Epidemiology: Back to the Future

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In 2018, the Society for Epidemiologic Research and its partner journal, the *American Journal of Epidemiology*, assembled a working group to develop a set of papers devoted to the "future of epidemiology." These 13 papers covered a wide range of topic areas and perspectives, from thoughts on our profession, teaching, and methods to critical areas of substantive research. The authors of those papers considered current challenges and future opportunities for research and education. In light of past commentaries, 4 papers also include reflections on the discipline at present and in the future.

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In 2018, the Society for Epidemiologic Research and the its partner journal, the *American Journal of Epidemiology* (*AJE*), assembled a working group to develop a set of *AJE* papers devoted to the "future of epidemiology." We considered a wide range of topic areas and perspectives, from thoughts on our profession, teaching, and methods to critical areas of substantive research. We asked authors to consider current challenges and future opportunities for research and education. In addition, we asked a group of leading epidemiologists to reflect on the discipline at present and in the future in light of past commentaries.

"Futuring" and prognostication is a tricky business. We are greatly influenced by history and present day thinking; true and meaningful "outside-the-box" thinking is a rare skill and event. It's often the case that scientific change is very incremental, with only occasional real change. "Disruptive innovation" is much harder to come by. More often than not, past epidemiologic commentaries on the field and its future adopted or recycled previous controversies and calls for change. Nonetheless, the field has seen progression in thinking, methods, and applications. Even though a universally adopted set of canons has not been established, progress toward clearer concepts, tools, and views of the place of epidemiology in public health and biomedical science has continued. This has not been without controversy and uncertainty, but as you will find in this issue of the *Journal*, threads of continuity have emerged.

PAST PERSPECTIVES (THE 90S)

As a framework for the papers in this issue, we will briefly consider a set of 3 commentaries from 1990s that can serve as a benchmark. Although similar commentaries were published before and after, we find these illustrative. In 1992, the *AJE* published an invited address on the future of epidemiology by Terris (1) in a special issue devoted to the 25th anniversary of Society for Epidemiologic Research.

Terris noted trends in the state of the academic discipline, including: 1) its greater concern with methodology and withdrawal from community and field studies, 2) a widespread overemphasis on statistical approaches, and 3) a lack of a biologic orientation. He called for greater attention in some areas, including the importance of clinical disciplines and collaboration with laboratory science and with occupational and environmental epidemiology. Moreover, he asked for more focus on the effectiveness of health services and on improving prevention programs.

He offered this plea: "We cannot remain indefinitely in our ivory towers; they may crumble around us. We need to foster epidemiologic research, not only by improving our methodology and sharing our scientific experience, but by helping to convince the American public and its legislators that prevention is far more important than treatment, that our expanded agenda for research needs full legislative and financial support,

and that the application of our findings to improve the health of the public must become the highest priority for health policy in the United States" (1, p. 915).

In 1996, Susser and Susser (2, 3) suggested a "momentum for a new era" of epidemiology. In their view, the limits of knowledge of risk factors and interventions directed solely at changing the behavior of individuals have proven insufficient and a change at societal levels was needed. They suggested a new paradigm based on technologic developments in biology, biomedical techniques, and information systems, including mining data across societies. They optimistically noted, "In the evolution of modem epidemiology, dominant paradigms have been displaced by new ones as health patterns and technologies have shifted. As happened with previous paradigms, the black box, strained beyond its limits, is soon likely to be subsumed if not superseded entirely by another paradigm. This paradigm reflects a particular era in our development as a discipline. In our view, we stand at the verge of a new era" (2, p. 672). They named the emerging era "eco-epidemiology" and referenced the paradigm of Chinese boxes, with relations within and between localized structures organized in a hierarchy of levels and with the analytic approach based on the determinants and outcomes at different levels of organization within and across contexts (using new information systems) and in depth (using new biomedical techniques). A preventive approach would include the application of both information and biomedical technology to find leverage at efficacious levels from contextual to molecular.

In an article published in 1996, Pearce offered the view that "[e]pidemiology has become a set of generic methods for measuring associations of exposure and disease in individuals, rather than functioning as part of a multidisciplinary approach to *understanding* the causation of disease in populations" (4, p. 682). He continued, "We seem to be using more and more advanced technology to study more and more trivial issues, while the major population causes of disease are ignored. Epidemiology must reintegrate itself into public health and must rediscover the population perspective" (4, p. 682).

BACK TO THE FUTURE

In the current issue of the *AJE*, the authors have provided broad, diverse, and sometimes conflicting viewpoints on what is important to epidemiology now and what will be important in the future. What can be gleaned from these viewpoints, how do they connect or diverge, and what are our overarching principles and goals? What are our methods, what are the most critical areas of investigation, and what is the future of training? Do we have reasons for optimism?

THE ROLE OF EPIDEMIOLOGY IN PUBLIC HEALTH

The debates about the place of epidemiology in public health, its mission and goals, and its applications and its methodologies that were mentioned in the commentaries from the 1990s continue in the present time. Galea and Keyes (5) call for a redefinition of epidemiology as fundamental to population health science, which will compel us to broaden our thinking and the questions we ask

—avoiding "subdisciplinary fragmentation"—and to provide a basis for a new way to teach future epidemiologists. They argue that this way of thinking allows reconciliation among the threads of the debates about methods, causal reductionism, and our fundamental mission to serve public health. Diez Roux (6) argues that retaining a connection to policy and practice is critical to the future of epidemiology but that there are multiple ways (beyond causal inference) in which epidemiology can be "consequential." Kuller (7) argues that academic epidemiology has lost its connection with public health and preventive medicine and that epidemiology has done poor job in identifying new epidemics. Samet and Woodward (8) suggest a blurring of the distinctions between the various professionals concerned with population health, with a resulting increase in interdisciplinarity.

METHODS, BIG DATA, AND TECHNOLOGY

As in the 1990s and the intervening period, quantitative methods and causal thinking have attracted much attention and a certain amount of scorn. While epidemiologists continue to debate a possible overemphasis on methods in research and teaching, rapid evolution in statistical methods, computing, and data technologies and the emergence of so-called big data and new biotechnologies have drawn considerable attention. The papers on methods and big data in this issue have provided much to think about with regard to the challenges and opportunities afforded by these almost revolutionary changes. What's notable in addition to the statistical and technologic advances is that multiple authors are advocating care in proceeding in the context of careful definition of research questions, adherence to epidemiologic principles, but also the opportunities that these tools and resources have to offer. For example, Glymour and Bibbins-Domingo (9) suggest that statistical methods are important but that we must prioritize the articulation of relevant research questions and develop strong study designs in the context of observational research that provide actionable clinical or population health relevance. They propose that new data sources (administrative records, technologies such as sensors) should be leveraged. Shortreed et al. (10) provide an overview of the integrity of and challenges in the use of electronic health records. Diez Roux (6) calls for greater methodologic diversity and opportunism. Harper (11) posits that observational epidemiology can be improved by better definitions of the research questions and inferential goals and greater use of quantitative bias analysis and alternate designs, and he emphasizes the importance of reproducible research standards. Manrai et al. (12) address the challenges and approaches to big data or "massive data sets," including the X-wide association study approach, and further describe ways to address confounding and other biases, as well as consideration of replication, triangulation, and other approaches in the assessment of effects. Cerda and Keyes (13) provide an overview of systems science and its application to epidemiology, which includes testing assumptions about mechanisms and identifying potential interventions. Although these systems approaches have their own challenges, they may offer one approach to bridging threads of epidemiologic, statistical, policy, and public health science.

AREAS OF INVESTIGATION

Lewnard and Reingold (14) offer an overview of current priorities and challenges in the epidemiologic investigations of infectious diseases. They highlight advances in the integration of molecular data with other data sources to facilitate surveillance, modeling, and public health practice. Infectious disease epidemiology has been at the root of our discipline, and much of how it successfully integrated biologic knowledge, social factors, and translation into public health practice, prevention, and policy can be applied to the study of chronic diseases and other health conditions.

Anderson et al. (15) address climate change, one of the most important global public health challenges of our time and in our future. The role of epidemiologists in climate science is critical and has been evolving. This area has many challenges and will require epidemiologists to further develop interdisciplinary approaches and new disciplinary knowledge and to wrangle big data in an especially challenging political context.

TRAINING AND THE PROFESSION

With the advent of new statistical methods, new complex data available across a wide range of disciplines, ever-evolving genomic, environmental, and other technologies, and adoption of these methods and technologies by epidemiologists, students will be confronted with significant challenges (16, 17). Applications to areas such as infectious disease, chronic disease, and climate change will be fertile incubators for these. In fact, as Samet suggests, these mega-trends will impact every level of our profession (8). What level of expertise in other disciplines will be required for future training? How will we prepare students for this future? Will students require training in the latest "-omics" technology, as Kuller indicates (7)? Computing technology, data wrangling, and analysis of big data will also challenge current teaching methods and training content. This also applies to the training of applied epidemiologists and those in public health practice (18). Emerging instructional technology has provided a new platform for diverse learning approaches and global outreach (19).

THE WAY FORWARD

The challenges and opportunities described in this issue of *AJE* clearly echo those in earlier commentaries by Terris, Susser and Susser, Pearce, and others. It could be argued that in fact, the current challenges (and opportunities) are magnified by the evolution of technology, data, methods, and other disciplines on which we rely. Yet, epidemiologists continue to rehash earlier debates, seemingly without resolution. Moreover, we are not immune to the political climate and are now experiencing significant challenges in the funding of research and public health practice, as well as the broader impacts of the politicization of science. As Terris noted, efforts to educate and enhance our discipline to the public and policy makers are critical (1).

Although self-reflection and debate are healthy and necessary, as in many scientific disciplines, we must confront this uncertainty of who we are, what our mission is, and what our relationship is to public health, medicine, and the broader scientific community. We must do this in a strategic and forward-looking manner. We would suggest that it is time to assemble a series of interrelated processes of evaluation, consensus building, and innovation. We call on leaders from our epidemiologic societies and other societies that engage epidemiology, academic and federal leaders, representatives from accrediting bodies, and others to develop a clear mission statement and blueprint for the epidemiology of the future. This needs to be done with a level of precision that will make it possible to debate and implement it in multiple settings in a timely fashion.

REFERENCES

1. Terris M. The Society for Epidemiologic Research (SER) and the future of epidemiology. *Am J Epidemiol*. 1992;136(8): 909–915.
2. Susser M, Susser E. Choosing a future for epidemiology: I. Eras and paradigms. *Am J Public Health*. 1996;86(5):668–673.
3. Susser M, Susser E. Choosing a future for epidemiology: II. From black box to Chinese boxes and eco-epidemiology. *Am J Public Health*. 1996;86(5):674–677.
4. Pearce N. Traditional epidemiology, modern epidemiology, and public health. *Am J Public Health*. 1996;86(5):678–683.
5. Galea S, Keyes KM. Epidemiology at the heart of population health science. *Am J Epidemiol*. 2019;188(5):883–885.
6. Diez-Roux AV. The unique space of epidemiology: drawing on the past to project into the future. *Am J Epidemiol*. 2019; 188(5):886–889.
7. Kuller L. Epidemiologists of the future: data collectors or scientists? *Am J Epidemiol*. 2019;188(5):890–895.
8. Samet JM, Woodward A. On being an epidemiologist. *Am J Epidemiol*. 2019;188(5):818–824.

9. Glymour MM, Bibbins-Domingo K. The future of observational epidemiology: improving data and design to align with population health. *Am J Epidemiol*. 2019;188(5):836–839.

10. Shortreed SM, Cook AJ, Coley RY, et al. Challenges and opportunities for using big health care data to advance medical science and public health. *Am J Epidemiol*. 2019;188(5):851–861.

11. Harper S. A future for observational epidemiology: clarity, credibility, transparency. *Am J Epidemiol*. 2019;188(5):840–845.

12. Manrai AK, Ioannidis JPA, Patel CJ. Signals among signals: Prioritizing nongenetic associations in massive data sets. *Am J Epidemiol*. 2019;188(5):846–850.

13. Cerda M, Keyes KM. Systems modeling to advance the promise of data science in epidemiology. *Am J Epidemiol*. 2019;188(5):862–865.

14. Lewnard JA, Reingold AL. Emerging challenges and opportunities in infectious disease epidemiology. *Am J Epidemiol*. 2019;188(5):873–882.

15. Anderson GB, Barnes EA, Bell ML, et al. The future of climate epidemiology: opportunities for advancing health research in the context of climate change. *Am J Epidemiol*. 2019;188(5):866–872.

16. Brownson RC, Samet JM, Chavez GF, et al. Charting a future for epidemiologic training. *Ann Epidemiol*. 2015;25(6):458–465.

17. Olshan AF. Reflections on the future of epidemiology: how students can inform our vision. *Curr Epidemiol Rep*. 2017;4(4):259–261.

18. Bensyl DM, King ME, Greiner A. Applied epidemiology training needs for the modern epidemiologist. *Am J Epidemiol*. 2019;188(5):830–835.

19. Werler MM, Stuver SO, Healey MA, et al. The future of teaching epidemiology. *Am J Epidemiol*. 2019;188(5):825–829.