The Next Generation of Large-Scale Epidemiologic Research: Implications for Training Cancer Epidemiologists

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There is expanding consensus on the need to modernize the training of cancer epidemiologists to accommodate rapidly emerging technological advancements and the digital age, which are transforming the practice of cancer epidemiology. There is also a growing imperative to extend cancer epidemiology research that is etiological to that which is applied and has the potential to affect individual and public health. Medical schools and schools of public health are recognizing the need to develop such integrated programs; however, we lack the data to estimate how many current training programs are effectively equipping epidemiology students with the knowledge and tools to design, conduct, and analyze these increasingly complex studies. There is also a need to develop new mentoring approaches to account for the transdisciplinary team-science environment that now prevails. With increased dialogue among schools of public health, medical schools, and cancer centers, revised competencies and training programs at predoctoral, doctoral, and postdoctoral levels must be developed. Continuous collection of data on the impact and outcomes of such programs is also recommended.

cancer epidemiologists; education; large-scale epidemiologic research

Abbreviation: NCI, National Cancer Institute.

It is sobering to reflect that about a quarter of a century ago, Fraser described epidemiology as a “low-technology” liberal arts science, claiming that it was a discipline “readily accessible to nonspecialists” (1, p.1). Hoover (2) succinctly pointed out that most epidemiologic research at that time could be described as “a cottage industry,” with small studies being conducted that were adequate for detecting large risks. We are now acutely aware of how a “revolution driven by high throughput and connective computing” is transforming the landscape of biomedical research (3). These rapidly evolving technologies and the looming presence of “big data” have similarly affected cancer epidemiology research. For example, innovative technologies, such as genomics, proteomics, metabolomics, and epigenomics facilitate better characterization of gene-environment interactions and of environmental risk factors through exposure-based agnostic analyses (i.e., environment-wide association studies) (4). These exciting new approaches, with their reliance on big data, mandate the need for large multidisciplinary studies that can refine the evaluation of both cancer risk and outcomes (5). Other emerging technologies available for application by the new generation of cancer epidemiologists include digital communication tools, advances in molecular classification of tumors (e.g., CpG island methylator phenotype in colon cancer), molecular imaging, and advanced biostatistical and bioinformatics tools.

New and innovative approaches to training epidemiologists are therefore needed to ensure the timely integration of these rapidly evolving technologies into state-of-the art molecular cancer epidemiology research. Furthermore, there is now a growing imperative to extend cancer epidemiology research that is etiological to that which is applied and has the translational potential to affect individual and public health (6). We recognize that a variety of skills might be needed to translate scientific findings into action according to the target audience and the research knowledge being translated.

The criticism of epidemiology as a “soft” science with many irreproducible results, though not unique to the discipline,
has been longstanding (7). Therefore, it has become even more urgent to address the need for a better understanding of the new high-throughput tools and measurements that are being integrated into the field.

This need to modernize the training of 21st-century cancer epidemiologists working in research institutions is now being recognized by numerous national organizations and societies. The following is a nonexhaustive list of recent examples of incremental initiatives and activities designed to begin to upgrade epidemiology training and practice. The American College of Epidemiology has outlined an initiative of its education committee to “determine feasibility and interest in providing online “mini-courses” in subjects not readily available in all schools and programs” (8). The International Epidemiological Association sponsors courses “to provide epidemiologists and public health professionals an opportunity to become acquainted with the advances in epidemiologic methods [such as new interfaces with molecular genetics and social epidemiology] that can enhance the role of epidemiology in clinical medicine and public health” (9). The Society for Epidemiologic Research organized a symposium in 2013 about the role of epidemiology in the era of molecular biology and genomics and earmarked for further discussion the question of how future epidemiologists should be trained and current epidemiologists be retrained to use and understand new molecular biology and technology in their research (10). However, the audiences for these types of courses may be more senior cancer epidemiologists and not junior faculty or those still in training.

The National Cancer Institute (NCI) sponsored a workshop in 2011 entitled “Next Generation Analytic Tools for Large Scale Genetic Epidemiology Studies of Complex Diseases” (11). One recommendation was the need for improved training and support for graduate students and postdoctoral fellows in how to analyze, display, and integrate these large-scale data sets—skills deemed critical for these next-generation studies. A similar need was identified as 1 of 8 important thematic recommendations that arose from an interactive discourse in 2012 between the NCI and the scientific community (12).

The American Association for Cancer Research, with funding from NCI’s Cancer Education and Career Development Program, has designed an annual intensive 1-week educational experience (Integrative Molecular Epidemiology Workshop) to accelerate the training of the next generation of cancer researchers who must be skilled in the integration of biology and epidemiology in studies of etiology and outcome.

We recognize that some existing training programs may have already incorporated various degrees of these concepts. Nevertheless, we do not know to what extent these concepts are being implemented into the curricula across training programs. It is also currently unknown whether these concepts are incorporated into formal didactic courses or informally introduced via other avenues (e.g., seminars). Without solid data, it is impossible to estimate how many current epidemiology training programs are effectively equipping epidemiology students with the knowledge and tools to design, conduct, and analyze the increasingly complex and expensive studies driven by technological advancements and the digital age, which are becoming the new norm. Midlevel and senior epidemiologists might also need retraining in some of these areas. Unfortunately, there is no data-driven consensus about how to design evidence-based training for epidemiologists, nor are there guidelines on how to educate junior and senior epidemiologists in 21st-century epidemiology.

Medical schools and schools of public health are recognizing the need to develop integrated programs to adapt to the new reality, and they are proactively discussing the opportunities and challenges to introducing public health curricula into medical education (13). Many of these apply to the training of cancer epidemiologists. Ogino et al. (14) stress the importance of being open-minded and flexible in designing integrated educational curricula and training programs. Kuller (15) has pointed out that recent trainees in epidemiology may have very solid quantitative skills but may lack sufficient knowledge in human biology and pathophysiology. This is compounded by the need for innovative approaches to train cancer epidemiologists in integrating these modern and rapidly evolving “omics” technologies outlined above into state-of-the-art cancer epidemiology research. We need to train cancer epidemiologists in new exposure measurements, how to conduct critical literature reviews, how to design appropriate studies to address multilevel analyses, how to construct the statistical models to evaluate these complex interactions, and in risk communication. To address the need for better knowledge dissemination and integration, the NCI has developed a Team Science Toolkit (www.teamscientetoolkit.cancer.gov). The toolkit is an online knowledge management system that collects and integrates knowledge, practical tools, resources, and strategies for team science that are readily accessible to the public (16).

Ness (17) has emphasized the important role of innovative thinking for training all epidemiologists and outlined a strategy for doing so. She suggests that the goal should be to incorporate innovation training within every epidemiology curriculum in the nation. We agree, but also emphasize that, although we need to educate future cancer epidemiologists in these new areas, we must not neglect rigorous training in basic epidemiologic methodology as the core of any cancer epidemiology curriculum. High-quality epidemiologic research in impeccably designed and well-powered studies with stringent quality control of data and specimen acquisition, as well as meticulous statistical analysis, must remain the centerpiece of any epidemiologic research plan (18).

Equally important as didactic learning is the valuable (and gratifying) role of 1-on-1 mentoring at the graduate, postgraduate, and faculty levels. To succeed in the emerging transdisciplinary environment, we might need new models of mentoring that enable researchers to work, innovate, and thrive in such settings (19). An NCI-sponsored panel workshop in 2013 on postdoctoral training highlighted the importance of postdoctoral cancer prevention fellowships and stressed the need to revisit the focus and curricula of these programs periodically (20). There is growing recognition that current epidemiologic research initiatives provide exciting opportunities for epidemiologists to launch collaborations with computational biologists, mathematicians, computer scientists, physicists, bioinformaticians, and systems biologists. Epidemiologists may struggle with effective communication

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with these diverse scientists and need to identify a common language. The traditional 1-on-1 mentoring model may not be effective, and several mentors in different disciplines may be needed. Furthermore, the teams usually include senior and junior investigators, postdoctoral and graduate students, and research support staff, and an ongoing challenge is academic recognition of the contributions of all investigators. Those senior investigators involved in collaborations among basic, clinical, and population scientists can include their doctoral students on the team, so that they may learn the mechanics and culture of team science first hand, enabling them to leverage team resources for their own research. Of course, this assumes ready access to these types of data for those students fortunate to be working at institutions where their mentors are actively participating in such consortial activities. Training fellowships that provide support and facilitate access to, and leverage of, existing consortial data as part of the dissertation research of doctoral students would do much to level the playing field for all trainees. One forward-thinking training program that could serve as a model is the Burroughs Wellcome Fund’s Institutional Program Unifying Population and Laboratory Based Sciences (21). This program is designed to “bridge the gap between the population and computational sciences and the laboratory-based biological sciences” and requires comentering across multiple disciplines (21). Finally, all academic institutions will need to create a culture that rewards team effort and contributions through revised tenure and promotion policies (22).

In summary, it is clear that to provide solid training guidelines for the next generation of cancer epidemiologists, we need the following: 1) increased dialogue between schools of public health, medical schools, and cancer centers; 2) current competencies for cancer epidemiology; 3) development of consensus on revised training programs at predoctoral, doctoral, and postdoctoral levels; and 4) continuous collection of data on the impact and outcomes of such programs. Specifically, we need a formal review of training curricula of schools of public health, cancer centers, and government training programs and a careful reassessment of funding mechanisms for training future investigators in state-of-the-art epidemiologic research.

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REFERENCES

