

Assessing Lung Cancer Risk from Adolescent Vaping Using Historical Tobacco Trends

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Abstract

Lung cancer is the leading cause of cancer deaths worldwide, and it is closely linked to cigarette smoking. Research shows a 20-30 year delay between smoking onset and subsequent lung cancer development. This delay underscores the importance of investigation into the long-term effects of newer nicotine products, especially e-cigarettes (e-cigs), which have become popular among adolescents. E-cigarettes deliver vaporized nicotine along with harmful chemicals like formaldehyde, heavy metals, and flavoring agents that can damage the lungs. Despite being deceptively marketed as safer than cigarettes, these products can still harm youth because of their addictive potential and appealing flavors. Studies show that vaping is linked to early signs of lung inflammation, oxidative stress, and damage to the alveoli sacs in the lung. While the full health impact of e-cigs may not be clear for decades, historical patterns of smoking tobacco products suggest that we could see similar delayed increases in lung disease, including cancer. Predictive models that combine vaping rates, chemical exposure, and early lung damage could help estimate future risks. There is an urgent need for long-term studies and early public health action. Early education on the dangers of e-cigs, stricter regulations, and monitoring teen vaping can help reduce future lung cancer and other respiratory diseases.

Introduction

Lung cancer is the leading cause of cancer-related deaths worldwide, with approximately 124,730 deaths estimated in the United States for 2025 (1). Approximately 85% of these cases are linked to tobacco use, primarily through traditional cigarette smoking (2). Historical data shows a strong correlation between smoking trends and lung cancer cases, largely due to a latency period of about 20 to 30 years between initial tobacco use and cancer diagnosis (3). This latency period means that many people who began smoking in early adulthood did not develop lung cancer until later in life. Nicotine, a highly addictive substance found in tobacco, is one of the main culprits for continued use and dependency. Although electronic cigarettes do not contain tobacco leaves, they still deliver nicotine and are therefore classified as tobacco products by the FDA.

Given the historic pattern in which increased tobacco use was followed by a delayed rise in lung cancer, it is important to look at the health effects of new and emerging nicotine products. Since the introduction of electronic cigarettes (commonly known as e-cigarettes or ecigs) to the United States in 2007, there has been a major shift in how nicotine products are used, particularly among adolescents (4). Unlike traditional cigarettes, e-cigarettes are available in modern designs and are often sold in sweet or fruity flavors, such as bubblegum and chocolate (5). These features have contributed to their popularity among youth. According to the Centers for Disease Control and Prevention (CDC), e-cigarettes are now the most commonly used tobacco product among teenagers in the United States (5). While often marketed or perceived as safer than cigarettes, many e-cigarette products contain harmful substances, including nicotine, formaldehyde, and heavy metals.

Considering the past impact of tobacco on public health, it is important to understand the long-term consequences of vaping (inhalation of nicotine-containing aerosol from electronic devices), especially in relation to youth addiction, future healthcare demands, and the

development of chronic conditions (25). Published research helps establish the relationship between tobacco products and lung cancer risk. Understanding these risks can help predict trends in public health over next decades.

Historical Smoking Trends and Lung Cancer Latency

Understanding historic smoking trends may allow for predicting the long-term risks associated with tobacco use, more specifically with lung cancer. Cigarette smoking became popular during the early to mid-20th century, especially following mass marketing campaigns and normalization during World War II (6). As smoking rates rose, the number of lung cancer diagnoses began to climb. However, this increase in lung cancer diagnoses was delayed. There was a significant time gap between the peak of cigarette use and the rise in lung cancer cases. This delay is known as the latency period and typically lasts between 20 and 30 years (3). People who began smoking at a young age often did not get diagnosed with lung cancer or related diseases until much later in life. This pattern has been well documented in epidemiological studies.

For example, U.S. data show that lung cancer deaths lag behind cigarette consumption by several decades. As cigarette use rose sharply through the mid-20th century, lung cancer death rates increased in both men and women after a delay of about 20 to 30 years (**Figure 1**). When smoking prevalence began to decline in the 1960s and 1970s, lung cancer mortality eventually followed the same downward trend, again with a noticeable lag.

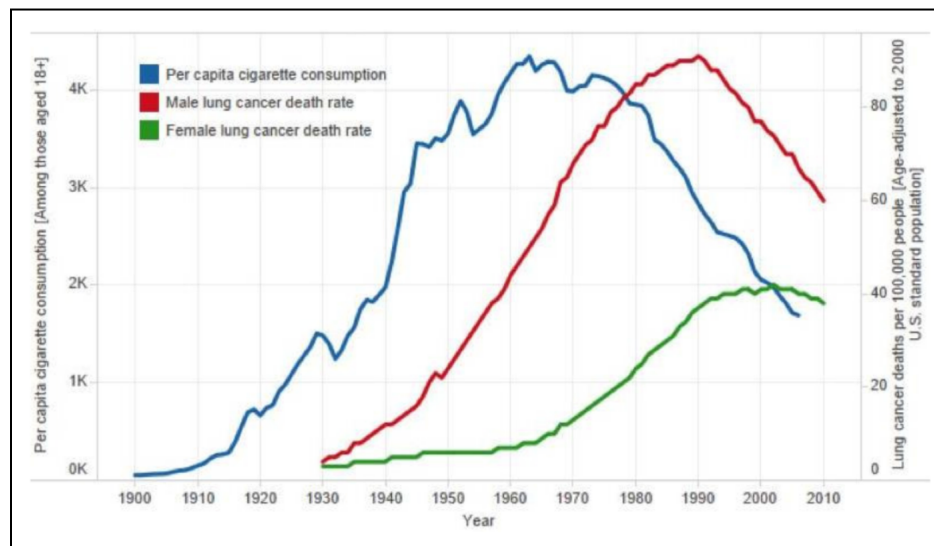


Figure 1. Trends in per capita cigarette consumption and lung cancer deaths in the United States from 1900 to 2010 (7)(24).

This delayed relationship illustrates how prolonged exposure to carcinogens in tobacco smoke leads to the gradual accumulation of genetic mutations that cause cancer. Understanding this latency is critical when evaluating the risks of newer nicotine products. Nicotine itself is not a carcinogen, but e-cigarettes deliver other chemicals that can damage lung tissue. If adolescent vaping follows a similar pattern to historical smoking, the full health impact may not be visible for decades.

Rise of Adolescent Vaping and Shifts in Nicotine Use

Over the past decade, e-cigarette use among U.S. adolescents has increased significantly. According to the 2024 National Youth Tobacco Survey, about 5.9% of middle and high school students, or approximately 1.63 million youth, reported current e-cigarette use (**Figure 2**) (8). In 2023, 89.4% of teens vaped flavored products, with 25.2 percent of youth reporting daily use (9). These statistics show a clear shift in youth nicotine consumption habits, with vaping now far more common than cigarette smoking.

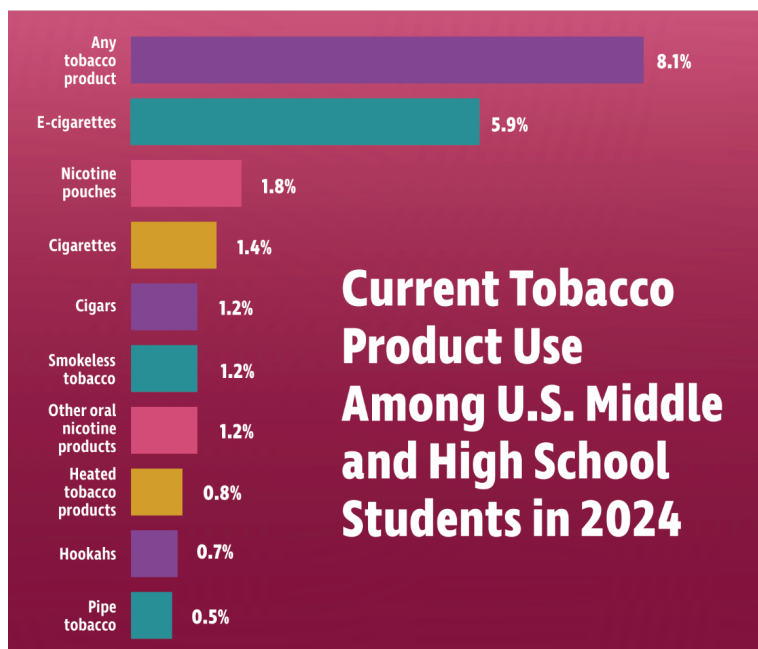


Figure 2. E-cigarettes are the most used tobacco product among American youth. (21)

Traditional cigarette smoking has declined to historic lows, with only about 1.4 percent reporting use, indicating that e-cigarettes have become the primary nicotine product for teens (10). Several factors contribute to the appeal of e-cigarettes among adolescents. One is the perception that vaping is less harmful than tobacco, which is supported by its sleek branding, targeted online marketing, and fewer visible short-term health effects. In addition, many products are available in appealing flavors like bubblegum and chocolate. Vapes are designed to be discreet, resembling USB drives or pens (11).

Despite being marketed as a safer alternative, e-cigarettes expose people to harmful substances including nicotine, volatile organic compounds, and heavy metals (12). Nicotine exposure during adolescence is especially concerning, as it can affect brain development and increase the likelihood of addiction to other substances later in life. In the late 2000s, public awareness and regulatory efforts were marketed against vaping, allowing the industry to expand rapidly among young people (13). Although agencies such as the CDC and FDA have since implemented restrictions, including flavor bans and age limits, the use of vapes remains widespread. The lasting effects of this early growth in youth vaping shows the need for continued research and stronger intervention.

Known Short-Term Health Effects of Vaping

Although the short-term health effects of vaping are now better known, the long-term consequences, particularly those related to cancer, remain unknown. This is mainly due to the latency period for cancer development. Vaping became widely available in 2007, so the long-term impact on public health may not be known for decades. One example was in 2019, during an outbreak of e-cigarette or vaping-associated lung injury (EVALI). This led to over 2,500 hospitalizations in the United States, with more than half of the cases requiring intensive care (14). Most were associated with vitamin E acetate found in illicit THC products, but individuals who vaped nicotine-only products also experienced serious symptoms such as chest pain, shortness of breath, and coughing (15).

Beyond EVALI, studies have linked vaping to lung inflammation and damage to the alveoli, which is a part of the lung required for gas exchange (23). The flavoring chemical, diacetyl, has been associated with a condition known as bronchiolitis obliterans, commonly referred to as “popcorn lung.” This causes permanent scarring and obstruction in the small airways (16). Other documented effects include worsened asthma, chronic bronchitis, and increased hospitalization for respiratory illness.

While e-cigarette use is increasing, lung cancer rates in the United States have been decreasing, a trend that mimics the decline in cigarette smoking over recent decades.

Vape aerosol contains several harmful chemicals that are also in cigarette smoke, with the concentration of some toxins being lower in e-cigarettes. Many E-cigarette devices are designed to deliver nicotine in concentrations similar to, or even higher than, traditional cigarettes (17). Vape aerosol has also been shown to contain aldehydes such as formaldehyde and acrolein, as well as heavy metals like chromium and lead. These substances are known to cause respiratory damage and cancer (18).

Chemical Type	Found in Vape Aerosol	Health Concern
Nicotine	Present in ~99%	Addictive, neurodevelopmental harm
Aldehydes (Formaldehyde)	Detected more at high temperature devices	Classified carcinogens, DNA damage
Metals	Chromium, nickel, lead, tin	Carcinogenic and respiratory toxins
Flavoring agents (ex: Diacetyl)	Common in flavored vapes	Linked to “popcorn lung”

Table 1. This table illustrates that while e-cigarettes may contain fewer toxins than combustible cigarettes, they are far from harmless (19)(20).

Predicting Future Lung Cancer Trends from Vaping

The latency period for lung cancer development remains a serious concern when evaluating the long-term health effects of vaping. According to the World Trade Center Health

Program's 2015 policy, the minimum latency period for trachea, bronchus, and lung cancers is ten years, but longer delays are common depending on the carcinogen and exposure level (21). This period explains why the health consequences of widespread adolescent vaping may not be apparent for decades.

Historical trends give a reliable precedent for predictive modeling. The rise in cigarette smoking during the mid-20th century was followed by a significant increase in lung cancer incidence 3 decades later. For example, in the United States, male lung cancer death rates peaked around 1990, nearly three decades after smoking rates reached their highest levels in the 1960s (6). This correlation between past usage and future disease cases emphasizes the predictive potential of historical models. While the chemical composition of vaping aerosol differs from that of combustible tobacco, many harmful substances, including known carcinogens, are present in both.

Current data suggests that e-cigarette use is associated with early signs of respiratory harm. A recent study published in 2023 in *The American Journal of Respiratory and Critical Care Medicine* found that adolescents who used e-cigarettes were more likely to have biomarkers linked to airway inflammation and oxidative stress, both of which are associated with carcinogenesis (22). These findings suggest a possible rise in future lung disease and cancer among current adolescent vapers. Further data is needed to make definitive links.

To address this gap, longitudinal studies are necessary. These studies could follow people over many years or decades to track health outcomes, calculate exposure, and identify early indicators of disease. Although difficult to design and maintain, longitudinal studies are important for capturing the delayed effects of vaping and understanding its role in cancer risk.

In the absence of decades-long data, researchers can also begin developing hypothetical predictive models. These models could integrate vaping prevalence, chemical exposure levels, and early biomarkers to estimate potential disease trends. By combining historical data with emerging health trends, it is possible to predict future challenges and act before they become widespread.

Conclusion

Vaping introduces harmful substances into the lungs and poses risks to respiratory health, especially among youth. Historical trends in tobacco use show that widespread use of a harmful product can lead to a delayed but significant increase in lung cancer incidence. Although current cancer rates have not yet reflected the impact of adolescent vaping, this could be due to the long latency period associated with cancer development.

There are still gaps in knowledge on the consequences of vaping. Because vaping is a relatively new trend, there has not yet been enough time to see its full long-term effects. As a result, we do not currently have large-scale data linking vaping to lung cancer.

Early surveillance and proactive public health preparedness are needed. Public health campaigns modeled after successful anti-smoking initiatives should target misinformation about vaping and emphasize its long-term risks. Schools can also play a role by incorporating vaping education into health curricula, especially since many teens begin using these products at a young age.

The rising popularity of vaping, especially among youth, combined with cancer's delayed onset, needs urgent attention. By using past trends as a predictive framework and acting early, we can reduce the risk of this preventable public health crisis.

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