Tobacco Use and Electronic Smoking Devices: Evidence of Harms and Prevention-and-Control Strategies — A Review

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I declare no financial and other conflicts of interest

Introduction

The global prevalence of tobacco smoking reaches about 15% of the world's population**,** with repercussions for public health, the economy, social security systems, and the environment. In response to anti-smoking campaigns against combustible cigarettes, the tobacco industry has invested in alternative products. Consequently, the market for electronic cigarettes**,** heated tobacco products, and other forms of nicotine consumption has expanded rapidly. It is therefore necessary to review emerging evidence that these products threaten users' mental and physical health, to implement effective **public policies** for their control, and to prepare health services to manage new forms of nicotine dependence.

Objectives

To review evidence on the harms of combustible cigarettes and other forms of nicotine consumptio**n** (e.g., electronic cigarettes and related devices), and to discuss strategies for prevention and control.

Methods — Review methodology

We conducted a narrative review, searching PubMed**,** Scopus**,** and SciELO. We prioritized review articles**,** clinical guidelines**, and** randomized, double-blind, controlled trials**.**

Keywords
Nicotine; Tobacco; Review; Electronic cigarettes. Electronic Nicotine Delivery Systems (ENDS); Tobacco Use Disorder

Epidemiology and trends in use

Tobacco smoking remains the **leading modifiable risk factor** for premature death and disabling disease worldwide. This results from its high prevalence and the presence of **highly harmful substances** in tobacco products. It is estimated that nearly **8 million people** die each year from tobacco-related diseases, imposing an annual **US$1.4 trillion** burden on the global economy. According to the **WHO**, there are roughly **1.25 billion** smokers worldwide, **50%** of whom will die prematurely due to cigarette consumption (1).

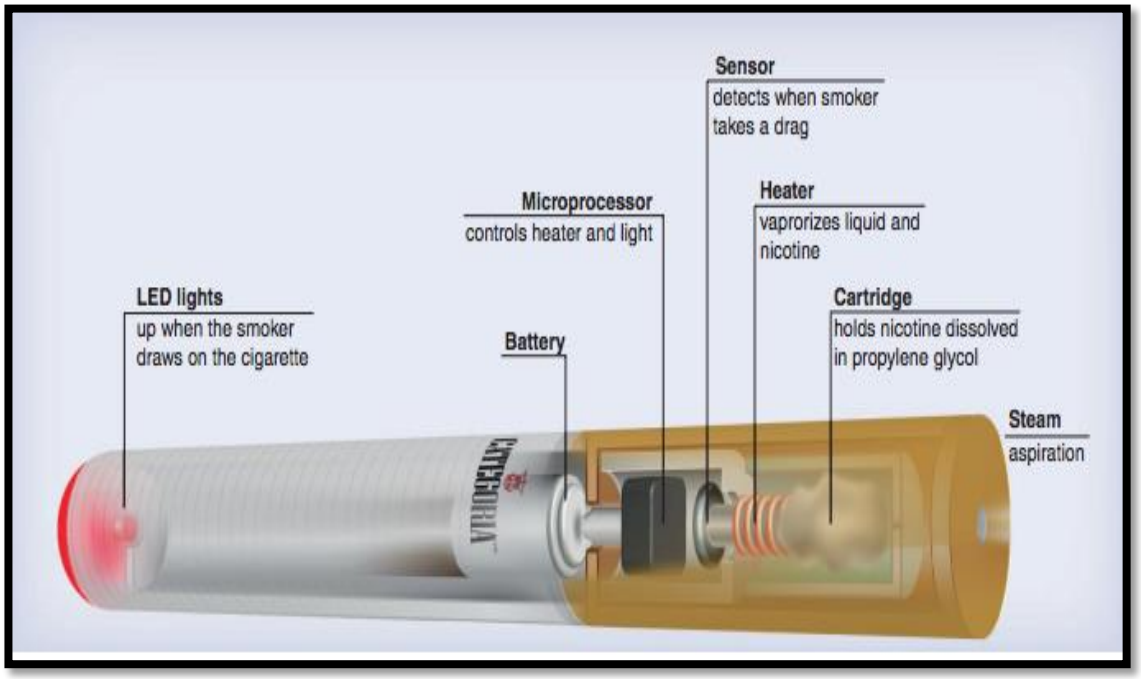
Brazil has been a Party to the **WHO Framework Convention on Tobacco Control** since 2006. Since then, there has been a marked decline in smoking prevalence. Nevertheless, the

tobacco industry continues to advance its interests through lobbying within governmental bodies and political spheres. In **2012**, **Anvisa** prohibited the use of flavored additives in tobacco products; **thirteen years later**, more than **1,000** flavored products had been authorized as a result of multiple legal actions against the agency (2). More intensive actions are still needed to control the **manufacture and distribution of illicit tobacco** in the country (3).

According to **Vigitel 2023** data, collected across Brazil's 26 states and the Federal District, **9.3%** of the adult population are smokers, with a predominance among men. The **2019 National Health Survey** (the most recent with a complete tobacco module) reported a prevalence of **12.8%** of Brazilians using tobacco-derived products (≈20.4 million people), **16.2%** among men and **9.8%** among women, indicating a downward trend compared with 2013 (**14.9%**) (4). The **2019 PeNSE** (National School Health Survey) documented increased **experimentation with waterpipe (narguilé) and electronic cigarettes** among adolescents, despite retail sales of the latter being prohibited in Brazil (5).

Electronic cigarettes (e-cigarettes, "vapes") are devices for **nicotine delivery**. Through a **mouthpiece**, the user creates **negative pressure** to inhale, which activates a **battery** that heats (≈100–300 °C) a **chamber** containing **e-liquid**—typically **nicotine**, **glycerin** and **propylene glycol**, plus **flavorings and other additives**—and, in some cases, **cannabis** or other substances. An **atomizer** produces an aerosol ("vapor") that is inhaled (Fig. 1). Newer devices often use **nicotine salts**, a formulation that reduces throat harshness and enables **higher-concentration nicotine** and more frequent/deeper puffs. Another trend is **synthetic nicotine** (not derived from tobacco), which may **increase dependence liability** and, in some jurisdictions, **evade tobacco-product regulations**.

Figure 1. Model of an electronic cigarette and its components.



In the United States, **electronic cigarettes are the most common initiation pathway** to nicotine use among youth (6).

Heated tobacco products (HTPs) generate aerosols containing nicotine and toxic chemicals by heating tobacco or activating a device that contains it. Despite "reduced-risk" claims, there is **no evidence demonstrating** that HTPs or e-cigarettes are **less harmful than conventional tobacco products**. E-cigarette emissions typically contain **nicotine and other toxic substances** that are harmful to users and to bystanders exposed to secondhand aerosols; moreover, some products marketed as "nicotine-free" **do contain nicotine**.

Higher **nicotine concentrations** in vapes and the widespread use of **nicotine salts**—a formulation that reduces throat harshness—together with **flavorings** promote **greater dependence** on the substance (7).

Another market trend is **snus/nicotine pouches**, small oral-mucosal sachets of nicotine often promoted as "tobacco-free" and usable anywhere. Although current prevalence remains relatively low, **use has grown rapidly**. **Philip Morris** acquired the **ZYN** brand for US$16 billion and established a manufacturing facility in Colorado, expanding into this market segment. The tobacco industry is also investing in **nicotine analogs** (e.g., **6-methyl nicotine**) as a strategy to **circumvent stricter tobacco regulations** (8).

Brazil's 2019 **PeNSE** school health survey documented an **increase in experimentation with waterpipe (narguilé) and electronic cigarettes** among adolescents (5).

Public policies have contributed to a **decline in smoking prevalence** in Brazil. The latest **2023** data indicate that **9.3%** of adults use tobacco (10.2% men; 7.2% women) (9).

In the United States, e-cigarettes have been the **most commonly used tobacco product among youth since 2014**. In **2024**, **3.5%** of middle-school students and **7.8%** of high-school students reported **past-30-day** e-cigarette use.

Snus/nicotine pouches are **microfiber sachets** containing **flavored nicotine powder** that users place in the mouth to dissolve **without spitting**. **Fig.2** In the U.S., sales have risen rapidly, and self-reported **past-30-day** use among high-school students increased from **0.8% to 2.4%** in recent surveys (6).

In the **United Kingdom**, in **2025**, **20%** of youth aged **11–17 years**—approximately **1.1 million** individuals—had **ever tried** e-cigarettes, and about **3%** reported **current use** (10).

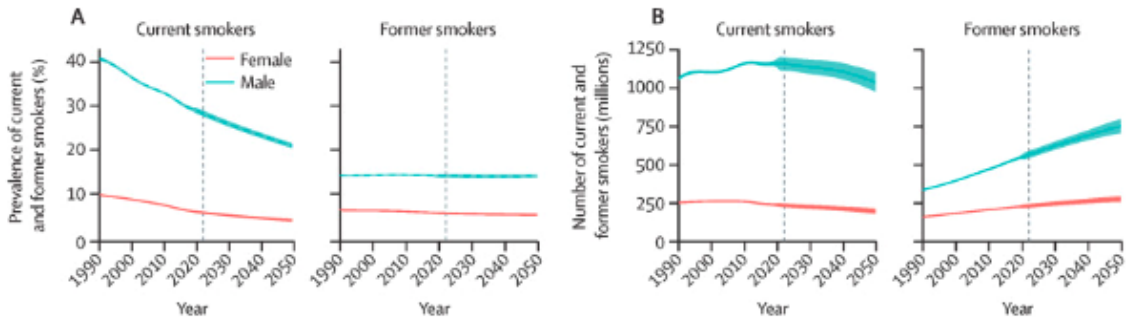
Figure 2. Innovative tobacco products: fourth-generation e-cigarettes, snus (nicotine pouches), and heated tobacco products.

A task force of epidemiologists published in *The Lancet* (2024) the following scenario: they project a decline in the global prevalence of smoking from the current 1.2 billion smokers to approximately one billion by 2025, despite population growth. However, the number of former smokers continues to increase and remains a risk group for several diseases for decades.

When examining the projected survival curve, there is a visible notch corresponding to the COVID-19 pandemic year, after which life expectancy resumes its upward trajectory until 2050.

This publication estimated that by 2050, tobacco use will account for 2,040 million years of life lost prematurely, assuming that the prevalence of smoking remains at approximately 25.5% of the adult population. They further estimated that if everyone stopped smoking today, global life expectancy would increase by nearly five years. It is a striking finding that acting upon a single modifiable risk factor could yield such a magnitude of improvement in both lifespan and quality of life (11). **Fig.3**

Figure 3. Estimated prevalence of smokers and former smokers worldwide



The U.S. CDC published a report in 2024 showing that, despite the reduction in smoking prevalence to approximately 11% of the population (28.8 million), an estimated 480,000 preventable deaths occurred in the United States in 2024. Smoking cost the United States more than US$600 billion in 2018, including over US$240 billion in healthcare expenditures and nearly US$372 billion in productivity losses. Tobacco use remains the leading cause of preventable disease and death in the United States (12).

Although e-cigarettes are the most commonly used tobacco products among U.S. adolescents, there has been growing awareness of their harms, resulting in a significant proportion of youth expressing a desire to quit electronic cigarette use.

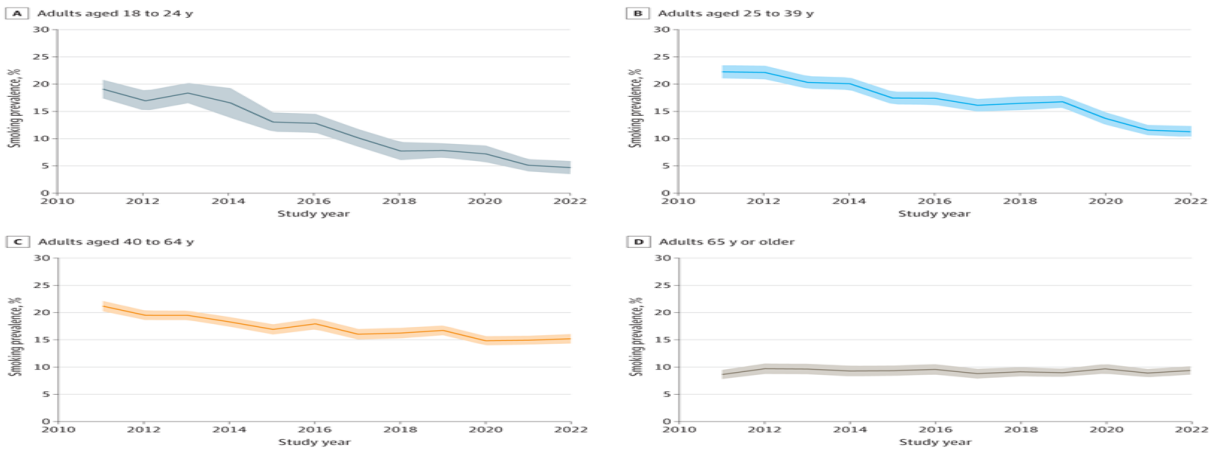
A study published in *JAMA Pediatrics* evaluated participants of the seventh wave of the PATH study. Among 3,024 vapers aged 15–17 years, 855 (29.1%) had quit or attempted to quit vaping in the past 12 months, indicating that more than 30% were in the contemplation or action stages of cessation. Most attempted to quit with social support only, and just 1.7% received pharmacological treatment.

Mobile applications, messaging interventions, and varenicline proved effective in cessation efforts among youth aged 15–17 years (13).

It is well established that among adults, approximately 70% wish to quit, particularly as they reach older age.

The research group that assessed the global burden of tobacco use in *The Lancet* noted that while prevalence is declining across all age groups, it remains stable among older adults. This finding highlights the need for targeted policies addressing this specific population group (11). **Fig.4**

Figure 4 Prevalence of smoking worldwide by age group



What sustains this market as so vigorous and profitable is the economic power of the tobacco industry. According to the 2025 report by the consulting firm Data Bridge Market Research, the tobacco market is approaching US$1 trillion annually, and other forms of nicotine consumption have been growing at a vertiginous pace.

The nicotine industry invests where returns are guaranteed. Combustible cigarettes remain the largest market, but there is an accelerated growth of electronic devices and nicotine pouches—already the main gateway products in Europe and the United States. The global vape market is estimated at US$25 billion annually.

Marketing strategy companies indicate a strong bet on so-called “risk reduction products.”

To illustrate this trend, Philip Morris acquired the Zyn nicotine pouch brand and its factory for US$16 billion, establishing a new US$600 million manufacturing facility in Colorado.

The industry’s need for innovation stems from one of the main counterpoints to the combustible cigarette market: regulatory restrictions that limit its commercialization.

Recommendations published in the report emphasize: focusing on flavorings, consumer experience, promoting products as lower-risk to health, and framing them as environmentally sustainable alternatives.

The report also suggests countering illicit trade by using contraband itself as an argument to reduce taxation-driven price increases.

In addition, it proposes developing new substances and product presentations designed to circumvent anti-tobacco legislation.

Organized crime dominates the Brazilian tobacco market. In 2023, Zklo et al. published a map of illicit cigarette distribution, showing that states bordering Paraguay receive contraband cigarettes, while central states host clandestine factories that circumvent enforcement to produce, distribute, and commercialize the product (3).

In 2023, the same author published another paper demonstrating how tobacco industry lawyers successfully blocked the enforcement of a 2012 law banning additives in cigarettes. In recent years alone, they managed to register 1,112 new tobacco products containing prohibited additives (2).

Following strategic recommendations, chemists have developed a substance named metatine, a nicotine derivative that falls outside the U.S. federal legal definition of a tobacco product and therefore does not require premarket tobacco product application (PMTA) authorization. SPREE BAR is a vape currently commercialized in the U.S. that contains metatine (without any tobacco- or nicotine-derived material), and thus is not regulated as a "tobacco product" under the Federal Food, Drug, and Cosmetic Act, remaining available without PMTA approval (8).

Health Risks

In 2024, Glantz et al. published a systematic review comparing nonsmokers, electronic cigarette users, combustible cigarette users, and dual users. Electronic cigarettes were associated with risks similar to regular cigarettes for vascular disease, stroke, and metabolic disorders, although combustible cigarettes were linked to more severe cases of asthma and COPD. Dual users exhibited a 50% higher risk across all six health outcomes assessed. The review also concluded that exclusive e-cigarette use conferred greater risk of life-threatening disease than abstinence (14).

There is no safe form of tobacco or nicotine consumption.

In 2014, the U.S. Surgeon General released a comprehensive report documenting all diseases caused by tobacco use, responsible for 50% of premature mortality among smokers. The leading causes of death worldwide are associated with smoking: myocardial infarction, stroke, chronic obstructive pulmonary disease, and multiple types of cancer (15).

Most e-cigarettes contain nicotine, a highly addictive substance, often delivered in high concentrations and in nicotine salt formulations. Nicotine can impair brain development in youth, affecting attention, learning, mood, and impulse control, with dependence establishing early. Aerosols may contain nicotine, carcinogens, heavy metals (nickel, tin, lead), ultrafine particles, and flavorings such as diacetyl, which has been linked to severe lung disease. Defective batteries may cause fires and explosions (16).

The perception of vaping as a harm reduction strategy was challenged in 2020, when a total of 2,668 cases of severe EVALI (e-cigarette or vaping-associated lung injury), including 68 deaths, were reported to the CDC (17).

In 2025, an Australian systematic review concluded that vapes should be considered carcinogenic to humans, as they contain numerous carcinogens (benzo[a]pyrene, acrolein, arsenic, benzene, cadmium, formaldehyde, styrene, toluene, heavy metals, and N-nitrosamines), which cause DNA damage consistent with mechanisms of cancer development in both human and animal studies (18).

Nicotine pouches, also known as *snus* or pouches (which do not contain tobacco leaves), represent a rapidly expanding market. Despite their short time on the market, a systematic review has already demonstrated increased risks of gum lesions, dental damage, impaired salivation, and potential carcinogenicity due to the presence of formaldehyde among their components (19).

In April 2025, ANVISA reaffirmed the prohibition of the importation, manufacture, and commercialization of e-cigarettes in Brazil, supported by leading Brazilian medical societies to protect public health. Although some studies have shown abstinence from combustible

cigarette use with electronic devices, participants in these studies remained nicotine-dependent through vaping, with many eventually engaging in dual use.

Measures for Treatment and Tobacco Control

In 2024, the World Health Organization issued comprehensive guidelines for the treatment of tobacco and nicotine dependence in adults. These guidelines emphasized behavioral and pharmacological support as the two main pillars of cessation therapy.

Brief counseling sessions lasting only a few minutes, as well as more intensive interventions, have a positive effect on cessation and are strongly evidence-based. Health professionals who present themselves as authoritative, express concern for the smoker's future, acknowledge the difficulty of cessation while encouraging its possibility, and provide practical strategies to overcome withdrawal symptoms (e.g., drinking water, deep breathing) can significantly improve cessation outcomes. Nicotine replacement therapy (NRT), with patches and gums, remains an over-the-counter option provided by Brazil's Unified Health System (SUS).

The WHO guidelines also introduced innovations such as digital interventions: smartphone applications, artificial intelligence tools, and text messaging. While further research is required to strengthen recommendations, these approaches are considered practical due to their low cost, wide reach, and high acceptability, especially among youth. Artificial intelligence presents a new pathway for cessation support, offering engagement and personalized communication along the quitting journey. In 2024, Bricker et al. reported the development of language tools for an effective cessation-support chatbot (20).

In 2023, a systematic review presented at the World Congress of Public Health assessed the use of artificial intelligence in smoking cessation. Only four randomized controlled trials were identified: three tested smartphone chatbot applications and one tested an internet-based avatar. Smokers using AI interventions were 60% more likely to achieve cessation. Although these studies reported high attrition and heterogeneity, limiting the strength of recommendations, they indicate promising therapeutic potential for further investigation (21).

WHO guidelines recommend first-line pharmacotherapies: nicotine replacement therapy combining a 24-hour patch (to control baseline withdrawal) with gum or lozenges (for breakthrough cravings). Bupropion, cytisine, and varenicline are also recommended. In cases of treatment failure, combining these drugs is suggested as a second-line strategy (22).

Increasing varenicline to 3 mg daily or doubling nicotine patch doses significantly improved cessation rates among smokers unresponsive to standard first-line therapy, as demonstrated by Cinciripini et al. (23).

A systematic review of cytisine highlighted its effectiveness in smoking cessation, with fewer adverse effects and comparable efficacy to varenicline. Recently, Rigotti et al. demonstrated that 3 mg administered three times daily was effective and offered improved adherence (25).

The WHO also strongly recommends that all hospitals and clinics record tobacco use status and integrate evidence-based cessation interventions into medical records. Health personnel should be trained to deliver these interventions, while cost considerations must always be taken into account.

An emerging area of research is the potential role of incretin-based therapies such as semaglutide and dulaglutide, which may help prevent post-cessation weight gain and alleviate

withdrawal symptoms. Wang (2024) found lower markers of tobacco use disorder among more than 220,000 semaglutide users (26).

Conclusions

Tobacco use remains a leading cause of preventable morbidity and mortality worldwide. The industry continues to expand its reach through new nicotine delivery systems, often targeting vulnerable populations predisposed to addiction.

Nicotine dependence must be recognized as a chronic relapsing disease requiring sustained clinical and pharmacological management. Evidence demonstrates that combining behavioral support with pharmacotherapy can triple cessation success rates, yet access to effective medications remains limited in several countries, including Brazil.

Public health policies must prioritize equitable access to cessation treatments and implement targeted strategies to protect high-risk groups—such as homeless populations, LGBTQI+ individuals, people living with HIV, Indigenous peoples, individuals with mental health disorders, Black populations, children and adolescents, and incarcerated individuals.

Enhancing access to both clinical and pharmacological treatment is imperative, as the most effective medications for nicotine dependence therapy are still unavailable in Brazil.

Expanding these measures is essential to reduce the global burden of tobacco-related disease and to advance cancer prevention and control efforts.

REFERENCES

1. World Health Organization. **WHO global report on trends in prevalence of tobacco use 2000–2030**. Geneva: World Health Organization; 2024.
2. Szklo AS, Carvalho A, Coutinho Marques de Pinho M, et al. **Bitter taste of the tobacco industry interference in Brazil**. *Tob Control.* 2024 Jul 22. Epub ahead of print. doi:10.1136/tc-2024-058690.
3. Szklo AS, Drope J. **The cigarette market in Brazil: new evidence on illicit practices from the 2019 National Health Survey**. *Tob Control.* 2024;33(Suppl 2):s128–s134. doi:10.1136/tc-2022-057847. PMID:37321852; PMCID:PMC11187383.
4. Instituto Brasileiro de Geografia e Estatística (IBGE); Diretoria de Pesquisas; Coordenação de Trabalho e Rendimento. **Pesquisa Nacional de Saúde 2019**. Rio de Janeiro: IBGE; 2019.
5. Instituto Brasileiro de Geografia e Estatística (IBGE); Diretoria de Pesquisas; Coordenação de População e Indicadores Sociais. **Pesquisa Nacional de Saúde do Escolar 2019**. Rio de Janeiro: IBGE; 2019.
6. Jamal A, Park-Lee E, Birdsey J, et al. **Tobacco product use among middle and high school students — National Youth Tobacco Survey, United States**. *MMWR Morb Mortal Wkly Rep.* 2024;73(41):917–924.
7. Kundu A, Sanchez S, Seth S, Feore A, Sutton M, Sachdeva K, et al. **Evidence update on e-cigarette dependence: a systematic review and meta-analysis**. *Addict Behav.* 2025;163:108243.

8. Jordt SE, Jabba SV, Silinski P, Berman ML. **An electronic cigarette pod system delivering 6-methyl nicotine, a synthetic nicotine analog, marketed in the United States as "PMTA exempt"**. *medRxiv* [Preprint]. 2023 Nov 22:2023.11.21.23298778. doi:10.1101/2023.11.21.23298778. Update in: *Tob Control.* 2025;34(3):414–418. doi:10.1136/tc-2023-058469. PMID:38045384; PMCID:PMC10690343.
9. Brasil. Ministério da Saúde. **Vigitel Brasil 2023** [Internet]. Brasília (DF): Ministério da Saúde; 2023 [cited 2025 Sep 28]. Available from: http://bvsms.saude.gov.br/bvs/publicacoes/vigitel_brasil_2023.pdf. ISBN:978-65-5993-476-8.
10. Action on Smoking and Health (ASH). **Fact sheets** [Internet]. London: ASH; [cited 2025 Sep 28]. Available from: https://ash.org.uk/resources/publications/fact-sheets.
11. Bryazka D, et al. **Forecasting the effects of smoking prevalence scenarios on years of life lost and life expectancy from 2022 to 2050: a systematic analysis for the Global Burden of Disease Study 2021**. *Lancet Public Health.* 2024;9(10):e729–e744.
12. Centers for Disease Control and Prevention. **Burden of cigarette use in the United States**. Atlanta (GA): Office on Smoking and Health, National Center for Chronic Disease Prevention and Health Promotion; 2024 Oct.
13. Williams BS, Kaye JT. Vaping Cessation Methods Used by Adolescents. *JAMA Pediatr.* 2025;179(9):1043–1044. doi:10.1001/jamapediatrics.2025.1974.
14. Glantz SA, Nguyen N, Oliveira da Silva AL. **Population-based disease odds for e-cigarettes and dual use versus cigarettes**. *NEJM Evid.* 2024;3(3):EVIDoa2300229. Epub 2024 Feb 27. doi:10.1056/EVIDoa2300229. PMID:38411454; PMCID:PMC11562742.
15. US Department of Health and Human Services. **The health consequences of smoking—50 years of progress: a report of the Surgeon General**. Atlanta (GA): Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health; 2014.
16. US Department of Health and Human Services. **E-cigarette use among youth and young adults: a report of the Surgeon General**. Atlanta (GA): National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health; 2016.
17. Krishnasamy VP; Lung Injury Response Epidemiology/Surveillance Task Force. **Update: characteristics of a nationwide outbreak of e-cigarette, or vaping, product use–associated lung injury — United States, August 2019–January 2020**. *MMWR Morb Mortal Wkly Rep.* 2020;69(3):90–94. doi:10.15585/mmwr.mm6903e2. PMID:31971931; PMCID:PMC7367698.
18. Stewart B. E-cigarette and Cancer: a qualitative risk assessment [Internet]. Sydney: Clinical Oncology Society of Australia (COSA); 2025 [cited 2025 Sep 28]. Available from: https://www.cosa.org.au/media/j4rjo4m3/cosa_research_report_on_e-cigarettes_and_cancer_final_july_2025.pdf.
19. Rungraungrayabkul D, Gaewkhiew P, Vichayanrat T, Shrestha B, Buajeeb W. **What is the impact of nicotine pouches on oral health: a systematic review**. *BMC Oral Health.* 2024;24(1):889. doi:10.1186/s12903-024-04598-8. PMID:39097712; PMCID:PMC11297755.
20. Bricker JB, Sullivan B, Mull K, Santiago-Torres M, Lavista Ferres JM. **Conversational chatbot for cigarette smoking cessation: results from the 11-step user-centered design development process and randomized controlled trial**. *JMIR Mhealth Uhealth.* 2024;12:e57318. doi:10.2196/57318. PMID:38913882; PMCID:PMC11303891.

21. Bendotti H, Marshall H, Lawler S, Gartner C, Ireland D. **A systematic review of conversational artificial intelligence for smoking cessation**. *Popul Med.* 2023;5(Suppl):A595. doi:10.18332/popmed/163890.
22. World Health Organization. **WHO clinical treatment guideline for tobacco cessation in adults**. Geneva: World Health Organization; 2024. Licence: CC BY-NC-SA 3.0 IGO.
23. Cinciripini PM, Green CE, Shete S, et al. **Smoking cessation after initial treatment failure with varenicline or nicotine replacement: a randomized clinical trial**. *JAMA.* 2024;331(20):1722–1731. doi:10.1001/jama.2024.4183.
24. González Pérez L. **Revisión sistemática sobre la eficacia y seguridad de la citisina contra la dependencia de nicotina**. *Farm Comunitarios.* 2024;16(3):24–28. Spanish. doi:10.33620/FC.2173-9218.(2024).17. PMID:39188785; PMCID:PMC11346260.
25. Rigotti NA, Benowitz NL, Prochaska J, Leischow S, Nides M, Blumenstein B, et al. **Cytisinicline for smoking cessation: a randomized clinical trial**. *JAMA.* 2023;330(2):152–160. doi:10.1001/jama.2023.10042. PMID:37432430; PMCID:PMC10336611.
26. Wang W, Volkow ND, Berger NA, Davis PB, Kaelber DC, Xu R. **Association of semaglutide with tobacco use disorder in patients with type 2 diabetes: target trial emulation using real-world data**. *Ann Intern Med.* 2024;177(8):1016–1027. Epub 2024 Jul 30. doi:10.7326/M23-2718. PMID:39074369.

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