An Overview of the Cancer Burden for Primary Care Physicians

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KEYWORDS

• Cancer burden • Cancer statistics • Cancer trends
• Cancer survival • Cancer prevention

Despite substantial decreases in cancer death rates in many industrialized countries, and an initial decrease in incidence rates in the United States, cancer remains a major problem. Nearly 1 in 2 men (44.9%) and more than 1 in 3 women (37.5%) in the United States will be diagnosed with some form of invasive cancer during his or her lifetime.[1] With the decline in heart disease mortality, cancer has become the most common cause of death under age 85 years; it will soon become the most common cause of death at all ages if current trends continue.[1] The number of people surviving after a diagnosis of cancer has increased from an estimated 8.9 million in 1997 to 11.1 million in 2005,[2] due to increased screening and advances in treatment. Furthermore, the public's awareness of cancer has increased because it is now socially acceptable to acknowledge and discuss having been diagnosed with cancer.

People's fear of cancer is also compounded by misunderstandings about the disease, the diversity of various forms of cancer, and by fatalism about whether individuals can realistically alter their personal risk. The sobering statistics provide little reassurance about lifetime risk. Although the public is flooded with information about cancer from the Internet and other sources, credible health messages often do not reach the intended audience or are misunderstood because of lack of context, low scientific literacy, or engrained cultural beliefs.

Primary care physicians and other caregivers are uniquely positioned to communicate with patients about their real risks of developing or dying from cancer and actions that can reduce these risks. Such information can offset misplaced fears that might otherwise cause patients to forego measures that have been proven to be effective,

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and instead to rely on other approaches that lack sound evidence of benefit. Although behavioral changes are often difficult, there is evidence that physician recommendations help to motivate changes such as quitting smoking[3,4] or receiving age-appropriate screening.

This article discusses the statistics used to measure the cancer burden in a manner intended to help primary caregivers communicate more effectively with patients about cancer. The basic terms used to measure incidence, mortality, and relative survival, and considerations that influence the interpretation of cancer trends are described; opportunities to accelerate progress in reducing cancer incidence and death rates are identified. The objective is to supplement, rather than duplicate, other information about cancer statistics provided annually by the American Cancer Society (www.cancer.org/statistics).[1]

BASIC TERMS

The most frequently used measures of cancer occurrence and survival are *counts* (the number of new cancer cases or deaths identified in a population during a defined time period, usually 1 year), *rates* (the counts of cases or deaths divided by the number of people at risk in a defined time period and population, often standardized for age), and *relative survival* (the proportion of cancer patients alive for a specified time period after their diagnosis compared with the corresponding proportion in a population of the same sex and age distribution without cancer). Other metrics used to describe the disease burden from cancer include *prevalence* or *survivorship* (usually defined as the number or percentage of people who have been diagnosed with cancer and are still alive) and *lifetime probability* (the average likelihood, or cumulative risk, of developing or dying from cancer during average life expectancy). Each of these terms is defined further and how the various metrics should or should not be used to describe the cancer burden is illustrated.

Counts

Counts represent the burden of disease and death in a population in terms of the number of people affected in a given year. Counts are not informative about the average risk of individuals in the population, because they make no inherent distinction between cases and deaths that occur in a large population and the same number of cases and deaths that arise from a small population. Nor are counts generally adjusted for the age of the population. Their chief value is that they are easily understood by the public and provide one measure of the burden that cancer imposes on medical and social support systems.

Rates

Incidence and death *rates* are the only measures that can be used to make valid comparisons of risk among populations that differ in size or age distribution. During a 1-year time period, the incidence or death rate in the population is synonymous with the average probability, or risk, that an individual in the population will be diagnosed with or die from cancer in that year. *Rates* are usually expressed per 100,000 people per year in adults, or per 1,000,000 people per year for childhood cancers. Age-standardized *rates*, discussed later, are the appropriate measures to use to compare risk among different populations or to monitor trends in risk in the same population over time. Unfortunately, *rates* are not as easily understood by the public as *counts*. An unfortunate consequence of this is that the public is often misled by inappropriate comparisons based on counts.

Age Standardization

One advantage of characterizing cancer occurrence as *rates* rather than *counts* is the potential to control for age. The annual probability of developing or dying from most types of cancer increases with age. **Fig. 1** shows that the age-related increase in the death rate from all types of cancer combined is higher in men than in women at all ages, but that the incidence rate is higher in women than in men between ages 20 and 54 years. The age-related increase is so large that more than three quarters (76%) of all invasive cancers occur among the less than one fifth (19%) of the United States population aged 55 years or older.[5]

Age standardization is often used to summarize the age specific rates into a single number for comparing populations in which the age distributions may differ.[6]

One method, called direct standardization, adjusts for age by assigning a common set of weights to the age-specific rates of the populations being compared.[7] Valid comparisons can only be made if the same age standard is applied to each of the populations of interest, which is not automatically the case. Different age "standards" have been used during different time periods in the United States to keep pace with changes in longevity. Furthermore, the age standard used for many international comparisons gives greater weight to younger age groups than the standards used in various affluent countries.

Relative Survival

Survival information is usually presented as "*relative survival*" or the proportion of people alive for a specified time period (usually 5 years) after the diagnosis of cancer, compared with a population of equivalent age and sex without cancer. Although *relative survival* is often referred to as a *rate*, it actually represents the comparison of 2 proportions rather than a rate. Another common misunderstanding is to interpret *relative survival* as being synonymous with survival (ie, avoiding death from any cause) in

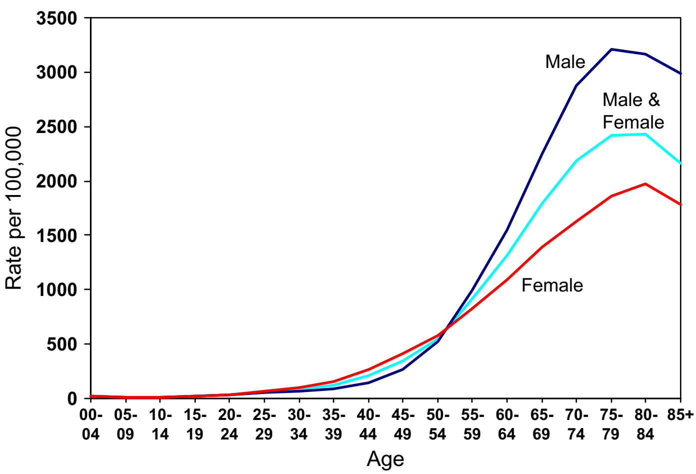

Fig. 1. Age-specific incidence rates for all cancer sites combined for men and women in the 9 original SEER areas, 2002. (*Data from* Surveillance, Epidemiology, and End Results Program, 1975–2004, Division of Cancer Control and Population Sciences, National Cancer Institute; 2007.)

the designated time period. Relative survival is generally higher than the absolute probability of remaining alive, especially for cancers that occur at older ages, because it adjusts for other causes of death that occur with or without the cancer of interest.

Prevalence and Survivorship

The term *prevalence* signifies the proportion of people alive who currently have the disease of interest. This term is rarely used to characterize the cancer burden, because for certain types of cancer there is no reliable way to know whether the tumor has been "cured" or is simply in remission. More commonly used are terms such as *cancer survivor* or *survivorship* that define *survivorship* broadly to include all those who have been diagnosed with cancer and are still alive. This number has increased over time to approximately 11 million people in 2005.[2] The increase in cancer survivors, whether expressed as a number or as a proportion of the population, is a function of several factors including improved treatment and increased screening. Screening has beneficial and artifactual effects on survival, as discussed later.

Lifetime Risk

Lifetime risk represents the average probability or risk that an individual in a population will develop or die from cancer during average life expectancy. Because *lifetime risk* describes the cumulative risk over a lifetime, it is strongly influenced by the life expectancy of the population. Situations arise in which the age-specific incidence or death rates from cancer decrease, yet the lifetime risk of developing or dying from cancer increases because of increasing life expectancy.

INTERPRETING CANCER STATISTICS

Count

Although they cannot be used to compare risk, counts are useful for quantifying the number of people affected by cancer and the relative frequency of different types of cancer. For example, the estimates shown in **Fig. 2** indicate that 4 cancer sites (lung, breast, prostate, and colon and rectum combined) accounted for about half of all cancer cases and deaths in the United States in 2008; breast and prostate cancer accounted for about 25% of all newly diagnosed cancers in women and men, respectively. An important caveat about the estimates in **Fig. 2** is that they are based on projections rather than data from the current year, because cancer registries and vital statistics offices need at least 3 years to process and publish the observed data from a given year. Each year, the American Cancer Society projects the number of cancer cases and deaths expected in the current year, based on projections from past years.[8,9] The 2008 projections were the most current when this article went to press. Updated estimates are available at (www.cancer.org/statistics). These projections are reasonably accurate compared with the observed data in past years.

Rates

Temporal trends in the age-standardized mortality rates are easier to understand and in some ways more informative than trends in incidence rates because they are less susceptible to the artifactual influence of new screening tests. Mortality data are also available for nearly all counties in the United States from 1930.[1] The trends in death rates from specific cancer sites are discussed first, because these are more meaningful biologically than the trends for all cancer sites combined.

The trends in age-standardized death rates for 7 selected cancer sites in men and 8 sites in women from 1930 to 2005 are shown in **Fig. 3**. These sites were chosen to illustrate the large changes (increases or decreases) in the death rates from certain

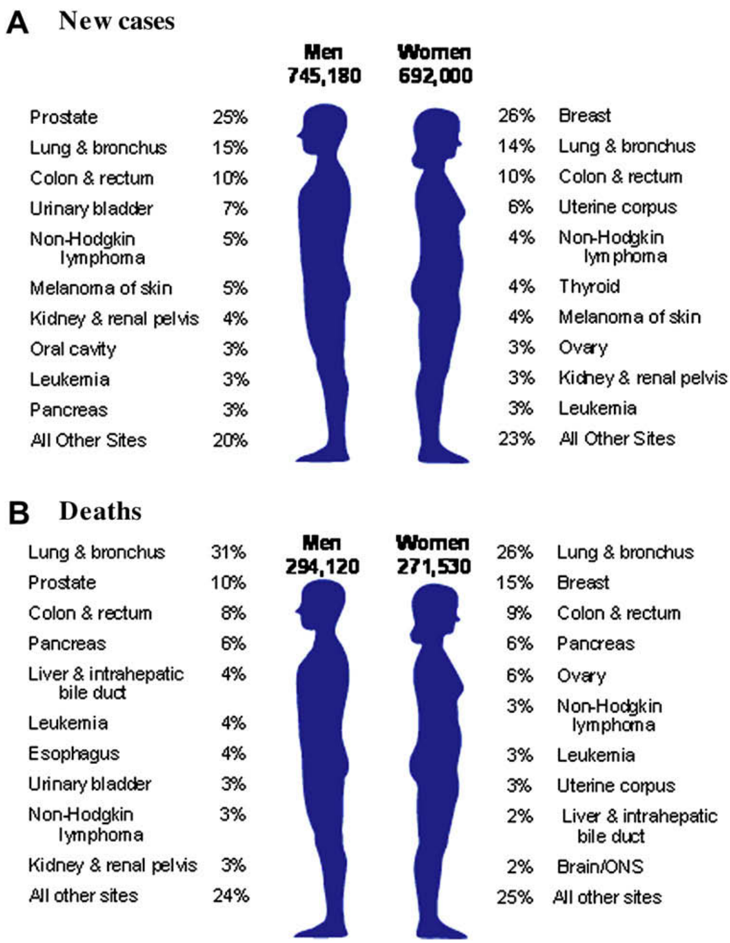

Fig. 2. (*A, B*) Number of cancer cases and deaths projected to occur in the United States in 2008 and the percentage contribution of the 10 most common sites of cancer. (*From* Jemal A, Siegel R, Ward E, et al. Cancer statistics, 2008. CA Cancer J Clin 2008;58:71–96; with permission.)

cancer sites over this time period. The remarkable increases in the death rates from cancers of the lung and bronchus that began in men before 1930, and in women by 1960, reflect the historical uptake of cigarette smoking. Equally remarkable are the decreases in death rates from lung cancer in men after 1990 and from cancers of the stomach, liver, and (in women) uterus since 1930. The decrease in lung cancer death rates among men reflects successful smoking cessation among adult male smokers since the 1950s. Smoking cessation accounts for 40% of the decrease in the death rate from all cancers combined in men since 1990.[10] The decrease in the death rate from stomach cancer is largely attributed to the introduction of refrigeration (which resulted in less use of salted and smoked foods and increased availability of fresh vegetables and fruit) and decreased prevalence of chronic infection with *Helicobacter pylori*.[11] The decrease in mortality from uterine cancer predominantly involves a decrease in cervical cancer mortality due to Papanicolaou (PAP) smear tests. The

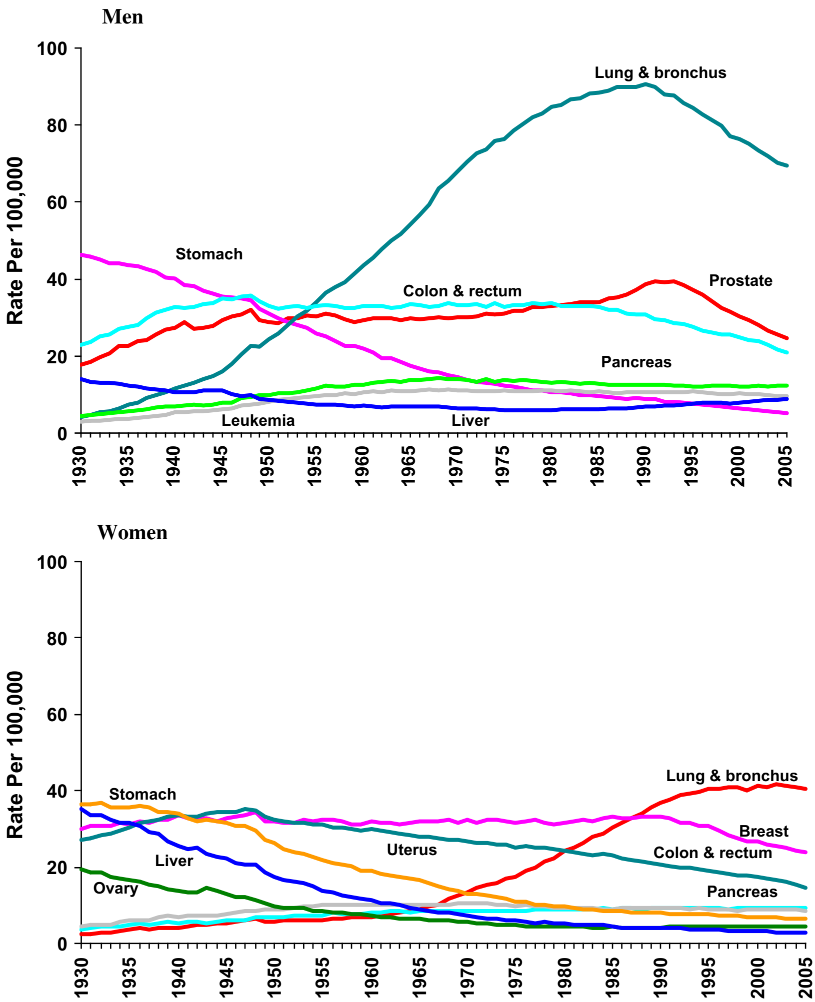

Fig. 3. Trends in the age-standardized* death rates for selected cancer sites in men and women: United States, 1930 to 2005. *Age-adjusted to the 2000 U.S. standard population and adjusted for delays in reporting. (*Data from* National Cancer Institute. Surveillance, Epidemiology, and End Results Program. Available at: www.seer.cancer.gov.)

age-standardized death rates from cancers, other than those shown in **Fig. 3**, have also decreased in recent years when analyzed by joinpoint analyses.[12] The death rates are currently decreasing for 10 of the top 15 cancer sites for mortality in men and women. Cancers with decreasing trends in both sexes include colorectum, stomach, kidney, brain, leukemia, non-Hodgkin lymphoma, and myeloma. Death rates are also decreasing in men for cancers of the lung, prostate, and oral cavity, and in women for cancers of the breast, cervix, and bladder.[12] This progress reflects a combination of primary prevention (principally reductions in smoking), and advances in early detection and treatment.

Temporal trends in the age-standardized incidence rates are shown for selected cancers in **Fig. 4**. These data span the period 1975 to 2005 for the 9 original registries

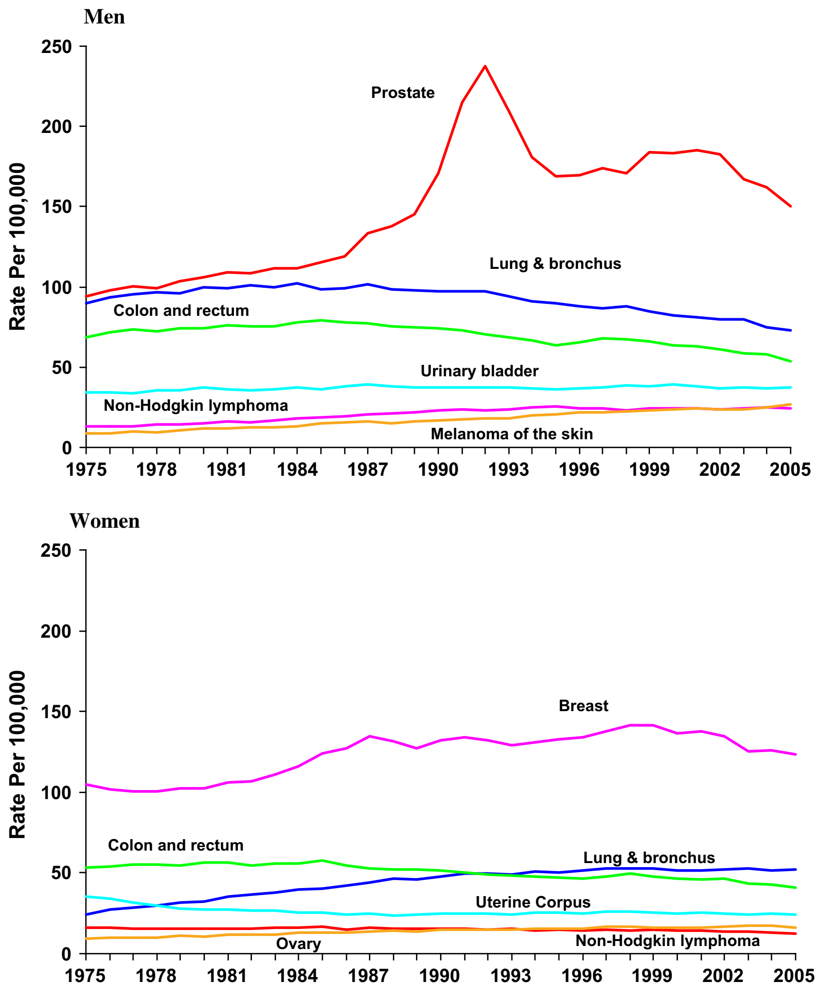

Fig. 4. Trends in the age-standardized* incidence rates for selected cancer sites in men and women: United States, 1975 to 2005. *Age-adjusted to the 2000 US standard population and adjusted for delays in reporting. (*Data from* Surveillance, Epidemiology, and End Results Program, Delay-adjusted Incidence database: SEER Incidence Delay-adjusted Rates, 9 Registries, 1975–2004, National Cancer Institute, 2007.)

operated by the National Cancer Institute's (NCI) Surveillance, Epidemiology and End Results (SEER) Program.[2] Cancers of the prostate and breast are the most commonly diagnosed invasive cancers in men and women, respectively. A large peak in the incidence of prostate cancer occurred during the early 1990s in men, following the introduction of widespread screening for prostate-specific antigen (PSA). This peak resulted from detection of a large number of small, slow-growing tumors, that in most cases qualify as cancer, but which might never have been diagnosed except for screening. The trend in incidence rates for prostate cancer illustrates that any interpretation of incidence rates must take into account changes in disease in detection or classification to be meaningful.

Trends in the incidence and death rates from all cancers combined for the United States are shown in **Fig. 5**. Although the trends for all cancers combined are not biologically meaningful, these trends indicate the extent to which progress is, or is not, being made in reducing the incidence and death rates from cancer in the United States. The incidence rate of all cancers combined, adjusted for delayed reporting of new cases, decreased by an average of 1.8% per year in men from 2001 to 2005, and by 0.6% per year in women from 1998 to 2005.[12] The death rates from all cancers combined decreased by 19.2% in men from 1990 to 2005, and by 11.4% in women from 1991 to 2005. Moreover, the rates are decreasing in all racial and ethnic groups except Native Americans.[12]

Effect of Growth and Aging of the Population

Growth and aging of the population profoundly affect the number of people (*counts*) who develop or die from cancer, but do not influence the age-specific or age-standardized *rates*. This point is illustrated in **Fig. 6**, which shows that the number of people who died of any form of cancer in the United States during the period 1970 to 2005 continued to increase most years, even after 1990, despite the substantial downturn in the age-standardized death rate, because the *counts*, unlike the rates, are not adjusted for growth and aging of the population. The decrease in the death rates since the early 1990s only partly offset the increase in the *counts* because of the increased number of people in older age groups when cancer becomes common.

The impact of growth and aging of the population on the cancer burden in the United States and globally has been projected to year 2050. **Fig. 7** shows the expected increase in size and shift in the age structure of the Unites States population, based on census projections. The population in 2000 is depicted in the area inside the silhouette, in relation to age and sex. The distribution projected to 2050 extends beyond the silhouette. Although the expected demographic changes may seem moderate, they will have a major impact on the number of people affected by cancer unless the decrease in the age-specific and age-standardized cancer rates continues and

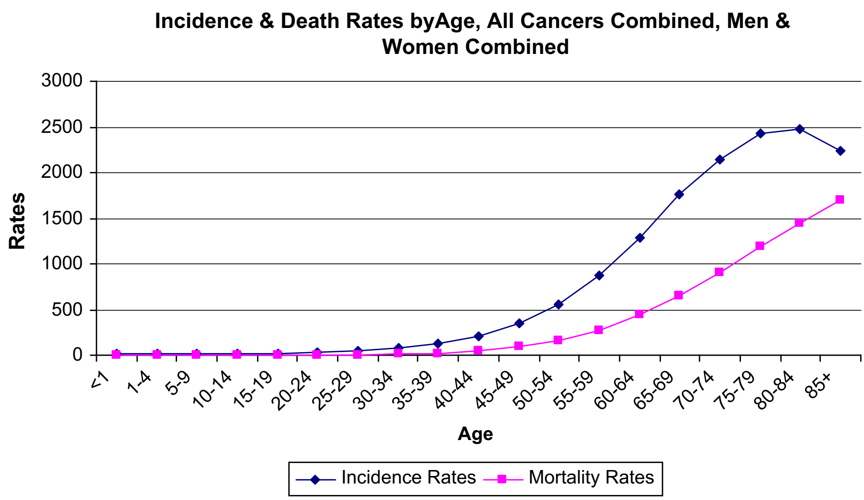

Fig. 5. Age standardization. Differences in trends of cancer death numbers and cancer death rates.

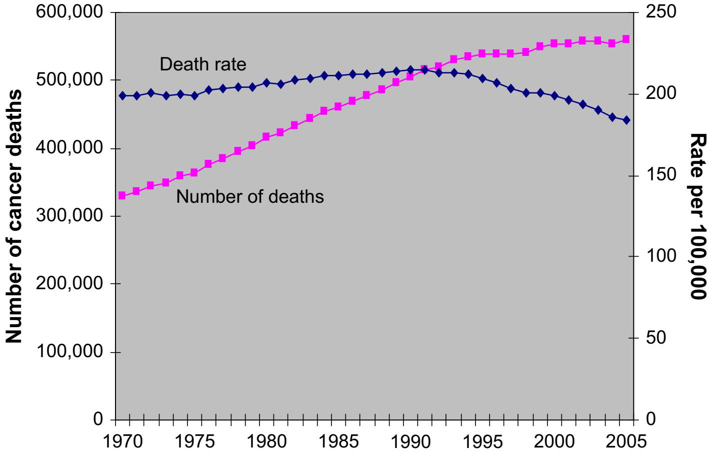

Fig. 6. Comparison of temporal trends in the number of cancer deaths that occur each year and the age-standardized death rate. (*From* Jemal A, Siegel R, Ward E, et al. Cancer statistics, 2008. CA Cancer J Clin 2008;58:71–96; with permission.)

accelerates. **Fig. 8** illustrates the projected increase in the number of incident cancers diagnosed annually in the United States between 2000 and 2050, if the incidence rates in 2000 continue unchanged. In this scenario, the total number of incident cases would approximately double between 2000 and 2050.[13] The costs of treating those who develop cancer would at least double by 2050, as shown in **Table 1**. In short, if current trends continue, the future will bring major increases in the cancer burden on medical, social, and economic support systems.

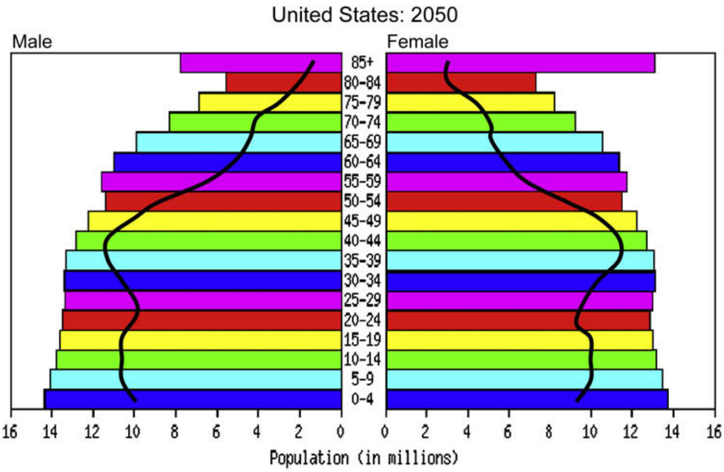

Fig. 7. Distribution of the United States population by age and sex in 2000 (inside silhouette) and projected to 2050. (*Data from* U. S. Census Bureau. International Data Base. Available at: www.census.gov/ipc/www/idb/pyramids.html.)

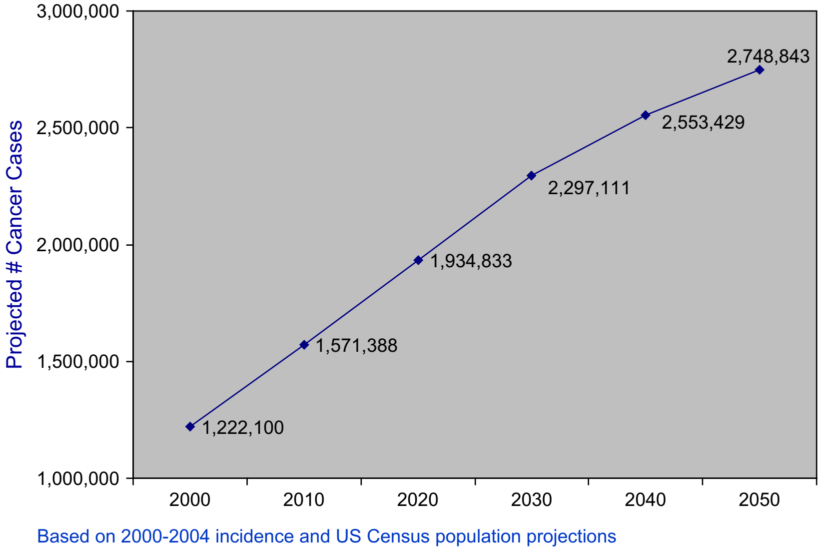

Fig. 8. The future without prevention: projected number of cancer cases diagnosed annually to 2050 if the incidence rates for 2002 to 2004 remain unchanged.

The impact of demographic changes on the projected number of cancer cases is expected to be even larger in economically developing countries than in developed countries. **Fig. 9** shows the number of cancers observed and expected at 5 time points from 1975 to 2050 in relation to regional levels of economic development.[14] The absolute number of new cancer cases nearly doubled between 1975 and 2002, and is projected to increase again by almost threefold between 2002 and 2050. Moreover, the proportionate distribution of these cases will shift progressively towards economically developing regions because of the increasing life expectancy in these regions and the global dissemination of tobacco smoking and Western lifestyles. No longer is it true that cancer predominantly afflicts people in rich countries.

Lifetime Risk

Table 2 shows the average probability that an individual will be diagnosed with some form of cancer, based on observed data from 2002 to 2004. As noted earlier, nearly 1 in 2 men and more than 1 in 3 women will be diagnosed with some form of cancer during average life expectancy.[1] Average lifetime risk has increased over time in the

Table 1
The future without prevention – health care costs

	2006	2050 Estimate
Cancer cases	1,399,970	2,748,843
Total costs	$206 billion	$405 billion
Direct medical costs	$72 billion	$154 billion

Estimated and expressed in 2007 dollars. Assumes incidence rate and cost per case remain constant.

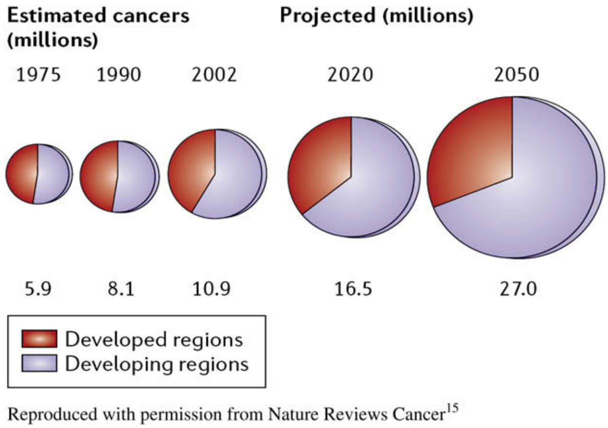

Fig. 9. Estimated numbers of new cases of cancer in the world, 1975 to 2050. (*From* Bray F, Moller B. Predicting the future burden of cancer. Nat Rev Cancer 2006;6:63–74; with permission.)

United States, because people are living longer and because sensitive screening tests can detect small or indolent tumors that might otherwise never have been diagnosed. Unfortunately, the increase in lifetime risk contributes to the public's perception and fear that cancer has become much more common than in the past. However, many of the tumors that are discovered by screening are small and are at a stage whereby surgical cure is possible; even watchful waiting may be appropriate. The sites that are most affected by screening include cancers of the prostate, breast, thyroid, and cutaneous melanoma.

Changes in Relative Survival

Five-year relative survival has increased for many types of cancer since the mid-1970s (**Table 3**). For some cancers, such as leukemia, non-Hodgkin lymphoma, testicular, and childhood cancers, relative survival has improved principally because of improvements in treatment. For other sites such as the colon, breast cancer in women, and possibly prostate cancer, *relative survival* has improved because of early detection and improvements in treatment. Some of the apparent improvements for cancers detectable by screening is artifactual, due to lead-time bias (detection of the tumor at an earlier stage, thereby lengthening the observation period between detection and death), or to the detection of less aggressive cancers that, in the past, might have escaped detection yet had little effect on longevity. For *relative survival*, as for *lifetime risk*, the artifactual effects of screening have the greatest effect on the incidence rate and relative survival for cancers of the breast, prostate, thyroid, and possibly melanoma. However, even for these sites, the artifactual effects of screening do not negate the real progress in reducing the death rates from these cancers in the general population.

Increase in the Number of "Cancer Survivors"

The Office of Cancer Survivorship defines a "cancer survivor" as someone who has been diagnosed with cancer and is still alive. By this definition, the number of cancer survivors has tripled in the United States since 1971, and now exceeds 11 million people.[2] Most cancer survivors (62%) had their cancer diagnosed within the previous

Table 2
Lifetime probability of developing cancer, 2002 to 2004[a]

Site	Risk
Men	
All sites[b]	1 in 2
Prostate	1 in 6
Lung and bronchus	1 in 13
Colon and rectum	1 in 18
Urinary bladder	1 in 27
Melanoma	1 in 41
Non-Hodgkin lymphoma	1 in 46
Kidney	1 in 59
Leukemia	1 in 67
Oral cavity	1 in 71
Stomach	1 in88
Women	
All sites[b]	1 in 3
Breast	1 in 8
Lung and bronchus	1 in 16
Colon and rectum	1 in 19
Uterine corpus	1 in 41
Non-Hodgkin lymphoma	1 in 53
Melanoma	1 in 61
Ovary	1 in 71
Pancreas	1 in 76
Urinary bladder[c]	1 in 85
Uterine cervix	1 in 142

[a] For those free of cancer at the beginning of the age interval.
[b] All sites exclude basal and squamous cell skin cancers and in situ cancers except urinary bladder.
[c] Includes invasive and in situ cancer cases.

Data from DevCan: Probability of developing or dying of cancer software. Version 6.2.1. Statistical Research and Applications Branch, National Cancer Institute; 2007. http://srab.cancer.gov/devcan.

10 years. Women are more likely than men and Caucasians are more likely than African Americans to survive longer than 10 years after diagnosis. Among male survivors, the 3 leading types of cancer are prostate (41%), colorectal (11%), and cancer of the urinary bladder (8%). Among female survivors, the leading cancers are breast (40%), uterine corpus (10%), and colorectal cancer (10%). Approximately 61% of cancer survivors are older than 65 years and therefore eligible for Medicare coverage; more than one third (38%) are of working age (20–64 years), and 1% are survivors of childhood cancer (<20 years).

Impact of Improvements in Prevention, Early Detection, and Treatment

Fig. 10 illustrates how different indices of the cancer burden are affected by improvements in prevention, early detection, and treatment. Advances in prevention reduce incidence and death rates but have no effect on relative survival. New screening tests

Table 3
Trends in 5-year relative survival (%),[a] United States, 1975 to 2003

Site	1975–1977	1984–1986	1996–2003
All sites	50	54	66
Breast (female)	75	79	89
Colon	51	59	65
Leukemia	35	42	50
Lung and bronchus	13	13	16
Melanoma	82	87	92
Non-Hodgkin lymphoma	48	53	64
Ovary	37	40	45
Pancreas	2	3	5
Prostate	69	76	99
Rectum	49	57	66
Urinary bladder	74	78	81

[a] Five-year relative survival rates based on follow-up of patients to 2004.
Data from Surveillance, Epidemiology, and End Results Program, 1975–2004, Division of Cancer Control and Population Sciences, National Cancer Institute; 2007.

typically increase the cancer incidence rate and relative survival but may or may not reduce death rates unless early diagnosis and treatment actually reduces mortality. Improvements in treatment increase relative survival and decrease death rates but have no effect on incidence rates.

SUMMARY

It is encouraging that the incidence and death rates from all cancers combined are currently decreasing in men and women and in nearly all racial and ethnic groups in the United States. The substantial decrease in cancer death rates (by more than 10% from 1992 to 2005) represents real progress in cancer control. These reductions in mortality are attributable to a combination of improvements in primary prevention,

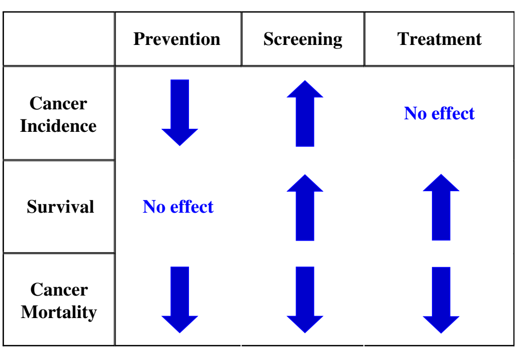

Fig. 10. How advances in prevention, screening, and treatment affect trends in cancer incidence and death rates and relative survival.

early detection, and treatment. The recent decrease in the overall cancer incidence rate is more difficult to interpret, and may in part be an artifact of the leveling off of mammography screening after 1999. In any event, the progress currently being made should be considered a starting point rather than a destination.[12] Further progress can be achieved by applying existing knowledge and evidence-based interventions more systematically to all segments of the population.

Primary care physicians are well positioned to communicate with patients about their real risks of cancer and actions that can be taken to reduce these risks. Smoking, excess weight, sedentary lifestyles, and failure to get screened all contribute to the excess burden of cancer.[15] Clinicians who ask patients about their tobacco use and counsel users to quit can motivate the first steps towards eventual successful cessation. Although integrating effective prevention measures into standard clinical care will require changes in health care policy and in clinical practice, the combination of these approaches is essential to prevent the massive anticipated increase in the number of cancer cases, due to growth and aging of the population.

COMMON QUESTIONS AND ANSWERS

1) **(Q) Are cancer rates increasing?**

   (A) The incidence and death *rates* from all cancers combined are now decreasing. Cancer rates did increase for several decades until the early 1990s among men and cancer incidence rates continued to increase until approximately 1999 among women. Increases that occurred in the past are largely explained by historical smoking patterns, the introduction of new screening tests for breast and prostate cancer, changes in reproductive patterns, and increases in obesity.

2) **(Q) If the rates are decreasing, why do so many people I know have cancer?**

   (A) There are several reasons for this; first, people are living longer and cancer is largely a disease of aging: second, people are more open to discussing the fact that they have cancer: and third, the incidence rate of several common cancers did increase in the past for the reasons discussed earlier.

3) **(Q) Isn't most cancer genetic?**

   (A) This depends on how one defines genetic. All cancers are inherently genetic in that the underlying problem is caused by damaged or malfunctioning genes. Malfunction of certain genes causes uncontrolled cell growth and proliferation and allows genetically damaged cells to become immortal and to spread to distant parts of the body. However, only a small fraction of cancers (less than 5%) are caused predominantly by inherited genetic problems.

4) **(Q) Isn't most cancer caused by environmental exposures?**

   (A) Again, this depends on how one defines "environmental". Whereas the public usually interprets "environmental" as synonymous with man-made industrial pollutants, cancer researchers define "environmental" more broadly to include all exposures that occur after conception. This includes nutrition, infectious agents, tobacco and alcohol use, physical inactivity, medical diagnostic procedures and treatments, sunlight, and radiation from natural and man-made sources.

   There are several dozen examples in which industrial chemicals and dusts cause cancer, especially in workers exposed to high concentrations over an extended time period, these occupational exposures have become uncommon in the United States since the 1970s. In general, Americans are exposed to pollutants at much lower levels now than in the past. The effect of current levels of contaminants in air, food, drinking water, and the general environment remains an active area of research. Although there is still much to be learned and a continuing need to enforce regulations that limit pollution, current evidence suggests that these exposures account for a small fraction of all cancers.

In contrast, "environmental" factors in the broader sense clearly influence the development of most cancers. Most cancers are caused by interactions between the genes that we inherit from our parents and exposures or events that affect the functioning of these genes. Some of these factors are well known and clearly modifiable. These include tobacco use, excessive intake of calories, physical inactivity, excessive alcohol consumption, prolonged use of hormone replacement therapy, and so forth. Others are less well identified.

There are many reasons to protect the environment and limit pollution, and it is certainly possible for those who are concerned to reduce their exposures further. However, concern about ambient pollutants should not become a substitute for actions that are known to be beneficial in avoiding cancer and protecting health: avoid all types of tobacco, maintain a healthy weight, get regular physical activity, follow guidelines for sun safety, and be sure to get age-appropriate recommended screening tests. A substantial fraction of cancers and deaths from cancer could be prevented by applying this knowledge.

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