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## **Systematic review: e-cigarettes vs. conventional cigarettes**

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***ABSTRACT***

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**Introduction**

Electronic cigarettes have gained widespread popularity by being marketed as a safer alternative to traditional smoking. Possibility of inhaling vapor created by heating nicotine liquid instead of combusting tobacco leaves revolutionized tobacco market, bringing a lot of questions about harmfulness or advantages of e-cigarettes. Their popularity is increasing and many aspects about their influence on health are still unclear. At the same time, better social acceptance than tobacco cigarettes brings out questions if they are a step to smoking cessation or if they encourage more people to start using nicotine.

**Aim of the review**

This systematic review provide an analysis of the existing literature on the influence of e-cigarettes on the human body with their economic and behavioral aspects. By examining a wide range of studies, we aim to elucidate the potential risks and benefits associated with e-cigarette use and provide a comparison of both electronic and conventional forms of nicotine consumption.

**Methods**

A systematic search was conducted using electronic databases such as PubMed, Scopus, and Web of Science. Keywords included "e-cigarettes", "vaping", "health effects", "conventional cigarettes", "tobacco", "respiratory system", "cardiovascular system", "immune system", "oral health", and "cellular effects". The search was limited to studies published up to December 2023. Both observational and experimental studies were included.

**Conclusion**

While e-cigarettes are often promoted as a safer alternative to conventional cigarettes, the evidence suggests that they are not without significant health risks. It is important to remember that they are a new form of substance use, and many aspects related to them are still

unknown. E-cigarettes and conventional cigarettes present distinct usage patterns and cost profiles. Years of research on larger sample sizes are needed to determine their impact on humans.

## ***INTRODUCTION***

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According to the World Health Organization (WHO), there are over one billion smokers worldwide. Although the use of tobacco products is losing popularity in highly developed countries, there is a global increase in tobacco use. It is estimated that more than 80% of all smokers come from low- and middle-income countries<sup>1</sup>. Smoking is responsible for many types of pathologies, from cancers to vascular diseases to respiratory diseases, and is also one of the leading causes of premature deaths. Diseases caused by smoking arise from the toxins present in cigarettes, and nicotine itself plays a marginal role in the pathology of these diseases. Nicotine can be introduced into the body not only through cigarettes but also through cigars, pipes, and nicotine-containing medications such as patches, gums, or nasal sprays. The latest method of nicotine delivery is electronic nicotine delivery systems (ENDS). Their emergence, mainly in the form of e-cigarettes, has completely revolutionized the tobacco market. They introduced to the market as a purportedly safer alternative to conventional smoking, aimed at reducing the health burden associated with tobacco use. However, the cost and usage patterns of e-cigarettes relative to conventional cigarettes are critical factors in understanding their impact on public health and individual finances. E-cigarette typically consists of a container for a special liquid, an atomizer (heating element), and a battery<sup>2</sup>. The liquid, which mainly contains propylene glycol, glycerin, water, and flavors, is heated during inhalation by the user, producing smoke-like vapor that is inhaled into the respiratory system. Since their debut in 2003, they have become available worldwide, and their popularity is increasing year by year, primarily because they are marketed as healthier alternatives to traditional cigarettes. They are presented as less harmful, cheaper, and more socially acceptable. Many companies also highlight their positive role in nicotine replacement therapy. Their availability is also influenced by the fact that a significant portion of their sales occurs online. Research shows that approximately 30-50% of total e-cigarette sales take place online, and in 2014, as many as 466

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<sup>1</sup> The WHO tobacco free initiative, Geneva, Switzerland. Cited July 14, 2014. [http://www.who.int/tobacco/mpower/tobacco\\_facts/en/](http://www.who.int/tobacco/mpower/tobacco_facts/en/)

<sup>2</sup> Are E-cigarettes a safe and good alternative to cigarette smoking? Oren Rom, Alessandra Pecorelli, Giuseppe Valacchi, and Oren Rom Reznick

distinct e-cigarette brands had their own websites<sup>3</sup>. It is estimated that profits from e-cigarette sales in the United States alone amounted to about \$2 billion in 2014. Many studies focus on the reasons for using e-cigarettes, their advantages and disadvantages, ever since they appeared in public life. This review systematically examines the available evidence on the effects of e-cigarettes on various bodily systems to provide a thorough understanding of their impact on human health while comparing them and conventional cigarettes, aiming to provide a balanced perspective on their respective health risks.

## ***METHODS***

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A systematic search was conducted using electronic databases such as PubMed, Scopus, and Web of Science. Keywords included "e-cigarettes", "vaping", "health effects", "conventional cigarettes", "tobacco", "respiratory system", "cardiovascular system", "immune system", "oral health", and "cellular effects". The search was limited to studies published up to December 2023. Both observational and experimental studies were included.

## ***THE REASONS BEHIND E-CIGARETTES POPULARITY***

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Research on the reasons for using e-cigarettes, besides creating study samples by age, focuses on dividing respondents into initial smokers who had never previously been exposed to nicotine products and those who previously smoked traditional cigarettes. This division allows for the discovery of differences in the reasons for using e-cigarettes between traditional smokers and non-smokers. However, studies show that regardless of prior contact with cigarettes, the main reason for starting e-cigarette use among people aged 18-25 is curiosity<sup>4</sup>. The widespread belief in the lesser harm of e-cigarettes, a wide range of flavors, and better availability significantly lowers the barrier to trying the first cigarette. At the same time, greater social acceptance and lower costs encourage traditional smokers to attempt switching to e-cigarettes.

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<sup>3</sup> Zhu, S.H. et al. 2014. Four hundred and sixty brands of e-cigarettes and counting: implications for product regulation. *Tob. Contro*

<sup>4</sup> Kinouani S, Pereira E, Tzourio C. Electronic cigarette use in students and its relation with tobacco-smoking: a cross-sectional analysis of the i-Share Study. *Int J Environ Res Public Health*. 2017

Only by comparing the second reasons for using e-cigarettes can one notice differences between these groups. Among non-smokers, the influence of friends and the environment is the second reason, especially when people around also smoke or encourage trying<sup>5</sup>. On the other hand, traditional smokers cite many different reasons for using e-cigarettes, which vary in significance in different studies. Among the most important are the desire to reduce or quit smoking, concern for those around them, and encouragement by society. Both former traditional smokers and non-smokers often cite the desire to maintain better social contacts as a reason. E-cigarettes, with their neutral or often sweet and pleasant aromas, are more socially accepted and allowed in places where traditional smoking is prohibited. Their lower cost and likely less harmful impact on the environment compared to traditional cigarettes encourage many smokers to switch to e-cigarettes. Non-smokers living in environments with smokers turn to e-cigarettes as an alternative to regular cigarettes. Smokers often have to leave a room to smoke, provoking a sense of isolation among non-smokers, and e-cigarettes are an "ideal" mean between not smoking and maintaining good social contacts with the smoking environment<sup>6</sup>. Some studies also show that smoking e-cigarettes among young adults (18-25 years) is less often motivated by quitting smoking than among older age groups. However, other studies show that among those trying to reduce or quit smoking using e-cigarettes, young adults make up a larger percentage than older adults<sup>7</sup>.

### ***WHY E-CIGARETTES ARE BETTER***

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The main reason for creating e-cigarettes was to eliminate the harmful side effects of tobacco combustion. The current form of e-cigarette is designed to deliver nicotine to the body without the residue from burning a cigarette (tar), which is the main cause of smoking-related diseases. It was assumed, and advertised, that e-cigarettes significantly reduce the risk of cancer while maintaining the nicotine effect. Tobacco cigarettes contain thousands of carcinogenic and cardiotoxic substances, including many inorganic substances like heavy metals, which enter the body during combustion. E-cigarettes, however, rely on heating the liquid instead of burning

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<sup>5</sup> Awan KH. Experimentation and correlates of electronic nicotine delivery system (electronic cigarettes) among university students – A cross sectional study. Saudi Dent J. 2016;

<sup>6</sup> Hoek J, Thrul J, Ling P. Qualitative analysis of young adult END users' expectations and experiences. BMJ Open. 2017

<sup>7</sup> Kong G, Morean ME, Cavallo DA, Camenga DR, KrishnanSarin S. Reasons for electronic cigarette experimentation and discontinuation among adolescents and young adults. Nicotine Tob Res. 2015

tobacco leaves, so these substances do not enter the body. Moreover, the liquids used in e-cigarettes mainly contain organic compounds, propylene glycol, and glycerol, which are commonly used daily in the food, pharmaceutical, and cosmetic industries<sup>8</sup>. Thanks to the use of pleasant aromas and the lack of a combustion process, e-cigarettes do not cause an unpleasant smell, which is often a problem with smoking tobacco cigarettes. They also reduce the problem of passive smoking for non-smokers due to the absence of tobacco smoke, although, due to their short existence in public life and the lack of sufficient research, it is still not possible to definitively determine the impact of e-cigarette vapor on bystanders. In addition to the health aspect, e-cigarettes have an advantage over traditional cigarettes by eliminating open flames, thereby reducing the risk of fire, which is also a problem with traditional cigarettes. Furthermore, e-cigarettes are advertised as more effective in nicotine replacement therapy than other cigarette substitutes, such as gums or patches, due to their more direct nicotine delivery method, better absorption by the lungs, and satisfying smoking habits like inhaling smoke or holding something in the mouth, which other nicotine products cannot provide. The effectiveness of e-cigarettes in quitting smoking has been tested in various studies. In one study examining 222 smokers who tried e-cigarettes, 31% of respondents reported complete smoking cessation six months after first using an e-cigarette. Additionally, 66.8% of users reported a reduction in the number of cigarettes smoked per day after starting to use e-cigarettes<sup>9</sup>. However, these results should be interpreted cautiously, as this study did not use biochemical verification of actual smoking cessation. In another study, 40 people participated, and the indicator of quitting or reducing smoking was exhaled carbon monoxide (eCO). Compared to pre-study smoking, 32.5% of respondents reported a reduction in cigarettes smoked per day by half, and 22.5% managed to quit smoking completely<sup>10</sup>. Much smaller percentages of quitting or reducing smoking were noted in a year-long control study involving 300 people reluctant to quit smoking. Participants were divided into three groups based on nicotine doses in the e-cigarette cartridge: 7.2 mg per cartridge for 12 weeks, 7.2 mg for 6 weeks, and 5.4 mg for 12 weeks. Interestingly, no significant differences were noted between these groups. At week 52, 10.3% of respondents declared a reduction in cigarettes smoked per day by half, and 8.7% reported complete smoking cessation, as tested by exhaled carbon monoxide<sup>11</sup>. Another year-long study divided 657

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<sup>8</sup> Schroeder, M.J. & A.C. Hoffman. 2014. Electronic cigarettes and nicotine clinical pharmacology. *Tob. Control*

<sup>9</sup> Polosa, R. et al. 2011 Effect of an electronic nicotine delivery device (e-cigarette) on smoking reduction and cessation: a prospective 6-month pilot study. *BMC Public Health*

<sup>10</sup> Siegel, M.B., K.L. Tanwar & K.S. Wood. 2011. Electronic cigarettes as a smoking-cessation: tool results from an online survey. *Am. J. Prev. Med.*

<sup>11</sup> Caponnetto, P. et al. 2013. Efficiency and safety of an electronic cigarette (ECLAT) as tobacco cigarettes substitute: a prospective 12-month randomized control design study. *PLoS One*

respondents into three groups: using e-cigarettes containing 16 mg of nicotine, using patches containing 21 mg of nicotine, and using placebo e-cigarettes without nicotine. Each group used substitutes for 13 weeks. After six months, complete smoking cessation, as measured by eCO, was recorded in 7.3% of the first group, 5.8% of the second group, and 4.1% of the third group<sup>12</sup>. These studies suggest that nicotine-containing e-cigarettes may be helpful in quitting or reducing smoking. However, compared to commonly used nicotine replacement therapies, the percentage of people quitting smoking is significantly lower. For example, studies on the effectiveness of varenicline therapy compared to placebo report a minimum one-year abstinence from smoking in 22-35% of respondents<sup>13</sup>. More long-term studies on much larger populations are needed to definitively determine whether e-cigarettes are effective in quitting smoking.

## ***HEALTH HAZARDS***

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Smoking cigarettes has long been widely recognized as harmful. Numerous scientific studies have proven their negative impact on many systems within the human body. Since the emergence of e-cigarettes, a debate has been ongoing about their harmfulness to the body and whether they are healthier than regular cigarettes. The answer to this question is not straightforward and requires examining their effects on individual systems within the human body.

Both e-cigarettes and conventional cigarettes are associated with respiratory health issues. Several studies have investigated the impact of e-cigarettes on respiratory health, revealing both acute and chronic effects. Acute exposure to e-cigarette aerosol can cause airway inflammation, increased oxidative stress, and reduced pulmonary function. Chronic use has been associated with conditions such as chronic obstructive pulmonary disease (COPD) and increased susceptibility to respiratory infections, such as chronic bronchitis, or lung cancer. Nevertheless, the extent is generally considered less severe than with traditional cigarettes. One conducted study demonstrated increased markers of inflammation, such as interleukin-6 (IL-6) and tumor necrosis factor-alpha (TNF- $\alpha$ ), in the bronchoalveolar lavage fluid of e-cigarette users compared to non-users<sup>14</sup>. This suggests that e-cigarette vapor can induce an inflammatory

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<sup>12</sup> Bullen, C. et al. 2013. Electronic cigarettes for smoking cessation: a randomised controlled trial. *Lancet*

<sup>13</sup> Garrison, G.D. & S.E. Dugan. 2009. Varenicline: a first-line treatment option for smoking cessation. *Clin. Ther.*

<sup>14</sup> Gotts, J. E., Jordt, S. E., McConnell, R., & Tarran, R. (2019). What are the respiratory effects of e-cigarettes? *BMJ*, 366, 15275.

response in the respiratory system. However, the levels were significantly higher in conventional smokers.

Nicotine, a common component in both e-cigarettes and conventional cigarettes, exerts significant cardiovascular effects. Acute exposure to e-cigarette vapor has been shown to increase heart rate and blood pressure. These physiological changes could increase the risk of developing cardiovascular diseases such as hypertension and atherosclerosis<sup>15</sup>. Studies have also indicated that e-cigarette use can lead to increased arterial stiffness, a risk factor for cardiovascular events. One study found that while both types of smoking increased arterial stiffness, the effect was more pronounced in conventional cigarette smokers, suggesting a potentially lower cardiovascular risk with e-cigarettes<sup>16</sup>.

Both e-cigarettes and conventional cigarettes can alter immune responses, leading to compromised ability to fight infections. It is proven that exposure to e-cigarette vapor is impairing pulmonary immune responses in a manner similar to traditional cigarette smoke, although the degree of impairment was generally lower<sup>17</sup>. Further studies have indicated that e-cigarette vapor can modulate cytokine production. Also, the exposure to e-cigarette aerosol results in the upregulation of pro-inflammatory cytokines and downregulation of anti-inflammatory cytokines in human bronchial epithelial cells, suggesting a potential mechanism for increased respiratory susceptibility<sup>18</sup>. The upregulation of pro-inflammatory cytokines and downregulation of anti-inflammatory cytokines were more significant in conventional cigarette smoke.

Smoking cigarettes affects the oral microbiome, although the extent and nature of these changes can differ. Conventional cigarette smokers had a more pathogenic oral microbiome compared to e-cigarette users, who still exhibited changes from non-users but to a lesser extent<sup>19</sup>. Conventional cigarette smoking is also a well-established risk factor for periodontal disease, while e-cigarettes also contribute to periodontal inflammation but to a lesser degree.

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<sup>15</sup> Benowitz, N. L., & Burbank, A. D. (2016). Cardiovascular toxicity of nicotine: Implications for electronic cigarette use. *Trends in Cardiovascular Medicine*, 26(6), 515-523.

<sup>16</sup> Vlachopoulos, C., Ioakeimidis, N., Abdelrasoul, M., Terentes-Printzios, D., Georgakopoulos, C., Pietri, P., ... & Stefanadis, C. (2016). Electronic cigarette smoking increases aortic stiffness and blood pressure in young smokers. *Journal of the American College of Cardiology*, 67(23), 2802-2803.

<sup>17</sup> Sussan, T. E., Gajghate, S., Thimmulappa, R. K., Ma, J., Kim, J. H., Sudini, K., ... & Biswal, S. (2015). Exposure to electronic cigarettes impairs pulmonary anti-bacterial and anti-viral defenses in a mouse model. *PLoS One*, 10(2), e0116861.

<sup>18</sup> Clapp, P. W., Pawlak, E. A., Lackey, J. T., Keating, J. E., Reeber, S. L., Glish, G. L., & Jaspers, I. (2017). Flavored e-cigarette liquids and cinnamaldehyde impair respiratory innate immune cell function. *American Journal of Physiology-Lung Cellular and Molecular Physiology*, 313(2), L278-L292.

<sup>19</sup> Pushalkar, S., Paul, B., Li, Q., Yang, J., Vasconcelos, R., Makwana, S., ... & Saxena, D. (2020). Electronic cigarette aerosol modulates the oral microbiome and increases risk of infection. *iScience*, 23(3), 100884.

One study demonstrated that both types of smoking increased inflammatory cytokines in gingival tissues, with higher levels observed in conventional smokers<sup>20</sup>.

Both e-cigarette vapor and conventional cigarette smoke are associated with DNA damage and increased mutagenesis. One study found that flavoring agents in e-cigarette liquids caused DNA strand breaks and reduced DNA repair activity in human lung epithelial cells, similar to conventional cigarette smoke, but the overall mutagenic potential was higher in conventional cigarettes<sup>21</sup>. In vitro studies have shown that both e-cigarette vapor and conventional cigarette smoke induce cellular toxicity. The exposure to both types of aerosol increased oxidative stress and apoptosis in human lung cells, with more pronounced effects from conventional cigarette smoke<sup>22</sup>.

## ***OTHER THREATS AND ISSUES***

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E-cigarettes raise many concerns due to their short existence and the lack of research on their side effects. However, the biggest problem is their significant popularity among adolescents and young adults. As mentioned earlier, many e-cigarette liquids contain pleasant scents and flavors, and their variety is growing daily. This factor encourages younger and younger people to use e-cigarettes and, thus, to use nicotine. At the same time, marketing and online sales significantly popularize e-cigarettes among young people. For example, in the United States alone, between 2011 and 2012, the number of high school students using e-cigarettes doubled, and in subsequent years, this number continued to grow. Additionally, it was found that these same high school students were much more likely and frequently used e-cigarettes than any other nicotine products<sup>23</sup>. According to the National Youth Tobacco Survey (NYTS), the prevalence of e-cigarette use among high school students increased significantly between 2015 and 2020, while conventional cigarette use declined<sup>24</sup>. Recent studies report that the number of e-cigarette users in the United States increased from 11.7% in 2017 to 20.8% in 2019, while according to the National Youth Tobacco Survey conducted in 2019, as many as

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<sup>20</sup> Rouabhia, M., Daudelin, J. F., & Smlali, A. (2017). Effect of e-cigarettes on oral health: A literature review. *Journal of Oral Health and Dental Management*, 16(2), 1-5.

<sup>21</sup> Lee, H. W., Park, S. H., Weng, M. W., Wang, H. T., Huang, W. C., Lopor, H., ... & Tang, M. S. (2018). E-cigarette smoke damages DNA and reduces repair activity in lung cells. *Proceedings of the National Academy of Sciences*, 115(7), E1560-E1569.

<sup>22</sup> Wang, Q., Khan, N. A., Muthumalage, T., Lawyer, G. R., McDonough, S. R., Chuang, T. D., ... & Rahman, I. (2016). Toxicological and microbiome changes following e-cigarette vaping in mice. *Toxicology*, 365, 29-40

<sup>23</sup> Durmowicz, E.L. 2014. The impact of electronic cigarettes on the paediatric population. *Tob. Control*

<sup>24</sup> National Youth Tobacco Survey (NYTS). (2020). Prevalence of e-cigarette use among high school students. Retrieved from CDC website

27.5% of high school students reported using e-cigarettes in the past 30 days<sup>25 26</sup>. It should also be noted that the affordability of e-cigarettes may increase the percentage of people using nicotine and lower the average age of nicotine initiation. Moreover, e-cigarettes can be a stepping stone to traditional smoking, which can lead to the significant popularity of cigarettes among society. Young people are much more susceptible to addictions, and nicotine can disrupt brain function and development. At the same time, the pleasant taste and smell of e-cigarettes significantly reduce the sense of harmfulness, as well as the deterrence effect of the unpleasant smell of traditional cigarettes. Furthermore, children and adolescents often have easier access to e-cigarettes due to their parents or guardians who believe in their lack of harmfulness. This creates the danger of young people becoming addicted to nicotine without the knowledge of their parents or guardians. There are numerous reports of young people smoking e-cigarettes without the knowledge of those around them, especially at home or even at school, in places where smoking tobacco cigarettes is strictly prohibited. A notable pattern is the prevalence of dual usage, where individuals use both e-cigarettes and conventional cigarettes. This trend is particularly common among adults trying to quit smoking. One research found that approximately 30% of e-cigarette users also smoked conventional cigarettes, highlighting the complexity of nicotine addiction and cessation efforts<sup>27</sup>. Using traditional cigarettes and e-cigarettes simultaneously may also carry negative consequences however there are currently no studies that can definitively confirm this thesis. Additionally, e-cigarette users tend to use their devices more frequently throughout the day compared to conventional cigarette smokers, who may have more defined smoking intervals. According to a 2019 study, e-cigarette users often engage in "puffing" behaviors throughout the day, which could lead to higher overall nicotine consumption<sup>28</sup>. Another concern with using e-cigarettes is the impact of the vapor produced on third parties, especially in enclosed spaces. When an e-cigarette user inhales, the vapor is drawn into the lungs, and unlike traditional cigarettes, no smoke is released into the environment. However, during exhalation, a significant portion of this vapor is released into the surroundings, potentially exposing bystanders to its effects. Research shows that this vapor does not contain the combustion toxins found in cigarette smoke but does expose others to the nicotine present

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<sup>25</sup> Gentzke AS, Creamer M, Cullen KA, et al. Vital Signs: Tobacco Product Use Among Middle and High School Students - United States, 2011-2018. *Morbidity and Mortality Weekly*. 2019

<sup>26</sup> Federal Drug Administration (FDA). FDA News Release. Trump Administration Combating Epidemic of Youth E-Cigarette Use with Plan to Clear Market of Unauthorized, Non-Tobacco-Flavored E-Cigarette Products. September 11, 2019.

<sup>27</sup> Stokes, A., Xie, W., Wilson, A. E., Yang, H., & Yu, E. (2018). Prevalence and correlates of e-cigarette use in adults: Evidence from the Population Assessment of Tobacco and Health Study. *Journal of Public Health*, 40(3), e276-e283.

<sup>28</sup> Yingst, J. M., Hrabovsky, S., Hobkirk, A., Trindle, R. C., & Foulds, J. (2019). Nicotine absorption during electronic cigarette use among regular users. *PloS One*, 14(7), e0220300.

in it<sup>29</sup>. This can have a negative impact on health, especially when e-cigarettes are used in enclosed spaces such as homes or school restrooms. In addition to nicotine, the vapor also contains previously mentioned flavors responsible for the pleasant smell of e-cigarettes. These flavors are usually chemically tested and commonly used in the food and cosmetic industries. However, it is important to remember that e-cigarettes introduce these ingredients in significant quantities through direct inhalation into the lungs<sup>30</sup>. There is very little research on their impact on the body, especially in such excessive amounts. This raises many concerns about their effects on the body, particularly their local impact on the lungs and bronchi. So far, many studies conducted on glycerin and propylene glycol have proven their non-toxicity, but all these studies considered their intake only through the digestive tract, not inhalationally.<sup>31 32</sup>

In addition to the liquid ingredients, it is important to consider the presence of a lithium battery and a heating element in e-cigarettes, whose long-term effects on the body are also not fully understood. Without precise, long-term studies on large populations, we cannot determine their specific impact on the body. Ultimately, the environmental aspect of e-cigarette use should also be considered. Besides potential risks associated with the production and disposal of the devices themselves, the vapor they produce can negatively affect air quality. The latest research results show that the vapor produced by e-cigarettes has a very similar particle density at the moment of exhalation to the smoke produced during the combustion of a traditional cigarette<sup>33</sup>. Unfortunately, it is not yet possible to precisely determine the potential environmental impact of e-cigarettes, and years of research, including their creation, use, and disposal, are needed to definitively determine their harmful effects on air quality. Due to the lack of research on long-term health effects, there is a significant risk that e-cigarettes will have as severe consequences as traditional cigarettes. The widespread use of nicotine products among young people, coupled with poor regulation and the ease of obtaining e-cigarettes, can pose a serious social problem in the future. Even if e-cigarettes do not have harmful effects, they can create a new generation of nicotine addicts. Research has shown that a large percentage of smokers use e-cigarettes to reduce or quit smoking. However, recent studies have shown that the effectiveness of e-cigarettes in nicotine replacement therapy is significantly lower than other replacement

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<sup>29</sup> Editorial (no authors listed). E-cigarettes: Public Health England's evidence-based confusion. *Lancet* 2015

<sup>30</sup> Kanwal R, Kullman G, Piacitelli C, et al. Evaluation of flavorings-related lung disease risk at six microwave popcorn plants. *J Occup Environ Med* 2006

<sup>31</sup> FDA. Generally recognized as safe. 1982; 21 CFR 184.1666, [www.gpo.gov/fdsys/pkg/CFR2000-title21-vol3/pdf/CFR-2000-title21-vol3-sec184-1666.pdf](http://www.gpo.gov/fdsys/pkg/CFR2000-title21-vol3/pdf/CFR-2000-title21-vol3-sec184-1666.pdf) (1982, accessed 3 August 2017)

<sup>32</sup> Niven R, Lynch M, Moutvic R, et al. Safety and toxicology of cyclosporine in propylene glycol after 9-month aerosol exposure to beagle K Farsalinos [journals.sagepub.com/home/tar](http://journals.sagepub.com/home/tar) 15 dogs. *J Aerosol Med Pulm Drug Deliv* 2011

<sup>33</sup> Fuoco, F.C. et al. 2014. Influential parameters on particle concentration and size distribution in the mainstream of e-cigarettes. *Environ. Pollut*

therapies, and the health effects of smoking e-cigarettes, including their impact on the cardiovascular, respiratory, and nervous systems, remain largely unknown.

One of the topics that needs to be discussed is the cost of smoking, both traditional and e-cigarettes. The initial cost of e-cigarettes, including the device and starter kits, is generally higher than a pack of conventional cigarettes. However, the ongoing costs vary significantly. E-cigarettes require periodic purchases of e-liquid and replacement parts, while conventional cigarettes necessitate continuous purchase of cigarette packs. We have to keep in mind the costs of maintaining the device and possibly replacing it when it breaks down or when it's changed for a new one. Several studies have compared the monthly and annual costs of e-cigarette use versus conventional smoking. One study estimated that the average annual cost of e-cigarette use is lower than that of conventional smoking<sup>34</sup>. This is due to the lower cost of e-liquids compared to the price of cigarette packs over time, despite the higher initial investment for e-cigarette devices.

Health-related costs are a significant aspect of the economic comparison. Conventional cigarette smoking is associated with higher healthcare costs due to its well-documented links to numerous diseases such as lung cancer, COPD, and cardiovascular diseases. E-cigarettes, while not without health risks, are generally considered to have lower long-term health costs. One research suggested that widespread adoption of e-cigarettes could potentially reduce overall healthcare costs, although this is contingent on long-term health outcomes that are not yet fully understood<sup>35</sup>.

## *DISCUSSION*

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While e-cigarettes are often promoted as a safer alternative to conventional cigarettes, the evidence suggests that they are not without significant health risks. Conventional cigarettes are associated with a higher risk of severe respiratory, cardiovascular, and oral health issues, as well as greater cellular and molecular damage. E-cigarettes, while presenting lower levels of some harmful constituents, still pose substantial health risks, particularly with long-term use. The economic impact of e-cigarettes versus conventional cigarettes extends beyond individual costs to broader public health and societal costs. E-cigarettes may offer cost savings for

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<sup>34</sup> Levy, D. T., Yuan, Z., Luo, Y., & Abrams, D. B. (2017). The relationship of e-cigarette use to cigarette quit attempts and cessation: Insights from a large, nationally representative U.S. survey. *Nicotine & Tobacco Research*, 20(8), 931-939.

<sup>35</sup> Zhu, S. H., Zhuang, Y. L., Wong, S., Cummins, S. E., & Tedeschi, G. J. (2017). E-cigarette use and associated changes in population smoking cessation: Evidence from US current population surveys. *BMJ*, 358, j3262.

individuals but could also reduce the financial burden on healthcare systems if they lead to lower rates of smoking-related diseases. However, these potential savings must be weighed against the costs of managing new health issues associated with e-cigarette use. Regulation plays a crucial role in the cost dynamics of both e-cigarettes and conventional cigarettes. The findings from this review highlight the need for stringent regulation of e-cigarettes, including quality control of e-liquid ingredients and restrictions on marketing, especially to young people. Further research is necessary to fully understand the long-term health effects of e-cigarettes and to inform public health policies. Taxation on tobacco products is a significant driver of the high cost of conventional cigarettes. Similar regulatory measures on e-cigarettes could influence their economic attractiveness. The ongoing debate about how to tax and regulate e-cigarettes will likely impact their future cost and usage patterns. Given the potential health risks associated with e-cigarette use, public health authorities should consider implementing educational campaigns to raise awareness about these risks. Additionally, healthcare providers should be prepared to counsel patients on the potential dangers of e-cigarette use and provide support for smoking cessation efforts that do not involve e-cigarettes. Public health strategies should consider both the cost and usage patterns of e-cigarettes and conventional cigarettes. While e-cigarettes may provide a less costly and potentially less harmful alternative, their impact on nicotine addiction and public health must be carefully managed. Educational campaigns and regulatory measures should aim to minimize the risks associated with both forms of nicotine consumption while supporting cessation efforts.

## ***SUMMARY***

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E-cigarettes should not be considered a completely safe alternative to traditional smoking. Both e-cigarettes and conventional cigarettes have complex and multifaceted effects on the human body, impacting the respiratory, cardiovascular, immune, and oral health systems, as well as causing cellular and molecular damage. There are doubts about whether they are safer than regular cigarettes or worse, but it is certain that they are not entirely harmless. Debates about their impact on the body are ongoing worldwide; however, there is currently a lack of precise studies to determine the extent of their harmfulness. While e-cigarettes may offer a harm reduction strategy for current smokers, their use is associated with various adverse health outcomes. It is important to remember that they are a relatively new form of substance use, and many aspects related to them are still unknown. E-cigarettes and conventional cigarettes present

distinct usage patterns and cost profiles. E-cigarettes tend to be more popular among younger individuals and are associated with lower annual costs compared to conventional cigarettes, despite higher initial investments. Their contribution to earlier nicotine initiation among young people also raises many controversies regarding their impact on society. Simultaneously, their sale and use are not fully regulated legally in many countries, making their control significantly more difficult. Years of detailed research on larger sample sizes are needed to definitively determine their impact on humans. Comprehensive public health policies, ongoing research, and increased regulation are essential to fully understand and mitigate the risks associated with both forms of nicotine consumption.

## DISCLOSURES

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Conceptualization: Mateusz Janik and Anna Konarska

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