

E-CIGARETTES

HEALTH EFFECTS

E-cigarettes are threatening to addict a new generation to nicotine. E-cigarette use among young people, many of whom were not smokers in the first place, has skyrocketed in recent years. Nearly 20% of high school students, one in five, use e-cigarettes, according to the [National Youth Tobacco Survey](#). Young people who use e-cigarettes are also more likely to start smoking cigarettes than their peers who do not vape.

E-cigarettes contain nicotine, sometimes at levels near or exceeding those found in combustible cigarettes. Nicotine is harmful to developing brains: younger users are more likely to become addicted, have more difficulty quitting and may be at higher risk for addiction to other substances in the future. While new products may be beneficial to smokers who completely switch from combustible tobacco, they still pose health risks and nonsmokers should never use them.

To date, no one knows the long-term effects of e-cigarette use, although research continues to investigate some of the rapidly emerging evidence of adverse effects on lung and cardiovascular health. Here's what we know about the health effects of e-cigarettes

- > A recent and **robust research literature review** of **e-cigarette** health effects found that use of these products has been associated with increased odds of chronic **cough, phlegm and bronchitis**, as well as **asthma** diagnoses.¹
- > Ongoing case studies and in vitro research that exposed human tissue to e-cigarette aerosol suggested that **e-cigarettes may be causing quantifiable injury to the small airways of the lungs** and were associated with a number of inflammatory diseases of the respiratory system, like pneumonia and interstitial lung disease.¹



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- > **Human cells exposed to vaped e-liquid have also been found to have decreased viability, with certain flavor compounds posing particular cell toxicity risks.** Other studies also showcased impaired immune cell function in the lungs, raising questions about e-cigarette users' susceptibility to bacterial and viral infections of the respiratory system. There is uncertainty regarding the way these infections may manifest given the potential for other lung injury and inflammation in lung tissue from e-cigarette use.¹
- > The first study to link e-cigarette use to cancer was published in October 2019. Researchers found that **mice exposed to e-cigarette aerosol for 54 weeks developed carcinomas of the lungs and abnormal bladder cell growth.**²

- Research indicates that **some flavors are potentially more toxic** than others.
 - » Researchers found that exposure to increased **cinnamon** flavoring caused significant **cell death** compared to other flavors.³
 - » Another concern related to flavoring stems from **pulegone** — a compound found in prepared oil extracts of certain **mint** plants. Pulegone is a **known carcinogen** and the tobacco industry has in the past reduced the amount of this compound in menthol tobacco products as a result of toxicity concerns. The **FDA banned pulegone as a food additive** in 2018, yet studies have identified that **substantial amounts of this additive are found in mint and menthol e-liquid** in the U.S. — raising concerns about the potential toxicity of these popular flavors.⁴
 - » Research also indicates that **mixing multiple flavors can be more toxic to cells** than exposure to just one flavor at a time.⁵

CARDIOVASCULAR HEALTH

- Research regarding the impact of e-cigarettes on cardiovascular health has yielded mixed results. Some studies have shown that short-term exposure to e-cigarette aerosol has no measurable harm on cardiovascular health. However, others suggest negative effects on resting heart rate, blood pressure and the cells that line the blood vessels. More extensive research is needed to gain perspective on the long-term effects of e-cigarette use on heart health.⁶

- Another pressing concern of e-cigarette use on cardiovascular health is the creation of carbonyl compounds from e-cigarette aerosol. Carbonyls are created when propylene glycol and glycerol — common solvents in e-liquid — are exposed to the high heat of an e-cigarette coil. Many of these carbonyl compounds have been previously associated with an increased risk of blood clot and atherosclerosis — a disease in which plaque builds on the walls of arteries, narrowing blood flow.⁶
- More research over a longer time period is needed to understand the full breadth of health consequences associated with the use of e-cigarettes as well as how their use compares to the well-established negative effects of long-term combustible cigarette use.

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Federal investigations into vaping-related illnesses

The emergence of vaping-related illnesses, which have prompted federal health agencies' investigations and advisories, underscore the urgency of research.

In August 2019, cases of e-cigarette or vaping use-associated lung injury (EVALI) sharply increased, afflicting e-cigarette users with respiratory and other symptoms, peaking in September 2019.⁷ As of February 18, 2020, a total of 2,807 hospitalized EVALI cases had been reported to the CDC in the U.S. with 68 cases resulting in deaths.⁷ A review of some of the affected e-cigarette users in two states reported that a majority of patients were experiencing cough, labored breathing, reduced blood oxygen levels and elevated white blood cell counts.¹ Symptoms of EVALI can also include respiratory symptoms (shortness of breath, cough, chest pain), gastrointestinal symptoms (nausea, vomiting, stomach pain, diarrhea), and other symptoms like fever, chills, and weight loss.⁷

A 2019 study by Mayo Clinic of 17 patients with vaping-related lung issues found that the injuries resembled "exposures to toxic chemical fumes, poisonous gases and toxic agents."⁸ Data from another study links EVALI cases to vitamin E acetate, an additive in THC-containing vaping products. Vitamin E acetate was present in bronchoalveolar-lavage (BAL) fluid in 48 out of 51 EVALI patients from 16 states, but it was not found in BAL fluid from the comparison group of 99 healthy individuals.⁹ Because 82% of the cases with specific substance use information available involved individuals who reported using THC-containing products, the FDA has recommended that consumers avoid purchasing vaping products of any kind on the street, using THC oil or modifying store-bought products.¹⁰

The CDC has recommended that those who use e-cigarettes consider quitting and that children and women who are pregnant should not use e-cigarettes. For those who use e-cigarettes and experience similar symptoms CDC recommends seeking prompt medical care.⁷ It is important to note that the CDC has not conclusively determined the cause of the EVALI illnesses and researchers are not sure what combination of short-term, long-term or repeated exposure may contribute to lung injury.¹¹

NICOTINE AND BRAIN DEVELOPMENT

Nicotine is an addictive substance, but its **level of addictiveness can vary substantially depending on its mode of delivery**. Nicotine delivered by the combustion of tobacco is the most addictive form.¹² The rise in popularity of e-cigarettes that can deliver levels of nicotine similar to combustible cigarettes is causing concern about the potential risk for addiction.¹³

- > Exposure to nicotine among youth is particularly dangerous since it has been shown to have an effect on key brain receptors, making **young people more susceptible to nicotine addiction**.¹⁴
- > There is some evidence that the effect of nicotine on developing brains may prime not just nicotine addiction, but **greater vulnerability to addiction to other drugs** as well.¹⁵
- > Studies in rats have shown that chronic nicotine exposure during adolescence can diminish cognitive functions like reduced attention span and enhanced impulsivity during adulthood. Adolescent rats exposed to nicotine showed altered long-term emotional responses including enhanced anxiety and fear and could result in a depression-like state during adulthood.¹⁶

In young people, the amount of nicotine needed to establish an addiction has been estimated at around 5 mg a day, or roughly one-quarter of an e-cigarette pod.

- > A study of university students found that e-cigarette use was significantly associated with higher levels of problematic alcohol/ illicit substance use and higher likelihood of drug use. E-cigarette use was also significantly associated with poorer self-esteem and greater scores on impulsivity, and that those who used e-cigarettes were more likely to have a history of ADHD, PTSD, gambling disorder, and anxiety.¹⁷

In young people, the amount of nicotine needed to establish an addiction has been estimated at around 5 mg a day, or roughly one-quarter of an e-cigarette pod.^{18,19} In recognition of these and other risks related to e-cigarettes, the U.S. surgeon general issued an advisory on e-cigarette use among youth, urging **parents, teachers, health professionals and states to take action to stop the epidemic among youth**.²⁰

PREGNANCY

- > Because most e-cigarettes contain nicotine, which can alter nerve cell functioning in developing organisms, especially during fetal development, **they should not be used by youth or pregnant women**.^{21,16}
- > **Pregnant women** who use nicotine are also at a greater risk for **stillbirth** and **preterm delivery**.¹³

CHEMICALS

While e-cigarettes may contain fewer toxins than combustible cigarettes, short and long-term effects of their use are unclear.²² What we do know is that they are not free of toxins and still **deliver harmful chemicals**.

- > **At least 60 chemical compounds** have been found in e-liquids, and still more are present in the aerosol produced by e-cigarettes.²³
- > **Heavy metals** such as cadmium, lead, nickel, tin and copper have all been detected in aerosols produced by e-cigarettes.²⁴

- > E-cigarettes produced fewer free-radicals than combustible cigarettes, however, even low levels of **repeated exposure to free-radicals** can cause oxidative stress, which increases the risk for cardiovascular and respiratory diseases.²⁵
- > Researchers have identified several substances which are either harmful or potentially harmful to e-cigarette users, including **delivery solvents and propylene glycol**, which can cause dry mouth and **upper respiratory infections** as well as pulegone, a known **carcinogen**.^{4,23}

EXPOSURE TO E-LIQUID

- > Accidental exposure or ingestion of **e-liquids** can be very dangerous and even **fatal** in case of **accidental swallowing or injection**.²³
- > There were **17,358 e-liquid exposure cases** between January 2010 and December 2018. The annual number of e-liquid exposure cases went up 4990% between 2010 and 2018, from 57 cases to 2901 cases.²⁶
- > Children under 5 years accounted for 68.4% of all **e-liquid exposure cases** and those aged 5-24 accounted for 14.7% of all e-liquid exposure cases from 2010-2018.²⁶

While e-cigarettes contain far fewer toxins than combustible cigarettes, they are not free of toxins and still deliver harmful chemicals.



EXPLOSIONS

- > **Defective, poorly manufactured and improperly modified e-cigarettes have also been known to explode and cause injury.** The rate of explosions is unknown, but both hospitals and burn centers have reported injuries from e-cigarettes.²³
- > In garbage trucks and waste management plants, lithium-ion batteries in e-cigarettes have been known to explode if damaged or exposed to extreme heat.²⁷ In California, 56% of the fires at waste facilities between 2016-2018 were reported to have been caused by lithium-ion batteries.²⁸

SECONDHAND AEROSOL EXPOSURE

- > **Exposure to aerosol from e-cigarettes** may expose non-users to nicotine, but research indicates that secondhand aerosol results in substantially lower exposure to toxicants and carcinogens than cigarette smoke. However, exposure among **vulnerable populations, including pregnant women and children, could still be dangerous**.²³

LUNG ILLNESS AND SEIZURES

- > The FDA is investigating whether a direct relationship exists between the use of e-cigarettes and **seizure risk or other neurological symptoms**. As of August 2019, the agency had received **127 reports** of seizure or other neurological symptoms that occurred between 2010 and 2019.²⁹

COVID-19

- > A paper published in June 2020 states that although there is no direct evidence suggesting the increased susceptibility of smokers/vapers towards COVID-19 infection, various indirect studies prove that this population is at higher risk of severe symptoms and need for mechanical ventilation, compared to non-smokers.³⁰ While analyzing factors associated with severe disease outcomes in patients admitted to hospitals in Wuhan, China, researchers showed that patients with a

history of smoking were significantly higher in the progression group with severe symptoms than in the improvement group of patients showing recovery (27.3% vs 3%).³¹

- A 2020 study with 1607 observations in their data found positive associations between the proportion of vapers and the number of COVID-19 cases and deaths in each U.S. state. With every 1% increase in weighted proportion of vapers in each state, the number of COVID-19 cases and deaths were significantly greater, suggesting that vapers may potentially be more susceptible to COVID-19.³²
- A 2020 study surveying adolescents and young adults 13-24 years old found that in comparison to non-users, testing positive for COVID-19 was five times more likely for people who had ever used e-cigarettes only, seven times more likely for people who had ever used both e-cigarettes and combustible cigarettes, and 6.8 times more likely for people who had used e-cigarettes and combustibles in the past 30 days.³³ Potential reasons cited for why e-cigarette and cigarette use were associated with testing positive for COVID-19 include:³³

- Heightened exposure to nicotine and other chemicals in e-cigarettes adversely affecting lung function
- Repeated touching of one's hands to the mouth and face during e-cigarette use
- Sharing e-cigarette devices

Research on the link between vaping and COVID-19 outcomes is rapidly evolving and more research is needed to clarify the relationship. However, there is evidence that indicates that vaping exacerbates COVID-19 infection rates.



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