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REVIEW

Comparing the Effects of e-Cigarettes and Traditional Cigarettes on Asthma in Adolescents: A Systematic Review

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Abstract: Asthma is one of the most common chronic diseases among teenagers, and environmental factors such as smoking worsen the condition. The growing popularity of e-cigarettes raises concerns over their potential effects on asthma in adolescents compared to traditional cigarettes. This systematic review sought to evaluate the differences between e-cigarettes and traditional cigarettes in relation to asthma diagnosis, exacerbations, and symptoms in adolescents using quantitative studies conducted between 2015 and July 2025. Following PRISMA guidelines, we searched PubMed, Scopus, and the Web of Science and found 427 articles. After removing duplicates (n=188) and ineligible studies (n=229), we included 10 studies (1 cohort, 9 cross-sectional). Inclusion criteria included focus on adolescents, comparison of e-cigarettes and traditional cigarettes, and studies with asthma-related outcomes. Study quality was evaluated using Newcastle–Ottawa Scale (NOS; scores 6–8/10). Extracted data were narratively synthesized and comparatively analyzed across exposure groups due to heterogeneity in study design, outcomes, and effect measures. e-cigarettes were found to increase the likelihood of developing asthma more than traditional cigarettes among adolescents (AOR=1.10–1.30). Statistically significant relationships were also detected between exacerbations of asthma and e-cigarette use (AOR=2.13; APR=1.54–1.85). The impact of traditional cigarettes (AOR=0.80–8.49) was mixed. The highest risk was observed in dual users. The sexual minority and non-Hispanic Black youth showed greater susceptibility. Self-reporting, along with data obtained from cross-sectional designs, created a lack of causation. Both e-cigarettes and traditional cigarettes were associated with increased asthma-related outcomes, with the highest risk observed in dual users. There is a need for aggressive policies including flavor and age restrictions, as well as focused policies for those most at risk. To understand the strategies needed to lessen the burden of asthma in children and youth, clinical designed longitudinal studies will help identify the specific devices and causational factors.

Keywords: asthma, e-cigarettes, cigarette, adolescents

Introduction

Asthma, a chronic inflammatory respiratory condition, is one of the most prevalent non-communicable diseases among adolescents, affecting approximately 10–15% of youth globally.[1] Characterized by reversible airway obstruction, bronchial hyperresponsiveness, and recurrent symptoms such as wheezing and shortness of breath, asthma significantly impacts quality of life, school attendance, and physical activity in this age group.[2] Adolescents are particularly vulnerable to environmental and behavioral triggers, including exposure to tobacco smoke, which is a well-established risk factor for asthma exacerbations.[3] In recent years, the rapid rise in e-cigarette use among adolescents has introduced new concerns about its potential respiratory effects, particularly in comparison to traditional combustible cigarettes.[4] Traditional cigarettes, which deliver nicotine through the combustion of tobacco, have long been associated with adverse respiratory outcomes, including asthma onset and exacerbations.[5] The harmful effects of cigarette smoke are attributed to its complex mixture of over 7,000 chemicals, including tar, carbon monoxide, and numerous carcinogens, which irritate airways and promote inflammation.[6] Despite declining smoking rates among adolescents in many countries, traditional

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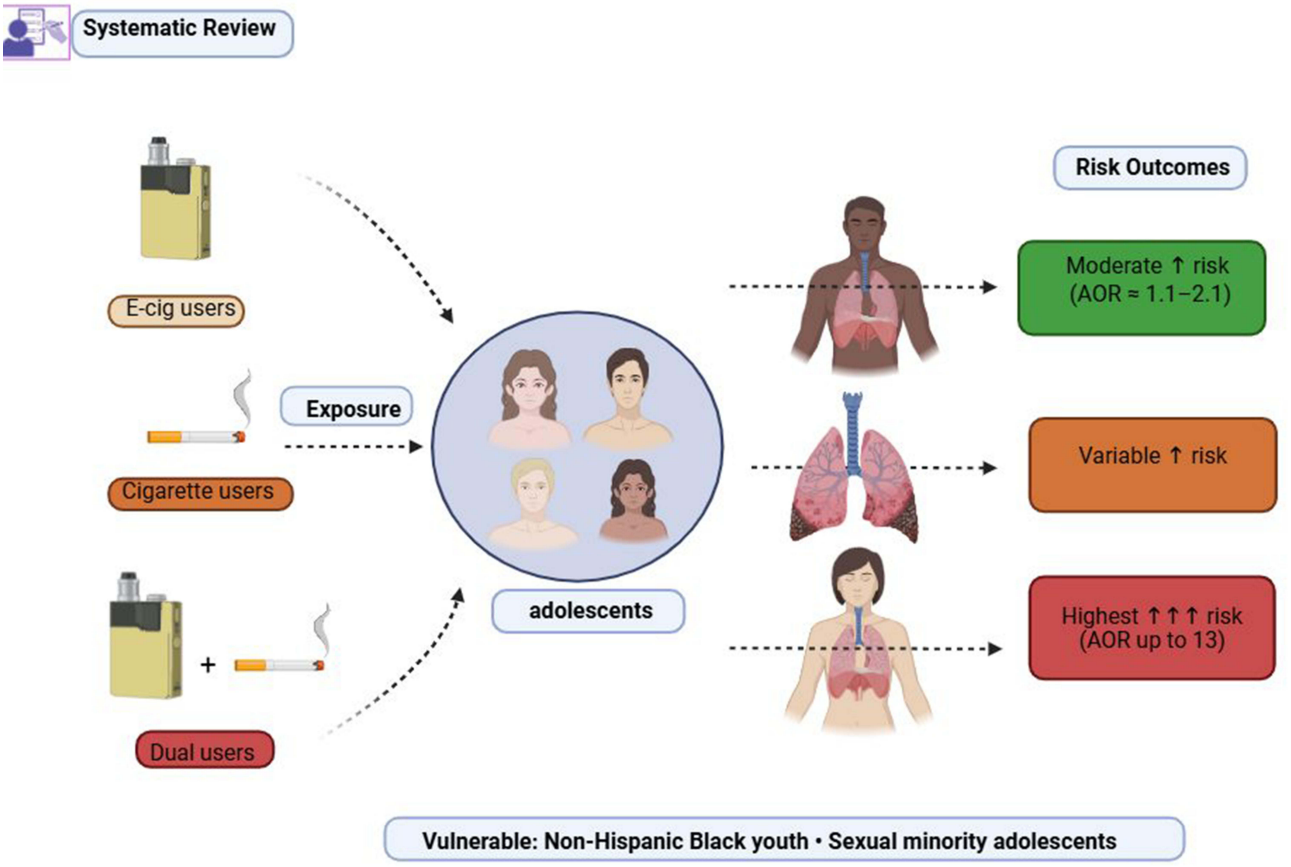
Graphical Abstract



cigarettes remain a public health concern, particularly in regions with less stringent tobacco control.[4] Concurrently, e-cigarettes, marketed as a safer alternative, have gained popularity among youth due to appealing flavors, aggressive marketing, and perceptions of reduced harm.[7] E-cigarettes deliver nicotine via aerosolized liquids containing propylene glycol, vegetable glycerin, and flavoring agents, but their long-term respiratory effects remain understudied.[8] The prevalence of e-cigarette use among adolescents has surged, with studies reporting that 19–27% of US high school students have used e-cigarettes in the past 30 days, compared to 5–7% for traditional cigarettes.[9,10] Although several meta-analyses have linked e-cigarette use to asthma, most include adult populations or broadly address respiratory risks without focusing exclusively on adolescents or distinguishing between sole and dual use.[11]

This shift in tobacco use patterns has prompted research into whether e-cigarettes pose similar, lesser, or greater risks to asthma compared to traditional cigarettes. Preliminary evidence suggests that e-cigarette aerosols may irritate airways and exacerbate asthma symptoms, potentially due to chemical constituents like acrolein and formaldehyde.[12,13] However, studies directly comparing e-cigarettes and traditional cigarettes in adolescents are limited, and findings are inconsistent. For instance, some studies report stronger associations between e-cigarette use and asthma prevalence (AOR=1.10–1.30;),[14] while others find dual use (e-cigarettes and cigarettes) to be the most harmful (AOR=3.64–13.07;).[10] These discrepancies may stem from variations in study design, outcome definitions, or confounding factors like secondhand smoke exposure.[15] Several gaps in the literature warrant a systematic review to clarify and contextualize existing evidence. First, most studies are cross-sectional, limiting causal inferences about the relationship between cigarette type and asthma.[16] Second, few studies provide direct comparisons of e-cigarettes and traditional

cigarettes within the same population, making it difficult to assess relative risks.[17] Third, the role of dual use, which is common among adolescents, remains poorly understood, despite evidence suggesting synergistic harm.[10] Finally, there is a lack of data on asthma severity, device-specific effects (eg, e-cigarette flavors), and vulnerable subgroups, such as ethnic minorities or sexual minority youth.[18] These gaps underscore the need for a comprehensive synthesis of evidence to guide public health policies and clinical recommendations. Another systematic review by Agache et al (2024), which informed EAACI guidelines (European Academy of Allergy and Clinical Immunology), evaluated the impact of tobacco smoke and e-cigarettes on asthma-related outcomes across all ages, For example, Li et al (2022) reported a pooled OR of 1.31 (95% CI: 1.22–1.42) for e-cigarette-associated asthma in adolescents (n=483,948) but did not contrast with traditional cigarettes or examine dual use.[19] Similarly, a recent umbrella review by Golder et al (2025) aggregated evidence from multiple systematic reviews on vaping harms in young people, finding consistent associations with asthma (pooled OR: 1.20–1.36 for diagnosis), yet it lacked adolescent-specific comparisons. Another systematic review by Agache et al (2024), which informed EAACI guidelines (European Academy of Allergy and Clinical Immunology), evaluated the impact of tobacco smoke and e-cigarettes on asthma-related outcomes across all ages, reporting increased risks for both exposures (eg, exacerbations), but was not limited to adolescents and did not quantify relative risks between the two products.[19–21] The main innovation of this review is threefold: (1) restricting the analysis to the adolescent population (12–19 years) to account for the unique vulnerability of this group; (2) conducting a direct comparison of the effects of e-cigarettes, traditional cigarettes, and dual use on three asthma outcomes—diagnosis, exacerbations, and current symptoms—an approach rarely undertaken in general meta-analyses; and (3) emphasizing emerging evidence from longitudinal and population-based studies, which can provide insights into temporality of associations. This structure enables us to compare both short-term warning outcomes (acute harms/exacerbations) and long-term consequences (new asthma diagnoses).[22] This systematic review aims to compare the impact of e-cigarettes and traditional cigarettes on asthma outcomes (diagnosis, exacerbations, and symptoms) in adolescents. By synthesizing data from original quantitative studies published between 2015 and July 2025, this review seeks to clarify the relative risks of each cigarette type, evaluate the effects of dual use, and identify research gaps. The findings will inform tobacco control strategies, regulatory frameworks, and targeted interventions to reduce the asthma burden among adolescents. Beyond its scientific contribution, a separate synthesis of the effects of each product type on adolescents may also have direct policy implications. For instance, if evidence indicates that e-cigarettes—either alone or in combination with conventional cigarettes—increase the risk of asthma exacerbations, this could justify stricter regulations such as flavor bans, age-access restrictions, or targeted interventions for vulnerable groups. While recent years have witnessed declines in adolescent use in some countries, racial/ethnic and gender disparities, along with heightened risks in specific subgroups (eg, sexual minority adolescents or certain racial groups), highlight that broad, population-wide interventions alone are insufficient.[23]

Methods

This systematic review was conducted following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines to ensure transparency and reproducibility.[24] The review protocol was registered in PROSPERO (CRD420251142919) to enhance methodological rigor.[25]

Search Strategy

A systematic search was conducted in PubMed, Scopus, and Web of Science for studies published between January 2015 and July 2025. Search strings were developed using Medical Subject Headings (MeSH) for PubMed and equivalent controlled vocabularies for Scopus and Web of Science, ensuring comprehensive coverage.[26] Keywords and synonyms included terms related to asthma (asthma, asthmatic, bronchial asthma, asthma exacerbation, asthma symptoms), e-cigarettes (electronic cigarettes, vaping, vape pens, ENDS, e-cigs, Vaping devices, E-liquids, Electronic Nicotine Delivery Systems (ENDS), Nicotine vaporizers, Personal vaporizer, E-hookah), cigarette (traditional cigarette, tobacco smoking, Cigarette Smoking, Tobacco Products, Conventional cigarette, Combustible cigarette, Tobacco cigarette, Smoking), and adolescents (Teenagers, Youth, Juvenile, Young people, Minor, Adolescence). Boolean operators (AND, OR) were used to combine terms. Example search string for PubMed: (“asthma” OR “asthmatic” OR “bronchial

asthma" OR "asthma exacerbation" OR "asthma symptoms") AND ("electronic cigarettes" OR "vaping" OR "e-cigs" OR "ENDS") AND ("cigarette smoking" OR "traditional cigarette" OR "tobacco smoking") AND ("adolescents" OR "teenagers" OR "youth"). The search was limited to articles in English. Reference lists of included studies were manually reviewed to identify additional relevant studies.

Inclusion and Exclusion Criteria

Inclusion Criteria

This systematic review included studies that focused on adolescents aged 12–19 years, encompassing terms such as teenagers, youth, or young people. Eligible studies were required to provide data enabling comparison of e-cigarettes and traditional cigarettes—either through direct head-to-head analyses or through separate/separable effect estimates for each exposure type—with asthma-related outcomes in adolescents. Only original quantitative studies, such as cohort, cross-sectional, or clinical trials, published in English between January 2015 and July 2025 were considered.

Exclusion Criteria

Studies were excluded if they focused solely on adults (aged ≥20 years), children under 12 years, or animals, or if they examined only one cigarette type (eg, e-cigarettes or traditional cigarettes) without comparison. Additionally, studies reporting non-asthma outcomes (eg, lung function, bronchitis, or EVALI), those that were reviews, qualitative studies, editorials, protocols, or abstracts without full text, and studies on other substances (eg, marijuana or hookah) that did not analyze e-cigarettes and traditional cigarettes separately were excluded. Studies were also excluded if they examined only one cigarette type without providing data on the other (ie, no direct comparison or separable estimates).

Study Selection

The search identified 427 articles (132 from PubMed, 179 from Scopus, 116 from Web of Science). After removing 188 duplicates, 239 unique articles remained. Of these, 61 were excluded as non-original (eg, reviews, editorials), 4 were outside the 2015–2025 timeframe, and 7 were in languages other than English. The remaining 167 articles were screened against inclusion/exclusion criteria. During title and abstract screening, 92 articles were excluded, primarily due to focusing on non-adolescent populations (eg, adults or children under 12 years), examining only one cigarette type without comparison, or reporting non-asthma outcomes (eg, lung function, bronchitis). In the full-text assessment, an additional 65 articles were excluded, mainly because they were qualitative studies, lacked asthma-related outcomes, or included substances other than e-cigarettes or traditional cigarettes (eg, marijuana, hookah) without separate analyses.[24] Titles and abstracts were independently reviewed by two reviewers, followed by full-text assessment of potentially eligible studies. Discrepancies were resolved through discussion, with a third reviewer consulted when consensus could not be reached.[26] Ultimately, 10 studies met all criteria and were included in the review. The selection process is documented in a PRISMA flow diagram (Figure 1).

Data Extraction

Data were extracted using a standardized form, including study design, population characteristics (eg, sample size, age, location), intervention/comparison details (eg, e-cigarette use, traditional cigarette use, dual use), asthma outcomes (eg, diagnosis, exacerbations, symptoms), results (eg, odds ratios, prevalence ratios), adjusted variables, statistical methods, study quality (Newcastle-Ottawa Scale [NOS] score), limitations, and notes. Data extraction was cross-checked for accuracy, with discrepancies resolved through discussion.[26]

Quality Assessment

The Newcastle-Ottawa Scale (NOS) was used to assess study quality, evaluating selection (eg, representativeness), comparability (eg, confounder adjustment), and outcome (eg, assessment method, follow-up).[27] The NOS was chosen for its validated framework in assessing non-randomized studies, widely used in systematic reviews of observational data.[28] Scores ranged from 0 to 10, with ≥7 indicating high quality. Two reviewers independently assessed quality, with discrepancies resolved through discussion or consultation with a third reviewer (see Supplementary Material and Supplementary Table S1).[26]

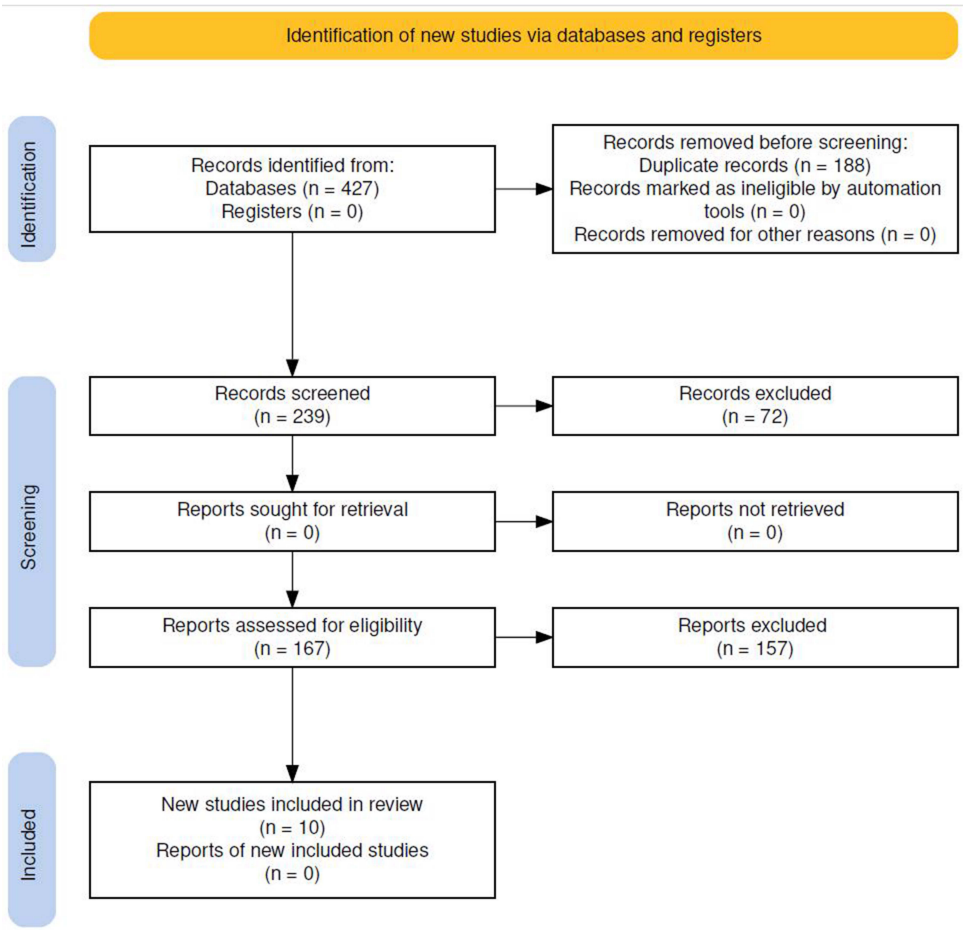


Figure 1 PRISMA flowchart of the study.

Data Synthesis

Due to heterogeneity in study designs (eg, cross-sectional, cohort), outcomes (eg, asthma diagnosis, exacerbations), and statistical measures (eg, AOR, aPR, IRR), a narrative synthesis was performed as meta-analysis was deemed inappropriate due to substantial clinical and methodological variability.[29] Results were organized by asthma outcome (diagnosis, exacerbations, symptoms) and cigarette type (e-cigarette, traditional, dual use). Effect sizes, confidence intervals, and key findings were summarized to compare the relative impact of e-cigarettes and traditional cigarettes.

Statistical Methods and Adjustments in Included Studies

No meta-analysis or additional statistical analyses were performed in this review due to heterogeneity in study designs, outcomes, and effect measures. The following summarizes the statistical approaches and adjustments reported in the included primary studies. Studies employed various statistical methods. Logistic regression was common (Yao et al, 2024; Wills et al, 2020), with some using multinomial logistic regression (Williams et al, 2023) or Poisson regression (Alnajem et al, 2020; Xie et al, 2020 [Population Assessment of Tobacco and Health, PATH]). Adjustments included age, sex, race/ethnicity, household tobacco exposure, and comorbidities (eg, COPD, obesity). Balan et al (2023) adjusted for multiple comorbidities (eg, diabetes, hypertension), while Alanazi et al (2022) included mental health mediators. Xie et al (2020 [Youth Risk Behavioral Surveillance System, YRBS]) lacked adjustments, limiting comparability. Sensitivity analyses (eg, Xie et al, 2020 [PATH]) and survey weights (eg, Williams et al, 2023) enhanced robustness in some studies.

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Results

Following the PRISMA flow diagram (Figure 1), 10 observational studies on adolescent e-cigarette use and asthma outcomes were included after screening 427 articles and excluding duplicates and ineligible studies (see Supplementary Material and Supplementary Table S2).

Study Characteristics

Ten studies (2015–2024), including one prospective cohort and nine cross-sectional studies, were analyzed (Table 1). Sample sizes ranged from 283 to 312,979, focusing on adolescents aged 12–19 years. Eight studies were conducted in the USA using nationally representative surveys (eg, PATH, YRBS), with one each from Kuwait and Sweden. Study quality, assessed via the Newcastle-Ottawa Scale (NOS), ranged from 6 to 8 (moderate to high). Selection scores were generally high (3–4/4) due to representative sampling, but outcome scores were lower (1–2/3) in most studies because of self-reported asthma diagnoses and exposures. Comparability scores (1–2/2) reflected adjustment for confounders like age, sex, race/ethnicity, and household exposures, though some studies (eg, Xie et al, 2020 [YRBS]) lacked adjustment, reducing comparability.

Asthma Outcomes

Asthma Diagnosis

Five studies reported on asthma diagnosis, including lifetime prevalence and incident cases (Table 2). E-cigarette use was consistently associated with increased lifetime asthma prevalence. Williams et al (2023) reported an AOR of 1.10 (95% CI: 1.02–1.18, p<0.01) for e-cigarette-only use,[14] while Wills et al (2020) found an AOR of 1.15 (95% CI: 1.02–1.30, p=0.02) for ever e-cigarette use and 1.30 (95% CI: 1.10–1.53, p=0.002) for current use.[13] Xie et al (2020 [YRBS]) noted higher asthma prevalence among current e-cigarette users (27.2%, 95% CI: 23.0–31.4) versus never users (20.2%, 95% CI: 18.4–22.0; p=0.003).[31] For incident asthma, Xie et al (2020 [PATH]) reported an IRR of 1.24 (95% CI: 1.01–1.53) for ever e-cigarette users, with stronger effects in current users (IRR=1.31, 95% CI: 1.01–1.71).[32] Traditional cigarette use showed inconsistent associations. Yao et al (2024) found a non-significant AOR of 2.23 (95% CI: 0.82–6.09, p=0.12) for sole cigarette/cigar use,[10] while Williams et al (2023) reported a non-significant AOR of 0.80 (95% CI: 0.60–1.05) for

Table 1 Study Characteristics

No.	Study	Design	Sample Size	Country	Survey	NOS Score
1	Yao et al, 2024[10]	Cohort (Models 1–3); Cross-sectional (Model 4)	11,748 (Models 1–2), 9,422 (Model 3), 2,421 (Model 4)	USA	PATH Study	8/9 (High)
2	Williams et al, 2023[14]	Cross-sectional	150,634	USA (California)	CSTS 2019-2020	7/10 (Good)
3	Balan et al, 2023[16]	Retrospective cross-sectional /case-control	312,979	USA	NHANES 2013-2018	7/10
4	Alanazi et al, 2022[17]	Cross-sectional	283	USA (Alabama)	N/A	6/10
5	Veldhuis et al, 2021[18]	Cross-sectional	30,113	USA	YRBS 2015 and 2017	7/10
6	Vasileiadou et al, 2021[30]	Cross-sectional (repeated surveys, 2008 and 2016)	4,627	Sweden	N/A	7/10
7	Xie et al, 2020 (PATH)[31]	Prospective cohort (2013–2018, waves 1–4)	21,618	USA	PATH study	8/10
8	Xie et al, 2020 (YRBS)[32]	Cross-sectional (secondary analysis of YRBSS 2017)	12,747	USA	YRBSS 2017	7/10
9	Wills et al, 2020[13]	Cross-sectional (2017 YRBSS)	12,672	USA	YRBSS 2017	7/10
10	Alnajem et al, 2020[15]	Cross-sectional	1,345	Kuwait	N/A	8/10

Table 2 Asthma Outcomes by Exposure Type

Study	Outcome	Exposure	Effect Size	95% CI	p-value
Yao et al, 2024[10]	New asthma diagnosis (Model 3)	Sole cigarette/cigar	AOR=2.23	0.82–6.09	0.12
Yao et al, 2024[10]	New asthma diagnosis (Model 3)	Sole e-cig	AOR=0.37	0.07–1.87	0.23
Yao et al, 2024[10]	New asthma diagnosis (Model 3)	Dual use	AOR=1.47	0.30–7.16	0.63
Yao et al, 2024[10]	Asthma interference (Model 4, most/all)	Sole cigarette/cigar	AOR=8.49	2.59–27.81	<0.01
Yao et al, 2024[10]	Asthma interference (Model 4, most/all)	Sole e-cig	AOR=1.17	0.26–5.34	0.84
Yao et al, 2024[10]	Asthma interference (Model 4, most/all)	Dual use	AOR=13.07	5.00–34.16	<0.0001
Williams et al, 2023[14]	Lifetime Asthma	E-cig only	AOR=1.10	1.02–1.18	<0.01
Williams et al, 2023[14]	Lifetime Asthma	Cig only	AOR=0.80	0.60–1.05	ns
Williams et al, 2023[14]	Lifetime Asthma	Dual E-cig+Cig	AOR=0.71	0.52–0.96	<0.05
Balan et al, 2023[16]	Asthma exacerbation	Daily cigarette use	AOR=1.12	1.009–1.260	0.025
Balan et al, 2023[16]	Asthma exacerbation	E-cigarette use	AOR=2.13	1.92–2.36	<0.0001
Balan et al, 2023[16]	Asthma exacerbation	Ultra-long cigarettes	AOR=4.85	3.33–7.06	<0.0001
Alanazi et al, 2022[17]	Susceptibility to e-cigarette use	Asthma group vs reference	β=−1.122	−1.743, −0.502	<0.001
Veldhuis et al, 2021[18]	Ever diagnosed with asthma	Inhaled substance use	RRR=1.26–1.74 (sexual minority)	Varies	Varies
Vasileiadou et al, 2021[30]	Current asthma	Cohort 2016 vs 2008	aOR=1.27	1.04–1.53	N/A
Xie et al, 2020 (PATH)[31]	Incident asthma	Ever e-cigarette use	IRR=1.24	1.01–1.53	N/A
Xie et al, 2020 (PATH)[31]	Incident asthma	Current e-cigarette use	IRR=1.31	1.01–1.71	N/A
Xie et al, 2020 (YRBS)[32]	Asthma prevalence	Current ENDs users	27.2%	23.0–31.4	0.003
Wills et al, 2020[13]	Asthma diagnosis	Ever e-cigarette use	AOR=1.15	1.02–1.30	0.02
Wills et al, 2020[13]	Asthma diagnosis	Current e-cigarette use	AOR=1.30	1.10–1.53	0.002
Alnajem et al, 2020[15]	Current wheeze	Current e-cigarette only	aPR=1.54	1.01–2.45	N/A
Alnajem et al, 2020[15]	Current asthma	Dual use	aPR=1.92	1.33–2.76	N/A

cigarette-only use.[14] Dual use (e-cigarettes + cigarettes) was associated with elevated but often non-significant risks (AOR=1.47, 95% CI: 0.30–7.16, p=0.63; Yao et al, 2024). Veldhuis et al (2021) noted inhaled substance use (including cigarettes) increased asthma risk in sexual minority youth (RRR=1.26–1.74), but specific cigarette effects were less clear.[18]

Asthma Exacerbations and Symptoms

Six studies examined asthma exacerbations or symptoms, including current wheeze, asthma attacks, emergency department (ED) visits, and interference in activities (Table 2). E-cigarette use was linked to increased symptoms. Alnajem et al (2020) reported an aPR of 1.54 (95% CI: 1.01–2.45) for current wheeze and 1.85 (95% CI: 1.03–3.41) for current asthma among e-cigarette-only users.[15] Balan et al (2023) found a strong association with exacerbations (AOR=2.13, 95% CI: 1.92–2.36, p<0.0001), particularly in those with higher serum hydroxycotinine levels.[16] Yao et al (2024) reported a non-significant AOR of 1.17 (95% CI: 0.26–5.34, p=0.84) for e-cigarette-only use in asthma interference.[10] Dual use consistently showed the strongest associations. Yao et al (2024) reported AORs of 13.07 (95% CI: 5.00–34.16, p<0.0001) for most/all interference and 3.64 (95% CI: 1.07–12.38, p=0.04) for some interference in dual users, with a significant pairwise comparison (dual vs sole e-cigarette: AOR=11.11, p<0.0001).[10] Alnajem et al (2020) found dual use associated with current wheeze (aPR=1.87, 95% CI: 1.44–2.42), current asthma (aPR=1.92, 95% CI: 1.33–2.76), and

Table 3 Subgroup Differences

Study	Subgroup	Outcome	Effect Size	95% CI	p-value
Xie et al, 2020 (YRBS)[32]	Non-Hispanic Black (NHB) - Current users	Asthma prevalence	38.3%	30.2–46.4	<0.05 (vs NHW)
Xie et al, 2020 (YRBS)[32]	Non-Hispanic White (NHW) - Current users	Asthma prevalence	26.3%	20.7–31.9	N/A
Veldhuis et al, 2021[18]	Lesbian female	Asthma risk	RRR=1.42	1.00–2.02	N/A
Veldhuis et al, 2021[18]	Bisexual female	Asthma risk	RRR=1.26	1.04–1.53	N/A
Veldhuis et al, 2021[18]	Gay males	Asthma risk	RRR=1.74	1.27–2.39	N/A
Veldhuis et al, 2021[18]	Bisexual male	Asthma risk	RRR=1.68	1.19–2.40	N/A
Vasileiadou et al, 2021[30]	Males without allergic rhinitis (AR)	Current asthma	AOR=1.83	1.09–3.07	N/A
Vasileiadou et al, 2021[30]	Male smokers	Current asthma	AOR=3.02	1.12–8.13	N/A

uncontrolled asthma (aPR=1.97, 95% CI: 1.35–2.88).[15] Household secondhand aerosol (SHA) exposure also increased risks, with frequent exposure (≥3 days) linked to current asthma (aPR=1.56, 95% CI: 1.13–2.16) and uncontrolled asthma (aPR=1.88, 95% CI: 1.35–2.62; Alnajem et al, 2020).

Traditional cigarette use had variable effects. Balan et al (2023) reported an AOR of 1.12 (95% CI: 1.009–1.260, p=0.025) for daily cigarette use and 4.85 (95% CI: 3.33–7.06, p<0.0001) for ultra-long cigarettes.[16] Yao et al (2024) found a significant AOR of 8.49 (95% CI: 2.59–27.81, p<0.01) for sole cigarette/cigar use in severe asthma interference, though results were inconsistent across studies.[10]

Ethnic and Sex Differences

Three studies highlighted subgroup differences (Table 3). Xie et al (2020 [YRBS]) found higher asthma prevalence among Non-Hispanic Black (NHB) adolescents using e-cigarettes (38.3%, 95% CI: 30.2–46.4) compared to Non-Hispanic White (NHW; 26.3%, 95% CI: 20.7–31.9; p<0.05).[31] NHB ever-users also had higher prevalence (29.9%, 95% CI: 24.0–35.9) than NHW (21.3%, p<0.01). Veldhuis et al (2021) reported elevated asthma risks in sexual minority youth, particularly lesbian (RRR=1.42, 95% CI: 1.00–2.02) and bisexual females (RRR=1.26, 95% CI: 1.04–1.53), and gay (RRR=1.74, 95% CI: 1.27–2.39) and bisexual males (RRR=1.68, 95% CI: 1.19–2.40), with synthetic marijuana moderating effects in lesbian females (RRR=5.88, 95% CI: 2.10–16.60).[18] Vasileiadou et al (2021) noted stronger asthma associations in males without allergic rhinitis (aOR=1.83, 95% CI: 1.09–3.07) and male smokers (aOR=3.02, 95% CI: 1.12–8.13) in Sweden.[30]

Limitations

All studies relied on self-reported asthma and exposure data, introducing recall bias. Cross-sectional designs (9/10 studies) limited causal inferences. Lack of clinical confirmation (eg, spirometry) was noted in Yao et al (2024) and Balan et al (2023). Small sample sizes (Alanazi et al, 2022; n=283) and low cigarette prevalence (Williams et al, 2023) reduced power. Missing data on asthma severity, e-cigarette device types, or exposure duration/frequency were common (eg, Veldhuis et al, 2021; Vasileiadou et al, 2021). Balan et al (2023) noted no temporality data, and Alnajem et al (2020) lacked medication adherence data. Selection bias (Alanazi et al, 2022) and non-responder bias (Vasileiadou et al, 2021) were additional concerns.

Summary

E-cigarettes and traditional cigarettes were associated with increased asthma diagnosis and exacerbations, with dual use consistently showing the highest risks (AOR up to 13.07; aPR up to 1.97). E-cigarettes had consistent but moderate effects (AOR=1.10–2.13), while traditional cigarettes showed variable impacts. Non-Hispanic Black and sexual minority adolescents were more vulnerable. Methodological limitations, particularly self-reported data and cross-sectional designs,

underscore the need for longitudinal studies with clinical outcomes. These findings are synthesized and interpreted in the following Discussion, with reference to Tables 1–3.

Discussion

Interpretation of Findings

This systematic review reported associations between e-cigarette use, traditional cigarette use, and increased asthma diagnosis and exacerbations among adolescents, with dual use posing the highest risk. E-cigarette use consistently showed moderate associations with asthma prevalence (AOR=1.10–1.30) and exacerbations (AOR=2.13; aPR=1.54–1.85), likely due to airway irritation from aerosolized chemicals like propylene glycol and flavorings.[8] As summarized in Table 2, e-cigarette use showed more consistent associations with asthma outcomes compared to traditional cigarettes, which had mixed findings. Traditional cigarette use had variable effects (AOR=0.80–8.49), possibly reflecting lower prevalence among adolescents or inconsistent reporting. Dual use exhibited the strongest effects, particularly for severe asthma interference (AOR=3.64–13.07; Yao et al, 2024) and uncontrolled asthma (aPR=1.97; Alnajem et al, 2020), suggesting synergistic harm from combined exposure to combustible tobacco and e-cigarette aerosols. The heightened vulnerability of Non-Hispanic Black and sexual minority youth[18,31] may reflect socioeconomic factors, targeted marketing, or stress-related health disparities.

Potential Mechanisms and Alternative Explanations

E-cigarette aerosols contain irritants (propylene glycol, vegetable glycerin, flavorings, acrolein, formaldehyde) that can cause airway inflammation, oxidative stress, and bronchial hyperresponsiveness, key factors in asthma. Traditional cigarettes deliver a wider array of combustion toxins, but their lower prevalence among adolescents may explain weaker associations. Dual use likely causes synergistic harm from combined exposures. Alternative explanations include reverse causation (adolescents with asthma symptoms may prefer e-cigarettes as perceived safer alternatives or for stress coping) and unmeasured confounding (eg, socioeconomic status, mental health issues, poly-substance use). Targeted marketing of flavored products to youth, especially vulnerable subgroups (sexual minority and non-Hispanic Black adolescents), may increase uptake and risk. The predominance of cross-sectional designs (9/10 studies) and self-reported data limits causal inference, with risks of recall and social desirability bias. Longitudinal studies with objective measures (eg, spirometry, biomarkers) are needed to clarify mechanisms and rule out confounders.

Comparison with Previous Literature

These findings align with prior studies linking e-cigarette use to respiratory outcomes. Bhatta and Glantz (2020) reported associations between e-cigarette use and chronic respiratory disease (AOR=1.29–1.39), though their study included adults.[12] The consistent e-cigarette-asthma link in adolescents[13,14] contrasts with the variable effects of traditional cigarettes, possibly due to declining smoking rates.[4] Dual use's stronger effects corroborate evidence of combined harm from multiple nicotine sources,[10] similar to findings in adult populations.[5] The elevated risks in ethnic and sexual minority groups echo studies on health disparities in tobacco use (CDC, 2023; Veldhuis et al, 2021), highlighting the need for targeted interventions. However, unlike some studies reporting stronger traditional cigarette effects,[5] this review found e-cigarettes equally or more impactful in adolescents, likely due to their higher prevalence.

Strengths of the Review

This review's strengths include a comprehensive search across PubMed, Scopus, and Web of Science (427 articles screened), ensuring broad coverage. Strict inclusion criteria focusing on adolescents, asthma outcomes, and quantitative studies enhanced specificity. The Newcastle-Ottawa Scale (scores 6–8/10) confirmed study reliability. Narrative synthesis accommodated heterogeneity in designs and outcomes, enabling nuanced comparisons of e-cigarette and traditional cigarette effects. Inclusion of diverse populations and subgroup analyses strengthened the findings.

Limitations of the Review

Several limitations must be acknowledged. Most studies (9/10) were cross-sectional, precluding causal inferences. Self-reported asthma and exposure data introduced recall bias, and lack of clinical confirmation (eg, spirometry) limited outcome validity.[10,16] Heterogeneity in outcome definitions (eg, wheeze vs exacerbations) and statistical measures (AOR, aPR, IRR) prevented meta-analysis. Some studies had small samples[33] or low cigarette prevalence,[14] reducing power. The review's restriction to English articles and exclusion of gray literature (eg, unpublished reports, theses, conference abstracts, and non-peer-reviewed sources) may have missed relevant studies. Finally, limited data on asthma severity, e-cigarette device types, or exposure duration hindered comprehensive risk assessment. These limitations have direct implications for future research. Longitudinal cohort studies with objective clinical measures (eg, spirometry, bronchial challenge tests) and biomarkers of exposure (eg, cotinine levels) are needed to establish temporality and causality. Standardized reporting of exposure characteristics (duration, frequency, device type, nicotine concentration, and flavor use) would enable dose-response analyses and identification of higher-risk products. Larger, nationally representative samples with stratified designs should examine direct head-to-head comparisons and disparities in vulnerable subgroups. Finally, multilingual searches and inclusion of gray literature in future reviews would enhance comprehensiveness and reduce potential publication bias.[34,35]

Implications for Policy and Practice

These findings underscore the need for robust tobacco control policies targeting both e-cigarettes and traditional cigarettes. Regulatory measures, such as banning flavored e-cigarettes and enforcing age restrictions, could curb adolescent use.[7] Public health campaigns should educate youth about the respiratory risks of both cigarette types, emphasizing dual use's amplified harm. School-based interventions and screening for asthma in high-risk groups (eg, Non-Hispanic Black, sexual minority youth) could mitigate exacerbations. Clinicians should assess e-cigarette and cigarette use in adolescents with asthma, integrating cessation support into management plans. Clinicians should assess e-cigarette and cigarette use in adolescents with asthma, integrating cessation support into management plans.

Future Research Directions

Longitudinal studies are critical to establish causality and assess temporality between cigarette use and asthma outcomes. Clinical outcomes (eg, spirometry, exacerbation rates) should complement self-reported data to enhance validity. Research should explore device-specific effects (eg, e-cigarette flavors, nicotine levels) and exposure duration/frequency. Studies on asthma severity and medication adherence in users are needed. Finally, investigating social determinants (eg, marketing, socioeconomic status) in vulnerable subgroups could inform equitable interventions.

Conclusion

This systematic review demonstrates that both e-cigarettes and traditional cigarettes contribute to asthma diagnosis and exacerbations in adolescents, with dual use posing the greatest risk (AOR up to 13.07; aPR up to 1.97). E-cigarettes showed consistent associations with asthma prevalence and symptoms, while traditional cigarettes had variable effects, likely due to lower prevalence. However, these findings must be interpreted with caution due to key methodological limitations. The predominance of cross-sectional designs (9/10 studies) and reliance on self-reported data limit causal inference and raise risks of recall bias, reverse causation, and unmeasured confounding. Heterogeneity in outcomes/measures and limited direct comparisons/subgroup analyses constrain conclusions on relative risks and disparities. While patterns suggest higher risks with e-cigarette use, especially dual use, longitudinal studies with objective measures are needed for confirmation. Non-Hispanic Black and sexual minority youth were particularly vulnerable, highlighting disparities in tobacco-related harm. These findings underscore the urgent need for stringent regulations, such as flavor bans and age restrictions, to curb adolescent use of both cigarette types. Public health campaigns and clinical interventions should prioritize education and cessation support, especially for high-risk groups. The reliance on cross-sectional, self-reported data limits causal inferences, necessitating longitudinal studies with clinical outcomes (eg, spirometry, exacerbation rates) to clarify the long-term impacts of e-cigarettes and dual use. Research on device-specific effects,

asthma severity, and social determinants is also critical. While e-cigarette use demonstrated more consistent associations with adverse asthma outcomes than traditional cigarette use, these findings must be interpreted with caution due to methodological limitations, particularly the reliance on cross-sectional designs and self-reported data. By addressing these gaps, policymakers and researchers can better mitigate the asthma burden among adolescents and protect respiratory health in this vulnerable population.

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