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The Descriptive Epidemiology of Cancer

Harris Pastides

Before epidemiologists or other health scientists can design studies to analyze the causes of a particular cancer, they must thoroughly understand the distribution of the disease's new cases throughout communities or larger populations. Where is it found in greater frequency? Does it appear to cluster, and, if so, is there something unusual about the environment where it is most common? Are males or females affected more commonly? Are there distribution differences among racial, ethnic, and economic groups? Although answers to these questions can provide critical leads about causation, the information will not be sufficient for determining the cause. Nevertheless, the design of an epidemiological study will benefit from such information.

Information about the distribution of cancer within the United States and internationally is facilitated by population-based cancer registries that record and summarize data on new cases of cancer in a population. Information, usually derived from registries, is available in publications from the American Cancer Society, the National Cancer Institute, the International Agency for Research on Cancer, and other organizations. Cancer incidence and mortality vary considerably throughout the United States by state and by gender. Across the world, there is even greater variation in the frequency of cancer. Some of the variation is due to differing diagnostic standards and access to medical care, although some is undoubtedly due to an underlying difference in exposure to risk factors by the populations being compared. Migrant studies compare cancer incidence or mortality rates for relocated ethnic populations with the rates that prevail in the country of origin as well as the country of adoption. These studies can shed light on the relative importance of genetic and environmental factors in the etiology of cancer.

Cancer epidemiologists have justifiably achieved a prominent place alongside other scientists engaged in the search for cancer's causes and cures. Much of the esteem they have won is a result of high-profile studies linking cancer with tobacco, radiation, nutritional factors, and other risk factors. Less celebrated are the countless reports describing the frequency of occurrence of cancer, the time trends in cancer rates, and the national and international geographic patterns of cancer incidence and mortality. The statistics derived from these "descriptive epidemiology" studies nonetheless continue to serve as the foundations of analytic studies; this is because etiologic hypotheses are often generated after careful observation of where and when specific cancers seem to occur at a higher rate than the background or expected rate. Of course, an etiologic hypothesis thus generated may be verified or discredited by subsequent epidemiological or other scientific research.

Descriptive studies are typically less useful when designed to address etiologic questions. Sometimes community concerns about apparent clusters of cancer have led to the use of descriptive epidemiological studies to confirm or allay suspicions of environmental cancer hazards. For example, it has been suggested that women who live in areas in which nuclear energy reactors are situated suffer high rates of breast cancer mortality and that the high rates are due to radiation "fallout."[1] A comprehensive descriptive epidemiology study done by the National Cancer Institute did not support this hypothesis,[2] in part because different boundaries dividing "exposed" and comparison populations were used, and additional descriptive studies would be unlikely to help in determining the validity of the hypothesis. Properly designed cohort or case-control studies would be far better able to address the issue of causality because they could estimate the lifetime radiation exposures of women and also adjust for potential confounding factors that might influence descriptive studies.

Regardless of whether the motivation for conducting descriptive studies is to generate or to test hypotheses, they must be designed, conducted, and analyzed with no less care than studies intended to examine risk-factor associations with cancer. If proper care is not taken, descriptive studies will divert scientific resources, especially public health department resources, away from more productive activities.

Descriptive epidemiology studies can also be used to evaluate cancer control activities. The US Food and Drug Administration and the numerous equivalent national agencies worldwide serve as arbiters of proposed new drugs, devices, and medical procedures. Descriptive studies can be used to monitor compliance and medical outcomes once new treatments are approved for practice. Additionally, these studies can help evaluate the effectiveness of educational, health promotional, screening, and other interventions aimed at reducing cancer risk among healthy persons and mitigating adverse outcomes among cancer patients.

In the discussion that follows, readers are assumed to have a working understanding of the basic measures of disease frequency and risk. Numerous basic epidemiology textbooks and references are available for the reader wishing to acquire more detailed information.[3,4]

Sources of Information

A wealth of information is available to students and others interested in learning about the incidence and mortality rates of cancer and related trends in the United States and worldwide. Some of the best sources, such as the National Cancer Institute (NCI), the American Cancer Society, and the World Health Organization's International Agency for Research on Cancer, offer printed and electronic documents. These three organizations can be accessed through the Internet and may provide expert information in response to specific questions, depending on their nature.

Incidence rates and five-year survival rates are published regularly by the SEER (Surveillance, Epidemiology, and End Results) Program of NCI.[5] This program periodically reports cancer statistics from regions encompassing about 26% of US inhabitants. This coverage includes 23% of African Americans, 40% of Hispanics, 42% of American Indians and Alaska Natives, 53% of Asians, and 70% of Hawaiian/Pacific Islanders living in the United States. Additionally, recent decades have seen an impressive increase in the number of states that operate populations-based cancer registries. These are excellent sources of up-to-date information and usually can provide detailed statistics on cancer rates at the level of special interest for a particular group of researchers (e.g., the town or county level).

Table 1–1 provides a variety of Web addresses, including those for the American Cancer Society, the National Cancer Institute, and the World Health Organization. The Web sites of these organizations can be

TABLE 1–1 Major Cancer Resources on the Internet

Organization name	*Address*
National Cancer Institute	http://www.cancer.gov/
American Cancer Society	http://www.cancer.org/
World Health Organization	http://www.who.int/en/
SEER Cancer Statistics	http://seer.cancer.gov/
International Agency for Research on Cancer	http://www.iarc.fr/
Oncolink	http://www.oncolink.upenn.edu/

extremely useful for students, cancer patients and their families, and others interested in statistical and related information (see also Appendix B).

The Magnitude of Cancer

Cancer Incidence and Prevalence

Projecting the number of new cases of cancer in the United States is an important task given that there is no national cancer registration system. By applying a statistical forecasting model to annual age-specific cancer incidence rates and age-specific population projections from the US Census, researchers predicted that in 2006 about 1,399,790 Americans would receive a diagnosis of cancer exclusive of basal and squamous cell skin cancers and in situ carcinoma of all sites except the urinary bladder.[6] More than a million other Americans would be diagnosed with basal and squamous cell skin cancers, according to the researchers.[6]

Over the course of a lifetime, about one of every two males and one of every three females in the United States will develop an invasive cancer. This estimate should dispel the belief held by some that cancer is a rare condition. The prevalence of cancer obviously represents an enormous burden of physical pain, psychological distress (for the patients as well as their families and friends), and financial cost (for under- and uninsured patients and for society at large).

When looking at trends in recent years, we see that cancer incidence rates were relatively stable in men from 1995 to 2002, but increasing slightly among women during this period.[7] This is likely explained by the observation that smoking in women peaked two decades later than among men. The incidence of colorectal cancer decreased slightly while prostate and female breast cancer incidence rates showed a slight increase between 1998 and 2002.[7]

Figure 1–1 presents the estimated percent distribution of new cancer cases, by sex, in the United States in 2006 exclusive of in situ cancers and basal and squamous cell skin cancers. Among men, the prostate is the predominant site affected by cancer. In fact, about 3 of every 10 men who develop cancer in the United States will develop prostate cancer. Lung cancer, which has a much higher case-fatality rate, has been decreasing in men over the past decade owing to a reduction in smoking among men during the last several decades. Still, lung cancer is the second most common type of cancer in men, and many opportunities exist for reducing its prevalence further. Cancers of the colon and rectum in combination rank third in frequency among males in the United States (these cancers are often grouped together in statistical presentations because of the difficulty of specifying the site of origin). These three cancers account for over half of new cancers in men.

Estimated New Cases

Males			Females		
Prostate	234,460	33%	Breast	212,920	31%
Lung/bronchus	92,700	13%	Lung/bronchus	81,770	12%
Colon/rectum	72,800	10%	Colon/rectum	75,810	11%
Urinary bladder	44,690	6%	Uterine corpus	41,200	6%
Melanoma of the skin	34,260	5%	Non-Hodgkin's lymphoma	28,190	4%
Non-Hodgkin's lymphoma	30,680	4%	Melanoma of the skin	27,930	4%
Kidney and renal pelvis	24,650	3%	Thyroid	22,590	3%
Oral cavity and pharynx	20,180	3%	Ovary	20,180	3%
Leukemia	20,000	3%	Urinary bladder	16,730	2%
Pancreas	17,150	2%	Pancreas	16,580	2%
All sites	**720,280**	**100%**	**All sites**	**679,510**	**100%**

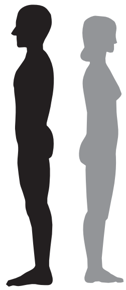

FIGURE 1–1 Estimated new cancer cases, 10 leading sites by sex, United States, 2006.

Note: Data for all sites except the urinary bladder exclude basal and squamous cell skin cancers and in situ carcinomas. Also, percentages may not total 100% due to rounding.
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Among women, breast cancer is the most commonly diagnosed cancer; it is responsible for nearly one-third of all new cancer diagnoses in women in the United States. Lung cancer incidence rates in women have been stable since 1998 after increasing for many years and surpassing colon and rectal cancers as the second most commonly diagnosed cancer.[6] The upward trend in smoking among women, especially teenagers and younger women, ranks as one of the major public health failures of the recent past. Fortunately, since 1985, the smoking prevalence in women has declined to a comparable degree as in men. Prevalence rates among women with less than 12 years of education are approximately three times higher than among women with 16 or more years of education.[8] Breast, lung, and colon/rectum cancers account for over half of all new cancers detected in women in the United States each year.

Cancer among children is much less common than among adults, yet it is the second leading cause of death among children aged 1–14 in the United States. It is estimated that about 9,500 new cases of cancer of all types occurred in children in 2006. Roughly two-thirds are leukemias, lymphomas, or cancers of the brain and central nervous system.[6] Fortunately, five-year relative survival rates for childhood cancers at all sites, combined, improved from 56% in 1974–1976 to 79% in 1995–2001.[7]

Since the early 1970s, the cancer incidence rate among children younger than 15 years has been rising. Relatively rapid increases in incidence have been observed for acute lymphoblastic leukemia, brain cancer (glioma), osteogenic sarcoma, and Wilms' tumor. The increases, because of their size, are unlikely to be due to statistical variability, improvement in diagnostic capabilities, or better reporting. The reasons for the rising incidence of these childhood cancers remain largely unknown, although numerous hypotheses about potential environmental causes have been suggested.

Cancer Mortality

For the first time since national mortality registration was begun in 1930, the actual number of recorded cancer deaths decreased in men (by 778), but increased in women (by 409) between 2002 and 2003. This net decrease was a first.[7] In recent years, the American Cancer Society has reported an unprecedented reduction in the cancer death rate in the population of the United States.[5] Although a gradual decline in cancer mortality had been suspected since 1994, the first documented reversal in the upward trend occurred in 1998. On the surface, this turnaround would seem to be a cause for celebration. Yet some researchers see larger opportunities for influencing cancer mortality in the fields of primary and secondary prevention and view the vast sums of money spent on cancer treatment (part of the "war on cancer") as having had a disappointing payoff.

Bailar and Gornick,[9] for instance, conducted a comprehensive analysis of site-specific cancer mortality data collected by the National Center for Health Statistics and the National Cancer Institute and demonstrated that death rates had actually been rising slowly but steadily until recently. They suggest that the important recent declines in cancers of the cervix, endometrium, colon, rectum, and stomach, as well as lung cancer in men, are mainly the result of decreasing incidence or earlier detection rather than improved treatment, and that the small increases in mortality from melanoma, cancer of the brain, prostate cancer, and breast cancer (in older women) reflect increasing disease incidence at these sites. Bailar, Gornick, and other scientists have argued for a shift in funding priorities by the government and other sponsors to take advantage of the large cancer prevention opportunities that exist.

Researchers at the American Cancer Society used similar data to estimate the number of cancer deaths expected in 2006. In this year, about 564,830 Americans would die of cancer, or over 1,500 persons per day.[6] That means cancer would be responsible for between one out of four deaths in 2006, making it the second leading cause of death in the United States after heart disease.[6] Table 1–2 shows the proportional mortality in the United States. As epidemiology and preventive medicine have continued to achieve great success in elucidating the primary causes of heart disease and implemented effective primary and secondary prevention

TABLE 1–2 Fifteen Leading Causes of Death, United States, 2003

Rank	*Cause of death*	*Number of deaths*	*Percent (%) of total deaths*	*Death rate**
	All causes	2,448,288	100.0	831.0
1	Heart diseases	685,089	28.0	231.6
2	Cancer	556,902	22.7	190.1
3	Cerebrovascular diseases	157,689	6.4	53.3
4	Chronic lower respiratory diseases	126,382	5.2	43.3
5	Accidents (unintentional injuries)	109,277	4.5	37.2
6	Diabetes mellitus	74,219	3.0	25.3
7	Influenza and pneumonia	65,163	2.7	21.9
8	Alzheimer disease	63,457	2.6	21.3
9	Nephritis, nephritic syndrome, and nephrosis	42,453	1.7	14.4
10	Septicemia	34,069	1.4	11.6
11	Intentional self-harm (suicide)	31,484	1.3	10.7
12	Chronic liver disease and cirrhosis	27,503	1.1	9.3
13	Hypertension and hypertensive renal disease	21,940	0.9	7.4
14	Parkinson disease	17,997	0.7	6.1
15	Assault (homicide)	17,732	0.7	6.0
	All other & ill-defined causes	416,932	17.0	

*Rates are per 100,000 population and age-adjusted to the 2000 US standard population.
Note: Percentages may not total 100% due to rounding. Symptoms, signs and abnormalities, events of undetermined intent, and pneumonitis due to solids and liquids were excluded from the cause of death ranking order.
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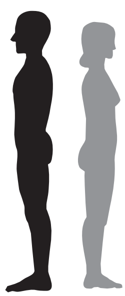
programs, death rates for this leading cause of death have declined markedly. Advances in clinical therapeutics and emergency medical services have, of course, also been significant. One consequence of this success, coupled with the slightly increasing trend in total cancer incidence, is that the relative proportion of total deaths due to cancer has been increasing until just recently.

Evidence that cancer mortality rates are declining in the United States was provided in a recent review from the National Center for Health Statistics. Data indicate that the death rate from all cancers combined has decreased by 1.5% per year since 1993 among men and by .8% per year since 1992 among women.[7] Major reductions were observed for lung cancer and for other smoking-related cancers. Continued vigilance with respect to smoking, continued improvement in the design of cancer prevention programs, improvements in cancer treatment, and greater access to effective cancer treatment are expected to help sustain this decline in future years.

Figure 1–2 shows the sex-specific cancer death rates projected for 2006. As can be seen, these do not mimic the incidence rates shown in Figure 1–1. Although prostate cancer is the most common cancer among men and breast cancer is the most common cancer among women, lung cancer is the leading cause of cancer death among men and women in the United States. This is true despite the fact that lung cancer remains one of the most preventable cancers. In fact, prostate, breast, and colon/rectal cancers (the other leading causes of cancer death in the United States) are also amenable to primary or secondary prevention techniques. From 1991 to 2002, lung cancer death rates among men have been declining by about 1.9% per year while among women they seem to be approaching a plateau after having increased for several decades.[6]

Estimated Deaths



Males			Females		
Lung/bronchus	90,330	31%	Lung/bronchus	72,130	26%
Colon/rectum	27,870	10%	Breast	40,970	15%
Prostate	27,350	9%	Colon/rectum	27,300	10%
Pancreas	16,090	6%	Pancreas	16,210	6%
Leukemia	12,470	4%	Ovary	15,310	6%
Liver and intrahepatic bile duct	10,840	4%	Leukemia	9,810	4%
Esophagus	10,730	4%	Non-Hodgkin's lymphoma	8,840	3%
Non-Hodgkin's lymphoma	10,000	3%	Uterine corpus	7,350	3%
Urinary bladder	8,990	3%	Multiple myeloma	5,630	2%
Kidney and renal pelvis	8,130	3%	Brain and other nervous system	5,560	2%
All sites	**291,270**	**100%**	**All sites**	**273,560**	**100%**

FIGURE 1–2 Estimated cancer deaths, 10 leading sites by sex, United States, 2006.

Note: Data for all sites except the urinary bladder exclude in situ carcinomas. Also, percentages may not total 100% due to rounding.
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Cancer is the second leading cause of death among children aged 1–14 in the United States (following accidents) and is the leading fatal disease. About 1,500 deaths per year are attributable to cancer in this age group.[6] In 2006, the cancer death rate, which has been falling for the past two decades, was 2.5 per 100,000 children aged 1–14, or approximately 12% of total deaths.[6]

Given recent progress in the early identification of cancer and in cancer treatment, it is predictable that the prevalence of cancer will increase because patients will survive longer. In the United States, an estimated 10.1 million people currently have cancer.[6] If that estimate is accurate, the prevalence of cancer is roughly 3.3% (based on a population estimate of approximately 299 million). Although the life expectancy of people with cancer who survive for at least five years is about the same as for people without cancer, the majority of the former will die of complications related to their cancer diagnosis.

Survival Rates

Cancer survival rates have improved immensely since the early 20th century. In the 1930s, fewer than 20% of patients diagnosed with cancer survived for five years. Today about 65% can expect five years of survival, and the five-year survival rate for children under age 15 is about 79%.[7] Undoubtedly, the rapid improvement in survival rates is attributable to several factors, including advances in clinical diagnostics and therapeutic interventions and more effective public health strategies (these have jointly resulted in earlier diagnosis of cancer). The promotion of public awareness of cancer's early warning signs and the introduction of mass screening programs aimed at uncovering latent or "subclinical" cancer have created an environment in which cancer is being identified at earlier stages than ever before. Yet work is needed in this area to extend the opportunities for enhanced survival to the economically disadvantaged segments of the US population, which have not realized the same increases in survival as the rest of the population.

Temporal Trends

As described above, total cancer incidence and mortality in the United States had been rising slightly until recently, when both indicators saw a slight decline. Between 1930 and 2006, the age-adjusted rate of total cancer mortality rose by 38% from 143 per 100,000 to 197.8 per 100,000. The major contributor to this rise was the increase in lung cancer deaths among both males and females. Figures 1–3 and 1–4 show that, during the same period in which the lung cancer mortality rate was increasing, mortality rates for most of the other leading causes of cancer death either decreased (e.g., stomach cancer in males and females and uterine cancer in females) or remained fairly constant. In fact, if the lung cancer death rate is omitted, the total age-adjusted death rate for cancer declined significantly between the middle of the 20th century and today. Fortunately, the lung cancer death rates in women seem to be plateauing after years of increases, and they continue to decline in men.

The percentage change in cancer survival over the past 20 years is presented in Table 1–3. Site-specific increases in survival rates may be attributed to earlier diagnosis, advances in treatment and care in general, or any combination thereof. As can be seen, increases have occurred for over half

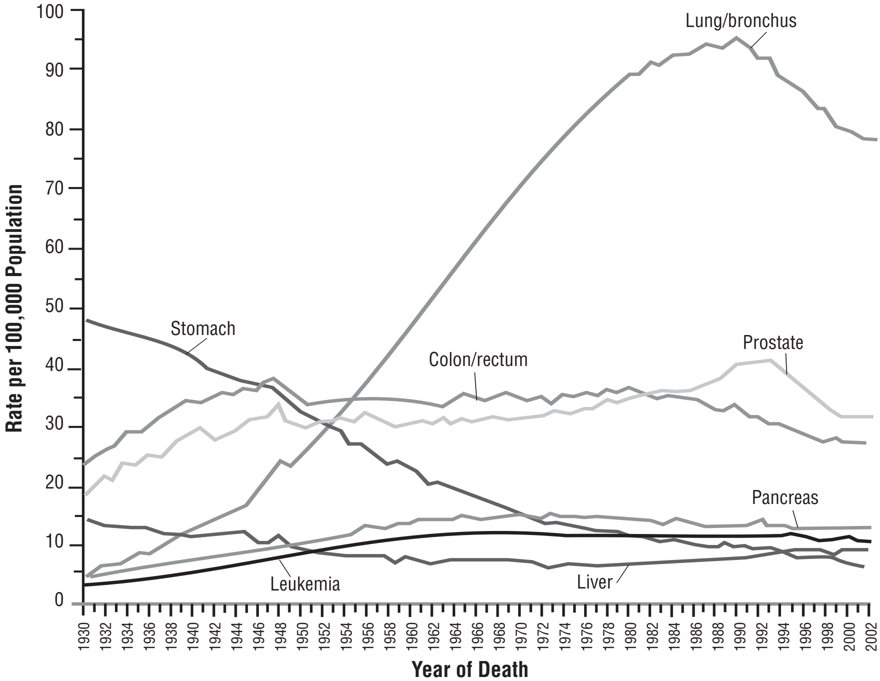

FIGURE 1–3 Age-adjusted cancer death rates, males by site, United States, 1930–2002.

Note: Rates are per 100,000 and are age-adjusted to the 2000 US standard population. Also, due to changes in ICD coding, numerator information has changed over time. Rates for cancers of the liver, lung/bronchus, and colon/rectum are affected by these coding changes.
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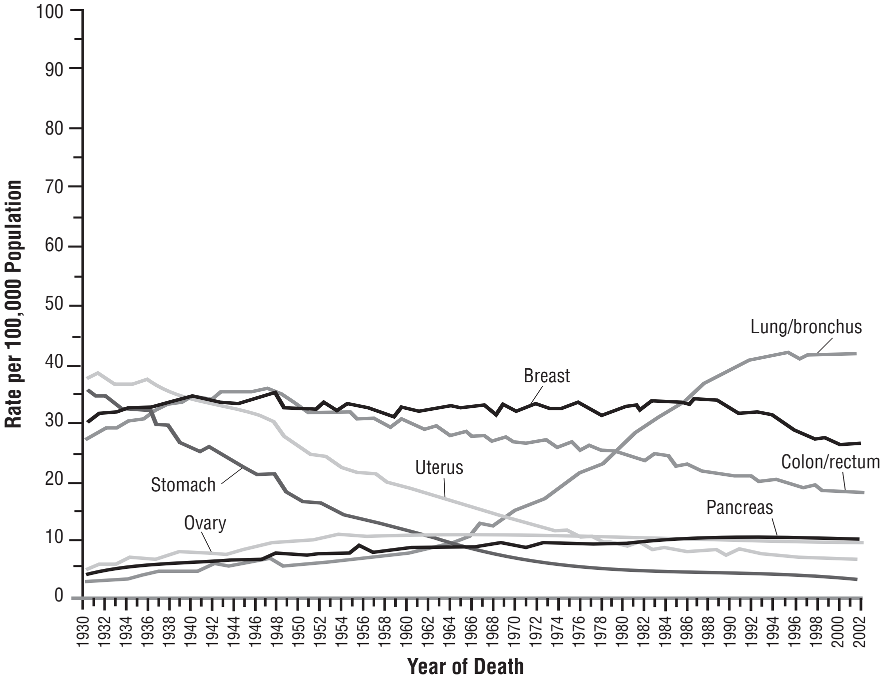

FIGURE 1–4 Age-adjusted cancer death rates, females by site, United States, 1930–2002.

Note: Rates are per 100,000 and are age-adjusted to the 2000 US standard population. Due to changes in ICD coding, numerator information has changed over time. Rates for cancers of the uterus, ovary, lung/bronchus, and colon/rectum are affected by these coding changes. Uterine cancer death rates are for uterine cervix and uterine corpus combined.
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of the cancer sites listed for both males and females; as improvement in therapeutic modalities continue to be generated, survival is likely to continue to be extended in the coming years and decades.

In examining cancer incidence and mortality trends, it is usually preferable to compare rates on a site-specific or histology-specific basis. Total cancer incidence and mortality rates are each a weighted average of the site-specific rates, and therefore a large increase or decrease in one type of cancer over time may obscure a smaller opposite trend among other cancer types. Also, improvements in diagnostic accuracy could lead to the misperception that a specific cell or histologic type of cancer has been increasing.

TABLE 1–3 Trends in SEER 5-Year Relative Survival Rates* for the Top 15 Cancers† for All Ages and Childhood Cancers, by Sex, 1975–1979 to 1995–2000

	Male			*Female*		
	Survival rate (%)		*Change (%)*‡	*Survival rate (%)*		*Change (%)*‡
Cancer site	1975–1979	1995–2000		1975–1979	1995–2000	
All Ages						
All sites§	42.7	64.0**	21.3	56.6	64.3**	7.7
Prostate	70.0	99.3**	29.3	-	-	-
Lung/bronchus	11.6	13.6**	2.0	16.6	17.2**	0.6
Colon/rectum	50.3	63.7**	13.4	52.3	63.1**	10.8
Urinary bladder	75.7	83.7**	8.0	70.6	76.2**	5.6
Non-Hodgkin's lymphoma	46.8	57.0**	10.2	49.9	61.7**	11.8
Melanoma of the skin	77.5	89.0**	11.5	86.5	92.2**	5.7
Oral cavity and pharynx	51.8	57.4**	5.6	56.1	61.5**	5.4
Leukemia	34.8	47.0**	12.2	37.2	45.7**	8.5
Kidney and renal pelvis	51.8	63.9**	12.1	51.3	63.9**	12.6
Stomach	15.2	22.1**	6.9	17.8	25.4**	7.6
Pancreas	2.6	4.2**	1.6	2.5	4.6**	2.1
Liver and intrahepatic bile duct	2.2	7.7**	5.5	6.4	9.6**	3.2
Brain and other nervous system	22.8	32.7**	9.9	26.0	33.4**	7.4
Esophagus	4.3	14.2**	9.9	6.4	14.7**	8.3
Larynx	66.4	66.7	0.3	63.5	59.6	–3.9
Breast (female)	-	-	-	74.9	87.7**	12.8
Corpus and uterus, NOS	-	-	-	86.4	84.4**	–2.0
Ovary	-	-	-	37.6	44.0**	6.4
Cervix uteri	-	-	-	69.0	72.7**	3.7
Thyroid	91.4	93.4	2.0	93.5	97.3**	3.8

(Continued)

TABLE 1–3 *(Continued)*

	Male			*Female*		
	Survival rate (%)		*Change (%)*‡	*Survival rate (%)*		*Change (%)*‡
Cancer site	1975–1979	1995–2000		1975–1979	1995–2000	
Age 0–19 Years (Childhood Cancers)§						
All sites	57.6	77.1**	19.5	68.3	81.0**	12.7
Bone and joint	43.3	71.1**	27.8	56.5	63.6	7.1
Brain and ONS	56.8	71.8**	15.0	60.2	75.3**	15.1
Hodgkin's lymphoma	85.8	96.4**	10.6	88.2	95.8**	7.6
Leukemia	44.2	74.5**	30.3	53.3	77.5**	24.2
ALL	52.0	82.0**	30.0	63.5	83.8**	20.3
AML	22.8	45.5**	22.7	20.5	54.2**	33.7
Neuroblastoma	51.6	65.5**	13.9	56.6	65.7**	9.1
Non-Hodgkin's lymphoma	42.1	78.5**	36.4	57.9	82.4**	24.5
Soft tissue	62.4	73.2**	10.8	69.6	70.8	1.2
Wilms' tumor	72.7	92.2**	19.5	76.3	91.9**	15.6

*Survival rates are based on follow-up of patients through 2001.
†Top 15 cancers includes the top 15 cancers for males and the top 15 cancers for females based on the age-adjusted rate for 1992–2001 for all races combined.
‡Change is absolute change and refers to the 1995–2000 rate minus the 1975–1979 rate.
§All sites exclude myelodysplastic syndromes and borderline tumors; ovary excludes borderline tumors.
**The difference in rates between 1975–1979 and 1995–2000 is statistically significant ($P < 0.05$).
-Survival rate not applicable.
Source: Reprinted with permission from Jemal A, et al., Annual report to the nation on the status of cancer, 1975–2001, with a special feature regarding survival, *Cancer*, vol. 101, pp. 3–27, © 2004 American Cancer Society.

Geographic Variation of Cancer

A careful examination of the geographic variation in cancer rates and in cancer risk factors is an excellent starting point for generating hypotheses about the etiologic factors that are responsible for cancer. Indeed, descriptive studies should precede case-control and cohort studies, for, among other things, they can help epidemiologists find the best populations for recruiting subjects. Assisted by information from geographic cancer surveys, which may include maps where incidence or mortality patterns are "geocoded," investigators may decide to select subjects in areas where the occurrence of a particular cancer is high in order to test etiologic hypotheses regarding risk factors for that cancer.

In China, for example, epidemiologists noted that there was a very high incidence of cancer of the esophagus in Linxian, a small city in the northeast, and in towns located in concentric rings around it. Descriptive studies showed that one in four residents were dying from it and that the rate of the disease declined with increasing distance from Linxian. The discovery of the high esophageal cancer rate in this locale was followed by speculation about environmental and dietary habits that could be causing the apparent epidemic. Theories cited as possibilities included the temperature of the food (too hot), the scraping of the esophagus through the practice of eating dried corn husks, the eating of moldy bread, and a deficiency of molybdenum in the soil. After much focused analytic investigation, the purported link between the epidemic and dietary factors gained plausibility, although a newer case-control study noted a serologic association between papillomavirus infection and the risk of esophageal cancer in a province of China.[10,11,12]

Unfortunately, descriptive epidemiology studies are too frequently overlooked in favor of analytic studies, either because they seem methodologically unsophisticated or because they do not provide direct evidence about causation. Yet the execution and interpretation of descriptive epidemiology studies of cancer are quite complex owing to the migratory patterns of modern populations as well as the lack of universally available, high-quality data on cancer incidence and mortality in defined populations. Furthermore, descriptive studies have historically provided a large number of productive leads about environmental, nutritional, lifestyle, and other types of risk factors. The often-cited estimate that approximately 80% of the worldwide cancer burden is related to environmental (nongenetic) factors is derived from the results of descriptive studies.[13]

Cancer incidence, the rate of newly diagnosed cancers in a defined population, is the preferred measure for uncovering differences in the geographic occurrence of cancer. Unfortunately, in many countries, especially developing nations, there are insufficient resources for providing reliable data on incidence. The problems include unequal distribution of healthcare resources, difficulty in gaining access to information about persons residing in remote areas, and unavailability of the advanced technical tools required for diagnosing cancer. Also, even when diagnostic technology is available, there is often no reliable registration system for recording and tabulating cancer incidence rates in a defined population. In these places, cancer mortality rates may provide somewhat better information about the underlying cancer risks in a population, because registration of the fact and cause of death, accompanied by basic descriptive characteristics of the decedent, is practiced everywhere.

Mortality rates are recorded in a relatively standardized manner throughout the world, in part due to the World Health Organization's International Classification of Diseases (ICD). The ICD provides uniform nomenclature for disease classification and a recommended format for death certificates.[14] As is well known, however, substantial errors in recording the cause of death can occur as a result of numerous factors, including lack of intensive medical investigation into the cause of death, poor access to health services, and the increasingly low autopsy rates in many countries. The problem of recording errors is likely to be exacerbated when cancer is the underlying cause of death because the patient is likely to have undergone a complex clinical course in the period leading to his or her demise.[15] Careful and intensive clinical and laboratory investigations are usually required to make an accurate identification of the primary site of cancer in an individual.

Note also that, because cancer is predominately a disease of older persons, nations with an older population profile would be expected to have higher cancer death rates. Therefore, international comparisons of cancer death rates must be age-adjusted. Often the World Health Organization's "standard world population" is used for this purpose.[16]

For cancers with a relatively low survival rate, such as those of the lung, liver, and stomach, differences in mortality rates should serve as reasonable approximations of differences in incidence rates. For cancers with more favorable survival rates, such as those of the breast and prostate, the use of mortality rates could result in a biased interpretation. For example, the recorded death rates for prostate cancer may be similar in a developed and a developing country, yet the developed country might in fact have a higher incidence rate but also a higher survival rate (due to advanced screening and treatment modalities). Therefore, when survival rates are substantially different between geographic regions, comparing mortality rates to arrive at an understanding of the underlying risk of cancer is not recommended.

Geographic and Ethnic Variation within the United States

In the most recent tabulations that compare the number of estimated new cancers and cancer deaths in the United States by state, the range is dramatically wide. States such as California, Florida, and New York have many more cancers recorded than do smaller states. Obviously, more populous states will have more cancers diagnosed. However, even if we calculate cancer incidence and mortality rates per 100,000 population, we should not take the rates as evidence of environmental risks until we adjust them in light of the age distributions of the states. States such as Florida and Arizona have much "older" populations because of the large retirement communities that abound in them. Consequently, cancer rates in these states will appear higher than in the "younger" states from which people tend to migrate upon retirement. Table 1–4

TABLE 1–4 Cancer Mortality by State

State	*Reported death rate per 100,000*	*State*	*Reported death rate per 100,000*
Alabama	212.3	Montana	194.2
Alaska	197.9	Nebraska	185.5
Arizona	175.2	Nevada	208.8
Arkansas	210.9	New Hampshire	202.4
California	180.9	New Jersey	204.7
Colorado	172.1	New Mexico	171.2
Connecticut	189.1	New York	190.7
Delaware	211.1	North Carolina	203.8
Dist. of Col.	238.7	North Dakota	183.2
Florida	188.2	Ohio	211.0
Georgia	203.6	Oklahoma	205.6
Hawaii	155.2	Oregon	198.1
Idaho	178.5	Pennsylvania	204.8
Illinois	207.1	Rhode Island	205.0
Indiana	213.4	South Carolina	208.7
Iowa	189.3	South Dakota	189.2
Kansas	189.0	Tennessee	215.4
Kentucky	226.9	Texas	194.9
Louisiana	228.1	Utah	150.6
Maine	211.7	Vermont	196.4
Maryland	207.7	Virginia	204.6
Massachusetts	203.9	Washington	194.2
Michigan	201.9	West Virginia	220.9
Minnesota	186.4	Wisconsin	192.9
Mississippi	221.5	Wyoming	187.4
Missouri	207.1	United States	197.8

Note: Average annual mortality rate for 1998–2002, age-adjusted to the 2000 US standard population.
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lists age-adjusted cancer mortality rates for all 50 states and the District of Columbia for the period 1998–2002. Once age has been taken into account, any apparent excess cancer risk in states such as Florida and Arizona disappears. Note, however, that there is still variability. For example, the District of Columbia, Kentucky, and Louisiana have cancer death rates that are 25–50% higher than states such as Utah, New Mexico, and Hawaii. Such differences in rates may be used to generate hypotheses about environmental, lifestyle, and ethnic or racial determinants of cancer. They may also indicate differences in the proportion of these populations that have access to health insurance or health services in general.

In the United States, as in most countries, there is a clear divide in morbidity and mortality rates along racial and ethnic lines; this situation is no different for cancer. By carefully describing the risk differentials and interpreting them in light of multifactorial etiologic theories, scientists can take the first steps toward effective cancer control.

In the case of all diseases, the number of deaths among certain minority groups, including Asians, Hispanics, Native Americans, and Pacific Islanders, is underestimated because these groups are underreported on death certificates.[17] Nevertheless, it is widely appreciated that cancer incidence and age-adjusted mortality rates vary by ethnic and racial status. For example, cancer death rates are higher in African Americans than in Caucasians for most sites. Among men during the years 1998–2002, the incidence rate for all sites combined was 23% higher, and the death rate was 40% higher for African American men compared to Caucasian men. Among African American women during these years, the incidence rate for all sites combined was 7% lower compared to Caucasian women, but the death rate was 18% higher.[7] Although cancer accounts for a smaller proportion of total deaths among African Americans than among all races combined, the age-adjusted rates for African Americans are still higher.

In the 1950s and 1960s, cancer death rates were much more similar for African Americans and Caucasians than current rates. However, during the 1970s, 1980s, and early 1990s, death rates climbed more precipitously among African American men and women than among Caucasians.[18] Since 1992 the death rate from all cancers combined has been decreasing among African Americans by about 1.2% per year. This decrease has been greater for African American males (2.1%) than African American females (0.4%).[19] Currently, as mentioned previously, incidence and death rates for African Americans are higher for nearly all cancers. Table 1–5 shows that death rates from prostate, stomach, and cervical cancers are noticeably higher. Two exceptions are breast cancer incidence and lung cancer mortality, which are both lower in African American women. The likely reasons for the observed excess cancer risk in African Americans are partially known. A higher proportion of African American men are exposed to several behavioral risk factors for cancer, including tobacco use and adverse dietary constituents. Also, in comparison with Caucasians, African American men and women have higher case-fatality rates because they are less likely to be screened for cancer and are therefore diagnosed at a later stage of cancer. Additionally, they are less likely to receive adequate treatment.[20] The increased cancer risk experienced by African Americans represents a multitude of economic and sociocultural factors that afford numerous opportunities for public health interventions, including health education and screening.

Other minority groups exhibit a complex pattern of cancer incidence and mortality, with nearly all having some higher site-specific cancer rates and some lower rates than Caucasians. Minority populations tend to have higher incidence and mortality rates for cancers of the uterine cervix, stomach, and liver.[7] As seen in Table 1–5, American Indian, Alaskan Natives, and Hispanic-Latino people have higher rates of stomach and liver cancer than whites. On the other hand, Asian Americans have lower rates of colorectal cancer, lung cancer, and female breast cancer than whites, but have higher rates of liver cancer incidence and mortality than any other racial or ethnic group. The description of cancer rates and risk factors among Hispanic Americans is especially challenging given the heterogeneous populations that make up this group.

TABLE 1–5 Age-Standardized Incidence and Death Rates* for Selected Cancers by Race and Ethnicity, United States, 1998–2002

	All races	*White*	*African American*	*Asian American/ Pacific Islander*	*American Indian/ Alaskan Native*	*Hispanic-Latino*
				Incidence Rates		
All sites						
Male	553.3	556.4	682.6	383.5	255.4	420.7
Female	413.5	429.3	398.5	303.6	220.5	310.9
Breast (female)	134.4	141.1	119.4	96.6	54.8	89.9
Colon and rectum						
Male	62.1	61.7	72.5	56.0	36.7	48.3
Female	46.0	45.3	56.0	39.7	32.2	32.3
Lung/bronchus						
Male	77.8	76.7	113.9	59.4	42.6	44.6
Female	48.9	51.1	55.2	28.3	23.6	23.3
Prostate	173.8	169.0	272.0	101.4	50.3	141.9
Stomach						
Male	12.3	10.7	17.7	21.0	15.9	17.2
Female	6.1	5.0	9.6	12.0	9.1	10.1
Liver and bile duct						
Male	9.3	7.4	12.1	21.4	8.7	14.1
Female	3.6	2.9	3.7	7.9	5.2	6.1
Uterine cervix	8.9	8.7	11.1	8.9	4.9	15.8

TABLE 1–5 *(Continued)*

	All races	*White*	*African American*	*Asian American/ Pacific Islander*	*American Indian/ Alaskan Native*	*Hispanic-Latino*
				Death Rates		
All sites						
Male	247.5	242.5	339.4	148.0	159.7	171.4
Female	165.5	164.5	194.3	99.4	113.8	111.0
Breast (female)	26.4	25.9	34.7	12.7	13.8	16.7
Colon/rectum						
Male	24.8	24.3	34.0	15.8	16.2	17.7
Female	17.4	16.8	24.1	10.6	11.8	11.6
Lung/bronchus						
Male	76.3	75.2	101.3	39.4	47.0	38.7
Female	40.9	41.8	39.9	18.8	27.1	14.8
Prostate	30.3	27.7	68.1	12.1	18.3	23.0
Stomach						
Male	6.3	5.6	12.8	11.2	7.3	9.5
Female	3.2	2.8	6.3	6.8	4.1	5.3
Liver and bile duct						
Male	6.8	6.2	9.5	15.4	7.9	10.7
Female	3.0	2.7	3.8	6.5	4.3	5.1
Uterine cervix	2.8	2.5	5.3	2.7	2.6	3.5

*Rates are per 100,000 and age-adjusted to the 2000 US standard population.
†Hispanics-Latinos are not mutually exclusive from Whites, African Americans, Asian Americans/Pacific Islanders, and American Indians/Alaskan Natives.
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Five-year survival rates are lower for African Americans than Caucasians, as seen in Table 1–6. Taking all cancer sites together, 56% of African Americans and 66% of Caucasians survived five years or more. For a cancer in which survival is known to be strongly related to the stage at diagnosis, such as female breast cancer, the survival differences are pronounced (76% among African Americans and 90% among Caucasians). On the other hand, for a cancer that is difficult to diagnose and is usually detected at a later stage, such as stomach cancer, the five-year survival rates are nearly identical (23% among African Americans and 21% among Caucasians). This suggests that the decreased survival time for African Americans is largely due to lack of early detection, at least in part, in which

TABLE 1–6 Five-Year Relative Cancer Survival Rates by Race, United States, 1995–2001

Site	*Caucasian relative 5-year survival rate for 1995–2001 (%)*	*African American relative 5-year survival rate for 1995–2001 (%)*
All sites	66	56
Brain	33	38
Breast (female)	90	76
Colon	65	55
Esophagus	16	10
Hodgkin's disease	86	80
Kidney	65	64
Larynx	68	51
Leukemia	49	38
Liver and bile duct	9	5
Lung/bronchus	16	13
Melanoma: skin	92	76
Multiple myeloma	32	33
Non-Hodgkin's lymphoma	61	52
Oral cavity	62	40
Ovary	44	38
Pancreas	4	4
Prostate	100	97
Rectum	65	56
Stomach	21	23
Testis	96	88
Thyroid	97	95
Urinary bladder	83	64
Uterine cervix	75	66
Uterine corpus	86	62

Source: Adapted with permission from Jemal A, et al., Cancer Statistics 2006, *CA: A Cancer Journal for Clinicians*, vol. 56, pp. 106–130, © 2006 Lippincott Williams & Wilkins.

case the public health community faces the challenge of increasing the number of screening and other prevention activities in targeted communities to narrow the gap.

International Geographic Variation

Studies of international variation are not possible without a large body of data to facilitate the elucidation of geographic patterns of cancer.[21] One of the most useful sources of information about the international cancer rates is the monograph series "Cancer Incidence in Five Continents."[22] Data on worldwide cancer incidence are presented and are used to support theories regarding the vast differences in the rates of specific cancers as well as in the total cancer burden in populations worldwide. It should be pointed out that the available data suffer from important limitations, namely, the overrepresentation of population-based cancer registries in developed nations, differences in the quality and coverage of the registries, and differences in the cancer classification systems used or the way they are used. For example, code 158 of the ninth revision of the International Classification of Diseases (ICD-9) is for malignant neoplasm of retroperitoneum and peritoneum. Under this code, the Finnish cancer registry includes only mesotheliomas (i.e., cancers of the peritoneum only), whereas registries in Brazil and Colombia and several in Hungary exclude "mesothelioma, not otherwise specified, of the peritoneum." To complicate matters further, the cancer registry of South Australia also includes tumors of the retroperitoneum in this category. As another example, under code 180, cervical cancer registries in Romania and certain states in Brazil include carcinoma-in-situ of the cervix. Investigators need to be aware of these and other reporting inconsistencies. Nevertheless, comparing and interpreting data provided by international registries can be done with reasonable confidence that the data are generally consistent.

Cancer in Developing Nations

The cancer experience observed in developing nations is reminiscent of that in the United States and Europe during the middle part of the 20th century. As Figure 1–5 shows, the burden of cancers related to tobacco use and modern western diets, such as cancers of the prostate and colon/rectum, are generally lower in developing areas such as Africa and Asia. Unfortunately, the rapid pace of economic development in many of these areas, especially in Asia, is expected to diminish these differences over the next several decades.

In 2002, there were an estimated 10.9 million new cancer cases diagnosed worldwide, 6.7 million deaths, and 24.6 million people living with cancer.[23] By 2020, the number of new cancer cases is expected to reach 15 million and the number of deaths 12 million. Nearly 70% of these deaths will occur in developing nations, and 80–90% of those who are diagnosed will have incurable cancer.[24,25] Clearly, the burden of cancer mortality will be far greater in the developing world. Currently, lung cancer is the main cancer in the world in terms of both incidence and mortality. In the developed world, the four deadliest cancers are lung, breast, colorectal, and prostate, all of which are related to lifestyle and diet. In the developing world, the deadliest cancers are lung, stomach, liver, and cervix. Aside from lung cancer, the other three predominant cancers in the developing world are likely related to infectious agents or are repercussions to infectious disease processes or recovery.[23]

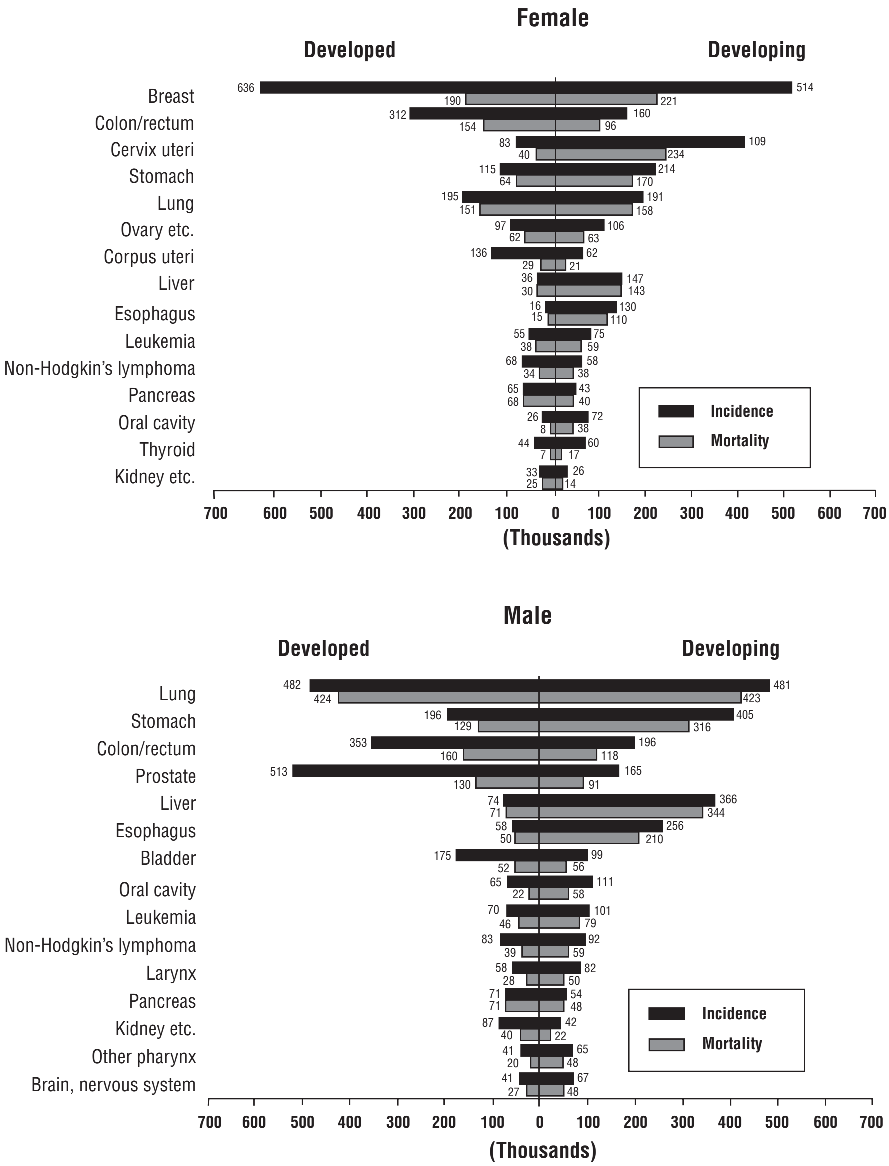

FIGURE 1–5 Estimated numbers of new cancer cases (incidence) and deaths (mortality) in 2002. Data shown in thousands for developing and developed countries by cancer site and sex.

Source: Reprinted with permission from Parkin DM, et al., Global Cancer Statistics 2002, *CA: A Cancer Journal for Clinicians*, vol. 55, pp. 74–108, © 2005 Lippincott Williams & Wilkins.

TABLE 1–7 Age-Adjusted Death Rates per 100,000 Population for Selected Sites for Nine Countries, 2002

	All sites		*Lung and bronchus*		*Breast*	*Stomach*	
Country	*Male*	*Female*	*Male*	*Female*	*Female*	*Male*	*Female*
United States	152.6	111.9	48.7	26.8	19.0	4.0	2.2
Australia	147.1	99.0	34.7	13.8	18.4	5.7	2.8
China	159.8	86.7	36.7	16.3	5.5	32.7	15.1
Greece	148.2	81.9	49.8	7.6	15.4	8.9	4.3
Israel	132.6	105.0	26.9	8.6	24.0	8.9	4.7
Mexico	92.3	86.0	16.6	6.6	10.5	9.9	7.2
Saudi Arabia	92.5	74.2	9.6	2.6	10.9	4.9	3.0
Venezuela	101.5	95.1	18.1	10.2	13.4	14.5	9.3
Zimbabwe	183.6	165.4	12.0	5.8	14.1	10.4	9.1

Note: Rates are age-adjusted to the World Health Organization world standard population.
Source: Adapted with permission from Jemal A, et al., Cancer Statistics 2006, *CA: A Cancer Journal for Clinicians*, vol. 56, pp. 106–130, © 2006 Lippincott Williams & Wilkins.

The profile of cancer mortality in China is of particular interest because its people and communities have been undergoing rapid economic and social development, as well as intense environmental change. Cancer is the leading cause of death among men (25%) and the third leading cause among women (18.6%). However, the disease burden is likely to shift in favor of heart disease and stroke as the prevalence of smoking, western diets, decreasing physical activity, and hypertension become more common.[26] Interestingly, the cancer death rate is higher among rural residents relative to their urban counterparts. This is likely to reflect lower access to medical care, especially cancer screening, but could also reflect some underlying differences in behavioral risks.

Table 1–7 shows the age-adjusted mortality rates by sex for three common sites and for all sites combined in eight countries. When comparing cancer rates among regions of the world, there can be a bias caused by failing to compare age-standardized cancer rates. Owing to the strong correlation between risk of developing cancer and age and also as a result of the younger age distribution of populations in developing areas, age-adjustment must be performed if the cancer rates of different regions, countries, and local areas are to be compared without bias.

Migrant Studies

The substantial variation in cancer's frequency of occurrence by geographic location offers important clues about cancer etiology. By studying groups who migrate from one country to another, evidence can be amassed to determine whether their cancer rates remain the same as those of the country of origin or become more like those of the new country of residence. In cases where an immigrant group maintains, in the new country, its old rate for a particular cancer, it is reasonable to suspect the presence of genetic component causes. In cases where the immigrants' cancer rate changes to approximate the rate for original inhabitants of the new country, it is reasonable to suspect the presence of environmental or lifestyle component causes.

Of course, observations of cancer rate stability or change must be interpreted in light of specific theories about cancer causation. For example, causation for a particular cancer might be multifactorial, which means the cancer can be caused by various factors operating together within one "causal web" or "causal wheel." Etiologic factors that are present in every causal web are said to be "necessary causes" whereas factors required by one web but not another are referred to as "component causes." The minimum set of factors contained within one cancer web composes a "sufficient cause"[27] (the set could include a combination of genetic, environmental, and lifestyle factors). If a migrant group settles into a cancer rate that is intermediate between the rates of the country of origin and the adopted country, genetic and environmental component causes might both be in play. However, the migrant group's cancer rate could merely be in a period of transition and still be changing, and in such a case a cross-sectional "snapshot" estimate of the migrant cancer rate would be a misleading basis for causal inference by itself.

One of the best-known landmark studies done by the International Agency for Research on Cancer (IARC) compared cancer rates among Africans residing in Ibadan, Nigeria; African Americans; and Caucasian Americans.[28] (Although perhaps of greater historical interest than currently relevant, the study is noteworthy because it helped pioneer the methodology of migrant studies.) Data retrieved from the population-based cancer registries in Nigeria and the United States in the 1960s are presented in Table 1–8. As pointed out by Doll and Peto,[13] the comparisons are to some degree limited, because the ancestors of African Americans were not chiefly from Nigeria; nevertheless, some inferences can be made. Most obvious is the general similarity between the cancer rates of African Americans and Caucasian Americans. The contrast between the cancer rates of Nigerians and African Americans is so great that it is not plausible to assume they result mainly from genetic dilution through interbreeding. Migrant studies of Japanese who migrated to Hawaii, Britons who went to Fiji, and Central Europeans who went

TABLE 1–8 Comparison of Cancer Incidence Rates for Ibadan, Nigeria, and Two Representative Populations of African Americans and Caucasians in the United States (Annual Incidence per Million People)*

Primary site of cancer	*Patients' sex*†	*Ibadan, Nigeria 1960–1969*	*United States African Americans*‡	*United States Caucasians*‡
Colon	M	34	349	294
			353	335
Rectum	M	34	159	217
			248	232
Liver	M	272	67	39
			86	32
Pancreas	M	55	200	126
			250	122
Larynx	M	37	236	141
			149	141
Lung	M	27	1,546	983
			1,517	979
Prostate	M	134	724	318
			577	232
Breast	F	337	1,268	1,828
			1,105	1,472
Cervix uteri	F	559	507	249
			631	302
Corpus uteri	F	42	235	695
			208	441
Lymphosarcoma§	M	133	10	4
at ages <15 yrs	F		5	3

*Ages 35–64 years, standardized for age as in source text.

†For brevity, wherever possible only the male rates have been presented, and sites for which rates among US Caucasians resemble those in the country of origin of the non-Caucasian migrants have been omitted.

‡For each type of cancer, upper entry shows incidence in San Francisco Bay area, 1969–1973; lower entry shows incidence in Detroit, 1969–1971.

§Including Burkitt's lymphoma. The cited rates are the average of the age-specific rates at ages 0–4, 5–9, and 10–14 years.

Source: Reprinted with permission from Doll R, Peto R. *The Causes of Cancer: Quantitative Estimates of Avoidable Risks of Cancer in the United States Today*, © 1981, Oxford University Press.

to North America and Australia, among other studies, lead to similar inferences.[13]

Summary

A comprehensive description of the distribution of cancer within a population according to geographic, temporal, and demographic characteristics is required before analytic studies can be designed to assess causal factors. The information generated from descriptive epidemiology studies often uncovers opportunities to reduce the incidence and mortality rates of cancer in the United States and worldwide. Students and researchers must not be too quick to look beyond descriptive statistics regarding "person, place, and time." The methodological competence that is required to manipulate, compare, and interpret descriptive data is taught in basic and intermediate epidemiology and biostatistics courses and should, therefore, be within reach of most persons using this text. Care is always needed in interpreting comparisons and trends, however, especially if the data have been derived from different sources or cover different time periods.

Statistics concerning the worldwide distribution of cancer highlight the contrasting risk profiles among persons who are of different races and ethnic backgrounds and who live in different physical, social, and economic environments. Careful interpretation of the statistics has led to many causal hypotheses and to some breakthroughs in the identification of etiologic agents. Recent cancer incidence and mortality data suggest that the slight, steady rise in the US cancer burden may have been reversed. Whether the trend is currently downward, substantial declines can be realized by using the information already in hand. There continue to be unmet opportunities for targeting prevention activities toward communities where cancer incidence or mortality remains high.

DISCUSSION QUESTIONS

1. Of major concern to society is whether cancer is more common today than in the past. Discuss this issue from a US perspective and use incidence and mortality data to help address it. How does the issue of changing trends in cardiovascular incidence affect the way we interpret the importance of cancer in our society?

2. Comparing cancer incidence rates between geographic locations affords opportunities to determine the causal factors responsible for the variation. Provide several reasons why such comparisons must be made judiciously, especially when cancer rates are being compared internationally.

3. Migrant studies have been used to help determine the relative importance of genetic and environmental factors in the causation of cancer. From your own experience or travels, identify three communities or populations with a large immigrant component and indicate how descriptive studies might help uncover information about the causes of cancer that could be useful to epidemiologists.

4. It has been alleged that industrial pollution from a large manufacturing facility that opened in 1954 was responsible for an apparent excess in lung cancer in the part of the county where the facility was located. How might you use available cancer statistics to provide a fuller basis for evaluating this allegation? Assume that the county is in a state in which there has been reasonable access to health care and that cancer registration has been conducted since the 1940s.

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