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Review Article

Review of an up-to-date, emphatic, and concise perspective on e-cigarettes

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ABSTRACT

Electronic cigarettes entered the market in 2007 as an alternative to conventional tobacco products, and their use has increased significantly worldwide. Due to the emergence of various harmful effects and attracting attention, their sale was banned in our country and many other countries. However, according to the research, the use of e-cigarettes is increasing rapidly in the world and in Türkiye, and the rate of use at young ages is quite high especially. Its supply can be easily made through online sales on many websites. Despite this growing popularity, little is known about the potential effects of e-cigarettes on human health. This is particularly important in the presence of flavoring compounds, solvents, additives, and other ingredients that are added intentionally or unintentionally and whose long-term effects are uncertain. This is because every day a new product with new ingredients, flavors, and properties is introduced to the market. Previous studies have focused on measuring known toxicants, particularly those found in traditional cigarettes, while fewer have investigated unknown compounds and transformation products formed during the e-cigarette process in these diverse and ever-evolving products. It seems that the e-cigarette market is growing and developing rapidly in our country, as in the whole world, and product sales continue to increase despite all kinds of bans. However, when we look at the literature, the research conducted is insufficient, as mentioned above, and there are points that need to be further emphasized.

Keywords: Analysis of e-cigarette, e-cigarette, e-cigarette compounds, e-cigarette laws

1. INTRODUCTION

The recognition of the detrimental effects of traditional combustion cigarettes has emerged as a significant societal concern in response to the increasing prevalence of non-combustible alternatives, such as electronic cigarettes (e-cigarettes) and heated tobacco products (HTPs). The e-cigarette was created by Herbert A. Gilbert in 1965. In his patent, Gilbert referred to it as a "smokeless non-tobacco cigarette" that serves as a substitute for traditional tobacco and paper combustion by generating heated, moist, and flavoured air [1]. The initial iteration of electronic cigarettes, known as first-generation e-cigarettes, exhibited a striking resemblance to conventional cigarettes. These devices were equipped with a rechargeable battery and an atomizer that housed

a nichrome wire and a filler substance designed to absorb an e-liquid solution. The composition of the e-liquid comprised propylene glycol and glycerol, which were supplemented with nicotine and various flavours. Subsequently, the advent of "second-generation e-cigarettes" occurred. The subsequent iteration of electronic cigarettes exhibited a larger form factor, resembling an instrument rather than adhering to the conventional shape of a tobacco cigarette. The components of the device included a battery and an atomizer, with the latter serving as a reservoir for e-liquid. This e-liquid was commercially available in bottles for the purpose of refilling the device. The smoke emissions of second-generation e-cigarettes were found to be higher in comparison to those of first-generation e-cigarettes. Subsequently, in more recent times, a new iteration of electronic cigarettes, known as third-generation e-cigarettes, has been introduced to the market. Typically, a third-generation electronic cigarette exhibits a substantial physical form and occasionally include batteries that may be adjusted to suit individual preferences. Certain components can be substituted, and the level of electrical power can be adjusted. These devices have the capability to generate a concentrated and voluminous emission of smoke particles, resulting in the formation of a "dense of smoke cloud." Nevertheless, the impact of electronic cigarettes on human health remains uncertain.

Electronic nicotine delivery systems (ENDS), colloquially referred to as electronic cigarettes or e-cigarettes, have gained widespread recognition as a comparatively less deleterious substitute for conventional cigarette smoking since their initial introduction to the market over sixteen years ago. E-cigarettes are composed of many components. These include a cartridge that contains an e-liquid, a heating element atomizer that is essential for heating the e-liquid, hence generating a vapour that can be breathed through a mouthpiece. Additionally, e-cigarettes are equipped with a rechargeable battery (Figure 1) [2]. Both electronic gadgets and various e-liquids can be easily obtained from retail stores or online vendors, and designed to provide nicotine to users. These products function by substituting tobacco with a solution containing nicotine benzoate salt, which is combined with a base of propylene glycol and glycerol. Additionally, e-cigarettes often incorporate various flavouring agents to enhance the user experience. The composition of the base consists of propylene glycol, glycerol, or a combination of both in different ratios, which are then diluted with distilled water [3].

E-liquid commonly consists of humectants and flavourings, which may or may not include nicotine. The mist generated by the sprayer bears resemblance to the act of smoking tobacco and is purportedly devoid of any adverse consequences [4]. Nevertheless, there have been reports indicating that the use of heat can result in the generation of novel breakdown chemicals that may pose potential hazards [5]. The concentration of nicotine, which is

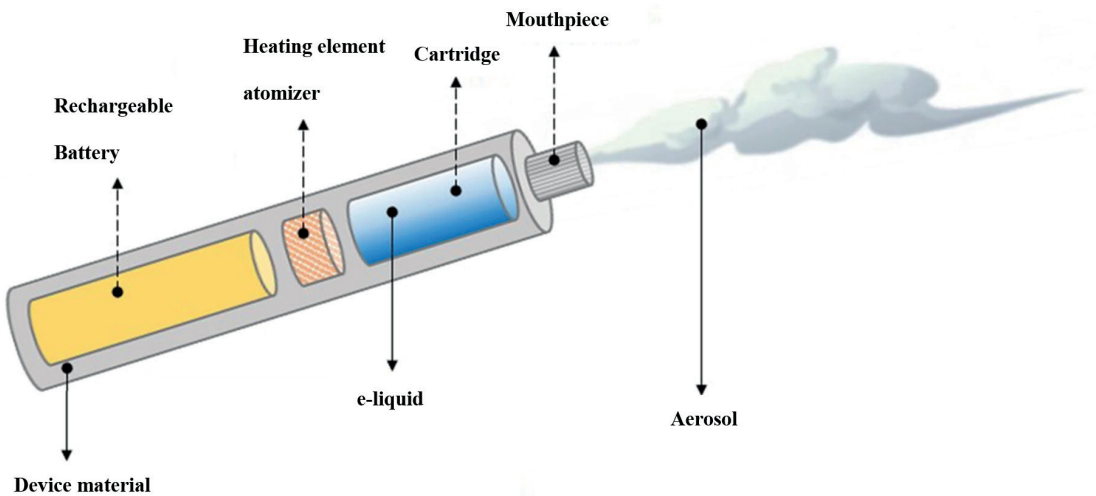

Figure 1. Structure of e-cigarette [2]

the primary addictive substance found in tobacco, exhibits variability between commercially accessible e-liquids, ranging from 0 mg/mL to 41.2 mg/mL [6]. Furthermore, it is worth noting that nicotine-free alternatives are also present in the market. Due to this rationale, electronic cigarettes are frequently regarded as a viable method for smoking cessation, as they have the potential to deter individuals from desiring conventional smoking. Nevertheless, this concept has yet to be substantiated by comprehensive evidence [7,8].

Due to the absence of combustion in e-cigarettes, which is responsible for numerous adverse health effects associated with tobacco usage, there is a prevailing belief that the act of using e-cigarettes, sometimes referred to as "vaping," is comparatively less hazardous than smoking conventional cigarettes [9]. Nevertheless, can they truly be considered devoid of risk? Is there enough toxicological data available for all the constituents utilized in e-liquids? Is the composition of the vapor inhaled during the heating process and its influence on health thoroughly understood? Can electronic cigarettes be utilized to decrease the consumption of tobacco? The questions mentioned do not have answers or waiting to be answered by scientists for the sake of public health, especially the health of adolescents and young people.

1.1. E-Cigarette Usage

The prevalence of combustible cigarette smoking in the United States has witnessed a notable decrease over the course of the last five decades. However, the electronic e-cigarette industry has experienced substantial growth since its launch in 2007 [10]. According to available data, the utilization of e-cigarettes among adults in the year 2018 was recorded at 3.2%, with a higher prevalence of 7.6% observed among young adults aged 18 to 24 years. Notably, the prevalence of e-cigarette use among high school students experienced a substantial rise from 1.5% in 2011 to a significant 27.5% by 2019 [10]. This increase in e-cigarette usage surpassed the prevalence of conventional cigarette use among the youth population. In 2019, over 30% of high school students in the United States disclosed their utilization of electronic cigarettes. Based on the findings of the "E-cigarette and Vape Market Size Report 2022-2030," it is evident that the global market for e-cigarettes and vapes reached a valuation of USD 18.13 billion in 2021. Furthermore, it is projected to exhibit a compound annual growth rate of 30.0% during the period from 2022 to 2030 [11]. The present paper is notable for its comprehensive analysis of the magnitude and potential of the e-cigarette industry. Additionally, the Center for Disease Control and Prevention (CDC) has provided data indicating that in the year 2020, approximately 20% of high school students and 5% of middle school students disclosed their engagement in e-cigarette usage [12]. In recent years, there has been a growing prevalence of electronic cigarette usage among young individuals. A research study including a sample size of 14,352 university students hailing from Belarus, Lithuania, Poland, Russia, and Slovakia revealed that a proportion of 1.1% of the respondents acknowledged using electronic cigarettes [13]. According to a study conducted in Canada, the prevalence of e-cigarette usage was found to be 6.5% [14]. Likewise, there have been reports indicating that in China, while the prevalence of traditional cigarette smoking has declined among adolescents, there has been a notable rise in the prevalence of current e-cigarette use. Specifically, among junior high school students, the rate of e-cigarette use increased from 1.2% in 2014 to 2.7% in 2019. Furthermore, among senior high school students, the rate of e-cigarette use experienced a 3.0% increase by 2019 [15]. As a result, a recent study estimated the number of vapers in the world to be 68 million by 2020 [16].

1.2. E-cigarette Usage in Türkiye

The introduction of e-cigarettes to the Turkish market commenced in 2007, with their distribution being facilitated through various channels such as media advertisements and direct marketing strategies. Nevertheless, it is worth noting that research conducted on e-cigarettes in Türkiye predominantly focuses on the adult population [17-19]. According to recent studies, the prevalence of e-cigarette usage among Turkish students stands at 2.9%, while among individuals aged 18 years and above, the rate is reported to be 19% [18]. Within the existing body of

literature, a notable absence of studies investigating the prevalence and utilization of electronic cigarettes among adolescents in Türkiye was observed.

The adolescent population is a significant demographic that the tobacco industry actively seeks to engage in Türkiye. Based on the findings of the 2017 Global Youth Tobacco Survey, it was observed that the overall prevalence of smoking among individuals aged 13-15 years is 7.7%. Further analysis revealed that the prevalence of smoking is 9.9% among males and 5.3% among females within this age group [19]. The researchers conducted on high school students in Türkiye was documented varying rates of smoking prevalence, ranging from 13.4% to 35.7% [20]. The tobacco business endeavors to sustain reliance on the novel goods it releases into the market.

Consequently, most individuals commenced utilizing electronic cigarettes to cease their smoking habit. While individuals first choose electronic cigarettes to cease smoking, the efficacy of electronic cigarettes in facilitating smoking cessation remains uncertain. The proliferation of electronic cigarette commercials, along with the online selling and marketing of these products, has led to a significant expansion in their usage. When an e-liquid purchase is typed in Turkish into the Google search engine, many products appear on the screen and can be easily purchased via e-shopping. Figure 2 shows an example purchase search. Hence, it is imperative to implement public health safeguards and procedures. The growing prevalence of e-cigarette usage, sometimes referred to as vaping, particularly among the younger population and individuals who have never smoked, is also generating apprehension around potential exposure to hazardous compounds.

1.3. E-Cigarette Products

E-cigarette devices work by heating a liquid mixture (e-liquid) with a metallic coil to produce a fine aerosol that the user inhales. The e-cigarette device is a device that can be used for a long time. The liquids filled in it are materials that are constantly consumed. E-liquid typically contains propylene glycol, glycerol, nicotine, flavourings, and other chemicals. Cinnamaldehyde, benzaldehyde, ethyl vanillin, ethyl maltol, and vanillin are specific chemicals that have been linked to cytotoxic effects on respiratory cells [21]. Diacetyl and acetylpropionyl, which can be found in e-cigarettes, have been linked to lung diseases. Ethyl maltol, the most commonly used flavouring agent, can be found in toxic concentrations [22]. Many flavouring chemicals are present in e-liquids, and some chemicals produce aldehydes by thermal decomposition [23].

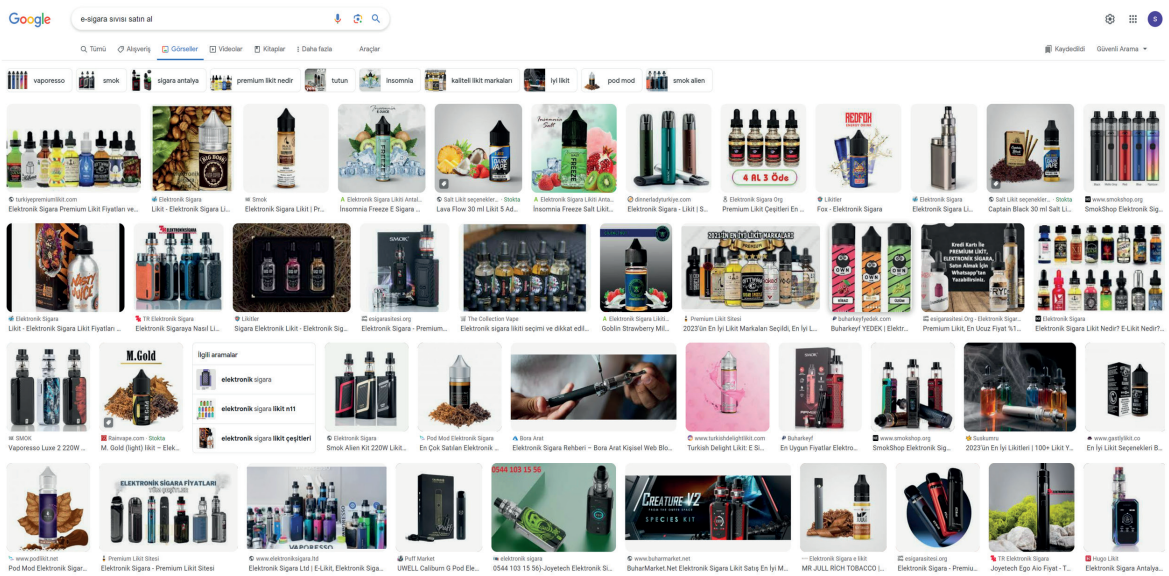

Figure 2. An example purchase search in Türkiye (Date of access: 21 September 2023).

The potential health risk is difficult because the concentration of flavouring chemicals is unknown. Manufacturers are not required to report chemicals or concentrations, and FDA regulations do not recommend guidelines for e-cigarette ingredients. However, information on chemical additives is typically not disclosed by manufacturers. Therefore, aerosols inhaled during e-cigarette use are complex mixtures of solvents and additives, as well as compounds formed during the e-cigarette process. Numerous brands of e-cigarette devices and a wide variety of e-liquid formulations, including more than 8,000 e-liquid flavors, are commercially available, and new e-cigarette devices and liquids are proliferating rapidly [24,25]. Although e-cigarettes have been proposed as a reduced-harm alternative to traditional tobacco-based products due to the reduced presence of well-studied toxicants produced during tobacco combustion, studies have begun to suggest that e-cigarette use has risks associated with vaping, such as lung injury, respiratory dysfunction, inhalation of carcinogenic carbonyls, and changes in gene expression [5]. Furthermore, since e-cigarette emissions are not completely inhaled, there is a potential for witness or secondary exposure to non-users from exhaled aerosols entering the environment [26]. Recent research has also provided insights into how e-cigarette components and emissions affect indoor air quality and exposure pathways [27,28].

The current state of e-cigarette marketing, focusing specifically on promotional methods and themes employed on social media platforms. The study confirmed the utilization of promotional tactics that are consistently employed by the e-cigarette industry, such as price promotions, the incorporation of youth-appealing themes, the inclusion of various flavors, and the utilization of celebrity/influencer marketing [29,30]. Additionally, the other study identified emerging promotional strategies, including the establishment or promotion of pro-vape communities through the use of vape community- and identity-related hashtags, as well as the incentivization of friend tagging [31]. It has been proposed that there is a necessity for implementing limitations on the marketing of e-cigarettes on social media platforms [32]. This measure aims to mitigate the influence of social media in promoting the commencement of e-cigarette use among young individuals and reinforcing their behavioral patterns. The implementation of restrictions should encompass the prohibition of promotional content related to e-cigarettes on social media platforms, specifically targeting individuals who are underage [30]. Additionally, it is imperative to enforce the inclusion of warning labels on pro-e-cigarette information disseminated through social media channels. Furthermore, it is crucial to develop and disseminate counter-messaging initiatives on social media platforms with the aim of deterring the use of e-cigarettes among young individuals and adults in this age group [31].

1.4. Laws of E-Cigarettes

The establishment of a list containing 93 “harmful and potentially harmful ingredients” (HPHCs) in cigarette smoke, cigarette filler, and smokeless tobacco products was undertaken by the US Food and Drug Administration (FDA) in 2012 and [33]. The draught guidance of Section 904(a)(3) of the Federal Food, Drug, and Cosmetic Act (FD&C Act) provided specific information regarding a representative subset of 20 Harmful and Potentially Harmful Constituents (HPHCs) that tobacco product makers are required to disclose [34]. Today, it continues to work to provide an adequate and sufficiently broad perspective on e-cigarette (Figure 3). It is important to note that this reporting requirement applies solely to combustible tobacco products. Furthermore, the Premarket Tobacco Products Applications for Electronic Nicotine Delivery (PMTA) guideline under Section 910 of the FD&C Act draught guidance specifies a total of 29 Harmful and Potentially Harmful Constituents (HPHCs) [35]. The concept of “ends” refers to the ultimate goals or objectives that individuals or organizations strive The Tobacco Products Directive (TPD) 2014/14/EU5 was implemented on May 4, 2016, with the aim of establishing regulations for nicotine-containing electronic cigarettes and refill boxes (Article 20). These regulations were put in place to safeguard human health and ensure compliance with the World Health Organization’s Framework Convention on Tobacco Control, as mandated by the European Union. The enforcement

Figure 3. FDA's webpage on e-cigarette (Date of access: 21 September 2023).

of the majority of rules outlined in Article 20 is carried out by the Medicines and Healthcare Products Regulatory Agency (MHRA) in the United Kingdom [36]. The transposition of the European Union Tobacco Products Directive (EU TPD) into the national legislation of other member states within the EU has been carried out, accompanied by the establishment of competent authorities responsible for its enforcement and supervision [37].

In 2020, FDA implemented sales limitations within the United States; however, these policies were limited in scope, targeting specific flavours and items [38]. Due to the presence of heterogeneity, complexity, and limited transparency in relation to e-cigarette products, there exists a lack of comprehensive understanding regarding the exposures resulting from e-cigarette usage. Consequently, predicting the health consequences associated with such usage becomes a challenging task, as exemplified by the EVALI outbreak in 2019, which was characterized by lung injuries linked to the use of e-cigarette or vaping products [39]. Given the increasing number of individuals utilizing e-cigarettes, the mounting proof linking e-cigarette usage to elevated smoking rates, and the absence of prior governmental oversight, there exists a substantial imperative to establish regulations pertaining to present e-cigarette utilization [40]. Certainly, it is imperative to address the existing knowledge gaps pertaining to chemistry, toxicological, as well as clinical and behavioral patterns in order to enhance our understanding of e-cigarette consumer safety and associated dangers [41]. Nevertheless, our current understanding of the comprehensive chemical composition of the vapor generated during the act of vaping, as well as the intricate mechanisms responsible to produce these substances, remains incomplete. In addition, the extensive assortment of e-cigarette products and diverse range of flavor offered on the market, along with frequent product modifications resulting from the growing popularity of e-cigarettes, pose considerable obstacles in conducting research on e-cigarettes and forecasting potential risks for users [16].

Based on recent developments, Mayor London Breed has officially enacted a municipal regulation that effectively prohibits the commercial transaction of electronic cigarettes within the jurisdiction of

San Francisco, located in the state of California, United States of America [42]. According to the World Health Organization, the utilization of nicotine-containing goods, including Electronic Nicotine Delivery Systems (ENDS), is deemed dangerous for young individuals and pregnant women [43]. The demise of an individual who had engaged in the usage of electronic cigarettes and had been admitted to a medical facility due to a grave respiratory ailment was recently documented by the Illinois Department of Public Health (IDPH) [44]. Ongoing investigations are being conducted by the Center for illness Control and Prevention (CDC) and FDA into the prevalence of severe lung illness among individuals who use electronic cigarettes [45]. According to the CDC, there have been a total of 380 documented occurrences of lung disease linked to the utilization of e-cigarette products throughout 36 states and one United States territory [46]. Additionally, six fatalities have been reported in the states of California, Illinois, Indiana, Kansas, Minnesota, and Oregon [46]. The Pharmaceuticals and Medical Devices Act prohibits the selling of e-liquids containing nicotine in Japan [47]. In 2008, the Ministry of Health in Türkiye made a rule to classify e-cigarette cartridges as pharmaceuticals and e-cigarette machines as medical equipment, mostly due to their elevated nicotine levels. Consequently, these entities are not eligible for inclusion within the framework of free trade. Both e-cigarettes and heated tobacco are tobacco products that have been found to have detrimental effects on human health. The year 2013 witnessed the implementation of a comprehensive set of regulations in Türkiye, which included the prohibition of e-cigarette advertising, smoking, and sales within enclosed spaces. The publication of Law No. 2149 on 'Electronic Cigarettes and Similar Devices and Certain Tobacco Products and Imitation Tobacco Products' occurred on February 25, 2020.

1.5. Analysis of E-Cigarette

It is evident that electronic cigarettes possess the potential to cause harm to the human body, even in the absence of nicotine. To date, a variety of well-documented hazardous substances, including as metals, carbonyls, free radicals, and phthalates, have been found and quantified in e-liquids and aerosols [36,48]. Several carbonyl compounds, including formaldehyde, acetaldehyde, and acrolein, have been identified in the emissions of electronic cigarettes. E-cigarettes have been documented to contain hazardous substances, including nitrosamines and diethylene glycol, which have the potential to cause adverse effects on human health. Aerosols emitted from electronic cigarettes have been found to include carcinogens and hazardous substances, including carbonyl compounds. Additionally, there have been reports indicating the presence and impact of carbonyl compounds and free radical generation in e-cigarette smoke. The length, volume, and generation of radicals during respiration are somewhat influenced by aerosol creation at elevated temperatures. However, it has been noted that excessively high levels of free radicals are detected at temperatures ≥100 °C, even when aerosol production is limited [49]. The manufacturing of aerosols and chemicals is contingent upon the availability of electrical power. When considering the power applied to the coil, the quantity of aerosols generated per puff varies between 0.27 and 1.1 mg/watt [50]. In relation to the initial and subsequent iterations of electronic cigarettes, it has been shown that these devices inadvertently generate carbonyl chemicals within the emitted vapor [51]. One potential factor contributing to the generation of carbonyl compounds is the process of liquid oxidation within electronic cigarettes. One potential factor contributing to the creation of carbonyl compounds is the oxidation process that occurs when certain liquids, such as GLY and PO, meet the heated nichrome wire in the atomizer of e-cigarettes. This contact leads to the conversion of these liquids into various carbonyl compounds, including formaldehyde, acetaldehyde, acrolein, glyoxal, and methylglyoxal. Moreover, the emission of e-cigarette aerosol is augmented by elevating the applied voltage from 3.2 to 4.4 V. Carbonyl compounds are synthesized when voltages beyond the threshold of 4 V, and their concentration exhibits a significant augmentation at 4.8 V. The observed values of carbonyl compounds exhibit variations among the five items as well as within the three assays conducted for each product. Dicarbonyl compounds, including glyoxal and methylglyoxal,

as well as oxide compounds like as propylene oxide and glycidol, are suggested for the purpose of thermally decomposing e-liquid. Nevertheless, there is a scarcity of analytical findings pertaining to these chemicals [52].

The primary focus of previous research on e-cigarette exposure has been to measure the quantities of specific elements that are commonly found in high concentrations in e-liquids, notably those present in combustible cigarettes [53]. The analyzes of these compounds in aerosols and the method used are summarized in Table 1. These compounds include tobacco alkaloids, polycyclic aromatic hydrocarbons, and formaldehyde [54,55]. Nevertheless, an increasing body of research has also examined chemicals that are special to e-cigarettes. These include substances that are produced through the breakdown of solvents found in e-liquid [56,57], impurities [2] and flavorings originating from the packing of e-liquid [48], and components of e-cigarette devices [58].

The assessment of chemical exposures from electronic cigarettes necessitates the identification of both recognized toxicants and unknown compounds present in e-cigarette aerosols. These unknown chemicals encompass unreported additives, transformation products, and pollutants that are produced during the vaping process. To facilitate proper regulatory measures and mitigate inadvertent dangers to those using e-cigarettes, it is imperative to possess a thorough comprehension of chemical exposures. Prior research has primarily concentrated on the quantification of established harmful substances, specifically those present in conventional cigarettes. However, there is a scarcity of studies examining unidentified compounds and the byproducts generated during the act of vaping, particularly in relation to the wide range of constantly evolving vaping devices. Previous investigations utilizing Gas Chromatography (GC) in conjunction with quadrupole or time-of-flight mass spectrometry have mostly concentrated on the characterization and detection of semi-volatile and volatile constituents within e-cigarette samples [59,60]. Also, the new studies have drawn attention to a very important point. They conducted quantitative analysis of various types of cannabinoids [61] in e-cigarettes and proved that there are products on the market that contain such compounds [62-64]. The application of Liquid Chromatography combined with Electrospray Ionization (ESI) High-Resolution Mass Spectrometry (LC-HRMS) has been employed for the qualitative examination of industrial chemicals, next generation insecticides, food additives, and pharmaceuticals. Furthermore, the utilization of LC-HRMS for off-target analysis offers notable advantages in terms of mass accuracy, sensitivity, and specificity owing to its exceptional resolving power [56,57]. Consequently, this technology is well-suited for sophisticated chemical fingerprinting applications. The integration of this comprehensive methodology has been previously employed for the detection and characterization of organic chemicals

Table 1. Puffing of EC generates smoke [53]

Volatile organic compounds	Carbonyls	Tobacco-specific nitrosamines	Polycyclic aromatic hydrocarbons/ phthalates	Heavy metals	Nicotine	Flavoring compound
GC-FID	HS-GC-MS	GC-MS	GC-MS	ICP-OES	GC-MS	GC-FID
GC-PID	SPME-GC-MS	LC-MS/MS	SIM-GCMS	ICP-MS	GC-NPD	TD-GC-MS
GC-MS	HPLC-UV	UPLC-MS	LC-MS		GC-NSD	
GC-IT-MS	HPLC-DAD		LC-MS/MS		GC-FID	
HS-GC-MS					GC-TSD	
TD-GC-MS					HS-SPME/GC-MS	
SPME-GC-MS					VUV-AMS	
SIFT-MS					TD-CGC-NPD	
					HPLC-UV	

in bodily fluids such as urine and blood, as well as in various environmental matrices including wastewater, food, and plant samples. However, its application to the study of e-cigarette samples has not yet been explored [65-67].

In conclusion, there are methods available in the literature that can analyze quantitatively various compounds of proven risk in cigarette analysis with high accuracy and precision. However, the main and most important question is what exactly is in these products that are legally restricted but frequently encountered on social media, the internet and sometimes on the street? What do individuals inhale in these products? What is the result of combustion in these products? The most important and dangerous question is what is added to the products that come up with a new flavor every day during the production process? Which banned substances do e-cigarettes make more accessible to users? These are the main questions that we scientists often need to answer. E-cigarettes appear every day under a different cover and present dangers that can cause irreversible damage to public health, especially the health of young people. Therefore, we urge analysts to look at the analysis of these substances with more intensity and effort.

2. CONCLUSION

The utilization of e-cigarettes has emerged as a subject of public health discourse both within the United States and on a global scale. Although e-cigarettes have the potential to aid in smoking cessation, their utilization is associated with heightened health hazards and an increased likelihood of addiction, particularly among adolescents. Numerous legislative measures at the federal, state, and local levels have exerted an influence on the realm of tobacco retailing, with a specific focus on the domain of electronic cigarettes. Nevertheless, the existence of legal loopholes and the increased availability of these products due to globalization contribute to their accessibility. Undoubtedly, a salient consideration pertains to the inherent lack of control associated with social media advertisements. It is advantageous to highlight public health concerns pertaining to various aspects, including the accessibility of tobacco products to young individuals, the exposure of consumers to a diverse array of tobacco products and marketing strategies within retail environments where they may seek smoking cessation aids, the exposure of consumers to unregulated or inadequate products, and the potential undermining of federal, state, and local regulations due to consumer access to prohibited products through online platforms and mail services.

Currently, the number of recognized compounds included in e-liquids and aerosols exceeds 400, with concerns regarding the existence of numerous yet unidentified constituents. The way these substances are incorporated into the production process, combined with other constituents, or introduced through alternative means remains uncertain. Although several substances included in this study are deemed to be safe for consumption, the potential effects of inhaling these chemicals remain uncertain. It is evident that certain factors have the potential to induce a range of health complications. The designation of inhalation of these compounds as an alternative route of exposure is justified and necessitates additional evaluation of their toxicity.

The endorsement of electronic cigarettes as a viable substitute for traditional cigarettes lacks formal validation. The presence of compounds inside aerosols can give rise to the potential hazard of second-hand exposure. The potential prolongation of industry regulation could result in the inadvertent exposure of a significant number of individuals to unfamiliar substances, so subjecting them to health risks that are yet undetermined. Although many compounds found in e-liquids are deemed acceptable for oral use, there exists a dearth of scientific investigation about their potential health implications when inhaled. Exposure to these substances by inhalation is expected to be correlated with various outcomes. The designation of chemicals as unique exposures and the need for urgent investigation is justified by this route of exposure. It is advisable to conduct additional comprehensive analyses to identify and quantify the ingredients. This is crucial to prevent the widespread adoption of these products, which

has led to a significant increase in nicotine addiction among the youth and has been associated with the recent surge in respiratory illnesses. It is imperative to exercise prudence in this matter.

Author contribution

Concept: SÖ, EGÖ; Design: SÖ, NÖC; Supervision: SL, NÖC; Data Collection and/or Processing: SÖ, SL; EGÖ; Literature Search: SÖ, SL; Writing: SÖ; EGÖ; Critical Reviews: SL, NÖC.

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Conflict of interest

The authors declared that there is no conflict of interest.

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