BIEGANEK, Paula, TOKARSKI, Michał and TOKARSKA, Angelika. Vaping and e-cigarette's as a danger of 21st century - overview of the lately reported side effects. Quality in Sport. 2024;20:53810. eISSN 2450-3118.
https://dx.doi.org/10.12775/QS.2024.20.53810
https://apcz.umk.pl/QS/article/view/53810

The journal has been 20 points in the Ministry of Higher Education and Science of Poland parametric evaluation. Annex to the announcement of the Minister of Higher Education and Science of 05.01.2024. No. 32553.
Has a Journal's Unique Identifier: 201398. Scientific disciplines assigned: Economics and finance (Field of social sciences); Management and Quality Sciences (Field of social sciences).
Punkty Ministerialne z 2019 - aktualny rok 20 punktów. Załącznik do komunikatu Ministra Szkolnictwa Wyższego i Nauki z dnia 05.01.2024 r. Lp. 32553. Posiada Unikatowy Identyfikator Czasopisma: 201398.
Przypisane dyscypliny naukowe: Ekonomia i finanse (Dziedzina nauk społecznych); Nauki o zarządzaniu i jakości (Dziedzina nauk społecznych).

The authors declare that there is no conflict of interests regarding the publication of this paper.
Received: 24.07.2024. Revised: 25.07.2024. Accepted: 14.08.2024. Published: 22.08.2024.

Vaping and e-cigarette's as a danger of 21st century - overview of the lately reported side effects

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ABSTRACT

Introduction and purpose: Vaping devices have gained popularity among youth and young adults due to their appealing flavors and the perception that they are less harmful than traditional tobacco cigarette's. However, emerging evidence suggests that vaping may expose users to high level of hazardous chemicals, potentially leading to severe lung injuries and other side effects. The purpose of this review is to look closely to the dangers. The aim of this review is to look closely at the various side effects of vaping and usage of e-cigarette's.

Materials and methods: This article is a literature review based on publications from PubMed and Cochrane Library, keywords included: vaping; e-cigarette's; cardiovascular effect; pulmonary effect; oral health.

The state of knowledge: Smoking is a major contributor to cardiovascular disease (CVD), including atrial fibrillation (AF) and venous thromboembolism (VTE). People who currently smoke have an increased rate of hospitalization for heart failure (HF). The surge in vaping and e-cigarette use has resulted in an epidemic of hospitalizations and fatalities among e-cigarette users due to acute lung injury, a newly identified condition known as e-cigarette or vaping use-associated lung injury (EVALI). Beside cardiovascular and pulmonary effects vaping and e-cigarette's are linked to various immediate and long-term health hazards.

Conclusions: Vaping poses significant health risks, particularly for young people. Side effects include respiratory problems, cardiovascular issues, and an increased risk of nicotine addiction. Additionally, exposure to harmful chemicals in e-cigarette aerosols can lead to long-term health complications. Despite its popularity as a safer alternative to smoking, the negative impacts of vaping are substantial and warrant serious attention and preventive measures.

Key words: vaping; e-cigarett's; cardiovascular effect,;pulmonary effects; oral health

Introduction

The popularity of electronic nicotine delivery systems has surged significantly over the last ten years. E-cigarettes and vaping devices were initially designed as alternatives for conventional tobacco smokers. However, they have seen limited success in smoking cessation and are not approved as cessation tools due to insufficient data proving their efficacy compared to currently approved nicotine replacement therapies. The aerosols produced by e-cigarettes are known to

cause various harmful health effects, though more research and long-term studies are necessary. While electronic devices have undergone four generations of evolution, the formulations of e-liquids have seen countless variations. Manufacturers incorporate hundreds of chemicals into e-liquids to craft flavors that appeal to people of all ages, genders, nationalities, and cultural backgrounds worldwide. This diversity results in an almost limitless array of chemical combinations used in creating the e-liquids found in today's market [1-3]. Although e-cigarettes and vaping products come in various types, they generally function similarly. A reservoir or cartridge holds an e-cigarette liquid (or e-liquid) and is connected to a battery-powered heating metal coil, which generates a mixture of vapor and fine particles (aerosol) inhaled through a mouth. Most e-liquids contain nicotine, often in high concentrations, along with flavoring agents. The solvents for nicotine or flavored products are typically water-based, like propylene glycol, but e-liquids can also be oil-based and include substances like tetrahydrocannabinol (THC), the primary psychoactive component in cannabis. Additionally, they contain small quantities of chemicals and heavy metals, such as acrolein, acetaldehyde, nickel, and lead, which can be toxic or carcinogenic. E-cigarettes are available in various shapes and sizes. Earlier models, which often looked like traditional cigarettes, had limited appeal for young people. The first significant rise in popularity among teenagers happened between 2013 and 2015, driven by the introduction of pen-like and larger, more complex devices available in numerous youth-friendly flavors. A second sharp increase in popularity occurred between 2017 and 2019 with the introduction of small, pod-based devices that use pre-filled cartridges [4,5]. The nicotine content in most e-liquids ranges from 15 to 50 mg/mL. E-cigarettes expose adolescents to nicotine toxicity and the risk of nicotine overdose, as they can absorb large amounts of nicotine in a short period. Youth e-cigarette use is growing in most regions globally. In the United States, the percentage of middle school students (ages 11-14) who reported using e-cigarettes in the past month rose from 0.6% in 2011 to 10.5% in 2019. Among high school students (ages 14-18), this rate increased from 1.5% to 27.5% over the same period. Interestingly, a significant number of e-cigarette users do not limit themselves to a single device or flavor. As a result, they expose themselves to chemicals produced by multiple e-devices and the diverse array of chemicals found in flavored e-liquids they select. This complexity in e-cigarette usage complicates efforts to pinpoint the sources of lung injury and inflammation caused by any specific device or chemical. Furthermore, many e-cigarette users also engage in conventional tobacco smoking, marijuana smoking, or vaping of THC. Each of these substances carries its own set of known and unknown health effects [6-8].

Pulmonary effect

Lung diseases linked to vaping have been documented since the modern electronic cigarette was invented. It was in the summer of 2019 that patients started arriving at healthcare centers in epidemic numbers, suffering from an acute respiratory illness associated with vaping. Pulmonary physiology is adversely affected by inhaling e-cigarette aerosols, leading to heightened airway reactivity, airway obstruction, inflammation, and emphysema [9-10]. Chemicals present in e-cigarette aerosols initially interact with the airways before being absorbed into the bloodstream. Once in circulation, these chemicals come into contact with vascular endothelial cells as they travel to various organ systems, including the heart. In 2019, the raise in popularity on vaping and e-cigarette's led to an epidemic of hospitalizations and fatalities among e-cigarette users due to acute lung injury, a new condition labeled e-cigarette or vaping use-associated lung injury (EVALI). As reported by the CDC on February 18, 2020, 2,807 patients in the USA have been hospitalized with EVALI, and there have been 68 confirmed deaths related to the condition [11-12]. Symptoms of EVALI (e-cigarette or vaping product use-associated lung injury) include difficulty breathing, chest pain, coughing, and coughing up blood. Gastrointestinal symptoms like nausea, vomiting, and abdominal pain, as well as general symptoms such as fever and fatigue, are also common. Patients often show signs of increased heart rate, rapid breathing, fever, and low oxygen levels in the blood [13]. In 2019 the study conducted by Chaumont, van de Borne and others aimed to evaluate the immediate effects of high-wattage electronic cigarette vaping, both with and without nicotine, on biomarkers of lung inflammation, transcutaneous gas tensions, and pulmonary function in young, healthy tobacco smokers. It also assessed the acute impact of nicotine-free vaping on arterial blood gas tensions in heavy smokers suspected of coronary artery disease. Using a single-blind, within-subject design, 25 young tobacco smokers participated in three experimental sessions in random order: sham vaping, and vaping with or without nicotine at 60 watts. Additionally, 20 heavy smokers were involved in an open-label, randomized parallel study, with 10 exposed to sham vaping and 10 to vaping without nicotine. Sham vaping refers to a control procedure used in research studies to mimic the act of vaping without actually exposing participants to the active components of e-cigarettes. In a sham vaping session, participants go through the same motions as they would during actual vaping—such as handling the device, inhaling, and exhaling—but the device either contains no e-liquid or contains a non-active substance. This allows researchers to control for the placebo effect and isolate the impact of the actual e-cigarette components (like nicotine or flavorings) by comparing the effects of sham vaping with those of genuine vaping. In the young tobacco smokers, compared to sham

vaping: 1) Serum club cell protein-16 levels increased after vaping without nicotine (mean ± SE, −0.5 ± 0.2 vs. +1.1 ± 0.3 μg/l, P = 0.013) and vaping with nicotine (+1.2 ± 0.3 μg/l, P = 0.009); 2) Transcutaneous oxygen tension decreased for 60 minutes after vaping without nicotine (lowest point, −0.3 ± 1 vs. −15.3 ± 2.3 mmHg, P < 0.001) and for 80 minutes after vaping with nicotine (lowest point, −19.6 ± 2.8 mmHg, P < 0.001). In heavy smokers, compared to sham vaping, vaping without nicotine reduced arterial oxygen tension for 5 minutes (+5.4 ± 3.3 vs. −5.4 ± 1.9 mmHg, P = 0.012) [14]. Another study conducted by Antoniewicz and Brynedal investigated the immediate effects of inhaling e-cigarette aerosol, with and without nicotine, on vascular and lung function in healthy volunteers. Seventeen healthy participants inhaled e-cigarette aerosol on two separate occasions, with and without nicotine, in a double-blind crossover design. Measurements of blood pressure, heart rate, and arterial stiffness (assessed through pulse wave velocity and pulse wave analysis) were taken at baseline, and then at 0 hours, 2 hours, and 4 hours after exposure. Dynamic spirometry and impulse oscillometry were also performed at these times, and again at 6 hours after exposure. The study found that e-cigarette aerosol with nicotine led to a significant increase in heart rate and arterial stiffness. Additionally, aerosol containing nicotine caused a notable rise in flow resistance, as measured by impulse oscillometry, suggesting obstruction in the conducting airways. Both types of e-cigarette aerosol resulted in elevated blood pressure. The findings indicate that inhaling e-cigarette aerosol with nicotine has immediate effects on both vascular and pulmonary functions, suggesting that long-term use could lead to adverse health outcomes [15,16].

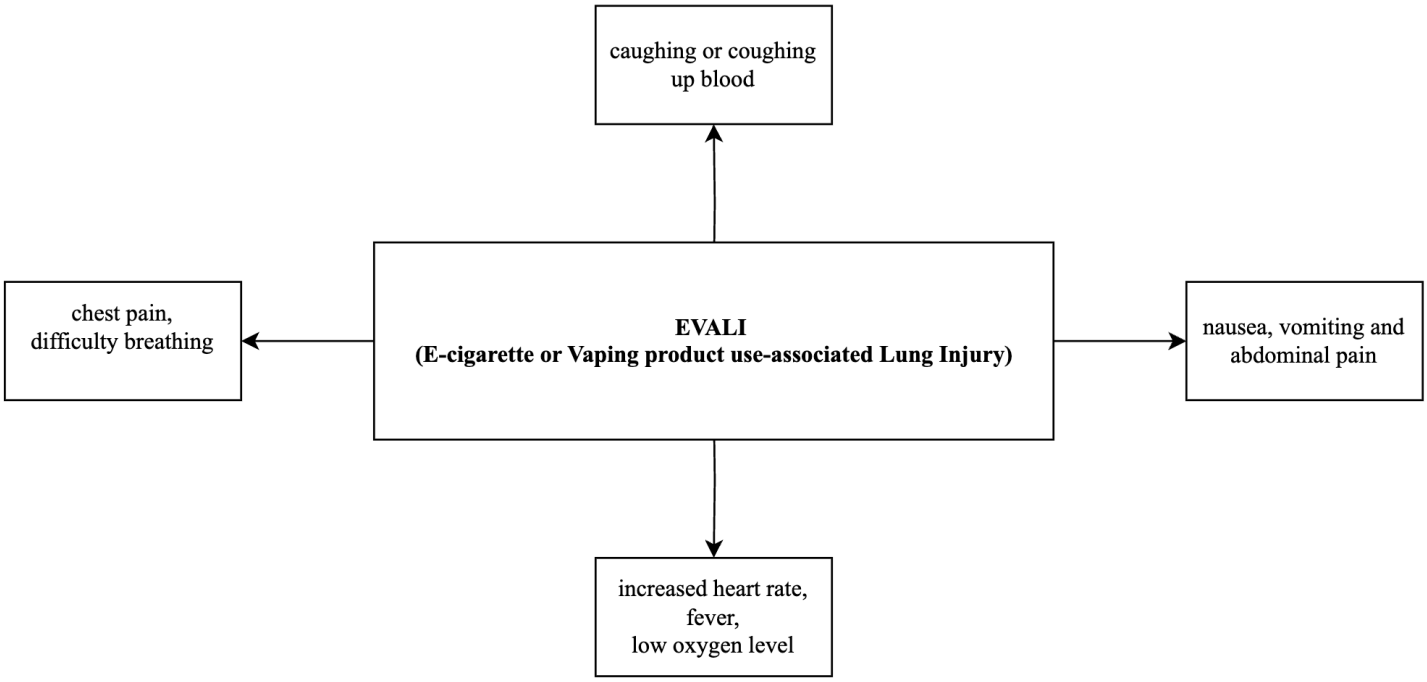

Figure 1. Summary of the symptoms of EVALI.

Cardiovascular effect

Smoking just one cigarette a day significantly raises the risk of developing coronary artery disease (CAD) and stroke. Individuals who smoke only one cigarette daily face 40-50% of the increased cardiovascular disease (CVD) risk compared to those who smoke 20 cigarettes daily. This elevated risk among light smokers is much higher than previously thought. Both active and passive tobacco smoking (secondhand smoke) elevate the occurrence of all stages of atherosclerosis, from endothelial dysfunction to different forms of cardiovascular disease (CVD). Over 7,000 chemicals found in tobacco, including nicotine, tar, and carbon monoxide, contribute to the development of CVD. These chemicals increase heart rate and myocardial contractility, cause inflammation, impair the endothelium, promote thrombus formation, and lower serum levels of high-density lipoprotein cholesterol. Smoking is a leading cause of cardiovascular disease (CVD), including atrial fibrillation (AF) and venous thromboembolism (VTE). Current smokers have a higher rate of hospitalization for heart failure (HF) [17,18]. Smoking contributes to hypertension and metabolic syndrome (MetS), both of which heighten the risk of CVD. There is no evidence so far to suggest that heat-not-burn tobacco products are safer than traditional cigarettes. Completely smoke-free environments safeguard both smokers and non-smokers from CVD [19]. Nicotine stimulates the sympathetic nervous system, directly

affecting the cardiovascular system. It binds to α3β4 nicotinic acetylcholine receptors located in postganglionic sympathetic nerve terminals and the adrenal medulla, leading to the release of catecholamines like norepinephrine and epinephrine. This release activates β-adrenergic receptors in the heart, which raises heart rate, enhances cardiac contractility, and increases the heart's workload. Prolonged overstimulation of the sympathetic nervous system can lead to cardiac remodeling, which contributes to the development of heart failure and increases the risk of arrhythmias [20,21]. In 2019 Jacob George and Muhammad Hussain performed clinical trial which purpose was to determine if switching from regular tobacco cigarettes to electronic cigarettes had any benefits for its users and overall vascular effects. The authors carried out a prospective, randomized controlled trial with an additional parallel nonrandomized preference cohort and a blinded endpoint. The study involved smokers aged 18 and older who had smoked at least 15 cigarettes per day for at least 2 years and had no prior cardiovascular disease. Participants were randomly assigned to use e-cigarettes with nicotine or e-cigarettes without nicotine for a duration of 1 month. Within 1 month of transitioning from traditional cigarettes (TC) to e-cigarettes (EC), there was a notable improvement in endothelial function (linear trend $b = 0.73\%$; 95% confidence interval [CI]: 0.41 to 1.05; $p < 0.0001$; TC vs. EC combined: 1.49%; 95% CI: 0.93 to 2.04; $p < 0.0001$) and a reduction in vascular stiffness (0.529 m/s; 95% CI: 0.946 to 0.112; $p = 0.014$). Female participants experienced greater benefits from switching compared to males in all comparisons. Those who adhered most closely to the switch to e-cigarettes saw the greatest improvements. There was no significant difference in vascular effects between e-cigarettes with nicotine and those without nicotine within the study period [22].

Study	Participant Group	Study Design	Experimental Conditions	Variables Measured	Results
Chaumont, van de Borne et al. [14]	n=45 (25 young tobacco smokers 20 heavy smokers)	Single-blind, within-subject; Open-label, randomized parallel	1) Sham vaping 2)Vaping without nicotine 3)Vaping with nicotine (60 watts)	1) Serum club cell protein-16 (CC16) levels 2)Transcutaneous oxygen tension 3) Arterial oxygen tension	1) Increase in CC16 levels after vaping without nicotine 2) Decrease in transcutaneous oxygen tension after vaping without nicotine 3) Decrease in arterial oxygen tension after vaping without nicotine in heavy smokers
Antoniewicz, Brynedal et al. [15]	n=17	Double-blind, crossover	1) Inhalation of e-cigarette aerosol without nicotine 2) Inhalation of e-cigarette aerosol with nicotine Inhalation of e-cigarette aerosol with nicotine	1) Blood pressure 2) Heart rate 3) Arterial stiffness 4) Dynamic spirometry 5) Impulse oscillometry	1) Increase in heart rate and arterial stiffness after inhalation of aerosol with nicotine 2) Increase in flow resistance after inhalation of aerosol with nicotine 3) Increase in blood pressure after inhalation of aerosol with and without nicotine
George and Hussain [22]	n=114 Smokers who smoked ≥15 cigarettes/day for ≥2 years; no prior cardiovascular disease	Prospective, randomized controlled trial	1) E-cigarettes with nicotine 2) E-cigarettes without nicotine	1) Endothelial function 2) Vascular stiffness	1) Improvement in endothelial function 2) Reduction in vascular stiffness 3) Greater benefits for female participants 4) No significant difference in vascular effects between e-cigarettes with nicotine and those without nicotine

Table 1.Summary of vaping e-cigarette's on respiratory and cardiovascular system

Mental health

Mental health issues associated with vaping, aside from addiction, have often been overlooked. It's possible that mental health effects of vaping have been overshadowed by concerns about its physical impacts. There may also be a tendency to regard smoking as a form of self-medication, which frames the behavior as a secondary issue rather than a primary factor in worsening mental health. These views might be reinforced by smokers 'own perceptions, as they often see smoking as a way to alleviate negative emotions. However, this perceived relief may actually be a result of addressing nicotine withdrawal symptoms rather than an actual improvement in

mental well-being. The adverse effects of combustible tobacco smoking on mental health could largely stem from the systemic inflammation caused by smoking or from related cardiovascular or lung diseases. Vaping, much like smoking, exposes individuals to nicotine and may encourage a passive and emotion-focused coping strategy. An added concern is that some vaping devices could deliver nicotine in higher concentrations than traditional combustible cigarettes, with potential, yet unknown, effects on the developing brain. Growing evidence points to vaping being linked to mental health issues similar to those associated with smoking. Indicators such as mood and anxiety disorders, suicidal thoughts, depressive symptoms, and negatively perceived mental health have all been associated with e-cigarette use. It seems that while we may have swapped one fiery habit for another, the emotional toll might still be burning bright [23-25]. Using nicotine during adolescence can significantly impact brain development and lead to long-term cognitive impairments. Nicotine exposure at this critical developmental stage is known to interfere with brain maturation, potentially causing deficits in memory, attention, and executive functions. These impairments can affect academic performance, problem-solving abilities, and overall cognitive flexibility. Adolescents exposed to nicotine may experience difficulties in maintaining focus, processing information, and making sound decisions due to these developmental disruptions. In addition to these cognitive effects, high nicotine consumption through vaping poses immediate health risks due to nicotine toxicity. Symptoms of nicotine toxicity can manifest in various ways, including headaches, abdominal pain, nausea, vomiting, and heart palpitations. These symptoms reflect the body's response to excessive nicotine levels, which can overstimulate the nervous system and disrupt normal physiological processes. Tremors in the hands and difficulty concentrating are also common, as nicotine can affect the central nervous system's functioning and lead to heightened anxiety and jitteriness [26-28].

Oral health

There is extensive evidence indicating that traditional cigarette smoking is a risk factor for periodontal disease and dental caries. However, research on whether e-cigarettes pose similar risks for dental caries and periodontal diseases remains limited [29]. For heavy smokers, switching from tobacco to ENDS (Electronic Nicotine Delivery Systems) might be less harmful for periodontal health and overall physical well-being, though it is not entirely risk-free. ENDS vapor contains components that are cytotoxic, genotoxic, and carcinogenic, potentially leading to various oral health issues. These chemicals increase the likelihood of tooth decay, periodontal disease, peri-implant complications, and oral mucosal lesions. The nicotine aerosols in ENDS

may pose a risk for oral cancer due to their carcinogenic content. Compared to traditional cigarettes, the risks associated with ENDS might be underestimated. This is due to factors such as the difficulty in regulating vaping behavior, the easy accessibility of ENDS, fewer restrictions on where vaping can occur, and more appealing flavors. While current evidence suggests that ENDS could be a safer alternative to conventional tobacco products, most oral symptoms reported by ENDS users are relatively mild and temporary compared to those experienced by traditional cigarette smokers. However, the potential dangers of ENDS should not be ignored [30, 31].

Conclusion

The adverse effects of vaping on young people are significant and multifaceted. Despite initial perceptions of vaping as a safer alternative to traditional smoking, emerging evidence highlights substantial health risks. Vaping has been linked to respiratory issues, cardiovascular complications, and an increased susceptibility to nicotine addiction. Furthermore, the exposure to potentially toxic and carcinogenic substances found in e-cigarette aerosols poses serious long-term health concerns. The appeal of vaping among youth, driven by enticing flavors and targeted marketing, exacerbates these risks, leading to a disturbing rise in use among adolescents and young adults. This demographic is particularly vulnerable to the negative impacts of nicotine on brain development, which can result in lasting cognitive and behavioral impairments. Given these findings, it is imperative to intensify public health efforts aimed at educating young people about the dangers of vaping. Policymakers, educators, and healthcare providers must collaborate to implement stricter regulations, enhance prevention programs, and provide support for those seeking to quit. Only through comprehensive and proactive measures can we mitigate the harmful effects of vaping and safeguard the health and well-being of our youth.

Statement of the author's contribution

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All authors have read and agreed with the published version of the manuscript.

Funding Statement: The study did not receive special funding
Institutional Review Board Statement: Not applicable
Informed Consent Statement: Not applicable
Conflict of Interest Statement: Not applicable

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