A New Strategy for Cancer Control Research

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Introduction
The 20th century saw the emergence of cancer as a leading cause of disease and death in the industrialized world. Cancer was the eighth most common cause of mortality at the beginning of the century, with a death rate in 1900 of 64 per 100,000 persons (1). At the close of the 20th century, it ranked second and reached a peak of 205.6 deaths per 100,000 in 1993 (2). Given current trends, cancer will replace cardiovascular disease as the leading cause of death early in the 21st century (3). Slowly at first, and then more rapidly since 1975, efforts to discover the causes and cures for cancer have intensified and received a substantial infusion of public and private support. Ammunition for the War on Cancer, a war initiated in 1971 by the National Cancer Act (4), has been developed primarily by the basic and clinical sciences. Earlier dreams of a “magic bullet” that would cure cancer have now given way to the realization that cancer is many diseases; thus, many bullets will be required for its control. Now, at the end of the century, we are benefiting from rapid advances in molecular biology and genetics that may hold promise for understanding the causes of cancer and for providing strategies for its prevention, early detection, and cure. Yet, despite the excitement engendered by recent discoveries at the molecular and cellular levels that may help to clarify the process of carcinogenesis, the reality is that cancer remains, to a large degree, a disease in which human behavior and societal factors play important causative roles. It has been estimated that as much as 50–75% of cancer mortality in the United States can be attributed to external, nongenetic factors, most of which are related to human behaviors such as tobacco use, overuse of alcohol, improper diet, lack of physical activity, overexposure to sunlight, and sexual activity leading to the development of cervical cancer, a cancer that was often fatal in the early 1900s. Even in 1913, the first cancer control recommendations included a call for cancer registration and the analysis of vital statistics, the study of the geographic distribution of disease and the influence of diet, and education to provide “a concise outline of accepted cancer facts” (5). In the first decades of this century, however, the medical profession generally did not readily accept the idea of cancer control, because cancer was much less common than it is now, and its outcome was usually dismal (6). Furthermore, the medical profession was resistant to governmental interference in the practice of medicine, and organized state and federal cancer control efforts were not likely to have its support (7).

A History of Cancer Control
The term cancer control has long been a source of confusion and debate. In fact, the scope of cancer control has changed with the emergence of new knowledge and will continue to evolve over time. The earliest reference to “cancer control,” of which we are aware, appeared in 1913 with the formation of the American Society for the Control of Cancer, which became the ACS in 1945 (9). The driving force behind the formation of this organization was concern about the need for the early surgical treatment of cervical cancer, a cancer that was often fatal in the early 1900s. Even in 1913, the first cancer control recommendations included a call for cancer registration and the analysis of vital statistics, the study of the geographic distribution of disease and the influence of diet, and education to provide “a concise outline of accepted cancer facts” (10). In the first decades of this century, however, the medical profession generally did not readily accept the idea of cancer control, because cancer was much less common than it is now, and its outcome was usually dismal (11). Furthermore, the medical profession was resistant to governmental interference in the practice of medicine, and organized state and federal cancer control efforts were not likely to have its support (11).

Legislative language first identified cancer control in 1937 when, with the formation of the NCI (PL 75-224), the Surgeon General was authorized to act through the Institute and the National Cancer Advisory Council to “cooperate with state health agencies in the prevention, control, and eradication of cancer.” Congress intended that the NCI would carry out intramural research and support extramural research and cancer
control, which it referred to as the “useful application of their results (12).” By the mid-1900s, the major focus of cancer control was the dissemination of research discoveries through communications and education. Research in cancer control per se was not yet part of the paradigm.

With the enactment of The National Cancer Act of 1971 (PL 92-218), Congress reaffirmed its support for cancer control and authorized specific dollar amounts for the Director of the NCI to carry out relevant programs with state and other health agencies (4). Prior to this time, as Breslow et al. (11) argued, the NCI had failed to carry out its mandate in cancer control, largely because of the lack of clarity in its conception. This derived primarily from the “lack of sharp differentiation between research and control... on the one hand and between control and health care on the other” (11). A working group formed after the 1971 act stated: “Cancer control seeks to find the means for combating cancer, whereas cancer control is concerned with identifying, community testing, evaluating, and promoting the application of means that are found (13).”

The Division of Cancer Control and Rehabilitation, reestablished in the NCI in 1973, was the first structural unit within the NCI devoted to cancer control (11). Although, by this time, efforts in cancer research had brought about notable advances such as Pap smear screening for cervical cancer, mammography use for the early detection of breast cancer, identification and regulation of some carcinogens in the workplace, and publication of the Surgeon General’s landmark Report on Smoking and Lung Cancer in 1964 (14), this organizational entity made it possible to begin a more systematic program in cancer control.

In the last quarter of the century, the science of cancer control was accelerated by the formation of the NCI’s Division of Cancer Prevention and Control in 1983, led by Peter Greenwald. The development and promulgation of a definition and framework for cancer control placed the field on a sound scientific basis and recognized the importance of research in this field. Greenwald and Cullen (15) defined cancer control research as “the reduction of cancer incidence, morbidity, and mortality through an orderly sequence from research on interventions and their impact in defined populations to the broad, systematic application of the research results.”

This definition was accompanied by a framework that described a linear series of phases from hypothesis generation (Phase I) to methods development (Phase II) to controlled intervention trials (Phase III). Studies in defined populations (Phase IV) and demonstration projects (Phase V) led to nationwide prevention and health services programs (15). The concept proposed a logical progression—from basic research through tests of intervention efficacy to community applications—that attempted to focus investigators on the need to build appropriate foundations before moving on to larger scale tests. This paradigm, which paralleled the model of drug development, effectively stimulated a generation of investigators to think more rigorously about cancer control science as an hypothesis-driven and evidence-based endeavor. The logical progression of inquiry gave cancer control researchers a focus and fostered a large body of new cancer control knowledge (16–21).

Cancer Control Accomplishments of the 20th Century

Until the very end of the 20th century, deaths from cancer have risen inexorably. Absolute numbers of deaths from cancer continue to increase in an aging population—539,508 cancer deaths in 1996 (2). Adjusting for the effect of age (direct age adjust-

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men to 1940 U.S. standard population), however, we have seen cancer deaths go from 79.6 per 100,000 in 1900 to a peak of 135.0 per 100,000 in 1990 and, since then, an annual decrease of 0.6% to 127.9 in 1996.3 This is the first sustained downward trend in the cancer death rate since the beginning of the century. During this period, decreases in mortality rates have been noted for cancers of the lung, pancreas, brain, and prostate in men, for breast and cervical cancers in women, and for cancers of the colon/rectum and stomach in both men and women (22). Decreases in incidence have also been noted for cancers of the lung (men), colon/rectum, prostate, urinary bladder, oral cavity and pharynx, and leukemia (22). Although evidence directly linking the decline in cancer to a reduction in smoking behavior, dietary modifications, changes in food preparation and storage, and screening is not often available at the national level, the relentless upward trend in cancer mortality has been reversed, and there are clear signs that cancer control research and its applications have played a major role (22–24).

There is good evidence, in particular, that the trends in cancer mortality can be linked to changes in behavioral risk factors. Since the 1964 Surgeon General’s report on the health consequences of smoking, the prevalence of smoking among adults has decreased significantly, from 45% in 1964 to <25% in 1995 (25). Today, there are as many former as current smokers in the population. Recognition of tobacco use as a health hazard and subsequent public health antismoking campaigns have resulted in changes in social norms to prevent the initiation of tobacco use, promote cessation of use, and reduce exposure to environmental tobacco smoke (26–28). Changes in smoking behavior prior to 1986 have been estimated to have resulted in the prevention of nearly 2.1 million smoking-related deaths between 1986 and the year 2000 (29).

An increased understanding, through behavioral research, of the barriers to cancer screening has made it possible to develop effective strategies to promote adherence to both breast and cervical cancer screening (16). The use of screening Pap smears for cervical cancer in this country has increased markedly, to the point where ~91% of women of ages 18 years and older report having been screened at least once (30). This test is a well-established part of routine preventive care, and death from cervical cancer is becoming an increasingly rare event in the United States, decreasing from 5.2/100,000 in 1973 to 2.7/100,000 in 1996 (2). Screening mammography has been shown to reduce mortality by 30% in women >50 years (31, 32), and its use has been widely adopted. In the period 1987–1990, there was a 2-fold increase in self-reported mammography use in every age and race/ethnic group (33), associated with the implementation of large-scale behavioral screening interventions. In 1992, a national survey reported 51% of women age 50 and over having had at least one mammogram in the previous year or two (30). As mammography rates have risen dramatically, overall breast cancer mortality has decreased (34).

Evidence supports the beneficial effects of fruit and vegetable consumption in protecting against cancer, but in the period 1989–1991, only 32% of U.S. adults reported eating five or more servings a day, and the mean intake was only about 4.3 servings (35). Major national efforts to help improve this food-related behavior, such as the “5 A Day for Better Health Program” that was initiated in October 1991 (36), have been associated with increases in daily fruit and vegetable consump-

3 L. A. Ries, personal communication.
tion to about 4.9 servings by 1994–1996 (37). Also, consumer awareness of the need to eat a minimum of five vegetables and fruits every day improved substantially between 1991 and 1997—from 8% of those surveyed to 39% (38).

Behavioral research into effective psychosocial and behavioral interventions for cancer survivors has led to practices that contribute to the reduction of cancer pain, enhancements in the quality of life, and in some cases, prolonged survival (20, 39–41). All of these salutary changes in the nation’s cancer burden can be attributed, at least partially, to the efforts of cancer control research and its successful application at multiple levels of the health care system and community (42, 43). The decreases in mortality for lung cancer and cervical cancer, in particular, provide compelling evidence that aggressive and sustained public health action in the control of cancer at the behavioral and societal levels can, over the long term, have dramatic results.

**Challenges for Cancer Control Research**

Despite our successes, we also have recognized limitations, challenges, and failures in cancer control. Although tobacco use has been decreasing overall, the rate of decline has slowed in recent years, especially among women and minorities (44, 45). Tobacco use by teenagers is on the rise (46). Data from the 1997 Youth Risk Behavior Survey indicate that the prevalence of current cigarette smoking among United States high school students increased from 27.3% in 1991 to 36.4% in 1997 and that, in 1997, 42.7% of students used cigarettes, smokeless tobacco, or cigars during the 30 days preceding the survey (47). The commercial interests of the tobacco industry remain a powerful countervailing force against the widely understood dangers of tobacco use addiction and the public health programs mounted to combat them. Likewise, although the use of mammography has risen dramatically overall, there still remain sizeable underserved segments of the population who are not getting appropriate screening (48). Pap smears can prevent deaths from cervical cancer, but we still have an estimated 4800 deaths/year (49). Most deaths are among older women, and screening is less common after menopause (50). Despite the body of evidence that a sedentary life style, weight gain, and obesity appear to increase the risk of developing cancer as well as other chronic diseases, such as noninsulin-dependent diabetes and cardiovascular diseases (51), these problems represent a growing health problem in the United States. Data from the third National Health and Nutrition Examination Survey (NHANES III, 1988–1994) indicated that 55% of United States adults were overweight or obese, with 22% classified as obese (52). Comparison of data from NHANES III with similar data from NHANES II (1976–1980) indicated that prevalence of obesity increased by 8%, and average weight increased by 3.6 kg. Also, recent findings show ~47% of the United States white population are not “very likely” to protect themselves against the harmful effects of sun exposure through appropriate behaviors, e.g., using sunscreen, wearing protective clothing, and seeking shade on a sunny day (53). Surveillance research continues to reveal troublesome disparities in cancer incidence and mortality by race/ethnicity and socioeconomic status that need to be better understood if interventions are to be effective in eliminating these differences (54). Finally, although organized systems of health care delivery are becoming the norm in the United States, there is no national population-based system to monitor the quality of care experienced by cancer survivors (55).

Thus, although there have been successes in cancer control and evidence that the burden of cancer may be decreasing in the United States, this is not a time to be complacent. Rather, it is time to look in new directions to achieve an even greater population impact. We must ask ourselves if we are appropriately prepared for this challenge. Is the logical next step for research in tobacco control and dietary modification further investment in large community and state-based trials and demonstration projects, in the conduct of more basic research, or some combination of these alternatives (56)? What are the roles of obesity and physical activity in cancer causation? The excitement generated by discoveries in molecular biology and genetics is driving much of the activity in cancer research, but how can the resulting opportunities be optimized for cancer control? One of the first areas where the biomedical, behavioral, and social sciences may intersect is in understanding the nature of tobacco addiction, the vulnerability of some people to its harmful effects, and the social practices and policies that influence tobacco use behaviors. As we learn more about the susceptibility to tobacco addiction of persons with certain genotypes, we may be able to tailor both pharmacological and behavioral interventions. But advances in genetics bring challenges as well. For example, too little is known about how best to communicate information on genetic susceptibility to patients and the public. Trade-offs exist for the individual between the benefits and the potential adverse psychosocial and economic effects of knowing one’s genetic status. Research on cancer risk communication and informed consent is needed in many areas, including communicating about the application of proven methods of chemoprevention, such as the use of tamoxifen to prevent breast cancer, and about screening tests where there is uncertainty about benefit (e.g., prostate-specific antigen, mammography for women ages 40–49, and hormone replacement therapy). A stronger evidence base is needed to define effective behavioral interventions that can lead to sun avoidance and a reduction in skin cancer (melanoma) incidence and mortality (57). The increasingly clear role of the human papillomavirus, hepatitis C, hepatitis B, EBV, and other viruses, as well as the role of _Helicobacter pylori_, in cancer etiology calls for effective prevention strategies and research on the role of behavior in their transmission. There is increasing appreciation of the association of low socioeconomic status and relative deprivation with adverse cancer outcomes, but how does understanding this relationship inform intervention research and public health action? The growing population of cancer survivors, now >8.1 million (49), requires answers for a number of questions related to decision making, treatment preferences, quality of life, reproductive health, the risks for second primary tumors, and social and economic threats to the quality of their long-term survival. Finally, fundamental changes in the way health care is delivered in the United States offer new opportunities for behavioral research to discover how cancer prevention and control interventions can be applied in large, organized, and integrated health care systems.

This brief survey of the challenges still facing us has included only a portion of the critical questions requiring answers from cancer control research. As we accept this considerable challenge, we must examine, once again, the basic tenets of the field, including the adequacy of the current definitions and frameworks that underpin cancer control research. It is now time to build on the achievements of the pioneers in the field of cancer control and look to the future.
A New Strategy

Review and Reorganization. From 1996 through 1998, the Cancer Control Program Review Group and the Cancer Prevention Program Review Group, which were established at the request of the Director of the NCI, convened to examine the cancer prevention and control program and to recommend new directions for a research agenda and the organizational infrastructure needed to support these recommended changes (8, 58). Important societal trends were identified that will have a major impact on cancer prevention and control at the beginning of the next century—an aging and more diverse population, the revolution in communications and informatics, the explosion in the rate of discovery in molecular biology and genetics, and the fundamental changes in our system of health care delivery. In addition, a public health agenda for the control of tobacco use is evolving, as well as new opportunities for health care systems, community organizations, families, and individuals to benefit from smoking prevention and cessation interventions. These trends collectively open up numerous new areas for cancer control research and emphasize the need for a refined strategy to guide us forward in efforts to further reduce the cancer burden in this country. In part, as a consequence of the Review Groups’ recommendations, two new extramural divisions, the Division of Cancer Prevention and the DCCPS, were created from the previous Division of Cancer Prevention and Control. This was the first major reorganization in the NCI’s cancer control program since 1984, and it has important implications for the cancer control research agenda.

The formation of two new NCI Divisions and their current rapid growth are indications of the new emphasis being placed on cancer control. Organizationally, the Division of Cancer Prevention is also concerned with the broad challenges of cancer control research. However, it will focus primarily on the biomedical aspects of prevention and, in particular, the increasing research opportunities in chemoprevention, nutrition and cancer, cancer biomarkers, and early detection research based on discoveries in cancer biology, drug development, and other basic sciences.

The establishment of the new DCCPS, based on the broad and far-reaching recommendations of the Cancer Control Review Group, has five major programmatic components: Epidemiology and Genetics Research, Behavioral Research, Cancer Surveillance Research, and Applied Research. The Office of Cancer Survivorship also is located in this Division because of the importance of epidemiology, behavioral sciences, and surveillance to the needs of survivors and their providers. Central to the mission of this Division is the emphasis on behavioral research, although it is recognized that effective behavioral interventions depend frequently on the application of discoveries in fundamental behavioral and biomedical sciences as well as epidemiology; surveillance is required to identify the populations for etiological and intervention research.

The New Strategy for Cancer Control. Our new strategy recognizes that human behavior is a major determinant of successful cancer control. It highlights the fact that behavioral intervention research has an underpinning in the basic sciences that requires ongoing support and integration into the cancer control process. Beyond that, behavioral research must be grounded firmly in epidemiological and surveillance research and informed by biomedical discoveries. Also, our strategy explicitly recognizes the importance of broader social and cultural influences on cancer control. The ultimate goals of cancer control are to reduce cancer risk, incidence, morbidity, and mortality and to improve the quality of life through application of research findings.

Cancer control research must address several realities that define the nation’s current health status, and it must evolve with the changing needs of the population. A dramatic reduction in tobacco use is needed among both adolescents and adults in the United States and beyond, if further advances are to be made in reducing the burden of tobacco-related cancers. A comprehensive cancer control strategy also should increase the proportion of Americans who follow the dietary guidelines formulated by the NCI and other organizations to maintain their recommended body weight, incorporate appropriate physical activity into their daily lives, and reduce their exposure to the sun and various infectious agents. The successful promotion of proven screening methods in breast, cervical, and colorectal cancers and their integration across diverse healthcare systems and communities could have a major impact in reducing mortality from these diseases. Interdisciplinary research is needed so that individual and family decisions about genetic testing are based on an understanding of gene and environmental interactions and their associated risks. The quality of life among cancer survivors can be improved, and the probability of second cancers can be reduced. The disproportionate burden of cancer experienced by some minority and medically underserved segments of the population and the influence of social inequalities on cancer outcomes must be understood so that attempts can be made to eliminate them.

The objective of our strategy is to foster a program that integrates epidemiological, genetic, behavioral, and cancer surveillance research to accelerate a reduction in the cancer burden. This means describing what we know about the etiology of cancer and the biological, behavioral, and social determinants of cancer risk, incidence, and mortality; developing effective behavioral interventions for reducing cancer incidence, morbidity, and mortality across all populations; improving the quality of life of cancer survivors; and developing innovations in methodology that will improve the way we assess cancer control needs and the impact of interventions. The program must be based on a sound, comprehensive surveillance strategy that includes both cancer registration of geographically well-defined populations as well as applied research based on these surveillance data. We view the new DCCPS as an integrated, interdisciplinary endeavor. The interaction of the cancer control disciplines within the divisional structure serves as a microcosm for how cancer control research can function in institutions and communities throughout the United States.

A Framework for Cancer Control. Cancer-related behaviors are multifactorial in nature and influenced by psychosocial, physiological, and biological factors as embodied in the biobehavioral model developed by Norman Anderson and his colleagues (59). The model was adapted to the problem of tobacco control in a way that illustrates these relationships (Fig. 1). The three overarching categories of factors—social, psychological, and biological—are mediated by behavioral, neurochemical, and physiological factors to influence behavioral end points in the individual, including tobacco use, dependence, cessation, and relapse. By recognizing the complexity of the determinants of tobacco use and addressing these behavioral mediators, the NCI’s research agenda has the potential to reduce tobacco-related cancers dramatically (60).

In addition to our adaptation of this causal framework for tobacco use and other behaviors, the framework adopted by the Advisory Committee on Cancer Control of the National Cancer Institute of Canada (61) is useful for understanding the struc-
Much more effort is needed to synthesize what we have learned at all levels of the health system and community. It answers the question of “What do we know?” and encompasses discovery from many health-related disciplines, including biomedical sciences, psychology, sociology, anthropology, and economics. Intervention research builds on the evidence base from epidemiological studies and fundamental research and then attempts to discover effective means to apply what has been learned at all levels of the health system and community. It answers the question of “What works?” Although interventions are primarily behavioral in cancer control, they also can be combined with pharmacological interventions, where appropriate, and can be sociological, legislative, or policy driven in nature. When successful, these interventions are promoted at the health system, community, state, and national levels, as well as in the clinic and at the bedside. The process is iterative; the application of these interventions generates new needs and hypotheses for further fundamental research, including basic biobehavioral research. Also, for applications to be effective, research on the process of dissemination and diffusion itself, including research on communication and informatics, is an essential part of the cancer control research framework.

The role of surveillance of cancer control measures and cancer outcomes is critical to cancer control and serves both to generate hypotheses for cancer control research and to assess the outcomes of cancer control interventions. Surveillance research answers the question “Where are we?”, but it also helps to form the question “Where do we need to go?”. Historically, population-based surveillance has served more of a descriptive and hypothesis-generating function. It now must be enhanced so that it also can clarify the connections between changes in risk factors and early detection behaviors and cancer outcomes, as well as the influences of the quality of health services and clinical treatment on cancer survival, quality of life, and mortality. Surveillance research must not only describe the cancer burden and track changes in cancer rates; it also must explain the reasons for observed disparities and trends in this cancer burden.

Finally, information synthesis is critical to cancer control. Synthesis answers the question “What’s next?” and is rightfully at the interface of all other cancer control research activities. Much more effort is needed to synthesize what we have learned from basic and fundamental research and epidemiology to determine when to move forward into intervention research. Likewise, a synthesis of intervention research results is needed before we decide whether it is time to move to applied public health and health services applications or whether more basic or other pre-intervention science research is needed. As an example, numerous community-level intervention studies in breast and cervical cancer screening have been carried out in underserved groups, but there presently is only limited understanding of the implications of this body of research. Although there have been selected meta-analyses (62–64), a more comprehensive approach to synthesis is needed. Much of cancer control practice in the behavioral area is still rooted in anecdote rather than evidence. Future cancer control practice must be based on a synthesis of available research findings in an effort to optimize the chances of developing successful cancer control strategies in this challenging area. Finally, synthesis is needed of the knowledge generated by surveillance research to further form the development of interventions and to generate new hypotheses for epidemiological and other more basic research.

**New Cancer Control Research Programs.** DCCPS has been organized to meet the challenges of cancer control for the next century. We now turn our attention to describing some selected new directions to provide specific examples of how the NCI can and will be supporting the research agenda in cancer control over the next decade.4

Our understanding of the etiology of cancer in populations is at the foundation of cancer control research and must be integrated into the process that leads to the development of successful interventions. Epidemiology is more than just a set of methods for measuring associations of exposure and disease in individuals (65). Rather, it is a multidisciplinary approach to understanding the causes of disease in populations. Epidemiology provides a substantial component of the scientific evidence for the development of preventive, including behavioral interventions, by explaining the contributions of biological, psychological, and social factors to cancer etiology. For example, epidemiological studies of the interaction of genetic susceptibility markers and environmental factors will permit more targeted screening, diagnosis, and treatment. Epidemiological research into the type, duration, and intensity of physical activity at various stages of life, and a synthesis of the results, will

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4 More current information is available at http://DCCPS.nci.nih.gov/DCCPS.
be needed to develop appropriate interventions to decrease the risk of colorectal and, possibly, breast cancer (66). Epidemiological evidence linking social inequalities to adverse cancer outcomes can be used to develop health policies to improve prevention, early detection, and treatment services to those in need. The new cancer control strategy will support a broad-based epidemiological program in all these areas and seek to link results to intervention development.

We are also fostering research in cancer epidemiology with substantial investments in resource infrastructure. Genetic epidemiology, for example, includes a network of cooperative family registries in breast and colon cancer and another network of centers studying individuals at high risk of cancer from inherited susceptibility. These new mechanisms bring epidemiology closer to the latest discoveries in the laboratory and clinic and allow us to understand the most effective interventions for genetically susceptible individuals. We must not forget, however, that epidemiology is fundamentally a population-based science, and it is the eventual link results to intervention development.

In the area of intervention research, we are funding basic biobehavioral research to improve our understanding of the mechanisms that govern cancer-related health behaviors. Among these behaviors, recognition of the overwhelming importance of tobacco use in the etiology of major cancers must be central to an effective cancer control strategy. A national prioritization of tobacco use in the etiology of major cancers must be central to an effective cancer control strategy. A national program is being built in cancer survivorship to conduct research on the identification, prevention, treatment, and care of the broad spectrum of conditions experienced by cancer survivors. The Office of Cancer Survivorship has the mandate to foster new research programs that recognize the unique needs of individuals who have been treated for cancer and who face many unanswered questions during an increasingly long period of survivorship. The cancer survivorship program will build on the opportunities provided by the associated programs in epidemiology, behavioral research, and surveillance while working closely with the cancer survivor and cancer advocacy communities. It will seek to under-

societal factors mediated through state- and community-level policy and media messages.

In other areas of primary prevention, we need to synthesize what has been learned from past research in diet, weight control, and physical activity as they relate to the control of cancer to determine “What’s next?” The research generated by the “5 A Day for Better Health” program has advanced our understanding of broadscale interventions that include the simple “use five fruits and vegetables a day” message, but now new research is needed on the determinants of dietary behavior, the interaction of dietary behavior, weight control and physical activity, more targeted diet-related interventions, and new methods of dietary assessment for tracking the impact of interventions. Continued efforts are needed to reach population subgroups at higher risk, evaluate dietary intake patterns, and develop effective behavioral interventions.

Effective interventions are needed to encourage people to get regular screening for cervical, breast, and colorectal cancers. New approaches are needed to identify individuals who do not adhere to screening recommendations and to develop interventions appropriate for them. Furthermore, research is needed to aid both individuals and providers in informed decision making for screening in the face of uncertain evidence of efficacy. New discoveries of biomarkers and genetic susceptibility will soon make screening tests available that must be evaluated in clinical trials and population-based settings. Concerns about the acceptability of these tests and adherence to them, as well as recruitment and retention to the trials themselves, are increasingly important areas for behavioral cancer control research.

Attention to the associations of race and ethnicity with cancer-related behaviors must be conceptually broadened to include considerations of the influence of socioeconomic class, immigrant status, culture, discrimination, and health care access on cancer outcomes (55, 67). These “upstream” influences on health behaviors may have powerful influences on cancer incidence and outcomes at a societal level because of their ubiquitous application to large segments of the population (68, 69). The new discoveries in molecular biology that have more limited application to high-risk populations may have dramatic impact for the individual but less at a societal level, yet they require our concerted attention. We will support new initiatives on the social and cultural influences in cancer outcomes simultaneously with our parallel emphasis on biomedical innovations.

Within the new structure for cancer control research, we now have the opportunity to harness the informatics and communication revolution to improve cancer outcomes. Innovative forms of health communication include, for example, tailored print communications, interactive kiosks, CD-roms, and an ever-growing array of new technologies. Increasingly, in an era of mass customization, these tailored strategies allow cancer control scientists to individualize and personalize cancer control messages and to offer people choices about the kinds of information they want and need. To date, the evidence of effectiveness in this area is very promising (70, 71).

A program is being built in cancer survivorship to conduct research on the identification, prevention, treatment, and care of the broad spectrum of conditions experienced by cancer survivors. The Office of Cancer Survivorship has the mandate to foster new research programs that recognize the unique needs of individuals who have been treated for cancer and who face many unanswered questions during an increasingly long period of survivorship. The cancer survivorship program will build on the opportunities provided by the associated programs in epidemiology, behavioral research, and surveillance while working closely with the cancer survivor and cancer advocacy communities. It will seek to under-
stand risk factors for recurrence, enhancements to the quality of life, the role of the family in survivorship, and the prevention of second malignancies and the sequela of cancer treatment. Finally, the survivorship research program will include health services studies of the impact of the cancer diagnosis on the ability of survivors to obtain health insurance and be productive members of the work force.

The current surveillance research program at the NCI, which includes the SEER program and other related applied research activities, is the standard for high-quality cancer surveillance. This program has developed the statistical and methodological data resources that enable a more definitive interpretation of cancer patterns and trends. Although cancer surveillance describes the cancer burden in this country admirably, it must be better able to explain the reasons for trends in the burden. As we expand the scope of cancer surveillance, new tools must be developed, and the SEER system must be connected to other data collection systems. Together these will help us understand cancer trends and, ultimately, the causes of cancer in defined populations. With the focus on population-based systems in cancer registration, from SEER programs or other high-quality cancer registries, additional data collection from cancer patients themselves needs to be supported to advance our knowledge about the outcomes of cancer treatments, including the quality of care and quality-of-life assessment. In addition, in these defined populations, innovative ways to connect risk factor and screening data to cancer outcomes need to be developed to better understand the link between population level changes in the determinants of cancer and these cancer outcomes. Sound methodological research to develop standardized, reliable, and accurate measures will be central to future progress. Further research will be expanded in statistical methods and modeling to provide quantitative estimates of the effects of recommendations, interventions, or population trends. This research expansion has particular value in answering questions that cannot be resolved by existing data. SEER and other high-quality cancer registries can also extend their traditional role in providing information and subjects for epidemiological studies by the wider application of rapid case ascertainment systems and by collecting biospecimens for genetic epidemiological studies. New infrastructure supporting cancer research in a network of large, established health maintenance organizations provides an opportunity for expanded health services and outcomes research. Finally, to fully exploit the opportunities that are offered by the expanding area of cancer surveillance research, training opportunities need to be developed for new investigators at the NCI as well as at academic centers around the country.

Need for Partnerships to Put Research into Action

The nation’s goals for cancer control will not be readily achieved without the collaboration of the multiple agencies and organizations concerned with the control of cancer. There already is a functioning network of organizations and individuals deeply committed to cancer control in this country, each with their own purposes and objectives. This enterprise has many partners, and we will name only a few. They include other federal agencies, such as the CDC, the Agency for Health Care Policy and Research (72), and the Health Care Financing Administration; voluntary organizations, such as the ACS; foundations, such as the Robert Wood Johnson Foundation; and numerous professional associations including the American College of Surgeons, the American Society for Preventive Oncology, the American College of Radiology, the American Society for Clinical Oncology, the American Association for Cancer Research, and the Society for Behavioral Medicine. Collaborations with these partners take several forms, includ-

ing the development of research infrastructure (e.g., the linkage of the SEER and Medicare databases with Health Care Financing Administration); programs to disseminate proven interventions (e.g., collaborative efforts by the CDC and the ACS that include the American Stop Smoking Intervention Study and the “5 A Day Program”); and planning efforts (e.g., NCI’s coordination with the North American Council of Central Cancer Registries, CDC, American College of Surgeons, and ACS to develop a national cancer surveillance program). The ACS and the NCI also have jointly sponsored major research programs and complement each other in the dissemination of cancer information to health care professionals and the public. A vital training and educational function is shared by the NCI and many professional organizations.

The basic premise of cancer control requires the “useful application of results” of cancer research (12). If we are to achieve a real impact on the cancer burden across the United States, the results of the cancer control research that NCI and other agencies support must be applied in programs that have wide-scale acceptance by states, localities, and health care systems. The interdisciplinary nature of the cancer control research endeavor is clear, as evidenced by the variety of strategies that we need to pursue. Scientists from diverse fields of biomedical research must effectively interact with behavioral scientists within the public health model if we are to make further advances in reducing the cancer burden on a broad scale. We now appear to have cancer on the run. The challenge before us is to use this new strategy for cancer control research to sustain a long-term and accelerated decline in the threat posed by this dreaded disease.

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