**The Effects of Vaping and the Risk of Lung Cancer Associated with It**

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 **Electronic cigarettes and other vaping devices have become a popular method of ingesting nicotine. Originally advertised as a way to help tobacco users quit conventional cigarettes, they have become very popular in today’s youth and among nonsmokers. These products are commonly marketed as a healthier alternative to ordinary cigarettes, leading to their rapid growth in use over the last decade. However, many researchers are worried that these products may not be as harmless as they are often made to seem. Although it is difficult to assess the long-term effects of these devices since they are so new, studies suggest that many of the substances used in the liquid that is vaporized in these products, have oncogenic potential. Contaminants that are known carcinogens such as heavy metals have also been found in this liquid, increasing the concern that these devices may have an association with lung cancer. A variety of studies conducted on animals have further demonstrated that certain components of these products have the ability to alter DNA, an action that has the potential to lead to cancer. While there is currently not enough research to directly link the use of electronic cigarettes with lung cancer, studies have suggested that this is a likely risk. As these devices continue to increase in popularity, further research is crucial to help prevent a potential rise in lung cancer incidents as well as other lung related diseases.**

**Introduction**

 Electronic cigarettes and vape pens have been marketed as a healthy alternative to cigarettes and have become extremely popular in today’s youth. Coming in many varieties, they are a quick and easy way to ingest nicotine and other addictive substances. However, as their prevalence in our society continues to increase, studies have suggested that they may not be as harmless as they are made to seem.

 Data has shown that lung cancer has the highest fatality rate out of all types of cancers worldwide (Bracken-Clarke et. al, 2020). Trends in lung cancer fatality have been gradually declining, following the discovery and education on the risks of smoking tobacco cigarettes. According to the CDC, cigarette use in those 17 years or younger has decreased from 35.1% in 1999 to 6.9% in 2014 (Famiglietti, Memoli, and Khaitan, 2020). However, tobacco use still remains the number one cause of lung cancer (Bracken-Clarke et. al, 2020). With the use of electronic cigarettes and other vaping products still rising and the lack of information on the long-term effects of these products, some researchers fear that lung cancer incidents may begin to rise once again.

 Unlike ordinary cigarettes, the use of electronic cigarettes has rapidly increased, especially in the younger population. According the CDC, the use of electronic cigarettes and other artificial smoking devices has increased from 4.3% in 1999 to 30.2% in 2014 (Famiglietti, Memoli, and Khaitan, 2020). This percentage continues to rise. Studies have found that the number of users of these products has more than tripled in middle school and high school aged individuals and more than doubled in those 18-24 years old (Famiglietti, Memoli, and Khaitan, 2020).

 These devices work by quickly heating up liquid, creating an aerosol for inhalation (Famiglietti, Memoli, and Khaitan, 2020). The liquid is typically composed of nicotine dissolved in a solvent, often glycerin or propylene glycol (Lee et. al, 2017). A variety of flavor components can then be added to make the product more desirable. These liquids are very customizable and can be tailored to the user’s liking (Bracken-Clarke et. al, 2020).

 Electronic cigarettes do not use combustion like ordinary cigarettes, eliminating the vast number of combustion by products, many of which are known carcinogens (Lee et. al, 2017). With this knowledge, many consumers believe that there is little harm in using these devices. However, as their popularity continues to increase, researchers in the medical community are questioning if this is actually the case.

**Recent Progress**

 There have been a variety of studies conducted in attempts to determine both the short-term and long-term effects of electronic-cigarette use. Some studies have broken down the components in vaping liquid and assessed their potential carcinogenic risk.

 Research suggests that nicotine itself has carcinogenic abilities. 80% of inhaled nicotine is metabolized into cotinine, which is ultimately excreted through urine (Lee et. al, 2017). This compound is believed to be noncarcinogenic. However, 10% of inhaled nicotine is believed to be metabolized into nitrosamines. Studies have seen tumor formation in a variety of animals after administering this compound (Lee et. al, 2017).

 Nitrosamines can then be further metabolized into methyldiazohydroxide or MDOH. This chemical has the ability to methylate DNA. Since healthy DNA is crucial for correct growth and division of all cells in the human body, this poses a great risk for the development of cancer. Studies have demonstrated this process in mice that were exposed to 10 mg/mL of electronic cigarettes for three hours a day for 12 weeks (Lee et. al, 2017). This amount of exposure is equivalent to someone who has lightly smoke electronic cigarettes for 10 years. The researchers observed the greatest methylation of DNA in in the lungs, followed by the bladder and heart (Lee et. al, 2017).

 Electronic cigarettes and other vaping devices can contain different concentrations of nicotine based on the user’s preference. These concentrations are often higher than those found in traditional cigarettes, making researchers concerned that the nicotine itself in these devices could pose a greater carcinogenic risk.

 Coming in many varieties, the additives used to add flavor to the liquid are another frequent area of study. One common additive that has been used in tobacco cigarettes since the early 20th century and is also popular in electronic cigarettes is menthol. Menthol is used to create a mint flavor as well as a cooling sensation for the user. In addition, it helps to minimize throat irritation, often making it an appealing to consumers (Bracken-Clarke et. al, 2020).

 Menthol has been known to be a potential oncogenic substance, both directly and due to its effects on nicotine metabolism. It has been observed to alter nicotine receptor sites in the brain, increasing nicotine’s affinity for them (Bracken-Clarke et. al, 2020). This results in greater exposure to the substance, increasing the risk for potential DNA damage.

 Ethyl maltol is frequently added to vaping liquid as a sweeting component. In a study conducted by Bitzer et. al, there was significant free radical generation in vitro in vaped ethyl maltol. This suggests that ethyl maltol has oncogenic effects. Furthermore, ethyl maltol has been known to form hydroxypyranone complexes when in the presence of iron or copper. These metals are often used to construct the coil which helps to rapidly heat the liquid. This results in even more radical generation, leading researchers to believe that ethyl maltol is a probable carcinogen (Bracken-Clarke et. al, 2020).

 Another common substance found in vaping liquid is diacetyl. Used to create a buttery flavor, this compound has been observed to facilitate the development of lung disease when used as an additive in popcorn (Bracken-Clarke et. al, 2020). In a recent study, this compound along with some of its derivatives, were found in 47 out of the 51 electronic cigarettes that were sampled (Bracken-Clarke et. al, 2020).

 In addition to compounds used for flavor, there are also commonly traces of heavy metals and other contaminants found in these liquids. This has been a big area of concern for researchers. Although the mechanism is not fully understood, heavy metals have been shown to have oncogenic properties and heavy metal particles have been associated with the development of lung cancer (Bracken-Clarke et. al, 2020).

 In electronic cigarettes, traces of these metals may be present in the liquid component due to contamination during production, as well as the metal coil that is used to vaporize the liquid. Furthermore, other metals are often used in the actual infrastructure of the device, which also have the potential to contaminate the liquid (Bracken-Clarke et. al, 2020).

 The liquid in the device is heated by the metal coil, which is often made of copper that is coated with a different type of metal. When this coil is heated, the temperature of the liquid rapidly increases, causing it to vaporize. However, the rest of the device is also heated in the process, which increases the possibility for the mobilization of heavy metal ions from the coil itself, as well as the surrounding pieces. This creates an even greater risk for heavy metal traces in the liquid (Bracken-Clarke et. al, 2020).

 Studies which have carefully analyzed this liquid have found microparticles of lead, chromium, strontium, and nickel, all of which are known to be carcinogens. This has been an alarming discovery as prolonged exposure to these chemicals can greatly increase one’s risk for developing cancer (Bracken-Clarke et. al, 2020).

**Discussion**

 The research that has been conducted on electronic cigarettes and vaping devices has demonstrated that these products likely have the ability to lead to lung cancer, despite what was previously thought. There are many known and probable carcinogenic substances contained within them that can be ingested into the user’s lungs through the vapor.

 These results demonstrate that the use of electronic cigarettes as an alternative to tobacco cigarettes may not be as harmless as it is made to seem. Even though these products eliminate all of the dangerous byproducts of combustion, they still contain chemicals that have been found to alter DNA.

 Furthermore, there has not been substantial evidence that these devices work as an effective tool to quit traditional smoking. In one study, 12,000 individuals were surveyed about their smoking habits. Those who used both electronic cigarettes and tobacco cigarettes smoked an average of 15.6 tobacco cigarettes per day, whereas those who did not use electronic cigarettes smoked an average of 14.4 tobacco cigarettes per day (Lee et. al, 2017).

 In addition, another study found a 28% lower likelihood of quitting smoking in those who smoked electronic cigarettes compared to those who had never smoked them (Lee et. al, 2017). On the other hand, a different study showed that those who smoked electronic cigarettes daily were 7.88 times more likely to quit tobacco smoking for at least 30 days (Lee et. al, 2017). However, there is much conflicting data on the topic so more research must be done to determine if electronic cigarettes are an effective tool to quit conventional smoking.

 Another major factor about electronic cigarettes that could potentially make them just as dangerous as traditional cigarettes is the accessibility and ease of using them. Unlike a traditional cigarette, electronic cigarettes do not produce much of a smell if any, making them available to use almost anywhere. In addition, consuming them is often simpler than a conventional cigarette. All the consumer must do is hold down on a button while inhaling, whereas tobacco cigarettes must be lit and do not last as long.

 The accessibility of electronic cigarettes is a large area of concern because it allows consumers to use them constantly throughout the day if they wish. This can increase the daily amount of nicotine ingested by the user, as well as the amount of other chemicals found in vaping liquid.

 Education on these risks is extremely important as the number of consumers continue to rise rapidly, especially in younger generations. Studies have shown that 88.2% of consumers believe that electronic cigarettes are healthier than traditional cigarettes and 11% believe they are completely healthy and can even boost physical health (Bracken-Clarke et. al, 2020). As more and more studies suggest the potential risks of using these devices, the idea that these products are not very harmful is beginning to look like a misconception.

 In addition to containing possible carcinogens that pose a risk for cancer development, the use of electronic cigarettes has also been linked to lung disease. In a study conducted in Wisconsin and Illinois, 53 individuals were identified who had developed syndromic pulmonary disease. All of these patients at used electronic cigarettes within 90 days of being diagnosed (Lee et. al, 2017).

 While there is not enough evidence to completely connect electronic cigarettes to lung cancer, there is reasonable evidence that suggests that the use of these products may increase one’s risk of developing lung cancer in their lifetime.

 When cigarettes first hit the market, many people believed they were good for your health. However, as those who smoked cigarettes aged, researchers realized this was not the case and connected tobacco use with the development of lung cancer. In order to prevent this a possible repeat of this scenario with electronic cigarettes, further studies must be conducted to assess the potential risks of these devices.

 Although the fatality rate of lung cancer has decreased since the cessation movement of tobacco smoking, it is threatened to possibly rise again with the frequent consumption of these new products. It is nearly impossible to determine the long-term effects of these products until they have been in use longer, but research over the probable effects is very important to help reduce their use.

**References**

Bracken-Clarke, D., Kapoor, D., Baird, Anne M., Buchanan, Paul J.,

Gately, K., Cuffe, S., and Finn, Stephen P. “Vaping and lung

cancer- A review of current data and recommendations”. Lung

Cancer. 153 (2020): 11-20.

Lee, HW., Park, SH., Weng, MW., Wang, HT., Huang, William C.,

Lepor, H., Wu, XR., Chen, LC., and Tang, MS. “E-cigarette

smoke damages DNA and reduces repair activity in mouse

lung, heart, and bladder as well as in human lung and bladder

cells”. Proceedings of the National Academy of Sciences of

the United States of America. (2017): 1560-1561.

Famiglietti, A., Memoli, Jessica W., and Khaitan, Puja G. “Are electronic

cigarettes and vaping effective tools for smoking cessation?”.

Journal of Thoracic Disease. 13 (2020): 384-395.