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The new nicotine epidemic: understanding the systemic harms of e-cigarettes in the adolescent population

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The growing use of electronic cigarettes (e-cigarettes) among adolescents represents a serious public health concern. Initially marketed as safer alternatives to traditional cigarettes, e-cigarettes are now the most prevalent nicotine products among youth. This narrative review summarizes evidence published up to May 2025 on the epidemiology, health effects, and prevention of e-cigarette use in children and adolescents. Recent surveys indicate a decline in traditional smoking among adolescents but a sharp increase in e-cigarette use, with up to one-third of youth reporting having tried vaping at least once. The widespread appeal of e-cigarettes is driven by flavour variety, social influence, and perceptions of reduced harm. However, evidence shows that vaping aerosols contain toxic substances capable of inducing oxidative stress, inflammation, and cellular injury. Adolescents are especially vulnerable: vaping has been associated with respiratory diseases such as asthma and bronchitis, endothelial dysfunction, immune suppression, and neurodevelopmental alterations linked to nicotine exposure. Moreover, e-cigarette use increases the likelihood of transitioning to conventional smoking and other risky behaviours, while 'dual use' of cigarettes and e-cigarettes further amplifies health risks. Effective prevention requires a comprehensive approach combining school-based education, parental and healthcare engagement, behavioural support, and public policies that restrict marketing and flavour availability. In conclusion, e-cigarette use poses significant health threats to adolescents, undermining decades of tobacco control progress. Coordinated public health interventions, regulatory enforcement, and continued research are essential to prevent nicotine dependence and protect the wellbeing of future generations.

KEYWORDS

adolescents, e-cigarettes, nicotine addiction, prevention strategies, public health, vaping

1 Background

Smoking remains one of the most significant public health challenges worldwide, persisting as a common habit despite the well-documented risks associated with tobacco use. In industrialized countries, nearly one-third of the population continues to smoke, and in Europe, tobacco consumption is the leading cause of premature death, accounting for approximately 700,000 deaths each year. Alarmingly, an

additional 1.3 million deaths involve non-smokers, including infants and children, who are particularly vulnerable to second-hand smoke exposure (1).

Epidemiological evidence has firmly established the causal link between cigarette smoking and a wide spectrum of diseases, with lung cancer being the most prominent. In countries where smoking prevalence has decreased, a corresponding decline in lung cancer incidence has been observed (2). Consequently, many governments have implemented comprehensive tobacco control measures—such as bans on advertising, graphic warning labels, restrictions on public smoking, and increased taxation—to make smoking less affordable and socially acceptable. Public health campaigns have further supported these efforts by promoting awareness of smoking-related health risks and encouraging cessation.

Despite these achievements, new alternatives to traditional tobacco have emerged, including vaping devices, nicotine replacement products (such as gums and patches), heated tobacco products (HTPs), and electronic cigarettes (e-cigarettes), with or without nicotine (3). E-cigarettes were developed as a potentially less harmful alternative to conventional cigarettes, intended to satisfy nicotine cravings without the combustion of tobacco. Although the concept dates back to the 1960s, the modern e-cigarette was introduced in 2003 by Chinese pharmacist Hon Lik. These devices typically consist of a power source (usually a lithium battery), a heating element, and a reservoir containing an ‘e-liquid’—a mixture of solvents such as water, propylene glycol, and glycerol, often combined with flavourings like mint, fruit, or confectionery aromas (3). Depending on the model, e-cigarettes may be nicotine-free (ENNDS) or contain variable concentrations of nicotine (ENDS). When heated, the liquid transforms into an aerosol that users inhale.

Since their introduction, e-cigarettes have evolved rapidly in both design and technology, from early ‘cig-a-like’ models resembling traditional cigarettes to vape pens, pod systems, and heat-not-burn (HnB) devices (3, 4). Well-known brands include IQOS and JUUL. IQOS heats specially processed tobacco sticks (HEETS or HeatSticks) to produce a nicotine-containing aerosol without combustion, while JUUL employs nicotine salts derived from tobacco in compact, USB-like devices. These innovations have contributed to the growing popularity of vaping, particularly among adolescents, who are drawn to the sleek designs, ease of use, and appealing flavours (3, 4).

Although initially marketed as a harm-reduction tool, mounting evidence indicates that e-cigarettes pose significant health risks, especially for children and adolescents. The increasing prevalence of e-cigarette use among youth, coupled with their potential for addiction and long-term health effects, represents a serious public health concern. This narrative review aims to summarize the current evidence on the epidemiology, health consequences, addictive potential, and prevention strategies related to e-cigarette use among children and adolescents.

2 Methods

This narrative review was conducted to critically synthesize current evidence regarding the epidemiology, health consequences, addictive potential, and prevention strategies

related to e-cigarette use among children and adolescents. The review did not aim to be exhaustive and therefore did not follow PRISMA guidelines. However, for transparency, this section describes the literature identification process to ensure comprehensive coverage of the existing literature.

A systematic literature search was performed across major biomedical and scientific databases, including PubMed, Scopus, and Web of Science, to identify relevant publications available up to May 2025. The search strategy combined Medical Subject Headings (MeSH) and free-text terms related to e-cigarette use and youth populations, including: ‘electronic cigarettes,’ ‘e-cigarettes,’ ‘vaping,’ ‘adolescents,’ ‘children,’ ‘youth,’ ‘nicotine dependence,’ ‘health effects,’ and ‘prevention.’ Boolean operators were used to optimize sensitivity and specificity of the search.

Eligible studies included peer-reviewed original research articles (observational, experimental, and interventional studies), systematic and narrative reviews, meta-analyses, and epidemiological reports that examined e-cigarette use in pediatric or adolescent populations. In addition, reports and surveillance data from authoritative public health institutions—such as the World Health Organization (WHO), the Centers for Disease Control and Prevention (CDC), and the European Commission—were included to ensure incorporation of the most current and policy-relevant evidence.

Studies were excluded if they were not published in English, focused exclusively on adult populations, lacked original or comparative data, or did not directly address health outcomes, risk factors, or preventive strategies related to e-cigarette use. Reference lists of eligible articles were manually screened to identify additional pertinent publications not captured in the initial database search.

Data extraction was performed qualitatively, with particular attention to study design, population characteristics, exposure definitions, outcome measures, and key findings. The analysis focused on four major domains: (1) prevalence and epidemiological trends, (2) physiological and psychological health effects, (3) addictive potential and behavioral consequences, and (4) prevention and intervention strategies. Findings were synthesized narratively to provide an integrated and critical overview of the current state of knowledge, identify gaps in the literature, and highlight priorities for future research and public health action.

This review was designed as a narrative review in order to provide a broad, integrative, and clinically oriented synthesis of the rapidly expanding and heterogeneous literature on e-cigarette use in children and adolescents. A narrative approach was considered most appropriate given the variability in study designs, populations, exposure definitions, outcome measures, and evolving product characteristics, which limit the feasibility of quantitative pooling or meta-analytic techniques. To enhance methodological rigor, the literature was critically appraised with attention to study quality, consistency of findings, and potential sources of bias. Greater weight was given to longitudinal studies, systematic reviews, large population-based surveys, and well-controlled experimental or mechanistic studies, while evidence from cross-sectional or self-reported data was interpreted with caution. Potential biases—including recall bias, reporting bias, residual confounding, and reverse causality—were explicitly considered when synthesizing results, particularly in

observational studies. Discrepancies between studies were examined in light of differences in age groups, device types, nicotine content, and regulatory contexts. This structured and critical narrative synthesis aimed to balance completeness with methodological transparency, allowing readers to assess the robustness, limitations, and clinical relevance of the evidence presented.

3 Results

3.1 Epidemiology

Recent national surveys among Italian adolescents aged 13–15 years were prioritized in this review because they provide high-quality, nationally representative data within a well-defined regulatory framework, allowing for a clear interpretation of trends in youth tobacco and e-cigarette use (4, 5). These data are particularly informative given Italy's long-standing tobacco control policies and legal prohibition of sales to minors, which offer a relevant context for assessing the real-world impact of regulation on adolescent behaviors. Between 2010 and 2022, the proportion of traditional cigarette smokers declined from 21% to 16%, while e-cigarette use rose markedly (5). Approximately 20% of adolescents reported regular e-cigarette use—more frequently among girls—and one-third (33%) had tried them at least once (5). Notably, despite legal restrictions on the sale of tobacco and vaping products to individuals under 18 years, most adolescents reported easy access through retail outlets, highlighting a critical gap between legislation and enforcement (5). Comparable trends have been observed in several other high-income countries, where declining rates of combustible cigarette smoking among adolescents have coincided with rising experimentation and regular use of e-cigarettes, although the magnitude of these shifts varies across regions according to differences in regulatory frameworks, market penetration, and enforcement policies, as documented in WHO and international surveillance reports (4, 5).

Multiple factors contribute to the growing popularity of e-cigarettes among youth (Table 1). Many adolescents perceive

vaping as harmless—or at least less harmful than conventional smoking—and are influenced by peer pressure, aggressive marketing, and the easy availability of products both in stores and online. Gender differences in usage patterns have also been reported: males generally show higher rates of lifetime, current, and dual e-cigarette use compared with females (6), although opposite findings have been documented in Italian cohorts (5).

Marketing strategies used by e-cigarette companies closely mirror those historically employed by the tobacco industry, emphasizing themes such as independence, rebellion, and social sophistication. Adolescents are particularly drawn to modern vaping devices for their sleek designs, user-friendly interfaces, and variety of appealing flavours, as well as for the discretion they offer in smoke-free settings. Importantly, most adolescents continue to believe that vaping is a safer alternative to smoking (7).

Based on the collective evidence analyzed in this review, the increasing prevalence of e-cigarette use among children and adolescents—together with their potential for nicotine addiction and as-yet-unknown long-term effects—emerges as a significant public health concern. Across the studies examined, health risks associated with these alternative products remain incompletely defined, particularly in younger populations. Nevertheless, the available evidence consistently indicates that, beyond nicotine, e-cigarette aerosols contain numerous chemical substances which, when vaporized, can generate toxic and potentially carcinogenic compounds with deleterious biological effects.

3.2 Health effects of e-cigarettes

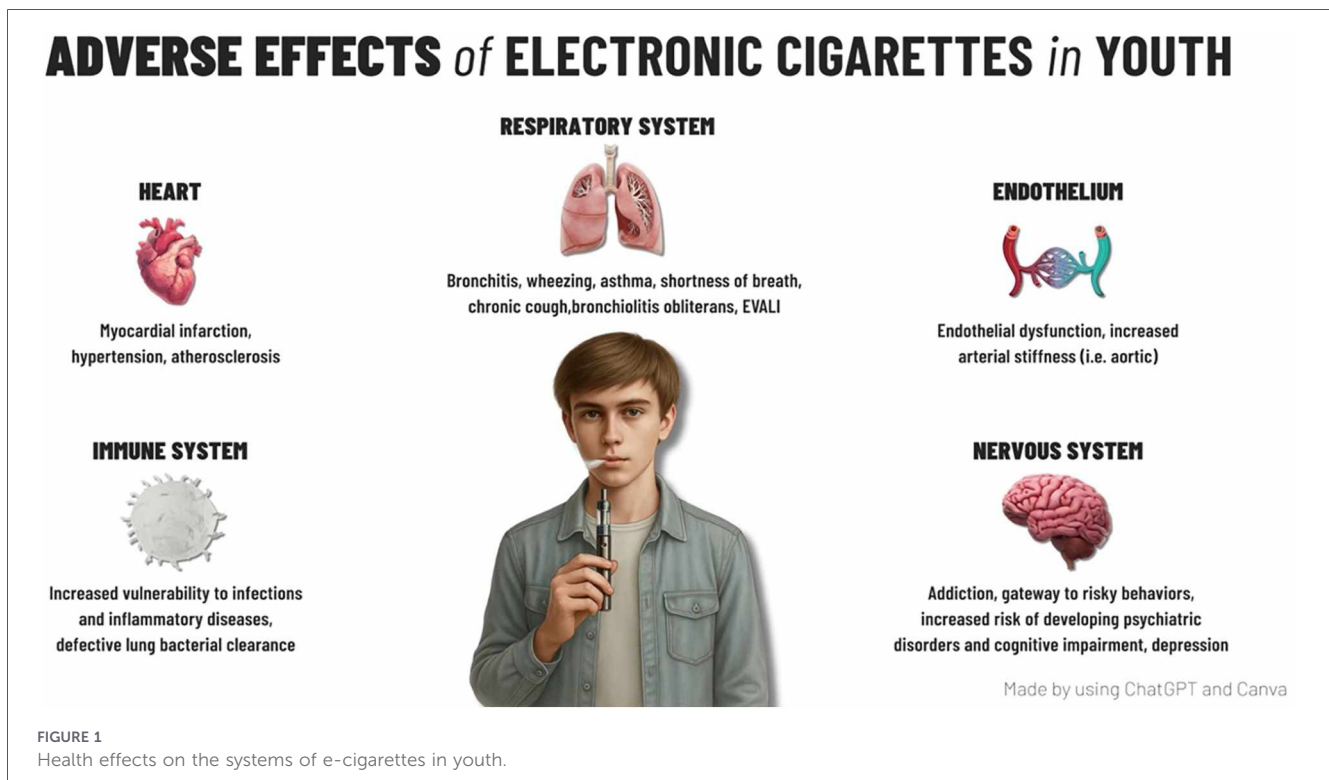
Although e-cigarettes were originally promoted as a safer alternative to traditional tobacco smoking (6), the body of evidence reviewed in this article indicates that their use is associated with substantial health risks, particularly among children and adolescents. During childhood and adolescence, the respiratory, cardiovascular, immune, and neurological systems are still developing and are therefore especially susceptible to the inflammatory, oxidative, and cytotoxic effects of e-cigarette aerosols. Figure 1 summarizes the principal health effects of e-cigarette use in young people.

3.2.1 Respiratory effects

Based on the experimental and epidemiological studies reviewed (8–18), vaping exposes users to aerosols containing harmful substances—including volatile organic compounds, aldehydes, and heavy metals—which have been associated with significant respiratory injury. A recent Australian study demonstrated that exposure to heated tobacco products (IQOS) was as detrimental to human lung cells as traditional cigarettes and e-cigarettes, inducing oxidative stress, inflammation, and cytotoxicity comparable to cigarette smoke (8). Toxic compounds such as formaldehyde, acrolein, and acetaldehyde were identified in IQOS emissions, reinforcing that these products cannot be considered safe alternatives. Children and adolescents who vape are at increased risk of bronchitis, wheezing, asthma, shortness of breath, and chronic cough, even when not using traditional cigarettes (8). E-cigarette use is associated with a higher prevalence of asthma symptoms and

TABLE 1 Predictive and protective factors for the use of the e-cigarette in young people.

Predictive factors	Protective factors
Age, sex, ethnicity	Regular participation in team sports
Tendency to internalize problems, break rules, enjoy frightening things	High regard for conventional social norms
Parental education, family structure, second-hand smoke exposure at home	Perception of the cost and danger of vaping
Poor academic performance	Monitoring by parents
Proximity of retailers to schools	Higher education level of the mother
Presence of friends who smoke	High college aspirations
Concomitant use of other substances	Positive engagement from teachers



exacerbations across sexes and age groups, and similar effects are observed with second-hand exposure to e-cigarette aerosols (9). A meta-analysis of 15 studies confirmed a significant association between e-cigarette use and asthma (pooled OR 1.39; 95% CI 1.28–1.51) (10).

Exposure to second-hand smoke—whether from traditional or e-cigarettes—further increases the risk of developing asthma, particularly when both parents smoke (11). Passive nicotine exposure among adolescents has been linked to bronchial symptoms [odds ratio [OR] 1.40; 95% confidence interval [CI] 1.06–1.84] and shortness of breath (OR 1.53; 95% CI 1.06–2.21) (12). Prenatal and postnatal exposure to second-hand smoke compound these risks and may result in lifelong reductions in respiratory function (11, 13).

A systematic review and meta-analysis involving over 900,000 participants reported that prenatal vaping exposure increases the likelihood of adverse neonatal outcomes by 53%, including low birth weight (OR 1.56; 95% CI 1.28–1.93), preterm birth (OR 1.49; 95% CI 1.27–1.76), and small-for-gestational-age infants (OR 1.48; 95% CI 1.16–1.89) (14).

Furthermore, many of the flavouring agents used to enhance the appeal of e-cigarettes—often unregulated by toxicological standards—pose additional respiratory risks (15). Diacetyl, a compound used in sweet flavours, has been associated with bronchiolitis obliterans ('popcorn lung'), a severe and irreversible form of lung damage (16). Similarly, cinnamaldehyde, a common additive in cinnamon-flavoured liquids, impairs ciliary motion in human bronchial epithelial cells by disrupting mitochondrial function and energy metabolism, thereby compromising mucociliary clearance (17). Other flavouring chemicals, including flavonoids, have been shown to produce immunosuppressive effects in pediatric populations (18).

One of the most serious vaping-related lung conditions is EVALI (E-cigarette or Vaping Product Use-Associated Lung Injury), first identified in 2019 in the United States (19). EVALI has been linked primarily to tetrahydrocannabinol (THC)-containing vaping products and vitamin E acetate. Symptoms typically include cough, chest pain, and dyspnea, with 80% of cases requiring hospitalization. During the 2019 outbreak, 2,807 adolescents were hospitalized, 20% required intensive care, and approximately 70 deaths were reported (19–21). Most affected patients exhibited persistent lung abnormalities even six months after diagnosis, underscoring the long-term impact of vaping-related lung injury.

3.2.2 Cardiovascular effects

Emerging evidence indicates that e-cigarette use may have deleterious cardiovascular effects, particularly when exposure begins during adolescence. Early exposure to nicotine and toxic aerosol constituents can accelerate arterial aging and endothelial dysfunction, thereby predisposing young users to long-term cardiovascular disease. The adolescent cardiovascular system—characterized by active vascular remodeling and an immature endothelium—is especially vulnerable to the oxidative stress and inflammation induced by e-cigarette aerosols (22).

Nicotine and other chemical components of vaporized e-liquids can impair endothelial function, increase arterial stiffness, and elevate blood pressure—recognized early markers of cardiovascular disease (23). Studies comparing traditional cigarettes and e-cigarettes have shown that both acutely increase aortic stiffness and blood pressure, with electronic cigarettes producing comparable detrimental effects when used for longer durations (24). In experimental animal models, chronic inhalation of e-cigarette vapor has resulted in endothelial

dysfunction and arterial stiffness similar to that caused by conventional cigarette smoke (25).

Given the prognostic value of elevated blood pressure and arterial stiffness as predictors of cardiovascular morbidity and mortality, these findings raise serious concerns about the potential lifelong cardiovascular consequences of vaping initiation during adolescence.

3.2.3 Immunological effects

Evidence suggests that e-cigarettes compromise immune function (26). Inhalation of e-cigarette aerosols alters both innate and adaptive immune responses, potentially increasing susceptibility to infections and inflammatory diseases (26).

In murine models, exposure to e-cigarette vapor significantly impaired pulmonary antimicrobial defenses (26). Mice exposed to e-cigarette emissions exhibited decreased bacterial clearance from the lungs following infection with *Streptococcus pneumoniae* compared with air-exposed controls. This impairment was partly attributed to reduced phagocytic activity of alveolar macrophages. Similarly, during influenza A virus infection, e-cigarette-exposed mice showed higher viral titers, worsened illness severity, and increased mortality (26).

These findings suggest that e-cigarette aerosols weaken host immune defenses, increasing vulnerability to both bacterial and viral pathogens—an especially concerning effect in children and adolescents, whose immune systems are still maturing (26).

3.2.4 Effects on mental health and neurodevelopment

Based on the body of experimental, clinical, and epidemiological evidence examined in this review, the effects of e-cigarettes appear to extend beyond physical health, with significant implications for adolescent brain development and mental health. The studies analyzed consistently highlight adolescence as a critical period of neurobiological maturation—particularly within the prefrontal cortex and limbic regions that regulate cognition, emotion, and decision-making—during which nicotine exposure may confer heightened vulnerability (27–32). Nicotine exposure during this phase can disrupt normal neurodevelopment through structural and functional alterations in neuronal circuitry (29–31).

Nicotine acts on nicotinic acetylcholine receptors, affecting neurotransmission and synaptic plasticity. Chronic exposure leads to receptor desensitization and altered dopamine signaling within the brain's reward pathway, heightening vulnerability to addiction (30, 33). Reactive oxygen species and oxidative stress contribute to these neurotoxic effects, inducing epigenetic modifications such as DNA methylation that reinforce addictive behaviors (32, 34). Damage to the prefrontal cortex—among the last brain regions to mature—can impair executive function, attention, and inhibitory control, particularly when nicotine use begins early in adolescence (35, 36).

Epidemiological data underscore these neurobiological findings. Analyses of the 2017 and 2019 U.S. Youth Risk Behavior Surveys revealed that adolescents who used e-cigarettes were significantly more likely to report depression, suicidal thoughts, and suicide attempts compared with non-users.

Notably, these associations were stronger among female adolescents, suggesting potential sex-specific vulnerability to the psychological effects of vaping (37).

Furthermore, the high nicotine concentrations found in some e-cigarette products—often exceeding those of traditional cigarettes—pose a substantial risk for dependence and addiction (27, 28). Serum nicotine levels can peak within minutes of inhalation, mirroring those of combustible cigarettes (38). Alarming, adolescents may develop dependence even at low levels of use, with withdrawal symptoms occurring after minimal exposure (39, 40). Persistent nicotine use induces lasting neuroadaptations, creating lifelong vulnerability to addiction (41–43).

Despite the presence of nicotine in most e-cigarette products (44), up to 80% of adolescents believe they are using nicotine-free devices (41, 45). Flavours further enhance the appeal and addictiveness of these products, with fruity, menthol, and sweet flavours being particularly popular (30, 32, 46). Many adolescents perceive fruit-flavoured products as less harmful than tobacco-flavoured ones and report that flavour availability strongly influences their willingness to vape; most would discontinue use if their preferred flavours were banned (47).

Taken together, these findings highlight how nicotine exposure through e-cigarettes jeopardizes both mental health and neurodevelopment in adolescents while reinforcing dependence through neurochemical and behavioral mechanisms.

3.2.5 The 'gateway effect'

A growing body of longitudinal evidence supports the 'gateway effect,' in which adolescent e-cigarette use increases the likelihood of later use of traditional cigarettes and other addictive substances. A U.S. high school cohort study demonstrated that e-cigarette use was significantly associated with subsequent initiation of combustible cigarette smoking, while the reverse relationship was not observed (48).

Nicotine's reinforcing properties are thought to prime the brain's reward circuitry, enhancing susceptibility to other addictive behaviors. This neurobiological vulnerability, coupled with psychosocial factors such as peer influence, exposure to other drug users, and sensation-seeking traits, contributes to an elevated risk of transitioning from vaping to smoking and polysubstance use (49, 50).

E-cigarette use among adolescents correlates with higher rates of alcohol, marijuana, and amphetamine consumption, as well as engagement in risky behaviors such as violence, unsafe sexual activity, and school misconduct—risks amplified in dual users of both e-cigarettes and combustible cigarettes (28, 51). Moreover, e-liquids can be used to aerosolize psychoactive substances including synthetic cannabinoids, methamphetamine, LSD, and crack cocaine, creating additional avenues for substance misuse (52).

Encouragingly, recent surveys indicate a gradual shift in perception, with an increasing proportion of students now recognizing e-cigarettes as equally or more addictive than traditional cigarettes (41). Nevertheless, the gateway phenomenon remains a critical public health issue, emphasizing the importance of early preventive interventions.

3.2.6 The 'dual users' phenomenon

Based on the evidence analyzed in this review, between about 30% and 60% of e-cigarette users continues to smoke conventional cigarettes simultaneously—a pattern commonly referred to as 'dual use' (53). The studies examined suggest that this behavior undermines the intended harm-reduction rationale of vaping and is associated with cumulative health risks exceeding those observed with exclusive use of either product (53–57).

Dual users exhibit the highest prevalence of respiratory symptoms, including wheezing and asthma (54). Vascular studies have shown that dual users experience marked endothelial dysfunction, reduced nitric oxide bioavailability, and increased oxidative stress—comparable to or even exceeding levels observed in exclusive smokers (53, 55, 56). These physiological changes contribute to greater cardiovascular risk, undermining claims that e-cigarette use represents a safer alternative.

Beyond physiological effects, qualitative studies suggest that dual users may be driven by complex psychological and behavioral factors. For instance, some report that vaping lacks the 'authenticity' and ritual satisfaction associated with smoking, leading them to alternate between both products. Others use e-cigarettes to reduce tobacco consumption without fully quitting (57).

Overall, the evidence synthesized in this review indicates that dual use represents a critical challenge for tobacco control, as it appears to sustain nicotine dependence and expose users to compounded toxic effects. On the basis of the studies analyzed, comprehensive cessation strategies that address both smoking and vaping behaviors emerge as essential for achieving meaningful public health gains.

4 Discussion

The growing use of e-cigarettes among children and adolescents represents a new and urgent public health challenge. Although initially marketed as safer alternatives to conventional cigarettes, e-cigarettes expose young users to nicotine and a range of harmful substances that can adversely affect multiple organ systems. The findings summarized in this review reveal that vaping poses significant respiratory, cardiovascular, immunological, and neurological risks, particularly in populations whose bodies and brains are still developing. Moreover, e-cigarette use in adolescence has been linked not only to nicotine dependence but also to higher rates of depression, anxiety, and engagement in other risky or addictive behaviors. Together, these data highlight the need for comprehensive, age-targeted prevention and cessation strategies (Table 2).

The findings of this review underscore a consistent and concerning pattern: across diverse geographic regions and study designs, e-cigarette use among children and adolescents is associated with a wide range of adverse health outcomes (53). The convergence of evidence from epidemiological, clinical, and experimental studies strengthens the inference that vaping is not a benign alternative to combustible tobacco, particularly for developing individuals. The observed associations between e-cigarette use and respiratory, cardiovascular, neurodevelopmental,

TABLE 2 Strategies to promote healthy behaviours and stop smoking.

Strategies for intervention	Description
Educational programs	Inform about the dangers of smoking and long-term consequences. Specific programs are needed during adolescence.
Prevention in pregnancy and family	Interventions aimed at youth, pregnant women, and parents, given the increased risk for children of smokers.
Cessation support	Offer direct support or through specialized services; spontaneous cessation in adolescents is rare.
Behavioral and technological interventions	Cognitive-behavioral strategies and SMS messages show moderate effectiveness in helping young people quit.
Pharmacological therapies	Nicotine replacement therapies (e.g., varenicline) have limited evidence in youth.
Public policies	Increase taxes, regulate advertising, ban flavors and misleading marketing.

and psychological effects suggest that early exposure to nicotine and aerosolized chemicals may exert both immediate and long-term biological consequences. Importantly, the consistency of these findings across multiple populations and methodologies supports the conclusion that the risks observed are not isolated or incidental, but reflect broader, systemic effects of e-cigarette use in youth. Furthermore, the strong associations between vaping and subsequent initiation of conventional cigarette smoking reinforce concerns regarding nicotine dependence and the 'gateway' phenomenon.

Despite these consistent trends, the generalizability of the findings must be interpreted with caution. Most available studies originate from high-income countries with specific regulatory environments, cultural norms, and patterns of product availability, which may not fully represent experiences in low- and middle-income settings. Differences in legislation, marketing practices, socioeconomic factors, and healthcare access may significantly influence both prevalence and health outcomes related to e-cigarette use. Additionally, variations in device types, nicotine concentrations, and flavor formulations—many of which evolve rapidly—limit the extent to which results can be extrapolated across regions or time periods. Nonetheless, the convergence of evidence across diverse populations suggests that the identified risks are broadly applicable, supporting the relevance of these findings to global public health efforts. Continued multinational, longitudinal research is essential to clarify causal pathways, assess long-term consequences, and guide the development of targeted prevention and regulatory strategies.

A robust prevention framework is essential to reduce the prevalence of nicotine and tobacco use among youth. Educational interventions should begin early and emphasize the short- and long-term health consequences of vaping and smoking. Prevention programs should also target expectant mothers and parents, as smoking during pregnancy increases the

risk of adverse neonatal outcomes, and parental smoking remains a strong predictor of later tobacco use in children (58). Pediatricians and gynecologists play a crucial role in early prevention, counseling families about the intergenerational effects of nicotine exposure and supporting cessation during pregnancy.

As children transition into adolescence, parental influence diminishes while peer pressure and social conformity gain importance. During this stage, smoking and vaping are often perceived as symbols of maturity or independence (59). Predictors of e-cigarette use among young people include demographic variables (such as age, sex, and ethnicity), certain personality traits (rule-breaking or sensation-seeking), family factors (low parental education, family instability, and second-hand smoke exposure at home), poor academic performance, proximity of retailers to schools, and the presence of peers who smoke (6). Conversely, participation in team sports, adherence to social norms, and engagement in structured extracurricular activities are protective factors associated with reduced e-cigarette and tobacco use (60). Additional protective factors include the perceived dangers and costs of vaping, parental monitoring, a mother's higher education level, strong academic aspirations, and positive teacher relationships (6).

Systematic reviews have identified three primary strategies for preventing tobacco and e-cigarette use in youth: school-based interventions, media campaigns, and community-based programs (61). These initiatives are most effective when implemented as part of a coordinated, multi-level approach sustained over time (61). For maximum impact, interventions should integrate public education, family engagement, and policy enforcement to reshape social norms around nicotine use. Pediatricians are particularly well positioned to deliver preventive counseling, identify at-risk adolescents, and provide early intervention before dependence develops.

For adolescents who already smoke or vape, cessation support remains a major challenge. Spontaneous cessation rates in individuals aged 15–21 years are as low as 4.1% (62), underscoring the need for structured and accessible treatment options. Currently, evidence on effective interventions for vaping cessation in youth is limited, and the optimal combination of behavioral and pharmacological approaches has yet to be established. Behavioral therapies—particularly those grounded in cognitive-behavioral and social-influence models—have shown modest but significant benefits, with an 11.8% abstinence rate compared to 7.5% in control conditions (63). Digital health technologies, such as mobile phone-based interventions and text message support, have also demonstrated promise in improving abstinence outcomes. A meta-analysis including over 27,000 participants aged 16–30 years found that SMS-based interventions increased continuous abstinence rates compared with inactive controls (RR 1.51; 95% CI 1.24–1.84) (64). These tools may represent cost-effective and scalable methods to engage adolescents in cessation efforts.

Pharmacological strategies for vaping cessation remain underexplored in younger populations. Nicotine replacement therapies, including varenicline, have shown limited evidence of benefit in adolescents, with low certainty compared to placebo (65). Future research should investigate tailored cessation strategies for adolescents, considering developmental, behavioral, and psychosocial factors that differ from adults.

Public health policy remains a cornerstone of prevention. Tax increases, advertising bans, and restrictions on the sale of flavored or youth-targeted products have proven effective in reducing tobacco consumption and may similarly limit e-cigarette uptake. The World Health Organization (WHO) has recently denounced the deceptive tactics of the tobacco and vaping industries, which continue to market their products to young people through appealing flavors, sleek designs, and misleading messages suggesting reduced harm. WHO's 2025 World No Tobacco Day campaign emphasized the urgent need for policies prioritizing children's health over corporate profit and called for comprehensive regulations banning flavors and youth-oriented marketing (5).

Ultimately, reducing youth e-cigarette use requires a coordinated effort across health care, education, legislation, and media (53). Prevention should begin in early childhood, reinforced by consistent messaging from parents, educators, and healthcare providers. Adolescents who already use e-cigarettes must be offered accessible cessation support, integrating behavioral and digital interventions where possible. By addressing both individual risk factors and broader environmental influences, public health initiatives can more effectively counteract the rising trend of vaping and its long-term health consequences.

This review has several limitations that should be acknowledged when interpreting its findings. First, as a narrative review, it does not follow a systematic review or meta-analytic methodology, which limits the ability to quantify effect sizes or establish causal relationships. The conclusions presented are therefore based on trends observed across heterogeneous studies rather than on pooled statistical analyses. Additionally, much of the available evidence relies on cross-sectional and observational data, which can identify associations but cannot definitively determine causality between e-cigarette use and health outcomes. Variability in study design, population characteristics, exposure definitions, and outcome measures further limits direct comparability across studies. Many findings also depend on self-reported data, which may be affected by recall bias or social desirability bias, particularly among adolescents. Moreover, the rapidly evolving nature of e-cigarette products and formulations means that some findings may not fully reflect current market trends or emerging devices. Finally, the predominance of studies conducted in high-income countries may limit the generalizability of the results to other sociocultural and regulatory contexts. Consequently, while the evidence consistently suggests harmful trends associated with youth e-cigarette use, these findings should be interpreted with caution, and further longitudinal and mechanistic research is needed to establish causal relationships and long-term outcomes.

5 Conclusion

E-cigarette use is a rapidly growing trend, particularly among adolescents, and represents a major emerging threat to public health. These devices often contain nicotine—a highly addictive substance—along with numerous chemical components capable of causing significant harm to the respiratory, cardiovascular, neurological, and immune systems. Evidence increasingly

demonstrates that e-cigarette use during adolescence can lead to nicotine dependence, impaired neurodevelopment, and an elevated risk of future substance use.

Ongoing research is essential to deepen our understanding of the long-term health consequences of vaping and to guide the development of effective prevention and cessation strategies. Public health efforts should focus on both the predictors and protective factors of e-cigarette use, promoting educational initiatives that empower young people to make informed, healthy choices.

Preventive actions are urgently needed to counteract the normalization of vaping among youth. Comprehensive approaches—integrating education, healthcare counseling, community engagement, and policy enforcement—are key to reducing the initiation and continuation of e-cigarette use. Furthermore, strong regulatory measures, including restrictions on marketing, flavor availability, and youth access, must be implemented to curb the ongoing spread of these products and protect the wellbeing of future generations (28).

Author contributions

VF: Investigation, Validation, Writing – review & editing, Writing – original draft, Formal analysis. EB: Methodology, Data curation, Investigation, Writing – review & editing, Writing – original draft. MP: Data curation, Methodology, Investigation, Writing – original draft, Writing – review & editing. LR: Methodology, Data curation, Writing – review & editing, Investigation, Writing – original draft. FR: Writing – review & editing, Writing – original draft, Investigation, Data curation, Methodology. SE: Writing – review & editing, Resources, Writing – original draft, Project administration, Funding acquisition, Supervision, Conceptualization.

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