances (31). This broad continuum of causes makes both causal inquiry and intervention research in social epidemiology much more complex than they are in the medical or even the traditional epidemiologic world. Even if the purpose of causal understanding in social epidemiology is to eventually identify actions, the broad understanding that we need cannot be achieved only by studying the impact of specific practicable actions today. Ultimately our goal is to understand reality better (including causes in the narrow sense but also describing phenomena and relationships) so that a range of possible actions can be identified. This goal requires the development of theoretically sound and empirically supported social explanations for the patterns that we see (91), and these explanations must draw on a range of different types of evidence that, when combined, strengthen our understanding of which factors are most important and how they work together (70, 91).

Using Complementary Methods to Generate Valid Explanations and Identify Effective Actions

The broad understanding of social patterning and social causation that is at the core of social epidemiologic inquiry (and that is critical to effective actions to improve health) will require

integrating many different types of evidence: rigorous quantitative causal inference from observational studies and natural experiments, true experimental studies, systems modeling, and real-life evaluations of interventions and policies under varying conditions (encompassing what is referred to as implementation science), including assessing the equity implications of policies (79, 122). The use of experiments and policy evaluation is important not only to identify effective actions but also to improve our fundamental understanding of the systems that drive health and health inequities (31). Additional methodological approaches, which often receive less attention in the discussion of epidemiologic methods, include surveillance and descriptive methods and qualitative comparative analyses.

Epidemiology has a long history of using surveillance not only to identify health problems in need of immediate action but also to provide insight into potential causes. From historical examples such as the work on the etiology of pellagra by Goldberger to recent work describing and inferring the drivers of the opioid epidemic in the United States (112), rigorous descriptive analyses have provided valuable insights relevant to understanding and to policy. The availability and access to more and more georeferenced and linked data on health and social circumstances provide unique opportunities for social epidemiology to refine its descriptions of the social patterning of health and its evolution over time.

Although there have been many calls for increasing the use of qualitative methods in public health, applications in social epidemiology have been limited (10). Qualitative methods can contribute to scientific understanding in social epidemiology by incorporating a more detailed and nuanced understanding of phenomena and processes that affect health across levels of organization, with attention to heterogeneity and context (10). Qualitative methods contribute to generating hypotheses and improving and interpreting the results of quantitative studies, but they can also contribute directly to causal understanding, providing insight into processes that quantitative studies can fail to capture (92). For example, qualitative comparative analysis is especially well suited to understanding conditional effects and, more specifically, causation resulting from multiple interacting factors (105). Increasing the use of qualitative approaches, and especially developing exemplars of the use of mixed methods approaches to advance knowledge on social epidemiology, is also an opportunity for the future.

Leveraging the Power of Harmonization, Replication, and Big Data

A major challenge in replicating and summarizing findings in social epidemiology has been the differences across studies in the definition and measurement of key social constructs. The large heterogeneity in definitional and measurement aspects is understandable, given the complexity of the factors that are being measured. Moreover, there are many reasons why epidemiologic findings may not fully replicate, including methodological issues (differences in confounder control, for example) as well as substantive reasons, including true heterogeneity in causal effects across samples as a result of different distributions of effect modifiers (74). Nevertheless, a greater focus on harmonization, replication, and evidence synthesis is a major need in the field. Systematic exploration of the robustness of results using quantitative bias analyses (54) as well as greater attention to systematically exploring heterogeneity (52) will also help facilitate evidence synthesis.

The rapid growth in the availability of large and often linked data sets ranging from administrative to genomic data and including high-dimensional social data of various types also creates opportunities for research in social epidemiology. Examples of this type of data include geographically referenced electronic health records, cell phone data on mobility, and policy or other contextual data. The use of these data sets can enhance the description of social patterning and thus yield

new insights into how the social world affects health. It may also improve observational studies of social etiology by facilitating the identification of instrumental variables (52). Longitudinal big data may also create opportunities for the analysis of natural experiments.

The availability of big data has also spurred interest in data discovery approaches such as environment-wide association studies (99) and machine learning approaches focused on pattern recognition and prediction as a complement to the hypothesis-testing approaches more common in social epidemiology (52, 116). Although applications of machine learning and data discovery approaches in social epidemiology are rapidly emerging, they are, for the most part, exploratory (66, 100, 108, 116), and the utility of these approaches in generating new insights remains to be determined. In addition, important questions have emerged regarding how algorithm-driven approaches can perpetuate biases and stereotypes (106). Finding the balance between theory-based and hypothesis-driven approaches and emerging data-driven approaches spurred by increased data availability and computational power will be an important challenge and opportunity for social epidemiology in the future.

Extending Interdisciplinarity: Beyond Epidemiology, Sociology, and Psychology

One of the defining features of social epidemiology has been its engagement with other disciplines, especially sociology, psychology, and human development. These interdisciplinary collaborations have facilitated the incorporation of new theories, measures, and analytical approaches (63). Growing interest in the social determinants of health within the clinical and biomedical world has spurred collaborations with medicine and nursing, including the incorporation of measures of social determinants into electronic health records (113) and the use of this information in clinical research (117). These are important areas for continued work to ensure that the use of social, race, or ethnic indicators does not contribute to stereotyping or perpetuate bias and racism. Growing interest in the health consequences of a range of public policies has also led to engagement with the fields of public policy, transportation, and urban planning. Creating the systems and infrastructures that allow partnerships to be established early to facilitate rigorous evaluation of the health and health equity impacts of a range of policy actions is also an area of opportunity for social epidemiology.

Another area for greater interdisciplinary collaboration involving social epidemiology is the area of climate and health and environmental factors more generally. Although there have been many examples of work in social epidemiology that has connected social determinants to environmental factors [including the long-standing and growing field of environmental justice (16)], the engagement of environmental and climate scientists has been relatively limited. Today these collaborations need to expand to the area of climate change and health. Significant opportunities include rigorous examinations of how environmental factors operating over the life course contribute to health inequities, the interactions between climate change and health inequities, and the impact of policies to address climate change on health inequities.

Understanding population patterns and social causation can benefit greatly from insights from law and the humanities, including history, ethics and related fields. One prime example is the call to expand the use of concepts, frameworks, and approaches drawn from critical race theory (44, 45) in order to improve the validity and social utility of research in social epidemiology by explicitly acknowledging the multifaceted ways in which systemic racism impacts health as well as the practice of health research itself. These calls challenge researchers to continuously reexamine their assumptions and their approaches, including how the lived experiences of communities are reflected in and inform the work (101). Another example is the call to move beyond stratification by race and gender to recognize how the intersectionality framework rooted in Black feminist scholarship

can aid in understanding the drivers of health inequities (13, 76). Reflecting on what critical race theory and intersectionality mean for questions, measures (46), study designs, conclusions, and actions in social epidemiology is a critical need and opportunity to advance scientific insights and actions.

Most importantly, the questions posed in social epidemiology, the data collected, the types of analyses done, and the way in which results are interpreted are all shaped in part by social and historical contexts and by the experiences and backgrounds of the researchers themselves. For these reasons, ensuring that researchers in social epidemiology reflect diverse backgrounds and lived experiences (in addition to different disciplines) is fundamental to the scientific rigor of the field and the social utility of the work it produces.

Advancing Emerging Critical Approaches to Understanding the Health Impacts of Systemic Racism and Its Policy Implications

Work in sociology and social epidemiology has highlighted the multifaceted ways in which structural racism, cultural racism, and individual-level discrimination affect the health of marginalized racial groups and contribute to health inequities (129). As noted by Williams et al. (129), "Racism has created a set of dynamic, interdependent, components or subsystems that reinforce each other, creating and sustaining reciprocal causality of racial inequities across various sectors of society" (p. 106). Racism impacts health through a set of interrelated structures and systems and is a fundamental cause [in the sense of Lieberson (77)] of health inequities across race and ethnic groups (102) in a way that is pervasive and operates through multiple evolving mechanisms across generations and over the life course. Despite the recognition of racism as a fundamental cause of ill-health, much work in health research continues to treat race as a purely individual-level descriptor and does not capture or address how racist structures, systems, and policies affect the health of racialized populations (17).

A number of scholars have discussed and questioned the ways in which race and racism are studied, discussed, and interpreted in health research, including social epidemiology. Specifically, social epidemiologists and other scholars and practitioners have called for explicit recognition of the health impacts of systemic racism in its many manifestations and have noted that explicit recognition of racism has implications for theories, concepts, and questions (4, 44, 48); measures and study designs (2, 35); and public health practice and policy (7, 8, 128). Most importantly, public health researchers and practitioners need to question and reflect on how they may perpetuate racism through existing theories, research questions, data collection, measures, and even analytical approaches (44, 87). Embracing emerging critical work on the links between racism and health; expanding the research agenda on racism and health to explicitly encompass systemic, structural, and policy factors (129); and considering the implications of this work for research, conclusions, and actions in social epidemiology are critical to both scientific rigor and effective public health and social action.

Going Global

Social epidemiology in the United States and in Europe has been, for the most part, focused on higher-income countries, and standard textbooks of social epidemiology (as well as the vast majority of published papers) tend to be focused on the United States and Europe (91). The utility of cross-country comparisons of health inequities and policies used to address health inequities has been noted (84), but rigorous studies of cross-country differences remain relatively rare and these comparisons have not been mined to their full potential. Although many insights

about the links between social organization and health may be common across the world, there are likely to be specificities and context-specific factors that affect the social patterning of health. In addition, local descriptions and locally generated knowledge can be powerful motivators of local action. Public health researchers and epidemiologists in lower-income countries have generated important insights and debates about the social determinants of health (120). Low- and middle-income countries can also provide opportunities for evaluation of the impact of novel policies and interventions. Documenting the magnitude, the determinants, and the impact of policies on health inequities globally remains a critical need.

A Broad Approach to Generating Socially Useful Research

In an insightful article written more than 30 years ago, Carol Weiss (125) reviewed the various ways in which social research relates to policy. **Table 1** illustrates the application of her framework to social epidemiology. It may very well be that social epidemiology affects policy most effectively through the enlightenment model. This assumption is especially appropriate given

Table 1 Models for how social epidemiology research may be used in policy. Models and definitions based on Weiss (125)

Model	Definition	Social epidemiology example	Comments and caveats
Knowledge-driven	Basic research identifies opportunity for application; applied research tests practical application; technologies and applications follow.	Physical activity behavior is influenced by social networks; social support for behavior change can be implemented via mobile phones and effectively changes behavior; a social support app is developed and implemented.	Social science knowledge often does not easily lend itself to a specific technology or application so examples are not common. This model is narrowly focused on individual-level interventions rather than on fundamental social causes. Basic social research more commonly influences policy in other ways (other models).
Problem-driven	A policy problem is identified and a decision has to be made; research is conducted (or identified) that sheds light on the problem and helps identify the best policy option to solve the problem.	Large differences in asthma incidence by race are identified. Research shows that environmental triggers linked to housing are related to asthma and differ by levels of neighborhood segregation. Housing remediation in high-poverty neighborhoods is adopted as policy to reduce asthma disparities.	Research can directly contrast policy options via quantitative analyses or provide context (quantitative or qualitative) that helps guide the decision, even if specific policy options are not quantitatively contrasted. Available research may not address the relevant knowledge gap; it can often be difficult to conduct research that specifically addresses the knowledge gap within the necessary time frame.
Interactive	Those engaged in developing policy seek information from a variety of sources and stakeholders, including but not limited to scientists. All pool their talents and beliefs to make sense of a problem and identify a solution.	Policy makers focused on improving conditions in childhood gather evidence from a range of groups (parents, teachers, child advocates, researchers). Researchers contribute understanding of living conditions in childhood and the many ways in which these conditions may influence health over the life course.	Scientists are one set of participants among many. Often they do not have convergent scientific evidence that bears directly and explicitly on the issue at hand, but they contribute as part of a group with different viewpoints to greater understanding and identification of a solution. It may not be possible to wait for more research, or it may be the kind of problem for which the type of additional research that could be conducted would not be directly relevant.
Political model	Policy makers have already taken a stand on a particular policy on the basis of history, experience, their view of the world (ideology), ethics, or past debates. Research is used to support the position.	To support related policy initiatives, advocates of increasing the minimum wage use research on the beneficial health impacts of increasing the minimum wage.	Research can be misrepresented or taken out of context to support a particular viewpoint. If all have access to the evidence and the evidence is not misrepresented, research as political ammunition can be a valid model of research utilization for policy.

(*Continued*)

Table 1 (*Continued*)

Model	Definition	Social epidemiology example	Comments and caveats
Tactical model	Policy makers use a lack of research as justification to delay action or use existing research as a way to defend unpopular decisions.	Lack of conclusive evidence on the causal effects of neighborhoods on health delays action to invest in marginalized neighborhoods.	Research is used as a tactic in politics rather than as a way to increase understanding or inform decisions.
Enlightenment model	The concepts, theories, and basic understandings that social science research has generated permeate the policy-making process.	Research on race differences in health and the multiple ways in which racism (structural, institutional, interpersonal) can impact health motivates policies aimed at achieving racial equity and modifying policies that sustain or increase racial inequities.	Influence of research on policy is not based on a single study or even a body of related studies. Rather, fundamental understanding driven by research affects the perceptions of the public as well as those of policy makers about problems, their causes, and their likely policy solutions. This model allows for the use of research that challenges dominant paradigms. This model can be vulnerable to misrepresentation of research or use of invalid research. Research findings can sometimes be contradictory, complex, or subject to variable interpretations and use. It can take time or be difficult for research findings to change beliefs/attitudes. Political will may be critical to allow science to impact policy via the enlightenment model.

the nature of the questions addressed by social epidemiology, where the narrowly targeted interventions or policy options that can be evaluated through individual studies likely have only minimal impact because they do not address the complex systemic forces that drive social differences in health (83). Under the enlightenment model, scientific findings regarding how the world works percolate through many different channels and, over time, provide decision makers with ways to make sense out of a complex world (125). Science also identifies new problems and suggests possible solutions (even if it does not specifically evaluate a given policy or intervention) and can in these ways influence the policy agenda in the long run. Most importantly, the enlightenment model also reflects how social epidemiology findings can influence public perceptions more broadly, challenge hegemonic explanations, and motivate social change by modifying how problems are perceived and which actions are considered desirable and even feasible. In this way, social epidemiology findings can expand the policy space (114). Fostering a greater awareness of the multiple ways in which social epidemiology findings can affect public perceptions and actions (including the empirical research that can shed light on these influences) is also an opportunity for the future.

CONCLUSION: TOWARD A SCIENTIFICALLY INSIGHTFUL AND TRANSFORMATIVE SOCIAL EPIDEMIOLOGY

At its core, social epidemiology is about generating fundamental knowledge. Because of its object of study, social epidemiology must necessarily be multimethod, interdisciplinary, and broad. Sometimes the knowledge generated by social epidemiology will lead to specific prescriptions for action, but other times (perhaps even most times) it will not. Rather, it will provide input into the broader social and political debate about the distribution and drivers of ill-health and their implications. This debate is what will ultimately drive actions and social change.

Addressing social inequities in health is much too important to be left only to epidemiologists. It is naïve to expect scientists alone to identify policies to fix entrenched inequities rooted in history and the economic and social systems that we have created. But a reinvigorated social epidemiology—one that embraces scientific rigor, comprehensive explanation, intellectual honesty, interdisciplinarity, and multiple methods and that does not shy away from the big problems

of inequality, racism, and the consequences of economic and social systems—can shed light on the drivers of population health and pull away the veil that often masks the social production of disease so that we as a society can decide what to do about it.

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