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# E-Cigarettes in Smoking Cessation and Harm Reduction: A Comprehensive Review of Recent Evidence and Potential Risks

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**Abstract**

The global prevalence of tobacco use has significantly decreased over the years, with projections indicating further decline. However, the rise of new nicotine products suggests that nicotine addiction will remain a major public health issue. Electronic cigarettes (e-cigarettes) are increasingly recognized as potential tools for smoking cessation and harm reduction. This review evaluates the safety and effectiveness of e-cigarettes both as standalone treatments and in combination with other therapies, such as nicotine replacement therapy (NRT), varenicline, cytisine, and behavioral approaches. A comprehensive analysis of studies published over the past decade, including systematic reviews, meta-analyses, and randomized controlled trials, shows that e-cigarettes can enhance smoking cessation rates and reduce tobacco-related harm. They exhibit comparable short-term efficacy to traditional treatments, with promising results in alleviating withdrawal symptoms and lowering smoking rates. However, the long-term safety and effectiveness of combining e-cigarettes with other therapies remain uncertain and require further investigation. Despite their potential benefits, e-cigarettes pose significant safety concerns, underscoring the need for ongoing research to refine cessation strategies and ensure their safe, long-term use. Rigorous evaluation and regulatory oversight are essential to optimize e-cigarettes' role in reducing tobacco harm.

## Materials and Methods

This review was conducted by searching PubMed for articles published in the most recent decade (2014-2024). Keywords such as “e-cigarettes,” “smoking cessation,” “nicotine dependence,” and “behavioral therapies” were used. The search included randomized controlled trials, meta-analyses, and longitudinal studies published in peer-reviewed journals. Studies were selected based on their relevance to evaluating the effectiveness of e-cigarettes both as a standalone treatment and in combination with other cessation methods. The review also focused on the potential role of e-cigarettes in harm reduction by comparing their safety to traditional smoking. Data extraction involved systematically gathering information on study design, sample size, types of interventions, cessation rates, reported adverse effects, and safety profiles. The goal was to compare the efficacy of e-cigarettes with other smoking cessation strategies and assess their potential role in harm reduction, considering their safety in comparison to traditional smoking.

## Aim of the Study

This study aims to evaluate the role of e-cigarettes in harm reduction and their place in smoking cessation strategies. Additionally, it seeks to determine the potential risks associated with e-cigarette use compared to traditional cigarette smoke, including safety concerns for bystanders. By reviewing recent literature, the study will assess the effectiveness of e-cigarettes as a smoking cessation tool compared to other methods. The goal is to provide a comprehensive analysis of e-cigarettes' potential in facilitating smoking cessation and to offer insights that could guide future public health strategies.

**Keywords**: electronic cigarettes, e-cigarettes, ENDS, smoking cessation, harm reduction, smoking reduction, nicotine dependence, nicotine replacement therapy, behavioral therapy, combination therapy, public health

## Introduction

### Epidemiology

According to the latest WHO report from 2024, the global prevalence of tobacco use among individuals aged 15 and older has significantly decreased from approximately 32.7% in 2000 to 22.5% in 2022, with projections indicating a further decline to 19.8% by 2030. This overall reduction is particularly notable among women, with rates expected to drop from 16.3% in 2000 to 5.7% by 2030. However, this positive trend is tempered by regional disparities; in the Eastern Mediterranean and Africa, rising tobacco use driven by population growth remains a significant issue. Despite global tobacco control efforts, adolescent nicotine use is still concerning. While traditional cigarette use is decreasing due to effective tobacco control measures, the use of e-cigarettes among adolescents is on the rise. Data reveal that children aged 13-15 in many countries can still easily obtain tobacco and nicotine products. Although regulations on e-cigarettes have led to some reduction in use, many adolescents continue to access these products, suggesting a shift in nicotine consumption patterns. This trend raises concerns that e-cigarette use may facilitate later transition to traditional cigarette smoking, as nicotine addiction formed through e-cigarettes could increase the likelihood of using conventional cigarettes in the future [1,2,3].

### Nicotine Dependence Mechanisms

Nicotine, the primary addictive substance in both cigarettes and e-cigarettes, plays a central role in the development of dependence by affecting the brain's reward system. This process starts when nicotine attaches to nicotinic acetylcholine receptors (nAChRs) in the brain, particularly the high affinity α4β2 nAChRs, which are critical for nicotine reinforcement and addiction. This binding initiates the release of neurotransmitters, notably dopamine. Recent research has also revealed the significant roles of additional nAChR subunits, such as α6 and β3, in enhancing the effects of nicotine. The subsequent release of dopamine generates pleasurable sensations, thereby reinforcing the link between nicotine use and reward. Over time, extended exposure to nicotine causes neuroadaptations, including alterations in receptor sensitivity and neurotransmitter levels, which contribute to the development of tolerance and addiction. As a result, individuals increasingly require higher doses of nicotine to achieve the same effects, perpetuating their dependence[4,5].

## Impact of COVID-19

The COVID-19 pandemic has introduced new complexities into smoking behaviors, with lockdown measures and associated stress impacting cessation efforts for some individuals, while heightened health concerns have prompted others to attempt to quit. This shifting landscape necessitates the development of targeted public health strategies to effectively address the evolving patterns of smoking and e-cigarette use during and after the pandemic [6,7].

## Brief History of E-Cigarettes

Electronic cigarettes (e-cigarettes) or electronic nicotine delivery systems (ENDS) have been under development by cigarette companies since at least 1963. The objective was to create alternatives to traditional tobacco products that could be promoted as having 'reduced harm 'or being 'socially acceptable, 'thus positioning them as healthier options by eliminating tobacco combustion. Although Philip Morris initiated research into nicotine aerosol technology in 1990, the company delayed the commercial introduction of its device, eventually launching the MarkTen model through its subsidiary NuMark in 2013. This delay was primarily attributed to concerns over potential FDA regulation of conventional tobacco products and the impact on political relationships with farmers. Meanwhile, Chinese pharmacist Hon Lik patented his version of the device in 2003, leading to the widespread attribution of the e-cigarette's invention to him [8].

## Objective of the Study

This review aims to evaluate the safety and effectiveness of e-cigarettes as a smoking cessation tool, assess their role in harm reduction relative to traditional smoking methods, and provide insights to guide future public health strategies.

## Evaluating E-Cigarette Safety vs. Traditional Smoking: Risks of Device Malfunctions, Chemical Exposure, and Health Effects

When considering the potential role of e-cigarettes in reducing smoking-related harm and aiding smoking cessation, it is essential to assess the overall safety of these devices. Scientific literature highlights potential risks associated with e-cigarettes, particularly concerning device malfunctions. Battery malfunctions in e-cigarette devices have been linked to serious accidents. An analysis of 238 reported e-cigarette-related injuries found that 53%

were due to explosive incidents, primarily caused by lithium-ion battery failures. A detailed study from 2016 to 2019 documented 159 e-cigarette-related injuries, with nearly 80% directly attributed to battery malfunctions. These incidents led to severe injuries, including second to third-degree burns, facial fractures, and dental damage [9]. Another review published focuses on global evidence regarding the health impacts of e-cigarettes. It analyzed hundreds of studies and found substantial to conclusive evidence that e-cigarettes contribute to environmental effects, such as waste, fires, and indoor airborne particulate matter [10].

E-cigarettes allow users to adjust the power settings of their devices, directly impacting the concentration of harmful chemicals in the aerosols they produce. Users who increase the power significantly elevate levels of harmful compounds. For instance, by raising the power from 3.7V to 4.8V results in a 50% increase in carcinogens like acetaldehyde and formaldehyde [11-15]. These substances are well-documented carcinogens, and their increased presence due to higher power settings underscores the variability in chemical exposure based on user adjustments. This highlights the need for standardized testing protocols and the development of devices that ensure consistent and safer operation across different settings, thereby minimizing health risks related to both unwanted chemical exposure and electronic failure [11-12].

The chemical composition of e-liquids and their resulting aerosols is crucial in evaluating e-cigarette safety. A detailed analysis of flavored e-liquids revealed the presence of 173 different chemical compounds across 189 samples, categorized into 22 chemical classes, such as aldehydes, carbonyls, and volatile organic compounds (VOCs). Heating these e-liquids can lead to the degradation of these chemicals into harmful by-products. For example, heating propylene glycol and glycerol, common base ingredients in e-liquids, produces toxicants such as formaldehyde and acrolein. Formaldehyde was detected in e-cigarette aerosols at concentrations ranging from 3.2 to 56.1 μg per puff, depending on the device's voltage settings. Acrolein, a potent respiratory irritant, was also found in significant quantities [13]. Additionally, flavoring agents like diacetyl and cinnamaldehyde, detected in 75% of tested e-liquids, have been linked to severe health issues, including bronchiolitis obliterans, a serious lung disease. These findings underscore the need for stringent regulation of e-liquid ingredients and ongoing research into the chemical transformations during vaping [14, 15].

Despite these concerns, recent studies support earlier assumptions about the lower relative harm of e-cigarette aerosols compared to tobacco smoke. E-cigarettes are often promoted as a less harmful alternative to traditional cigarettes due to generally lower levels of carcinogens. A systematic review comparing e-cigarette aerosols to cigarette smoke found that

e-cigarettes produce significantly lower concentrations of several known carcinogens. For example, levels of N'-nitrosonornicotine (NNN), a tobacco-specific nitrosamine (TSNA), were up to 97% lower in e-cigarette aerosols than in cigarette smoke, with concentrations ranging from 0.46 to 8.2 ng/mL. Formaldehyde levels in e-cigarette emissions were approximately 90% lower compared to conventional cigarette smoke, with concentrations between 4.5 to 6.4 μg per 10 puffs. The odds ratio (OR) for developing smoking-related cancers, such as lung cancer, is significantly lower for e-cigarette users compared to traditional smokers, with some studies indicating an OR as low as 0.15 for e-cigarette users compared to 1.0 for conventional cigarette smokers. Although these reductions suggest a potentially lower risk, the presence of any carcinogenic compounds in e-cigarette aerosols still poses a health risk [15, 16].

Non-flavored e-cigarettes might offer additional safety advantages over flavored variants due to the reduced presence of harmful flavoring chemicals. Studies comparing emissions from non-flavored and flavored e-cigarettes found that the absence of flavoring agents like diacetyl and cinnamaldehyde significantly reduces the production of toxic by-products. For instance, the concentration of acetaldehyde, a harmful carbonyl compound, was 65% lower in non-flavored e-cigarette aerosols compared to flavored ones, with levels ranging from 0.5 to 1.2 μg/mL. The odds ratio (OR) for developing respiratory conditions such as asthma was also lower for users of non-flavored e-cigarettes (OR = 1.10) compared to users of flavored products (OR = 1.39) [16].

It is important to note that e-cigarettes still pose potential risks to non-smokers. A study published in 2023 examined the pulmonary effects of subchronic third-hand exposure to e-cigarette vapor in a mouse model. Young mice were exposed to a towel soaked in e-cigarette vapor for four weeks. Mice exposed to third-hand e-vapor without nicotine showed alveolar enlargement, reduced bronchial responsiveness, increased epithelial thickening in large airways, increased epithelial layers in small airways, alveolar enlargement, and increased small airway collagen deposition compared to sham-exposed controls, indicating a decline in lung health due to inflammation and fibrosis [17]. Additionally, a review published in April 2023 highlighted the generation of indoor airborne particulate matter (substantial to conclusive evidence). There is substantial evidence that nicotine e-cigarettes can cause dependence or addiction in non-smokers, and strong evidence that young non-smokers who use e-cigarettes are more likely than non-users to initiate smoking and become regular smokers. E-cigarettes can cause various health issues, including poisoning, immediate toxicity upon inhalation (including seizures), and lung injuries related to e-cigarette use (EVALI)[10,18].

Regulatory agencies should mandate full disclosure of all ingredients in e-liquids and require manufacturers to implement safety features that minimize risks associated with device malfunctions and toxicant exposure. Establishing stringent guidelines for both device safety and e-liquid composition will be crucial in mitigating the health risks associated with e-cigarette use. Medicinal e-cigarettes would need to meet the standards for consumer e-cigarettes as well as additional requirements to meet efficacy, safety, and quality criteria under medicines regulation. By enforcing these standards, regulators can help ensure that e-cigarettes are a safer alternative to traditional smoking and protect public health [19,20].

**Global Trends and Evidence on E-Cigarettes as a Harm Reduction Tool**

Researchers explores dynamic shifts in tobacco harm reduction strategies, particularly in countries where alternative nicotine products such as e-cigarettes, heated tobacco products (HTPs), and snus are gaining traction. Data from the United Kingdom, Sweden, Norway, New Zealand, and Japan indicate significant declines in smoking rates compared to neighboring countries with less aggressive adoption of these alternatives, such as Australia and certain EU member states. The findings suggest that incorporating alternative nicotine products into health policies may substantially accelerate smoking rate reductions. For instance, in the United Kingdom, where e-cigarettes are promoted as effective smoking cessation tools, the smoking rate decreased by 4 percentage points between 2014 and 2020, a notably better result compared to EU countries where e-cigarettes are less prevalent. New Zealand also saw a faster reduction in smoking rates due to higher e-cigarette adoption, despite having similar traditional tobacco control measures to Australia. Conversely, Australia, where e-cigarettes are less popular, has not achieved comparable results. Sweden demonstrates the impact of snus, a low-toxicity oral tobacco product, which has contributed to the lowest smoking rate and tobacco-related mortality in Europe. Norway has experienced similar benefits from snus. Japan, with the introduction of HTPs since 2015, reports a decline in smoking, with 76% of HTP users not smoking conventional cigarettes, indicating the effectiveness of these products in replacing smoking. Surprisingly, smoking rates in Japan are lower than in Australia, despite stricter tobacco control measures in the latter [21,22].

The study initially published in 2016 and updated in 2020, involving 39 COPD patients, provides compelling evidence suggesting significant health benefits from switching from conventional cigarettes to e-cigarettes. At the start of the study, participants smoked an average of 22.1 (±4.7) conventional cigarettes daily. After five years, this average dropped significantly

to 1.4 (±1.6) cigarettes per day ($p < 0.001$). The control group, which did not use e-cigarettes, showed no substantial change in their smoking habits. Additionally, 45% of the e-cigarette users achieved complete abstinence from conventional cigarettes by the end of the study period, as verified by eCO levels (≤7 ppm). Among those who continued smoking (dual users), the average daily cigarette consumption decreased from 23.7 (±5.4) to 3.0 (±0.5), representing at least an 80% reduction. Shifts in e-cigarette preferences were noted, with an increase in users switching from standard e-cigarettes to those with lower nicotine concentrations over time. Subjective health improvements were observed, with the COPD Assessment Test (CAT) score decreasing significantly in the e-cigarette group, indicating better symptom management. COPD exacerbations fell from 2.3 (±0.9) per year to 1.1 (±1.0), suggesting a potential reduction in the frequency of severe COPD episodes. Lung function, measured through spirometry, showed marked improvements in the e-cigarette group, including significant increases in post-bronchodilator FEV1 and FVC values. Additionally, the number of patients progressing to less severe stages of COPD according to GOLD criteria increased in the e-cigarette group. The 6-minute walk test (6MWD) results also improved significantly in the e-cigarette group compared to the control group [23].

In contrast, two recent systematic reviews present a more cautious perspective on the health impacts of e-cigarettes. The 2023 review, focusing on respiratory health, found that out of 66 respiratory test measurements, 65% were not statistically significant. While some tests indicated improvements, others showed declines that were not clinically relevant. The review concluded that e-cigarettes do not appear to cause additional harm to respiratory health compared to smoking, but the quality of the studies was low, and the evidence remains inconclusive regarding potential benefits [24]. Similarly, another 2023 review on cardiovascular effects found that nearly two-thirds of the cardiovascular tests showed no significant difference between e-cigarettes and tobacco smoking. Although a few studies reported potential benefits, such as reduced systolic blood pressure in hypertensive users, the overall evidence is of low to very low certainty. The review highlighted that e-cigarettes do not incur additional cardiovascular risks, but the observed benefits are not robust and require further investigation [10, 25].

The authors argue that the World Health Organization (WHO) should more actively support and promote harm reduction-based strategies. Despite global tobacco control efforts, including the WHO Framework Convention and MPOWER measures, the pace of smoking reduction remains inadequate, with the number of smokers worldwide staying relatively constant over recent decades. The authors advocate for a more robust endorsement of alternative

nicotine products as part of a comprehensive smoking cessation strategy. They recommend combining stronger regulations and taxes on combusted tobacco products with the promotion of less harmful alternatives to accelerate progress in reducing smoking rates [21, 26].

**Comparative Analysis of E-Cigarettes and Nicotine Replacement Therapy for Smoking Cessation: Efficacy and Limitations**

Nicotine Replacement Therapy (NRT) encompasses several products aimed at aiding smoking cessation by providing controlled doses of nicotine to reduce withdrawal symptoms and cravings. The main forms of NRT include nicotine patches, gum, lozenges, and inhalers. Nicotine patches deliver a steady dose of nicotine through the skin over a 24-hour period and are available in varying strengths such as 7, 14, and 21 mg. Nicotine gum and lozenges release nicotine through the mucous membranes in the mouth, with gum typically offered in 2 and 4 mg doses and lozenges in 2 and 4 mg strengths. These products are widely approved methods of smoking cessation and can be found in various flavors to improve user compliance [27, 28]. NRT functions by providing a controlled amount of nicotine that alleviates withdrawal symptoms and reduces cravings. Nicotine patches deliver a consistent level of nicotine, which helps diminish the severity of withdrawal symptoms and supports gradual reduction of nicotine dependence. Nicotine gum and lozenges offer a more immediate nicotine release, which helps manage cravings and withdrawal symptoms on demand. This steady supply of nicotine aids users in managing their addiction without the harmful chemicals found in cigarettes. For instance, nicotine gum releases nicotine as it is chewed, while lozenges dissolve slowly to provide a steady nicotine dose [27, 28].

The effectiveness of NRT in smoking cessation is relatively modest, with about 10% of users managing to quit smoking for at least six months. This success rate reflects challenges related to adherence and long-term commitment to the therapy. Studies indicate that approximately 2 to 4 additional people per 100 who use NRT quit smoking compared to those who do not use any treatment. Despite its benefits, such as reducing cravings and withdrawal symptoms, achieving long-term cessation often requires ongoing motivation and support, suggesting that while NRT is a useful tool, it is not always sufficient on its own for sustained smoking cessation [4, 27, 28].

The efficacy of e-cigarettes as tool for smoking cessation in comparison to nicotine replacement therapy (NRT) has been a significant focus in recent research. In a pivotal 2019 study published in *The New England Journal of Medicine*, involving 886 participants, found

that the one-year abstinence rate for the e-cigarette group was 18.0%, notably higher than the 9.9% rate observed in the NRT group. Adherence to the e-cigarette regimen was significantly higher (80%) compared to the NRT regimen (9%) at 52 weeks. While e-cigarette users reported more throat or mouth irritation (65.3% vs. 51.2%) and nausea (37.9% vs. 31.3%), they experienced greater reductions in cough and phlegm production. No significant differences in wheezing or shortness of breath were observed between the groups. The findings from this 2019 study are consistent with both previous and recent reviews that compared nicotine e-cigarettes to NRT and found higher quit rates among e-cigarette users [29].

An updated review from the Cochrane Database of Systematic Reviews in 2024, including 88 studies with 27,235 participants, reaffirmed and expanded upon earlier findings. The review highlights three main comparisons: nicotine e-cigarettes versus NRT, nicotine e-cigarettes versus nicotine-free e-cigarettes, and nicotine e-cigarettes versus behavioral support or no support. The evidence indicates a high level of certainty that nicotine e-cigarettes lead to higher smoking cessation rates compared to NRT, with an estimated additional 2 to 6 individuals per 100 achieving cessation (RR 1.59, 95% CI 1.29 to 1.93). Nicotine e-cigarettes were also found to be more effective than nicotine-free e-cigarettes, with an additional 2 to 16 individuals per 100 achieving cessation (RR 1.46, 95% CI 1.09 to 1.96) [30, 31].

In terms of adverse effects, nicotine e-cigarettes and NRT both have reported issues, though the types and frequencies vary. E-cigarette users reported higher rates of throat or mouth irritation (65.3%) and nausea (37.9%) compared to NRT users (51.2% and 31.3%, respectively). Serious adverse events (SAEs) were rare across both treatments, with insufficient evidence to definitively determine differences between groups due to imprecision (RR 1.20, 95% CI 0.90 to 1.60). When nicotine e-cigarettes were combined with NRT, studies showed increased smoking cessation rates compared to NRT alone, but this finding should be interpreted with caution due to high heterogeneity in the results and potential bias in some studies. Nicotine e-cigarettes in combination with NRT were more effective than single NRT forms, indicating that combined therapies might enhance cessation success [29, 30, 31].

## Evaluating E-Cigarettes in Combination with Nicotine Replacement Therapy and Pharmacological Treatments

The most recent review published in 2023 in the *Cochrane Database of Systematic Reviews*, titled *Pharmacological and Electronic Cigarette Interventions for Smoking Cessation in Adults: Component Network Meta-Analyses*, analyzed 332 studies that met the inclusion

criteria, with 319 studies providing usable data. These studies collectively involved 157,179 adult tobacco smokers, offering a comprehensive analysis of the effectiveness of various interventions used to treat nicotine dependence. The authors highlight challenges associated with combining e-cigarettes with pharmacotherapy, including the need for further research on the long-term safety and efficacy of such treatments. As e-cigarettes are relatively new tools, their long-term health effects remain under investigation. However, current evidence suggests that combining e-cigarettes with pharmacological therapy may be beneficial in treating nicotine addiction. The potential benefits, such as improved abstinence rates and alleviation of withdrawal symptoms, may result from the synergistic effects of e-cigarettes and traditional medications [32].

Among the pharmacotherapies recognized by the WHO as essential in treating nicotine dependence are Nicotine Replacement Therapy (NRT), Varenicline (Chantix and Champix), Cytisine (Tabex), Bupropion (Zyban or Wellbutrin), and Nortriptyline (Norpress, available only in New Zealand for smoking cessation). Nortriptyline appears to lead to the lowest cessation rates, with only 6 to 11 per 100 individuals successfully quitting smoking. Other medications have also proven effective but to a lesser degree. E-cigarettes, varenicline, and cytisine are most likely to aid in smoking cessation. The results indicated that varenicline, cytisine, nicotine e-cigarettes, and combined NRT had similar effectiveness, with no clinically significant differences between them. The best outcomes in reducing serious adverse events were observed with nicotine e-cigarettes and cytisine. Among 100 people, 10 to 19 might quit smoking using e-cigarettes, 12 to 16 using varenicline, and 10 to 18 using cytisine. In comparison, only 6 out of 100 people might quit smoking without any medication, e-cigarettes, or with a placebo. Notably, nicotine e-cigarettes, varenicline, and cytisine were more effective than single forms of NRT and other available therapies, such as bupropion or nortriptyline. This suggests that these interventions may offer better support for smoking cessation, especially compared to standard NRT and pharmacotherapy. The review also notes that combining different forms of NRT, such as nicotine patches with fast-acting NRT, shows effects comparable to those of e-cigarettes, varenicline, and cytisine. The authors underscore the need for further research, particularly given the limited number of studies combining e-cigarettes with pharmacotherapy and NRT [19, 32- 36].

A study published in October 2023 explored the combination of varenicline with e-cigarettes. The combination of electronic nicotine delivery systems (ENDS) with varenicline may be an effective approach for transitioning from traditional cigarette smoking to using ENDS. The number of cigarettes smoked dropped sharply in the first weeks of treatment and

remained low in subsequent weeks. The achieved four-week smoking abstinence rate of 28% compares favorably with other studies involving individuals who were not actively seeking treatment to quit smoking. The reduction in cigarette dependence was significant, while ENDS dependence rates remained stable. Comparing these results with data from the EAGLES trial, where the six-month quit rate for varenicline monotherapy was 21.8%, one could infer that ENDS may further increase the abstinence rate in combined therapy [34- 37].

**Effectiveness of Cognitive Behavioral Therapy and Motivational Interviewing Combined with E-Cigarettes in Smoking Cessation**

Cognitive Behavioral Therapy (CBT) and Motivational Interviewing (MI) are considered key approaches in treating nicotine addiction, each addressing different aspects of the condition. CBT focuses on identifying and modifying cognitive distortions and unhealthy behavioral patterns that sustain smoking. It teaches patients coping strategies for managing nicotine cravings and avoiding smoking triggers, as well as skills for handling relapses. MI, on the other hand, involves an empathetic dialogue aimed at resolving ambivalence about quitting smoking and enhancing internal motivation. MI helps patients build self-efficacy and maintain commitment to the cessation process [37].

Both behavioral therapies have proven effectiveness, particularly in short-term smoking cessation. CBT, whether used alone or in combination with other methods, has demonstrated its effectiveness in improving coping with addiction. Participants in CBT programs generally manage nicotine cravings and withdrawal effects more effectively. MI, meanwhile, effectively supports increased motivation to quit smoking by helping patients maintain engagement and address issues related to the cessation process. Studies suggest that the combination of CBT and MI with nicotine e-cigarettes can significantly increase abstinence rates in the short term. For instance, studies have shown that after 12 weeks, the abstinence rate was 21.9% for those using CBT with nicotine e-cigarettes, compared to 9.1% for those receiving counseling alone. After 24 weeks, this difference in effectiveness diminished, with abstinence rates at 17.2% for the CBT and nicotine e-cigarette group compared to 9.9% for the counseling group [37].

Compared to other smoking cessation methods, such as pharmacotherapy or e-cigarettes, CBT and MI offer different benefits. Behavioral therapies like CBT and MI focus on the psychological aspects of addiction and may be less invasive than pharmacotherapy. They provide an opportunity to address the psychological issues critical for effective smoking cessation without the need for medication. In contrast, e-cigarettes address the physical aspects

of addiction, such as nicotine dependence, offering an alternative to traditional cigarettes. While pharmacotherapy is effective, it may be associated with side effects, whereas e-cigarettes present a lower risk but may still have various adverse effects.

The combination of CBT and MI with e-cigarettes can yield promising results, although different approaches may produce varying effects. For example, studies show that CBT combined with nicotine e-cigarettes resulted in higher abstinence rates after 12 weeks (21.9%) compared to counseling alone (9.1%). After 24 weeks, this difference decreased (17.2% in the CBT and nicotine e-cigarette group compared to 9.9% in the counseling group). On the other hand, non-nicotine e-cigarettes combined with counseling showed variability in outcomes: after 12 weeks, the abstinence rate was 17.3% in the non-nicotine e-cigarette and counseling group, which was not significantly different from the counseling-only group (9.1%). However, after 24 weeks, the abstinence rate in the non-nicotine e-cigarette group increased to 20.5%, suggesting potential long-term benefits [38].

In conclusion, the combination of behavioral therapies with e-cigarettes may offer benefits, but the effects are more pronounced in the short term, and long-term efficacy requires further research and support. Adverse events, such as cough and dry mouth, were common across all groups, with nicotine e-cigarette users experiencing a higher rate of adverse effects (94%) compared to those using non-nicotine e-cigarettes (93%) and those receiving only counseling (73%) [37-38].

## Conclusions

The ongoing evolution in nicotine dependence and smoking reflects notable progress, with a global decline in tobacco use. However, regional disparities and rising adolescent tobacco use highlight the need for targeted public health interventions. Smoking remains a major public health challenge, with significant healthcare costs and widespread harm. This underscores the importance of continuous research and the refinement of treatment protocols for nicotine addiction, in line with evidence-based practices.

E-cigarettes, often promoted as a safer alternative to traditional smoking, introduce their own set of safety concerns. Issues such as device malfunctions and harmful chemicals in e-liquids pose significant risks. While e-cigarettes reduce exposure to some carcinogens compared to conventional cigarettes, the presence of other harmful by-products in aerosols underscores the need for stringent regulatory oversight and ongoing research to ensure user safety.

Comparative studies show that e-cigarettes may offer some benefits over traditional nicotine replacement therapies (NRT) in reducing smoking but are less effective for achieving complete nicotine abstinence. Combining e-cigarettes with NRT and pharmacological treatments shows promise for enhancing cessation rates. However, the long-term safety and effectiveness of these combinations, especially in vulnerable populations like pregnant women, require further exploration. Behavioral therapies such as cognitive-behavioral therapy (CBT) and motivational interviewing (MI) are crucial for addressing the psychological aspects of nicotine addiction. When combined with e-cigarettes, these interventions offer significant short-term benefits, though their long-term impact needs more research. Integrating behavioral support with e-cigarettes provides a comprehensive approach to smoking cessation, but further studies are needed to refine these methods and assess their sustained effectiveness.

Despite their potential as smoking cessation aids, e-cigarettes present limited overall effectiveness and significant safety concerns. There is an urgent need for stricter regulations to ensure the safety of e-cigarette products and high-quality long-term cohort studies to better understand their impact. Without standardized, safe devices, it is challenging to determine the effectiveness of e-cigarettes for smoking cessation definitively. Additionally, the potential threat e-cigarettes pose to youth necessitates careful monitoring and regulation.

In summary, a multifaceted approach integrating behavioral therapies with pharmacological treatments, along with rigorous regulatory oversight of e-cigarette products, is essential for enhancing smoking cessation success and protecting public health. This strategy will address the complexities of nicotine dependence and ensure continued progress in combating smoking-related diseases.

From our review, several weaknesses in common research designs have been identified. A major limitation in long-term studies was the reliance on self-reported adherence without consistent assessment measures. Additionally, participant motivation for quitting smoking was rarely well-defined, and many studies lacked a thorough preparatory phase.
Furthermore, there is a significant gap in data for low- and middle-income countries, which are in greatest need of smoking cessation strategies to combat the tobacco epidemic.

Currently, it is premature to include all e-cigarettes in smoking cessation strategies. The focus should be on identifying e-cigarette characteristics that optimize smoking cessation while minimizing adverse health outcomes and removing those products that do not meet these criteria from the market.

## Disclosure

### Author's contribution

Conceptualization: Mateusz Górka and Zuzanna Kudas; Methodology: Mateusz Górka and Zuzanna Kudas; Software: Krzysztof Szerej; Check: Krzysztof Szerej; Formal analysis: Anna Wojtkiewicz and Weronika Stec; Investigation: Weronika Stec and Magda Piekarska; Resources: Magda Piekarska and Mateusz Górka; Data curation: Mateusz Górka and Krzysztof Szerej; Writing - rough preparation: Mateusz Górka; Writing - review and editing: Zuzanna Kudos and Krzysztof Szerej; Visualization: Zuzanna Kudas; Supervision: Mateusz Górka; Project administration: Anna Wojtkiewicz and Magda Piekarska;

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