Review

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Exploring the Practice of Dual Vaping: Health Risks and Behavioral Patterns in Nicotine and Cannabis E-Cigarette Users

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Abstract: Background: E-cigarettes, initially designed for nicotine consumption, are now increasingly being used to smoke cannabis, resulting in a growing trend known as "dual vaping." This term describes individuals, referred to as "dual users," who use e-cigarettes for both substances. This study aims to review and analyse existing research on dual vaping, with a focus on the associated health risks and behavioral patterns. **Methods:** A systematic search on PubMed was performed up to August 2023. Studies investigating individuals who use electronic cigarettes for vaping tobacco and cannabis, either chronically or episodically, were included. Articles that met the inclusion criteria were thoroughly reviewed and analysed. **Results:** A total of 1,778 studies were screened, of which 53 articles were reviewed, and 25 met the inclusion criteria. Four main characteristics emerged: the demographic variables of users, their health risks, behaviours, and predisposing factors to smoking. Dual Vaping was found to be prevalent among younger men, White and Hispanic populations, and individuals with higher economic status and educational level. The use of one substance was shown to predispose individuals to the use of the other, often leading to concurrent use of both substances. Peer influence and positive expectations regarding e-cigarettes were identified as significant predictors of dual use. Dual Vapers exhibited a higher susceptibility to respiratory and systemic symptoms compared to those who exclusively vaped nicotine or cannabis. Moreover, a notable prevalence of psychiatric disorders, such as substance use disorders, anxiety, and depression, was observed in this group. Fruit-flavored e-cigarettes were the most preferred option among Dual Vapers when using both nicotine and cannabis. **Conclusion:** Current evidence is insufficient to fully elucidate the long-term impacts of dual vaping on physical and mental health, particularly when compared to individuals who have never vaped. Further studies are needed to gain a more comprehensive understanding of this behaviour.

Keywords: E-cigarette; vaping; dual vaping; cannabis use; tabacco use

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1. Introduction

Electronic Cigarettes (also known as e-cigarettes, e-cigs, vapes) were first developed in China in 2003 and later disseminated to other Western countries with the aim of aiding cigarette users in smoking cessation. However, recent meta-analyses have shown minimal effectiveness of e-cigarettes for this purpose and have also raised concerns about their safety [1,2]. Most electronic cigarettes vaporize a mixture known as "e-liquid" or "juice", which typically contains nicotine, glycerine or propylene glycol, and a flavouring agent [3]. The use of the devices for smoking cannabis has gained popularity, leading to a significant rise in individuals who use vapes for both cannabis and tobacco, a practice referred to as Dual Vaping [3,4].

1.1. Generations of Electronic Smoking Devices

Since their introduction on the market, electronic cigarettes have undergone several modifications in their appearance, design, battery power, atomizers, and nicotine delivery systems. Today, four generations are recognized [5,6]: a) devices shaped like a traditional cigarette, featuring an atomizer that produce aerosol by heating the juice, thereby avoiding tobacco from combustion; b) pen style devices with an atomizer and a larger tank compared to the first generation; c) devices with even a larger tanks, adjustable batteries, allowing voltage and power variation by the user; d) the latest and most popular models, which are refillable.

1.2. The Use of Cannabis in Devices

A survey conducted among university students in the United States (US) revealed that the majority of individuals who used e-cigarettes to vaporize a substance other than nicotine reported using cannabis use or its derivatives [3]. The addition of fragrant flavors enables users to discreetly smoke tetrahydrocannabinol (THC), masking the characteristic odor of traditional cannabis cigarettes [7]. This compound is often consumed through vapes in the form of hash oil (a highly concentrated D-9-tetracannabidiol) or dried cannabis buds and leaves [8]. In a single session, users can inhale up to 50 mg of THC, compared to approximately 12mg delivered by a typical marijuana joint [9]. Rapid THC delivery and higher quantities increase the risk of hallucinations, psychosis, cannabinoid hyperemesis syndrome, as well as mental health and behavioural disorders [9].

1.3. The Use of Cannabis and Tobacco

There is sufficient evidence supporting the bidirectional association between tobacco smoking and cannabis smoking [10,11]. According to Mattinglyet al., this association is also confirmed between nicotine and cannabis vaping [12]. This may be explained by the interplay between the endocannabinoid and nicotine systems, partly due to the proximity of their receptors in the reward system, including the midbrain, hippocampus, and amygdala [13]. Although most individuals vape nicotine and cannabis separately, the practice of mixing these substances in the same liquid has been growing, especially among young people [12]. Combined use is associated with a greater risk of respiratory discomfort, physical and mental health problems, increased cannabis dependence, and greater difficulty in quitting both substances when compared to using just one [4,11].

1.4. Harmful Effects of Electronic Cigarettes

THC vaping is strongly associated to the development of the E-cigarette or Vaping Use-Associated Lung Injury (EVALI), a clinical condition responsible for a public health crisis in the US in 2020, resulting inthe hospitalization of 2,807 people with 68 deaths [14]. One potential causal agent of the EVALI is vitamin E acetate, used as a thickening agent in homemade THC e-liquid sold on the black market [15]. Most patients with EVALI report respiratory symptoms, such as cough, dyspnea, and chest pain, along with gastrointestinal and constitutional symptoms [16]. Computed tomography typically reveals bilateral ground-glass opacities in the lungs, with pneumomediastinum, pleural effusion, and pneumothorax reported as possible complications [17].

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E-cigarettes may also alter the human immune system by decreasing B lymphocytes counts and inducing a pro-inflammatory state in the airways, increasing the risk of respiratory infections [18]. A similar pro-inflammatory state may occur in the perioral region, leading to changes in the oral microbiota and deterioration of periodontal, dental, and gingival health [19].

The vaporization of e-liquid produces fine particulate matter, similar to tobacco-combustion products, potentially increasing the risk of platelets aggregation and cardiovascular diseases [20]. Furthermore, research evidence suggests harmful effects of vaping on endothelial function and arterial thickness, which increase the long-term risk of coronary events [21].

During vaporization, trace metals that are potential carcinogens, such as nickel, chromium, cadmium, aluminium, and lead, can leach from the atomizer into the e-liquid and be inhaled [22]. However, as this technology is relatively recent, there is no confirmed evidence yet linking electronic cigarettes use to the development of cancer.

The increasing use of electronic cigarettes, particularly for dual vaping of tobacco and cannabis, presents emerging health risks that are not yet fully understood. This study aims to synthesise current evidence on dual vaping, its health impacts, and predisposing factors, contributing to the understanding of its public health implications.

2. Materials and Methods

This systematic literature review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines [23]. The protocol for this review was registered on Open Science Framework (OSF) Registries on November 28, 2023: https://osf.io/gsazv.

2.1. Search Strategy and Eligibility Criteria

A systematic search was performed on PubMed database, between February 12th and August 6th, 2023, using the following keywords: (cannabis OR marijuana OR cannabinoids OR cannabidiol OR thc) AND (tobacco OR nicotine) AND (vape OR vaping OR electronic OR e-cigarette OR pods OR juice).

Eligible studies included those involving humans and evaluating chronic or episodic use of tobacco and cannabis via electronic cigarettes. Articles were included if written in Portuguese, English, French, Spanish, or Italian. Reviews, comments, editorials, case reports, and studies in animals or in vitro were excluded.

2.2. Study Selection and Data Extraction

The first and last authors independently screened the titles and abstracts of all studies identified during the search. The full-texts manuscripts of studies that passed the initial screening were subsequently reviewed. Any disagreements during the screening process were resolved through discussion between the authors. Data extraction was performed by the first author and reviewed by the second author. The extracted data included: (1) title, (2) year of publication, (3) country, (4) sample size and age, (5) type of study and methods, (6) main findings, and (7) limitations.

3. Results

The search identified 1,778 records on PubMed **(**Figure 1**)**. After an initial screening of titles and abstracts, 53 articles were selected for full-text review. Of these, 25 studies met the inclusion criteria and were included in this review. The selected articles focused on four themes: user demographics, health risks, behaviours, and predisposition to nicotine and cannabis co-use.

Study characteristics are reported in Table 1. Most studies were carried out in the US, with combined sample size of 424,116 participants, ranging in age from 12 to 86 years. All studies were published between 2019 and 2023.

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3.1. Demographics of Users

Uddin et al. (2020) analysed the differences between three groups of vapers: dual (nicotine and cannabis), predominantly nicotine, and predominantly cannabis users.24 They found an association between dual vaping and increasing age compared to nicotine-predominant vaping (dual users = 17.2% aged 18-24 years, 19.7% aged 45-69 years; nicotine-predominant users = 33.2% aged 18-24 years, 23.7% aged 45-69 years). Most users across all the three categories were men (58.5% in the dual use group), had an educational background, and reported a family income above the poverty line. Among dual vapers, the majority were White (54.0%), followed by Hispanics (27.1%), Blacks individuals (14.9%), and other groups (4.00%).

Watson et al. (2020) analysed 3,980 dual vapers and, in contrast, found a higher prevalence of women (53.5%) with an average age of 36 years. The majority of their sample (28.8%) was aged between 25 and 34 years.25 However, they reported a high prevalence of White participants (71.0%), followed by Hispanics (11.0%) and Blacks (10.0%).

Young-Wolff et al. (2021) studied 363 adolescents aged 12-17 years in Northern California and found that 40% were dual vapers [26]. Most were male (66.7%), and the most prevalent ethnicities were non-Hispanic Whites (53.7%), Hispanics (23.1%), and Asians and Pacific Islanders (19.0%). Adolescents with a higher family income were more likely to use vaping ($80,000–$120,000, aORs=2.05–3.34; >$120K, aORs=3.68–9.48) compared to those with a family income of less than 80,000 dollars.

Saran et al. (2022) conducted an online survey with 503 vape-users in the US and identified 357 dual users [27]. Among these, men were predominant (63.2%), and most were Whites (87.4%). This study reported that 78.4% of dual users were married or living with a partner, 81.1% identified as heterosexual, 77.5% had reported a bachelor's degree or higher, 90.2% held a full-time job, and 83.7%) were current cigarette smokers.

3.2. EVALI

Werner et al. (2020) studied the reports of EVALI submitted to the Center for Disease Control and Prevention (CDC) up to January 2020, which included 60 fatal and 2,558 non-fatal cases [28]. Non-exclusive THC vapers accounted for 67% of fatal cases and 79% of non-fatal cases. Non-exclusive nicotine vapers represented 56% and 55%, respectively. Dual vapers represented 27% of fatal cases and 40% of non-fatal cases. Finally, 4% and 6% of cases involved individuals who did not vape any substances.

Blount et al. (2020) analysed bronchoalveolar fluid from 51 hospitalised patients with a confirmed or probable diagnosis of EVALI. Among them, 77% reported vaping cannabis, 67% nicotine, and 51% both substances [29]. A higher prevalence of THC vaping among EVALI patients (86%, n = 1,604) was observed in the report by Moritz et al. (2019) [30]. Other studies have reported somewhat conflicting results regarding the higher prevalence of EVALI between cannabis-only vapers and dual vapers.

Lewis et al. (2019) examined 53 EVALI reports submitted to the Utah Department of Health [31]. Of those, 92% vaped THC, 66% nicotine, and 60% both. Layden et al. (2020) reported that all patients with EVALI in their study (n = 98) had vaped in the previous 90 days (a finding also noted in a smaller study with only 8 participants) [33], with 92% vaping in the preceding week [32]. Of the 81 patients interviewed, 27% vaped only THC, 11% only nicotine, and 60% both. Kligerman et al. (2021), after diagnosing 160 patients with EVALI according to the computed tomography findings, found that 48.1% vaped only THC, 9.4% only nicotine, and 42.5% both substances [34]. Interestingly, a significant was observed between the substance vaped and the presence of documented fever: 68.8% of t cannabis-only vapers had fever, compared to 66.2% of dual vapers and 33.3% of nicotine-only vapers. Despite this difference, the presence of fever did not affect the severity of the lung injury.

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3.3. Other Health Consequences

Smith et al. (2022) [35] surveyed 112 individuals who reported dual vaped within the past 30 days, utilizing the Global Assessment of Individual Needs Short Screener (GAIN-SS) scale [35]. They observed that the majority demonstrated a moderate to high risk of internalizing problems (mean ±standard deviation: 3.00 ± 1.60), externalizing problems (1.80 ± 1.50), and substance use disorder (2.00 ± 1.50). Other studies have similarly identified a higher prevalence of cannabis dependence and nicotine dependence among dual vapers compared to those using only one substances [27]. Additionally, a high prevalence of substance use disorder involving alcohol, opioids, cocaine, and hallucinogens, for instance, as well as depression and anxiety, was reported [26].

Case et al. (2022) used data from the Texas Adolescent Tobacco and Marketing Surveillance System to describe symptoms related to the e-cigarette use [16]. Compared to non-users, dual vapers and nicotine vapers reported a higher risk of respiratory symptoms such as cough, chest pain, wheezing, and shortness of breath, relative cannabis vapers (aOR = 2.35, 95% CI: 1.30, 4.25; AOR = 1.86, 95% CI: 1.22, 2.81, respectively). Regarding gastrointestinal symptoms, cannabis-only vapers reported a higher prevalence (AOR = 2.41, 95% CI: 1.53, 3.79), followed by the nicotine-only group (AOR = 2.03, 95% CI: 1.38, 2.99), and dual vapers (AOR = 2.03, 95% CI: 1.15, 3.57). Overall, the risk of constitutional symptoms, including headache, appetite changes, dehydration, tiredness, fever, and weight fluctuations was highest among dual vapers, followed by the nicotine-only and cannabis-only groups.

3.4. Behaviors

Moustafa et al. (2022) conducted a prospective cohort study using questionnaires with ninth graders to identify the pattern of cannabis and nicotine vaping use and users' characteristics [36]. Compared to non-users, dual vapers were more likely to have used cigarettes (OR = 2.39, 95% CI = 1.05, 5.45) and alcohol (OR = 4.39, 95% CI = 2.71, 7.11) in the last six months. They also reported higher odds of peer vaping (OR = 1.20, 95% CI = 1.08, 1.34), sensation seeking (OR = 1.11, 95% CI = 1.07, 1.15), and positive e-cigarette expectations (OR = 1.17, 95% CI = 1.10, 1.24). Positive e-cigarettes expectations were also observed in the study published by Bessenyei et al. (2023) (OR = 1.05, 95% CI: 1.01–1.10, p = .022) [37].

In the report by Dugas et al. (2020), nicotine-only vapers were more likely to report a lifetime quitting attempt (77.1%, n = 35) than dual users (62.5%, n = 8) [38]. However, more dual vapers (37.5%) perceived that e-cigarettes helped them quit compared to the nicotine-only group (28.6%). Conflicted results were found in Saran et al. [27], where dual users, when compared to nicotine-only vapers, were more likely to have tried quitting. The dual group has also begun vaping nicotine at a younger age, used higher nicotine concentrations, was more likely to buy their nicotine vape online or from friends/family than from a gas station, and was less likely to use nicotine vape as a replacement for combustible cigarettes. Compared to cannabis-only vapers, dual vapers started using cannabis vape at a younger age, were more likely to endorse having a state medical marijuana card and purchase their vape online or from friends/family than from a dispensary.

Watson et al. (2020) collected data from an online survey involving 3,980 adults aged ≥18 years [25]. They reported using THC- and nicotine-containing electronic vaping products (EVPs). In the previous three months, a high percentage also smoked marijuana (90.1%) and conventional cigarettes (63%). Additionally, this study evaluated the most common flavours preferred, with fruit (71%), candy (39.4%), mint (35.2%), and menthol (34.3%) being the top preferences for THC-containing EVP, and fruit (59.9), menthol (45.6), mint (37.3) and tobacco (34.2) for nicotine-containing EVP.

3.5. Predisposing Factors

Taleb et al. (2020) showed that, compared to non-users, the use of e-cigarettes (aOR = 1.67, 95 % CI = 1.32, 2.11) was associated with marijuana vaping [39]. Participants who believed e-cigarettes were "equally addictive" to cigarettes were less likely (aOR = 0.79, 95 % CI = 0.65, 0.97) to ever vape marijuana than those who considered e-cigarettes less addictive than cigarettes. Furthermore, the

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odds of vaping marijuana increased in a dose-dependent manner as the lifetime frequency of e-cigarette use increased. Compared to participants who used e-cigarettes for 10 days or less in their lifetime, those who used them for 11 to 50 days (aOR = 1.61, 95 % CI = 1.22, 2.13), 51 to 100 days (aOR = 2.13, 95 % CI = 1.41, 3.22), and more than 100 days (aOR = 2.69, 95 % CI = 1.89, 3.82) were more likely to ever vaped marijuana. A significant positive association between e-cigarette use and marijuana vaping was also found in many other studies [40–47], with odds ratios varying from 2.16 (95 % CI = 1.20, 3.89) in Lee et al. (2021) [43] and (19.76 (95 % CI = 17.29, 22.57) in Keyes et al. (2022) report [44]. Furthermore, in the latterstudy, it was reported that those who vaped and smoked nicotine were more than 40 times likely to vape and smoke cannabis. In the study by Baldassarri et al. (2020), an association between nicotine and cannabis vaping was only seen for adults aged 25 to 54 years (aOR =4.6, 95% CI=2.70, 7.78) [40]. Among youths aged 18 to 24 years, such an association was not confirmed (aOR = 0.9, 95% CI=0.33, 2.26).

4. Discussion

The present systematic literature review is the first to comprehensively address the phenomenon of dual vaping, the broad spectrum of tobacco and cannabis co-users through vaping demographics data reveal that dual vaping is predominantly observed among younger individuals, particularly men, and is more common in White and Hispanic populations with higher economic status and educational status. Additionally, the notable prevalence of dual vaping among married individuals (or those living with a partner) and heterosexuals suggests that this behaviour transcends typical risk groups, necessitating a broader scope of intervention strategies.

Health-related findings emphasise the compounded risks of dual vaping compared to the use of a single substance. Dual vapers were more likely to experience respiratory and constitutional symptoms, with EVALI cases linked to this group [14–17]. Expanding research on EVALI, particularly outside the United States, is crucial for understanding its global implications. Mental health outcomes are equally concerning, with a high prevalence of psychiatric disorders, including substance use disorders, anxiety, and depression, among dual users [26,27,35]. Since depression itself is an important economic issue associated with high direct and indirect costs in many age groups, [48] dual vaping represents a potentially costly public health challenge that requires immediate attention.

Behavioural aspects of dual vaping highlight a complex interplay between tobacco, cannabis, and alcohol use. Frequent alcohol consumption and cigarette smoking were commonly reported among dual vapers, reflecting shared behavioural patterns [36,37]. Peer influence and positive expectations surrounding e-cigarettes emerged as significant predictive factors for dual vaping. Regarding flavored vapes, fruit flavours were the most commonly preferred among dual users, underscoring their appeal. Several studies have demonstrated a bidirectional relationship between nicotine and cannabis vaping [10–13], where the use of one substance increases the likelihood of using the other, ultimately fostering co-use. This phenomenon may be attributed to the interaction between the endocannabinoid and nicotine systems, which share overlapping receptor pathways in the brain's reward system [13].

Despite the growing body of research on electronic cigarettes, studies specifically exploring dual vaping remain limited. Most of the included studies were conducted in the United States, and PubMed was the sole database used for this review, which may limit the generalizability of the findings.

5. Conclusion

The rising prevalence of dual vaping, particularly among younger individuals and those with higher socioeconomic status, presents a significant public health challenge. The concomitant use of e-cigarettes for both tobacco and cannabis introduces unique risks that compound the associated harms. Documented health issues include respiratory problems, systemic inflammation, and psychiatric complications, underscoring the urgent need for targeted prevention measures and stricter regulation of vaping products. Future research should aim to encompass diverse populations

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and demographics, investigate long-term health outcomes, and explore the specific behaviors of dual vaping users to develop more precise measures to mitigate the health consequences of combined vaping of tobacco and cannabis.

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