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# DISPOSABLE E-CIGARETTES AND ADOLESCENT NEUROLOGICAL DEVELOPMENT: A REVIEW OF POTENTIAL THREATS

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## ABSTRACT

The rapid proliferation of disposable e-cigarettes represents a new wave in the youth vaping epidemic, posing a significant threat to adolescent health. These devices are characterized by high-concentration nicotine salts, a vast array of youth-appealing flavors, and discrete, easy-to-use designs, which have led to alarming rates of initiation and use among teenagers. This review article aims to synthesize the current scientific literature on the neurological consequences of disposable e-cigarette use during the critical developmental window of adolescence. The methodology involved a structured review of literature from PubMed and other scientific databases from 2019 to the present. Key findings from the reviewed literature indicate that exposure to high levels of nicotine during adolescence can disrupt the maturation of the prefrontal cortex, leading to lasting deficits in cognitive functions, including attention, memory, and executive control. Furthermore, evidence points to a strong association between adolescent vaping and an increased risk for mood disorders, such as depression and anxiety, and a heightened vulnerability to addiction to other substances. The chemical constituents of e-liquids, including flavorings and heavy metals, may also contribute to neuro-inflammation and neurotoxicity. In conclusion, the use of disposable e-cigarettes by adolescents is a major public health crisis with potentially severe and long-lasting consequences for neurological development and mental health. Urgent regulatory action, targeted public health campaigns, and further longitudinal research are imperative to mitigate this threat.

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## KEYWORDS

Disposable e-cigarettes, Vaping, Adolescence, Brain Development, Nicotine, Neurotoxicity, Cognitive Function

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## Introduction

The landscape of tobacco and nicotine products has been radically transformed over the past decade, with electronic cigarettes (e-cigarettes) emerging as a dominant force, particularly among youth [1, 2]. While initially marketed as a harm-reduction tool for adult smokers, these devices have given rise to a public health crisis among adolescents who have never smoked combustible tobacco [3]. The latest and most concerning phase of this crisis is the surge in popularity of fourth-generation disposable e-cigarettes [4]. Unlike earlier models, these single-use devices require no maintenance, are relatively inexpensive at the point of purchase, and, most critically, deliver extremely high concentrations of nicotine via protonated nicotine salt formulations that reduce the aversive harshness of inhalation [5].

This ease of use, combined with aggressive marketing on social media platforms and a vast array of candy- and fruit-like flavors, has made disposable e-cigarettes exceptionally appealing to teenagers [6, 7]. This trend is occurring during adolescence, a unique and critical neurodevelopmental period characterized by significant remodeling of brain circuits, particularly within the prefrontal cortex, which governs executive functions, decision-making, and impulse control [8]. The developing adolescent brain exhibits heightened sensitivity to the neurotoxic and addictive effects of nicotine [8, 9]. Exposure during this vulnerable window can permanently alter brain structure and function, leading to long-term consequences. Therefore, the primary objective of this review is to synthesize and evaluate the current body of evidence regarding the impact of disposable e-cigarette use on the neurological development of adolescents. We will examine the effects of high-concentration nicotine on cognitive functions, mental health, and addiction vulnerability, as well as the potential neurotoxic roles of other chemical constituents in e-cigarette aerosol.

## Methodology

This review article is based on a structured search of scientific literature. The primary database searched was PubMed (National Center for Biotechnology Information), supplemented by PsycINFO and Web of Science to ensure comprehensive coverage. The search was restricted to articles published between January 1, 2019, and October 2025, to focus on the most current research, particularly that which addresses the rise of modern disposable products.

Search terms included various combinations of keywords using Boolean operators (AND, OR). Key terms were: ("disposable electronic cigarette" OR "vaping" OR "e-cigarette" OR "JUUL" OR "Puff Bar") AND ("adolescent" OR "youth" OR "teenager") AND ("brain development" OR "neurological" OR "cognitive function" OR "executive function" OR "neurotoxicity" OR "mental health" OR "depression" OR "anxiety" OR "addiction").

Inclusion criteria for articles were: (1) original research, systematic reviews, or meta-analyses; (2) published in English in a peer-reviewed journal; (3) focused on human adolescents or relevant animal models of adolescent neurodevelopment; and (4) investigated the effects or correlates of e-cigarette use on neurological, cognitive, or mental health outcomes. Exclusion criteria included articles focused solely on adults, studies on smoking cessation without a non-smoking youth comparison, and articles where the full text was not accessible. The selected articles were analyzed and synthesized thematically to construct the following sections.

## Results

The synthesis of the selected literature reveals several key themes regarding the impact of disposable e-cigarettes on adolescent neurodevelopment.

### Prevalence and Patterns of Use

Recent national surveys demonstrate a dramatic shift in the e-cigarette market, with disposable products becoming the most commonly used device type among middle and high school students [2]. Studies show that flavors are a primary driver for initiation and continued use, and the high nicotine concentration in these products is associated with more frequent use and greater dependence [7, 10]. The ease of access, despite regulations, remains a significant problem [1].

### **Impact of Nicotine on Brain Structure and Function**

The literature confirms that the adolescent brain is uniquely vulnerable to nicotine [8]. Nicotine acts on nicotinic acetylcholine receptors (nAChRs), which are crucial for synaptic plasticity and circuit maturation. Animal models show that adolescent nicotine exposure leads to a reduction in the size of the prefrontal cortex and alters synaptic activity, which can persist into adulthood [8, 9]. These structural changes are the biological basis for the functional deficits observed in human users.

### **Cognitive and Executive Function Deficits**

A growing body of evidence directly links adolescent vaping with poorer cognitive performance. Studies comparing adolescent vapers to non-users have found significant deficits in areas of memory, attention, and executive function [3, 11]. For example, adolescent e-cigarette users report more difficulty concentrating, remembering, or making decisions than their non-using peers, a finding consistent with nicotine's disruptive effect on prefrontal cortex development [11, 12].

### **Association with Mental Health Disorders**

There is a strong, bidirectional association between adolescent e-cigarette use and mental health problems [13]. Large-scale surveys show that youth who vape are significantly more likely to be diagnosed with depression, anxiety, and ADHD [13, 14]. While some adolescents may initiate vaping to self-medicate symptoms of anxiety or depression, nicotine itself can exacerbate these conditions by dysregulating mood-related neurotransmitter systems, creating a harmful cycle of dependence and worsening mental health [13, 15].

### **Role of Flavorings and Other Chemicals**

Beyond nicotine, other chemicals in e-cigarette aerosol may pose a neurological risk. Many flavoring chemicals, while safe for ingestion, have unknown toxicological profiles when inhaled [16]. Some flavorings, like cinnamaldehyde, have been shown to induce inflammation and oxidative stress, which are pathways that can lead to neuronal damage [17]. Furthermore, heavy metals like lead and nickel, known neurotoxins, have been detected in the aerosol of some devices, presenting another potential vector for neurological harm in chronic users [18].

### **Discussion**

The findings of this review indicate that the popularity of disposable e-cigarettes among youth is a public health emergency with profound neurological implications. The high-nicotine, youth-appealing nature of these products effectively exploits the biological vulnerabilities of the adolescent brain [8, 10]. The observed deficits in cognitive function are particularly concerning, as they can impact academic achievement, social development, and long-term life outcomes [3, 11].

The strong link between vaping and mental health disorders is a critical area of concern [13, 14]. This relationship is complex and likely bidirectional, but the evidence suggests that nicotine exposure can worsen underlying conditions, making it harder for adolescents to manage their mental health and increasing their dependence on nicotine. Furthermore, the "gateway effect" remains a significant issue. By priming the adolescent reward system, nicotine use via e-cigarettes significantly increases the likelihood of subsequent use of combustible tobacco and other illicit substances [19, 20].

A major limitation in the current literature is the relative novelty of disposable products, meaning most human studies are cross-sectional. More longitudinal research is urgently needed to establish causality and track the long-term neurological trajectory of adolescents who use these devices. Nonetheless, the convergence of evidence from human correlational studies, animal models, and toxicological analyses provides a strong basis for immediate public health action.

## Conclusions

The use of disposable e-cigarettes by adolescents is not a benign behavior; it is an exposure to a neurotoxicant during a critical period of brain development. The evidence synthesized in this review strongly indicates that adolescent vaping is associated with significant risks, including impaired cognitive function, increased incidence of mental health disorders, and a heightened risk of addiction. The potential for long-term, irreversible neurological harm is substantial.

Future research should focus on longitudinal cohort studies to track the cognitive and mental health outcomes of adolescent users over time. Further toxicological studies are also needed to clarify the specific neurotoxic effects of the thousands of available flavor chemicals. From a public health perspective, policy efforts must be strengthened to close regulatory loopholes that allow flavored disposable products to flood the market, and robust public education campaigns are needed to counter industry marketing and accurately inform teenagers, parents, and educators of the profound risks vaping poses to the developing brain.

## Disclosure

### Authors' contributions

Conceptualisation: ZK

Methodology: SK

Software: JK,NS

Check: SK, NS

Formal analysis: SK

Investigation: JK

Resources: ZK

Data curation: ZK,NS

Writing-rough preparation: SK

Writing-review and editing: JK

Visualization: ZK,JK

Project administration: NS, SK

Supervision: ZK, SK

All authors have read and agreed with the published version of the manuscript.

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