Lung Cancer Statistics

Lindsey A. Torre, Rebecca L. Siegel, and Ahmedin Jemal

Abstract Lung cancer is the leading cause of cancer death among both men and women in the United States. It is also the leading cause of cancer death among men and the second leading cause of cancer death among women worldwide. Lung cancer rates and trends vary substantially by sex, age, race/ethnicity, socioeconomic status, and geography because of differences in historical smoking patterns. Lung cancer mortality rates in the United States are highest among males, blacks, people of lower socioeconomic status, and in the mid-South (e.g., Kentucky, Mississippi, Arkansas, and Tennessee). Globally, rates are highest in countries where smoking uptake began earliest, such as those in North America and Europe. Although rates are now decreasing in most of these countries (e.g., United States, United Kingdom, Australia), especially in men, they are increasing in countries where smoking uptake occurred later. Low- and middle-income countries now account for more than 50 % of lung cancer deaths each year. This chapter reviews lung cancer incidence and mortality patterns in the United States and globally.

Keywords Lung cancer • Cancer incidence • Age-standardized rate (ASR) • Cancer mortality • Five-year relative survival • Cancer statistics • Age • Race/ethnicity • Socioeconomic status (SES) geographic variation • Trends • United States • Global • International • Global patterns • Cancer burden

Introduction

Lung cancer was rare before the twentieth century, [1] but is now the leading cause of cancer death in both men and women in the United States, accounting for 27 % of cancer deaths in 2014 [2]. Lung cancer is also the leading cause of cancer death in men and the second leading cause of cancer death (after breast cancer) in women worldwide [3]. It was estimated that 1.8 million new lung cancer cases and 1.6 million

L.A. Torre • R.L. Siegel • A. Jemal (✉)
Surveillance and Health Services Research, Intramural Research Department, American Cancer Society, 250 Williams Street, 30303 Atlanta, Georgia, USA
e-mail: Ahmedin.Jemal@cancer.org

A. Ahmad, S. Gadgeel (eds.), *Lung Cancer and Personalized Medicine*, Advances in Experimental Medicine and Biology 893,
DOI 10.1007/978-3-319-24223-1_1

lung cancer deaths occurred in 2012 worldwide, accounting for about 19 % of all cancer deaths [3]. Worldwide variation in the lung cancer burden and trends are primarily driven by historical differences in the uptake and reduction in tobacco use [4].

Common Indicators in Cancer Statistics

Incidence

Cancer incidence is the number of newly diagnosed cancer cases in a population during a specific time period, usually expressed as a rate per 100,000 persons. The numerator includes only cases diagnosed during the given time period, and only primary sites (i.e., metastatic cancers are not counted). The denominator includes only the population at risk for that type of cancer. For example, males would not be included in the denominator for cervical cancer incidence rates, because they are not at risk for cervical cancer.

Age-standardized rates (ASR) are used to compare cancer occurrence between two or more populations with different age structures. It is necessary to account for differences in population age distributions because the frequency of cancer generally increases with age (except for some types of cancers in children). For instance, crude (unstandardized) lung cancer incidence rates are much lower for men in Alaska (a young population) compared to men in Florida (an older population); however, once they are age adjusted, the rates are virtually the same. Age-standardized rates are constructed by taking a weighted average of the rates in each 5 year age group, where the weights are the proportion of persons in that age group in a defined "standard population."

Mortality

Cancer mortality is the number of cancer deaths in a population during a given time period, usually expressed as a rate per 100,000 persons. The numerator includes only deaths which occurred during the given time period, and the denominator includes only the population at risk for that type of cancer. Cancer mortality rates reflect both incidence and survival. For cancers with universally high case fatality, such as lung and pancreatic cancers, mortality rates may sometimes be used as a proxy for incidence rates.

Survival

Cancer survival is the length of time a person lives following cancer diagnosis. Relative survival represents the percentage of cancer patients who are living after a specified time period since cancer diagnosis compared to the expected survival of a cancer-free population of the same age, race, and sex.

Data Sources

Incidence and Mortality in the United States

Incidence rates for 2006–2010 were obtained from the North American Association of Central Cancer Registries (NAACCR)'s Incidence-CiNa Analytic File [5]. The file contains incidence data from the Surveillance, Epidemiology, and End Results (SEER) Program of the National Cancer Institute and the National Program of Cancer Registries (NPCR) of the Centers for Disease Control and Prevention (CDC). Together, SEER and the NPCR collect cancer incidence data for the entire United States population [6]. Incidence trends for whites and blacks were based on data from SEER (9 registries), covering 1975–2010; for other racial/ethnic groups, SEER (13 registries) data covering 1992–2010 were used. Five-year survival rates were based on cases diagnosed from 2003 to 2009 and followed through 2010 in SEER areas (18 registries).

Mortality data for the United States are obtained from the CDC's National Center for Health Statistics (NCHS) through the SEER Program's SEER*Stat database [7]. The accuracy of recording lung cancer as an underlying cause of death is high in the United States, with death certificates capturing about 89 % of lung cancer deaths in one study [8]. All incidence and mortality rates are age-standardized to the 2000 United States standard population.

Global Incidence and Mortality

Incidence and mortality rates for 2012 were obtained from GLOBOCAN 2012, published by the International Agency for Research on Cancer (IARC). GLOBOCAN estimates cancer incidence and mortality rates in each country of the world using different methods depending on the accuracy and availability of data [9]. Coverage of population-based cancer registries ranges from 1 % in Africa, 6 % in Asia, and 8 % in Latin America to 42 % in Europe, 78 % in Oceania, and 95 % in North America [10]. Mortality data are available for about one third of the world population, and are generally of higher quality in high-income countries [11]. IARC also makes available historic incidence and mortality data in its Cancer Incidence in Five Continents database [10] and World Health Organization Cancer Mortality Database [12]. Global incidence and mortality rates were age-standardized to the 1960 world standard population, and therefore cannot be compared to the United States rates which are generally age-standardized to the 2000 United States standard population.

Lung Cancer Patterns in the United States

Lung cancer rates and trends in the United States vary dramatically by demographic and geographic characteristics such as sex, age, race/ethnicity, state, and socioeconomic status, with incidence and mortality showing generally similar patterns because of

the low survival rate [13]. Most of these differences reflect differences in smoking patterns, [4] with lung cancer death rates beginning to increase at the population level two to three decades after widespread smoking has begun and peaking three to four decades after peak smoking in the population [14]. Cigarette smoking is by far the most important risk factor for lung cancer; 82 % of lung cancer deaths in the US are due to smoking [15].

Age

Lung cancer takes decades to develop after smoking initiation, and is thus rare before age 30 and peaks in the elderly (Fig. 1). Lung cancer rates tend to drop off after around 80 years, likely due to competing mortality from other causes or diminished accuracy of classification [16].

During 2006–2010, the average annual lung cancer incidence rate among United States men ranged from 1.3 cases per 100,000 in age 30–34 years to 585.9 in age 85–89 years. Among women, incidence ranged from 1.4 in age 30–34 years to

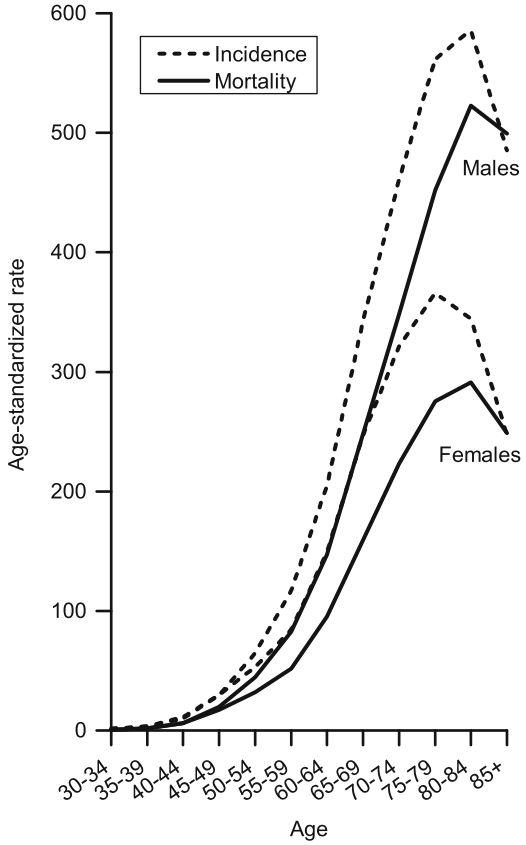

Fig. 1 Lung cancer incidence and mortality rates by sex and age, United States, 2006–2010. Rates are per 100,000 and age-adjusted to the 2000 U.S. standard population

365.8 in age 75–79 years. The median age at diagnosis of lung cancer of men and women combined was about 70 years, with approximately 10 % of cases occurring in those younger than 55 years, 53 % in those 55–74 years, and 37 % in those 75 years and older [17].

Mortality patterns by age closely follow incidence patterns. In 2006–2010, mortality rates among men ranged from 0.6 per 100,000 among those 30–34 years to 522.8 among those 80–84 years. Mortality rates among women ranged from 0.5 per 100,000 among those 30–34 years to 291.2 among those 80–84 years. The median age at death from lung cancer for men and women combined was about 72 years, with about 9 % of deaths occurring among those younger than 55 years, 50 % in those 55–74 years, and 41 % in those 75 years and over [17].

Race/Ethnicity

During 2006–2010, male lung cancer incidence rates were highest among blacks (94.7 per 100,000), followed by non-Hispanic whites (82.9 per 100,000), American Indians/Alaska Natives (70.2 per 100,000), Asians/Pacific Islanders (48.8 per 100,000), and Hispanics (45.9 per 100,000) (Fig. 2). Among women, incidence rates were highest among non-Hispanic Whites (59.9 per 100,000), followed by American Indians/Alaska Natives (52.1 per 100,000), Blacks (50.4 per 100,000), Asians/Pacific Islanders (28.0 per 100,000), and Hispanics (26.6 per 100,000) (Fig. 2). These differences primarily reflect historical smoking patterns. Historically, black men smoked

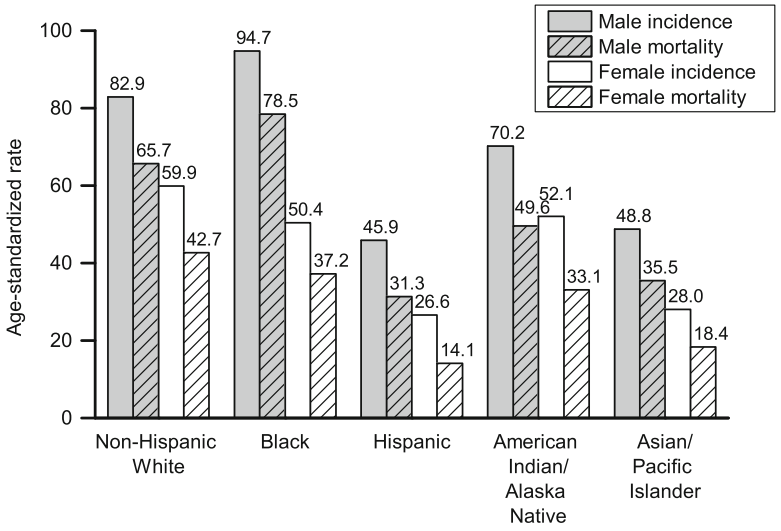

Fig. 2 Lung cancer incidence and mortality rates by sex and race/ethnicity, United States, 2006–2010. Rates are per 100,000 and age-adjusted to the 2000 U.S. standard population. Nonwhite race categories are not mutually exclusive of Hispanic origin (Source: Siegel et al. [2])

at higher rates than white men and men of other racial/ethnic groups. In contrast, black and white women historically smoked at similar rates. However, in the past few decades, black teenagers initiated smoking at lower rates than white teenagers.

Among males, Blacks have the highest mortality rates, followed by non-Hispanic Whites; among females, non-Hispanic Whites have the highest mortality rates, followed by Blacks. Among both males and females, these are followed by American Indians/Alaska Natives, Asians/Pacific Islanders, and Hispanics (Fig. 2). However, it is worth noting that significant heterogeneity in lung cancer rates exist within these broad racial/ethnic groups according to geography and subpopulation. For instance, lung cancer incidence rates in 1999–2004 among American Indian/Alaska Native men range from 22.1 per 100,000 in the Southwest to 116.5 in Alaska. Among women, incidence rates in 1999–2004 range from 10.3 per 100,000 in the Southwest to 97.4 in the Northern Plains [18]. Among Asian Americans, lung cancer incidence rates in 2004–2008 ranged from 30.1 per 100,000 among Asian Indian and Pakistani men to 73.4 among Vietnamese men, while they ranged from 12.1 per 100,000 among Asian Indian and Pakistani women to 31.8 among Vietnamese women [19].

In men, lung cancer mortality rates have been decreasing in all racial/ethnic groups except American Indians/Alaska Natives during the most recent time period (Fig. 4). However, the magnitude of the decreases vary by race/ethnicity. From 2001 to 2010, rates decreased annually by an average of 3.3 % in Black males, 2.8 % in Hispanics, 2.4 % in Whites, and 1.6 % in Asians/Pacific Islanders, while rates were stable in American Indians/Alaska Natives [20]. Among females, lung cancer mortality rates are decreasing among all racial/ethnic groups except American Indians/Alaska Natives and Asians/Pacific Islanders (Fig. 4). From 2001 to 2010, rates decreased annually by an average of −1.1 % in Hispanic females, −1.0 % in Black females, and −0.9 % in Whites, while rates remained stable in American Indians/Alaska Natives and Asians/Pacific Islanders [20].

Sex

Lung cancer mortality rates among females have historically been lower than males, peaking at about 40 deaths per 100,000, or about half of the peak rate of 90 deaths per 100,000 among males (Fig. 3). These patterns are similar when broken down by racial/ethnic group (Fig. 4).

Lung cancer incidence and mortality among males began to increase around the 1920s following the uptake of smoking among men around the turn of the twentieth century [1]. Lung cancer mortality has been decreasing among men since the early 1990s, reflecting widespread smoking cessation that began around 1964 with the release of the United States Surgeon General's report, which concluded that smoking was causally related to lung cancer [21]. Lung cancer incidence and mortality rates among women began to increase in the 1960s (Fig. 3), reflecting the later uptake of smoking among women around the 1930s and 1940s [22]. Smoking cessation among women in the United States began around the 1980s, [22] and mortality rates have been decreasing among women since the 2000s [17].

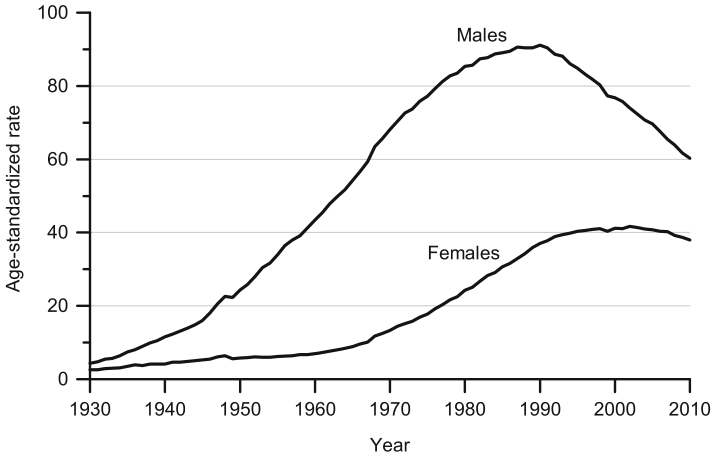

Fig. 3 Lung cancer mortality rates by sex, United States, 1930–2010. Rates are per 100,000 and age-adjusted to the 2000 U.S. standard population. Due to changes in ICD coding, numerator information has changed over time; rates include deaths from lung, bronchus, pleura, trachea, mediastinum, and other respiratory organs (Source: US Mortality Volumes 1930–1959, US Mortality Data 1960–2010, National Center for Health Statistics, Centers for Disease Control and Prevention)

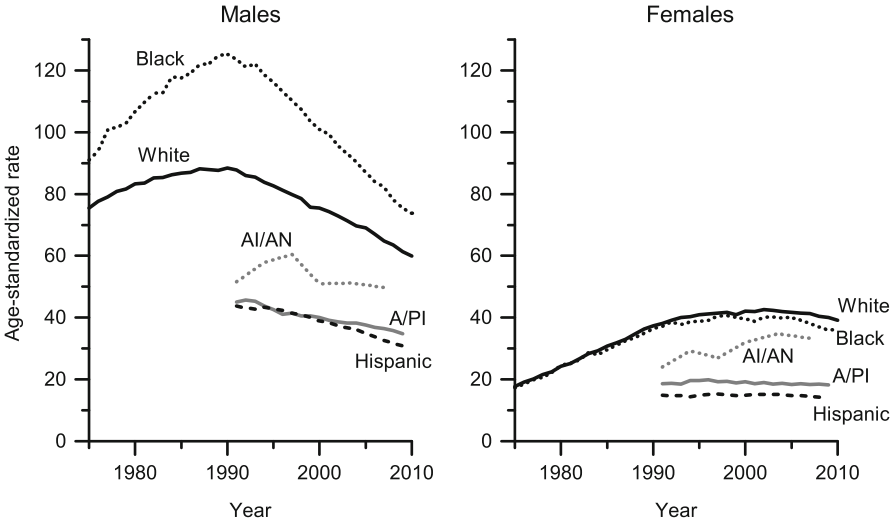

Fig. 4 Lung cancer mortality rates by sex and race/ethnicity, United States, 1975–2010. Rates are per 100,000 and age-adjusted to the 2000 U.S. standard population. Rates for American Indians/Alaska Natives are based on the Contract Health Service Delivery Area counties. Hispanic is not mutually exclusive from whites, blacks, Asian/Pacific Islanders, and American Indians/Alaska Natives. Data for whites rather than non-Hispanic whites is presented because ethnicity data was not available prior to 1990. Mortality data for Hispanics exclude cases from Connecticut, the District of Columbia, Louisiana, Maine, Maryland, Minnesota, Mississippi, New Hampshire, New York, North Dakota, Oklahoma, South Carolina, Vermont, and Virginia. Abbreviations: AI/AN American Indian/Alaska Native; A/PI Asian/Pacific Islander

Socioeconomic Status

Lung cancer rates are primarily linked to socioeconomic status through smoking patterns. In the United States, those with more education and resources are more likely to quit or not initiate smoking [23, 24]. In 2012, smoking prevalence among adults was 32.1 % among those with a 9–11th grade education, 23.1 % among those with a high school education, and 9.1 % among college graduates [25]. The smoking prevalence among those below the poverty threshold was 27.9 %, while the prevalence among those at or above the threshold was 17.0 % [25]. People with a high school diploma or an incomplete high school education are less likely than those with a partial or complete college education to attempt to quit smoking [26].

The higher smoking prevalence among individuals of lower socioeconomic status is reflected in higher lung cancer rates. Among a cohort of US cancer patients diagnosed between 1973 and 2001, the lung cancer incidence rate among men with less than a high school diploma was 166.6 per 100,000, while the rates among high school graduates and college graduates were 123.9 and 57.6, respectively. The relationship was similar among women, with an incidence rate of 71.6 among those with less than a high school diploma, followed by rates of 59.1 among high school graduates and 35.9 among college graduates [27]. In the same cohort, rates also demonstrated a similar trend by family income, ranging from 91.0 per 100,000 among men in the highest income group to 150.9 among men in the lowest income group; rates among women were 45.9 in the highest income group and 81.4 in the lowest income group [27].

Geographic Variation

There is significant regional and state variation in lung cancer rates (Table 1) [13]. Among males, lung cancer mortality rates during 2006–2010 ranged from 27.5 in Utah to 97.1 in Kentucky. Rates were also high in Mississippi (95.4), Arkansas (90.1), Tennessee (89.5), and Alabama (87.4). The lung cancer burden is generally highest in states where tobacco has historically been grown and processed [13]. In addition to Utah, mortality rates were low in New Mexico (43.4), Colorado (44.2), California (47.2), and Hawaii (48.8). Among females, mortality rates during 2006–2010 ranged from 16.8 in Utah to 55.8 in Kentucky. The low rates in Utah can be attributed to the cultural prohibition against smoking among the large Mormon population [13]. Other states with low rates include Hawaii (25.9), New Mexico (28.6), Colorado (31.3), and North Dakota (32.2). Other states with high rates in women were West Virginia (50.9), Delaware (47.7), Indiana (46.7), Oklahoma (46.6), and Tennessee (46.6).

There is substantial variation in lung cancer mortality trends by state relative to the national trends. While the lung cancer death rate has been decreasing among men in the United States, the trends vary by state. For instance, the rates of decrease

Table 1 Lung cancer incidence and mortality rates (per 100,000 population, age-adjusted to the 2000 Standard US population) by sex, race, and state, United States, 2006–2010

	All races						White						Black					
	Both sexes		Males		Females		Both sexes		Males		Females		Both sexes		Males		Females	
State	Incidence	Mortality	Incidence	Mortality	Incidence	Mortality	Incidence	Mortality	Incidence	Mortality	Incidence	Mortality	Incidence	Mortality	Incidence	Mortality	Incidence	Mortality
Alabama	74.9	60.3	103.2	87.4	54	40.8	77.5	62.1	103	86.9	58.2	43.6	65.1	54	105	90.9	39	30.6
Alaska	70.8	52.8	83.8	61.8	60.4	45.8	68.6	50.9	78.3	58.1	60.6	45.2	62.8	51	^	^	^	^
Arizona	54	40.6	61.8	49.8	47.9	33.2	55.3	41.8	63	51	49.1	34.3	53.3	42	59.7	55.2	49.2	32.8
Arkansas†‡	81.1	64.6	108.4	90.1	60.4	45.4	81.6	64.9	107.5	89.1	61.8	46.5	77.8	65.6	117.6	104.8	50.3	39.1
California	51.2	38.7	60.4	47.2	44.4	32.3	52.9	40	60.8	47.6	47	34.4	63.8	50.9	81.1	67.2	51.7	39.3
Colorado	49.2	36.7	56.1	44.2	44.2	31.3	49.4	36.9	56.1	44.1	44.7	31.7	54.9	43.8	65.8	56.5	47.1	34.7
Connecticut	66.1	44.2	75.5	52.7	59.5	38.2	66.9	44.8	75.2	52.7	61.3	39.3	60.3	42	80.5	58.6	46.3	31
Delaware	74.9	56.4	87.1	68.2	65.8	47.7	76.6	57.5	87.9	68.6	68.1	49.2	67.9	53.1	84.4	68.9	56.1	41.6
Washington DC	60.3	46.1	77.5	61.9	48.1	35	39.4	31.4	46.6	37.6	32.8	25.8	71.5	55.3	97	78.6	55.1	40.6
Florida	66.8	48.8	79.4	61.4	56.7	38.8	68.4	50	79.7	61.8	59.3	40.5	53.6	41.1	78.6	63.7	35.8	25.4
Georgia	71	52.9	93.3	73.1	55	38.7	74.6	55.2	94.2	73.7	60.1	41.7	62.5	48.1	94.5	75	42.6	31.8
Hawaii	50	36	64.3	48.8	38.7	25.9	55.1	42.8	62.6	50	48.5	36.4	46.3	39.8	^	^	^	^
Idaho	53.5	41	61.5	49.2	47.2	34.5	53.5	41.3	61.7	49.6	47.2	34.7	^	^	^	^	^	^
Illinois	71.5	51.8	86.7	65.8	60.9	41.9	71.4	51.4	85.4	64.6	61.5	42	81.7	63.2	106.6	86.3	65.5	48.6
Indiana	77.4	60.5	96.4	79.4	63.5	46.7	77.1	60.4	95.6	79	63.7	46.9	84.4	68.1	111.5	94.7	65.6	50.4
Iowa	67.6	49.3	84.7	64.1	54.9	38.3	67.4	49.3	84.4	63.9	54.7	38.4	101.3	71.9	128.4	97.2	82.1	52
Kansas	65.7	51.2	80.2	66.8	54.5	39.4	65.2	50.7	79.4	65.9	54.3	39.1	76.5	64	95.6	86.5	62.8	48.9
Kentucky	99.6	73.2	125.9	97.1	80.3	55.8	99.8	73.2	125.6	96.7	80.7	56	106.8	80.7	144.2	114.1	82.9	59.1
Louisiana	75.7	59.4	99.6	80.9	57.7	43.6	74.9	58.4	94.5	76.1	60	45.3	79.5	63.7	118.4	98.4	53	40.3
Maine	77.5	56.1	91.5	69.9	67.3	46	77.8	56.3	91.9	70.1	67.5	46.2	^	^	^	^	^	^
Maryland	63.5	49.6	74.4	61.7	55.8	40.8	65.7	50.9	74.6	61.3	59.3	43.2	61.1	50.3	78.5	69.6	50.1	37.9
Massachusetts	69.7	49.7	78.3	60.6	64.1	42.1	71.6	51.2	79.4	61.8	66.7	44	49.6	35.3	68.6	52.5	37.2	23.9
Michigan	71.9	54.1	86.1	68.2	61.6	43.9	70.4	53.4	83.3	66.7	61	43.8	82.8	62.4	109.1	85.3	64.8	47

(continued)

Table 1 (continued)

	All races						White						Black					
	Both sexes		Males		Females		Both sexes		Males		Females		Both sexes		Males		Females	
State	Incidence	Mortality	Incidence	Mortality	Incidence	Mortality	Incidence	Mortality	Incidence	Mortality	Incidence	Mortality	Incidence	Mortality	Incidence	Mortality	Incidence	Mortality
Minnesota§	–	43.9	–	53.3	–	37	–	43.9	–	53.1	–	37.3	–	45.6	–	59	–	35.2
Mississippi	80.1	64.3	112.7	95.4	56.2	42	81.3	64.5	109.6	91.7	60.2	44.6	76.7	63.5	120.6	105.3	47	35.8
Missouri	77.5	59	95.6	76.5	64.3	46.2	77	59.1	94.7	76.3	64	46.4	86.6	63.1	108.5	85.6	71.9	48.4
Montana	61.8	45.1	68.9	52.1	56.3	39.6	60.1	44.5	66.9	51.3	54.9	39.1	^	^	^	^	^	^
Nebraska	61.3	46.2	74.6	60.3	51.2	35.5	60.7	46	73.8	60	50.8	35.4	80.2	60.8	97.4	79.4	66.2	46.5
Nevada†¶	69.5	52.4	75.7	59.7	64.7	46.5	73.2	55.5	77.6	61.7	69.9	50.5	54.9	44.1	65.4	51.8	46.2	37.1
New Hampshire	69.8	49.8	80.1	59	62.2	43.3	69.6	50.3	79.6	59.5	62.1	43.7	^	^	^	^	^	^
New Jersey	62.4	44.8	72.8	55.8	55.3	37.2	64.3	46.3	73.8	56.7	58	39.1	62.4	46.3	81.8	65.5	50	34.5
New Mexico	44.7	35.1	52.9	43.4	38.1	28.6	46.5	36.6	54.4	44.8	40.1	30.1	61.5	48.2	89.6	74	35.7	^
New York	64.3	43.5	76.3	54.3	56	36.1	68	46.2	78.5	56.2	60.8	39.1	52.8	36.4	71.3	51	41.5	27.6
North Carolina	73.9	55.7	96.7	76.6	57.2	40.7	74.9	56.4	95	74.7	60	42.9	70.7	54	107.8	89.1	46.5	32.1
North Dakota	53.8	41.5	68.1	54.1	43.3	32.2	52.4	40.4	66.9	53.4	41.5	30.7	^	^	^	^	^	^
Ohio†¶	74.2	57.1	92.6	74.8	60.7	44.2	73.4	56.6	91.1	73.7	60.3	44	84	66.4	111.3	92.8	66.1	49.2
Oklahoma	77.1	60.8	96.1	79.6	62.7	46.6	75.2	61.4	93.4	79.8	61.5	47.4	76.7	59.1	106.2	82.2	54.8	42
Oregon	63.2	49.5	70.6	58.4	57.6	42.7	62.9	50	69.8	58.9	57.7	43.3	72.2	59.9	93.2	79.8	53.2	42.7
Pennsylvania	68.9	50.5	84.4	65.8	57.9	39.6	67.9	49.9	83.1	65	56.9	39.1	85.7	63.3	107.2	84.9	72.5	50.2
Rhode Island	72.1	51.4	84.1	64.9	64.5	42.6	73.2	52.2	85.5	65.8	65.3	43.4	60.7	43.9	59.7	52.9	62.9	37.3
South Carolina	71	55.6	94.1	77.1	53.9	39.9	73.4	56.9	93.3	75.7	58.3	42.8	62.7	51.3	96.5	83.2	40.1	30.6
South Dakota	59.1	46	73.8	61.9	48	34.1	57.9	45.3	72.6	60.8	46.7	33.8	^	^	^	^	^	^
Tennessee	79.1	64.5	103.4	89.5	61.3	46.6	79.8	64.7	103.3	88.7	62.5	47.3	75.5	65.9	105.5	100.8	55.7	44

Texas	61.6	46.2	78.2	60.7	49	35.4	61.1	45.8	76.6	59.2	49.4	35.7	73.6	58.2	106.4	88.7	51.5	37.9
Utah	28.1	21.6	34.1	27.5	23.3	16.8	28	21.4	34	27.3	23.1	16.7	55.5	53.4	^	^	^	^
Vermont	72.2	52.5	81.2	62.3	65.6	45.1	72.5	52.8	81.5	62.9	65.9	45.2	^	^	^	^	^	^
Virginia†	65.9	51.4	82.2	67.1	53.9	40	66.7	51.7	81	65.7	56	41.4	68.6	55.8	97.6	83.2	49.5	38.4
Washington	63.5	48.5	72.1	57	57.3	42.1	64.4	49.5	72.1	57.6	58.7	43.5	71	53.2	87.1	65.7	57.8	42.7
West Virginia	85.7	65.2	106.4	84.3	70	50.9	86.1	65.6	106.7	84.7	70.6	51.4	78.3	61.2	109.4	85.4	54.1	42.7
Wisconsin	62	46.9	73.6	58.4	53.4	38.4	59.3	46	69.9	57	51.6	38	90.4	70.4	123.9	103.4	67.2	47.7
Wyoming	51.1	42.4	57.3	49.9	46	36.4	51	42.6	57.3	50.4	45.8	36.3	^	^	^	^	^	^

Sources

Incidence: NAACCR, 2013. Data are collected by cancer registries participating in the National Cancer Institute's SEER program and the Centers for Disease Control and Prevention's National Program of Cancer Registries

Mortality: US Mortality Data, National Center for Health Statistics, Centers for Disease Control and Prevention

^ Statistic not displayed due to fewer than 25 cases

† This state's data are not included in US combined rates because they did not meet high-quality standards for one or more years during 2006–2010 according to the North American Association of Central Cancer Registries (NAACCR)

‡ Rates are based on incidence data for 2006–2008

§ This state's registry did not submit 2006–2010 cancer incidence data to NAACCR

¶ Rates are based on incidence data for 2006–2009

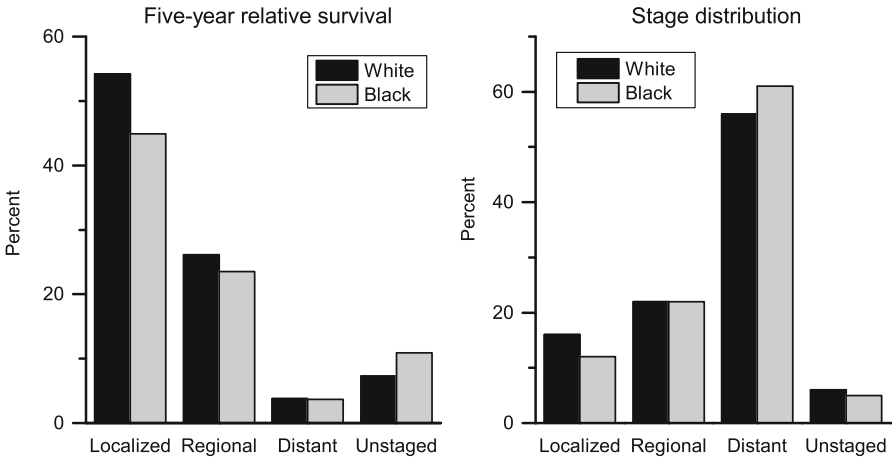

Fig. 5 Lung cancer 5 year relative survival and stage distribution, United States, 2003–2009 (Source: Howlader [17])

in California, which was the first state to enact comprehensive tobacco control measures, are nearly twice that of many states in the Midwest and South [13]. Among females, while overall national lung cancer death rates have leveled off and begun to decrease, rates in several states in the Midwest and South continue to increase [13, 28]. These states are characterized by low excise taxes on cigarettes and lack of other tobacco control policies [28].

Survival

Lung cancer survival is low and has seen only marginal increases since the mid-1970s [17]. Based on data from the nine oldest SEER registries, the 5 year relative survival rate increased from 12 % for patients diagnosed during 1975–1977 to 18 % for those diagnosed during 2003–2009 [17].

Cancer survival depends largely on stage at diagnosis (Fig. 5). For lung cancer patients diagnosed in 2003–2009, the 5 year relative survival rate was 54 % for localized stage disease, 26 % for regional stage, and 4 % for distant stage [17]. However, only 15 % of cases were diagnosed at the localized stage, while 22 % were diagnosed at the regional stage and 57 % were diagnosed at the distant stage [17].

Survival is lower in blacks (14 %) than in whites (18 %) [17] because blacks are less likely to receive standard treatment and are more likely to be diagnosed at an advanced stage (Fig. 5). Survival also declines with age. The 5 year relative survival rate for those diagnosed before the age of 45 is 27 %, compared to 19 % among those diagnosed at ages 55–64 and 12 % among those diagnosed at age 75 or greater [17].

Global Lung Cancer Patterns

Worldwide, lung cancer is the leading cause of cancer death in men and the second leading cause of cancer death in women, with approximately 1.8 million new cases and 1.6 million deaths annually [3]. Across the world, the lung cancer burden varies substantially across countries and regions.

Global Variations in Incidence and Mortality

The significant worldwide variation in lung cancer rates largely reflects differences in the stage and degree of the tobacco epidemic, though differences in air pollution are also a factor. Among males, the highest incidence and mortality rates occur in Central, Eastern, Southern, and Western Europe, Northern America, Micronesia/Polynesia, and Eastern Asia (Figs. 6 and 7), whereas the lowest rates occur in Middle, Western, and Eastern Africa. Overall, incidence rates range from 1.7 per 100,000 in Western Africa to 53.5 in Central and Eastern Europe, while mortality rates range from 1.5 in Western Africa to 47.6 in Central and Eastern Europe [3].

In men, lung cancer incidence rates are about 50 % higher in more-developed regions (44.7 cases per 100,000) compared to less-developed regions (30.0 per 100,000) [3]. However, due to their larger populations, less-developed regions accounted for about 60 % (1.1 million out of 1.8 million) of all lung cancer cases in 2012 [3]. The lung cancer burden among males is predominantly shaped by smoking

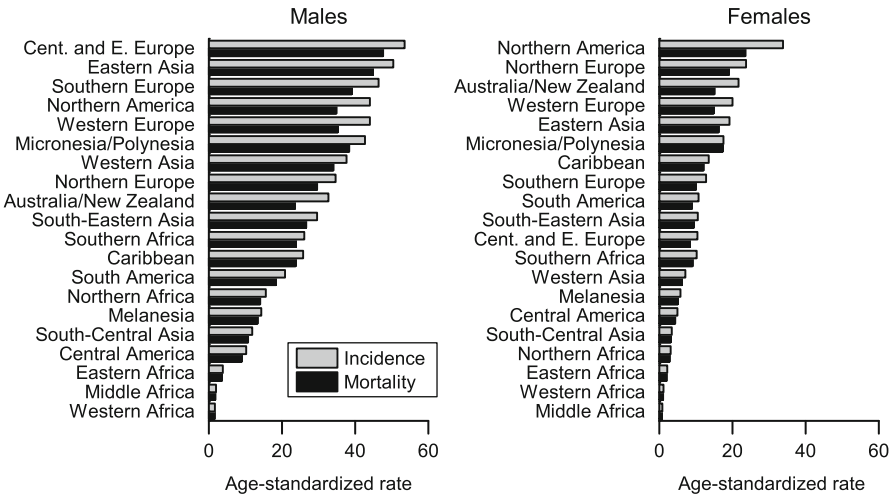

Fig. 6 Lung cancer incidence and mortality rates by sex and world region, 2012. Rates are per 100,000 and age-adjusted to the 1960 world standard population (Source: Ferlay [3]. Accessed on 12/13/2013)

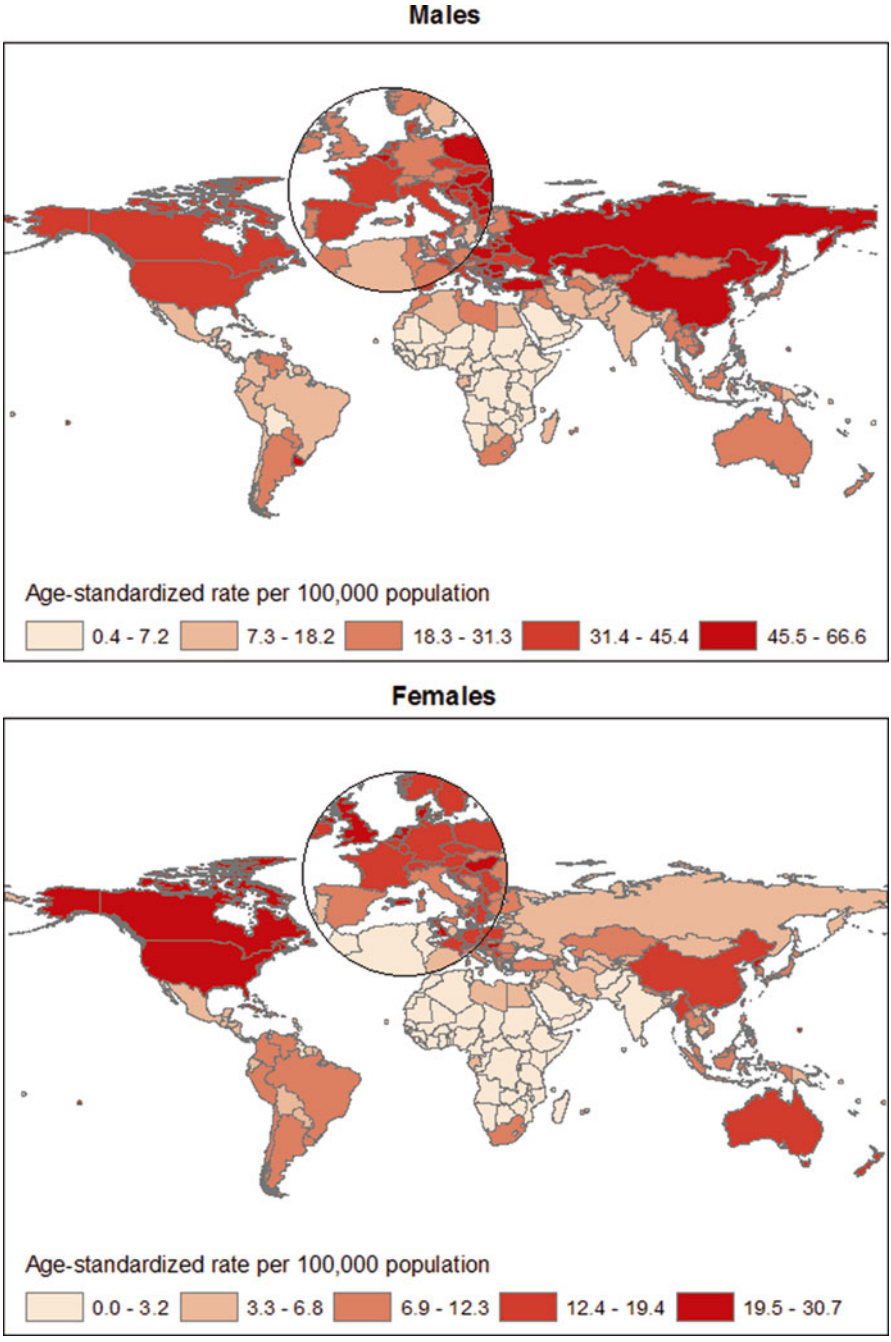

Fig. 7 International variation in lung cancer mortality by sex, 2012. Rates are per 100,000 and age-adjusted to the 1960 world standard population (Source: Ferlay [3]. Accessed on 3/5/2014)

patterns, although other factors, such as air pollution and occupational exposures, also play a role [29].

Among females, the highest incidence and mortality rates occur in Northern America, Northern and Western Europe, Australia/New Zealand, and Eastern Asia (Figs. 6 and 7). The lowest rates occur in Middle, Western, Eastern, and Northern Africa. Overall, incidence rates among females range from 0.8 per 100,000 in Middle Africa to 33.8 in Northern America, while mortality rates range from 0.7 in Middle Africa to 23.5 in Northern America [3]. By country, mortality rates vary from 0.0 in Comoros, Samoa, and Niger to 30.7 in North Korea [3]. The lung cancer burden among females, while largely linked to smoking patterns, is also related to other risk factors including air pollution and occupational exposures [29]. In Eastern Asia in particular, where smoking among women remains uncommon, indoor air pollution from cooking and heating plays a significant role [29, 30].

Variation in the lung cancer burden exists not only across regions, but also across countries and even within each country. For example, in Africa, male lung cancer incidence rates range from 0.4 per 100,000 in Niger to 32.3 in La Reunion. In many countries, there is also wide variation in lung cancer rates within the country [3]. For instance, in Singapore among men, lung cancer rates for the Indian population are 17.4 per 100,000, compared to 34.0 in the Malay population and 44.7 in the Chinese population [10]. In females, variation within regions and within countries is also notable. For example, in Eastern Europe, incidence rates range from 6.1 per 100,000 in Ukraine to 33.2 in Hungary [3]. In New Zealand, lung cancer incidence is 25.0 per 100,000 among Pacific Islanders and 79.0 among the Maori population [10].

Survival

Survival for lung cancer is poor and does not vary a great deal between high-income and low- and middle-income countries, although high-income countries may have slightly better survival rates due to improved detection and access to treatment. For example, 5 year relative survival for lung cancer is 7 % in India and 9 % in Thailand, compared to 17 % in Australia and 18 % in Canada [31].

Global Trends in Incidence and Mortality

In countries where smoking uptake began earliest, such as Canada, the United States, United Kingdom, and Australia, lung cancer incidence and mortality rates among males have been declining since the 1970s–1990s [12]. Rates among males are now also declining in most countries of Europe and North America, as well as select countries in South America (Argentina, Chile, Costa Rica, Mexico) and high-income populations of Asia, such as Hong Kong, Singapore, Japan, and South Korea [12]. In contrast, in countries where the smoking epidemic began more

recently, including low- and middle-income countries of South America and Asia, lung cancer mortality rates continue to rise [12]. Little incidence and mortality data exists for Africa, but evidence suggests that smoking is becoming more prevalent among males in many countries in Sub-Saharan Africa, [32] which could lead to increasing lung cancer rates in the future.

Lung cancer trends among women differ from those among men due to a different progression of smoking uptake. In countries where smoking uptake among women began earlier, lung cancer incidence and mortality rates are approaching a peak or have peaked in recent years. For instance, lung cancer mortality rates among adult women aged 30–74 in Denmark and the United States have been decreasing since 1995 and 1992 respectively, and rates in Canada have been stable since 1996 [33]. In other countries where the tobacco epidemic began later, especially in Western and Southern Europe and most countries of Eastern Europe and South America, rates continue to increase [33]. In many low- and middle-income countries where the tobacco epidemic has not yet begun, limited evidence indicates that lung cancer rates have remained low. For these countries, however, data is scarce, and detecting lung cancer trends may be difficult. Smoking among women is on the rise in many countries where it was previously rare, such as Russia and Ukraine, which will likely lead to increasing lung cancer rates in the future [34, 35].

Summary

Lung cancer is the leading cause of cancer death in the United States in both men and women. Patterns are primarily driven by smoking. Rates are highest in males, people of lower socioeconomic status, and in certain states of the South and Midwest. Lung cancer incidence and mortality rates at the national level are decreasing among both males and females, although trends are not equal across demographic or geographic groups. For instance, lung cancer mortality rates continue to rise among females in select states of the South and Midwest. As people of higher socioeconomic status are now less likely to initiate smoking and are more likely to quit, the burden of lung cancer in the United States also falls increasingly to those of lower socioeconomic status.

Worldwide, lung cancer is the leading cause of death among men and the second leading cause of death among women, after breast cancer. Lung cancer incidence and mortality rates are highest in high-income countries such as those in Europe, North America, and Oceania where smoking uptake occurred earliest, although rates are now decreasing in many of these countries. Rates are also high in Eastern Asia, driven by a rapid uptake of smoking among males and exposure to indoor air pollution among females. Rates continue to increase in many low- and middle-income countries where smoking uptake occurred later. Lung cancer deaths can be averted through tobacco control measures aimed at prevention of smoking initiation as well as smoking cessation.

References

1. Proctor RN (2001) Tobacco and the global lung cancer epidemic. Nat Rev Cancer 1(1):82–86. doi:10.1038/35094091
2. Siegel R, Ma J, Zou Z, Jemal A (2014) Cancer statistics, 2014. CA Cancer J Clin 64(1):9–29. doi:10.3322/caac.21208
3. Ferlay J, Soerjomataram I, Ervik M, Dikshit R, Eser S, Mathers C, Rebelo M, Parkin D, Forman D, Bray F (2013) GLOBOCAN 2012 v1.0, cancer incidence and mortality worldwide: IARC cancerbase No. 11 [Internet]. International Agency for Research on Cancer. http://globocan.iarc.fr. Accessed 12 Dec 2013
4. Thun M, Peto R, Boreham J, Lopez AD (2012) Stages of the cigarette epidemic on entering its second century. Tob Control 21(2):96–101. doi:10.1136/tobaccocontrol-2011-050294
5. Copeland G, Lake A, Firth R, Wohler B, Wu XC, Stroup A, Russell C, Zakaria D, Miladinovic Z, Schymura M, Hofferkamp J, Kohler B (eds) (2013) Cancer in north America: 2006–2010. Volume two: registry-specific cancer incidence in the United States and Canada. North American Association of Central Cancer Registries, Inc., Springfield
6. Centers for Disease Control and Prevention (2013) National Program of Cancer Registries (NPCR). http://www.cdc.gov/cancer/npcr/about.htm. Accessed 3 Dec 2013
7. Surveillance Epidemiology and End Results (SEER) (2013) Program (www.seer.cancer.gov). SEER*stat database: mortality – all COD, aggregated with state, total U.S. (1969–2010) <Katrina/Rita Population Adjustment>, National Cancer Institute, DCCPS, Surveillance Research Program, Surveillance Systems Branch, released April 2013. Underlying mortality data provided by NCHS (www.cdc.gov/nchs)
8. Doria-Rose VP, Marcus PM (2009) Death certificates provide an adequate source of cause of death information when evaluating lung cancer mortality: an example from the Mayo Lung Project. Lung Cancer 63(2):295–300. doi:10.1016/j.lungcan.2008.05.019
9. Ferlay J, Shin HR, Bray F, Forman D, Mathers C, Parkin DM (2010) Estimates of worldwide burden of cancer in 2008: GLOBOCAN 2008. Int J Cancer 127(12):2893–2917. doi:10.1002/ijc.25516
10. Forman DBF, Brewster DH, Gombe Mbalawa C, Kohler B, Piñeros M, Steliarova-Foucher E, Swaminathan R, Ferlay J (eds) (2013) Cancer incidence in five continents, vol X (Electronic version). IARC. http://ci5.iarc.fr. Accessed 9 Dec 2013
11. Mathers CD, Fat DM, Inoue M, Rao C, Lopez AD (2005) Counting the dead and what they died from: an assessment of the global status of cause of death data. Bull World Health Organ 3(3):171–177. doi:10.1590/S0042-96862005000300009
12. World Health Organization International Agency for Research on Cancer (2013) Cancer mortality database. http://www-dep.iarc.fr/WHOdb/WHOdb.htm. Accessed 13 Dec 2013
13. Jemal A, Thun MJ, Ries LA, Howe HL, Weir HK, Center MM, Ward E, Wu XC, Eheman C, Anderson R, Ajani UA, Kohler B, Edwards BK (2008) Annual report to the nation on the status of cancer, 1975–2005, featuring trends in lung cancer, tobacco use, and tobacco control. J Natl Cancer Inst 100(23):1672–1694. doi:10.1093/jnci/djn389
14. Lopez AD, Collishaw N, Piha T (1994) A descriptive model of the cigarette epidemic in developed countries. Tob Control 3(3):242–247
15. National Center for Chronic Disease Prevention and Health Promotion Office on Smoking and Health (2014) The health consequences of smoking – 50 years of progress: a report of the surgeon general. Centers for Disease Control and Prevention (US), Atlanta
16. Spitz MR, Wu X, Wilkinson A, Wei Q (2006) Cancer of the lung. In: Schottenfeld D, Fraumeni J Jr (eds) Cancer epidemiology and prevention, 3rd edn. Oxford University Press, New York, pp 638–658
17. Howlader N, Noone AM, Krapcho M, Garshell J, Neyman N, Altekruse SF, Kosary CL, Yu M, Ruhl J, Tatalovich Z, Cho H, Mariotto A, Lewis DR, Chen HS, Feuer EJ, Cronin KA (eds) (2013) SEER cancer statistics review, 1975–2010, National Cancer Institute. Bethesda. http://seer.cancer.gov/csr/1975_2010/, based on November 2012 SEER data submission, posted to the SEER web site, April 2013

18. Espey DK, Wu XC, Swan J, Wiggins C, Jim MA, Ward E, Wingo PA, Howe HL, Ries LA, Miller BA, Jemal A, Ahmed F, Cobb N, Kaur JS, Edwards BK (2007) Annual report to the nation on the status of cancer, 1975–2004, featuring cancer in American Indians and Alaska Natives. Cancer 110(10):2119–2152. doi:10.1002/cncr.23044
19. Gomez SL, Noone AM, Lichtensztajn DY, Scoppa S, Gibson JT, Liu L, Morris C, Kwong S, Fish K, Wilkens LR, Goodman MT, Deapen D, Miller BA (2013) Cancer incidence trends among Asian American populations in the United States, 1990 to 2008. J Natl Cancer Inst. doi:10.1093/jnci/djt157
20. Edwards BK, Noone AM, Mariotto AB, Simard EP, Boscoe FP, Henley SJ, Jemal A, Cho H, Anderson RN, Kohler BA, Eheman CR, Ward EM (2013) Annual report to the nation on the status of cancer, 1975–2010, featuring prevalence of comorbidity and impact on survival among persons with lung, colorectal, breast, or prostate cancer. Cancer. doi:10.1002/cncr.28509
21. Warner KE, Mendez D (2010) Tobacco control policy in developed countries: yesterday, today, and tomorrow. Nicotine Tob Res 12(9):876–887. doi:10.1093/ntr/ntq125
22. Centers for Disease Control and Prevention (2001) Women and smoking: a report of the surgeon general. U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health, Rockville
23. Centers for Disease Control and Prevention (CDC) (2009) Cigarette smoking among adults and trends in smoking cessation – United States, 2008. MMWR Morb Mortal Wkly Rep 58 (44):1227–1232
24. Caraballo RS Centers for Disease Control and Prevention (CDC) (2013) Cigarette smoking-United States, 2006–2008 and 2009–2010. MMWR 62 (Suppl 3):81–84
25. Agaku IT, King BA, Dube SR (2014) Current cigarette smoking among adults – United States, 2005–2012. MMWR Morb Mortal Wkly Rep 63(2):29–34
26. Centers for Disease Control and Prevention (CDC) (2011) Quitting smoking among adults – United States, 2001–2010. MMWR Morb Mortal Wkly Rep 60 (44):1513–1519
27. Clegg LX, Reichman ME, Miller BA, Hankey BF, Singh GK, Lin YD, Goodman MT, Lynch CF, Schwartz SM, Chen VW, Bernstein L, Gomez SL, Graff JJ, Lin CC, Johnson NJ, Edwards BK (2009) Impact of socioeconomic status on cancer incidence and stage at diagnosis: selected findings from the surveillance, epidemiology, and end results: National Longitudinal Mortality Study. Cancer Causes Control 20(4):417–435. doi:10.1007/s10552-008-9256-0
28. Jemal A, Ma J, Rosenberg PS, Siegel R, Anderson WF (2012) Increasing lung cancer death rates among young women in southern and midwestern States. J Clin Oncol. doi:10.1200/jco.2012.42.6098
29. Ezzati M, Henley SJ, Lopez AD, Thun MJ (2005) Role of smoking in global and regional cancer epidemiology: current patterns and data needs. Int J Cancer 116(6):963–971. doi:10.1002/ijc.21100
30. IARC working group on the evaluation of carcinogenic risks to human (2010) Household Use of Solid Fuels and High-temperature Frying. IARC monographs on the evaluation of carcinogenic risks to humans, vol 95. Lyon, International Agency for Research on Cancer
31. Coleman MP, Forman D, Bryant H, Butler J, Rachet B, Maringe C, Nur U, Tracey E, Coory M, Hatcher J, McGahan CE, Turner D, Marrett L, Gjerstorff ML, Johannesen TB, Adolfsson J, Lambe M, Lawrence G, Meechan D, Morris EJ, Middleton R, Steward J, Richards MA (2011) Cancer survival in Australia, Canada, Denmark, Norway, Sweden, and the UK, 1995–2007 (the International Cancer Benchmarking Partnership): an analysis of population-based cancer registry data. Lancet 377(9760):127–138. doi:10.1016/s0140-6736(10)62231-3
32. Pampel F (2008) Tobacco use in sub-Sahara Africa: estimates from the demographic health surveys. Soc Sci Med 66(8):1772–1783. doi:10.1016/j.socscimed.2007.12.003
33. Torre LA, Siegel RL, Ward EM, Jemal A (2014) International variation in lung cancer mortality rates and trends among women. Cancer Epidemiol Biomarkers Prev 23(6):1025–1036

34. Giovino GA, Mirza SA, Samet JM, Gupta PC, Jarvis MJ, Bhala N, Peto R, Zatonski W, Hsia J, Morton J, Palipudi KM, Asma S (2012) Tobacco use in 3 billion individuals from 16 countries: an analysis of nationally representative cross-sectional household surveys. Lancet 380(9842):668–679. doi:10.1016/s0140-6736(12)61085-x
35. Perlman F, Bobak M, Gilmore A, McKee M (2007) Trends in the prevalence of smoking in Russia during the transition to a market economy. Tob Control 16(5):299–305. doi:10.1136/tc.2006.019455