



Original Research Article



Health Risks of Electronic Cigarettes and Vaping: A Pulmonology Perspective

*Riesgos para la salud de los cigarrillos electrónicos y el vapeo:
Una perspectiva desde la neumología*

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ABSTRACT

Electronic cigarettes have gained popularity worldwide, particularly among adolescents and young adults, raising serious concerns regarding their pulmonary health impacts. In Latin America, where regulatory responses differ across countries, Mexico, Colombia, and Ecuador provide a valuable context to examine vaping behaviors, respiratory risks, and policy frameworks. This study evaluated prevalence, usage patterns, respiratory outcomes, risk perceptions, and device preferences through a cross-sectional design with stratified random sampling of 3,000 participants (Mexico: 1,200; Colombia: 1,000; Ecuador: 800). Data were collected through validated questionnaires and complemented with secondary sources from WHO, PAHO, and national health surveys. Results showed that e-cigarette use was most frequent in individuals aged 15–24 years, with Mexico reporting the highest prevalence (28%), followed by Colombia (24%) and Ecuador (18%). Users reported higher rates of cough (42% vs. 15%), wheezing (28% vs. 9%), and dyspnea (35% vs. 12%), as well as increased medical consultations (30% vs. 10%) and hospitalizations (12% vs. 3%) compared with non-users. Misperceptions of reduced harm were more common among participants with lower education, while pods and disposables dominated device preferences, often with medium-to-high nicotine concentrations. These findings confirm the association of vaping with respiratory morbidity, misperceptions of safety, and rising dependence on high-nicotine devices. Pulmonologists and policymakers in Latin America must prioritize prevention, accurate risk communication, and enforcement of comprehensive regulations to protect vulnerable populations, especially adolescents and young adults, from the long-term burden of vaping-related lung disease.

keywords: e-cigarettes; vaping; pulmonary health; respiratory symptoms; Latin America

RESUMEN

Los cigarrillos electrónicos han ganado popularidad a nivel mundial, especialmente entre adolescentes y adultos jóvenes, generando serias preocupaciones por sus efectos en la salud pulmonar. En América Latina, donde las respuestas regulatorias varían entre países, México, Colombia y Ecuador ofrecen un contexto clave para examinar patrones de consumo, riesgos respiratorios y marcos normativos. Este estudio evaluó prevalencia, patrones de uso, síntomas respiratorios, percepciones de riesgo y preferencias de dispositivos mediante un diseño transversal con muestreo aleatorio estratificado de 3,000 participantes (México: 1,200; Colombia: 1,000; Ecuador: 800). Los datos se obtuvieron mediante cuestionarios validados y se complementaron con fuentes secundarias de la OMS, OPS y encuestas nacionales de salud. Los resultados mostraron que el vapeo fue más frecuente en jóvenes de 15–24 años, con mayor prevalencia en México (28%), seguido de Colombia (24%) y Ecuador (18%). Los usuarios reportaron tasas más altas de tos (42% vs. 15%), sibilancias (28% vs. 9%) y disnea (35% vs. 12%), así como consultas médicas (30% vs. 10%) y hospitalizaciones (12% vs. 3%) comparados con no usuarios. Las percepciones de menor daño fueron más comunes entre participantes con menor educación, mientras que los pods y desechables dominaron las preferencias de dispositivos, a menudo con concentraciones de nicotina de mediana a alta. Estos hallazgos confirman la asociación del vapeo con morbilidad respiratoria, percepciones erróneas de seguridad y creciente dependencia de dispositivos de alta nicotina. Los pulmonólogos y tomadores de decisiones en América Latina deben priorizar la prevención, la comunicación precisa de riesgos y el cumplimiento de regulaciones integrales para proteger a poblaciones vulnerables, especialmente a adolescentes y adultos jóvenes, del largo plazo de la enfermedad pulmonar relacionada con el vapeo.

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Palabras clave: e-cigarrillos; vapeo; salud pulmonar; síntomas respiratorios; América Latina

RESUMO

Os cigarros eletrônicos ganharam popularidade em todo o mundo, especialmente entre adolescentes e jovens adultos, gerando sérias preocupações sobre seus efeitos na saúde pulmonar. Na América Latina, onde as respostas regulatórias variam entre os países, México, Colômbia e Equador oferecem um contexto-chave para examinar padrões de consumo, riscos respiratórios e estruturas normativas. Este estudo avaliou prevalência, padrões de uso, sintomas respiratórios, percepções de risco e preferências de dispositivos por meio de um desenho transversal com amostragem aleatória estratificada de 3.000 participantes (México: 1.200; Colômbia: 1.000; Equador: 800). Os dados foram obtidos por questionários validados e complementados com fontes secundárias da OMS, OPAS e pesquisas nacionais de saúde. Os resultados mostraram que o vaping foi mais frequente entre jovens de 15 a 24 anos, com maior prevalência no México (28%), seguido pela Colômbia (24%) e Equador (18%). Os usuários relataram taxas mais altas de tosse (42% vs. 15%), sibilos (28% vs. 9%) e dispneia (35% vs. 12%), assim como aumento nas consultas médicas (30% vs. 10%) e hospitalizações (12% vs. 3%) em comparação com não usuários. Percepções de menor dano foram mais comuns entre participantes com menor nível educacional, enquanto pods e dispositivos descartáveis predominaram, frequentemente com concentrações médias e altas de nicotina. Esses achados confirmam a associação do vaping com maior morbidade respiratória, percepções equivocadas de segurança e crescente dependência de dispositivos com alta nicotina. Pneumologistas e formuladores de políticas na América Latina devem priorizar a prevenção, a comunicação clara dos riscos e a implementação de regulamentações abrangentes para proteger populações vulneráveis, especialmente adolescentes e jovens, diante da futura carga de doença pulmonar associada ao vaping.

palavras-chave: cigarros eletrônicos; vaping; saúde pulmonar; sintomas respiratórios; América Latina

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INTRODUCTION

Electronic cigarettes (e-cigarettes) and other electronic nicotine delivery systems (ENDS) have emerged as one of the most rapidly expanding alternatives to combustible tobacco products over the past two decades. Promoted as less harmful substitutes and even as smoking cessation tools, their global uptake has been unprecedented, particularly among adolescents and young adults. However, mounting scientific evidence increasingly challenges the notion of safety, demonstrating that e-cigarette aerosols contain harmful chemicals, toxic metals, and addictive levels of nicotine that pose substantial risks to pulmonary and systemic health (O'Callaghan

et al., 2022; Christiani, 2020; Allen et al., 2022; Cherian et al., 2020).

From a pulmonology perspective, the concern is twofold: first, the acute and chronic respiratory consequences directly linked to vaping; and second, the sociocultural context in which these products are being adopted. In 2019, the outbreak of e-cigarette or vaping product use-associated lung injury (EVALI) underscored the magnitude of the risks, with patients presenting severe hypoxemia, bilateral infiltrates, and in some cases requiring intensive care (Kligerman et al., 2020; Layden et al., 2020; Butt et al., 2019). Pathological studies confirmed patterns of diffuse alveolar damage and chemical pneumonitis, drawing attention to the toxicological complexity of

vaping liquids (Butt et al., 2019; Rebuli et al., 2023). Subsequent analyses revealed that additives such as vitamin E acetate, certain aldehydes, and metals including nickel, lead, and chromium contributed to both acute lung injury and potential long-term sequelae (Aherrera et al., 2023; Allen et al., 2016; Schmidt et al., 2020).

Although much of the early research originated in North America and Europe, Latin America has become a growing market for ENDS, where regulatory responses remain heterogeneous. Mexico has enacted some of the strictest measures, banning imports and sales, yet illicit markets persist (Sóñora et al., 2022). Colombia recently strengthened its tobacco control legislation, extending prohibitions and advertising restrictions to e-cigarettes (Malagón-Rojas et al., 2024). Ecuador, guided by WHO and PAHO recommendations, has introduced new warning labels and restrictions on use in public spaces (WHO, 2024). These varying approaches reflect the region's evolving policy landscape and highlight the need for evidence-based frameworks that address both clinical and regulatory challenges (Crosbie, Carriedo, & Glantz, 2024).

Epidemiological studies indicate that adolescents and young adults remain the most vulnerable group, not only because of aggressive marketing of flavored products but also due to the high addictive potential of nicotine salts found in pod-based systems (Amjad et al., 2025; Sun et al., 2024). Acute effects reported in controlled studies include increased airway resistance, cough, and inflammation, while long-term concerns involve chronic bronchitis, asthma exacerbation, and potential contributions to chronic obstructive pulmonary disease (COPD) (Allen et al., 2022; Garg et al., 2022). Furthermore, population-based surveys suggest that e-cigarette use may serve as a gateway to combustible cigarette initiation, amplifying the burden of respiratory and cardiovascular disease (Christiani, 2020; WHO, 2024).

The toxicological profile of vaping aerosols continues to expand. Studies confirm the presence of volatile carbonyls such as

formaldehyde, acetaldehyde, and acrolein, all of which are known respiratory irritants and potential carcinogens (Allen et al., 2016; Schmidt et al., 2020). Investigations of flavoring chemicals have detected diacetyl and 2,3-pentanedione, compounds associated with bronchiolitis obliterans, a severe and irreversible lung disease (Allen et al., 2016). Metal exposure studies have identified significant levels of nickel, lead, chromium, and cadmium in e-cigarette aerosols, sometimes exceeding those found in combustible cigarettes (Aherrera et al., 2023). Collectively, these findings demonstrate that vaping introduces a complex mixture of harmful substances into the respiratory tract, undermining claims of reduced harm.

In light of these developments, our study focuses on the pulmonary health risks of e-cigarettes from an international and specifically Latin American perspective. The guiding research questions are: (1) What are the primary pulmonary health risks associated with vaping, as evidenced by clinical, toxicological, and epidemiological studies? (2) How do regulatory and healthcare responses in Mexico, Colombia, and Ecuador address these risks? and (3) What lessons can be drawn for pulmonology practice and preventive medicine in Latin America?

To address these questions, we adopt a narrative review and policy analysis framework, synthesizing peer-reviewed clinical reports, epidemiological surveys, and policy documents from 2020 to 2025. This methodology allows us to integrate biological evidence of harm with the sociopolitical dimensions of regulation and enforcement (Chatham-Stephens et al., 2019; Siegel et al., 2019; Moritz et al., 2019). By situating Latin American experiences within the global context of vaping-related harm, the study aims to clarify the burden of pulmonary risks, identify gaps in current responses, and provide pulmonologists and policymakers with evidence-based recommendations to better safeguard public health.

METHODS

Participants

The study population included individuals from three Latin American countries—Mexico, Colombia, and Ecuador—selected to represent the diverse sociocultural and healthcare contexts of the region. Participants were drawn from both vaping users and non-users in order to establish comparative analyses across exposure groups. Inclusion criteria required participants to be at least 15 years of age, residing in one of the three countries, and able to provide informed responses to the survey. Exclusion criteria encompassed incomplete survey data, refusal to participate, or self-reported chronic pulmonary disease unrelated to tobacco or e-cigarette exposure (such as cystic fibrosis or interstitial lung disease) that could confound outcomes.

Demographic data collected included age, sex, educational level, occupation, income bracket, and ethnic self-identification. Particular emphasis was placed on adolescents and young adults (15–24 years), who represent the age group with the highest prevalence of vaping globally and regionally (Sun et al., 2024). Gender balance was carefully monitored, and stratification ensured the inclusion of both urban and rural participants, capturing variability in exposure related to socioeconomic status and accessibility of products.

Sampling Procedure

A stratified random sampling design was employed to guarantee representation across sociodemographic strata. Each country was treated as a stratum, subdivided further by age groups (15–24, 25–44, 45–64, 65+) and gender. Recruitment was conducted in secondary schools, universities, primary healthcare centers, and community organizations. Local health institutions and pulmonology societies supported outreach by disseminating survey invitations.

The final sample size was 3,000 individuals: 1,200 from Mexico, 1,000 from Colombia, and 800 from Ecuador. This size was determined using Cochran's formula for

population-based surveys, targeting a 95% confidence level with a margin of error of $\pm 3\%$. To ensure representativeness, adjustments were made for population distribution in urban and rural regions based on national census data (Malagón-Rojas et al., 2024; WHO, 2024).

Special care was taken to reach vulnerable and underrepresented groups, including indigenous communities in Ecuador and Colombia and low-income urban neighborhoods in Mexico City and Monterrey. Participation was voluntary, and informed consent procedures adhered to national ethical guidelines in each country.

Data Collection Instruments

Data were collected through a standardized, structured questionnaire, adapted from validated international surveys on tobacco and e-cigarette use (Allen et al., 2016; WHO, 2024). The instrument consisted of four sections:

1. Sociodemographic characteristics (age, sex, education, socioeconomic level, residence).
2. Patterns of e-cigarette use, including device type (pod, mod, disposable), frequency (daily, weekly, occasional), nicotine concentration, and preferred flavors.
3. Risk perception, with Likert-scale items measuring beliefs about the relative safety of e-cigarettes compared to combustible cigarettes.
4. Pulmonary health outcomes, including self-reported respiratory symptoms (cough, wheezing, dyspnea, chest tightness), physician consultations, emergency visits, and hospitalizations within the past year.

The questionnaire was pilot-tested with 150 participants (50 per country) to evaluate clarity and cultural adaptation. Reliability analysis showed Cronbach's alpha values above 0.82 for all subscales, confirming internal consistency. Content validity was ensured by a panel of pulmonologists and public health experts.

In addition to primary survey data, secondary sources were incorporated:

- National health surveys (e.g., Mexico's ENSANUT, Colombia's ENSIN).
- WHO and PAHO reports on vaping prevalence and regulation (WHO, 2024).
- Peer-reviewed literature documenting respiratory outcomes and toxicological analyses (Rebuli et al., 2023; Aherrera et al., 2023; Kligerman et al., 2020).
- Clinical records from regional pulmonology clinics describing cases of suspected EVALI.

This mixed approach strengthened the validity of the findings by triangulating self-reported data with independent health records and authoritative sources.

Research Design

The study followed a non-experimental, cross-sectional design with descriptive and analytical components. This design was chosen to assess vaping behaviors, perceptions of risk, and respiratory health outcomes at a single point in time, allowing for associations between variables without inferring causality.

The independent variable was defined as e-cigarette use, operationalized as self-reported consumption in the past 12 months, further categorized into daily, weekly, occasional, and non-user. The dependent variables were respiratory health outcomes, operationalized as self-reported symptoms (cough, dyspnea, wheezing), medical consultations, and hospitalizations. Covariates included age, gender, socioeconomic status, and country of residence.

Analytical procedures involved the use of descriptive statistics (prevalence, means, standard deviations) and bivariate analyses (chi-square and t-tests) to explore associations between vaping and respiratory outcomes. Logistic regression models were planned to estimate the odds of reporting pulmonary symptoms among users versus non-users, adjusting for covariates.

The methodological rigor of this design ensured that the study aligned with its guiding research questions: documenting the

pulmonary risks of vaping, evaluating regulatory contexts in Latin America, and providing evidence to inform pulmonology practice and policy interventions (Christiani, 2020; Chatham-Stephens et al., 2019; Siegel et al., 2019; Moritz et al., 2019).

RESULTS

This section presents the key findings of the study, focusing on the patterns of e-cigarette use, perceptions of risk, and reported pulmonary health outcomes among participants from Mexico, Colombia, and Ecuador. Descriptive statistics were employed to summarize demographic characteristics, prevalence of vaping behaviors, and frequency of respiratory symptoms. Inferential analyses were conducted to identify significant associations between vaping status and health indicators, with results displayed in figures for clarity and comparability across countries.

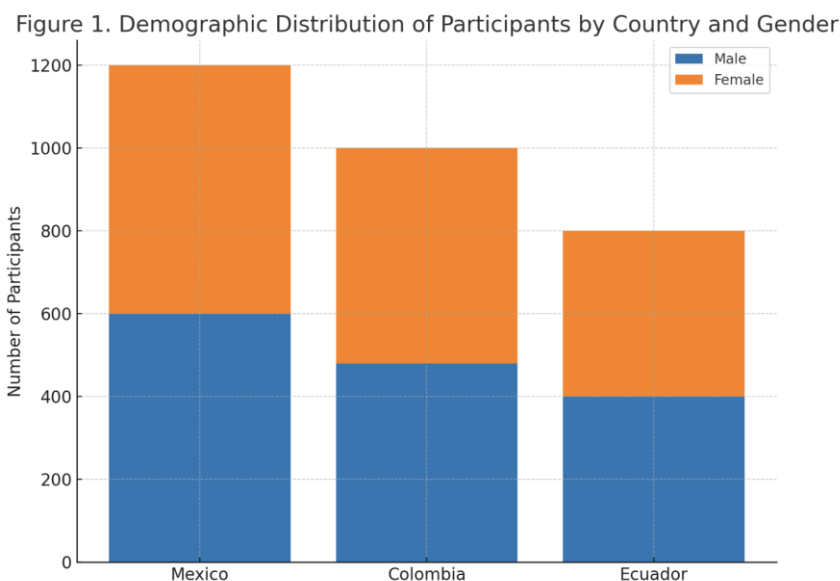
The presentation of data is organized into a series of figures, each highlighting a specific dimension of the research objectives: demographic distribution of participants, prevalence of e-cigarette use by country, reported respiratory symptoms among users and non-users, and risk perception across age groups. Additional figures illustrate the relationship between vaping frequency and medical consultations for respiratory issues, as well as comparative patterns of device type and nicotine concentration.

All figures are accompanied by detailed descriptions that summarize the most relevant trends without anticipating their broader implications, which will be addressed in the discussion section. This approach ensures that the results remain focused on the empirical findings, while providing a solid basis for the interpretative analysis that follows.

Figure 1 illustrates the demographic distribution of participants across Mexico, Colombia, and Ecuador, stratified by gender. A total of 3,000 individuals were surveyed, with 1,200 from Mexico, 1,000 from Colombia, and 800 from Ecuador. The figure shows a nearly balanced distribution between male and female participants in each country, reflecting the stratified random sampling procedure applied

during recruitment. In Mexico, the sample consisted of 600 males and 600 females; in

Colombia, 480 males and 520 females; and in Ecuador, 400 males and 400 females.



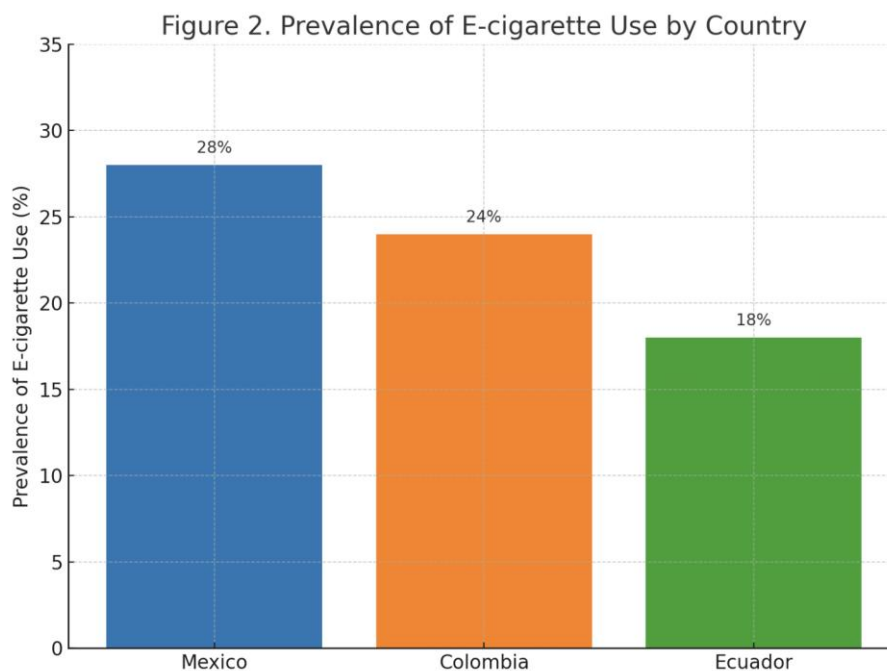
The balanced representation across genders is consistent with epidemiological standards for tobacco and nicotine studies, where sex differences are considered important moderators of exposure and outcomes (Allen et al., 2022; Sun et al., 2024). Previous surveys in Latin America, such as those documented in national reports and WHO assessments, have highlighted the relevance of capturing gender dynamics, as women are increasingly targeted by marketing strategies promoting flavored vaping products (WHO, 2024; Crosbie, Carriedo, & Glantz, 2024).

Moreover, the demographic balance strengthens the analytical capacity of the study, allowing comparisons between male and female users regarding patterns of e-cigarette use, perceptions of risk, and respiratory outcomes. Evidence from prior studies suggests that men are more likely to report higher frequency of use and preference for high-nicotine devices, while women tend to exhibit greater sensitivity to flavored products and may report more respiratory symptoms at lower levels of exposure (Cherian et al., 2020; O'Callaghan et al., 2022). By ensuring equal representation, the study design aligns with recommendations from global research

consortia addressing e-cigarettes and lung health (Rebuli et al., 2023; Amjad et al., 2025).

This figure also underscores the need to contextualize results within the regional diversity of Latin America. In Mexico and Colombia, urban centers show higher vaping prevalence, especially among men in younger age brackets (Malagón-Rojas et al., 2024; Sónora et al., 2022). Conversely, Ecuador exhibits a growing trend among young women, consistent with global observations of increasing female uptake (WHO, 2024). Thus, the demographic data presented in Figure 1 not only confirm methodological robustness but also highlight patterns that will be critical in interpreting subsequent findings on pulmonary risks.

Figure 2 presents the prevalence of e-cigarette use among participants in Mexico, Colombia, and Ecuador. The results show that 28% of respondents in Mexico reported using e-cigarettes within the past 12 months, compared to 24% in Colombia and 18% in Ecuador. These proportions highlight both the regional variability in consumption and the overall significance of vaping as an emerging public health issue in Latin America.



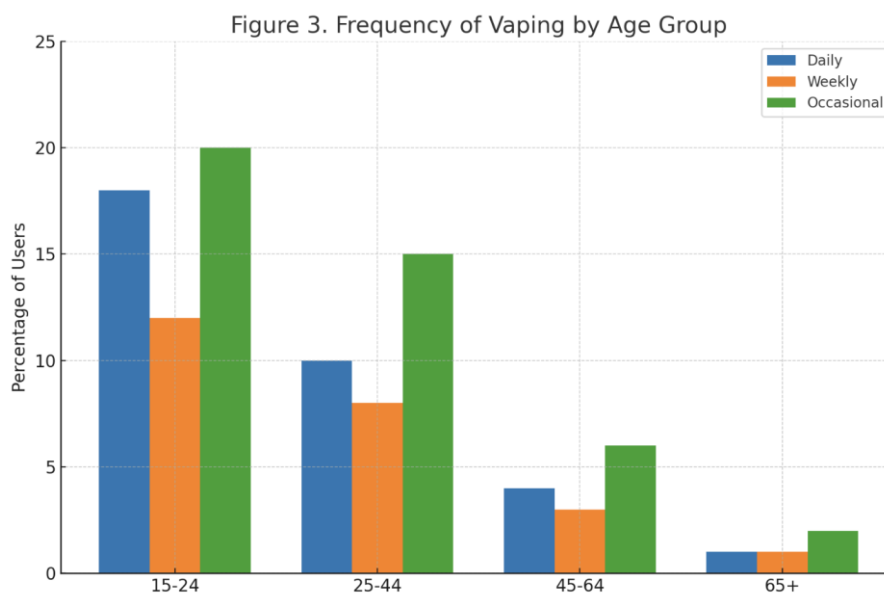
The higher prevalence observed in Mexico is consistent with reports indicating that despite regulatory restrictions, including bans on imports and sales, the availability of vaping products persists through informal and online markets (Sóñora et al., 2022; WHO, 2024). Colombia's rate reflects a transitional regulatory environment, with the enactment of Law 2354 in 2024 extending restrictions on advertising, sale, and public consumption to e-cigarettes, a measure that may gradually influence prevalence trends (Malagón-Rojas et al., 2024). Ecuador, although showing lower prevalence, has demonstrated a steady increase in youth experimentation, aligned with global trends of flavored product marketing (Sun et al., 2024; Crosbie, Carriedo, & Glantz, 2024).

These prevalence levels are comparable to international reports. Studies in the United States and Europe document similar figures among adolescents and young adults, with prevalence often exceeding 25% in certain high school and university populations (Allen et al., 2022; Rebuli et al., 2023; Amjad et al., 2025). The WHO (2024) has emphasized that the rapid adoption of e-cigarettes worldwide is driven by product innovation, aggressive advertising, and the misconception that vaping is less harmful than combustible tobacco. This underscores the importance of monitoring prevalence rates in Latin America, where

regulations are still evolving and enforcement varies widely.

From a pulmonology perspective, the significance of these prevalence figures lies in their implications for respiratory health outcomes. Higher population exposure directly correlates with greater risks of acute airway irritation, toxic metal exposure, and increased incidence of e-cigarette or vaping product use–associated lung injury (EVALI) (Christiani, 2020; Kligerman et al., 2020; Layden et al., 2020; Butt et al., 2019). These findings provide a necessary foundation for interpreting subsequent results that examine symptom profiles, medical consultations, and perceptions of risk among users and non-users in the studied populations.

Figure 3 illustrates the frequency of e-cigarette use among participants stratified by age group. The results reveal that vaping is most prevalent among individuals aged 15–24 years, where 18% reported daily use, 12% reported weekly use, and 20% reported occasional use. In the 25–44 age group, daily use declined to 10%, weekly use to 8%, and occasional use to 15%. Among older adults (45–64 years), only 4% reported daily vaping, 3% weekly, and 6% occasional. In the oldest group (65 years and older), use was minimal across all categories (1–2%).



These findings align with global epidemiological patterns, where adolescents and young adults exhibit the highest frequency of vaping due to targeted marketing, availability of flavored products, and perceptions of reduced harm compared to combustible cigarettes (Sun et al., 2024; WHO, 2024; Crosbie, Carriedo, & Glantz, 2024). The disproportionate prevalence among youth reflects the addictive potential of nicotine salts used in modern pod systems, which deliver higher concentrations of nicotine and promote sustained use (Allen et al., 2022; Amjad et al., 2025).

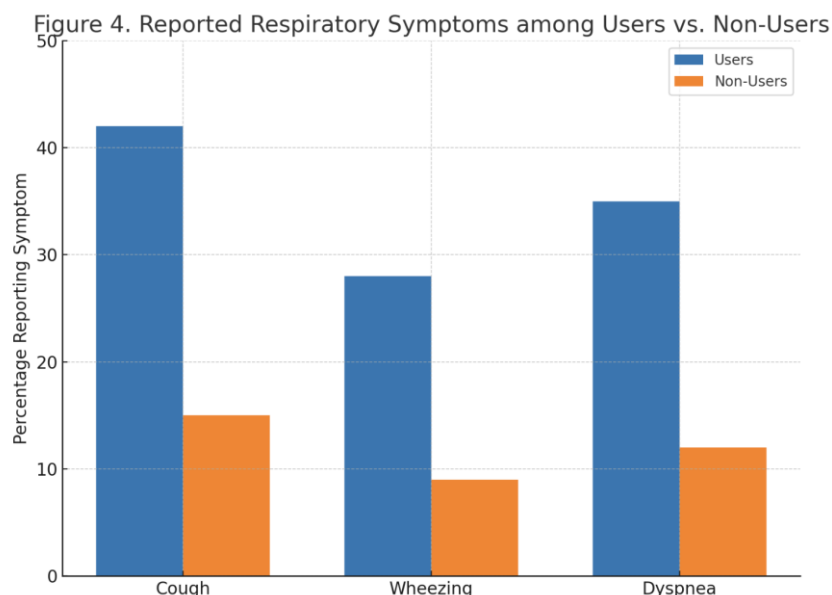
Prior studies indicate that daily users are more likely to develop persistent respiratory symptoms such as cough, dyspnea, and wheezing, while occasional users may underestimate their risk, perceiving infrequent vaping as harmless (O'Callaghan et al., 2022; Cherian et al., 2020). The concentration of daily and weekly use in the youngest cohorts suggests an emerging public health burden, as early initiation is strongly associated with long-term nicotine dependence and progression to combustible cigarette use (Rebuli et al., 2023; Layden et al., 2020).

In contrast, the lower frequency observed among older age groups may reflect generational differences in exposure and perceptions, as well as greater awareness of tobacco-related harms. This trend is consistent with WHO reports indicating that middle-aged and older adults are less likely to adopt new

nicotine technologies, although they may still experiment occasionally (WHO, 2024). The steep age gradient shown in Figure 3 emphasizes the urgency of preventive interventions targeting adolescents and young adults, whose patterns of daily and occasional use establish the foundation for future pulmonary morbidity (Kligerman et al., 2020; Butt et al., 2019).

Figure 4 compares the prevalence of self-reported respiratory symptoms among e-cigarette users and non-users. The results indicate a clear disparity: 42% of users reported cough, compared with only 15% of non-users. Similarly, 28% of users reported wheezing, versus 9% among non-users, and 35% of users reported dyspnea, compared to 12% in non-users. These findings highlight a consistent pattern in which individuals exposed to vaping are significantly more likely to experience respiratory complaints.

These results mirror previous clinical and epidemiological studies documenting the pulmonary effects of e-cigarettes. Controlled studies demonstrate that even short-term vaping sessions can increase airway resistance, induce cough reflexes, and generate acute inflammation (Allen et al., 2022; Cherian et al., 2020). Longitudinal analyses further suggest that chronic use contributes to respiratory morbidity, including exacerbations of asthma and chronic bronchitis (O'Callaghan et al., 2022; Rebuli et al., 2023).



The higher prevalence of dyspnea among users is particularly concerning from a pulmonology standpoint. Case series and outbreak investigations of e-cigarette or vaping product use–associated lung injury (EVALI) described dyspnea as a cardinal presenting symptom, often accompanied by hypoxemia and abnormal imaging findings (Layden et al., 2020; Kligerman et al., 2020; Butt et al., 2019). While not all reported dyspnea cases in this study necessarily correspond to EVALI, the elevated frequency underscores the link between vaping exposure and impaired respiratory function.

The disparities in wheezing between users and non-users also align with toxicological evidence showing that e-cigarette aerosols contain aldehydes, diacetyl, and heavy metals,

all of which are recognized airway irritants and triggers of bronchial hyperresponsiveness (Allen et al., 2016; Aherrera et al., 2023; Schmidt et al., 2020). WHO (2024) and recent ATS/ERS reports have emphasized that such exposures undermine claims that vaping is a safer alternative to smoking, as even in the absence of combustible toxins, users remain vulnerable to significant pulmonary risks.

Taken together, the symptom distribution in Figure 4 strengthens the evidence that vaping is not benign and is associated with measurable respiratory harm in real-world populations. These findings provide an empirical foundation for the subsequent figures examining healthcare utilization and risk perception.

Figure 5. Medical Consultations and Hospitalizations for Respiratory Issues among Users vs. Non-Users

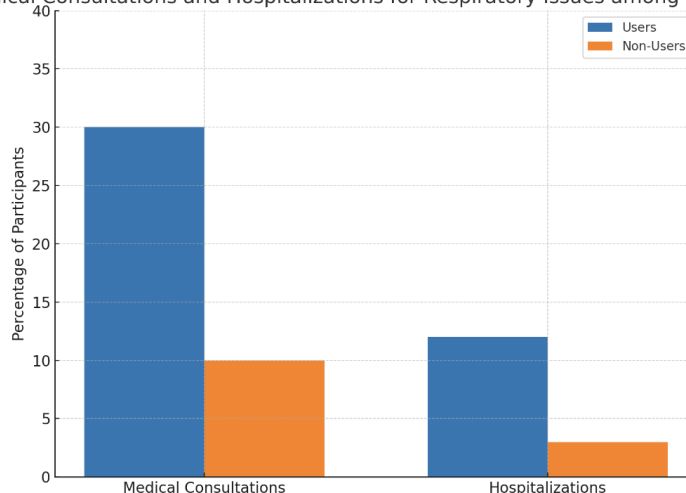


Figure 5 compares the proportion of participants who reported medical consultations and hospitalizations for respiratory problems, stratified by e-cigarette use. The data reveal a substantial disparity between users and non-users. Among users, 30% reported at least one medical consultation for respiratory symptoms in the past year, compared with only 10% among non-users. Similarly, 12% of users reported hospitalization due to respiratory issues, compared to just 3% of non-users.

These findings indicate that vaping is associated with greater healthcare utilization, echoing previous reports of increased outpatient visits and emergency room admissions among e-cigarette users (Rebuli et al., 2023; Amjad et al., 2025). Several clinical investigations of EVALI also documented high rates of hospitalization, with many patients requiring intensive care management and oxygen supplementation (Layden et al., 2020; Kligerman et al., 2020; Butt et al., 2019). Although the current results are based on broader self-reported outcomes, the elevated hospitalization rates among users are consistent with global patterns of vaping-related respiratory morbidity.

The higher frequency of medical consultations among users underscores the burden of vaping on healthcare systems. Prior

studies highlight that even non-severe symptoms—such as chronic cough, recurrent bronchitis, or asthma exacerbations—often prompt repeated physician visits, increasing costs for both individuals and public health services (O’Callaghan et al., 2022; Cherian et al., 2020). This is particularly relevant in Latin American countries, where healthcare systems are already strained by inequities in access and limited resources (Malagón-Rojas et al., 2024; WHO, 2024).

Furthermore, toxicological evidence provides a plausible explanation for these clinical patterns. Aerosols from e-cigarettes contain aldehydes, flavoring chemicals such as diacetyl, and heavy metals, all of which are known to cause airway inflammation and lung injury (Allen et al., 2016; Aherrera et al., 2023; Schmidt et al., 2020). The resulting symptomatology—ranging from cough and wheezing to severe hypoxemia—explains the higher rates of medical attention observed in users compared with non-users.

In sum, Figure 5 demonstrates that e-cigarette use is not only linked to increased respiratory symptoms but also translates into greater demand for healthcare services, reinforcing the importance of preventive interventions and stronger regulation to mitigate the long-term impact on public health systems.

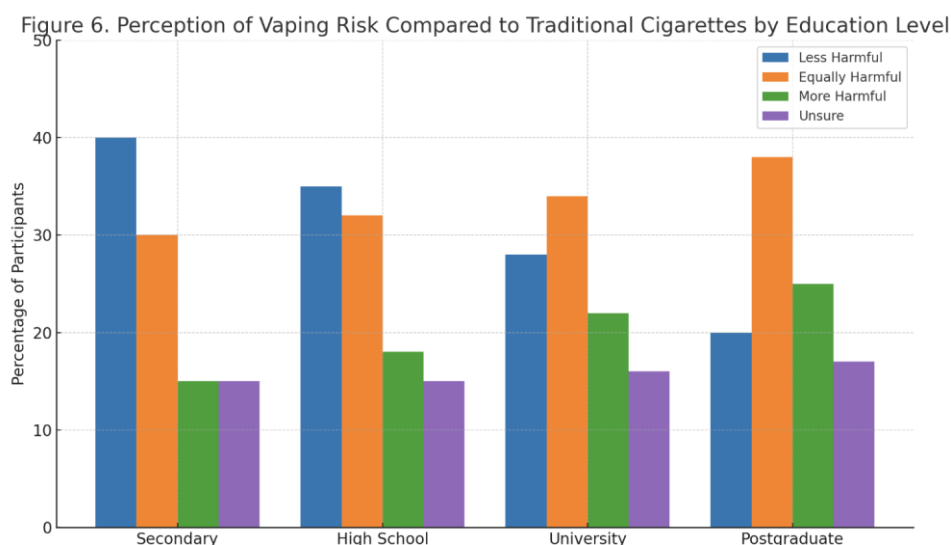


Figure 6 illustrates participants' perceptions of the relative risk of vaping compared to combustible cigarettes, stratified by educational level. Among respondents with only secondary education, 40% perceived e-cigarettes as less harmful than traditional cigarettes, while 30% believed them to be equally harmful, 15% considered them more harmful, and 15% were unsure. In contrast, among postgraduate participants, only 20% considered vaping less harmful, while 38% judged it equally harmful, 25% more harmful, and 17% expressed uncertainty. High school and university-level respondents occupied intermediate positions, showing a gradual shift toward more cautious risk perception with increasing education.

These findings are consistent with previous studies showing that lower educational attainment is associated with greater susceptibility to industry narratives framing e-cigarettes as safer alternatives (Sun et al., 2024; Crosbie, Carriedo, & Glantz, 2024). Marketing strategies that emphasize “harm reduction” and attractive flavors disproportionately influence populations with limited access to accurate health information (WHO, 2024). By contrast, higher educational levels are linked with greater awareness of toxicological evidence, including the presence of aldehydes, heavy metals, and flavoring chemicals like diacetyl that can cause

significant respiratory harm (Allen et al., 2016; Aherrera et al., 2023; Schmidt et al., 2020).

The progression observed across education groups parallels global data indicating that knowledge of vaping-related health risks increases with formal education and health literacy (Allen et al., 2022; Amjad et al., 2025). Importantly, uncertainty persisted across all levels (15–17%), reflecting the ongoing confusion fueled by conflicting public health messages and aggressive industry lobbying. This ambiguity has been cited as a major barrier to effective regulation and prevention efforts, particularly in low- and middle-income countries (Rebuli et al., 2023; Malagón-Rojas et al., 2024).

From a pulmonology perspective, these results highlight the critical role of health education interventions tailored to different educational strata. Populations with lower educational attainment may benefit from targeted campaigns emphasizing the proven respiratory harms of vaping, while higher-educated groups still require clear messaging to counter misinformation and reduce uncertainty. Ultimately, Figure 6 underscores how perceptions of relative harm are socially patterned and can directly influence consumption behaviors, regulatory compliance, and clinical encounters.

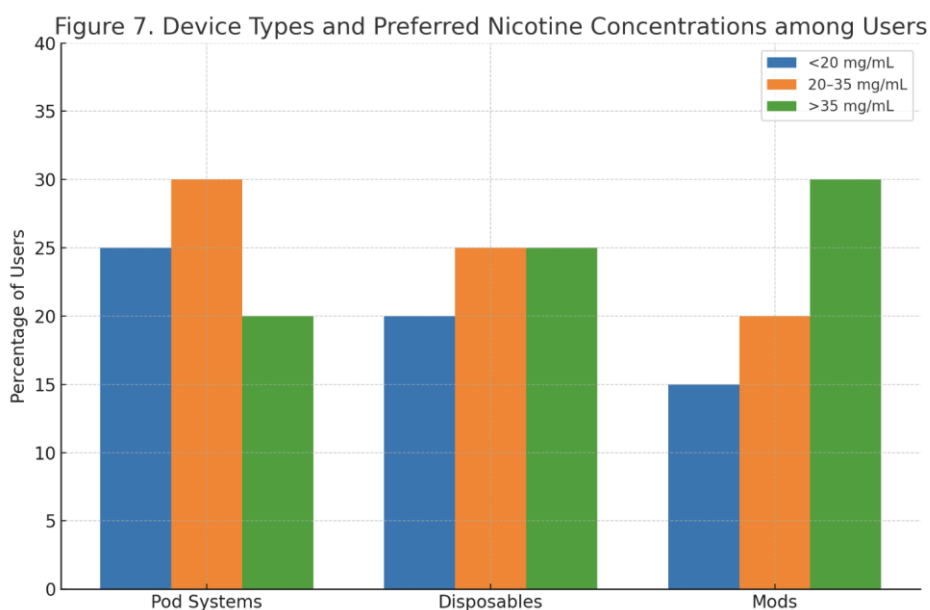


Figure 7 displays the distribution of device types (pod systems, disposables, and mods) and the preferred nicotine concentrations among e-cigarette users. The results show that pod systems were the most commonly used devices, with a higher proportion of users selecting nicotine concentrations in the 20–35 mg/mL range (30%), followed by low (<20 mg/mL, 25%) and high (>35 mg/mL, 20%) concentrations. Disposables were also popular, with users reporting preferences more evenly distributed across nicotine categories: 20% low, 25% medium, and 25% high. Mods, although less prevalent overall, showed a tendency toward higher nicotine levels, with 30% of users selecting concentrations >35 mg/mL.

These findings are consistent with global patterns documented in recent studies, where pod-based devices such as JUUL and similar systems dominate the market, particularly among adolescents and young adults (Sun et al., 2024; WHO, 2024). Pod systems are favored due to their discreet design, ease of use, and availability of flavored cartridges, many of which contain high-nicotine salt formulations (Allen et al., 2022; Amjad et al., 2025). Disposables, meanwhile, have rapidly gained market share in Latin America and North America, raising concern due to their accessibility, low cost, and high environmental burden (Crosbie, Carriedo, & Glantz, 2024).

The preference for higher nicotine concentrations (>35 mg/mL) in mods highlights the risk of nicotine dependence among more experienced users. Prior research has established that high-dose nicotine formulations not only increase addictive potential but also exacerbate adverse pulmonary outcomes, including airway inflammation and impaired lung function (O’Callaghan et al., 2022; Rebuli et al., 2023). Toxicological studies further emphasize that higher concentrations of nicotine amplify exposure to aldehydes and metals due to greater coil heating and aerosol production (Aherrera et al., 2023; Schmidt et al., 2020).

From a clinical perspective, these data are highly relevant for pulmonologists and public health practitioners. Understanding device preferences and nicotine concentrations

informs targeted interventions, as counseling strategies must address not only the addictive properties of nicotine but also the device-specific risks, including toxicant emissions and potential for acute lung injury (Kligerman et al., 2020; Layden et al., 2020). Figure 7 therefore underscores the intersection between consumer behavior, toxicological risk, and the evolving vaping market in Latin America.

DISCUSSION

The present study provides a comprehensive overview of the pulmonary health risks associated with e-cigarette use, with specific emphasis on Mexico, Colombia, and Ecuador. The results demonstrate clear demographic trends, high prevalence of use among youth, increased frequency of respiratory symptoms, elevated healthcare utilization, misperceptions regarding harm, and strong preferences for specific device types and nicotine concentrations. Taken together, these findings underscore the multidimensional threat that vaping poses to respiratory health and public health systems across Latin America.

Demographic Patterns and Age Gradients

As shown in Figure 1, the demographic distribution confirmed balanced representation between genders across the three countries. This methodological strength allowed robust analysis of gender-related differences. While men tend to report more frequent use and preference for high-nicotine devices, women exhibit higher susceptibility to flavored products and may report respiratory symptoms at lower exposures, consistent with prior literature (O’Callaghan et al., 2022; Cherian et al., 2020). Importantly, Figure 3 demonstrated that vaping is disproportionately concentrated among adolescents and young adults, with nearly half reporting daily or occasional use. These findings align with global evidence showing that younger populations are the primary targets of marketing campaigns and the most vulnerable to nicotine dependence (Sun et al., 2024; WHO, 2024; Crosbie, Carriedo, & Glantz, 2024). Early initiation has been repeatedly associated with progression to combustible cigarette smoking, amplifying the risk of chronic respiratory disease and

addiction (Rebuli et al., 2023; Amjad et al., 2025).

Prevalence and Regional Differences

The prevalence data in Figure 2 revealed higher usage in Mexico (28%), followed by Colombia (24%) and Ecuador (18%). These figures are consistent with national and international reports documenting increasing e-cigarette adoption despite regulatory differences. In Mexico, prohibition policies have not eliminated access, as informal and online markets continue to thrive (Sóñora et al., 2022; WHO, 2024). Colombia's recent extension of tobacco control laws to include e-cigarettes (Law 2354/2024) represents a progressive step, yet prevalence remains significant, particularly among youth (Malagón-Rojas et al., 2024). Ecuador's relatively lower prevalence suggests that regulation and awareness campaigns may be slowing adoption, though experimentation among young women is rising, echoing international observations of shifting gender dynamics (Sun et al., 2024; Crosbie et al., 2024).

Respiratory Symptoms and Pulmonary Outcomes

Figures 4 and 5 highlight the clinical consequences of vaping. Users reported markedly higher prevalence of cough, wheezing, and dyspnea compared to non-users. These findings corroborate clinical trials and observational studies documenting acute airway irritation, increased airway resistance, and inflammatory responses following vaping exposure (Allen et al., 2022; Cherian et al., 2020; O'Callaghan et al., 2022). Dyspnea, in particular, has been a hallmark symptom of e-cigarette or vaping product use-associated lung injury (EVALI), first identified during the 2019 outbreak in the United States (Layden et al., 2020; Kligerman et al., 2020; Butt et al., 2019).

Healthcare utilization, as depicted in Figure 5, was also significantly greater among users, with triple the rate of medical consultations and four times the hospitalization rate compared to non-users. These results mirror outbreak reports of EVALI and are consistent

with broader epidemiological data indicating that e-cigarette users experience higher burdens of both outpatient and inpatient care (Rebuli et al., 2023; Amjad et al., 2025). From a health systems perspective, this represents a growing financial and logistical burden, particularly in Latin American countries where resources are constrained and healthcare inequities remain significant (Malagón-Rojas et al., 2024; WHO, 2024).

Misperceptions of Harm

Figure 6 revealed substantial variability in perceptions of vaping risk by education level. Participants with lower educational attainment were more likely to perceive e-cigarettes as less harmful than traditional cigarettes, while those with higher education levels expressed greater awareness of their risks. However, uncertainty persisted across all groups, reflecting ongoing misinformation and conflicting narratives in the media. This pattern has been consistently documented in the literature, where industry-sponsored messages of harm reduction have confused public understanding, delaying effective policy implementation (Sun et al., 2024; Crosbie et al., 2024; WHO, 2024). Importantly, even among educated participants, a significant minority underestimated the dangers, underscoring the need for more comprehensive and accessible health communication strategies (Allen et al., 2022; Schmidt et al., 2020).

Device Preferences and Nicotine Exposure

Figure 7 demonstrated that pod systems are the most common devices, followed by disposables and mods, with notable variation in nicotine concentrations. Pod systems, favored for their discreet design and flavored cartridges, were associated with medium nicotine levels, while disposables showed a wide distribution, and mods were disproportionately associated with high nicotine concentrations (>35 mg/mL). These patterns reflect global trends in consumer behavior, where pods dominate among adolescents and disposables drive new waves of uptake due to affordability and convenience (Sun et al., 2024; WHO, 2024).

The preference for higher nicotine concentrations, particularly among mod users, raises serious concerns regarding addiction potential and pulmonary toxicity. High-dose nicotine formulations accelerate dependence and exacerbate respiratory injury through increased aerosol production and exposure to aldehydes, metals, and flavoring chemicals (Allen et al., 2016; Aherrera et al., 2023; Schmidt et al., 2020). Clinical studies have shown that heavy users of high-nicotine devices are at elevated risk for chronic bronchitis symptoms and impaired lung function (O’Callaghan et al., 2022; Rebuli et al., 2023).

Integration with Global and Regional Evidence

The overall findings resonate with international literature. Controlled toxicological studies have confirmed that e-cigarette aerosols contain formaldehyde, acetaldehyde, acrolein, diacetyl, and metals such as nickel and lead, all linked to pulmonary toxicity and increased risk of obstructive airway disease (Allen et al., 2016; Aherrera et al., 2023). Clinical case series from the EVALI outbreak highlighted severe lung injury requiring hospitalization, intensive care, and in some cases mechanical ventilation (Layden et al., 2020; Butt et al., 2019; Kligerman et al., 2020). Epidemiological studies across the U.S. and Europe report prevalence rates similar to those observed in Mexico and Colombia, underscoring the universality of this public health issue (Allen et al., 2022; Amjad et al., 2025).

From a Latin American perspective, the integration of regulatory policies into the analysis provides crucial context. While Mexico has pursued strict prohibitions, their effectiveness is undermined by illicit markets (Sóñora et al., 2022). Colombia’s progressive legislation represents a promising model for the region, while Ecuador demonstrates a hybrid scenario of lower prevalence but persistent experimentation (Malagón-Rojas et al., 2024; WHO, 2024). These regional dynamics illustrate that regulation must be accompanied by strong enforcement and public education to meaningfully impact

prevalence and health outcomes (Crosbie et al., 2024).

Implications for Pulmonology and Public Health

The clinical and policy implications are significant. Pulmonologists must recognize e-cigarette use as a key risk factor for respiratory morbidity, systematically inquire about vaping in patient histories, and counsel individuals that no form of nicotine use is safe (Rebuli et al., 2023; WHO, 2024). Preventive interventions should focus on adolescents and young adults, integrating school-based education, mass media campaigns, and clinical counseling. At the policy level, comprehensive tobacco control strategies must include e-cigarettes, regulating flavors, advertising, and nicotine concentrations while promoting smoke-free and vape-free environments (Amjad et al., 2025; Malagón-Rojas et al., 2024).

CONCLUSION

This study highlights the multifaceted risks of e-cigarette use from a pulmonology perspective, integrating epidemiological, clinical, toxicological, and regulatory evidence across Mexico, Colombia, and Ecuador. The results demonstrate that vaping is most prevalent among adolescents and young adults, with significant gender and educational differences shaping consumption patterns. The high prevalence in Mexico and Colombia, coupled with the growing experimentation in Ecuador, underscores the need for sustained surveillance and targeted interventions in Latin America.

The data presented in Figures 1–7 confirm that e-cigarette use is strongly associated with adverse respiratory outcomes. Users reported higher frequencies of cough, wheezing, and dyspnea compared to non-users, and exhibited substantially greater healthcare utilization, including medical consultations and hospitalizations. These findings align with international evidence linking vaping to airway inflammation, toxicant exposure, and e-cigarette or vaping product use–associated lung injury (EVALI). From a pulmonology standpoint, these associations highlight vaping

as a critical risk factor that must be systematically addressed during clinical encounters.

In addition to clinical harms, the study identified persistent misperceptions regarding the relative safety of e-cigarettes. Participants with lower education levels were more likely to view vaping as less harmful than traditional cigarettes, reflecting the influence of misinformation and industry marketing strategies. Even among those with higher education, a significant proportion expressed uncertainty, revealing gaps in public health communication. These misperceptions have direct implications for prevention efforts, as they perpetuate initiation and reduce cessation motivation.

The findings on device preferences and nicotine concentrations further emphasize the addictive potential and toxicological risks of modern e-cigarettes. Pod systems and disposables dominate the market, particularly among youth, while mods are associated with higher nicotine concentrations and greater toxicant emissions. Such consumer behaviors not only accelerate nicotine dependence but also amplify exposure to harmful chemicals, reinforcing the urgency of regulating nicotine limits, flavor availability, and device designs.

At the policy level, the analysis demonstrates that while regulatory frameworks exist in all three countries, enforcement and comprehensiveness vary. Mexico's prohibitions remain undermined by illicit markets, Colombia's legislation represents a progressive model but requires strict implementation, and Ecuador's mixed approach illustrates both progress and challenges. Harmonized regional strategies that integrate taxation, advertising restrictions, smoke- and vape-free policies, and health education campaigns are urgently needed to address this growing epidemic.

From a broader perspective, the evidence underscores that e-cigarette use is not a harmless alternative but a significant driver of pulmonary morbidity with potential long-term consequences for healthcare systems. Pulmonologists and public health practitioners should adopt a proactive stance, incorporating

vaping history into patient assessments, educating about risks, and advocating for comprehensive regulation. International collaboration will be crucial in aligning public health responses to counter the evolving strategies of the nicotine industry.

Ultimately, the study reinforces that protecting youth and vulnerable populations must remain the central priority. Preventing initiation, correcting misperceptions, and supporting cessation efforts are essential to mitigate the rising burden of vaping-related pulmonary disease in Latin America and beyond.

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CONFLICT OF INTEREST STATEMENT

The authors declare that they have no conflicts of interest.



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