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Global Cancer Statistics

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Introduction

A choice of statistics is available for measuring the impact of cancer on the community. One should think about the exact purpose of the exercise and what comparisons are required before deciding which statistics are most appropriate.

Incidence is the number of new cases occurring. It can be expressed as an absolute number of cases per year (which tells us about the volume of new patients presenting for treatment) or as a rate per 100,000 persons per year. The latter approximates the average risk of developing a cancer, which is particularly useful in making comparisons among populations (countries, ethnic groups, or different periods within a country, for example).

Mortality is the number of deaths occurring, and the *mortality rate* is the number of deaths per 100,000 persons per year. At first sight, such statistics might seem to be of little value (except perhaps to morticians). However, the number of deaths is one indication of the outcome, or impact, of cancer because it represents the product of incidence and the fatality of a given cancer. *Fatality*, the inverse of survival, is the proportion of cancer patients who die, and this is generally assumed to be the most severe sequel of the disease.

Mortality rates therefore measure the average risk to the population of dying of a specific cancer, whereas fatality (defined as 1–survival) represents the probability that an individual with cancer will die of it. Mortality rates are sometimes used as a convenient proxy measure of the risk of acquiring the disease. This use does, however, assume that survival or fatality is constant among the populations being compared. Because this is rarely the case—at least when comparisons are made among countries—it is safer to use mortality as measure of outcome.

Prevalence of disease measures the number of persons alive at a particular time who have the disease of concern. Regarding cancer, no clear agreement exists about what is meant by "having" the disease. Some authors take it to mean ever having been diagnosed with cancer, even if this was many years ago, and the subject is cured. This is clearly a useless statistic.

Knowing the number of people being treated for cancer (or, at least, still being followed-up medically for the disease) would be more helpful. Such a statistic is not only hard to obtain, but it would certainly vary from one place to another, depending on medical practice. However, since *cure* is often interpreted as meaning survival beyond 5 years, at least for statistical purposes, a useful compromise is to estimate prevalence as the number of

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people alive who have had a cancer diagnosed within the last 5 years.[1]

Several other more complex statistics have been used to measure the impact of disease. They include person-years of life lost (how many years of normal life span are lost because of deaths from cancer) and disability or quality-adjusted life-years lost. The latter measures attempt to give a numerical score to the years lived with a reduced quality of life between diagnosis and death (where quality = 0) or cure (quality = 1).

In this article, we present estimates of the incidence of and mortality from cancer, both as numbers of cases and deaths, and as the annual rates of incidence or mortality per 100,000 population.

The rates are age-standardized to take into account differences in the age structure of the populations being compared. This is necessary because risk of cancer incidence and mortality is very powerfully determined by age, so that populations containing a high proportion of old people tend to have higher rates than populations with mainly young people. Because we wish to know the risk irrespective of this incidental ("confounding") effect, we compare populations as if they had the same age structure—that of the so-called "world standard population."

The ratio of mortality to incidence represents the approximate fatality for a given cancer. A figure of 0.7, for example, means that 70% of patients with new cases will die (or, conversely, that 30% will survive). Because most deaths attributable to cancer occur within 5 years of diagnosis, "survival" as obtained with the formula 1–mortality/incidence is close to the 5-year survival rate obtained by the actual follow-up of groups of new cancer cases.[2,3]

Incidence data are available from cancer registries. The number of cancer registries has increased steadily over the years; such registries cover entire national populations or subsamples of selected regions. They also provide statistics on cancer survival, making it possible for incidence to be estimated from mortality. Mortality data by cause are available for many countries because of registration of vital events, although the degree of detail and quality of the data (both the accuracy of the recorded cause of death and the completeness of registration) vary considerably.

With such data, estimations of the numbers of new cancer cases and deaths by site, sex, and age group are possible. These estimations are more or less accurate for different countries, depending on the extent and accuracy of locally available data.

The most recent comprehensive estimates are for 1990[4] (also P. Pisani, PhD; D.M. Parkin, MD; F.I. Bray, MSc; and J. Ferlay, International Agency for Research on Cancer [IARC], Lyon, France, unpublished data, 1998). In this paper, these estimates are presented for 23 world "areas" defined by the United Nations (Fig. 1). However, the estimates are built up at country level, and to obtain the full information available, readers should refer to the CD-ROM "GLOBOCAN."[5] The information can also be accessed, although with less flexibility in the analyses possible, on the Internet (http://www-dep.iarc.fr/dataava/globocan/globojava.html).

Developed countries are areas 10, 12, and 17-21 of Figure 1; *developing countries* are the remaining areas. This convention is used throughout this article. The terms *westernized* and *industrialized* are used as synonyms of *developed*. No attempt has been made to estimate incidence or mortality of nonmelanoma skin cancer because of the difficulties of measurement and consequent lack of data. The "all cancer" total therefore excludes such tumors.

Methods of Estimation

Rates for five broad age groups (0–14, 15–44, 45–54, 55–64, and 65 and over) and sex were estimated for as many individual

Figure 1
23 World Areas Studied

countries as possible. Age-standardized incidence rates were calculated using the weights of the "world standard" population (0.31, 0.43, 0.11, 0.08, and 0.07) in these five age classes. The area estimates were obtained by combining age- and sex-specific rates for component countries as a weighted average (using the corresponding country populations).

The sources of data for the countries of the 23 world areas and the methods used to produce estimates of incidence and mortality in each of them are summarized in Parkin et al[4] and P. Pisani, PhD; D.M. Parkin, MD; F.I. Bray, MSc; and J. Ferlay, IARC, Lyon, France, unpublished data, 1998.

In summary, incidence rates for a country were obtained whenever possible from cancer registries serving the whole population or a representative sample of it. In like manner, national mortality data from the World Health Organization (WHO) mortality data bank were used to obtain information on cancer deaths. For some countries, a correction factor was applied to account for known and quantified under-reporting of mortality.

Occasionally, mortality data from a sample of the country were used in the absence of national statistics. The most prominent example of this was the use of information from disease surveillance points representing a random sample of some 9.6 million (0.8%) of the Chinese population.[6] Occasionally, mortality data collected by cancer registries were used.

In the absence of either of these data sources, we built up an estimate of cancer incidence from available information on

Table 1
Average 5-Year Survival (%) in the US,* Europe, India,* China, * and Developing Countries; and Estimated 5-Year Survival (%) for Selected Cancer Sites by World Region

	Oral Cavity & Pharynx	Stomach	Colon & Rectum	Pancreas	Larynx	Lung	Melanoma	Breast (Female)	Cervix Uteri	Corpus Uteri	Ovary	Prostate	Testis	Bladder	NHL	Hodgkin's Disease	Leukemias
Registry	**Relative/Average 5-Year Survival**																
SEER	53	21	60	4	65	14	88	84	69	84	46	88	95	81	51	81	42
EUROCARE	35	18	41	4	57	8	NA	67	59	72	32	NA	85	NA	NA	66	27
India	26	7	42	2	37	7	45	49	48	69	42	40	NA	18	22	37	20
China	51	18	32	5	54	8	48	60	49	72	41	40	74	47	32	46	10
Developing countries	31	14	38	5	38	8	47	55	49	69	41	40	47	42	28	44	16
Region	**Estimated 5-Year Survival**																
Australia/ New Zealand	76	29	54	2	62	13	85	68	62	80	40	63	90	68	56	74	44
North America	70	34	61	7	71	20	78	73	54	87	45	79	91	80	61	76	39
Northwestern Europe	60	21	46	0	52	7	74	63	54	75	32	49	89	57	56	67	32
Southern Europe	61	17	45	0	44	8	70	57	57	73	43	22	89	61	57	65	32
Eastern Europe	42	10	30	12	34	12	55	53	41	50	43	40	69	46	43	53	24
Japan	56	53	57	7	74	21	40	74	65	62	38	52	82	70	50	79	21

Table 1 (Continued)
Average 5-Year Survival (%) in the US,* Europe, India,* China, * and Developing Countries; and Estimated 5-Year Survival (%) for Selected Cancer Sites by World Region

Region	Oral Cavity & Pharynx	Stomach	Colon & Rectum	Pancreas	Larynx	Lung	Melanoma	Breast (Female)	Cervix Uteri	Corpus Uteri	Ovary	Prostate	Testis	Bladder	NHL	Hodgkin's Disease	Leukemias
	Estimated 5-Year Survival																
Latin America & Caribbean	51	21	45	0	42	14	63	61	54	64	41	43	74	52	38	49	20
China	38	19	33	6	55	8	44	61	49	74	42	40	69	48	33	58	10
Southeast Asia	37	17	36	5	42	9	51	56	48	68	40	41	57	45	29	47	15
S.Central Asia	38	11	33	9	38	8	57	49	45	64	42	39	58	31	24	50	19
Middle East & North Africa	41	16	37	9	40	8	61	54	49	68	48	40	71	45	27	49	15
Sub-Saharan Africa	41	16	37	7	40	10	51	56	49	67	42	41	57	43	29	46	17
Developed countries	59	28	49	0	51	13	73	65	51	73	40	64	86	64	55	65	31
Developing countries	39	18	36	5	41	9	56	56	48	66	42	41	65	43	30	49	15
World	46	21	44	1	46	11	69	61	49	71	39	58	78	56	43	56	20

*From population-based cancer registries.
†Age-adjusted on the distribution of world cases (site-specific). NA = not available; NHL = non-Hodgkin's lymphoma.
Data sources: US relative survival from SEER,[8] cases diagnosed 1986 to 1993; relative survival for India and China and average survival for developing countries from Sankaranarayanan et al;[7] average survival for Europe from Berrino et al.[9]

the relative frequency of different cancers (by age group and sex), applied to an overall "all sites" incidence figure for the corresponding area. These "all sites" figures were derived from such data as could be found for the corresponding geographic area.

For some countries, data could be found on mortality but not on incidence. In these cases, incidence was estimated using sets of regression models that, for a given area, cancer, and sex and age group, predict incidence from mortality, based on cancer registry data from the same area.

The opposite was also true: incidence rates were available for some countries in which no data on mortality existed. For these countries, we used information on cancer survival to obtain estimates of mortality. Three sources of data on population-based survival were used, the Cancer Survival in Developing Countries project by the IARC,[7] which provides cancer survival in populations of China, the Philippines, Thailand, India, and Cuba for all of the sites considered; the Surveillance, Epidemiology, and End Results (SEER) program covering 10% of the United States population;[8] and the EUROCARE project providing figures from several European cancer registries.[9]

Table 1 shows population-based relative survival probabilities for the United States (cases diagnosed from 1989 to 1993[8]), Europe,[9] China,[7] and India,[7] and the average survival recorded by ten registries in developing countries (Shanghai and Qidong, China; Barshi, Madras, Bangalore, and Bombay, India; Rizal, Philippines; Chiang Mai and Khon Kaen, Thailand; and Cuba).[7]

These are the only population-based data available in less affluent countries. For this reason, we take their mean as the best available indication of cancer survival in developing countries, although we recognize that these ten registries are far from a representative sample of the whole region. A thorough discussion of the accuracy and limitations of these data can be found in Sankaranarayanan et al.[7]

Table 1 also shows estimates of 5-year survival based on the ratio of deaths to cases by geographical region. These estimates of survival are age-adjusted using the age distribution, by site, of worldwide incident cases for males and females combined.

Differences between these estimates and the crude rates of the three data sources used in compiling the Table are partly the result of age standardization. The age distribution of patients for any cancer site in developing countries is significantly younger than that of patients in developed countries because of the younger age of the population in developing countries.

Standardization of survival rates on the age distribution of world cases (which include those of developing countries) tends therefore to emphasize survival rates of younger patients, which, for several sites, are more favorable. This explains why, for example, the age-adjusted estimated survival from lung cancer in North America is better (20%) than that reported by SEER (14%).

Results

Global Estimates

The most recent estimate, that for 1990,[4] suggests a total of 8.1 million new cases, divided almost exactly between developed and developing countries. This represents an increase of about 37% since our first estimates 15 years ago for 1975, a rate of growth (2.1% per year) that is faster than that of the world population (1.7% per year).

In the same year (1990), we estimate that 5.2 million cancer deaths occurred, about 55% of which occurred in developing countries.

Table 2 shows the number of new cancers and cancer deaths for 25 sites in males and females and for both sexes combined. Table 3 shows the age-stan-

Table 2
Estimated Number of New Cancer Cases and Deaths (Thousands) by Type of Cancer, World Totals

Cancer Type	Incidence						Mortality					
	Male		Female		Both		Male		Female		Both	
	Number	(%)	Number	(%)	Number	(%)	Number	(%)	Number	(%)	Number	(%)
Mouth	141	(3.3)	70	(1.8)	212	(2.6)	66	(2.2)	34	(1.5)	100	(1.9)
Nasopharynx	40	(0.9)	18	(0.5)	57	(0.7)	24	(0.8)	11	(0.5)	35	(0.7)
Other pharynx	77	(1.8)	17	(0.4)	94	(1.2)	50	(1.7)	12	(0.5)	62	(1.2)
Mouth/pharynx	258	(6.0)	105	(2.8)	363	(4.5)	140	(4.7)	56	(2.5)	197	(3.8)
Esophagus	213	(5.0)	103	(2.7)	316	(3.9)	193	(6.5)	92	(4.1)	286	(5.5)
Stomach	511	(11.9)	287	(7.6)	798	(9.9)	397	(13.4)	230	(10.3)	628	(12.1)
Colon/rectum	402	(9.4)	381	(10.1)	783	(9.7)	222	(7.5)	215	(9.7)	437	(8.4)
Liver	316	(7.4)	121	(3.2)	437	(5.4)	306	(10.3)	121	(5.4)	427	(8.2)
Pancreas	92	(2.1)	79	(2.1)	170	(2.1)	90	(3.0)	78	(3.5)	168	(3.2)
Larynx	118	(2.7)	17	(0.4)	136	(1.7)	65	(2.2)	9	(0.4)	74	(1.4)
Lung	772	(18.0)	265	(7.0)	1,037	(12.8)	693	(23.4)	228	(10.2)	921	(17.8)
Melanoma	50	(1.2)	55	(1.5)	106	(1.3)	17	(0.6)	16	(0.7)	33	(0.6)
Breast (female)	0	(0.0)	796	(21.0)	796	(9.8)	0	(0.0)	314	(14.1)	314	(6.1)
Cervix uteri	0	(0.0)	371	(9.8)	371	(4.6)	0	(0.0)	190	(8.5)	190	(3.7)
Corpus uteri	0	(0.0)	142	(3.7)	142	(1.8)	0	(0.0)	42	(1.9)	42	(0.8)
Ovary	0	(0.0)	166	(4.4)	166	(2.1)	0	(0.0)	101	(4.5)	101	(1.9)
Prostate	396	(9.2)	0	(0.0)	396	(4.9)	165	(5.6)	0	(0.0)	165	(3.2)
Testis	36	(0.8)	0	(0.0)	36	(0.4)	8	(0.3)	0	(0.0)	8	(0.2)
Bladder	203	(4.7)	58	(1.5)	261	(3.2)	86	(2.9)	28	(1.3)	115	(2.2)
Kidney	92	(2.1)	59	(1.6)	150	(1.9)	49	(1.7)	30	(1.3)	78	(1.5)
Brain, CNS	69	(1.6)	58	(1.5)	127	(1.6)	52	(1.8)	43	(1.9)	95	(1.8)
Thyroid	22	(0.5)	65	(1.7)	87	(1.1)	6	(0.2)	14	(0.6)	20	(0.4)
NHL	126	(2.9)	95	(2.5)	221	(2.7)	72	(2.4)	54	(2.4)	126	(2.4)
HD	37	(0.9)	22	(0.6)	59	(0.7)	17	(0.6)	9	(0.4)	26	(0.5)
Multiple myeloma	29	(0.7)	28	(0.7)	57	(0.7)	23	(0.8)	22	(1.0)	45	(0.9)
Leukemia	130	(3.0)	101	(2.7)	231	(2.9)	103	(3.5)	81	(3.6)	184	(3.6)
All sites*	4,293	(100.0)	3,790	(100.0)	8,083	(100.0)	2,957	(100.0)	2,225	(100.0)	5,182	(100.0)

*Excludes non-melanoma skin cancer.

CNS = central nervous system; HD = Hodgkin's disease; NHL = non-Hodgkin's lymphomas.

Data sources: Parkin et al [4] and P. Pisani, PhD; D.M. Parkin, MD; F.I. Bray, MSc; and J. Ferlay, IARC, Lyon, France, unpublished data, 1998.

Table 3
Estimated Age-Standardized Incidence and Mortality Rates per 100,000 (World Standard) by Type of Cancer, World Totals

Type of Cancer	Incidence		Mortality	
	Male	Female	Male	Female
Mouth	6.6	2.9	3.1	1.4
Nasopharynx	1.8	0.7	1.1	0.4
Other pharynx	3.6	0.7	2.4	0.5
Mouth/pharynx	12.1	4.4	6.6	2.3
Esophagus	10.2	4.2	9.3	3.8
Stomach	24.5	11.6	19.1	9.2
Colon/rectum	19.4	15.3	10.7	8.6
Liver	14.7	4.9	14.2	4.9
Pancreas	4.4	3.1	4.4	3.1
Larynx	5.7	0.7	3.1	0.4
Lung	37.5	10.8	33.7	9.2
Melanoma	2.3	2.2	0.8	0.6
Breast (female)	0.0	33.0	0.0	12.9
Cervix uteri	0.0	15.4	0.0	8.0
Corpus uteri	0.0	5.9	0.0	1.7
Ovary	0.0	6.8	0.0	4.2
Prostate	19.8	0.0	8.2	0.0
Testis	1.3	0.0	0.3	0.0
Bladder	9.9	2.3	4.2	1.1
Kidney	4.3	2.4	2.3	1.2
Brain, CNS	3.0	2.3	2.3	1.7
Thyroid	1.0	2.6	0.3	0.6
NHL	5.6	3.8	3.3	2.2
HD	1.5	0.8	0.7	0.4
Multiple myeloma	1.4	1.1	1.1	0.9
Leukemia	5.6	4.0	4.4	3.2
All sites*	**203.2**	**154.3**	**141.0**	**90.2**

*Excludes non-melanoma skin cancer.
CNS = central nervous system; HD = Hodgkin's disease; NHL = non-Hodgkin's lymphomas.
Data sources: Parkin et al [4] and P. Pisani, PhD; D.M. Parkin, MD; F.I. Bray, MSc; and J. Ferlay, IARC, Lyon, France, unpublished data, 1998.

Figure 2A
Incidence and Mortality of the 15 Most Common Cancers in Males

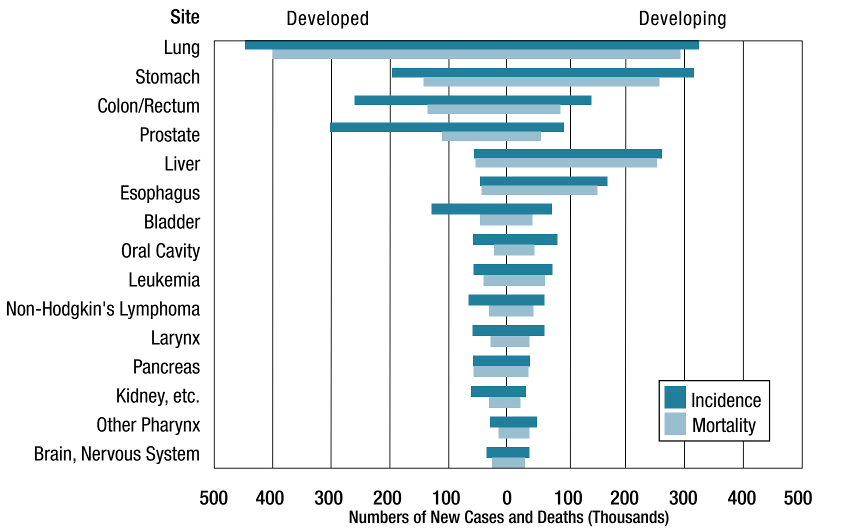


Figure 2B
Incidence and Mortality of the 15 Most Common Cancers in Females

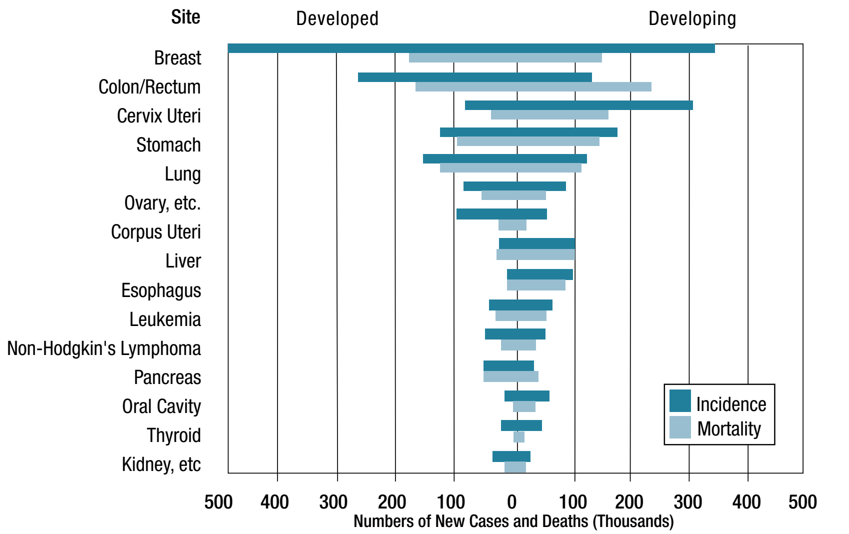


Table 4
Estimated Number of New Cancer Cases and Deaths (Thousands), All Sites, by World Area

	Incidence						Mortality					
	Male		Female		Both		Male		Female		Both	
World Area	Number	(%)	Number	(%)	Number	(%)	Number	(%)	Number	(%)	Number	(%)
Eastern Africa	89	(2.1)	86	(2.3)	175	(2.2)	57	(1.9)	47	(2.1)	104	(2.0)
Middle Africa	30	(0.7)	28	(0.7)	58	(0.7)	21	(0.7)	19	(0.9)	40	(0.8)
Northern Africa	47	(1.1)	46	(1.2)	92	(1.1)	32	(1.1)	27	(1.2)	59	(1.1)
Southern Africa	33	(0.8)	29	(0.8)	62	(0.8)	24	(0.8)	18	(0.8)	42	(0.8)
Western Africa	65	(1.5)	65	(1.7)	130	(1.6)	47	(1.6)	39	(1.8)	86	(1.7)
Caribbean	28	(0.7)	27	(0.7)	55	(0.7)	19	(0.6)	16	(0.7)	35	(0.7)
Central America	50	(1.2)	68	(1.8)	118	(1.5)	30	(1.0)	34	(1.5)	64	(1.2)
South America (temperate)	60	(1.4)	64	(1.7)	124	(1.5)	37	(1.3)	31	(1.4)	68	(1.3)
South America (tropical)	158	(3.7)	167	(4.4)	325	(4.0)	111	(3.8)	98	(4.4)	209	(4.0)
North America	634	(14.8)	572	(15.1)	1,206	(14.9)	296	(10.0)	260	(11.7)	555	(10.7)
E. Asia: China	866	(20.2)	528	(13.9)	1,395	(17.3)	724	(24.5)	384	(17.3)	1,108	(21.4)
E. Asia: Japan	224	(5.2)	163	(4.3)	387	(4.8)	128	(4.3)	84	(3.8)	212	(4.1)
E. Asia: Other	59	(1.4)	60	(1.6)	118	(1.5)	43	(1.5)	35	(1.6)	79	(1.5)
S.E. Asia	181	(4.2)	192	(5.1)	374	(4.6)	138	(4.7)	116	(5.2)	254	(4.9)
S.Central Asia	452	(10.5)	488	(12.9)	941	(11.6)	325	(11.0)	296	(13.3)	621	(12.0)
Western Asia	64	(1.5)	57	(1.5)	121	(1.5)	45	(1.5)	33	(1.5)	78	(1.5)
Eastern Europe	435	(10.1)	406	(10.7)	841	(10.4)	331	(11.2)	258	(11.6)	589	(11.4)
Northern Europe	182	(4.2)	186	(4.9)	368	(4.6)	123	(4.2)	110	(4.9)	234	(4.5)
Southern Europe	244	(5.7)	197	(5.2)	442	(5.5)	174	(5.9)	117	(5.3)	290	(5.6)
Western Europe	350	(8.2)	324	(8.5)	674	(8.3)	229	(7.7)	185	(8.3)	414	(8.0)
Australia/NZ	38	(0.9)	34	(0.9)	72	(0.9)	20	(0.7)	16	(0.7)	36	(0.7)
Melanesia	2	(0.0)	3	(0.1)	5	(0.1)	2	(0.1)	2	(0.1)	3	(0.1)
Micro/Poly	1	(0.0)	1	(0.0)	1	(0.0)	0	(0.0)	0	(0.0)	1	(0.0)
Developed countries	2,109	(49.1)	1,881	(49.6)	3,990	(49.4)	1,301	(44.0)	1,030	(46.3)	2,331	(45.0)
Developing countries	2,185	(50.9)	1,909	(50.4)	4,094	(50.6)	1,656	(56.0)	1,195	(53.7)	2,851	(55.0)
All Areas	**4,293**	**(100.0)**	**3,790**	**(100.0)**	**8,083**	**(100.0)**	**2,957**	**(100.0)**	**2,225**	**(100.0)**	**5,182**	**(100.0)**

Micro/Poly = Micronesia/Polynesia; NZ = New Zealand.
Data sources: Parkin et al [4] and P. Pisani, PhD; D.M. Parkin, MD; F.I. Bray, MSc; and J. Ferlay, IARC, Lyon, France, unpublished data, 1998.

Table 5
Estimated Age-Standardized Incidence and Mortality Rates per 100,000 (World Standard), All Sites, by World Area

World Area	Incidence		Mortality	
	Male	Female	Male	Female
Eastern Africa	178.0	145.3	115.0	81.3
Middle Africa	160.4	124.9	115.5	82.7
Northern Africa	105.6	94.6	73.7	56.1
Southern Africa	247.4	187.8	181.6	114.7
Western Africa	140.0	118.5	100.4	73.2
Caribbean	199.0	175.5	133.7	105.7
Central America	154.7	180.1	97.5	92.5
South America (temperate)	255.1	230.1	158.5	106.9
South America (tropical)	196.9	185.0	139.9	111.0
North America	369.9	277.5	170.8	117.7
Eastern Asia: China	179.2	105.3	150.5	77.1
Eastern Asia: Japan	270.9	166.8	154.1	79.9
Eastern Asia: Other	235.7	179.9	176.8	108.6
Southeastern Asia	130.4	115.7	100.7	71.3
South Central Asia	106.3	109.9	77.3	67.8
Western Asia	131.4	108.3	93.9	63.5
Eastern Europe	269.4	172.8	204.9	102.9
Northern Europe	270.0	234.5	177.3	125.4
Southern Europe	256.0	177.6	176.3	94.6
Western Europe	294.8	210.4	188.3	106.5
Australia/New Zealand	312.7	254.0	161.5	109.2
Melanesia	165.4	185.6	107.7	108.0
Micronesia/Polynesia	204.5	205.2	129.6	98.0
Developed countries	299.6	208.9	182.8	105.4
Developing countries	151.9	122.0	116.7	78.0
All Areas	**203.2**	**154.3**	**141.0**	**90.2**

Data sources: Parkin et al [4] and P. Pisani, PhD; D.M. Parkin, MD; F.I. Bray, MSc; and J. Ferlay, IARC, Lyon, France, unpublished data, 1998.

dardized incidence and mortality rates.

Some differences exist in the profile of cancers worldwide, depending on whether incidence or mortality is the focus of interest.

Lung cancer is the main cancer in the world today, whether considered in terms of numbers of cases (1.04 million) or deaths (921,000), because of the high case fatality (the ratio of mortality to incidence is 0:89). Stomach cancer is second in importance (789,000 cases, 628,000 deaths). Although breast cancer is the third most common cancer overall (796,000 new cases), it ranks fifth as a cause of death because of its relatively favorable prognosis (the ratio of mortality to incidence is about 40%). Cancers of the colon and rectum (783,000 cases, 437,000 deaths) and liver (437,000 cases, 427,000 deaths) rank more highly than female breast cancer as cause of death. We gathered breast cancer data for females only.

Figure 2 summarizes these results, showing the 15 most common cancers for males and females (as numbers of new cases) and the corresponding numbers of deaths in the developing and developed regions of the world.

Table 4 shows the numbers of new cases of and deaths from cancer by world area, and Table 5 shows the corresponding age-standardized rates. The numbers range from 1.4 million cases in China (17% of the world total) and 1.2 million in North America (15%) to about 1,100 in Micronesia/Polynesia. For the world as a whole, the sex ratio (male to female) for cancer deaths is 1.33, which is greater than the sex ratio for incidence (1.13) because of the more favorable prognoses of female cancers.

The age-standardized rates in Tables 3 and 5 express the actual risk of developing or dying from cancer, irrespective of the age distribution of the population. Thus, for men the risk of cancer is highest in North America (age-standardized incidence rate 369.9 per 100,000), a consequence, as described later in this article, of the high contemporary rates of prostate cancer. The risk of dying of cancer, in contrast, is highest in Eastern Europe, with an age-standardized incidence rate for all sites of 205 deaths per 100,000 population. Mortality rates in all other developed regions are about 180, although incidence is more variable (260 to 310).

In females, the region with the highest incidence of cancer is again North America (age-standardized incidence rate 277.5), whereas mortality is highest in Northern Europe (age-standardized incidence rate 125.4), followed by North America, Southern Africa, and tropical South America.

Lung Cancer

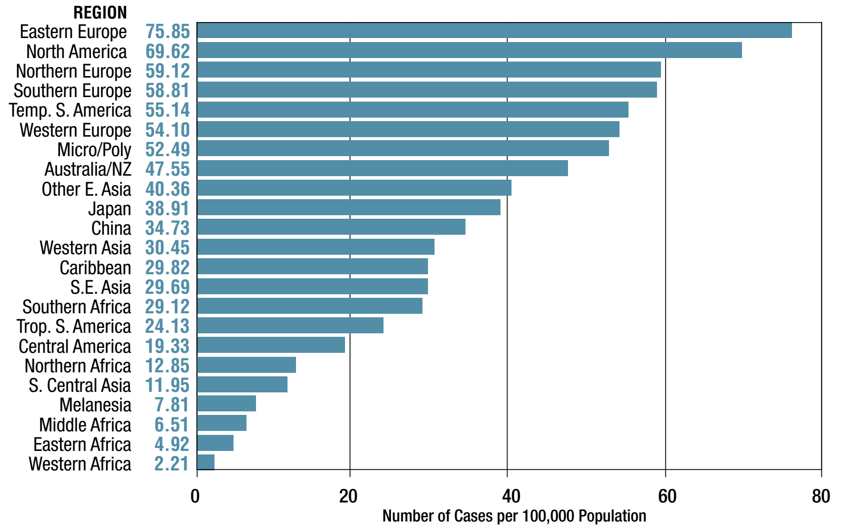
Lung cancer was the most common cancer in 1990, in terms of both incidence (1.04 million new cases; 12.8% of the world total) and mortality (921,000 deaths; 17.8% of the world total); 58% of new cases occur in developed countries.

Worldwide, it is by far the most common cancer of men, with the highest rates observed in North America and Europe (especially Eastern Europe). Moderately high rates are also seen in temperate South America, Australia/New Zealand, and parts of Eastern Asia (Fig. 3). In females, incidence rates are lower (overall, the rate is 10.8 per 10^5 women, compared with 37.5 per 10^5 men). The highest rates are in North America and Northern Europe. The incidence in China is high (age-standardized rate 13.4 per 10^5), similar to that in, for example, Australia/New Zealand (16.1).

Lung cancer remains a highly lethal disease. Survival at 5 years measured by the SEER program in the United States is 14%, the best recorded at the population level. The average survival in Europe is 8%, the same as that of developing countries.

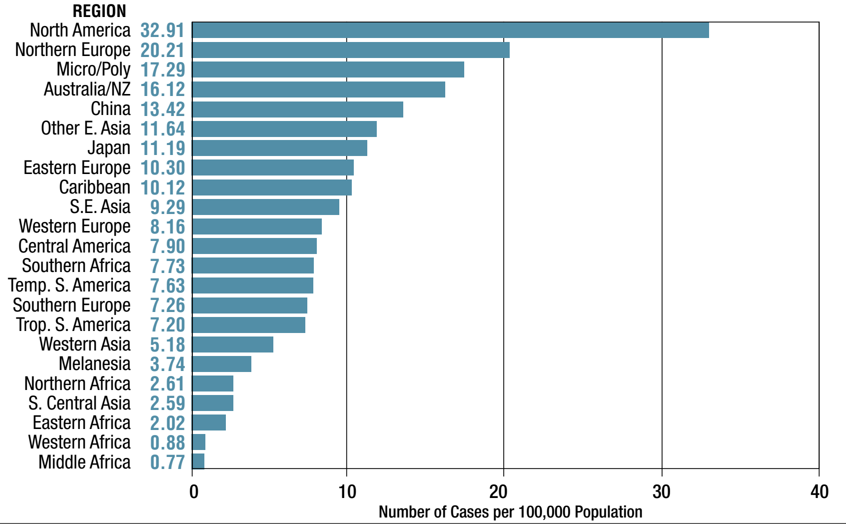
The most important cause of lung cancer is tobacco smoking, and incidence rates in a country closely reflec the histo-

Figure 3A
Incidence of Lung Cancer in Males by World Region



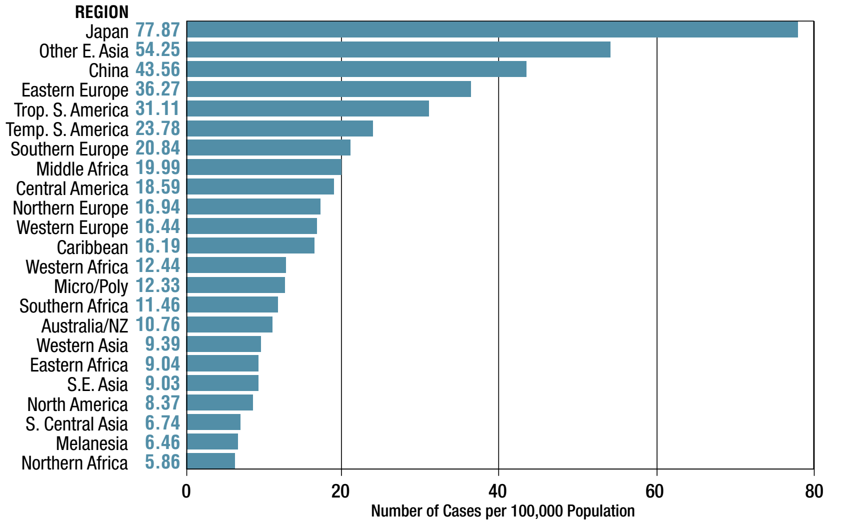
Micro/Poly=Micronesia/Polynesia; NZ=New Zealand; Temp.=temperate; Trop.=tropical.

Figure 3B
Incidence of Lung Cancer in Females by World Region



Micro/Poly=Micronesia/Polynesia; NZ=New Zealand; Temp.=temperate; Trop.=tropical.

Figure 4A
Incidence of Stomach Cancer in Males by World Region



Micro/Poly=Micronesia/Polynesia; NZ=New Zealand; Temp.=temperate; Trop.=tropical.

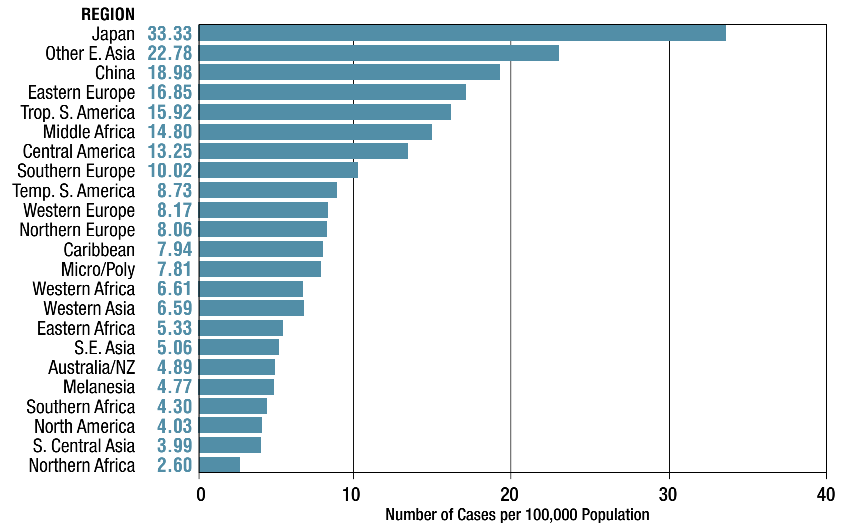
ry of tobacco smoking.[10] We have estimated the proportion of lung cancer cases caused by tobacco smoking by examining the observed incidence in different areas compared with that expected based upon incidence rates in nonsmokers from several large cohort studies.[11]

Updating the results to 1990, we find that 86% of cases in men and 49% in women are caused by smoking, although considerable regional variation exists in this figure. Thus, in countries or regions with a long history of smoking, 90% or more of cases in men are tobacco related. The fraction is much lower in Africa and Southern Asia. The proportions are more variable in women, even in Europe, where they range from 80% in the United Kingdom to virtually nil in Spain and Portugal, where incidence rates are the same as in nonsmoking women in the United States and Japan.

Time trends in lung cancer reflect past exposure to cigarette smoking. Our estimate of the numbers of cases worldwide has increased by 16% since 1985 (an increase of 4% in men and 21% in women). This represents an increase of about 2.5% in the actual risk in men and 9.5% in that in women (the remainder is the result of population growth and aging).

The overall upward trend disguises considerable difference among countries. In men, several populations have now passed the peak of the tobacco-related epidemic, and incidence rates are now declining (for example, in the United States and the countries of Northern and Western Europe). In contrast, incidence and mortality are increasing rapidly in Southern and Eastern European countries. In women, the "epidemic" is less advanced. Most western countries are still showing a rising trend in incidence and mortality, although for some there is, so far, no evidence of this (Spain), whereas for others (United

Figure 4B
Incidence of Stomach Cancer in Females by World Region



Micro/Poly=Micronesia/Polynesia; NZ=New Zealand; Temp.=temperate; Trop.=tropical.

Kingdom) the peak of risk now may have been reached.

Stomach Cancer

Stomach cancer is the second most frequent cancer, with 798,000 new cases (9.9% of the total) and 628,000 deaths (12.1% of cancer deaths), although it is only in fourth rank in women (Fig. 2).

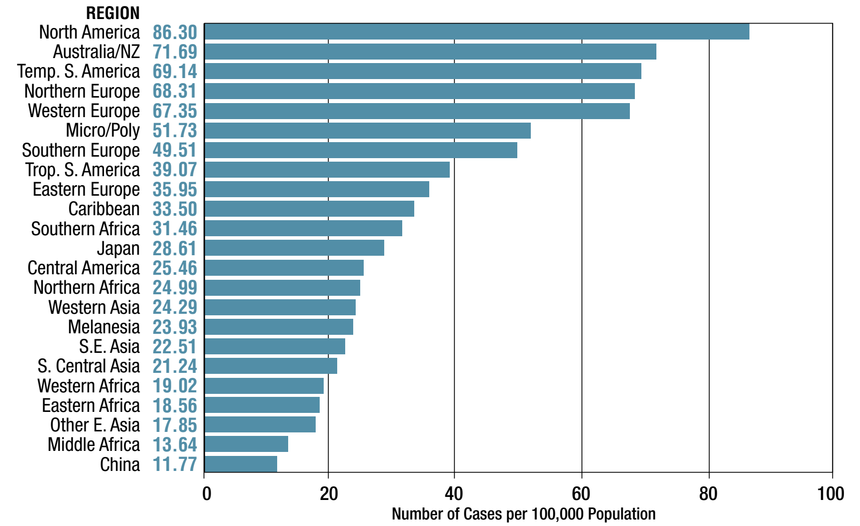
Thirty-eight percent of cases occur in China, where it remains the most common cancer in both sexes, as it is elsewhere in Eastern Asia. Age-standardized incidence rates are highest in Japan (77.9 per 100,000 in men, 33.3 per 100,000 in women). High rates are also present in both sexes in Eastern Europe and tropical South America (Fig. 4). The rates are low in Eastern and Northern Africa, North America, and South and Southeast Asia (age-standardized incidence rate in men 5.9 to 9.0 per 100,000 and 2.6 to 5.3 per 100,000 in women).

Survival for stomach cancer is moderately good only in Japan (53%), where mass screening by photofluoroscopy has been practiced since the 1960s. Other areas with better survival are North America (21% based on the SEER data, 34% age-adjusted estimate) and Australia and New Zealand (29%), possibly because of early diagnosis after a greater number of endoscopic examinations performed for gastric disorders. Survival is 18% on average in European registries and is consistent with the age-adjusted estimates. Elsewhere, survival varies from 10% (Eastern Europe, including Russia) to 21% in Latin America.

The differences in risk among countries are usually assumed to be related to dietary factors, which are important in determining the risk of individuals in epidemiologic studies. Their importance is consistent with the descriptive data and studies of migrants.

Recently, the importance of *Helicobacter pylori* has been recognized. The

Figure 5
Incidence of Breast Cancer in Females by World Region



Micro/Poly=Micronesia/Polynesia; NZ=New Zealand; Temp.=temperate; Trop.=tropical.

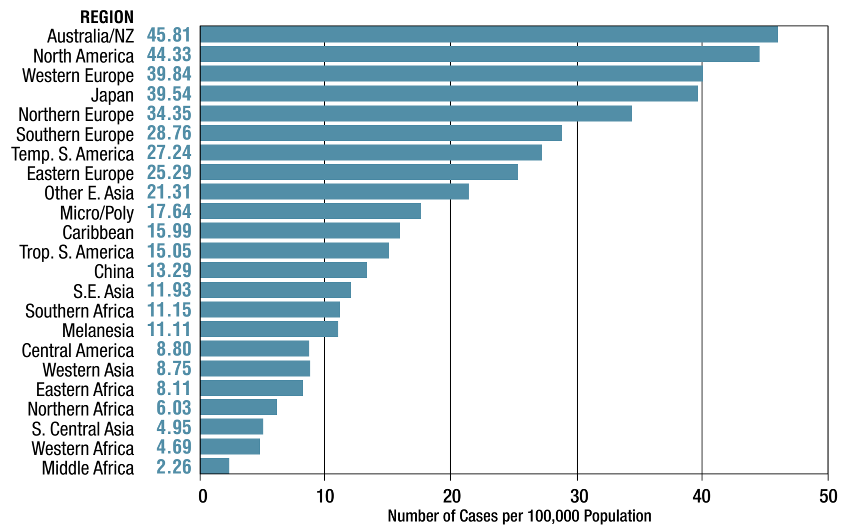
IARC[12] has accepted *H. pylori* as a human carcinogen, based on ecological correlation studies (such as the EUROGAST study[13]), a host of case-control studies, and, more usefully, several cohort studies. The combined odds ratio from these studies is 2.1.[14] *H. pylori* is assumed to have an indirect action because it provokes gastritis, which is a precursor of gastric atrophy, metaplasia, and dysplasia. The role of dietary and other exogenous factors may be synergistic or antagonistic.

The proportion of the population infected with *H. pylori* is large in developing countries, ranging from 80% to 90%; individuals contract the infection at a young age, and it persists throughout life. In developed countries, the prevalence is lower. Assuming a value of 50% (and 80% in developing countries) and a relative risk of 2.1, the number of new cases of stomach cancer attributed to the bacterium is 337,800, representing 42% of the world total of these cancers (47% in developing countries and 35% elsewhere).

A steady decline has occurred in gastric cancer incidence and mortality in most countries. Our world estimate of the number of new cases in 1990 was just 6% greater than that in 1985, which, given the population increase and aging, represents a decline of 4% to 5% in age-adjusted risk. This decline may be related to improvements in preservation and storage of foods. It also may represent changes in the prevalence of *H. pylori* by birth cohort, perhaps because of reduced transmission in childhood, following a trend toward improved hygiene and reduction of crowding.[15]

In any case, one can confidently expect a continuing decline in age-adjusted incidence and mortality from stomach cancer. If the observed rate of decline in the last 5 years continues, the expected number of new cases in 2010

Figure 6A
Incidence of Colon and Rectal Cancer in Males by World Region



Micro/Poly=Micronesia/Polynesia; NZ=New Zealand; Temp.=temperate; Trop.=tropical.

will be about 1 million, an increase of 30% rather than the 58% additional cases resulting simply from population growth and aging.

Breast Cancer

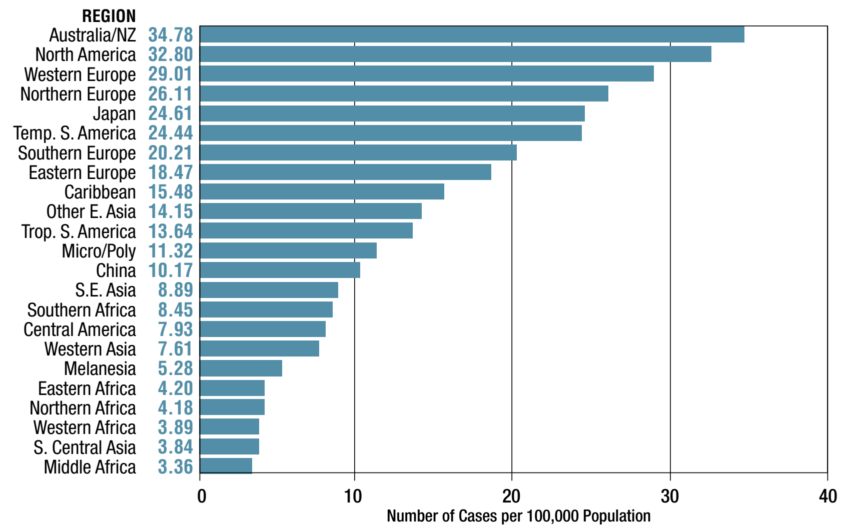
In terms of number of new cases, breast cancer is the third most frequent cancer in the world (796,000 cases in 1990) and by far the most common malignancy of women (21% of all new cases). Worldwide, the ratio of mortality to incidence is about 61%. As a result, breast cancer ranks as the fifth cause of death from cancer overall, although it is still the leading cause of cancer mortality in women (the 314,000 annual deaths represent 14.1% of cancer deaths in females).

Incidence rates are high in all of the developed areas (except Japan, where it is third after stomach and colon and rectal cancer), with the highest age-standardized incidence in the United States (87.1 per 100,000) (Fig. 5). The incidence is more modest in North Africa, South America, and Eastern, Southeastern, and Western Asia, but it is still the most common cancer of women in these geographic regions. The rates are low (less than 30 per 100,000) in most of sub-Saharan Africa (except South Africa) and in Asia. The lowest incidence is in China (age-standardized incidence rate 11.8 per 100,000).

The prognosis for breast cancer is generally rather good, as illustrated by the survival figures in Table 1. The highest crude survival is reported by the SEER program, 84%, consistent with the age-adjusted estimate for North America of 73%. Survival rates are high in Japan (74%) and Australia/New Zealand (68%) and lower in Europe (53% to 63%, consistent with the EUROCARE crude rate of 67%). Elsewhere survival ranges from 49% to 61%.

The prevalence of carriers of the major susceptibility genes (BRCA1 and BRCA2) in the general population is low,

Figure 6B
Incidence of Colon and Rectal Cancer in Females by World Region



Micro/Poly=Micronesia/Polynesia; NZ=New Zealand; Temp.=temperate; Trop.=tropical.

and the variation observed among populations (0.05% to 1%) could account for only a small part of the observed international and interethnic variation. Most cases must, therefore, be the consequence of different environmental exposures. Indeed, risk changes markedly after migration, particularly if this takes place at a young age. An important increase occurs among first-, second-, and third-generation Asian migrants to the United States.[16]

The major influences on breast cancer risk appear to be certain reproductive factors and, less certainly, diet.[17] Few attempts have been made, however, to quantify the magnitude of risk differentials among populations, which might be explained by such factors.

Incidence rates of breast cancer are increasing in most countries, and the changes are usually greatest in areas where rates were previously low. Since our estimates for 1985, overall incidence rates increased about 0.5% annually (excluding China, where data sources were changed between estimates).

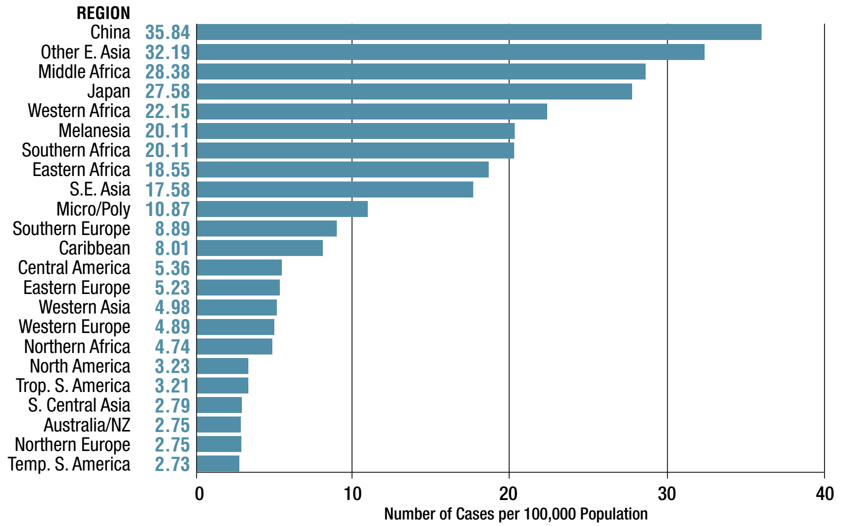
At this rate of growth, about 1.35 million new cases would be expected in 2010. However, cancer registries in China are recording annual increases in incidence of more than 5%, and in those elsewhere in Eastern Asia, increases are not much less. Assuming a modest 3% growth in Eastern Asia, the world total in 2010 would be 1.45 million, an 82% increase over the figure for 1990.

Colon and Rectal Cancer

Colon and rectal cancer accounted for 783,000 new cases in 1990 (9.7% of the world total) and caused 437,000 deaths (8.4% of the world total).

Unlike the situation with most sites, incidence and mortality were not much different in males and females (ratio 1.05:1.00). In terms of incidence, colon and rectal cancers rank third in frequency in men and second in women. It is a slightly

Figure 7
Incidence of Liver Cancer in Males by World Region



Micro/Poly=Micronesia/Polynesia; NZ=New Zealand; Temp.=temperate; Trop.=tropical.

less prominent cause of mortality (fourth in both sexes because of the relatively favorable prognosis) thanks to the fact that survival is on average better than that of cancer at other, less common sites. Survival at 5 years is 60% as reported by the SEER program; 41% and 42%, respectively, as reported by European and Indian cancer registries; and slightly lower in China and developing countries (32% and 38%, respectively). The lowest estimated survival is in Eastern Europe (30%).

The incidence of colon and rectal cancer is higher in developed countries than in developing countries; the lifetime probability of developing colorectal cancer in developed countries is 4.6% in men and 3.2% in women. The highest incidences are in Australia/New Zealand, North America, and Northern and Western Europe. Moderately high incidence rates are seen in Southern and Eastern Europe and temperate South America. Incidence rates are low in Africa and Asia, except Japan, which now has an incidence equivalent to that in Europe (Fig. 6).

Colon cancer and rectal cancer are similar in their geographical distribution. However, less variation occurs among countries with rectal cancer than with colon cancer. Thus, in high-risk populations, the ratio of colon cancer to rectal cancer is 2:1 or more (especially in females). In low-risk countries, rates are similar, and in India rectal cancer is even slightly more common.

These large geographic differences probably represent the effects of different environmental exposures, presumably mainly dietary. That the risk of colon cancer is quite labile to environmental change has long been evident from migrant studies.[18,19] Now, the rates in Japanese men and women in the United States—at least for colon cancer—exceed those in the white population. The incidence rates of colon cancer have increased in most areas, especially in men, since 1985, although North America is an exception to this trend.

Liver Cancer

Liver cancer is the fifth most important cancer worldwide in terms of numbers of cases (437,000, or 5.4% of new cancer cases) but fourth in terms of mortality (427,000 deaths, 8.2% of the total). This difference reflects the extremely poor prognosis for this cancer; survival rates are 3% to 5% as reported by cancer registries in the United States and developing countries. Consistently low rates are estimated everywhere.

Eighty percent of cases (and deaths) are in developing countries. As shown in Figure 7, the areas of high incidence are Western and Central Africa (where liver cancer is responsible for 25% of all cancers in men), Eastern and Southeast Asia, and Melanesia. The incidence is low in developed areas (only in Southern Europe does any substantial risk exist) and in Latin America and South Central Asia.

Worldwide, the major risk factors for liver cancer are infection with the hepatitis viruses, hepatitis B and C, and consumption of foods contaminated with aflatoxin. Both viruses confer a 20-fold increased risk of liver cancer.[20] Because hepatitis B virus is more prevalent, the distribution of infection worldwide largely explains the patterns of liver cancer. The exception is Japan, where chronic infection with hepatitis B virus is uncommon but where the generations most at risk of liver cancer have a relatively high rate of infection with hepatitis C virus.[21]

With knowledge of the relative risk and prevalence of infection in different areas, we can estimate the proportion of cases attributable to the two viruses, which is more than 75% of cases worldwide and 85% of cases in developing countries. Here is a powerful case for preventive action. At least for hepatitis B, a vaccine is available, which is effective in preventing infection in childhood. Its success in preventing liver cancer is being formally tested in controlled trials in China and Gambia.

Although it will be some time before these trials give the final answer to the question of how much protection vaccination provides, a dramatic demonstration of the results of community vaccination is already available from Taiwan. Here, hepatitis B immunization of newborns was introduced in 1984, and in children 6 to 9 years of age in birth cohorts receiving vaccination, a dramatic decrease in incidence of liver cancer has occurred.[22]

Prostate Cancer

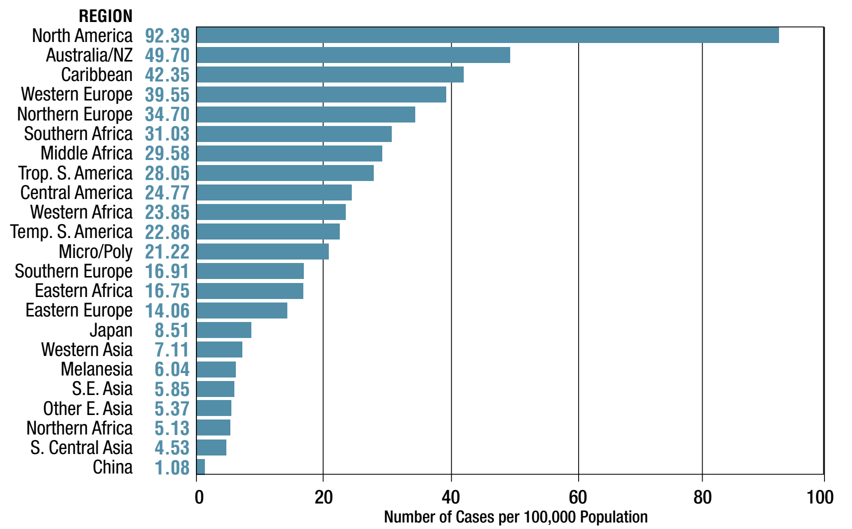
Prostate cancer is the sixth most common cancer in the world (in terms of number of new cases) and fourth in importance in men. The total annual number of cases is 396,000, which represents 9.2% of cancers in men (14.3% in developed countries and 4.3% in developing countries). It is a less prominent cause of death from cancer, with 165,000 deaths (5.6% of cancer deaths in men, 3.2% of all cancer deaths). The prognosis is relatively good, as reflected by age-adjusted estimates of survival rates (Table 1).

More than any other, this is a cancer of the elderly. Thus, in developed countries, 82% of cases occur in men older than 65 years. To place this fact in context, even on a world basis, 81% of cases occur in the elderly.

Incidence rates are now influenced by the diagnosis of latent cancers found during the screening of asymptomatic individuals. In areas where this practice is common, the "incidence" may be very high (95.1 per 100,000 in the United States, for example, where it is now by far the most commonly diagnosed cancer in men).

Incidence is also high in Northern and Western Europe and Australia/New Zealand. The age-adjusted rates show that several developing areas also have relatively high incidence rates, particularly sub-Saharan Africa, tropical South

Figure 8
Incidence of Prostate Cancer by World Region



Micro/Poly=Micronesia/Polynesia; NZ=New Zealand; Temp.=temperate; Trop.=tropical.

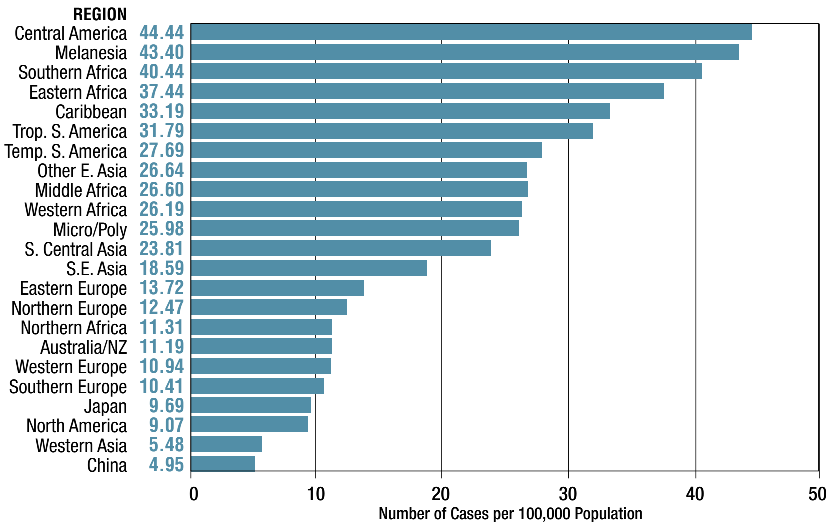
America, and the Caribbean (Fig. 8). In contrast, the incidence rates in Asia, particularly China, are low. Even when comparison is made after age standardization, the difference in risk between China and North America is more than 80-fold.

A considerable part of the international differences in prostate cancer incidence certainly reflect different diagnostic practices. Asymptomatic prostate cancers detected in tissue obtained during prostatectomy, or at autopsy, must be registered as "incident" cancers, and the extent of such practices can greatly influence recorded rates.[23,24] The introduction of screening with prostate-specific antigen has led to an enormous increase in the diagnosis of prostate cancer in the United States, with recorded incidence doubling between 1984 and 1992.

The prevalence of latent prostate cancer shows much less variation than does that of clinical prostate cancer, although the ethnic-specific ranks are much the same as for incidence.[25] The frequency of latent carcinoma of the prostate in Japan is increasing (as is that of clinical prostate cancer) and approaching the prevalence for whites in the United States.

Mortality rates show less diversity than does incidence. In fact, survival is significantly greater in high-risk countries (88% reported by SEER versus 41% in developing countries). However, this more favorable prognosis could well be the result of more latent cancer being detected by screening procedures; this would also explain the absence of any change in mortality despite the large increase in incidence.[8] Nevertheless, quite a marked gradient in mortality still exists, with age-standardized mortality rates ranging from 0.7 per 100,000 in China to 22.2 per 100,000 in the Caribbean (the age-standardized mortality in North America is 18.5 per 100,000).

Figure 9
Incidence of Cervical Cancer by World Region



Micro/Poly=Micronesia/Polynesia; NZ=New Zealand; Temp.=temperate; Trop.=tropical.

Migrants from low-risk countries to areas of higher risk show marked increases in incidence (for example, Japanese living in the United States). Some of this change reflects an elimination of the "diagnostic bias" influencing the international incidence rates, but part is almost certainly the result of changes in environment (possibly, for example, the diet). Nevertheless, the interethnic variations in incidence observed within countries—e.g., among whites, blacks, and Asians in the United States—imply that important genetic determinants of risk exist and that the prevalence of the relevant genes differs among populations. Currently, polymorphisms in the genes controlling androgen metabolism seem to provide at least part of the explanation.[26]

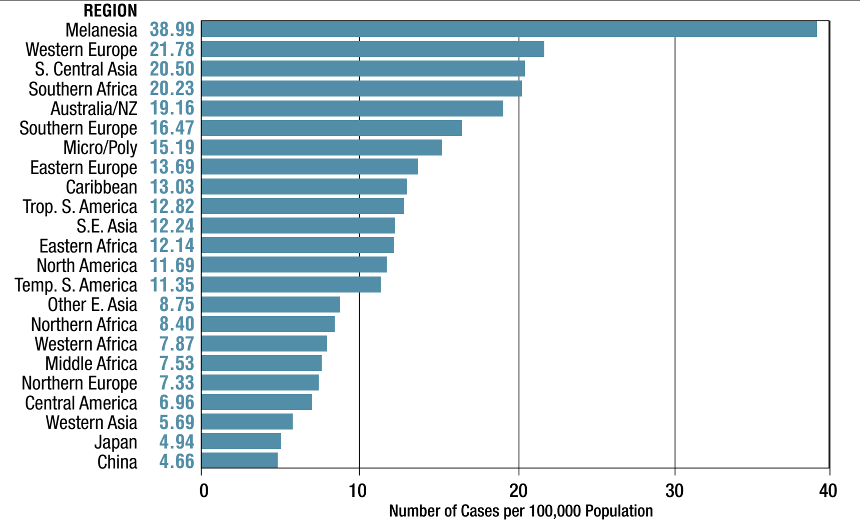
The incidence of prostate cancer has risen briskly over the last 5 years; the annual increase worldwide is approximately 3.7%. The supply of prevalent latent cancers in the subset of the population reached by opportunistic screening seems exhausted, and incidence began to decline in the United States after 1992.[8,27] Similar trends have been reported in Australia.[28]

As noted earlier, a great deal of this was the result of the huge surge in the United States (the 9.5% annual increase between 1985 and 1990). Nevertheless, even supposing no further increase occurs in the United States, if change continued at this rate over the next 20 years, almost 1 million new cases per year could be expected by the year 2010.

Cervical Cancer

Cervical cancer is the seventh most common cancer, overall, and the third most common in women, in whom it comprises 9.8% of all cancers (371,200 new cases per year). In general terms, it is much more common in developing countries, where 78% of cases occur and where cer-

Figure 10
Incidence of Cancer of the Lip, Oral Cavity, and Pharynx in Males by World Region



Micro/Poly=Micronesia/Polynesia; NZ=New Zealand; Temp.=temperate; Trop.=tropical.

vical cancer accounts for 15% of female cancers, with a lifetime risk of about 3%, whereas in developed countries it accounts for only 4.4% of new cancers, with a lifetime risk of 1.1%.

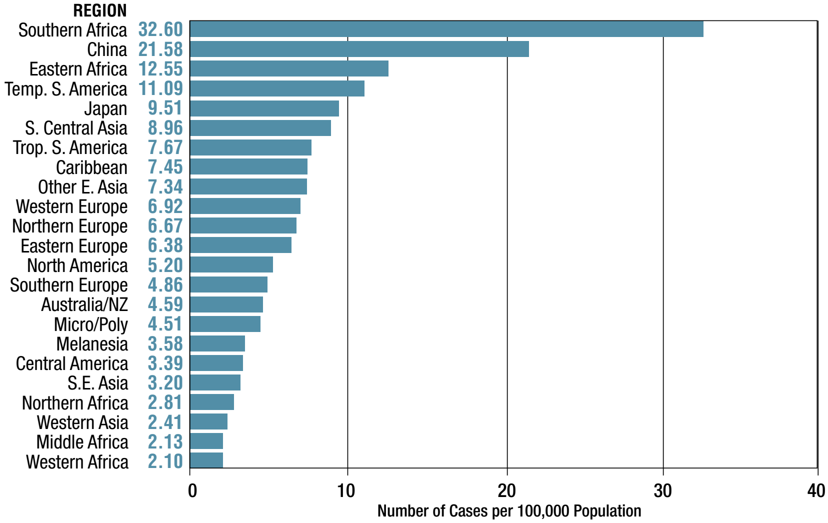
The highest incidence rates are observed in Latin America and the Caribbean, sub-Saharan Africa, and Southern and Southeast Asia (Fig. 9). In developed countries, the incidence rates are generally low, with age-standardized rates less than 14 per 100,000. Very low rates are also observed in China and Western Asia.

Mortality rates are much lower than incidence. Worldwide, the ratio of mortality to incidence is 51%. Survival rates vary among regions, with quite good prognosis in low-risk regions (69% reported by SEER and 59% by European registries). Even in developing countries, however, where many cases are at a relatively advanced stage when diagnosed, survival rates are fair, averaging 48%.[7] The poorest survival is estimated for Eastern Europe.

Human papillomavirus (HPV) is now accepted as the most important cause of cervical cancer.[29] Case-control studies suggest a very high risk associated with presence of the virus in middle age. With sensitive detection techniques, HPV is found in nearly all cervical cancers and might, therefore, be considered a necessary cause. It is not clear, however, to what extent the international variation in incidence relates to population prevalence of HPV. Prevalence of HPV among the controls in case-control studies suggests a rough correlation between HPV prevalence and incidence (10% to 20% in high-incidence countries, 5% to 10% in low-incidence countries). Other cofactors (e.g., parity, contraceptive use) probably modify the risk in women infected with HPV.

Cervical cancer incidence and mortality have declined substantially, and

Figure 11A
Incidence of Esophageal Cancer in Males by World Region



Micro/Poly=Micronesia/Polynesia; NZ=New Zealand; Temp.=temperate; Trop.=tropical.

this is most clearly observed in western countries, where well-developed screening programs exist. Declines are also evident in some developing countries, particularly China, where the estimated age-standardized incidence rate in 1990 was 5.0, compared with 17.8 in 1985. Although some of the difference reflects changing data sources, cancer registry results also indicate a dramatic decline in rates in recent years.

Because of these trends, cervical cancer has ceded its place as the leading cancer in developing countries to breast cancer, and only in sub-Saharan Africa, Central America, South Central Asia, and Melanesia is it now the main cancer of women.

In the world ranking of the most common cancers, after cervical cancer are three sites for which most cancers are caused by tobacco smoking: mouth and pharynx, esophagus, and urinary bladder.

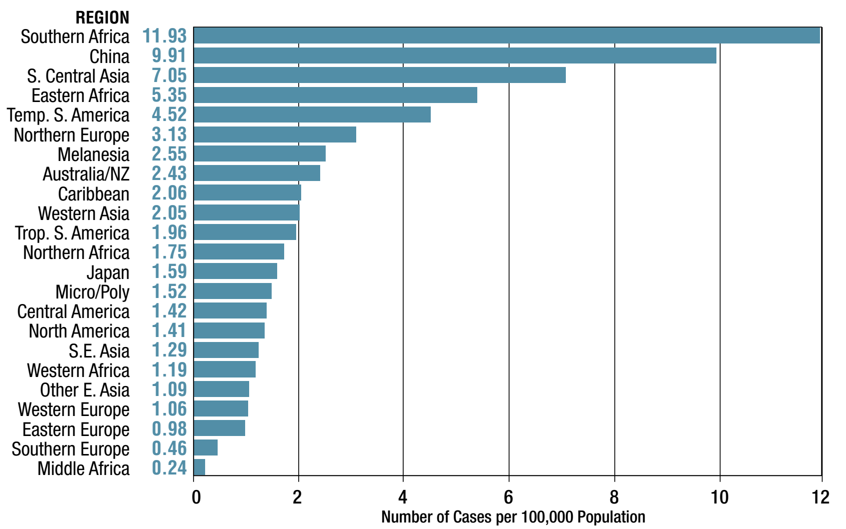
Cancers of the Mouth and Pharynx

Cancers of the mouth and pharynx account for 363,000 annual new cases worldwide and almost 200,000 deaths. They are 2.5 times more common in men than in women. The risk is similar in developed and developing countries; the age-standardized incidence rates are 13.5 versus 11.5 for males and 3.0 versus 5.1 for females in developed and developing countries, respectively.

The area of highest risk in men is Melanesia, where the age-standardized incidence rate is 39. It is followed by Western Europe (21.8), South Central Asia (20.5), Southern Africa (20.2), and Australia/New Zealand (19.2) (Fig. 10).

Cancers of the mouth and pharynx are a heterogeneous group of neoplasms, among which nasopharyngeal cancer (NPC) has the least in common with the others. Areas of high and intermediate risk for NPC are Southeastern China and

Figure 11B
Incidence of Esophageal Cancer in Females by World Region



Micro/Poly=Micronesia/Polynesia; NZ=New Zealand; Temp.=temperate; Trop.=tropical.

Northern Africa. Genetic susceptibility in these high-risk populations is strongly suspected to interact with known environmental causes.

Tobacco smoking and alcohol consumption are the major causes of cancers of the mouth and pharynx in developed countries and Southern Africa, whereas tobacco chewing explains the high incidence in some developing countries. This is reflected in large differences among the relative frequencies of the component subsites (mouth, pharynx, and nasopharynx) in different geographic areas. For example, 95% of these cancers are localized to the mouth in Melanesia, where tobacco chewing is the only cause, whereas in Western Europe, 56% are localized to the mouth and the remaining to the pharynx (NPC accounts for less than 5% of all).[4]

Mortality is on average 30% lower than incidence because of moderately good survival. Age-adjusted survival is more than 55% in developed countries (North America, Northern and Western Europe, and Japan). It is lower in Eastern Europe and developing countries. The lower survival estimated for China and Eastern Asia (lower than that of Africa) is partly the result of the fact that at least 70% of these cancers are localized to the pharynx and nasopharynx, and cancers in these areas have a poorer prognosis.

Esophageal Cancer

Esophageal cancer is the eighth most common cancer worldwide, responsible for 316,000 new cases in 1990 (3.9% of the total), and the sixth most common cause of death from cancer, with 286,000 deaths (5.5% of the total). Cancer of the esophagus is the fourth site characterized by very poor survival together with the liver, pancreas, and lung. Ten percent of patients survive at least 5 years in the United States[8] and 5% in Europe.[9]

Geographic variation in incidence is

striking. Even at the level of world areas, a 15-fold difference exists between high-risk Southern African men and low-risk Western African men. In women, the difference is 20-fold between high-risk Southern Africa and China and low-risk Southern Europe. Other areas of relatively high risk are Eastern Africa, South America, and Southern Asia (particularly in women) (Fig. 11).

Geographic variability is even more marked when smaller units are studied; for example, when comparisons are made among countries or even within countries (e.g., Africa or France). It seems that the environmental carcinogens responsible also show important geographic differences.[30] In Europe and North America, 90% of esophageal cancer is caused by tobacco plus alcohol. In the high-risk countries of South America, hot beverages, particularly hot maté (an herbal infusion), are important. Nutritional deficiencies, and possibly exogenous carcinogens, may underlie the high rates in central Asia and China.

Bladder Cancer

The worldwide estimate for new cases of bladder cancer is 261,000 annually. Only one fifth of the cases occur in women (58,000). High-risk areas are those where the effects of long exposure to tobacco smoking are still evident, namely, Europe and North America. The incidence is also high in Northern Africa (age-standardized incidence rate 23.3) and Western Asia (10.9), where infection with the parasite *Schistosoma mansoni* is still endemic (Fig. 12).

An average of 45% of these cancers occurring in men in developed countries are attributed to tobacco smoking. Some occupational exposures also contribute to the high risk in developed countries. Bladder cancer is rare in women (18th in order of frequency); however, an increase is expected, as for all tobacco-related cancers.

We observe substantial variation worldwide in the estimated survival from bladder cancer. It is very good in North America (80% estimated, 81% SEER; see Table 1) but only 40% in developing countries. No measure is available for Europe. Part of this inconsistency is an artefact resulting from different practices adopted by cancer registries with respect to the inclusion of in situ and sometimes benign tumors. For example, noninvasive bladder cancers are included in incidence by the SEER program[31] but not by most of the Indian cancer registries.[32]

Leukemias

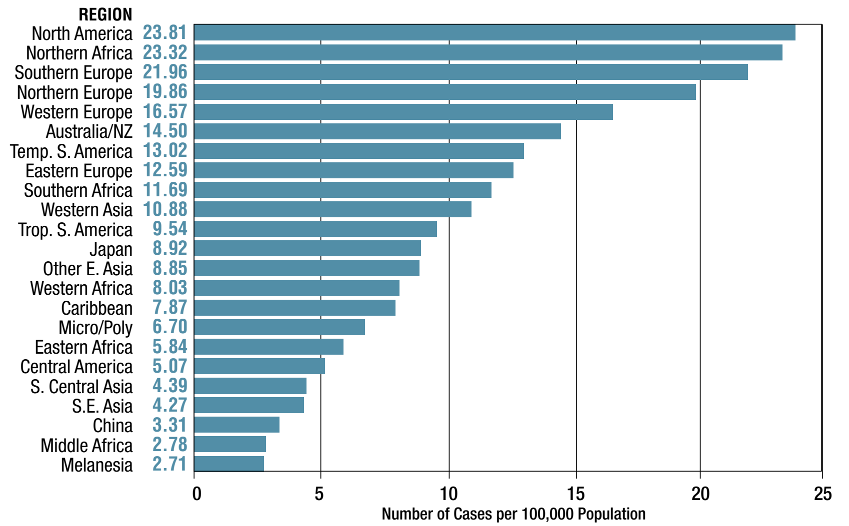
Leukemias account for 231,000 new cases each year and 184,000 deaths. This high ratio of deaths to cases (80%) reflects the poor prognosis of this cancer in many parts of the world, where the complex treatment regimens required are not available. The range of incidence rates is about six- to eightfold, with the lowest rates in sub-Saharan Africa (probably representing failure of diagnosis to some extent) and the highest in North America and Australia/New Zealand.

Mortality does not vary as much as does incidence because of better survival (and hence lower mortality) in developed countries, where survival is two (Europe) to three times (United States) better than it is in developing countries (Table 1).

Lymphomas

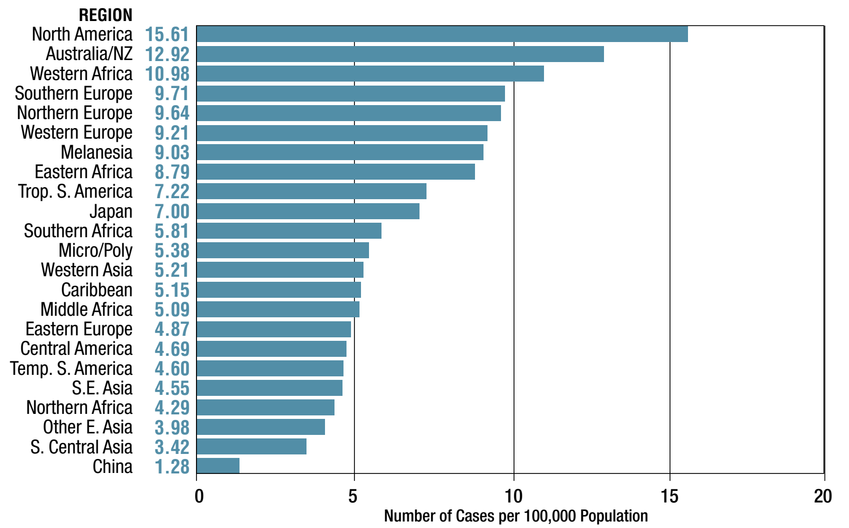
Lymphomas (including myeloma) accounted for 337,000 new cases in 1990 and 197,000 deaths. Almost two thirds of the cases are non-Hodgkin's lymphomas, and this form of lymphoma is also responsible for two thirds of the deaths. Incidence and mortality from these cancers are highest in developed areas (North America, Europe, Australia/New Zealand), where substantial increases in incidence and mortality rates have occurred in recent decades. High rates are also seen in Western and Eastern Africa, in part because of a high incidence of childhood Burkitt's lymphoma). Rates are low in Eastern and

Figure 12
Incidence of Bladder Cancer in Males by World Region



Micro/Poly=Micronesia/Polynesia; NZ=New Zealand; Temp.=temperate; Trop.=tropical.

Figure 13
Incidence of Non-Hodgkin's Lymphoma in Males by World Region



Micro/Poly=Micronesia/Polynesia; NZ=New Zealand; Temp.=temperate; Trop.=tropical.

South Central Asia (Fig. 13).

Because Hodgkin's disease is less common and the prognosis is more favorable, although it accounts for 18% of lymphoma cases, it is responsible for just 13% of deaths. The geographic pattern is similar to that of non-Hodgkin's lymphoma. Incidence is especially low in Eastern Asia and the Pacific islands.

For myeloma, the highest rates are, again, observed in developed countries. A few populations of African origin also display moderately elevated rates, for example, males in the Caribbean and Southern Africa and females in Middle Africa. At least 50% and 65% (age-adjusted) of patients with non-Hodgkin's and Hodgkin's lymphoma, respectively, survive the disease in wealthy countries. Only one half to two thirds of patients survive in developing countries, where the expensive treatment regimens are not widely available.

Pancreatic Cancer

Pancreatic cancer is responsible for 168,000 deaths per year and is the ninth most common cause of death from cancer in both sexes combined, a relative position higher than that of incidence (it is 13th in incidence) because of the poor prognosis (the mortality to incidence ratio is 98%). The sex ratio is close to 1 (as for colorectal cancer), whereas it is about 2 for all other cancers of the digestive system.

Most cases and most deaths (66%) occur in developed countries, where incidence and mortality rates are between 6 and 10, respectively, in men and 4 and 6.5, respectively, in women. The only developing countries with rates in this range are in Central and temperate South America. The apparent small survival advantage in developing countries (5% surviving at 5 years versus 0% surviving in developed regions) is consistent with measurement error for a cancer site that is highly lethal everywhere in the world.

Ovarian Cancer

Ovarian cancer (165,000 cases and 101,000 deaths) is the sixth most common cancer and cause of death from cancer in women (4.4% of cases and 4.5% deaths). Incidence rates are highest in developed countries (Fig. 14), with rates in these areas exceeding 8 per 100,000, except in Japan. The incidence in temperate South America is relatively high.

Cancer of the Corpus Uteri

Cancer of the corpus uteri resembles ovarian cancer in its geographic distribution. However, it appears more important as a cause of new cases (142,000, or 3.7% of cancers in women) than as a cause of death (42,000 deaths, or 1.9% of cancer deaths in women) because of the favorable prognosis.

Survival is good, close to that of cancer of the breast, and is reported as 84% in the United States and 72% in Europe. The proportion of patients with uterine cancer surviving up to 5 years in developing countries is greater than the proportion surviving that long with breast cancer. The highest incidences are in North America (age-standardized incidence rate 15.0), Europe (9.9 to 11.1), and temperate South America (12.6). Rates are low in Southern and Eastern Asia (including Japan) and in most of Africa (except Southern Africa) (Fig. 15).

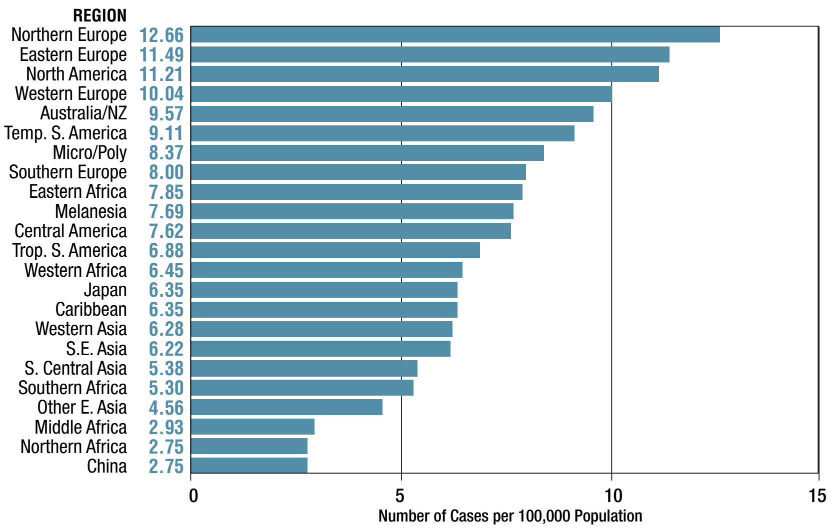
Kidney Cancer

Kidney cancer (150,000 new cases annually, 1.9% of the world total, and 78,000 deaths) has the highest rates in North America and Western, Northern, and Eastern Europe. Incidence rates are low in Africa, Asia (except in Japanese males), and the Pacific.

Laryngeal Cancer

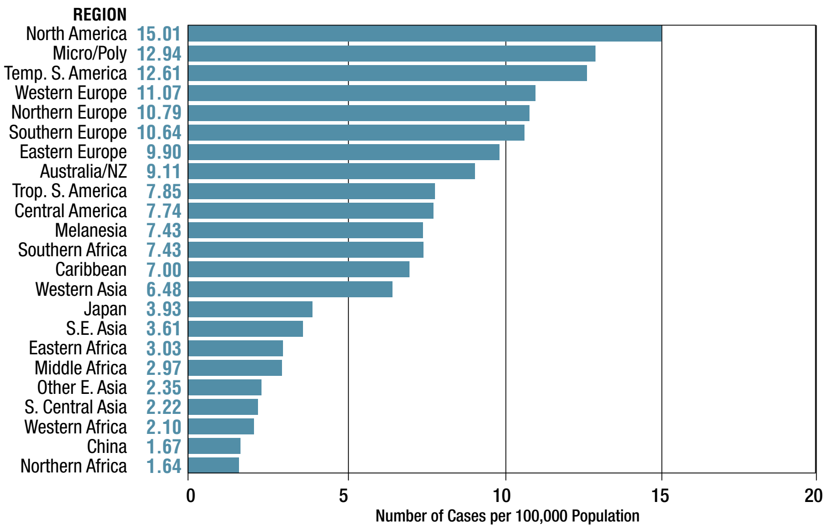
Laryngeal cancer (136,000 new cases and 73,500 deaths) is predominantly a cancer of men, in whom it is responsible for 2.7% of cases and 2.2% of deaths. The sex ratio (almost 7:1) is greater than for any other

Figure 14
Incidence of Ovarian Cancer by World Region



Micro/Poly=Micronesia/Polynesia; NZ=New Zealand; Temp.=temperate; Trop.=tropical.

Figure 15
Incidence of Cancer of the Corpus Uteri by World Region



Micro/Poly=Micronesia/Polynesia; NZ=New Zealand; Temp.=temperate; Trop.=tropical.

site, and it is a rare cancer of women, particularly in developed countries. For men, the high-risk areas are Europe (Eastern, Southern, and Western), temperate South America, and Western Asia. In Western Asia, laryngeal cancer accounts for more than 6% of cancers in men.

Cancers of the Brain and Nervous System

Cancers of the brain and nervous system account for 127,000 new cases and 95,000 deaths annually (1.6% of new cancers, 1.8% of cancer deaths). The highest rates are observed in developed areas (Australia/New Zealand, North America, Northern Europe) and the lowest in Africa and the Pacific islands. Brain tumors are probably considerably under-diagnosed in developing countries, which lack sophisticated diagnostic technology. Mortality statistics tend to be unreliable also, in part because of confusion between primary and metastatic cancers.

Melanoma

Malignant melanoma of skin is a tumor particularly common in white-skinned populations living in sunny climates. Thus, high rates of incidence are found in Australia and New Zealand (age-standardized incidence rate 27.9 in men and 25.0 in women) and North America (10.9 in men and 7.7 in women).

Skin melanoma has a high survival rate in developed areas (Table 1), with the best rates in Australia and New Zealand (85%), probably because educational campaigns there have resulted in early diagnosis for most tumors. Survival in developing countries is poorer (about 40%), partly because of late diagnosis and limited access to therapy but also because the tumors are generally acral melanomas located on the soles of the feet, which have a poorer prognosis than do other melanomas.

Thus, the range of mortality rates among areas of the world is much less than that of incidence rates. In all, 105,000 new cases are estimated annually (with slightly more in women than in men, sex ratio 0.9) and 33,000 deaths, more of which occur in men (sex ratio 1.1).

Thyroid Cancer

Thyroid cancer (87,000 new cases) is much more common in females than in males (sex ratio 0.33), and it is responsible for 1.7% of cancers in women. Incidence is high in the island nations of the Pacific, and rates are also high in Central America, Japan, and “other” East Asia (Korea and Hong Kong). The prognosis for thyroid cancer is good (the ratio of mortality to incidence worldwide is 0.23), so that it accounts for comparatively few deaths (20,000 or 0.4% of all cancer deaths).

Testicular Cancer

Testicular cancer is relatively rare, with 36,000 new cases annually, accounting for 0.8% of cancers in men. The highest rates are observed in Europe (Western and Northern), temperate South America, North America, and Australia/New Zealand. The highest incidence rates occur in men aged 15 to 44 years, and testicular cancer is the most common cause of cancer among men in this age range in developed countries (11.5% of new cases).

Testicular cancer is a rare cause of cancer mortality (8,000 deaths per year), although the good prognosis depends on the availability of expensive chemotherapy (cisplatin). Although the ratio of mortality to incidence is favorable in developed countries (0.14), it is much less optimistic in the developing world (0.36).

Conclusions

The information presented in this paper is a mixture of real data, extrapolations from limited samples, and informed guesses. It is, nevertheless, the best contemporary information on global patterns of cancer incidence and mortality. The data show, even at the rather crude level of 23 large areas, a tremendous range of diversity in the risk of different cancers and of death from cancer. The figures show which are the priority areas for research and indicate where implementation of current technology (in treatment and prevention) would be most fruitful.

The global disparities in incidence of certain preventable cancers (e.g., that of the cervix) and in survival from several that are treatable (e.g., lymphoma, leukemia, testicular cancer) show a lack of equity in health care that is apparently determined solely by the hazard of where one is born.

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