Special Section: Lung Cancer

Introduction

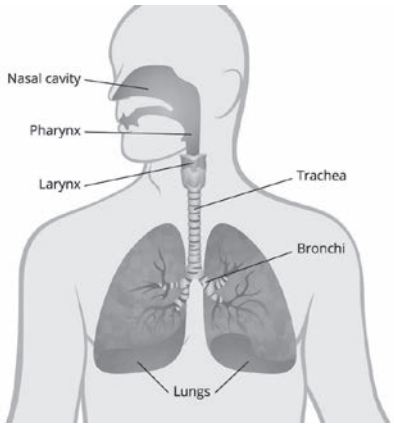
Lung cancer is the second most commonly diagnosed cancer in both men and women but the most common cause of cancer death, leading to more deaths in 2020 than breast, colorectal, and prostate cancers combined. This burden disproportionately affects people with lower socioeconomic status. Although approximately 80% of lung cancers are caused by cigarette smoking,[1] the toll among people who have never smoked is substantial, ranking among the top 10 causes of cancer death when categorized separately.[2]

Lung cancer is usually fatal because most cases are diagnosed at a late stage and treatment has generally been ineffective. However, over the past two decades, advances in the understanding of tumor biology and the development of targeted treatment, coupled with the introduction of screening, have led to exciting improvements in survival. This special section provides an overview of lung cancer occurrence in the US, including information about risk factors, prevention, and early detection, as well as what the American Cancer Society is doing to reduce the burden.

Lung Anatomy

The lungs are a pair of large, spongy, cone-shaped organs in the chest that are part of the respiratory system, which also includes the trachea (windpipe) and the muscles of the chest wall and diaphragm (Figure S1). The lungs are separated from one another by a cavity called the mediastinum, which houses the heart, trachea, esophagus, and many lymph nodes. The right lung is made up of three lobes and is slightly larger than the left lung, which has two lobes. The main function of the lungs is to facilitate respiration by moving air and transferring oxygen into the bloodstream while clearing the body of carbon dioxide and other waste gases. Air enters the lungs through the trachea during inhalation and passes into bronchi (branch-like air passages) that subdivide into tiny bronchioles ending in air sacs called alveoli, where gas transfer occurs. Carbon dioxide and other waste gases are expelled through the trachea during exhalation. The lungs also serve a vital role in the defense of the body by filtering inhaled, potentially harmful particles, such as dust, mold, viruses, and bacteria. However, some inhaled toxins contribute to lung cancer occurrence.

Figure S1. Anatomy of the Respiratory System

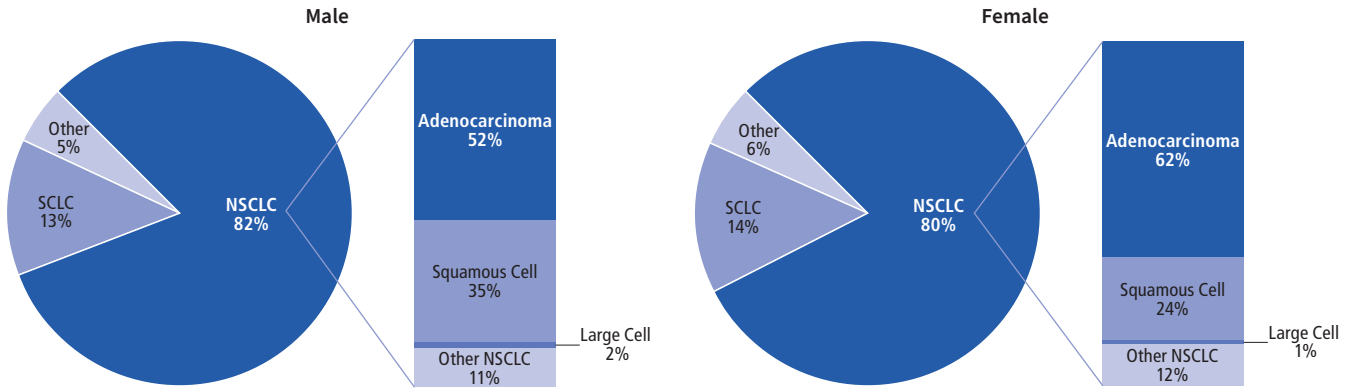


Source: https://www.cdc.gov/cancer/lung/basic_info/what-is-lung-cancer.htm.

What Are the Different Types of Lung Cancer?

Lung cancer encompasses a variety of biologically distinct tumors.[3] The two primary types of lung cancer are non-small cell lung cancer (NSCLC), which accounts for 81% of cases, and small cell lung cancer (SCLC), which accounts for 14% of cases. NSCLC is further categorized as adenocarcinoma, which is slightly more common in women, followed by squamous cell carcinoma and large cell carcinoma (Figure S2).[4] Squamous cell carcinoma was the most common subtype prior to the 1960s and the introduction of filtered cigarettes, which are thought to contribute to increased incidence of adenocarcinoma via deeper inhalation and increased exposure to smoke toxicants.[5] Adenocarcinoma originates in the glands that secrete mucus. It is generally more treatable than other subtypes because it is more likely to be located in the

Figure S2. The Distribution of Lung Cancer by Histologic Subtype (%), US, 2015-2019



SCLC: Small cell lung cancer; NSCLC: Non-small cell lung cancer. Percentages for NSCLC subtypes represent the proportion of total NSCLC cases. Percentages may not total 100% because of rounding.

Source: North American Association of Central Cancer Registries, 2022.

lung periphery and to have mutations that can be targeted by treatment.[6-8] (For more information, see page 36.) Squamous cell carcinoma is more aggressive than adenocarcinoma and originates in cells that line the lung airways.[9] Large cell carcinoma can originate in any portion of the lung and is more aggressive than the other two NSCLC subtypes.

SCLC is named for the small, round appearance of the cells under a microscope. The most common subtype is small cell carcinoma (oat cell cancer), followed by combined small cell carcinoma. SCLC is slightly more common in women (14%) than in men (13%) and is generally more aggressive than NSCLC. Consequently, SCLC patients are more likely than NSCLC patients to have disease that has spread beyond the lungs at the time of diagnosis (94% versus 70%),[10] making treatment difficult.[11] Even for those patients who successfully undergo chemotherapy, which is the primary treatment, only a limited number achieve long-term disease control.

How Many Lung Cancer Cases and Deaths Are Expected to Occur in 2023?

In 2023, an estimated 238,340 people (117,550 men and 120,790 women) will be diagnosed with lung cancer, and 127,070 people will die from the disease (Table 1).

How Many People Alive Today Have a History of Lung Cancer?

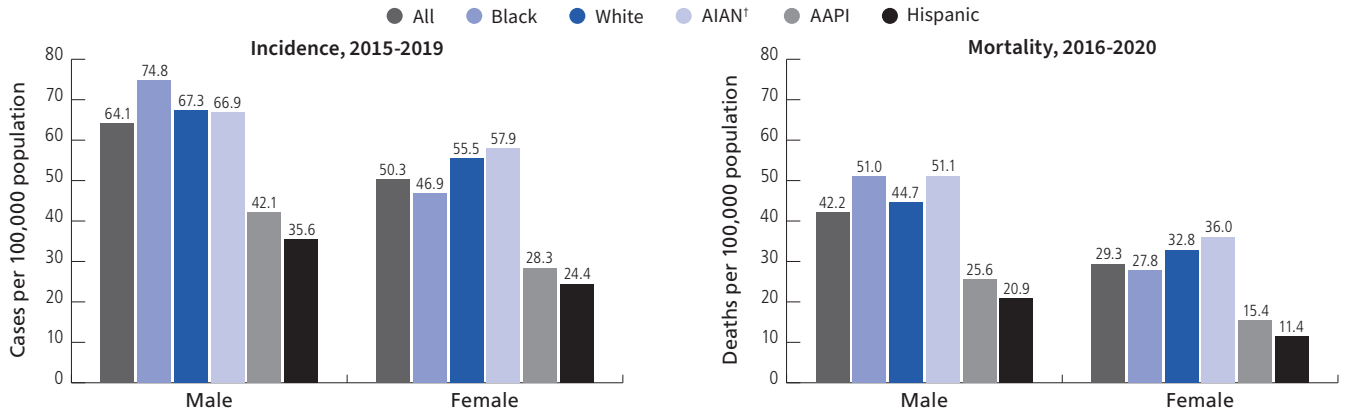
As of January 1, 2022, there were 654,620 men and women in the US with a history of lung cancer,[12] many of whom were living with metastatic disease.[13] About 80% of these individuals were 65 years of age or older, reflecting the advanced median age of diagnosis (71 years).[14] More than half (55%) of lung cancer survivors were diagnosed within the past 5 years because of the low survival.[12] (See page 36.)

What Is the Risk of Developing Lung Cancer?

The lifetime risk of developing lung cancer is approximately 6.2% among men and 5.8% among women, or 1 in 16 men and 1 in 17 women during their lifetime (Table 6). However, these probabilities are based on lung cancer occurrence in the general population so the risk is substantially higher for those with a history of smoking.[15]

The risk of lung cancer also increases with age, partly because the disease grows for many decades before symptoms develop. More than half (53%) of cases are diagnosed at age 70 or older, and 83% of cases are diagnosed at ages 65 and older. However, the age distribution varies by histologic subtype and race and

Figure S3. Lung Cancer Incidence and Mortality Rates* by Sex, Race, and Ethnicity, US



AAPI: Asian American and Pacific Islander individuals; AIAN: American Indian and Alaska Native individuals. *Age adjusted to the 2000 US standard population. †For AIAN individuals, incidence data are restricted to Purchased/Referred Care Delivery Area counties, and mortality data are adjusted for misclassification on death certificates. All racial groups are exclusive of individuals identifying as Hispanic.

Sources: Incidence, North American Association of Central Cancer Registries 2022; Mortality, National Center for Health Statistics 2022.

ethnicity. For example, NSCLC incidence peaks in ages 80-84 for men but in ages 75-79 for women,[16] likely reflecting sex differences in smoking. (See page 37.) For SCLC, incidence peaks in ages 75-79 among both men and women. Incidence among Black men peaks about 5 years earlier than among White men for both NSCLC and SCLC.

How Does Lung Cancer Risk Vary Between Different Population Groups?

Sex

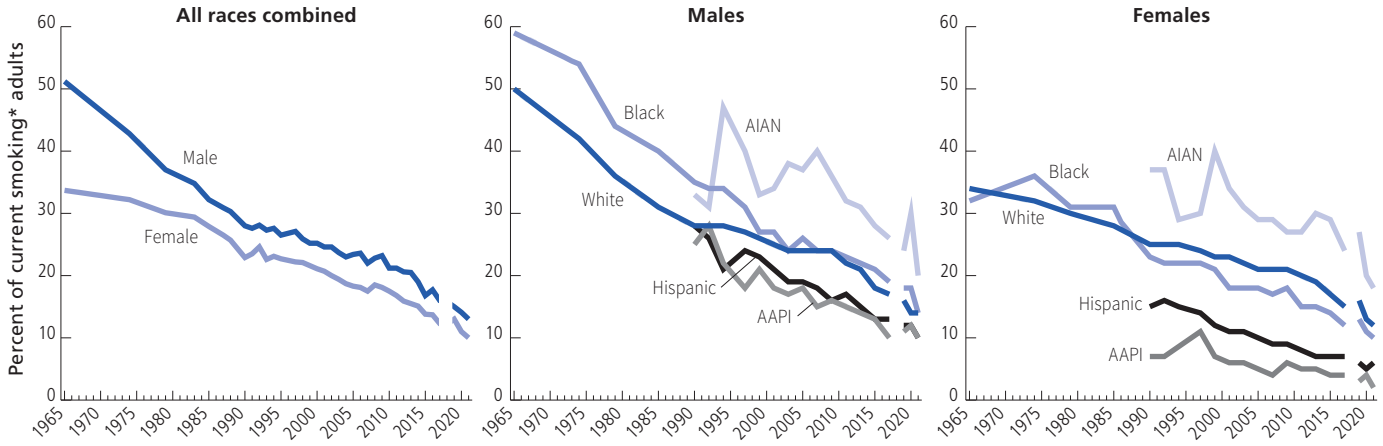
Lung cancer incidence during 2015-2019 was 27% higher among men (64.1 per 100,000) than women (50.3 per 100,000; Figure S3), largely due to historically higher smoking prevalence in men (Figure S4). However, this pattern varies by age and racial and ethnic group. For example, young non-Hispanic White (hereafter White) and Hispanic women have higher lung cancer rates than their male counterparts.[17, 18] Notably, this reversal in risk is not fully explained by smoking patterns. The sex gap for mortality is wider than for incidence, with death rates in men (42.2 per 100,000 during 2016-2020) 44% higher than those in women (29.3 per 100,000). This is due in part to differences in the distribution of subtypes and lower survival in men. (See information on lung cancer survival on page 36.)

Race & Ethnicity

Lung cancer incidence is highest among Black men, whereas mortality is highest among both Black and American Indian and Alaska Native (AIAN) men (Figure S3). AIAN men and women have had the highest smoking prevalence by far since at least the early 1990s, when data first became available (Figure S4). In some regions, including the East, Northern Plains, and Pacific Coast, lung cancer incidence among AIAN women is similar to or higher than among their male counterparts.[19] AIAN women have the highest mortality of any racial or ethnic group, 10% higher than White women, who rank second (Figure S3).

Lung cancer incidence and mortality among Asian American and Pacific Islander (AAPI) and Hispanic individuals is lower than that among other racial and ethnic groups (Figure S3) due to historically lower smoking prevalence (Figure S4). However, data for broadly defined racial and ethnic groups mask large differences within these heterogeneous populations, of which there are many examples.[20] Although lung cancer incidence in AAPI men overall is about 40% lower than in White men, one study found that it is 40% higher among Samoan men.[21] Another study reported that among never-smoking women in California and Hawaii, lung cancer was higher in AAPI women than in White women, and was highest in Chinese American

Figure S4. Trends in Smoking Prevalence by Sex, Race, and Ethnicity, US, 1965-2021



AAPI: Asian American and Pacific Islander individuals; AIAN: American Indian and Alaska Native individuals. *Ever smoked 100 cigarettes in lifetime and now smoke every day or some days. All racial groups are exclusive of individuals identifying as Hispanic beginning in 1990. All estimates are age adjusted. Due to changes in National Health Interview Survey (NHIS) survey design, estimates from 2019 onward are not directly comparable to prior years and are separated from the trend line.

Sources: Adult cigarette smoking prevalence 1965-2018, Health United States: 2019; NHIS 1990-2021.

women.[22] Similarly, among Hispanic individuals in Florida, lung cancer mortality rates among Cuban men were more than 50% higher than in Puerto Rican men and double those in men of other Hispanic origin groups, although rates were still lower than those in Whites.[23]

Socioeconomic Status

The risk of lung cancer is greater in persons with lower socioeconomic status (SES).[24] For example, lung cancer death rates in individuals ages 25-74 with ≤12 years of education are nearly 5 times higher in men and 4 times higher in women compared to those in persons with ≥16 years of education.[25] This disparity reflects historical differences in smoking prevalence that remain today. In 2021, for example, 21% of individuals without a high school diploma and 31% of individuals with a GED smoked cigarettes compared to 3% of individuals with a graduate degree. (See page 55.) Persons with low SES are also more likely to be diagnosed with advanced-stage disease[26] and lack access to high-quality cancer care.[27, 28]

Place of Residence

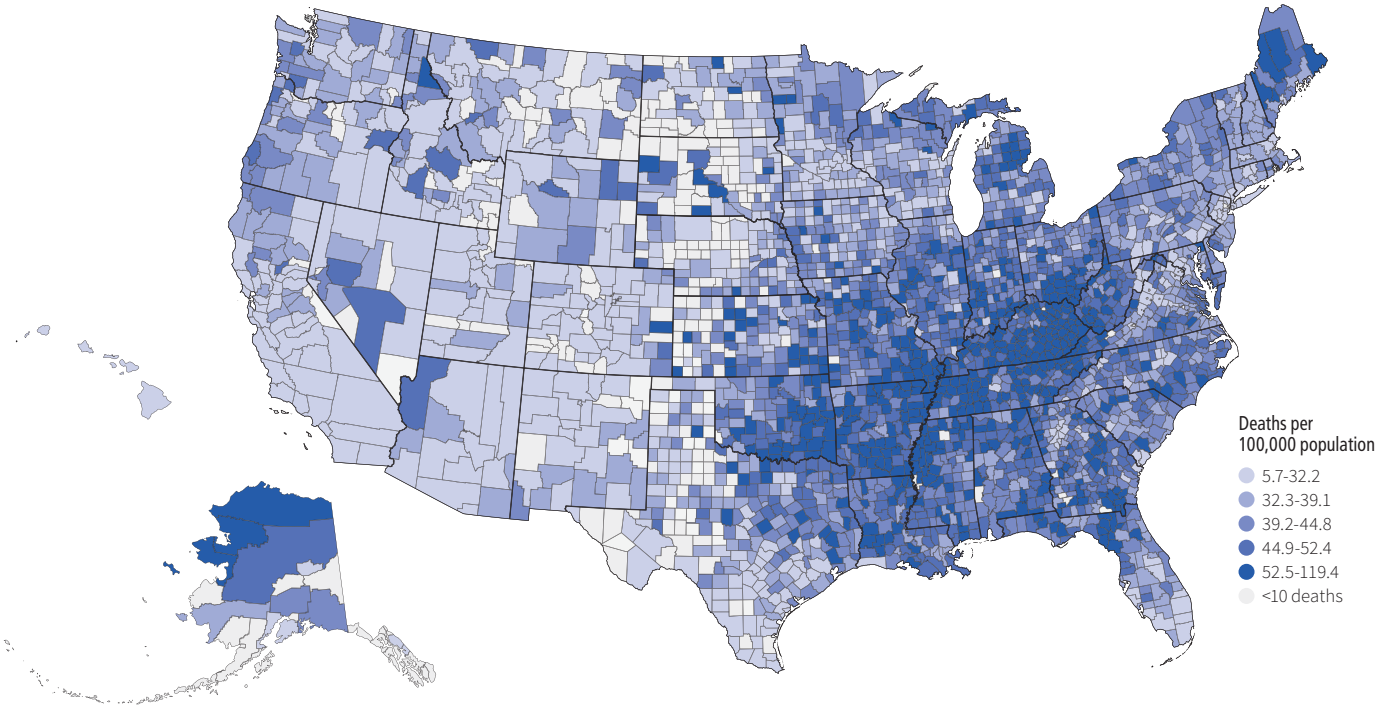
The states with the highest lung cancer mortality rates are Kentucky, West Virginia, Mississippi, and Arkansas (Table 5), all of which have the highest historical and current smoking prevalence.[29] However, there are also pockets of high lung cancer mortality in other states, including in the South and Appalachia (Figure S5). Among AIAN individuals, incidence for those living in the Northern Plains is nearly 5 times higher than for those living in the Southwest, where rates are 64% lower than White individuals living in the region.[19]

How Has Lung Cancer Occurrence Changed Over Time?

Lung cancer incidence and mortality trends closely mirror the tobacco epidemic with a lag of several decades.[30] As a result, lung cancer patterns differ by sex because women started smoking in large numbers later than men and were also much slower to begin quitting.[15] Lung cancer mortality rates rose from 3 to 4 per 100,000 in 1930, peaked at 91 per 100,000 men in 1990 and 42 per 100,000 women in 2002 before declining by 58% (38 per 100,000) and 36% (27 per 100,000), respectively, through 2020 (Figure S6). Reductions in mortality began several decades after the release of the first US Surgeon General's Report on Smoking and Health in 1964, which motivated people to quit smoking.[31]

Continued reductions in smoking are reflected in steady declines in lung cancer incidence of 2.6% per

Figure S5. Lung Cancer Mortality Rates* by County, 2016-2020



*Age adjusted to the 2000 US standard population.
Source: National Center for Health Statistics, 2022.

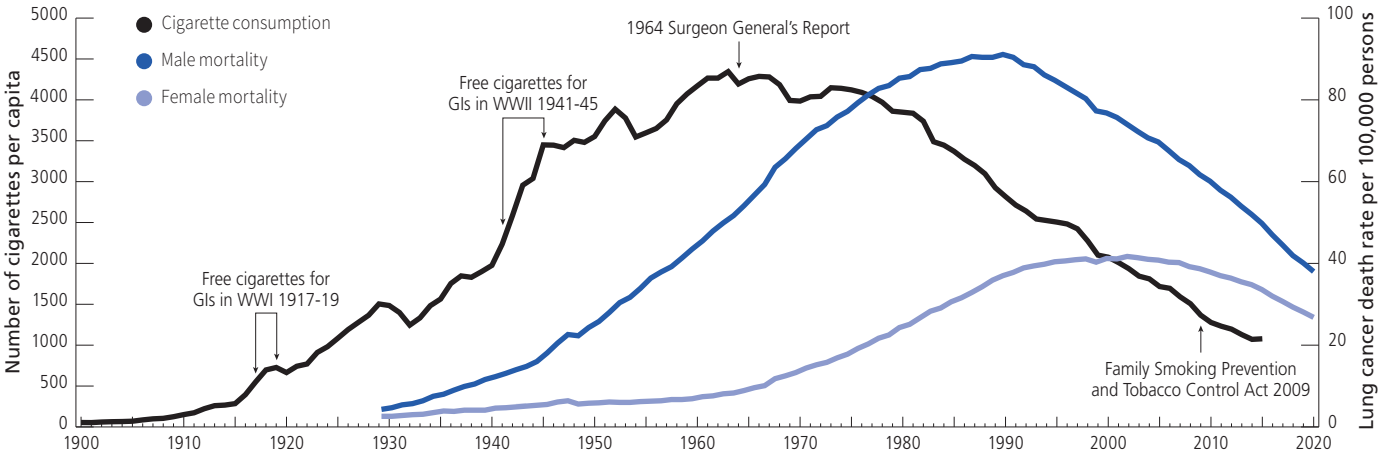
year in men and 1.1% per year in women since around 2006. However, an increase in the incidence of localized-stage disease of 4.5% per year from 2014 through 2018[32] suggests that people are being diagnosed earlier. This is probably at least in part due to the uptake of screening, which was first recommended for people at high risk of lung cancer in 2013,[33] as well as increased access to care through the Affordable Care Act. At the same time, the decline in mortality has accelerated from 3% per year in men and 2% per year in women during 2005 to 2014 to 5% and 4% per year, respectively, during 2014 to 2020.[2] This progress outpaces declines in incidence and likely reflects recent advances in treatment,[34, 35] as well as earlier detection.[36]

Differences by Race and Ethnicity

Among men, lung cancer mortality rates have been declining since at least 1990 in each racial and ethnic group, with the steepest drop among Black men (Figure S7). The more favorable trend in Black men likely reflects rapid historic declines in cigarette smoking prevalence (Figure S4) driven by steeper reductions in adolescent cigarette smoking initiation compared to other racial and ethnic groups.[37-41] As a result, the disparity in lung cancer mortality among Black versus White men dropped from 40% higher in the early 1990s to 14% higher during 2016-2020 (Figure S3).

Among women, lung cancer mortality rates continued to increase until the early or late 2000s in all racial and ethnic groups, with the steepest rise in AIAN women (Figure S7). Consequently, lung cancer mortality in AIAN women surpassed that in Black and White women circa 2000, reflecting their high smoking prevalence (Figure S4). Since the early to late 2000s, mortality has declined among women in all racial and ethnic groups, with the fastest pace among Black women. As a result, the lung cancer mortality rate in Black women was 4% lower than White women in 1990 but 17% lower in 2020. Like Black men, the more favorable lung cancer mortality trend in Black women reflects steeper declines in smoking prevalence.[37-41]

Figure S6. Trends in Tobacco Consumption and Lung Cancer Mortality Rates* by Sex, 1900-2020



*Age adjusted to the 2000 US standard population. Rates exclude deaths in Puerto Rico and other US territories. Note: Due to changes in ICD coding, numerator information for mortality rates has changed over time.

Source: Death rates: US Mortality Data, 1960-2020, US Mortality Volumes, 1930-1959, National Center for Health Statistics. Cigarette consumption: 1900-1999: US Department of Agriculture. 2000-2015: Consumption of Cigarettes and Combustible Tobacco – United States, 2000-2015. *MMWR Weekly Rep* 2016; 65(48);1357-1363.

Mortality rates among Hispanic individuals have consistently been lower than any other racial and ethnic group (Figure S7), largely due to their low smoking prevalence (Figure S4) and intensity of smoking. Hispanic smokers are more likely to be light (≤10 cigarettes/day) or intermittent smokers than any other racial or ethnic group.[42, 43]

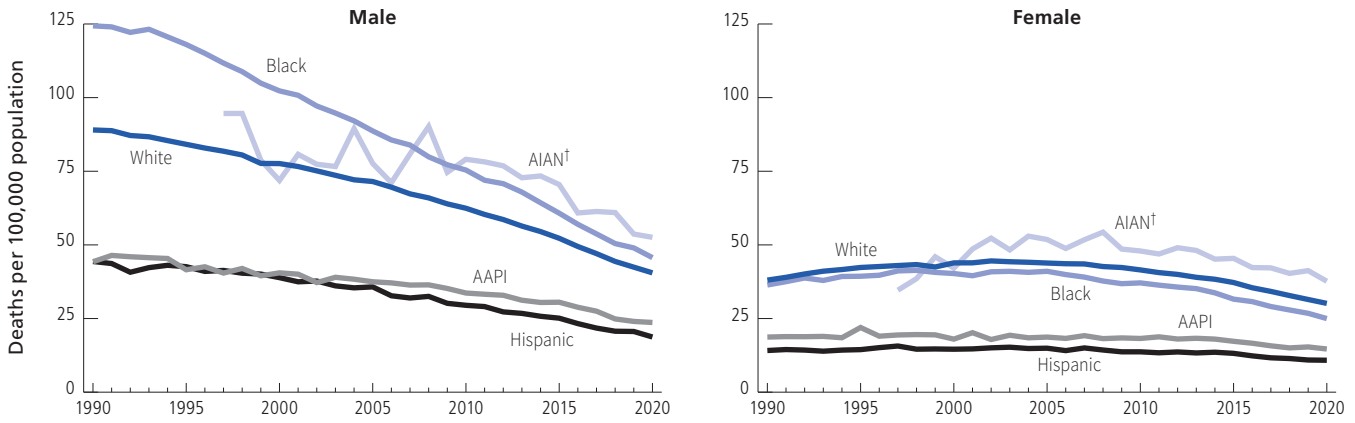
Lung Cancer Survival

After decades of little improvement, recent advancements in treatment have led to longer survival for lung cancer patients.[8, 35] Progress is mostly confined to NSCLC and is more evident in 2-year versus 5-year relative survival rates. For example, among women, 2-year relative survival for NSCLC increased slightly from 32% in 1975-1976 to 36% in 1997-1998, then rose to 54% in 2017-2018 (Figure S8). Increases were similar in men, from 25% to 28% to 43%, respectively. Advances in treatment that have likely contributed to this progress include molecular therapies targeting important mutations, such as in the epidermal growth factor receptor *(EGFR)* and anaplastic lymphoma kinase *(ALK)* genes;[44] immune checkpoint inhibitors, which boost patient immune response;[45, 46] improvements in staging;[47] and video-assisted surgery.[34] In contrast, 2-year relative survival for SCLC has increased little in absolute terms but doubled in relative terms, from 10% and 8% among women and men, respectively in 1975-1976, to 15% and 13% in 1997-1998 and 19% and 16% in 2017-2018 (Figure S8).

Lung cancer survival rates are higher among women than men (Figure S9), partly reflecting earlier-stage diagnosis and differences in subtype distribution. For example, 28% of women are diagnosed at a localized stage compared to 23% of men (Figure S10). However, 5-year survival rates are higher among women at every stage of diagnosis, albeit mostly confined to NSCLC (Figure S11). Reasons for higher survival in women are unclear but may reflect differences in tumor characteristics and hormones that influence treatment response.[48, 49] Female lung cancer patients are also more likely to have tumors with genetic mutations, such as in the *EGFR* gene, that are amenable to targeted therapies.[50]

Survival rates also vary by race and ethnicity, ranging from 26% among AAPI individuals to 19% among AIAN individuals (Figure S9), in part because of higher frequency of *EGFR* mutations among AAPI individuals diagnosed with lung cancer.[50] However, White individuals are most likely to be diagnosed with localized-stage disease among both men and women (Figure S10). Lower survival in some groups likely reflects less access to early detection, curative-intent surgery, and new therapies.[51-53] Survival

Figure S7. Trends in Lung Cancer Mortality Rates* by Sex, Race, and Ethnicity, US, 1990-2020



AAPI: Asian American and Pacific Islander individuals; AIAN: American Indian and Alaska Native individuals. *Age adjusted to the 2000 US standard population. †Data for AIAN individuals begin with 1997 to include Oklahoma and are adjusted for racial misclassification on death certificates. All racial groups are exclusive of individuals identifying as Hispanic.

Source: National Center for Health Statistics, 2022.

data for AAPI, Hispanic, and AIAN people should be interpreted with caution due to potential loss to follow-up and racial misclassification.[54]

What Are the Risk Factors for Lung Cancer?

The primary risk factor for lung cancer is cigarette smoking, which accounts for about 80% of lung cancer cases and deaths (Figure 4).[1] Cigarette smoking increases the risk of lung cancer 25-fold in both men and women compared to people who never smoked.[15] Other exposures that increase risk include secondhand smoke, radon, asbestos and some other occupational exposures, air pollution, and arsenic in drinking water. Low fruit and vegetable intake may increase risk although evidence is still accumulating.[55]

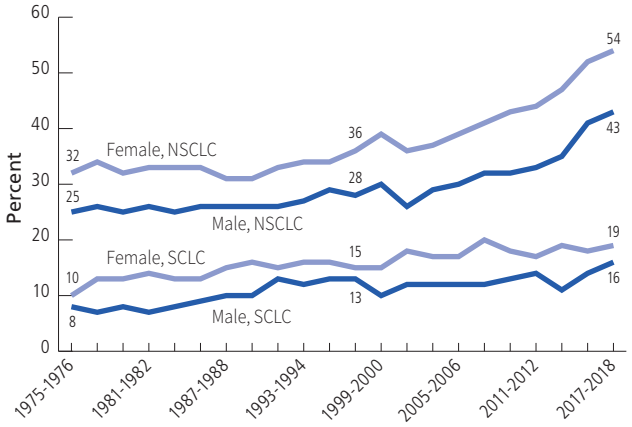
Tobacco Use

Cigarette Smoking

Cigarette smoking began to increase in the early 20th century among men, and after World War II among women,[56-58] peaking in the mid-1960s with adult smoking prevalence in 1965 at 51% among men and 34% among women (Figure S4, and Figure S6). While consumption cannot be differentiated by sex before 1965, studies suggest that the decline among men began in the mid-1950s, with increases in consumption among women outweighing the decline among men until the 1960s.[30] The pace of the decline in smoking prevalence has been steeper in men than in women because of differences in cessation and transient upticks in female smoking.[17] In 2021, adult cigarette smoking was 13% in men and 10% in women,[43] a 75% and 70% relative reduction, respectively, since 1965 because of increased awareness about the health hazards of cigarette smoking, increased excise taxes on cigarette products, prohibiting smoking in public places, and counteradvertising among other tobacco control policies. (See Tobacco Control Policies section, page 40.)

Historically, smoking prevalence was much higher among Black men than White men, but the gap has narrowed since around 1990 and been eliminated as of 2021 (Figure S4). In contrast, smoking prevalence among Black women was similar to White women prior to 1990 but has since been several percentage points lower. According to data from the National Health Interview Survey, current adult cigarette smoking prevalence in 2021 was 14% in both Black and White men, but 10% and 12% in Black and White women, respectively. The favorable trends in Black individuals are largely due to the sharp decline in smoking initiation among Black adolescents beginning in the late 1970s.[37] Additionally,

Figure S8. Trends in 2-year Relative Survival Rates for Lung Cancer by Sex and Subtype, US, 1975-2018



NSCLC: Non-small cell lung cancer; SCLC: Small cell lung cancer. Survival is based on patients diagnosed during 1975 through 2018, followed through 2019.

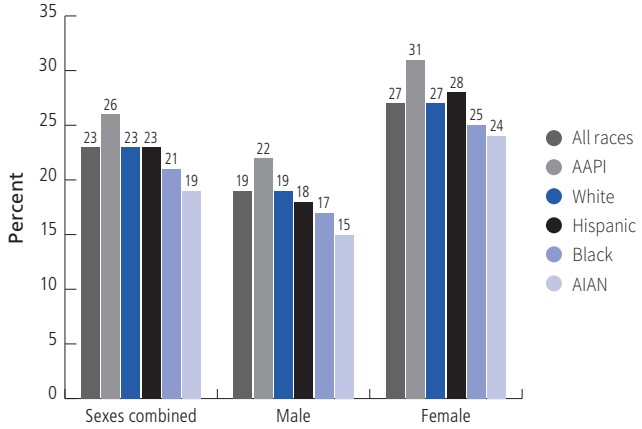
Source: Surveillance, Epidemiology, and End Results 8 Registries, 2022.

compared to White people, Black people are more likely to smoke lightly or intermittently.[42] A majority (80%) of Black people who smoke consume menthol cigarettes compared to 34% of White people who smoke.[59] While it has been hypothesized that menthol cigarette smoking may contribute to elevated lung cancer burden among Black men, research findings have not generally supported this hypothesis.[60-62] Research does suggest that Black people are more susceptible to smoking-related lung cancer compared to White people.[63]

AIAN individuals have the highest smoking prevalence of any racial or ethnic group, with 25% of AIAN adults currently smoking cigarettes in 2020.[29] Unlike most racial and ethnic groups, smoking prevalence among AIAN women has been similar to men since the early 1990s, when data first became available (Figure S3). However, smoking varies by region, with the highest reported prevalence in the Northern Plains (42% in both men and women) and the lowest in the Southwest (19% in men and 15% in women).[64] Higher prevalence of smoking is largely due to historical and ongoing structural racism that has contributed to lower education and income levels[65] and inadequate access to quality health care,[66, 67] as well as targeted deceptive tobacco product advertising.[68-70] There is also a lack of tailored smoking-cessation programs[71] that recognize the cultural importance of traditional tobacco use in some regions.[72] As a result, AIAN individuals have fewer quit attempts and slower cessation compared to other racial and ethnic groups.[29]

Cigarette smoking varies considerably by country of origin and nativity. For example, among the Hispanic population, smoking prevalence is higher among US-born versus foreign-born women and among Puerto Rican individuals (17% in men and 16% in women in 2017-2019) than Cuban individuals (7% and 12%, respectively), though Cuban individuals are more likely to smoke heavily.[73] Similarly, cigarette smoking prevalence among AAPI individuals is higher among Filipino (12%) individuals than Chinese (7%) or Asian Indian (6%) individuals.[21] Smoking prevalence among Native Hawaiian individuals is higher than any other AAPI group, similar to that among AIAN individuals, with 19.6% of Native Hawaiians living in Hawaii reporting current cigarette smoking during 2018 to 2020.[74] Native Hawaiian individuals, along with Black individuals, have a higher smoking-related risk of lung cancer compared to White, Japanese American, or Hispanic individuals.[59]

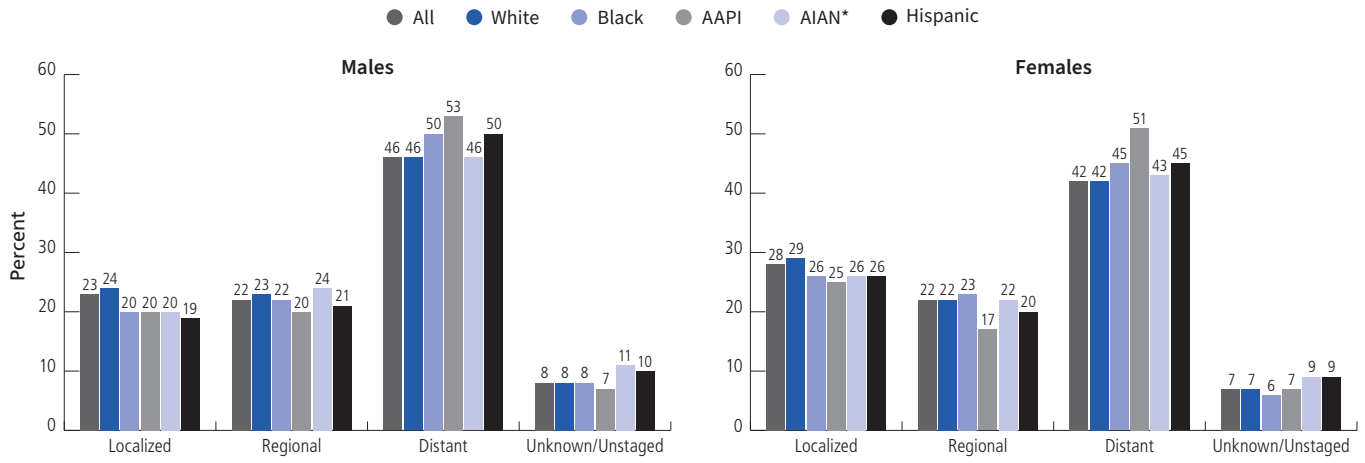
Figure S9. 5-year Relative Survival Rates for Lung Cancer by Sex, Race, and Ethnicity, US, 2012-2018



AAPI: Asian American and Pacific Islander individuals; AIAN: American Indian and Alaska Native individuals. Survival rates are for patients diagnosed during 2012-2018, all followed through 2019. All racial groups exclude individuals identifying as Hispanic.

Source: Surveillance, Epidemiology, and End Results 17 Registries, 2022.

Figure S10. Stage at Diagnosis by Sex, Race, and Ethnicity, US, 2015-2019



AAPI: Asian American and Pacific Islander individuals; AIAN: American Indian and Alaska Native individuals. *Data for AIAN individuals are restricted to Purchased/Referred Care Delivery Area counties. All racial groups are exclusive of individuals identifying as Hispanic.

Source: North American Association of Central Cancer Registries, 2022.

Other Combustible Tobacco Products

Other forms of combustible tobacco products associated with an increased risk of lung cancer include cigars, pipes, and waterpipes. Current cigar users are more than three times as likely to die from lung cancer compared to individuals who have never smoked any combustible tobacco product.[75] Compared to White people, Black people are more than twice as likely to smoke cigars.[76] In contrast to patterns of cigarette use, waterpipe use is more prevalent among younger individuals and individuals with higher educational attainment.[77] For more information about other combustible tobacco products, see page 55.

Secondhand Smoke

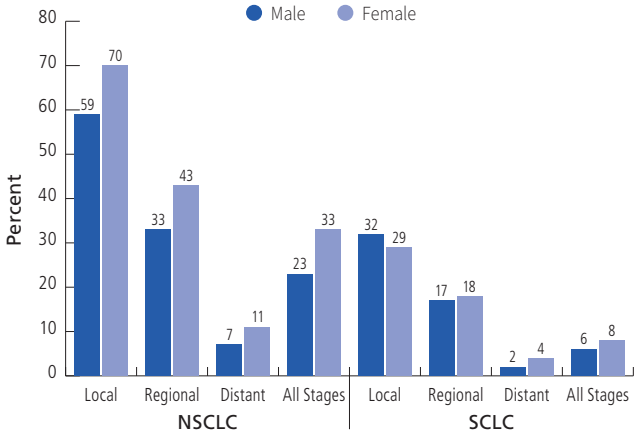
Secondhand smoke, or involuntary exposure to tobacco smoke, is the third most common cause of lung cancer in the US,[78] with a disproportionate influence on Black individuals and families with lower income.[79] Secondhand smoke contains numerous toxic chemicals, including at least 50 known carcinogens,[80] and is associated with the greatest risk for small cell lung cancer.[81] For more information about secondhand smoke, see page 56.

Personal and Family History

A history of lung disease, including asthma, chronic bronchitis, COPD, emphysema, pneumonia, and tuberculosis, is associated with increased risk of lung cancer.[82, 83] These diseases are thought to influence cancer risk through chronic inflammation of lung tissue.[84-87] The estimated excess lung cancer risk ranges from 16% among those with a history of asthma to 2.5-fold among those with a history of COPD.[88]

In addition, some people are at increased risk because of genetic predisposition.[89] Knowledge of inherited lung cancer dates to the 1960s, when excess mortality was noted among relatives of 270 lung cancer patients.[90] The International Lung Cancer Consortium estimates that individuals with a first-degree relative with lung cancer are at a 50% increased risk of the disease, with the strongest association for a diagnosed sibling (82%).[91] Specific genetic syndromes and mutations that have been associated with excess risk include Li-Fraumeni syndrome (variants in the *TP53* tumor-suppressor gene),[92] *EGFR* pathogenic variants,[93, 94] and possibly *BRCA2*, which has been associated with earlier onset of lung cancer by about 12 years[95] and risk among women.[96]

Figure S11. 5-year Relative Survival Rates for Lung Cancer by Subtype, Stage at Diagnosis, and Sex, US, 2012-2018



NSCLC: Non-small cell lung cancer; SCLC: Small cell lung cancer. Survival rates are for patients diagnosed during 2012-2018, all followed through 2019.

Source: Surveillance, Epidemiology, and End Results 17 Registries, 2022.

Environmental Exposures

Radon

Radon gas is a direct by-product of the radioactive decay of radium-226, part of a lengthy chain of radioactive decay for uranium-238, which is present naturally in rocks and soils.[97] Radon is thought to be the second-leading cause of lung cancer after cigarette smoking,[98] with the greatest risk for people who smoke.[99, 100] Individuals can lower their risk of radon exposure by having their home tested for the gas, regardless of where they live, and taking recommended steps to mitigate exposure when necessary (cdc.gov/radon/radon-action.html).[101, 102]

Asbestos and Other Occupational Exposures

Occupational exposures associated with increased lung cancer risk include chemical mixtures, such as soot and coal-tar pitch, and compounds such as nickel, chromium, and asbestos.[103] In addition, people who work in aluminum production, painting, and steel founding have elevated risk. Work that involves heavy asbestos exposure increases the risk of lung cancer by approximately 70%,[104] with exposure to longer and thinner fibers associated with stronger risk.[105] Studies of the effectiveness of workplace interventions to limit exposure and mitigate risk remain scarce.

Air Pollution

Air pollution is estimated to account for about 1%-2% of lung cancer deaths in the US.[106] Outdoor air pollution is made up of a variety of pollutants from many sources, including power generation, transportation, and industrial and agricultural emissions.[107, 108] Inhaling particulate matter, a microscopic mixture of solid and liquid pollutants, is linked to an 8%-9% increased risk of lung cancer.[108-110] Levels of particulate matter are highest in the Eastern US, but are generally low compared to other parts of the world, such as Asia, North Africa, and the Middle East. Sources of indoor air pollution include coal use in homes,[111, 112] burning of biomass for cooking and heating,[113] and cooking oil fumes.[114, 115] The use of electricity or natural gas for heating and cooking, as well as improved home ventilation, can help prevent increased lung cancer risk due to poor indoor air quality.

Arsenic

High levels of arsenic in drinking water (at least several hundred micrograms per liter) have been strongly associated with lung cancer in Chile and Taiwan,[116-118] but the risk for lower levels, as found in the US, is less clear.[116, 119-122] Only a few US counties, mostly in the Southwest, have mean concentrations exceeding 10 µg/L, the Environmental Protection Agency's maximum concentration limit.[122, 123]

Tobacco Control Policies

Since the publication of the landmark 1964 Surgeon General's Report on the health hazards of cigarette smoking, tobacco control has led to dramatic declines in cigarette consumption (Figure S6) and, consequently, lung cancer incidence and mortality. Some of the most important tobacco control measures include insurance coverage of tobacco cessation, tobacco excise taxes, laws against smoking in public places, counteradvertising, increasing the tobacco sales age to 21, federal regulation, and funding for evidence-based tobacco control programs.[124] Collectively, these measures have contributed to substantial declines in tobacco use in the US.

Tobacco Excise Taxes

Increasing excise taxes on tobacco products regularly and significantly is one of the most effective tobacco control policies. It promotes smoking cessation among adults, discourages initiation in adolescents, and lowers the number of cigarettes smoked among those unable to quit. For each 10% increase in the price of cigarettes, cigarette consumption decreases by an estimated 3%-5%.[125] The decrease is nearly double among youths and individuals with lower SES.[125-128] The federal cigarette tax has been $1.01 since 2009, and the average state tax was $1.91 as of October 1, 2022,[129] ranging from $0.17 in Missouri to $4.50 in the District of Columbia.[29]

Smoke-free Public Places

Comprehensive smoke-free laws (prohibiting smoking in workplaces, restaurants, bars, and gaming facilities) reduce secondhand smoke exposure and youth initiation while increasing cessation, thereby reducing the risk of smoking-related diseases.[78, 125] As of October 2022, 62.5% of the US population lived in areas covered by 100% smoke-free laws in the workplace, restaurants, and bars.[130]

Smoking Cessation

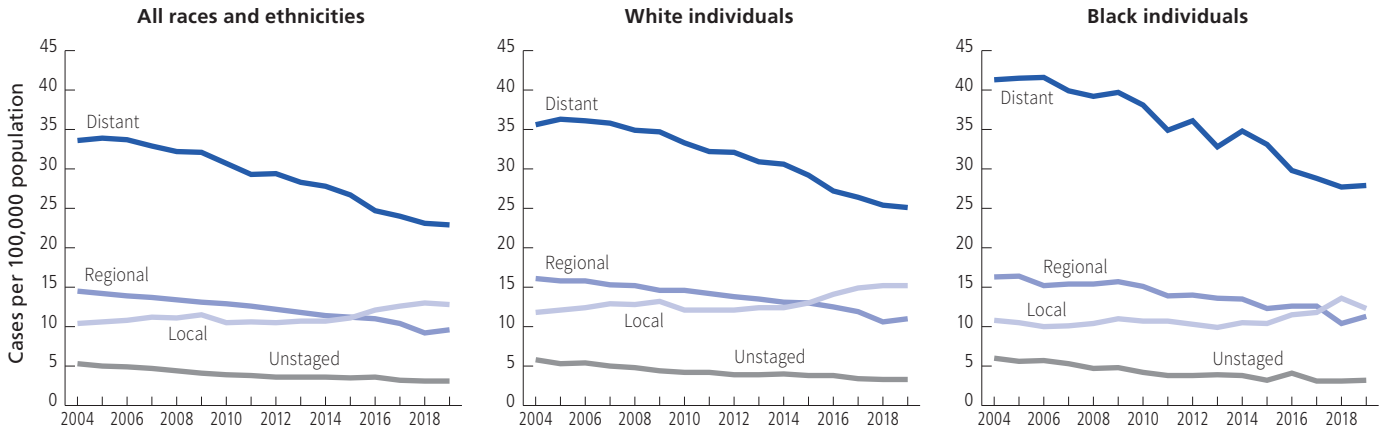
Smoking cessation is associated with a reduced risk of lung cancer and is beneficial at any age, with benefits increasing with earlier age at successful cessation.[125] Those people who smoke and quit before age 40 reduce their risk of lung cancer by 90% compared to those who continue to smoke throughout their lifetime. In general, people who smoke for their entire adult life lose a decade or more of life compared to people who never smoke because of premature death from lung cancer and other smoking-related diseases.[131, 132] Successful cessation usually takes an average of six attempts and increases with the use of FDA-approved cessation medications with counseling.[125, 133, 134] Although cessation attempts are highest among Black and AAPI individuals, successful cessation is highest among White individuals,[29] perhaps related to the use of cessation aids.[135] For more information about reducing tobacco use and exposure, see page 57.

Lung Cancer Screening

Lung cancer screening trials in the 1970s using chest radiography (x-rays) with or without sputum (mucus and other matter brought up from the lungs by coughing) examination showed no improvement in patient outcomes.[136] In 2011, however, screening high-risk individuals (ages 55 to 74 years with a 30+ pack-year smoking history) with annual low-dose computed tomography (LDCT)[137, 138] in the National Lung Screening Trial (NLST) was associated with a 20% reduction in lung cancer mortality compared to chest radiography. More recently, two European trials reported even larger mortality reductions among participants with more moderate disease risk.[139, 140] The American Cancer Society and the US Preventive Services Task Force (USPSTF) began recommending lung cancer screening using LDCT for high-risk individuals in 2013,[35] and have since expanded the eligibility criteria to people ages 50-80 years with a 20+ pack-year smoking history who currently smoke or have quit within the past 15 years.[141] Pack-years is a measurement of smoking history that takes into account duration and quantity of cigarette consumption, both of which determine lung cancer risk. An individual who smokes one pack a day for 20 years and one who smokes two packs a day for 10 years both have a 20 pack-year smoking history. Individuals who do not meet the 20 pack-year threshold, or who do but quit more than 15 years ago, are still at a 10-fold increased risk of lung cancer compared to people who have never smoked.[142] There were approximately 8.5 million adults eligible for lung cancer screening in 2020.

Despite evidence that screening in high-risk populations reduces lung cancer mortality, uptake has been low, especially in several Southern states with a high lung cancer burden.[143] The exception to this pattern is Kentucky, which although still low, has one of the highest screening rates in the country (13.7% in 2018) as a result of community-engaged programs,[144] governmental support,[145] expanded Medicaid eligibility, and no preauthorization requirement for lung cancer screening in Medicaid fee-for-service coverage.[143, 146] Despite generally low uptake, the proportion of cases diagnosed at a localized stage began to increase

Figure S12. Trends in Lung Cancer Incidence Rates* by Race and Stage, US, 2004-2019



*Age adjusted to the 2000 US Standard Population and adjusted for delays in case reporting. Rates for White and Black individuals are exclusive of individuals identifying as Hispanic.

Source: Surveillance, Epidemiology, and End Results 17 Registries, 2022.

following the 2013 USPSTF guideline update, surpassing regional stage in 2016 (Figure S12).

In contrast to recent screening rates for some other cancers,[147] lung cancer screening rates did not decline in the first year of the COVID-19 pandemic and, in fact, increased in 19 states between 2019 and 2020.[148] While this increase is promising, national screening rates among eligible high-risk individuals (about 8.5 million people) remain low (6.5% in 2020). People who are screened are more likely to be older, female, and current smokers,[149] with the greatest barriers to screening among Black and socioeconomically disadvantaged individuals.[150] Patient and provider education is important for increasing uptake among eligible adults, with patients often placing trust in the decision of their provider.[151]

The Economic Impact of Lung Cancer

Lung cancer causes a substantial loss of earnings in the US, approximately $13 billion in 2019,[152] which does not include the costs associated with a cancer diagnosis such as treatment and caregiving. As cancer treatment advances, as it has for lung cancer, the cost of those treatments increases, causing cancer patients and their families to face increasing out-of-pocket costs to receive treatment.[153-155] The high cost associated with a lung cancer diagnosis likely exacerbates economic disparities among diagnosed individuals, a disproportionate number of whom are already impoverished due to higher smoking prevalence among those with low SES.[24]

What Is the American Cancer Society Doing About Lung Cancer?

Research

The American Cancer Society, through our Extramural Discovery Science program, funds individual investigators at medical schools, universities, research institutes, and hospitals throughout the US. Currently, this program is funding $28 million in lung cancer research through 70 research grants. Ongoing research includes:

- Determining how to deliver high-quality cancer care that maximizes patient quality of life and delivers care that is consistent with patients' values and preferences
- Targeting cancer stem cells to induce anti-tumor immunity in small cell lung cancer

- Predicting and tracking response to immunotherapy by harnessing information from cell-free DNA in the blood
- Developing diagnostic tools for the early detection of lung cancer and the discovery of precision medicine to provide personalized targeted treatment
- Utilizing an updated CRISPR approach to identify new tumor-specific vulnerabilities that can be targeted in combination with existing therapies in non-small cell lung cancers

National Lung Cancer Roundtable

Since its inception in 2017, the American Cancer Society National Lung Cancer Roundtable (NLCRT) has galvanized more than 190 organizations and over 200 leading experts, as well as patient and caregiver advocate representatives, at the national, state, and local levels to collectively partner to problem-solve and achieve enduring systematic change to reduce deaths from lung cancer. The NLCRT engages experts in multidisciplinary problem-solving collaborations, catalyzes action to create, build, and strengthen innovative solutions, and develops and disseminates evidence-based interventions and best practices. The work of the roundtable is guided by its Steering Committee and conducted through the efforts of its 10 strategic priority task groups.

The NLCRT engages in public and provider education, targeted research, and health policy initiatives. The roundtable advances lung cancer-related health equity by identifying and working to overcome barriers to equitable access to promote implementation, uptake, and adherence of lung cancer screening and nodule detection and management, promote guideline-concordant staging, and optimize the use of biomarker testing to guide appropriate and timely therapy and care, eliminate the pervasive stigma associated with lung cancer, and strengthen state-based initiatives.

The NLCRT was recommended by the 2022 President's Cancer Panel Report as a priority cancer control model that effectively harnesses the collective power and expertise of the entire lung cancer community to close gaps in cancer screening by connecting people, communities, and systems to improve equity and access. The NLCRT's mission is to create lung cancer survivors.

Visit NLCRT.org for more information.

Advocacy

Our advocacy affiliate, the American Cancer Society Cancer Action Network℠ (ACS CAN), is involved in advocacy efforts at both the federal and state levels that reduce the prevalence of tobacco product use and increase access to quality lung cancer screening, treatment, and care. Following are some of the ways ACS CAN is fighting to reduce the impact of tobacco and lung cancer in the US.

- ACS CAN advocates for insurance coverage for comprehensive biomarker testing in state-regulated insurance plans including Medicaid when supported by medical and scientific evidence.
- The organization sponsors research seeking to better understand private insurance coverage for comprehensive biomarker testing in lung cancer.
- ACS CAN works to improve clinical trial diversity and searchability, including for lung cancer, by improving clinicaltrials.gov, enabling electronic health records to automatically screen patients for trials, and modernizing outdated eligibility criteria for trial entry.
- The organization advocates for evidence-based tobacco control policies to prevent initiation and aid in cessation, including increases in tobacco excise taxes, comprehensive smoke-free laws, insurance coverage for tobacco cessation services, funding for tobacco control programs, and federal regulation of tobacco products, including the prohibition of all flavors in all tobacco products.
- ACS CAN advocates for insurance coverage with no cost sharing of lung cancer screening by all payers, including Medicare, Medicaid, and private insurers.

- The organization believes that the American public should be made aware of the known information concerning the potential problem of radon contamination in certain housing areas in the US and how to reduce such a risk. ACS CAN urges federal, state, and local governments to approve legislation that reduces the potential health threat posed by radon by implementing public awareness campaigns and requiring disclosure of radon levels by builders, homeowners, schools, and daycare facilities.
- ACS CAN supports a cap on total out-of-pocket spending for Medicare beneficiaries.
- The organization advocates that Medicare and Medicaid provide coverage of patient navigation services. Patient navigators have shown to help increase cancer screening rates among historically marginalized racial and ethnic populations by providing access to disease prevention education, conducting community outreach, and facilitating public education campaigns. Additionally, given that many cancer screening guidelines are based on family history and personal risk factors, patient navigators can offer individualized advice and help patients assess individual eligibility, improving compliance by increasing a patient's cancer knowledge and understanding their unique health risks. As such, health care systems should prioritize the use of patient navigators for helping to move cancer patients smoothly and effectively through separate phases of cancer care.

Resources for Lung Cancer Patients and Their Families

Lungevity
lungevity.org
Lung Cancer HELPLine: 1-844-360-5864

Lungevity is the nation's leading lung cancer-focused nonprofit organization. Their goal is to change outcomes for people with lung cancer through research, education, and support. They have numerous education and supportive resources available to lung cancer patients, including peer-to-peer support and survivorship programs.

Cancer*Care*
cancercare.org/diagnosis/lung_cancer

Cancer*Care* provides free professional support services for lung cancer patients and their families. These include financial assistance, support groups, and educational materials.

American Lung Association
lung.org
Lung HelpLine: 1-800-LUNG-USA (1-800-586-4872)

The American Lung Association is the nation's leading organization working to save lives by improving lung health and preventing lung disease through education, advocacy, and research. They provide education on and supportive resources for lung cancer patients and their families, as well as resources to help with smoking cessation.

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