



Vaping and COVID-19 pandemic: changes in e-cigarette use and conclusions for the future – narrative review

Vaping i pandemia COVID-19: zmiany w używaniu e-papierosów i wnioski na przyszłość – przegląd narracyjny

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Abstract

Introduction and Objective. Electronic cigarettes (e-cigarettes) have become the most common form of nicotine consumption among adolescents and young adults. Little is known about the impact of government-imposed restrictions during the COVID-19 pandemic on the vaping behaviour of both adolescents and adults. This study aimed to explore scientific research concerning the prevalence of e-cigarette usage following the onset of the COVID-19 pandemic.

Review Methods. A systematic, comprehensive search of English-language literature in online databases (PubMed, Web of Science, Elsevier, Scopus, Google Scholar) was conducted from January 2023 – June 2023. A key word search was conducted for publications published from March 2020 when the COVID-19 pandemic was announced to December 2022.

Brief description of the state of knowledge. Most of the analyzed articles reported changes in e-cigarette use during the COVID-19 pandemic. The reasons for the increase in the use of e-cigarettes during the pandemic included: boredom, loneliness, stress caused by lockdown, and online purchases. The decrease in e-cigarette consumption is attributed to stay-at-home orders causing barriers to e-cigarette access, limited peer group gatherings, and increased time spent at home with the family. The Covid-19 pandemic also impacted attempts to stop the use of e-cigarettes.

Summary. Understanding the factors that influenced changes in e-cigarette use during the COVID-19 pandemic should be used to develop prevention programmes for adolescents and young adults. Educating young people and increasing knowledge about the harmful effects of using e-cigarettes may contribute to reducing the initiation of using e-cigarettes, and is a strong incentive to quit smoking.

Key words

use, e-cigarette, vaping, COVID-19

Abbreviations

COVID-19 – Coronavirus disease 2019, **EU** – European Union; **EVALI** – electronic cigarette or vaping product use-associated lung injury; **PRISMA** – Preferred Reporting Items for Systematic Reviews; **SARS-CoV-2** – severe acute respiratory syndrome coronavirus 2; **UK** – United Kingdom; **US** – United States

Streszczenie

Wprowadzenie i cel pracy. Elektroniczne papierosy (e-papierosy) stały się najpowszechniejszą formą zażywania nikotyny wśród młodzieży i młodych dorosłych. Niewiele wiadomo na temat wpływu ograniczeń nałożonych przez rząd podczas pandemii COVID-19 na zachowania związane z wapowaniem zarówno wśród nastolatków, jak i dorosłych. Celem tego badania było przeanalizowanie badań naukowych dotyczących rozpowszechnienia używania e-papierosów po wybuchu pandemii COVID-19.

Metody przeglądu. Systematyczne, kompleksowe przeszukiwanie literatury anglojęzycznej w internetowych bazach danych (PubMed, Web of Science, Elsevier, Scopus, Google Scholar) prowadzono od stycznia do czerwca 2023 roku. Wyszukiwanie według słów kluczowych przeprowadzono dla publikacji opublikowanych od marca 2020 roku, kiedy to została ogłoszona pandemia COVID-19, do grudnia 2022 roku.

Opis stanu wiedzy. Większość analizowanych artykułów raportowała zmiany w korzystaniu z e-papierosów w czasie pandemii COVID-19. Przyczyny wzrostu używania e-papierosów w trakcie pandemii były następujące: nuda, samotność, stres wywołany izolacją oraz możliwość łatwego nabycia ich w Internecie. Spadek konsumpcji e-papierosów przypisuje się nakazom pozostania w domu, powodującym bariery w dostępie do nich, ograniczonej liczby spotkań w grupach rówieśniczych i zwiększonej ilości czasu spędzanego w domu z rodziną. Pandemia COVID-19 wpłynęła również na próby zaprzestania używania e-papierosów.

Podsumowanie. Zrozumienie czynników, które wpłynęły na zmiany w używaniu e-papierosów podczas pandemii COVID-19, powinny zostać wykorzystane do opracowania programów profilaktycznych dla młodzieży i młodych dorosłych. Edukacja młodych ludzi i zwiększanie wiedzy na temat szkodliwych skutków używania e-papierosów może przyczynić się

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do ograniczenia inicjacji używania e-papierosów i stanowi silną zachętę do rzucenia palenia.

Słowa kluczowe

COVID-19, e-papieros, waporyzacja, używanie

INTRODUCTION AND OBJECTIVE

E-cigarettes, also known as electronic nicotine delivery system, have gained popularity as the predominant method of nicotine intake among teenagers and young adults [1,2]. Originating in 2003 in China [3], followed by launches in the United States (US) in 2006 [4], and Europe in 2005 [5], these devices have been marketed as ostensibly ‘safer’ substitutes for conventional tobacco smoking. These devices are promoted as smoking cessation tools, but e-cigarettes are rarely used for this purpose by young people [4]. Although electronic cigarettes show lower toxicity compared to cigarettes, they still contain harmful substances [6]. There are fears that e-cigarettes could become a ‘gateway’ to cigarette smoking [7, 8]. Studies indicate, that the use of electronic cigarettes by adolescents and young adults increases the risk that they will ever use combustible cigarettes [3].

Studies indicate that e-cigarettes contain high levels of toxic compounds [9] that adversely affect the cardiovascular, respiratory and gastrointestinal systems, [10, 11]. An increased risk of cancer cannot be ruled out [12]. Young people are often not informed about the ingredients of electronic cigarettes and the adverse effects of their use [4]. Lack of knowledge about electronic cigarettes among adults and youth is pervasive, with many being unaware that early exposure to nicotine increases the likelihood of lifelong nicotine addiction, and that the most popular devices provide higher levels of nicotine than traditional cigarettes [13].

E-cigarettes pose a public health risk as they are attractive to youth and maybe a first choice for nicotine initiation. The reasons that young adults and adolescents use e-cigarettes include social acceptance, curiosity, taste/flavourings, quick use, and lack of odour [1]. Research suggests that electronic cigarettes have a ‘gateway’ effect to cannabis use and combustible cigarettes [1, 4]. Smokers who do not engage in daily e-cigarette use demonstrate a higher likelihood of becoming chronic tobacco users compared to those who refrain entirely from vaping [14].

Numerous studies have shown that adolescents who smoke cigarettes and have experimented with electronic cigarettes are more inclined to start using traditional cigarettes later [7, 15–20]. Additionally, it suggests that electronic cigarette users are also more likely to use other substances [21]. Young people point to the appeal of e-cigarettes because of the flavours used and the flavourings added to the e-liquids used for vaping [1, 22]. Teens report vaping ‘everywhere’ in the school, including bathrooms, cafeterias, and stairwells [23].

The increasing prevalence of electronic cigarette usage among young adults and teenagers is frequently linked to sophisticated marketing strategies [24]. Research has indicated that higher exposure to advertising among the youth is associated with an increase in e-cigarette usage [25]. Notably, the most substantial levels of exposure occur through social media channels [2, 26] and within retail environments [27]. Adolescents perceive advertisements promoting flavoured e-liquids as directed towards their demographic rather than targeting older cohorts [28]. Such advertising endeavours engender the heightened allure and

proclivity to procure and sample e-cigarettes [29]. Notably, flavours play an important role in online marketing of electronic cigarettes [2], the sweet flavours especially increase the appeal of all e-cigarettes [30]. Among individuals who engage in e-cigarette usage, fruit-flavoured e-cigarettes (such as strawberry or cherry) emerge as the prevailing choice in terms of flavour preference [31]. New e-cigarettes (such as Pod and Pod-Mods) mimic common electronics, making them additionally attractive to young people [32]. The COVID-19 (coronavirus disease 2019) pandemic affected changes in daily life which included changes in e-cigarette use, especially among young adults [33] and adults.

Restrictions during the pandemic affected access to and use of e-cigarettes by young adults (bans on leaving home, limited social gatherings, and closing of tobacco stores) [34, 35]. Studies have shown changes in nicotine use related to availability (closing of some stores, malls) or ‘stay at home’ orders, resulting in a reduction of smoking/vaping. Other studies, however, indicate higher levels of smoking to reduce stress or loneliness at home [36]. To date, little is known about the impact of government-imposed restrictions during the COVID-19 pandemic on adolescent and adult e-cigarette use behaviour.

This review shows how the frequency of electronic cigarette use by young people and adolescents changed during the pandemic. Also examined are their associations with future intentions to quit using e-cigarettes. Understanding how e-cigarette use changed during the COVID-19 pandemic is important because it affects coping with e-cigarette use after the pandemic [33, 34].

REVIEW METHODS

Search Strategy. A systematic, comprehensive search of English-language literature in online databases (PubMed, Web of Science, Elsevier, Scopus, Google Scholar) was conducted from January 2023 – June 2023. A key word search was conducted for publications dating from March 2020 when the COVID-19 pandemic was announced, to December 2022. This date limitation was selected because of the announcement of the COVID-19 pandemic, and the resulting restrictions put in place during this period to prevent the spread of the disease. The reference lists of the included articles were manually searched to identify any articles not originally indexed in these databases.

The literature search used key words related to e-cigarette use during the pandemic, e.g. ‘e-cigarette’, ‘vaping’, ‘use’, and ‘COVID-19’. A total of 172 articles were found. Two researchers (ML and MZ) independently checked the titles, abstracts and full texts of the articles. The reference lists were then checked to identify other potentially eligible articles for review. A third researcher (DK) resolved any disagreements. Narrative review methodology and the established Cochrane rapid review process were used.

Selection criteria. The inclusion criteria for the articles are as follows: 1) the study designs included meta-analyses,

cross-sectional studies, case-control studies, and cohort studies of the connection between e-cigarette use and the COVID-19 pandemic, 2) they were available in English, 3) the research sample was greater than 20, 4) have been published in a peer-reviewed journal as a pre-print or report. As a result, 41 articles on electronic cigarette use during the COVID-19 pandemic were selected. Two reviewers approved inclusion of articles in the review, with excellent agreement ($k = 0.90$).

Exclusion criteria. Included duplicate articles, conference abstracts, reports, and commentaries issued before 2020, and publication in a language other than English. All articles were peer-reviewed.

Study criteria. Two researchers (ML and MZ) independently reviewed the titles of identified references and eliminated any irrelevant studies. One reviewer (ML) reviewed all abstracts and rated those which should be included in the review. A second reviewer (MZ) double-checked a random sample of 20% of the abstracts to ensure consistent application of the eligibility criteria.

The full text of the remaining studies was obtained and reviewed independently by two authors (ML and MZ) of the review. Any inconsistencies were resolved through discussion and intervention by a third (DK) independent author. Articles were displayed by summary and title. Duplicate and irrelevant items were excluded by the researchers. The remaining English-language manuscripts were subject to full-text review.

Various factors were taken into account when selecting studies, including authors, the main purpose of the study, year of publication, results and type of research. Finally, for the purposes of this review, the following information was obtained from each research: study population; outcome type (e-cigarette use, COVID-19), and results.

Study selection. 172 articles were initially searched. 41 articles met the eligibility criteria according to Preferred Reporting Items for Systematic Reviews (PRISMA), and addressed the change in the prevalence of e-cigarette use during the pandemic (Fig. 1). The research included

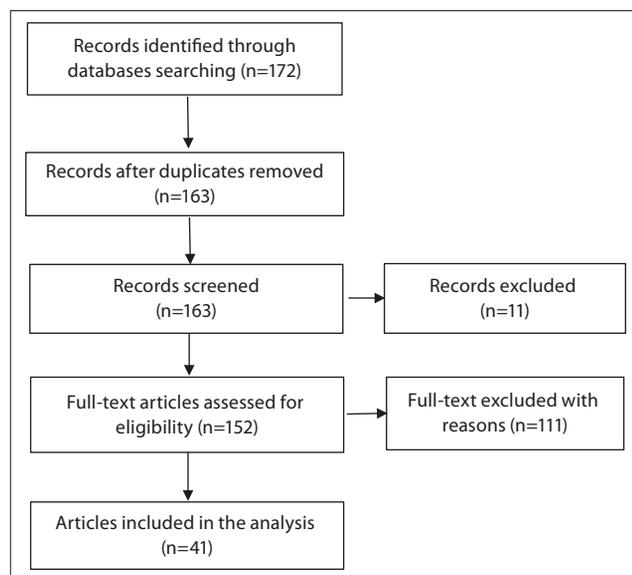


Figure 1. PRISMA Diagram of Study Selection

in the review covered the period from 2020 – 2022. Eight manuscripts were published in 2020, 19 in 2021, and 14 in 2022. All articles reported studies conducted on samples from one country, with most of the studies conducted in the United States ($n = 25$). The review also included studies from the United Kingdom ($n = 4$), Canada ($n = 3$), Italy ($n = 2$), Belgium ($n = 1$), Poland ($n = 1$), South Korea ($n = 1$), Iran ($n = 1$), China ($n = 1$), Iceland ($n = 1$), and Saudi Arabia ($n = 1$).

In total, 26 articles presented studies based on cross-sectional designs, 6 were based on longitudinal designs, 2 were cohort studies, 2 were screening studies, 1 was a qualitative study, 3 were interview studies, and 1 was a review. Additionally, 23 studies concerned adults, and 18 articles concerned young adults and adolescents.

BRIEF DESCRIPTION OF THE STATE OF KNOWLEDGE

Changes in the use of e-cigarettes. Of the 41 articles researching the prevalence and changes in electronic cigarette use during the COVID-19 pandemic, 15 reported an increase in e-cigarette use/vaping [37–51], while 16 studies found a decrease in e-cigarette use/vaping [52–67], and various changes in e-cigarette use were reported in 10 studies [68–77]. Table 1 shows selected studies.

Within the compendium of 41 articles, 16 studies demonstrate a decrease in e-cigarette use. This decrease in consumption is attributed to multifarious factors: stay-at-home directives causing barriers to e-cigarette access, limited peer-group gatherings, and increased time spent in the home with family. Especially blockades introduced at the start of the COVID-19 pandemic and staying indoors reduced e-cigarette use [62, 65].

E-cigarettes with restricted access to stores were more likely to report reduced e-cigarette use [55]. In contrast, in a study by Adriaens et al., one in seven pre-during lockdown returned partially or completely to smoking during lockdown [69].

The COVID-19 pandemic has also influenced attempts to quit e-cigarette use. Perceptions of risk play a significant role in influencing the use of electronic cigarettes. Tattan-Birch et al. reported that 12.2% of smokers who had recently attempted to quit smoking were motivated by COVID-19 [54], while Kalkhor et al. found that 41% of electronic cigarette users tried to quit because of the pandemic [73]. Streck et al. demonstrated that the pandemic led to an increased interest to quit smoking in 42% of individuals who use e-cigarettes, with 20% of them actually making quit attempts since the onset of the pandemic [70].

While the pandemic provided an incentive to quit smoking, it might also have prompted vapers to return to smoking. Popov et al. reported that transient smokers/e-cigarette users were wanted to quit due to concern about their health, but many felt that the stress of the COVID-19 pandemic was unbearable without the use of tobacco [64]. Participants who perceived risks to health from electronic cigarettes were more likely to have decreased or quit their use of e-cigarettes [50].

Thus, stress reduction or loneliness were one of the reasons for increase e-cigarette use [36]. Moreover, among analyzed studies, risk factors associated with vaping were: boredom and spending more time at home, possibility of online purchase, social substance-using occasions, opportunities to be away from the watchful eyes of parents/guardians (on-campus learning) [37,39,43,44].

Table 1. Changes in the prevalence of e-cigarette use during the COVID-19 pandemic

Authors, Year of Publication	Type of Study/ material	Country	Main objective	Prevalence of e-cigarette use
Gaiha, 2020 (1)	cross-sectional/ human	US	changes in the access and use of e-cigarettes since the beginning of the COVID-19 pandemic among adolescents and young adults	↓
Sokolovsky, 2021	longitudinal/ human	US	changes in tobacco use since campus closure, focusing on smoking and frequency of electronic nicotine vaping	↓
Tattan- Birch, 2020	cross-sectional/ human	UK	to estimate the links between reported COVID-19, e-cigarette use, and the extent to which COVID-19 prompted vaping, trying to quit smoking and smoking, and smoking more at home	↓ (11.2% attempts to quit)
Kreslake, 2020	cross-sectional/ human	US	to investigate whether the COVID-19 pandemic has affected e-cigarette use among young people	↓
White, 2021	screening survey/ human	US	assessing the relationship between risk perceptions of tobacco products for COVID-19, and changes in tobacco use since start of the pandemic	↑ (27,3%) ↓ (23,8%)
Klemperer 2020	cross-sectional/ human	US	changes in tobacco use among dual users and motivation to quit because of COVID-19	↓ (24.9%) ↓ (21.2% attempts to quit) ↑ (29,1%)
Hopkins, 2021	cross-sectional/ human	Canada	assessment of changes in e-cigarette use among adolescents and young adults in response to the COVID-19 pandemic	↓ no changes (55.3%)
Gallus, 2022	cross-sectional/ human	Italy	assessment of changes in e-cigarette use in comparison to usage patterns during the pandemic	↑
Caponnetto, 2020	cross-sectional/ human	Italy	assessment of changes in e-cigarette use during COVID-19, investigating smoking-related behaviour during the social distancing and stay-at-home policies for COVID-19	↑
Kalkhoran, 2021	cross-sectional/ human	US	analysis of changes in the use of flammable cigarettes and e-cigarettes among adults	↑ (23%) no changes (41%) ↓ (41% attempts to quit)
Adriaens, 2020	cross-sectional/ human	Belgium	assessing the impact of vaporizer shop closures on vaping and/or smoking behaviour among current vapers	↑ (25%) no changes (60%) ↓ (6% attempts to quit)
Hwang, 2022	cross-sectional/ human	South Korea	changes in the use of tobacco products during the COVID-19 pandemic	↑ (39.8%) no changes (33%) ↓ (27.2%)
Rosenthal, 2022	cross-sectional/ human	US	whether the use of cigarettes and e-cigarettes by young adults varies according to socio-demographic conditions, mental health, and the use of other substances	↑
Dumas, 2022	longitudinal/ human	Canada	investigate e-cigarette use during the COVID-19 pandemic	↑
Sylvestre, 2022	longitudinal/ human	Canada	examination of changes in substance use before and during the COVID-19 pandemic in young adults	↑
Sun, 2022	cross-sectional/ human	China	changes in tobacco use, intentions, and attempts to quit during the COVID-19 pandemic	↑ (5.2%) no changes (87.4) ↓ (7.5%)
Sharma, 2020	cross-sectional/ human	US	evaluation of the use of vaping products	↓ (44%)
Streck, 2021	cross-sectional/ human	US	assessing respondents' perceptions of COVID-19 risk from smoking or vaping, interest in quitting smoking, trying to quit, and changing tobacco consumption during a pandemic	↑ (27%) ↓ (20% attempts to quit)
Chaffee, 2021	cohort/ human	US	comparison of drug use and physical activity-related behaviours among adolescents before and after the reduction of staying at home	↓
Kalan, 2021	cross-sectional/ human	Iran	analysis of beliefs and behaviours related to tobacco use and COVID-19 infection	↓
Jackson, 2022	cross-sectional/ human	UK	to measure whether the prevalence and actual effectiveness of various smoking cessation aids has changed since the Covid-19 pandemic	↓
Case, 2022	interview/ human	US	how the COVID-19 pandemic affected young adults' perceptions and behaviours about vaping	↑ (54%)
Kale, 2022	longitudinal/ human	UK	assessing changes in smoking and vaping in the first year of the COVID-19 pandemic, identifying the factors associated with any changes, and examining whether COVID-19 acted as a source of motivation for smokers and vapers to quit	↓ (25% attempts to quit)
Gonzalez, 2021	screening/ human	US	whether smoking, e-cigarette use, and the rate of consumption of these products differed before and after the pandemic lockout order	↓
Giovenco, 2021	interview/ human	US	identification of the factors of change in the patterns of use and access to inhaled tobacco products during the initial COVID-19 'blockage' period	↓
Clendennen, 2021	cross-sectional/ human	US	assessment of the link between perceived stress and addiction and increased, decreased, or sustained use of marijuana, e-cigarettes, and cigarettes due to COVID in the last 30 days	↑ (34%) no changes (43%)

Table 1. Changes in the prevalence of e-cigarette use during the COVID-19 pandemic (continuation)

Authors, Year of Publication	Type of Study/ material	Country	Main objective	Prevalence of e-cigarette use
Popova, 2021	qualitative research, focus groups/ human	US	to investigate how smoking and vaping changed in the first year of the COVID-19 pandemic	↓
Denlinger-Apte, 2022	cohort/ human	US	assessment of changes in the use of cigarettes and e-cigarettes	↓
Thorisdottir, 2021	longitudinal, population-based study/ human	Iceland	mental health and substance use impacts of the COVID-19 pandemic	↓
Klein, 2021	interview/ human	US	changes in tobacco use among young adults	↑
BinDhim, 2021	cross-sectional/ human	Saudi Arabia	studying the prevalence of certain behavioural health risk factors, indirect risk factors, and chronic diseases at different time points in 2020	↑
Yingst, 2021	cross-sectional/ human	US	assessment of use frequency, reasons for the change in use, and attempts to quit smoking	↑
Wang, 2021	cross-sectional/ human	US	characteristics of e-cigarette use behaviour among adolescents	↑
Merz, 2020	cross-sectional/ human	US	how the COVID-19 pandemic changed e-cigarette user habits and risk perceptions	↑ (32%) no changes (58%) ↓ (10%)
Mantey, 2022	cross-sectional/ human	US, Texas	e-cigarette susceptibility or use analysis	↑
Gentzke, 2021	cross-sectional/ human	US	widespread use of tobacco products among adolescents	↑
Jankowski, 2022	cross-sectional/ human	Poland	assessment of the current prevalence and use patterns of tobacco and e-cigarettes	↑
Layman, 2022	review/ human	US	review of the literature on drug use trends among adolescents during the SARS-CoV-2 (COVID-19) pandemic	↓
Kale, 2021	cross-sectional/ human	UK	to investigate the link between vaping and self-reported diagnosed/suspected Covid-19; changes in vaping behaviour since Covid-19 and factors associated with these changes; as well as whether Covid-19 has motivated current or recent ex-vapers to quit	↑ (42%) no changes (48.3%) ↓ (9.7%)
Romm, 2022	longitudinal/ human	US	changes in tobacco and e-cigarette use among young adults before and during the COVID-19 pandemic and related risk/protection factors	↑ (23.2%) ↓ (28.6%)
Yang, 2021	cross-sectional/ human	US	changes in the use of any of the four tobacco products during the COVID-19 pandemic, including new initiation, quitting, switching, or changes in consumption levels	↑

↓ decrease of the prevalence, ↑ increase of the prevalence

DISCUSSION

The review centers on examining the prevalence of e-cigarette use and the shifts that occurred during the course of the COVID-19 pandemic. In numerous studies conducted during that time, an attempt was made to comprehend changes in health behaviours, including aspects such as alcohol consumption, smoking/vaping, substance use, dietary habits, physical activity. One of the main objectives of these researches was to understand the factors associated with changes in risky behaviour, especially among young people. Understanding the determinants of the prevalence of vaping is of paramount importance as it provides valuable information for the development of preventive programs.

These studies also contribute to identifying the risk and protective factors influencing health behaviours during such extraordinary circumstances as a pandemic. Preventive actions based on the findings of research can contribute to improving public health and mitigating the adverse health effects of the pandemic on society. The focus should be on providing education about the risks associated with

vaping and persuading society that they are not a healthier alternative to traditional smoking.

Among 41 studies, 15 showed an increase in e-cigarette use [37–51]. The reasons for this increase indicated in these articles were boredom, loneliness, stress caused by lockdown, possibility of online purchase or on-campus learning while far away from home.

Additionally, 10 of the studies demonstrated both increases and decreases in usage prevalence [68–77].

Vaping can be perceived as more socially acceptable than traditional smoking and may be considered a less harmful addiction. This perception may lead to the approval of e-cigarette use among young people by adults. There was a general attitude that e-cigarettes were younger, newer, modern, and marked as a cooler product. People also perceived e-cigarettes as less risky because of their role as a cessation product.

We need to be aware that there is a lack of information about e-cigarettes. In this context, individuals such as parents, educators, youth advocates, and healthcare providers play a crucial role in safeguarding young individuals from the adverse effects associated with tobacco products,

including e-cigarettes. In addition, healthcare providers in particular can enhance their patient screening practices by incorporating inquiries about the usage of all forms of tobacco products, including e-cigarettes. This approach allows for a more comprehensive assessment of consumption patterns of tobacco product, and facilitates targeted assistance for those individuals seeking to quit their tobacco product usage.

Perceiving a higher risk of both contracting COVID-19 and experiencing severe complications is linked to a greater motivation to quit smoking. This implies that the threat of COVID-19 may act as a strong incentive for smokers to seek cessation.

It is important not to downplay tobacco cessation initiatives because of the ongoing pandemic; in fact, there is a pressing demand for creative approaches to assist individuals who wish to quit smoking, especially during this challenging period.

Some factors have been shown to be effective in preventing substance use: restrictions on social gatherings, reduced substance availability and accessibility, and increased time spent at home with the family. It is probable that these factors have provided significant safeguards against substance use during the COVID-19 pandemic, as evidenced by the decrease in prevalence documented in the majority of the reviewed studies. The decreases in vaping during lockdown may be attributed to the shift in the social function of smoking among young people due to social isolation. Additionally, it could be linked to the higher probability of young smokers successfully quitting, when compared to older smokers.

However, the diverse measures implemented to curb the transmission of COVID-19, such as wearing mask, maintaining physical distance, and community lockdowns with limitations on social gatherings, may have adversely affected both mental health and social welfare. This impact could potentially lead to an increase in or worsening of substance use behaviours. Craig et al. reported that both mental health problems and substance use (with over 50% of youth engaging in some form of substance use in the past 90 days) among adolescents increased during the pandemic [78]. COVID-19 stress has also been found to be associated with substance use (alcohol use, binge drinking, cannabis use, and vaping), particularly when used alone [79]. In Canada, Chaiton et al. documented that the majority of individuals between the ages of 16–25 who engaged in substance consumption, exhibited an escalated pattern of substance use during the pandemic. Specifically, there was a net increase of +37% in the use overall of electronic cigarettes (e-cigarettes) during the COVID-19 pandemic [80].

Some mitigation measures were more drastic, such as border closures, city and town lockdowns, curfews, stringent restrictions on social gatherings, including religious services, limited access to workplaces and entertainment venues such as restaurants, theatres, and sports events, together with mandates for physical (or social) distancing and mask-wearing. In many locations these initiatives involved the closure of schools, limitations on youth services, such as sports clubs and extracurricular programmes, and the prohibition of social gatherings. Such restrictions could be effective in preventing risky behaviour by deprivation of the opportunity to use drugs or alcohol, etc. [37].

On the other hand, as a result of the COVID-19 pandemic, more people may have been thinking about their health,

and potentially thinking about quitting smoking/vaping. In addition, the overlapping awareness of the EVALI epidemic in the USA which caused lung injury through the illegal use of cannabis products in e-cigarettes, may have changed the perception of harm, as daily nicotine vaping decreased significantly between 2019–2020. Higher risk perceptions for COVID-19 were associated with reductions in tobacco use since the pandemic began for exclusive e-cigarette users and dual users [50, 68, 72, 77, 81–84]. These findings suggest that an increased perception of risks may lead to a reduction in e-cigarette use. Given the significant influence of risk perceptions on health behaviours, it is beneficial to provide education that connects vaping to health harms, such as lung damage. These results also imply that health professionals can utilize the pandemic as an opportunity to promote nicotine cessation, or at least reduce its use.

Based on 41 studies published to date, including the presented review, the overall results imply that the prevalence of e-cigarettes use in the initial period of the pandemic, decreased due to the lockdown and related e-cigarette purchase restrictions. However, these positive results of the overall decrease in e-cigarette use should be treated with some caution. Most studies indicate an increase in the prevalence of e-cigarette use during the COVID-19 pandemic among young adults and adolescents, as well as adults. More data is needed to better characterize how the COVID-19 pandemic may have affected e-cigarette use.

Public health implication. The COVID-19 pandemic and the implemented preventive measures introduced (orders and prohibitions) have had an impact on the demand and supply of e-cigarettes among adolescents and young adults. This review highlights the necessity for further research to comprehend how the COVID-19 pandemic has altered e-cigarette usage, and how it has presented opportunities for changing e-cigarette use behaviour. This information is crucial for devising effective solutions to decrease the use of e-cigarettes and other substances during future pandemics.

Essential public health protection measures should be implemented, such as prohibiting the sale of e-cigarettes to individuals under the age of 18, and imposing restrictions on the online sale of e-cigarettes. Raising awareness among youths about the effects of using e-cigarettes should be a key component of addiction prevention efforts. These findings should prompt governments to focus on implementing and promoting tobacco-free homes, and intensifying efforts to enforce the ban on smoking and the use of e-cigarettes in public places.

Recommendations for future research. This review suggests the need for further longitudinal studies to assess the latent and long-term impact of the COVID-19 pandemic on e-cigarette use behaviour among adolescents, young adults, and adults. Further research will allow possible meta-analyses of e-cigarette use during and after the COVID-19 pandemic. These analyses are essential for gaining a comprehensive understanding of how the pandemic affected e-cigarette use and to what extent, as well as for identifying the underlying causal factors.

Limitations of the study. Most of the studies featured in the presented review are cross-sectional studies in which exposure and effects are measured over the same period.

In several studies which used longitudinal designs and cohort designs, the measures of performance varied, and observations were of limited duration.

SUMMARY

Understanding the factors that influenced changes in e-cigarette use during the COVID-19 pandemic should be used to develop prevention programs for adolescents and young adults. Educating young people and increasing knowledge about the harmful effects of using e-cigarettes (not only during the pandemic) may contribute to reducing the initiation of using e-cigarettes, and is a strong incentive to quit smoking.

Data Availability Statement

Data sharing not applicable.

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Conflicts of Interest

The authors declare no conflict of interest

REFERENCES

- Burt B, Li J. The electronic cigarette epidemic in youth and young adults: A practical review. *JAAPA*. 2020;33(3):17–23. <https://doi.org/10.1097/01.JAA.0000654384.02068.99>
- Bhatt JM, Ramphul M, Bush A. An update on controversies in e-cigarettes. *Paediatr Respir Rev*. 2020;36:75–86. <https://doi.org/10.1016/j.prrv.2020.09.003>
- US Department of Health and Human Services. E-cigarette use among youth and young adults. A report of the surgeon general. 2016. https://e-cigarettes.surgeongeneral.gov/documents/2016_SGR_Exec_Summ_508.pdf (access 2023.08.11).
- Fadus MC, Smith TT, Squeglia LM. The rise of e-cigarettes, pod mod devices, and JUUL among youth: Factors influencing use, health implications, and downstream effects. *Drug Alcohol Depend*. 2019;201:85–93. <https://doi.org/10.1016/j.drugalcdep.2019.04.011>
- History of e-cigarettes. http://www.e-papierosow.edu.pl/historia_e-papierosow.html (access 2023.08.11).
- National Academies of Sciences, Engineering, and Medicine, Health and Medicine Division, Board on Population Health and Public Health Practice, Committee on the Review of the Health Effects of Electronic Nicotine Delivery Systems. *Public Health Consequences of E-Cigarettes*; Eaton DL, Kwan LY, Stratton K. National Academies Press (US): Washington, DC, USA, 2018; ISBN 978-0-309-46834-3. <http://www.ncbi.nlm.nih.gov/books/NBK507171> (access 2023.08.11).
- Primack BA, Soneji S, Stoolmiller M, et al. Progression to Traditional Cigarette Smoking After Electronic Cigarette Use Among US Adolescents and Young Adults. *JAMA Pediatr*. 2015;169(11):1018–1023.
- Soneji S, Barrington-Trimis JL, Wills TA, et al. Association Between Initial Use of e-Cigarettes and Subsequent Cigarette Smoking Among Adolescents and Young Adults: A Systematic Review and Meta-analysis. *JAMA Pediatr*. 2017;171(8):788–797.
- Jensen RP, Luo W, Pankow JF, et al. Hidden formaldehyde in e-cigarette aerosols. *N Engl J Med* 2015;372(4):392–394.
- Chen H, Li G, Chan YL, et al. Maternal e-cigarette exposure in mice alters DNA methylation and lung cytokine expression in offspring. *Am J Respir Cell Mol Biol* 2018; 58(3):366–377.
- Crotty Alexander LE, Drummond CA, Hepokoski M, et al. Chronic inhalation of e-cigarette vapor containing nicotine disrupts airway barrier function and induces systemic inflammation and multi-organ fibrosis in mice. *Am J Physiol Regul Integr Comp Physiol* 2018;314(6):R834–R847.
- Visser WF, Klerx WN, Cremers HWJM, et al. The Health Risks of Electronic Cigarette Use to Bystanders. *Int J Environ Res Public Health*. 2019;16(9):1525.
- Kanchustambham V, Saladi S, Rodrigues J, et al. The knowledge, concerns and healthcare practices among physicians regarding electronic cigarettes. *J Community Hosp Intern Med Perspect*. 2017;7(3):144–150.
- Doran N, Brikmanis K, Petersen A, et al. Does e-cigarette use predict cigarette escalation? A longitudinal study of young adult non-daily smokers. *Prev Med*. 2017;100:279–284.
- Leventhal AM, Strong DR, Kirkpatrick MG, et al. Association of electronic cigarette use with initiation of combustible tobacco product smoking in early adolescence. *JAMA* 2015;314(7):700–707.
- Unger JB, Soto DW, Leventhal AM. E-cigarette use and subsequent cigarette and marijuana use among Hispanic young adults. *Drug Alcohol Depend*. 2016;163:261–264.
- Spindle TR, Hiler MM, Cooke M, et al. Electronic cigarette use and uptake of cigarette smoking: A longitudinal examination of U.S. college students. *Addict Behav*. 2017;67:66–72.
- East K, Hitchman SCB, Bakolis I, et al. The Association Between Smoking and Electronic Cigarette Use in a Cohort of Young People. *J Adolesc Health* 2018;62(5):539–547.
- Azagba S, Baskerville NB, Foley K. Susceptibility to cigarette smoking among middle and high school e-cigarette users in Canada. *Prev Med*. 2017;103:14–19.
- Loukas A, Marti CN, Cooper M, et al. Exclusive e-cigarette use predicts cigarette initiation among college students. *Addict Behav*. 2018;76:343–347.
- Temple JR, Shorey RC, Lu Y, et al. E-cigarette use of young adults motivations and associations with combustible cigarette alcohol, marijuana, and other illicit drugs. *Am J Addict*. 2017;26(4):343–348.
- Harrell MB, Weaver SR, Loukas A, et al. Flavored e-cigarette use: characterizing youth, young adult, and adult users. *Prev Med Rep*. 2016;5:33–40.
- Truth Initiative. What's behind the explosive growth of JUUL. <https://truthinitiative.org/news/behind-explosive-growth-juul> (access 2023.08.10).
- Hammond D, Reid JL, Burkhalter R, et al. E-cigarette Marketing Regulations and Youth Vaping: Cross-Sectional Surveys, 2017–2019. *Pediatrics*. 2020;146(1):e20194020. <https://doi.org/10.1542/peds.2019-4020>
- Centers for Disease Control and Prevention. National Youth Tobacco Survey (NYTS). 2014. www.cdc.gov/tobacco/data_statistics/surveys/nyts (access 2023.08.10).
- Paek H-J, Kim S, Hove T, et al. Reduced harm or another gateway to smoking? Source, message, and information characteristics of E-cigarette videos on YouTube. *J Health Commun*. 2014;19(5):545–560.
- Govindarajan P, Spiller HA, Casavant MJ, et al. E-cigarette and liquid nicotine exposures among young children. *Pediatrics*. 2018;141(5):e20173361.
- McKelvey K, Baiocchi M, Ramamurthi D, et al. Youth say ads for flavored e-liquids are for them. *Addict Behav*. 2019;91:164–170.
- Vasiljevic M, Petrescu DC, Marteau TM. Impact of advertisements promoting candy-like flavoured e-cigarettes on appeal of tobacco smoking among children: an experimental study. *Tob Control*. 2016;25(e2):e107–e112.
- Kroemer NB, Veldhuizen MG, Delvy R, et al. Sweet taste potentiates the reinforcing effects of e-cigarettes. *Eur Neuropsychopharmacol J Eur Coll Neuropsychopharmacol*. 2018;28(10):1089–1102.
- Report. Special Eurobarometer 506. Attitudes of Europeans towards tobacco and electronic cigarettes. European Union, 2021. https://www.drugsandalcohol.ie/33761/1/Eurobarometer_2020_cigarettes_ebs_506.pdf (access 2023.08.12).
- Perez M, Crotty Alexander LE. Why is vaping going up in flames? *Ann Am Thorac Soc*. 2020;17(5):545–549. <https://doi.org/10.1513/AnnalsATS.201910-802PS>
- Clausen M, Romm KF, Berg CJ, Ciceron AC, Fuss C, Bennett B, Le D. Exploring young adults' e-cigarette use behaviour during COVID-19. *Tob Prev Cessat*. 2022;8:45. <https://doi.org/10.18332/tpc/155332>. eCollection 2022.
- Wharton MK, Islam S, Abadi MH, et al. COVID-19 Restrictions and Adolescent Cigarette and E-cigarette Use in California. *Am J Prev Med*. 2023;64(3):385–392. <https://doi.org/10.1016/j.amepre.2022.09.014>
- Gentzke AS, Wang TW, Jamal A, et al. Tobacco product use among middle and high school students—United States, 2020. *MMWR Morb Mortal Wkly Rep*. 2020;69(50):1881–1888. <https://doi.org/10.15585/mmwr.mm6950a1>
- Carreras G, Lugo A, Stival C, et al. Impact of COVID-19 lockdown on smoking consumption in a large representative sample of Italian adults. *Tob Control*. 2022;31:615–622. <https://doi.org/10.1136/tobaccocontrol-2020-056440>

37. Caponnetto P, Inguscio L, Saitta C, et al. Smoking behaviour and psychological dynamics during COVID-19 social distancing and stay-at-home policies: A survey. *Health Psychol Res.* 2020;8(1):9124. <https://doi.org/10.4081/hpr.2020.9124>
38. Rosenthal SR, Wensley IA, Noel JK. Eliminating Disparities in Young Adult Tobacco Use: The Need for Integrated Behavioural Healthcare. *RI Med J.* (2013). 2022;105(2):38–42.
39. Dumas TM, Ellis WE, Van Hedger S, et al. Lockdown, bottoms up? Changes in adolescent substance use across the COVID-19 pandemic. *Addict Behav.* 2022;131:107326. <https://doi.org/10.1016/j.addbeh.2022.107326>
40. Sylvestre MP, Dinkou GDT, Naja M, et al. A longitudinal study of change in substance use from before to during the COVID-19 pandemic in young adults. *The Lancet Regional Health – Americas* 2022;8:100168. <https://doi.org/10.1016/j.lana.2021.100168>
41. Gentzke AS, Wang TW, Cornelius M, et al. Tobacco Product Use and Associated Factors Among Middle and High School Students – National Youth Tobacco Survey, United States, 2021. *Surveillance Summaries* 2022;71(5):1–29. <https://doi.org/10.15585/mmwr.ss7105a1>
42. Case KR, Clendennen SL, Shah J, et al. Changes in marijuana and nicotine vaping perceptions and use behaviours among young adults since the COVID-19 pandemic: A qualitative study. *Addict Behav Rep.* 2022;15:100408. <https://doi.org/10.1016/j.abrep.2022.100408>
43. Mantey DS, Omega-Njemnobi O, Ruiz FA, et al. Remote versus In-Person Learning During COVID-19: Comparison of E-Cigarette Susceptibility and Ever Use among a diverse cohort of 6 th Grade Students in Texas. *Nicotine Tob. Res.* (2022). 2023;25(2):254–260. <https://doi.org/10.1093/ntr/ntac084>
44. Klein EG, Koopman Gonzalez S, Pike Moore S, et al. Pulling Your Mask down to Smoke: Qualitative Themes from Young Adults on Nicotine Use during a Pandemic. *Subst. Use Misuse*, 2021;56(4):437–441. <https://doi.org/10.1080/10826084.2020.1869264>
45. BinDhim NF, Althumiri NA, Basyouni MH, et al. Exploring the Impact of COVID-19 Response on Population Health in Saudi Arabia: Results from the “Sharik” Health Indicators Surveillance System during 2020. *Int. J. Environ. Res. Public Health* 2021;18(10):5291. <https://doi.org/10.3390/ijerph18105291>
46. Yingst JM, Krebs NM, Bordner CR, et al. Tobacco Use Changes and Perceived Health Risks among Current Tobacco Users during the COVID-19 Pandemic. *Int J Environ Res Public Health.* 2021;18(4):1795. <https://doi.org/10.3390/ijerph18041795>
47. Wang TW, Gentzke AS, Neff LJ, et al. Characteristics of e-cigarette use behaviours among US youth, 2020. *JAMA Netw Open.* 2021;4(6):e2111336. <https://doi.org/10.1001/jamanetworkopen.2021.11336>
48. Jankowski M, Ostrowska A, Sierpiński R, et al. The Prevalence of Tobacco, Heated Tobacco, and E-Cigarette Use in Poland: A 2022 Web-Based Cross-Sectional Survey. *Int J Environ Res Public Health* 2022;19(8):4904. <https://doi.org/10.3390/ijerph19084904>
49. Gallus S, Stival Ch, Carreras G, et al. Use of electronic cigarettes and heated tobacco products during the Covid-19 pandemic. *Sci Rep.* 2022;12:702. <https://doi.org/10.1038/s41598-021-04438-7>
50. Yang Y, Lindblom EN, Salloum RG, et al. Perceived health risks associated with the use of tobacco and nicotine products during the COVID-19 pandemic. *Tob Induc Dis.* 2021;19:46. <https://doi.org/10.18332/tid/136040>
51. Clendennen SL, Case KR, Sumbe A, et al. Stress, Dependence, and COVID-19-related Changes in Past 30-day Marijuana, Electronic Cigarette, and Cigarette Use among Youth and Young Adults. *Tob. Use Insights* 2021;14:1179173X211067439. <https://doi.org/10.1177/1179173X211067439>
52. Gaiha SM, Lempert LK, Halpern-Felsher B. Underage Youth and Young Adult e-Cigarette Use and Access Before and During the Coronavirus Disease 2019 Pandemic. *JAMA Netw Open.* 2020;3(12):e2027572. <https://doi.org/10.1001/jamanetworkopen.2020.27572>
53. Sokolovsky AW, Hertel AW, Micalizzi L, et al. Preliminary impact of the COVID-19 pandemic on smoking and vaping in college students. *Addict Behav.* 2021;115:106783. <https://doi.org/10.1016/j.addbeh.2020.106783>
54. Tattan-Birch H, Perski O, Jackson S, et al. COVID-19, smoking, vaping and quitting: a representative population survey in England. *Addiction* 2020;116(5):1186–1195. <https://doi.org/10.1111/add.15251>
55. Kreslake JM, Simard BI, O'Connor KM, et al. E-Cigarette Use Among Youths and Young Adults During the COVID-19 Pandemic: United States, 2020. *Am J Public Health.* 2021;111(6):1132–40. <https://doi.org/10.2105/AJPH.2021.306210>
56. Hopkins DB, Al-Hamdani M. Young Canadian e-cigarette users and the COVID-19 pandemic: examining vaping behaviours by pandemic onset and gender. *Front Public Health.* 2021;8:620748. <https://doi.org/10.3389/fpubh.2020.620748>
57. Sharma P, Ebbert JO, Rosedahl JK, et al. Changes in substance use among young adults during a respiratory disease pandemic. *SAGE Open Med.* 2020;8: 2050312120965321. <https://doi.org/10.1177/2050312120965321>
58. Chaffee BW, Cheng J, Couch ET, et al. Adolescents’ substance use and physical activity before and during the COVID-19 pandemic. *JAMA Pediatr.* 2021;175(7):715–22. <https://doi.org/10.1001/jamapediatrics.2021.0541>
59. Kalan ME, Ghobadi H, Taleb ZB, et al. COVID-19 and beliefs about tobacco use: an online cross-sectional study in Iran. *Environ Sci Pollut Res Int.* 2021;28(30):40346–40354. <https://doi.org/10.1007/s11356-020-11038-x>
60. Jackson SE, Cox S, Shahab L, et al. Prevalence of use and real-world effectiveness of smoking cessation aids during the COVID-19 pandemic: a representative study of smokers in England. *Addiction* 2022;117(9):2504–2514. <https://doi.org/10.1111/add.15903>
61. Kale D, Perski O, Herbec A, et al. Changes in Cigarette Smoking and Vaping in Response to the COVID-19 Pandemic in the UK: Findings from Baseline and 12-Month Follow up of HEBECO Study. *Int J Environ Res Public Health.* 2022;19(2):630. <https://doi.org/10.3390/ijerph19020630>
62. Gonzalez M, Epperson AE, Halpern-Felsher B, et al. Smokers Are More Likely to Smoke More after the COVID-19 California Lockdown Order *Int J Environ Res Public Health.* 2021;18(5):2582. <https://doi.org/10.3390/ijerph18052582>
63. Giovenco DP, Spillane TE, Maggi RM, et al. Multi-level drivers of tobacco use and purchasing behaviours during COVID-19 „lockdown”: A qualitative study in the United States. *Int J Drug Policy.* 2021;94:103175. <https://doi.org/10.1016/j.drugpo.2021.103175>
64. Popova L, Henderson K, Kute N, et al. I’m Bored and I’m Stressed: A Qualitative Study of Exclusive Smokers, ENDS Users, and Transitioning Smokers or ENDS Users in the Time of COVID-19. *Nicotine Tob Res.* 2023;25(2):185–192. <https://doi.org/10.1093/ntr/ntab199>
65. Denlinger-Apte R, Suerken CK, Ross JC, et al. Decreases in smoking and vaping during COVID-19 stay-at-home orders among a cohort of young adults in the United States. *Prev Med.* 2022;156:106992. <https://doi.org/10.1016/j.ypmed.2022.106992>
66. Thorisdottir IE, Asgeirsdottir BB, Kristjansson AL, et al. Depressive symptoms, mental wellbeing, and substance use among adolescents before and during the COVID-19 pandemic in Iceland: a longitudinal, population-based study. *Lancet Psychiatry* 2021;8(8): 663–672. [https://doi.org/10.1016/S2215-0366\(21\)00156-5](https://doi.org/10.1016/S2215-0366(21)00156-5)
67. Layman HM, Thorisdottir IE, Halldorsdottir T, et al. Substance Use Among Youth During the COVID-19 Pandemic: a Systematic Review. *Curr. Psychiatry Rep.* 2022;24(6):307–324. <https://doi.org/10.1007/s11920-022-01338-z>
68. Merz W, Magraner J, Gunge D, et al. Electronic cigarette use and perceptions during COVID-19. *Respir Med.* 2022;200:106925. <https://doi.org/10.1016/j.rmed.2022.106925>
69. Adriaens K, Van Gucht D, Lommel SV, et al. Vaping during the COVID-19 lockdown period in Belgium. *BMC Public Health* 2021;21:1613. <https://doi.org/10.1186/s12889-021-11637-4>
70. Streck JM, Kalkhoran S, Bearnot B, et al. Perceived risk, attitudes, and behaviour of cigarette smokers and nicotine vapers receiving buprenorphine treatment for opioid use disorder during the COVID-19 pandemic. *Drug Alcohol Depend.* 2021;218:108438. <https://doi.org/10.1016/j.drugalcdep.2020.108438>
71. Sun Y, Wang MP, Cheung YTD, et al. Changes in tobacco use at the early stage of the COVID-19 pandemic: Results of four cross-sectional surveys in Hong Kong. *Tob Induc Dis.* 2022;20:26. <https://doi.org/10.18332/tid/145935>
72. White AM, Li D, Snell LM, et al. Perceptions of Tobacco Product-Specific COVID-19 Risk and Changes in Tobacco Use Behaviours Among Smokers, E-Cigarette Users, and Dual Users. *Nicotine Tob Res.* 2021;23(9):1617–1622. <https://doi.org/10.1093/ntr/ntab053>
73. Kalkhoran SM, Levy DE, Rigott NA. Smoking and E-Cigarette Use Among U.S. Adults During the COVID-19 Pandemic. *Am J Prev Med.* 2022;62(3):341–349. <https://doi.org/10.1016/j.amepre.2021.08.018>
74. Hwang J. Subjective Changes in Tobacco Product Use among Korean Adults during the COVID-19 Pandemic. *Int J Environ Res Public Health.* 2022;19(6):3272. <https://doi.org/10.3390/ijerph19063272>
75. Romm KF, Patterson B, Crawford ND, et al. Changes in young adult substance use during COVID-19 as a function of ACEs, depression, prior substance use and resilience. *Subst Abus.* 2022;43(1):212–221. <https://doi.org/10.1080/08897077.2021.1930629>
76. Kale D, Herbec A, Perski O, et al. Associations between vaping and Covid-19: cross-sectional findings from the HEBECO study.

- Drug Alcohol Depend. 2021;221:108590. <https://doi.org/10.1016/j.drugalcdep.2021.108590>
77. Klemperer EM, West JC, Peasley-Miklus C, et al. Change in tobacco and electronic cigarette use and motivation to quit in response to COVID-19. *Nicotine Tob Res.* 2020;22(9):1662–1663.
78. Craig S, Ames ME, Bondi BC, et al. Canadian Adolescents' mental health and substance use during the COVID-19 pandemic: associations with COVID-19 stressors. *Can J Behav Sci.* 2020;1–27. <https://doi.org/10.31234/osf.io/kprd9>
79. Dumas TM, Ellis W, Litt DM. What Does Adolescent Substance Use Look Like During the COVID-19 Pandemic? Examining Changes in Frequency, Social Contexts, and Pandemic-Related Predictors. *J Adolesc Health.* 2020;67(3):354–361. <https://doi.org/10.1016/j.jadohealth.2020.06.018>
80. Chaiton M, Dubray J, Kundu A, et al. Perceived Impact of COVID on Smoking, Vaping, Alcohol and Cannabis Use Among Youth and Youth Adults in Canada. *Can J Psychiatry.* 2022;67(5):407–409. <https://doi.org/10.1177/07067437211042132>
81. Gupta PS, Kalagher KM. Where There Is (No) Smoke, There Is Still Fire: a Review of Trends, Reasons for Use, Preferences and Harm Perceptions of Adolescent and Young Adult Electronic Cigarette Use. *Curr Pediatr Rep.* 2021;9:47–51. <https://doi.org/10.1007/s40124-021-00240-1>
82. Yang Y, Kelly BC, Pawson M, et al. Vaping in a Time of Pandemics: Risk Perception and Motivations for Electronic Cigarette Use. *Nicotine Tob Res.* 2022; nta050. <https://doi.org/10.1093/ntr/ntac050>
83. Grummon AH, Hall MG, Mitchell CG, et al. Reactions to messages about smoking, vaping and COVID-19: two national experiments. *Tob Control.* 2020;31(3):402–410. <https://doi.org/10.1136/tobaccocontrol-2020-055956>
84. Herbec A, Brown J, Jackson SE, et al. Perceived risk factors for severe Covid-19 symptoms and their association with health behaviours: Findings from the HEBECO study. *Acta Psychol (Amst).* 2022;222:103458. <https://doi.org/10.1016/j.actpsy.2021.103458ta>