Commentary

Cancer Epidemiology, Biomarkers & Prevention

New Directions in Cancer Control and Population Sciences

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Abstract

Cancer control science has been evolving since it first became a focus for cancer research and program activities a century ago. The evolution of the field has responded to historical megatrends along the way that keep it relevant to the cancer-related needs of society. This commentary describes some of the key trends and developments now influencing cancer control and population sciences that reflect societal change and new tools and concepts in modern biomedical science. New directions include the impact of climate change, health care delivery research, the growth of population health science, data science, precision medicine, data sharing, implementation science, and new technologies, including social media and new geospatial methodologies. *Cancer Epidemiol Biomarkers Prev; 26(8); 1165–9. ©2017 AACR.*

Cancer control science is continually evolving to meet the needs of the population and the changing scientific and sociocultural environment. As it evolves, it incorporates new biologic discoveries, clinical advances, new technologies, and social structures, or political realities (1). It has always been difficult to define as a distinct science. Unlike cell biology, oncology, sociology, and other well-defined disciplines, it is a complex mix of scientific approaches with no specific theoretical base, no unique set of tools, and no academic degree that recognizes expertise in the field. However, cancer control science does have a clear set of goals. It conducts basic and applied research in the behavioral, social, and population sciences to create or enhance interventions that, independently or in combination with biomedical approaches, reduce cancer risk, incidence, morbidity, and mortality, and improve quality of life (2). Its definition has benefited from the concept of the cancer continuum that organizes cancer control science along the entire trajectory of cancer research from prevention to end-of-life care (2). It is by nature a multidisciplinary enterprise drawing on cancer biology, epidemiology, behavioral, social, and communication sciences; health services research; surveillance technologies; and the challenges of dissemination and implementation. The richness and intellectual excitement in cancer control science derives not only from the opportunity to work across disciplines, but also from the continuing introduction of new perspectives, approaches, and technologies.

This commentary covers my personal view on where the field has been and some of the new directions it is now taking.

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Cancer Control History

At the beginning of the last century, the diagnosis of cancer was considered a death sentence by those struck down by the disease and by the physicians faced with treating it. "Cancer" was not spoken of openly because it was feared as the end of life and carried with it the shame of stigma (3). Perhaps the first time "cancer control" entered the medical vocabulary was in 1913, when a group of gynecologic surgeons gathered in New York City to formulate a response to the devastating consequences of cervical cancer, then the most common cancer among women (4). Their approach was to institute early detection practices, health education, and cancer registration, all mainstays of what we currently know as cancer control. This group of physicians formed the American Society for the Control of Cancer, which later became the American Cancer Society (ACS; ref. 4).

Cancer control progressed over the early part of the century focused primarily on educational efforts, carried out by "armies" of volunteers supported by the ACS and others to bring the message to people that cancer could be recognized early and treated if only one were aware and acted on the seven warning signs of cancer (3).

In 1937, the National Cancer Institute (NCI) was established and charged to do cancer research and to show "the useful application of results" (5). However, the focus remained on cancer therapeutics. When the National Cancer Act was signed in 1971, cancer control was first specified as an area of concentration for federally supported activities. When the Division of Cancer Control and Rehabilitation was established in 1973, it was the first NCI structural unit dealing directly with cancer control. By this time, the field could point to advances with the Pap smear in cervical cancer screening, the development of mammography for breast cancer screening, and increased efforts at tobacco control following the landmark Surgeon General's Report in 1964. This division later became the Division of Cancer Prevention and Control under the leadership of Peter Greenwald who, with Joseph Cullen, codified cancer control as a scientific, not simply a programmatic, endeavor with a framework of research stages (6).

The next phase of evolution of cancer control research came in 1996 when a review of the growing field, initiated by NCI leadership, resulted in the formation of the Division of Cancer Control and Population Sciences (7). Cancer control emerged with a more integrated framework that recognized the importance of behavioral and social sciences, outcomes, and survivorship research in addition to epidemiology, early detection, applied research, and surveillance (1, 8).

Discoveries, innovations and societal change since that time have brought cancer control to where it is today. These factors have included research based on the discoveries of the Human Genome Project like studies of gene–environment interactions and genome-wide association studies in the early 2000s, which have become a priority across the NIH (Bethesda, MD; ref. 9), the Clinical and Translational Science Awards beginning in 2006 (10), which have led to a new view of the nature of translational science and expansion of dissemination and implementation research (11, 12), and more recently the increased attention paid to health care coverage and improvements generated by the Affordable Care Act (13).

Megatrends

These organizational milestones reached by cancer control research over the last 100 years have paralleled the organizational evolution of the field. They have responded to societal trends and scientific developments that have helped define directions for cancer control science. In the 1996 review of cancer control research, certain "megatrends" were identified that characterized these large-scale societal trends (1). They included the aging and increased diversity of the population, the great strides being made in molecular biology and genetics, the reorganization of health care away from the fee-for-service model, and the leaps and bounds made in communication and information technology as the computer age began to influence all aspects of science. Cancer control research funders needed to respond to each of these megatrends when considering the kinds of research they would support.

Current Status

Cancer control research is now a robust field of scientific inquiry and intervention development with a number of salient characteristics. It has always been clearly multidisciplinary, but now it involves the skills of an even more diverse group of scientists including geneticists, computational biologists, anthropologists, ecologists, communication specialists, health informaticists, and policy makers to name a few. By virtue of this multidisciplinarity, it works at multiple levels of biologic organization—from genes to society. Cancer control scientists are individually capable of studies of genetic susceptibility and the discovery and use of biomarkers for early detection and disease diagnosis and progression. They are able to understand individual and group behaviors that put people at risk of cancer and when modified can contribute to decreased cancer morbidity and mortality. They explore the processes of treatment and health care to understand and improve cancer care and outcomes and they are driven to better grasp the critical social determinants of cancer and the underlying reasons for the persistence of cancer health inequities (14). The field has continued to grow to encompass the needs generated by the megatrends of the last several decades.

Cancer Control Frameworks

Cancer control scientists now frequently use several different frameworks for organizing the field. Perhaps the most common is the cancer continuum, which recognizes the progression of a cancer process in populations starting from a state where people are asymptomatic and at risk of cancer (2).

Early detection or screening is the next phase and one rich with opportunities for new imaging technologies and biomarkers to make tests ever more sensitive and specific. Cancer control scientists work in the diagnostic phase in terms of helping to deliver more effective therapies and developing informed decision-making strategies when evidence may be complex and difficult to present to patients especially with cultural differences and literacy challenges. Finally, cancer control science focuses on the period of survivorship and the issues facing individuals after cancer treatment.

A second major organizational framework is related not to the stage of cancer development, but to the stage of research. This has been called the Dynamic Model of Cancer Control Research. It reflects an integrated and interrelated process from basic biomedical and behavioral research to intervention research to surveillance, all tied together with research syntheses methods and resulting in policy change or implementation science (1). This model has morphed into a more recent framework reflecting increased interest in the translational science continuum (15). In this framework basic discovery (bench) is translated into interventions (bedside) and to populations eventually becoming engrained into health systems, community practice, health policy, and other societal sectors.

A final cancer control framework that I will mention there is the multilevel framework of healthcare outcomes proposed by Taplin and colleagues (16). Here, the levels take a clinical and patient-oriented focus with the ultimate outcome of improved cancer-related health care. Levels start with the individual patient and rise through family and social supports to the provider team and practice settings, all in the context of community, state, and national environments (16).

In these frameworks used in modern cancer control science, the concept of team science has been foundational. Cancer control research benefits from the input of multiple disciplines and is unlikely to succeed by the efforts of single individuals. Inherent in this team science approach and closely related to it is the concept of transdisciplinary science wherein teams made up of investigators from multiple disciples work together on common problems bringing their own expertise to the table, but relaxing the traditional disciplinary boundaries to produce knowledge not possible from a single disciplinary approach (17, 18). The integration of these concepts suggests that the most successful methods of science translation are accomplished by teams using a transdisciplinary approach (19). The Division of Cancer Control and Population Science of the NCI has substantially advanced cancer control research by supported numerous team and transdisciplinary efforts including the Transdisciplinary Tobacco Use Research Centers, Centers for Population Health and Health Disparities, Centers of Excellence in Cancer Communications Research, and Transdisciplinary Research in Energetics and Cancer centers (10).

New Directions

What are the current societal trends that might influence cancer control going forward? We are still driven by same forces that were identified in 1996: the aging of our citizenry, the diversity of the population and the unequal burden of disease, advances in molecular biology and genetics, the reorganization of health care, and new developments in communication and information technology. New influences on cancer control research include both social and environmental changes as well as shifts in the fundamental organization of information.

Perhaps first among these are concerns about global climate change and its impact on health. This challenge looms large and is beginning to generate a new body of work in epidemiology, environmental, and global health. Although it is as yet not entirely clear how it will influence a noncommunicable disease like cancer, there will likely be shifts in food availability, changes in the ozone layer with increased sun exposure and radiation, possible increased exposure to toxic chemicals with disruptions in the weather cycles and increased exposure to particulate matter and other carcinogens with increased air pollution (20). Cancer control science must be ready to respond to this other trends in what 21st-century medicine and population health will hold (12).

Partially stimulated by issues debated around the Affordable Care Act but also simply by the increased complexity and costs of cancer care, health care access, and quality are increasingly recognized as a critical realm of cancer control research and have stimulated reorganization and reemphasis on health services and outcomes research at the NCI. Cancer control research is now looking closer at the reasons for variations in the quality of care across the country and for ways to advise practitioners to improve the cancer care they deliver (13). As mentioned above a new framework for understanding the complexity of multilevel influences on the cancer care system is driving new cancer control research (16, 21).

A third and related influence on cancer control science is the movement towards population health science in many academic centers and public health agencies across the country. Population health science is not just public health in new clothes, but the study of the multilevel determinants of health in populations beyond the organization of medical care. For cancer researchers, it incorporates the biological and mechanistic aspects of disease along with the clinical manifestations and social determinants into an understanding of cancer as the result of a complex system of etiologic factors, any one of which might be a target for intervention (22, 23).

A fourth megatrend is the advent of data science or "big data," which has raised new questions and new possibilities for cancer control research. Large volumes of data are now available not only from "-omics," but from electronic health records and social media. How are we to deal with the new challenge of approaching data agnostically and looking for useful patterns rather than the traditional approach of hypothesis driven research? What are the methodologic issues that arise from interpreting large amounts of data empirically? Along with all the other disciplines already part of cancer control science, we now add computational biology.

Closely connected to the onslaught of "big data" is the move toward precision medicine (24). Precision medicine aims to collect, connect and apply vast amounts of research data and health information to understand why individuals and populations have different disease experiences. It aims to help guide more precise and predictive medical and population health approaches. Because cancer control works at multiple levels it is well positioned to contribute to and act upon the model of precision medicine from genes to society (25). There is controversy about the ability of precision medicine to improve population health, particularly if limited to -omic research (26) Rebbeck has advocated for a focus on precision prevention and an integrated team science approach (23). However, the term *precision population health* may more accurately reflect the broader emphasis of cancer control research on populations, including a strong multilevel perspective on biology, clinical presentation, and population science using more precise methods and tools (22).

A sixth trend is more of a structural change in how scientists are required to perform their research. There is a major NIH-led push to increase the sharing of data collected by citizen tax dollars in the United States. It is now a requirement of federal grants to have a data sharing plan in a proposal for funding (27). This is a major shift from the days when individual investigators would have tight proprietary oversight into data they collected for a particular study. The implications may be that we will see a shift from the laborious primary collection of data to more routine use of existing datasets originally assembled by others (28). This major trend could have a substantial impact on cancer control science, especially for epidemiologic cohort studies that have increasing required very large numbers of participants and great costs. The challenges may shift from skills in recruitment, survey development, and other forms of data collection to issues of data standardization and harmonization and the curating of self-reported data, examination results and biospecimens so that more investigators can make use of fewer well-managed large data repositories. The several large cohort consortia supported by the NCI have pioneered methods of data sharing across existing cohorts and been highly productive (29).

A seventh trend is toward the development of dissemination and implementation science. This trend represents the logical end point of the dynamic model of cancer control research and the last stage of translational research referenced above. It has not been a traditional realm of study for cancer control scientists, but now as dissemination and implementation research is exploding and the methodologies for the field are developing (30), more attention is being paid to the task of taking effective interventions and actually putting them into play in communities, health systems, guidelines, and health policy (31). This is an important trend to pursue if the field is to realize its maximum impact on the cancer burden, persistent disparities, and adverse trends.

Completing this list of eight new trends are myriad new technologies, which provide tools for cancer control research. It is abundantly clear to many researchers that there may be something of value in learning how to access and harness the new social media tools. Data extraction methods can provide insights into cancer behaviors and practices (32). Investigators are using them to reach individuals for research studies who were becoming increasingly hard to access because of barriers to face-to-face, mailed, and telephone surveys. The use of smartphones for ecologic momentary assessment represents an entirely new form of data collection open to cancer control research (33).

Finally, among these new technologies are the tools used in geospatial approaches to data gathering, intervention development, and surveillance (34). Today with these new tools and the collaboration of medical geographers (yet another new discipline in cancer control research), studies of the environmental context of cancer development are becoming much more possible and richer in the process.

As the recent NCI conference "Geospatial Approaches to Cancer Control and Population Sciences" demonstrated, this new addition to the cancer control toolkit will have numerous applications. Active research is now pursuing the use of geospatial technologies to define walkability and other variables relevant to physical activity in local environments (35), cancer related prevention behaviors like vaccination and early detection practices (36), methods for defining inequities in cancer outcomes by measures of the built environment and social deprivation and even elucidating biologic mechanisms that might be influenced by neighborhood of residence (37). Geospatial methods lend themselves to studies of health services and access to and quality of cancer care as well as to studies of environmental exposures (38). Finally, these new methods help refine our surveillance capabilities, including more precise ways of defining the catchment areas around cancer centers (39).

The developments in the discipline of medical geography and the geospatial techniques they have spawned represent a new and exciting extension of cancer control science that can contribute to improved population health. Cancer control and population science will continue to evolve as major societal trends present new challenges and opportunities.

Conclusion

Cancer control and population science has many opportunities to have an impact on cancer population health in the years to come. The challenges are presented by the societal forces we face as well as the serious nature of the disease we study. New tools abound that were not available just 15 years ago including new biomarkers, functional electronic health records, social media, advances in exposure science, better linkages of cancer registry data and administrative health records, and the rich promise of geospatial technologies. These tools and the orientation of cancer control science to the population we serve must be directed at accelerating the decline in the cancer burden nationally.

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References

1. Hiatt RA, Rimer BK. A new strategy for cancer control research. Cancer Epidemiol Biomarkers Prev 1999;8:957–64.
2. National Cancer Institute. Cancer control framework and synthesis rationale. Available from: https://cancercontrol.cancer.gov/od/about.html.
3. Breslow L, Agran L, Breslow DM, Morganstern M, Ellwein L. Cancer control: implications from its history. J Natl Cancer Inst 1977;59 (2 Suppl):671–86.
4. New York City Cancer Committee. History of the American Society for the Control of Cancer, 1913–1943. New York, NY: New York City Cancer Committee; 1944.
5. Department of Health and Human Services. National Cancer Act of 1937, 1937, Pub. L. No. 244, (August 5, 1937).
6. Greenwald P, Cullen JW. The new emphasis in cancer control. J Natl Cancer Inst 1985;74:543–51.
7. Abrams DB. A new agenda for cancer control research: Report of the Cancer Control Review Group. Washington, DC: National Academies Press; 1997.
8. Miller SM, Bowen DJ, Croyle RT, Rowland JH. Handbook of cancer control and behavioral science: a resource for researchers, practitioners, and policymakers. Washington, DC: American Psychological Association; 2009. p. 652.
9. Simonds NI, Ghazarian AA, Pimentel CB, Schully SD, Ellison GL, Gillanders EM, et al. Review of the gene-environment interaction literature in cancer: what do we know? Genet Epidemiol 2016;40:356–65.
10. Zerhouni E. Medicine. The NIH roadmap. Science 2003;302:63–72.
11. Khoury MJ, Clauser SB, Freedman AN, Gillanders EM, Glasgow RE, Klein WM, et al. Population sciences, translational research, and the opportunities and challenges for genomics to reduce the burden of cancer in the 21st century. Cancer Epidemiol Biomarkers Prev 2011; 20:2105–14.
12. Khoury MJ, Lam TK, Ioannidis JP, Hartge P, Spitz MR, Buring JE, et al. Transforming epidemiology for 21st century medicine and public health. Cancer Epidemiol Biomarkers Prev 2013;22:508–16.
13. National Cancer Institute. Healthcare Delivery Research Program. Available from: https://healthcaredelivery.cancer.gov.
14. Krieger N, Chen JT, Waterman PD, Rehkopf DH, Subramanian SV. Painting a truer picture of US socioeconomic and racial/ethnic health inequalities: the Public Health Disparities Geocoding Project. Am J Public Health 2005;95:312–23.
15. Czajkowski SM, Lynch MR, Hall KL, Stipelman BA, Haverkos L, Perl H, et al. Transdisciplinary translational behavioral (TDTB) research: opportunities, barriers, and innovations. Transl Behav Med 2016;6:32–43.
16. Taplin SH, Anhang Price R, Edwards HM, Foster MK, Breslau ES, Chollette V, et al. Introduction: Understanding and influencing multilevel factors across the cancer care continuum. J Natl Cancer Inst Monogr 2012;2012:2–10.
17. Hall KL, Feng AX, Moser RP, Stokols D, Taylor BK. Moving the science of team science forward: collaboration and creativity. Am J Prev Med 2008;35 (2 Suppl):S243–9.
18. Croyle RT. The National Cancer Institute's transdisciplinary centers initiatives and the need for building a science of team science. Am J Prev Med 2008;35(2 Suppl):S90–3.
19. Hiatt RA. Epidemiology: key to translational, team, and transdisciplinary science. Ann Epidemiol 2008;18:859–61.
20. Portier CJ, Tart KT, Carter S, Dilworth C, Grambsch A, Gohlke JM, et al. A human health perspective on climate change: a report outlining the research needs on the human health effects of climate change; 2010. Available from: https://www.niehs.nih.gov/health/materials.
21. Taplin SH, Rodgers AB. Toward improving the quality of cancer care: addressing the interfaces of primary and oncology-related subspecialty care. J Natl Cancer Inst Monogr 2010;2010:3–10.
22. Keyes KM, Galea S. Setting the agenda for a new discipline: population health science. Am J Public Health 2016;106:633–4.
23. Rebbeck TR. Precision prevention of cancer. Cancer Epidemiol Biomarkers Prev 2014;23:2713–5.
24. Marcus PM, Pashayan N, Church TR, Doria-Rose VP, Gould MK, Hubbard RA, et al. Population-based precision cancer screening: a symposium on evidence, epidemiology, and next steps. Cancer Epidemiol Biomarkers Prev 2016;25:1449–55.
25. Khoury MJ, Iademarco MF, Riley WT. Precision Public Health for the Era of Precision Medicine. Am J Prev Med 2016;50:398–401.
26. Khoury MJ, Galea S. Will precision medicine improve population health? JAMA 2016;316:1357–58.
27. Guttmacher AE, Nabel EG, Collins FS. Why data-sharing policies matter. Proc Natl Acad Sci U S A 2009;106:16894.
28. New York State Department of Health and Human Services. All of Us Research Program. Available from: https://www.nih.gov/research-training/ allofus-research-program.
29. Cox DG, Dostal L, Hunter DJ, Le Marchand L, Hoover R, Ziegler RG, et al. N-acetyltransferase 2 polymorphisms, tobacco smoking, and breast cancer risk in the breast and prostate cancer cohort consortium. Am J Epidemiol 2011;174:1316–22.
30. Proctor EK, Chambers DA. Training in dissemination and implementation research: a field-wide perspective. Transl Behav Med. 2016 May 3. [Epub ahead of print].

31. Chambers DA, Feero WG, Khoury MJ. Convergence of implementation science, precision medicine, and the learning health care system: a new model for biomedical research. JAMA 2016;315:1941–2.
32. Freedman RA, Viswanath K, Vaz-Luis I, Keating NL. Learning from social media: utilizing advanced data extraction techniques to understand barriers to breast cancer treatment. Breast Cancer Res Treat 2016; 158:395–405.
33. Dunton GF, Whalen CK, Jamner LD, Henker B, Floro JN. Using ecologic momentary assessment to measure physical activity during adolescence. Am J Prev Med 2005;29:281–7.
34. Richardson DB, Volkow ND, Kwan MP, Kaplan RM, Goodchild MF, Croyle RT. Medicine. Spatial turn in health research. Science 2013;339:1390–2.
35. Sallis JF, Cerin E, Conway TL, Adams MA, Frank LD, Pratt M, et al. Physical activity in relation to urban environments in 14 cities worldwide: a cross-sectional study. Lancet 2016;387:2207–17.
36. Alford-Teaster J, Lange JM, Hubbard RA, Lee CI, Haas JS, Shi X, et al. Is the closest facility the one actually used? An assessment of travel time estimation based on mammography facilities. Int J Health Geogr 2016;15:8.
37. Gomez SL, Glaser SL, McClure LA, Shema SJ, Kealey M, Keegan TH, et al. The California Neighborhoods Data System: a new resource for examining the impact of neighborhood characteristics on cancer incidence and outcomes in populations. Cancer Causes Control 2011;22:631–47.
38. Gonzales FA, Jones RR, Deardorff J, Windham GC, Hiatt RA, Kushi LH. Neighborhood deprivation, race/ethnicity, and urinary metal concentrations among young girls in California. Environ Int 2016;91:29–39.
39. Su SC, Kanarek N, Fox MG, Guseynova A, Crow S, Piantadosi S. Spatial analyses identify the geographic source of patients at a National Cancer Institute Comprehensive Cancer Center. Clin Cancer Res 2010;16: 1065–72.