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The Future Workforce in Cancer Prevention: Advancing Discovery, Research, and Technology

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Abstract

As part of a 2 day conference on October 15 and 16, 2009, a nine-member task force composed of scientists, clinicians, educators, administrators, and students from across the United States was formed to discuss research, discovery, and technology obstacles to progress in cancer prevention and control, specifically those related to the cancer prevention workforce. This article summarizes the task force's findings on the current state of the cancer prevention workforce in this area and its needs for the future. The task force identified two types of barriers impeding the current cancer prevention workforce in research, discovery, and technology from reaching its fullest potential: 1) limited cross-disciplinary research opportunities with underutilization of some disciplines is hampering discovery and research in cancer prevention, and 2) new research avenues are not being investigated because technology development and implementation are lagging. Examples of impediments and desired outcomes are provided in each of these areas. Recommended solutions to these problems are based on the goals of enhancing the current cancer prevention workforce and accelerating the pace of discovery and clinical translation.

Keywords

Cancer prevention; training; workforce; technology; research

Introduction

A worldwide cancer research effort is revealing cancer's causes, quantifying patterns of incidence, proposing new intervention strategies, testing novel treatments in clinical trials, and monitoring long-term patient outcomes. Steady improvements in cancer outcomes may

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be attributed to many factors, among them widespread access to health care and the increasing availability of effective prevention, diagnosis, and treatment methods. Research suggests that future demand for cancer prevention activities will increase dramatically [1]; it is far less clear that the capacity of the cancer prevention workforce will grow to adequately meet this demand. Specifically, growth is constrained by societal values (*e.g.*, resource allocation), as well as the need for a collaborative workforce of specialists from diverse fields that is well prepared to advance discovery, research, and technology in this area. The problem is that while health care policy and associated economic resources may change rapidly, the education and training of scientists and other professionals in cancer prevention and control will take a decade or more; thus, it is important now to take stock of the readiness of the workforce to meet the challenges that are looming.

Current work related to cancer prevention spans many traditional scientific disciplines, including epidemiology, biostatistics, and the behavioral sciences. In a recent review, Lippman and Hawk [2] chronicled the pioneering preclinical and clinical achievements of these traditional practitioners in the areas of chemoprevention, immunology, surgery, and behavioral science.

Now, state-of-the-art, innovative technologies are opening new vistas in cancer prevention research. For example, epidemiologic studies of cancer incidence that employ low-cost gene sequencing are yielding large data sets that are being mined for clues to cancer prevention. Thus, it is apparent that future progress in cancer prevention discovery, research, and technology will require highly trained specialists from a broadening spectrum of disciplines (*e.g.*, oncology, genetics, molecular epidemiology, biology behavioral science and medical physics). In addition, because researchers and practitioners from these diverse fields will have to communicate and collaborate with one another well in order to be effective, many (from both traditional and emerging disciplines) will likely need specialized training in cancer prevention. However, the literature is incomplete regarding the workforce-related needs that may constitute obstacles to continued progress, *e.g.*, the size and discipline composition of the workforce that will be engaged in research and development in this area has not been well defined.

This manuscript reports the efforts of one task group to identify and propose solutions to obstacles to progress in cancer prevention and control that are associated with the scientific workforce and its workforce-training issues. In particular, this article examines how these issues can constrain the pace of progress in discovery, research, and technology. To accomplish this, the task group performed a literature search and conducted a critical analysis of the obstacles by means of a Delphi process.

Methods and Materials

Makeup and Purpose of the Multidisciplinary Task Force

This report was prepared by the Discovery, Research and Technology Taskforce, which was formed at the workshop titled “The Future of the Cancer Prevention Workforce”, held at The University of Texas MD Anderson Cancer Center in Houston, Texas, on October 15 and 16, 2009. The task force was charged with identifying issues that challenge the cancer prevention workforce specifically in the areas of discovery, research, and technology. Each member of the task force participated in the workshop, subsequent teleconferences, and other activities in the preparation of this report. The task force was composed of nine individuals from a variety of disciplines engaged in cancer prevention, including cancer genetics, cancer epidemiology and etiology, cancer biology, radiation physics, surgical oncology, pharmacogenetics/genomics, cancer research training, and professional oncology education. The task force included physicians and scientists from all levels of the typical career trajectory within a university medical institution, from graduate student to postdoctoral fellow, junior faculty, senior tenured faculty, and administrator. The task force members' institutional affiliations included two comprehensive cancer centers, a large private medical school, and one US government health organization.

Review of Literature Relevant Workforce Issues in Cancer Prevention

As part of the task force's work, the members first identified and shared literature related to workforce issues in cancer prevention and control; this information was to set the context for and serve as a baseline for subsequent analysis of workforce-related barriers to progress in the field. A summary of that informal literature review is reported here. The literature on cancer incidence, cancer prevention clinical practices, and cancer prevention workforce predicts an emergent and cautionary situation. Cancer incidence is projected to increase by 45% in the next 20 years, largely in older adults and minorities [3]. At the same time, the number of people who survive cancer is increasing and the number of cancer survivors who will need tertiary cancer prevention, including surveillance and screening to prevent recurrent or second cancers, is predicted to exceed 18 million in the United States by 2010 [4]. Based on these reports, it follows that demand for health care practitioners, technologists, and researchers with expertise in cancer prevention and control will clearly increase over the next decade and possibly beyond.

The literature on cancer incidence and etiology from recent years reveals that many of the cancers diagnosed today could have been prevented had existing knowledge and technologies been applied [5]. This finding strongly suggests that additional emphasis on preventing cancer and initiatives designed specifically to do so would lead to reduced cancer incidence, reduced mortality, and lower costs (*e.g.*, costs of diagnosis and treatment, lost productivity, and end-of-life care). Encouragingly, standard clinical practice already includes several prevention strategies against cancer, such as risk assessment, genetic counseling, cancer screening, and vaccination against viruses linked to cancer incidence [6–11]. However, strategic policy planning documents, statements from professional societies, and cancer education surveys advise more training to ensure a prepared cancer prevention workforce [1, 12, 13]. Together, these reports underscore our society's urgent and vital need for additional discovery, research and development, and clinical translation in the field of cancer prevention.

Despite the clear need for cancer prevention activities however, it is unclear that sufficient resources will be available to augment the cancer prevention workforce, in part because resources have been mainly allocated to cancer treatment activities, and practitioners in those fields are themselves facing workforce challenges. The task force identified numerous reports that project shortages of primary care physicians, medical physicists, medical oncologists, physician assistants, and oncology nurses [14–16]. Furthermore, it is anticipated that oncology workforce shortages by the year 2020 will become major obstacles to realizing the full benefits of research and technology in the fields of cancer prevention and control [1].

Numerous challenges not only in patient care but also in screening and prevention arise in addressing cancer incidence among an aging and increasingly diverse population in the United States [17]. Primary care physicians recognize the goal of integrating cancer prevention strategies into clinical practice; however, little formal training exists that focuses on cancer genetics or cancer prevention and early detection in US medical schools [12, 13]. Such a lack of training could be overcome by increasing medical residents' knowledge of cancer prevention through special education programs [13] but the few programs that do exist are not well known. The American Society of Clinical Oncology (ASCO), which generally focuses on cancer treatment (*i.e.,* managing diagnosed malignancies), has made a commitment to increase cancer prevention awareness among its membership by establishing its Cancer Prevention Committee (CaPC) [18]. The CaPC's major objectives are to promote efforts related to the discovery and validation of new cancer prevention approaches; to promote technologies (such as imaging) to identify and quantify cancer risk; to encourage the discovery of environmental risk factors and develop methods or technologies to mitigate them; to encourage the discovery and validation of surrogate markers for cancer end points and relevant molecular events in carcinogenesis; and to advance the appropriate climate of reimbursement needed to accomplish these goals [18].

The CaPC recently surveyed ASCO members to learn about their current level of involvement in clinical prevention activities. The committee found that barriers to the members' participation in these activities exist but that the members are interested in increasing their knowledge and ability to integrate cancer prevention into their oncology practices [19]. The CaPC's efforts are important for making cancer prevention a more routinely practiced component of the cancer care continuum; however, the committee's main focus is on increasing physicians' awareness and implementation of existing cancer prevention knowledge. Thus, identification of research and discovery needs in the field of cancer prevention remains a priority.

The Office of Academic Affairs at The University of Texas MD Anderson Cancer Center has begun to contribute to this effort; it conducted an educational needs assessment in 2009 to evaluate the current need for professional cancer prevention education health care providers. The survey, which included 42 questions and was administered through email with Internet responses to 250 physicians (including deans and directors of fellowship and residency programs), directors of physician and physician assistant training programs, and institutional leaders of 20 comprehensive cancer centers, had a 51% response rate. The vast majority (78%) of the survey respondents stated that a need exists for training programs in cancer prevention and screening (unpublished results).

Finally, the literature review confirmed that broad consensus supports the need to advance our understanding of carcinogenesis; to improve the early detection and treatment of cancer, surveillance, and follow-up care; and to promote healthy lifestyles. Discovery, research, and technology in these areas will be key in preventing new, recurrent, or treatment-induced secondary cancers, an essential step toward improving overall outcomes for cancer survivors [20]. Thus, improving standards of clinical practice will be predicated on the efforts of a well-trained, innovative, and effective multidisciplinary workforce engaged in the enterprise of discovery, research, and technology in cancer prevention [21]. The results of this literature review served as the basis and provided the context for the next step in the task force's analysis of workforce issues in cancer prevention, that is, application of the Delphi method to the question of the obstacles that currently impede progress in this area.

Implementation of the Delphi Method To Identify Constraints on the Pace of Progress in Discovery, Research, and Technology

To identify obstacles to progress in cancer prevention related to discovery, research and technology the task force implemented the Delphi method [22], which has been used to address other complex health care challenges [23]. We focused on several key aspects of cancer prevention, including discovery, research, and technology, and the associated workforce issues. In our implementation of the Delphi method, members of the task force answered questions in iterative rounds. For each round, one of us (WN) served as facilitator and provided a summary of the results from the previous round. We achieved consensus after the second and final round. Literature searches proceeded concurrently with and after the Delphi rounds; they were guided, in part, by questions and results that arose during each iteration.

Results/Synthesis

The panel identified eight items that impede progress in discovery, research, and technology in the field of cancer prevention, with emphasis on workforce issues. The group also proposed several solutions to accelerate progress, including the expansion or modification of existing capacities and the introduction of new initiatives, all with the main goal of enhancing the cancer prevention workforce (Table 1). The impediments appear to fall into two broad categories: 1) limited cross-disciplinary research with underutilization of some disciplines, and 2) a lag in developing and implementing technologies necessary to perform research in tantalizing but unexplored avenues of discovery. The task force focused on these two broad categories to propose potential solutions to enhance the cancer prevention workforce.

Limited Opportunities for Training in Cross-disciplinary Research and Underutilization of Some Disciplines' Discovery and Research in Cancer Prevention

Developing a cancer prevention workforce that can both build on existing knowledge and technologies and, importantly, that will be highly innovative will require that individuals from diverse disciplines be motivated to pursue careers in cancer prevention and control. Moreover, greater numbers of individuals who are trained in cancer prevention in addition to their primary discipline will be needed at every level of the career spectrum. Multidisciplinary training would enrich the workforce by providing broader and deeper knowledge from divergent disciplines, including cancer biology and medicine as well as biomedical science, public health, and bioengineering. At its core, the cancer prevention workforce would gain members who have a common language and a shared foundational knowledge of the principles of cancer prevention. Enriched and multidisciplinary collaborative problem-solving teams could stimulate and nurture the generation of new ideas and hypotheses to be tested to meet emerging challenges in cancer prevention.

More students may be encouraged to focus their careers on cancer prevention if they are exposed early to the key problems that need to be addressed in the field. Such exposure may be accomplished via broadly accessible survey courses, seminars, or research experiences for students in the sciences, public health, medicine, and engineering fields [24–27]. Moreover, as cancer prevention discovery, research, and technology become increasingly interdisciplinary and therefore as reliant upon physical and computational sciences as on biology, we must address how to prepare students to work effectively across all these disciplinary lines. Therefore, it follows that undergraduate and graduate training should promote collaborative and cross disciplinary problem solving. One strategy could be to encourage or require participation in cross-disciplinary team activities, with trainees and faculty facilitators or instructors drawn from widely divergent fields [28].

The task force specifically recommends that individuals engaged in research be recruited into environments that stimulate, facilitate, and support cancer prevention problem solving through cross-disciplinary collaboration. Immersion into education and research activities should encourage students to participate in dynamic research groups that foster collaboration and the reciprocal exchange of ideas among all members. This type of environment would embody all of the positive aspects of multidisciplinary team science highlighted in a recent commentary by Disis and Slattery [29]. Drawing on literature from the behavioral sciences and the business world, these authors provide a conceptual framework that describes how increased team diversity not only promotes innovation but also creates greater networks that facilitate both the dissemination and adoption of new ideas generated by the team. [29]. The desired outcome is that the ideas developed within these diverse teams will lead to the greatest advances in science and human health. Cancer prevention efforts, which span behavioral, clinical, laboratory, and epidemiologic research, and clinical practice, are fertile ground in which to grow such dynamic teams.

Promoting team science in cancer prevention and including emerging and nontraditional disciplines into these teams present several challenges. For example, a limited number of institutional programs and funding mechanisms are currently available to individuals from backgrounds outside of those typically found in the cancer prevention realm (*e.g.*, mathematicians, chemists, engineers, computer scientists); those programs and mechanisms that exist are difficult to find and, in some cases, underutilized. Moreover, the career paths in many of these disciplines lack a visible trajectory toward cancer prevention and control. For these reasons, the task force suggests that the following strategies be implemented to help remove the roadblocks impeding progress in effective cross-disciplinary research: 1) Develop more effective ways to recruit researchers in cancer prevention training, particularly individuals from diverse disciplines 2) formulate a core curriculum specifically educating research students and scientists about the fundamentals of cancer prevention, biology, medicine, and ethics that are requisite for collaborative problem solving in cancer prevention; 3) generate greater numbers of highly innovative cross-disciplinary training opportunities; and 4) establish and promote clear career trajectories for individuals who elect to incorporate cancer prevention into their work.

At the same time, research institutions will be challenged to adopt new systems for rewarding their students' and faculty's success. The days of the sole scientist conducting his or her own projects in comparative isolation are giving way to multidisciplinary teams of scientists attacking a cancer prevention problem simultaneously from several approaches. This trend has been spurred by the National Institutes of Health through increased funding for Specialized Programs of Research Excellence (SPORE) grants, multidisciplinary Program Project (P01) grants, and Research Project (R01) grants that allows for multiple principal investigators. In complementary fashion, success in team science should also be rewarded though promotion and tenure. However, the criteria for promotion and tenure at many leading institutions still tend to heavily weigh those accomplishments that are attributed to an individual reform, both broad and local, will be essential if team science is to be perceived as a meritorious and career path [30]. Furthermore, educational contributions to prepare the next generation of cancer prevention scientists, clinicians, allied health professionals, and technologists should be recognized and rewarded as vital components of academic institutions' missions. It is critical to underscore the importance of clear and honest portrayals of the opportunities for advancement in team science; without this is would be difficult to attract the most promising young scientists, physicians, engineers, and technologists to invigorate and enrich the discovery workforce in Cancer Prevention.

Time Lag Between the Development of New Technologies and Their Implementation in Cancer Prevention Activities

A second important issue is the lag in technological development and implementation in research and practice that could be overcome by diversifying and increasing the cancer prevention workforce. One area of inquiry conspicuously impeded by the rather limited capabilities of current technology is the modeling of individual risk that incorporates multiple levels of information, such as genetic, lifestyle, and environmental factors, and the use of these models in clinical outcome studies.

Consider, for example, the risks associated with exposure to radiation in diagnostic and therapeutic medical procedures. In most cases, the risk to an individual patient is small in relation to the benefit from the procedure, but not negligible. This emerges as an important cancer prevention issue because the number of exposed individuals is large and the use of ionizing radiation in medicine is increasing [31]. In the United States, approximately half of all cancer patients receive radiotherapy. These patients are at elevated lifetime risk (in some, upwards of a 50% increase) for developing a radiogenic leukemia or solid tumor [32–35]. However, recent studies have revealed that, with the selection of the appropriate type of radiotherapy, the predicted lifetime second cancer risk can be reduced to 5% or less [36–38]. Furthermore, exposures can be further reduced by making relatively minor engineering improvements to current radiotherapy equipment [39]. Despite the obvious logic of preventing second cancers by reducing therapeutic radiation exposures, research activities in this area are comparatively sparse and few centers, if any, attempt to perform personalized risk assessments for individual patients [40].

The reasons for this gap in prevention efforts are not immediately obvious. Radiation is the most extensively studied carcinogen besides tobacco, and numerous models are available to calculate radiation exposure and cancer risk [41]. The task force, however, concluded that the rate-limiting factor in the pace of progress has been the workforce addressing this issue. This work is being carried out mainly by research faculty and trainees in medical physics, a niche discipline with only a few thousand practicing professionals in the United States [15]. Presently, most medical physicists lack the time and resources to participate in routine practice-based cancer prevention activities. The problem is compounded by the fact that research on this topic is being conducted at only a few academic centers. Furthermore, medical physics training programs [15], to our knowledge, do not include courses on radiation risk assessment or other specialized topics relevant to cancer prevention. With few faculty working in this area and few or no didactic courses in graduate training programs, the number of medical physicists focusing on cancer prevention will remain small for the foreseeable future.

As another example, genetic tools play an increasing role in risk assessment and testing interventions for a broad spectrum of common cancers; however, the best way to integrate these tools for nonhereditary cancers is unclear. Although only 5%–10% of cancers are known to be associated with highly penetrant hereditary syndromes, thousands of the cancer cases that occur every year in the United States are attributable to genetic predisposition, and the magnitude of risk conferred by these altered genes is dramatic [42]. Research on cost-effective mechanisms to transfer state-of-the-art cancer genetics/genomics technologies into clinical practice is needed to enhance cancer prevention and control efforts in the community, especially in this age of genome-wide association studies and personalized medicine [43–46]. Commercial laboratories now capitalize on genome-wide association studies by offering genome scans for polymorphisms associated with disease and by using various algorithms to calculate absolute risk estimates for individuals. However, it is not known whether these scanning technologies are well calibrated or whether the risk estimates provided by the algorithms are accurate. The recently revised ASCO policy statement on genetic and genomic testing highlights the difficulties in attaining direct clinical utility from these types of tests, especially for low-penetrance genetic variants [43].

Conversely the genetic cancer risk assessment process incorporates genetic analysis and empiric risk models to estimate cancer risk and provide personalized risk-appropriate cancer screening and risk-reduction strategies for individuals and families. However, this process requires knowledge of genetics and oncology and communication skills in patient and family counseling [42, 47]. As genetics-based diagnostic and risk assessment tools for cancer move from bench to bedside, the demand grows for broad-spectrum clinical research to determine how these genetic technologies affect the individual, the family, and society. Health services research is also needed to investigate the problems and limitations of delivering cancer genetics services to the larger community, including underserved populations. Therefore, interdisciplinary training programs are needed to prepare researchers who are proficient at this interface of genetics/genomics, social and behavioral science, and clinical research [48].

Summary and Recommendations

As discoveries, innovative research, and groundbreaking technology drive science rapidly forward, several factors limit our ability to ensure a workforce capable of supporting and accelerating the field of cancer prevention and control, potentially preventing us from translating research into practice at an appropriate or desirable pace. Inherent challenges in creating and sustaining a dynamic workforce in the field of cancer prevention research, discovery, and technology include difficulty in attracting scientists early in their careers and retaining those already in the cancer prevention workforce. In contrast to career paths in cancer-focused basic science research and clinical practice, trajectories within the field of cancer prevention are unclear. Besides those in the traditional population of science-based professions, many new investigators do not realize the breadth of disciplines encompassed within the field of cancer prevention. Moreover, they may not see how their expertise may be valued and vital for solving critical problems in cancer prevention. The availability of foundational or core courses in cancer prevention may help generate interest in the field and stimulate interest in pursuing more specialized training. There exist several training programs and fellowships designed to provide the tools and skill sets requisite for establishing and attaining a successful career in cancer prevention; however, many early-career scientists either do not know that these programs exist, some may not realize that they are eligible to apply, and others may have been discouraged from applying since they are trained in fields historically external to cancer prevention. In addition, the primary emphasis on cancer diagnosis and treatment at most cancer centers and the attractiveness of careers in commercial research may draw some scientists, engineers, and technologists, junior and senior alike, away from careers in prevention. The allure of these alternatives may be particularly strong for those individuals from disciplines outside the biomedical sciences who are interested in careers in cancer research but may have even less knowledge of the applicability of their expertise to cancer prevention. Therefore, creating a high-capacity infrastructure for multidisciplinary team research may be strengthened by illuminating and promoting clear career trajectories and establishing environments that nurture multidisciplinary research in cancer prevention.

Individualized risk assessment and modeling are becoming more important in the field of cancer prevention as technological advances allow simultaneous examination of multiple genetic and environmental risk factors. These models may contribute to the development and implementation of prevention measures along the continuum from primary to tertiary prevention. One element missing from the equation is the fortification of a diverse and robust cancer prevention workforce that can refine and translate important discoveries into clinical applications. By strengthening the existing cancer prevention workforce and by expanding it to include those necessary professions that have been historically under-represented, we can improve our ability to pursue new avenues for cancer prevention and comprehensive cancer control strategies that will reduce the burden of cancer for individuals, families, and society.

To overcome the obstacles to developing and sustaining a cancer prevention workforce dedicated to discovery, research, and technology, the task force has made four recommendations (Table 2). First, develop a foundational cancer prevention curriculum that is offered to trainees from multiple disciplines. Second, actively recruit individuals from disciplines that are under-represented in but critical to cancer prevention research. This type of recruitment could be accomplished, for example, with overview talks at meetings of professional and scientific societies. Scholars already engaged in cancer prevention should seek opportunities to explain their research to young investigators in diverse fields and promote cancer prevention as an exciting and interesting critical career choice to battling cancer. Third, as our ability to generate terabytes of data from single experiments intersects with universal application of electronic medical record systems, investigators in the cancer prevention field should actively recruit individuals with interests in information technology and informatics. In addition, because translating research findings into applicable technologies will require the talents of investigators beyond the traditional fields involved in cancer prevention, these individuals should also be recruited actively. Fourth, to train these new recruits, greater numbers of innovative cancer prevention training programs are needed to stimulate multidisciplinary training and increase capacity in the workforce. Systematic evaluation of the breadth and depth of currently funded training programs would ideally identify current gaps and areas of emphasis, and these findings may justify allocating additional resources to cancer prevention training and education. Furthermore, among the resources that may be in short supply are institutions and centers of cancer prevention research and technological development to act as magnets, attracting young investigators and health care professionals into the field.

Developing a diverse and highly trained workforce will require a significant investment but it will yield public health and economic benefits by reducing the global burden of cancer. In the United States, approximately two thirds of the economic cost to society from cancer is associated with morbidity and mortality, while only about one third attributable to direct patient care [49]. These figures suggest a latent economic gain that could be achieved by focusing on cancer prevention measures.

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Table 1

Current needs, gaps, and underutilized areas relevant to cancer prevention discovery, research, and technology

1	Establishing a workforce that crosses a variety of disciplines (*e.g.*, to incorporate new technology, build better risk models)		
2	Developing individualized models of risk		
3	Creating new technologies to further develop risk biomarker research		
4	Increasing use of electronic medical records in order to perform new outcome studies		
5	Increasing competence across the workforce in high-performance and high-capacity instruments:		
		a.	Supercomputers
		b.	Gene-sequencing systems
		c.	Data repositories
6	Promoting research to support evidence-based decision making:		
		a.	Using practice guidelines (not patient specific)
		b.	Accounting for personalized risks
		c.	Knowing how/when to transition from a to b above
7	Enabling sophisticated risk modeling in disciplines such as radiation and medical oncology		
8	Accelerating the pace of research progress so that the rapid evolution of medical practice continues		

Table 2

Recommendations for developing and sustaining a cancer prevention workforce to enhance discovery, research, and technology

1	Provide multilevel cancer prevention core curriculum to trainees from multiple disciplines; add cancer prevention modules/content to graduate and medical school curricula
2	Actively recruit under-represented disciplines; create a forum to stimulate collaboration; reach out to professional societies to promote and increase multidisciplinary conferences and meetings
3	Increase the number of electronic medical record and information technology scientists and engineers contributing to cancer prevention
4	Evaluate the current breadth and depth of cancer prevention training grants (e.g. determine if there is a need for more grants or for a different emphasis in the mix of grants).
5	Establish new models of cancer prevention training at US academic institutions, cancer centers, and other magnets