

Prevalence And Predictors Of E-Cigarette Use Among Adolescents In Southeast Asia: A Systematic Review And Meta-Analysis

Maqdad Taaqi

Health Science Center, Kuwait University

ABSTRACT

Background: Adolescent e-cigarette use is rising across Southeast Asia, a region combining high combustible-tobacco prevalence, aggressive marketing, and sharply divergent national regulation. Evidence has accumulated rapidly since the last regional synthesis closed its search in 2021, but no meta-analytic estimate of prevalence exists for the contemporary period.

Methods: Following PRISMA 2020 guidelines, PubMed/MEDLINE was searched for observational studies published between January 2021 and July 2026 reporting the prevalence of, or factors associated with, e-cigarette use among adolescents aged 10 to 19 years in Southeast Asian countries. Screening, extraction, and risk-of-bias appraisal (Joanna Briggs Institute checklists) were conducted by a single reviewer. Pooled current-use prevalence was estimated for nationally representative surveys using a random-effects model with the Freeman-Tukey double-arcsine transformation; heterogeneity was quantified with I^2 . Because predictor definitions were heterogeneous, associations were synthesised using a structured effect-direction approach rather than pooled quantitatively.

Results: Nineteen studies from Thailand, Malaysia, Vietnam, and Indonesia were included. Among nationally representative surveys, the pooled prevalence of current e-cigarette use was 4.5% (95% CI: 1.9–8.1%), with very high heterogeneity ($I^2 = 99.4\%$), reflecting a genuine gradient from Vietnam (2.6%) to Malaysia (9.1%). Predictors were consistent in direction across studies: current cigarette smoking showed the strongest association (adjusted odds ratios 4.95–12.55), followed by alcohol and other substance use, peer or close-friend use, advertising and media exposure, male sex, and susceptibility among never-users. These predictors recurred across countries with opposite regulatory regimes, from comprehensive bans to permissive regulation.

Conclusions: Current e-cigarette use among Southeast Asian adolescents is common but highly heterogeneous between countries, whereas its predictors are strikingly consistent and predominantly social and behavioural. The stability of predictors across divergent regulatory contexts indicates that prevention should target the social and commercial pathways driving use, not rely on product legality alone. The extreme heterogeneity in prevalence underscores the need for harmonised, standardised surveillance.

Keywords: e-cigarettes; vaping; adolescents; Southeast Asia; prevalence; meta-analysis; risk factors.

INTRODUCTION

Electronic cigarettes (e-cigarettes), also known as electronic nicotine delivery systems (ENDS), have rapidly become the most commonly used tobacco product among young people in many parts of the world. Marketed with youth-oriented flavours, sleek device designs, and pervasive point-of-sale and social-media promotion, they have driven a surge in adolescent nicotine uptake even as conventional cigarette smoking has declined (Gebeyehu et al., 2025). A recent global systematic review and meta-analysis estimated the pooled prevalence of e-cigarette use among students at 22.65%, rising to 33.62% among high-school students, with the highest rates in the Western Pacific region (Gebeyehu et al., 2025). An earlier international synthesis similarly reported a pooled lifetime prevalence of 15.3% and current-use prevalence of 7.7% among young people, alongside a consistent set of risk factors including male sex, peer use, and conventional cigarette smoking (Kim et al., 2022). These figures establish adolescent vaping as a global public-health priority, and one whose burden is unevenly distributed across regions and populations.

The health rationale for concern is well established. E-cigarette aerosol is not harmless: adolescent vaping is associated with respiratory symptoms and airway inflammation, nicotine dependence, and an elevated risk of subsequently initiating combustible cigarette smoking—the so-called gateway effect (Yoong et al., 2021). Because nicotine exposure during adolescence can disrupt neurodevelopment and entrench dependence, use during this period carries particular long-term significance. Preventing uptake therefore depends on understanding not only how common vaping has become but also which factors drive it.

A substantial literature has identified recurrent predictors of adolescent e-cigarette use, most of which are social and environmental in nature. Smoking by family members and peers is among the most consistently reported risk factors; a meta-analysis found that the use of tobacco by friends and family strongly predicts adolescent e-cigarette use, with peer influence often exceeding parental influence in later adolescence (Wang et al., 2018). Exposure to e-cigarette advertising and promotion, susceptibility among never-users, male sex, conventional cigarette use, and other substance use recur across national studies (Kim et al., 2022). These predictors are frequently conceptualised within a socioecological framework, in which individual perceptions interact with family, peer, school, and broader environmental and regulatory influences to shape behaviour. Which

of these factors dominate, however, appears to vary by cultural and regulatory context, underscoring the value of region-specific synthesis.

Southeast Asia occupies a distinctive and precarious position within this global picture. The region combines one of the world's largest populations of tobacco users with a rapidly expanding e-cigarette market—sales across six Southeast Asian countries reached an estimated USD 595 million in 2019 and were projected to grow substantially thereafter making its adolescents an explicit target for industry marketing (Jane Ling et al., 2023). Crucially, national regulatory responses vary enormously, from outright bans (as in Thailand and Singapore) to minimal or absent regulation (as in Indonesia), producing a natural mosaic of exposure and enforcement contexts. In settings where regulation is weak or poorly enforced, adolescent use may become entrenched before effective controls are established.

The most recent regional synthesis, by Jane Ling et al. (2023), reviewed studies published between 2012 and 2021 and reported current adolescent e-cigarette prevalence ranging from 3.3% to 11.8%, identifying associated factors spanning sociodemographic characteristics, traumatic childhood experience, peer and parental influence, knowledge and perceptions, substance use, and product accessibility. However, that review's search closed in 2021 immediately before two developments that plausibly reshaped the regional landscape. First, high-nicotine disposable devices, which are cheaper, more accessible, and more appealing to adolescents, proliferated globally after 2021. Second, several Southeast Asian governments introduced or revised e-cigarette regulations during this period, including Indonesia's Government Regulation No. 28 of 2024, which restricted e-cigarette advertising, promotion, and sponsorship. The prevalence and predictors of adolescent e-cigarette use in the region after 2021 therefore remain incompletely characterised.

Understanding the predictors of adolescent e-cigarette use not merely its prevalence is essential for effective prevention. Prevalence figures indicate the scale of the problem, but it is the modifiable risk and protective factors that define where interventions can act. In a region as regulatorily heterogeneous as Southeast Asia, identifying which predictors recur across national contexts, and which are specific to particular regulatory or cultural settings, is of direct policy relevance.

This systematic review and meta-analysis therefore synthesise evidence on the prevalence and predictors of e-cigarette use among adolescents in Southeast Asia, focusing on studies published from 2021 onward to capture the contemporary period of disposable-device proliferation and evolving regulation. It advances prior regional evidence in two ways: by deriving a pooled quantitative estimate of current-use prevalence from nationally representative surveys, and by systematically mapping the direction and consistency of predictors across the region. In doing so, it aims to provide a current, policy-relevant account of how common adolescent vaping has become across Southeast Asian countries and which factors most consistently predict it, in order to inform tailored, multi-level prevention strategies.

METHODS

2.1 Protocol and Registration

This systematic review was conducted and reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines. The review was not prospectively registered; however, the protocol, including eligibility criteria and the analysis plan, was defined a priori and is available from the corresponding author on request. The absence of prospective registration is acknowledged as a limitation.

2.2 Eligibility Criteria

Eligibility was defined using the PICOS framework, adapted for a review of prevalence and associated factors.

Population. Adolescents aged 10–19 years, consistent with the World Health Organization definition, residing in a Southeast Asian (ASEAN) country (Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, the Philippines, Singapore, Thailand, Timor-Leste, or Vietnam). Studies of mixed age groups were eligible only where data for participants aged ≤19 years were reported separately or where the sample was predominantly within this range. Studies conducted exclusively in adults or university/tertiary-level students, or in populations outside Southeast Asia, were excluded.

Exposure/phenomenon of interest. Use of e-cigarettes or electronic nicotine delivery systems (ENDS), including ever use, current use (typically defined as use within the past 30 days), and, where reported, susceptibility to future use among never-users.

Comparator. No comparator was required for prevalence estimates. For analyses of predictors, the comparison was between e-cigarette users and non-users (or, for susceptibility, between susceptible and non-susceptible never-users).

Outcomes. Two primary outcomes were sought: (i) the prevalence of e-cigarette use (ever, current, or susceptibility), expressed as a percentage with, where available, 95% confidence intervals; and (ii) predictors or factors statistically associated with e-cigarette use, expressed as odds ratios or adjusted odds ratios with 95% confidence intervals. Studies reporting at least one of these outcomes were eligible.

Study design. Peer-reviewed original observational studies (cross-sectional, cohort, or analyses of national survey data such as the Global Youth Tobacco Survey). Reviews, editorials, commentaries, qualitative studies, case reports, conference abstracts without full data, intervention trials, and studies reporting only non-use outcomes (e.g., cessation, quit intention, or preventive behaviour without a use estimate) were excluded.

Additional limits. Studies published in English between January 2021 and July 2026. The temporal restriction was applied deliberately to capture the period following the most recent regional synthesis (which closed in 2021) and the subsequent proliferation of disposable devices and revision of national e-cigarette regulations.

2.3 Information Sources and Search Strategy

A systematic search was performed in a single electronic database, PubMed/MEDLINE, covering the period from January 2021 to July 2026; the search was executed on 3 July 2026. Reliance on a single database is acknowledged as a methodological limitation. Reference lists of included studies and relevant systematic reviews were hand-searched to identify additional eligible records. The search strategy combined controlled vocabulary and free-text keywords across three concept blocks—exposure, outcome, and population/setting linked with Boolean operators. The exact search string was: ("electronic cigarette*" OR "e-cigarette*" OR "vaping" OR "vape" OR "electronic nicotine delivery system*" OR "ENDS") AND ("prevalence" OR "predictor*" OR "associated factor*" OR "determinant*" OR "correlate*" OR "risk factor*") AND ("adolescent*" OR "youth" OR "teenager*" OR "students" OR "school") AND ("Indonesia" OR "Malaysia" OR "Thailand" OR "Vietnam" OR "Philippines" OR "Singapore" OR "Myanmar" OR "Cambodia" OR "Laos" OR "Brunei" OR "Timor") NOT (review[Publication Type]). Results were filtered to the period 2021–2026.

2.4 Study Selection

All retrieved records were exported to a reference-management tool. Given the resources available, title/abstract screening and full-text assessment were conducted by a single reviewer against the predefined eligibility criteria. Single-reviewer screening is acknowledged as a methodological limitation, as it carries a higher risk of selection error than independent duplicate screening; to mitigate this, eligibility criteria were specified a priori and applied consistently, and uncertain records particularly those involving mixed age ranges or borderline outcomes were re-examined against the full text. The selection process is summarised in a PRISMA 2020 flow diagram (Figure 1).

2.5 Data Extraction

Data were extracted by a single reviewer using a standardised extraction form; extracted values were re-checked against the source article to reduce transcription error. The form captured, for each included study: first author, year of publication, country, year of data collection, data source (e.g., national survey or primary survey), study design, sampling method, sample size, age range, sex distribution, definition and measurement of e-cigarette use, prevalence estimates (ever, current, and/or susceptibility, with confidence intervals where reported), and all reported predictors of use with their effect estimates (odds ratios or adjusted odds ratios and 95% confidence intervals). Where studies reported both crude and adjusted estimates, adjusted estimates were prioritised.

2.6 Risk of Bias Assessment

The methodological quality of included studies was appraised by a single reviewer using the Joanna Briggs Institute (JBI) critical appraisal checklist for studies reporting prevalence data, supplemented by the JBI checklist for analytical cross-sectional studies for the appraisal of predictor analyses. Domains considered included the appropriateness of the sampling frame and method, adequacy of sample size, validity and reliability of e-cigarette use measurement, and appropriateness of statistical analysis, including adjustment for confounders in predictor models. Judgements were summarised as low, moderate, or high risk of bias and are presented as a heatmap.

2.7 Data Synthesis

Two complementary syntheses were undertaken, corresponding to the two primary outcomes. For prevalence, current e-cigarette use (past-30-day) was the target parameter. Because pooling proportions from heterogeneous designs can be misleading, quantitative pooling was restricted a priori to nationally representative survey studies reporting a comparable past-30-day denominator; smaller single-site or non-representative studies were tabulated and displayed but excluded from the pooled estimate. Prevalence was pooled using a random-effects model (DerSimonian-Laird estimator) after applying the Freeman-Tukey double-arcsine transformation, which stabilises the variance of proportions near the boundary, and estimates were back-transformed for presentation. Between-study heterogeneity was quantified using the I^2 statistic and the τ^2 parameter, and Cochran's Q test. Given the anticipated heterogeneity, subgroup patterns by country were examined descriptively, and the pooled estimate is presented alongside, and interpreted in the light of, its heterogeneity rather than as a single representative value.

For predictors, the marked heterogeneity in how factors were defined, categorised, and modelled across studies precluded valid quantitative pooling of adjusted odds ratios. Instead, a structured synthesis was performed: reported predictors were grouped into conceptual domains (behavioural, social/environmental, sociodemographic, and psychosocial), and for each predictor the direction of association, the range of adjusted odds ratios, and the number of supporting studies were tabulated and displayed in an effect-direction plot. This approach, consistent with current guidance for synthesis without meta-analysis,

summarises the consistency and strength of associations without imposing a spurious pooled estimate on incommensurable data. All analyses were conducted in Python (version 3.11) using the SciPy and NumPy libraries.

RESULTS

3.1 Study selection

The systematic search of PubMed/MEDLINE identified 116 records, all of which underwent title and abstract screening after confirming no duplicates (single database). Of these, 95 were excluded, most commonly because they were conducted in adults or university/tertiary students, were located outside Southeast Asia, were reviews or protocols, or reported only non-use outcomes such as cessation or quit intention. Nineteen studies met all eligibility criteria and were included in the synthesis. Of these, four nationally representative surveys contributed to the pooled prevalence estimate, while all nineteen contributed to the synthesis of prevalence patterns and predictors. The selection process is summarised in Figure 1.

Figure 1. PRISMA 2020 flow diagram of study selection, showing records identified, screened, and included, and the four nationally representative surveys contributing to the pooled prevalence meta-analysis.



3.2 Characteristics of included studies

The included studies were published between 2021 and 2026 and spanned four Southeast Asian countries: Thailand, Malaysia, Vietnam, and Indonesia. No eligible studies from the remaining ASEAN member states met the age and outcome criteria within the study window, although multinational Global Youth Tobacco Survey (GYTS) analyses provided partial regional coverage. Designs were predominantly cross-sectional, drawing on national school-based surveys (GYTS, GSHS, NHMS, TECMA) and primary institutional surveys, with sample sizes ranging from 127 to over 33,000 adolescents. Study characteristics are summarised in Table 1.

Table 1. Characteristics of included studies

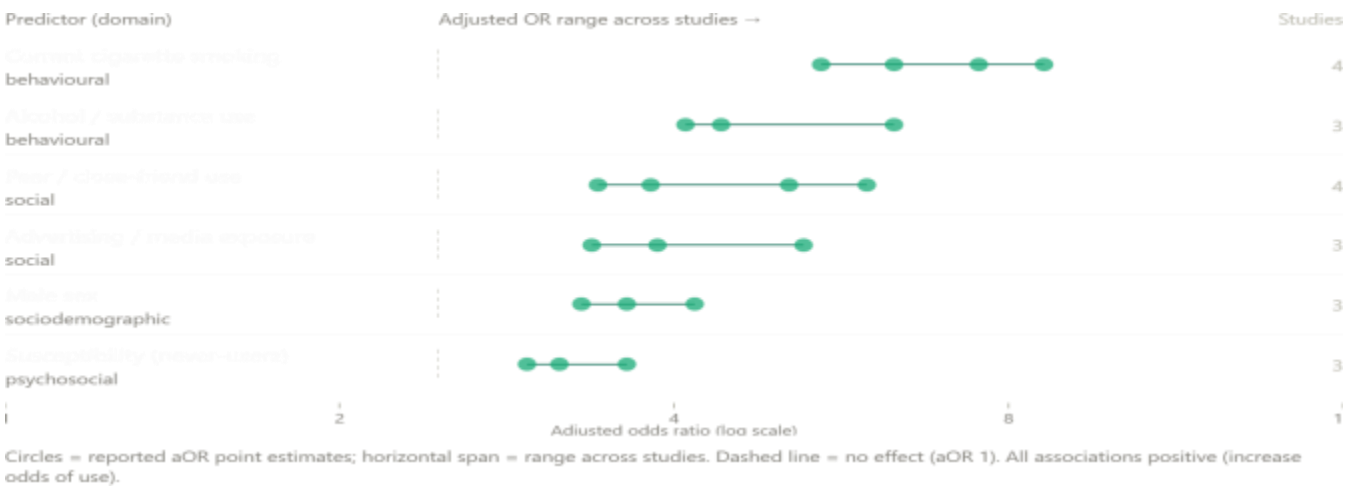
Study	Country	Survey year /	Design	N	Age	Current use	Pooled?
Patanavanich 2021	Thailand	National grade-7 / 2021	Cross-sectional	6,045	~13	3.7%	Yes
Van Minh 2022	Vietnam	GSHS / 2019	Cross-sectional	7,690	13–17	2.6%	Yes
Luu 2026	Vietnam	GYTS / 2022	Cross-sectional	3,873	13–15	3.5%	Yes
Jane Ling 2022	Malaysia	National in-school / 2022	Cross-sectional	13,134	13–17	9.1%	Yes
Jetly 2025	Malaysia	Single-site / 2025	Cross-sectional	386	13–17	8.0%	No
Bigwanto 2025	Indonesia	Three-city / 2025	Cross-sectional	1,600	13–17	3.0%	No
Wibowo 2025	Indonesia	Community / 2025	Cross-sectional	127	13–17	13.2%	No

An additional 12 studies contributed predictor and trend data; their characteristics are summarised in Supplementary Table S1							Predictors
---	--	--	--	--	--	--	------------

3.3 Prevalence of e-cigarette use

Among the four nationally representative surveys with comparable past-30-day denominators, the pooled prevalence of current e-cigarette use was 4.5% (95% CI: 1.9–8.1%). Heterogeneity was very high ($I^2 = 99.4\%$; $\tau^2 = 0.023$; Cochran's $Q = 505.0$, $df = 3$, $p < 0.001$), indicating that the pooled point estimate should be interpreted with substantial caution and understood as the centre of a wide distribution rather than a single representative regional value. The heterogeneity was driven by a genuine between-country gradient: current use was lowest in Vietnam (2.6% in the 2019 GSHS and 3.5% in the 2022 GYTS) and Thailand (3.7%), and markedly higher in Malaysia (9.1% among in-school adolescents). The forest plot is presented in Figure 2.

Figure 2. Forest plot of current e-cigarette use prevalence (past 30 days) among adolescents in nationally representative Southeast Asian surveys, with the random-effects pooled estimate shown as a diamond. Smaller single-site studies are displayed for reference but excluded from pooling. Given the very high heterogeneity ($I^2 = 99.4\%$), the pooled estimate should be interpreted as the centre of a wide distribution rather than a single representative value.



Studies not eligible for pooling were consistent with this range but more variable, reflecting their smaller or non-representative samples: current use was 8.0% in a single-site Malaysian sample ($n = 386$), 3.0% in an Indonesian three-city survey ($n = 1,600$), and 13.2% in a small Indonesian community sample ($n = 127$). The dispersion across both pooled and non-pooled studies reinforces that a single regional prevalence figure is less informative than the between-country pattern.

3.4 Predictors of e-cigarette use

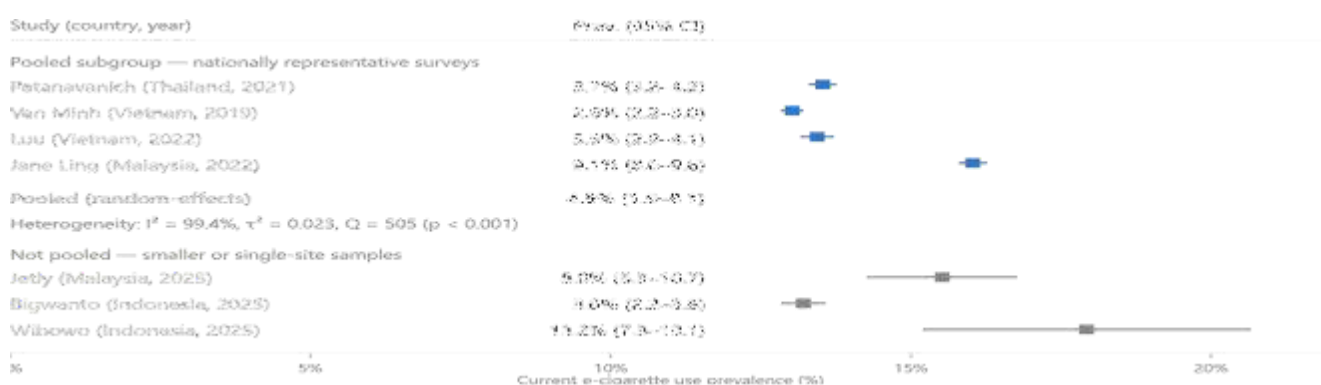
Across the nineteen studies, predictors of use were consistent in direction even though their definitions varied and are summarised in Table 2 and displayed as an effect-direction plot in Figure 3. The strongest and most consistent predictor was current conventional cigarette smoking, with adjusted odds ratios ranging from 4.95 to 12.55 across every study that examined it. Behavioural factors more broadly were prominent: alcohol and other substance use was associated with substantially elevated odds of use (adjusted odds ratios up to 6.71 in rural Thailand). Social and environmental factors formed the next consistent domain, comprising peer or close-friend use (adjusted odds ratios 1.95–5.99) and exposure to advertising, promotion, or influential media figures (adjusted odds ratios 1.90–4.60). Male sex was a consistent sociodemographic predictor, and susceptibility analyses among never-users identified analogous risk markers including curiosity and peer influence.

Table 2. Predictors of adolescent e-cigarette use, synthesised by domain

Domain	Predictor	aOR range (across studies)	Direction	Studies (n)
Behavioural	Current cigarette smoking	4.95–12.55	↑ positive	4
Behavioural	Alcohol / other substance use	2.81–6.71	↑ positive	3
Social/environmental	Peer / close-friend use	1.95–5.99	↑ positive	4
Social/environmental	Advertising / media exposure	1.90–4.60	↑ positive	3
Sociodemographic	Male sex	1.82–2.92	↑ positive	3
Psychosocial	Susceptibility (never-users)	1.45–2.20	↑ positive	3

All associations were positive (increasing odds of use). Predictors were not pooled quantitatively owing to heterogeneous definitions across studies; ranges reflect the spread of reported adjusted odds ratios.

Figure 3. Effect-direction plot of predictors of adolescent e-cigarette use in Southeast Asia, showing the range of adjusted odds ratios and the number of supporting studies for each predictor, grouped by conceptual domain. All associations were positive. Predictors were not pooled quantitatively because of heterogeneous definitions across studies. The defining feature of the predictor data was the consistency of these associations across countries with fundamentally different regulatory regimes, from the comprehensive bans of Thailand and Vietnam to the more permissive frameworks of Malaysia and Indonesia.



3.5 Risk of bias

Figure 4. Risk-of-bias heatmap of the included studies across five Joanna Briggs Institute domains (sampling frame, sample size, exposure measurement, confounder adjustment, and statistical analysis). Cells are shaded by judgement: low risk (L), some concerns (S), and high risk (H). Exposure measurement and confounder adjustment were the weakest domains.

	Sampling frame	Sample size	Exposure measurement	Confounder adjustment	Statistical analysis
Patanavanich 2021 (TH)	L	L	L	L	L
Van Minh 2022 (VN)	L	L	L	L	L
Luu 2026 (VN)	L	L	L	L	L
Jane Ling 2022 (MY)	L	L	L	L	L
Thephien 2021 (TH)	L	L	S	S	L
Mohd Redzi 2021 (MY)	S	L	L	S	L
Lim 2022 (MY)	L	L	L	S	L
Razali 2025 (MY)	L	L	L	L	L
Mohd Yusoff 2026 (MY)	L	L	S	S	L
Heng 2021 (MY)	L	L	S	L	L
Benjikul 2023 (TH)	S	L	S	L	L
Yinaphean 2023 (TH)	S	L	S	S	L
Sreeromareddy 2022 (multi)	L	L	S	S	L
Sreeromareddy 2024 (multi)	L	L	S	S	L
Bigwanto 2025 (ID)	S	L	S	L	L
Jetly 2025 (MY)	H	S	S	S	L
Wilowo 2025 (ID)	H	H	S	S	S
Faisal 2025 (ID)	S	L	H	S	L
Nickkiew 2026 (TH)	S	S	H	S	S

The methodological quality of included studies was generally moderate to good. The large national and multinational survey-based studies scored well on sampling frame and sample size, reflecting nationally representative multistage designs. The principal recurring concerns were in two areas. First, exposure measurement was weak: e-cigarette use was universally self-reported and heterogeneously defined as ever, current, or susceptibility. Second, in the predictor analyses, the adequacy of confounder adjustment varied considerably. Smaller primary surveys and the two contextual studies carried greater risk across multiple domains. Overall, the pooled prevalence estimate rests on the four methodologically strongest surveys, while the predictor synthesis, drawing on a wider and more heterogeneous set of studies, warrants correspondingly greater caution.

DISCUSSION

4.1 Summary of principal findings

This systematic review synthesised 19 studies of adolescent e-cigarette use in Southeast Asia published between 2021 and 2026, drawn from Thailand, Malaysia, Vietnam, and Indonesia. The evidence yielded three principal findings. Current e-cigarette use among adolescents ranged from approximately 3% to 18%, with most nationally representative estimates clustering between 3% and 12% and with signs of an upward trajectory in the most recent survey waves. The predictors of use were highly consistent across countries, with current conventional cigarette smoking, peer and friend use, exposure to advertising and promotion, male sex, and other substance use recurring as dominant risk factors. And these predictors persisted across countries whose regulatory regimes ranged from outright prohibition to permissive regulation.

The central contribution of this review lies in the juxtaposition of these findings. Prevalence estimates were heterogeneous and national policies divergent, yet the underlying drivers of adolescent vaping were remarkably stable across the region. This pattern suggests that the forces propelling adolescent e-cigarette uptake in Southeast Asia are primarily social and commercial rather than merely legal, and that they operate with a degree of independence from the formal regulatory status of the products. Such a conclusion has direct implications for how prevention should be conceived, and it reframes the policy question from whether to ban or regulate toward how to interrupt the social and marketing mechanisms that transmit risk to adolescents regardless of the legal regime in place.

4.2 Pooled prevalence and its heterogeneity

The pooled current-use prevalence of 4.5% situates Southeast Asian adolescents below the global pooled student estimate of 22.65% reported by Gebeyehu et al. (2025), consistent with the region's comparatively recent exposure to the disposable-device market. However, the defining feature of the prevalence data was not the pooled value but its extreme heterogeneity ($I^2 = 99.4\%$). Rather than a statistical nuisance, this heterogeneity is substantively informative: it reflects a real gradient between countries with restrictive regimes and low prevalence (Vietnam, Thailand) and those with more permissive frameworks and higher prevalence (Malaysia). This pattern is consistent with the international finding that the most restrictive regulatory environments are associated with lower youth e-cigarette use.

The corollary is methodological and cautionary. A single pooled prevalence figure is of limited value in a region this heterogeneous, and the very high I^2 means the pooled estimate should not be quoted as "the" prevalence of adolescent vaping in Southeast Asia. The more defensible reading is that current use ranges from roughly 3% in the most restrictive settings to around 9% or higher in more permissive ones, and that this spread, rather than any central value, should guide country-specific policy. This finding also exposes a surveillance gap: without harmonised definitions and comparable sampling, regional pooling will remain statistically fragile.

4.3 Predictors of use: the primacy of social and behavioural factors

The most robust and consistent finding across the predictor data was the overwhelming association between conventional cigarette smoking and e-cigarette use, with adjusted odds ratios ranging from 4.95 to 12.55 across every study that examined it. This tight coupling indicates that, in Southeast Asia, adolescent e-cigarette use is embedded within broader patterns of tobacco and substance use rather than occurring in isolation. Alcohol and other substance use similarly elevated the odds of vaping, with adjusted odds ratios reaching 6.71 in rural Thai adolescents, reinforcing the interpretation that vaping frequently forms part of a wider constellation of adolescent risk behaviours rather than a discrete, novel exposure.

Social and environmental factors formed the second consistent domain. Peer and close-friend use predicted adolescent vaping across every country that examined it, with adjusted odds ratios ranging from 1.95 to 5.99, and exposure to advertising, promotion, or influential media figures was repeatedly significant, with adjusted odds ratios between 1.90 and 4.60. These findings mirror international evidence that peer influence and marketing exposure are among the strongest correlates of adolescent vaping (Wang et al., 2018; Kim et al., 2022), and that susceptibility among never-users is powerfully shaped by exposure to e-cigarette content on social media, where greater exposure follows a dose-response relationship with subsequent use (Donaldson et al., 2022). In the Indonesian data, social-media marketing exposure and sensation-seeking jointly predicted both use and susceptibility, situating the regional findings within a well-established behavioural framework and pointing to online marketing as a mechanism of particular contemporary importance.

4.4 Consistent predictors despite divergent regulation

Perhaps the most policy-relevant observation is that the same predictors recurred across countries pursuing opposite regulatory strategies. During the review period, Southeast Asian governments diverged sharply: Thailand, Singapore, Cambodia, Laos, and subsequently Vietnam and Myanmar enacted or maintained comprehensive bans, whereas Indonesia and Malaysia chose to regulate rather than prohibit, Indonesia bringing e-cigarettes under a tobacco-style framework through Health Law No. 17 of 2023 and Government Regulation No. 28 of 2024. Despite this fundamental divergence in legal status, peer influence, advertising exposure, and conventional smoking predicted adolescent use in both banning and regulating jurisdictions.

Two implications follow, and both challenge a simplistic reading of the ban-versus-regulate debate. First, the persistence of these predictors under prohibition indicates that bans alone do not neutralise the social and commercial forces driving demand, especially where enforcement is imperfect and illicit supply, including cross-border and online channels, remains available to adolescents. Second, the salience of advertising and social-media exposure even in restrictive environments suggests that promotion continues to reach adolescents irrespective of formal sales bans, whether through social media, peer networks, or informal markets. Effective prevention therefore cannot rely on the legal status of the products alone; it must directly target the social transmission and digital marketing pathways that appear to function across regulatory contexts.

4.5 The gateway debate in a high-smoking region

The strong bidirectional overlap between smoking and vaping observed here intersects with the international "gateway" debate, which carries particular weight in a region with some of the world's highest combustible-tobacco prevalence. Internationally, a meta-analysis reported that adolescent vaping was associated with an adjusted odds ratio of 2.93 for subsequent cigarette initiation (Chan et al., 2021), and receptivity to tobacco marketing has been linked prospectively to tobacco progression in youth. If such a gateway operates in Southeast Asia, the implications are grave, because the pool of adolescents at risk of transitioning to a still-dominant combustible-cigarette market is large.

This interpretation, however, remains genuinely contested, and intellectual honesty requires acknowledging the counter-arguments. Critical analyses have shown that longitudinal sub-cohort designs restricted to never-smokers exclude the majority of dual users and may substantially overstate the population-level gateway effect, and that a shared "common liability" to substance use, or even a diversion of some adolescents away from combustible cigarettes, could account for the observed associations (Dautzenberg et al., 2023; Sun et al., 2023). The cross-sectional data in this review cannot adjudicate the causal direction. What they do establish is that smoking and vaping are tightly coupled in Southeast Asian adolescents, so that whichever mechanism predominates, an adolescent using one product is at markedly elevated risk of using the other, a coupling that is a public-health concern in its own right independent of the gateway question.

4.6 Implications for policy and practice

The findings support a multi-level prevention strategy tailored to the regional evidence rather than to any single regulatory model. At the interpersonal level, the dominance of peer influence and the tight coupling with conventional smoking argue for school-based interventions that address social norms and that treat cigarette and e-cigarette prevention as an integrated rather than a separate task. At the environmental level, the consistent salience of advertising and social-media exposure supports comprehensive restrictions on promotion, flavours, and point-of-sale visibility, measures that remain incompletely implemented across much of the region even where sales are nominally banned.

Beyond these measures, the data point to specific high-yield targets. Because male sex and existing substance use consistently marked elevated risk, screening and targeted intervention for adolescents already using alcohol or tobacco could improve efficiency. Because online marketing emerged as a mechanism reaching adolescents across regulatory contexts, digital platform regulation and media-literacy interventions warrant particular emphasis. Finally, the contextual evidence excluded from the primary synthesis is instructive: the finding that e-cigarette use was associated with loss of autonomy among adolescent smokers in Indonesia (Faisal et al., 2026) indicates that dependence can be established early in adolescence, strengthening the argument for prevention that acts before initiation rather than after dependence has formed.

4.7 Strengths and limitations

This review has several strengths. It provides a contemporary update that carries regional evidence into the disposable-device and post-regulation period, it addresses both prevalence and predictors rather than either alone, and it tabulates effect estimates across conceptual domains to identify the most consistent drivers. The dual focus on prevalence and predictors, combined with an explicit risk-of-bias assessment, gives the synthesis analytical depth beyond a simple prevalence summary. The limitations are nonetheless substantial and calibrate the confidence that can be placed in the conclusions. The search was restricted to a single database (PubMed/MEDLINE) with single-reviewer screening and extraction, raising the risk of missed studies and error; studies published in national languages or indexed only in regional databases were likely under-represented, which probably explains the absence of eligible studies from several ASEAN member states. All included studies were cross-sectional, precluding causal inference about predictors, and e-cigarette use was self-reported and inconsistently defined,

limiting the comparability of prevalence estimates as reflected in the risk-of-bias assessment. The evidence base was further dominated by Malaysia, Thailand, and Vietnam, with sparse Indonesian data and none from the remaining member states, constraining generalisation. Together these constraints indicate a clear priority for future research: prospective, harmonised, multi-country surveillance using standardised e-cigarette-use definitions, capable of tracking both prevalence and its determinants as the regional market and its regulation continue to evolve.

CONCLUSION

This systematic review and meta-analysis of 19 recent studies establishes two contrasting patterns in adolescent e-cigarette use across Southeast Asia. The pooled prevalence of current use among nationally representative surveys was 4.5% (95% CI: 1.9–8.1%), but this figure masks extreme between-country heterogeneity ($I^2 = 99.4\%$), with use ranging from roughly 3% in restrictive settings such as Vietnam and Thailand to around 9% or higher in more permissive Malaysia. In sharp contrast to this heterogeneous prevalence, the predictors of use were strikingly consistent: current conventional cigarette smoking, peer and close-friend use, exposure to advertising and social media, male sex, and other substance use recurred as dominant risk factors across every country examined. The most consequential finding is that these predictors persisted across countries pursuing fundamentally different regulatory strategies, from outright prohibition to permissive regulation, indicating that the social and commercial forces driving adolescent vaping operate with considerable independence from the legal status of the products. Effective prevention therefore requires a multi-level approach that directly interrupts peer transmission and youth-oriented marketing, integrates cigarette and e-cigarette prevention, and targets adolescents already engaged in other substance use, rather than depending on product legality alone. These conclusions are tempered by the cross-sectional nature of the evidence, its reliance on self-reported and inconsistently defined measures, the very high heterogeneity of the pooled estimate, and the concentration of data in a few countries, all of which underscore the need for harmonised, prospective, multi-country surveillance using standardised definitions.

Declarations

Conflicts of interest: The author(s) declare no conflict of interest.

Data availability: All data analysed in this review are derived from the included published studies, which are available from their respective publishers. The extraction dataset is available from the corresponding author on reasonable request.

Ethical approval: Not applicable; this systematic review used only previously published data and did not involve new studies on humans or animals.

REFERENCES

1. AlDukhail, S. K., El Desouky, E. D., Monshi, S. S., Al-Zalabani, A. H., Alanazi, A. M., El Dalatony, M. M., Shubayr, M. A., Elkhobby, A. A., Alqahtani, M. M., Alhazmi, A. S., & Aldossary, M. S. (2025). Electronic cigarette use among adolescents in Saudi Arabia: A national study, 2022. *Tobacco Induced Diseases*, 23, 1–10. <https://doi.org/10.18332/tid/197410>
2. Albadrani, M. S., Tobaiqi, M. A., Muaddi, M. A., Aljohani, A. E., Alkhalidi, Y. M., & Abouzied, M. E. (2024). A global prevalence of electronic nicotine delivery systems (ENDS) use among students: A systematic review and meta-analysis of 4,189,145 subjects. *BMC Public Health*, 24(1), 3311. <https://doi.org/10.1186/s12889-024-20858-2>
3. Benjakul, S., Nakju, S., & Termsirikulchai, L. (2023). Factors associated with e-cigarette use among vocational students: A cross-sectional multistage cluster survey, Thailand. *Tobacco Induced Diseases*, 21, 120. <https://doi.org/10.18332/tid/170421>
4. Bigwanto, M., Péntzes, M., Kodriati, N., Rachmawati, E., Amalia, B., & Widati, S. (2025). E-cigarette use and susceptibility among Indonesian youth: The role of social environment, social media, and individual factors. *BMC Public Health*, 25(1), 2756. <https://doi.org/10.1186/s12889-025-24013-3>
5. Chan, G. C. K., Stjepanović, D., Lim, C., Sun, T., Shanmuga Anandan, A., Connor, J. P., Gartner, C., Hall, W. D., & Leung, J. (2021). Gateway or common liability? A systematic review and meta-analysis of studies of adolescent e-cigarette use and future smoking initiation. *Addiction*, 116(4), 743–756. <https://doi.org/10.1111/add.15246>
6. Conner, M., Grogan, S., Simms-Ellis, R., Cowap, L., Armitage, C. J., West, R., Marshall, A. M., & Siddiqi, K. (2021). Association between age at first reported e-cigarette use and subsequent regular e-cigarette, ever cigarette and regular cigarette use. *Addiction*, 116(7), 1839–1847. <https://doi.org/10.1111/add.15386>
7. Dautzenberg, B., Legleye, S., Underner, M., Arvers, P., Pothegadoo, B., & Bensaidi, A. (2023). Systematic review and critical analysis of longitudinal studies assessing effect of e-cigarettes on cigarette initiation among adolescent never-smokers. *International Journal of Environmental Research and Public Health*, 20(20), 6936. <https://doi.org/10.3390/ijerph20206936>
8. Donaldson, S. I., Dormanesh, A., Perez, C., Majmundar, A., & Allem, J. P. (2022). Association between exposure to tobacco content on social media and tobacco use: A systematic review and meta-analysis. *JAMA Pediatrics*, 176(9), 878–885. <https://doi.org/10.1001/jamapediatrics.2022.2223>

9. Faisal, D. R., Nababan, H. Y., Suryati, T., Tarigan, I. U., & Edwin, V. A. (2026). Loss of autonomy among active adolescent smokers in Indonesia and its associated factors: A cross-sectional study using GYTS 2019. *Korean Journal of Family Medicine*. Advance online publication. <https://doi.org/10.4082/kjfm.25.0287>
10. Gebeyehu, N. A., Gelaw, K. A., Atalay, Y. A., Walle, B. G., Gesese, M. M., & Admass, B. A. (2025). Global prevalence of e-cigarette use among students: Systematic review and meta-analysis. *PLOS ONE*, 20(12), e0332160. <https://doi.org/10.1371/journal.pone.0332160>
11. Glasser, A., Abudayyeh, H., Cantrell, J., & Niaura, R. (2019). Patterns of e-cigarette use among youth and young adults: Review of the impact of e-cigarettes on cigarette smoking. *Nicotine & Tobacco Research*, 21(10), 1320–1330. <https://doi.org/10.1093/ntr/nty103>
12. Heng, P. P., Daud, N. A. A. M., Ahmad, M. H., Rani, F. E. M., Yassin, M. A. B. M., Cheah, Y. K., Lim, K. H., & Ab Rahman, J. (2021). Susceptibility to e-cigarette initiation among tobacco product naïve adolescents in Malaysia (TECMA). *Tobacco Induced Diseases*, 19, 89. <https://doi.org/10.18332/tid/142900>
13. Jafari, K., Joshaghani, N., Wascher, A., & Gunturu, S. (2025). Social media and e-cigarette use among adolescents and young adults: A systematic review of the role of influencers and platforms in promoting vaping culture. *European Psychiatry*. Advance online publication. <https://doi.org/10.1192/j.eurpsy.2025.782>
14. James, P. B., Bah, A. J., Kabba, J. A., Kassim, S. A., & Dalinjong, P. A. (2022). Prevalence and correlates of current tobacco use and non-user susceptibility to using tobacco products among school-going adolescents in 22 African countries. *Archives of Public Health*, 80(1), 121. <https://doi.org/10.1186/s13690-022-00881-8>
15. Jane Ling, M. Y., Abdul Halim, A. F. N., Ahmad, D., Ahmad, N., Safian, N., & Mohammed Nawi, A. (2023). Prevalence and associated factors of e-cigarette use among adolescents in Southeast Asia: A systematic review. *International Journal of Environmental Research and Public Health*, 20(5), 3883. <https://doi.org/10.3390/ijerph20053883>
16. Jane Ling, M. Y., Ahmad, N., Mohamed Nawi, A., & Md Sabri, S. R. (2022). Current e-cigarette use among in-school adolescents in West Malaysia. *PLOS ONE*, 17(1), e0263355. <https://doi.org/10.1371/journal.pone.0263355>
17. Jetly, K., Ismail, A., Hassan, N., & Mohammed Nawi, A. (2025). Tobacco product users among school-going adolescents in Malaysia: Prevalence and associated factors. *Malaysian Journal of Medical Sciences*, 32(2), 148–163. <https://doi.org/10.21315/mjms-11-2024-907>
18. Khouja, J. N., Suddell, S. F., Peters, S. E., Taylor, A. E., & Munafò, M. R. (2021). Is e-cigarette use in non-smoking young adults associated with later smoking? A systematic review and meta-analysis. *Tobacco Control*, 30(1), 8–15. <https://doi.org/10.1136/tobaccocontrol-2019-055433>
19. Kim, J., Lee, S., & Chun, J. (2022). An international systematic review of prevalence, risk, and protective factors associated with young people's e-cigarette use. *International Journal of Environmental Research and Public Health*, 19(18), 11570. <https://doi.org/10.3390/ijerph191811570>
20. Leventhal, A. M., Strong, D. R., Kirkpatrick, M. G., Unger, J. B., Sussman, S., Riggs, N. R., Stone, M. D., Khoddam, R., Samet, J. M., & Audrain-McGovern, J. (2015). Association of electronic cigarette use with initiation of combustible tobacco product smoking in early adolescence. *JAMA*, 314(7), 700–707. <https://doi.org/10.1001/jama.2015.8950>
21. Lim, K. H., Cheong, Y. L., Lim, H. L., Ghazali, S. M., Kee, C. C., Cheah, Y. K., Lim, K. K., & Mohd Ghazali, S. (2022). Correlates of dual/poly tobacco use among school-going adolescents in Malaysia. *Tobacco Induced Diseases*, 20, 52. <https://doi.org/10.18332/tid/148247>
22. Loukas, A., Paddock, E. M., Li, X., Harrell, M. B., Pasch, K. E., & Perry, C. L. (2019). Electronic nicotine delivery systems marketing and initiation among youth and young adults. *Pediatrics*, 144(3), e20183601. <https://doi.org/10.1542/peds.2018-3601>
23. Luu, N. M., Diep, P. B., Phan, T. H., Duong, T. A., Hoang, V. M., Phan, H. T., Do, T. T. T., & Kim, B. G. (2026). Prevalence and factors associated with e-cigarettes and heated tobacco products use among Vietnamese adolescents. *Journal of Community Health*, 51(2), 240–248. <https://doi.org/10.1007/s10900-025-01535-w>
24. Mohd Radzi, N. A., Saub, R., Mohd Yusof, Z. Y., Dahlui, M., & Sujak, S. L. (2021). Nicotine dependence among adolescents single and dual cigarette users. *Children*, 8(2), 144. <https://doi.org/10.3390/children8020144>
25. Mohd Yusoff, M. F., Saminathan, T. A., Robert Lourdes, T. G., Riyadzi, M. R., & Abd Hamid, H. A. (2026). Trends in e-cigarette use among adolescents in Malaysia, 2016–2022: A secondary dataset analysis of national surveys. *Tobacco Induced Diseases*, 24. <https://doi.org/10.18332/tid/219767>
26. Norkaew, J., Intarak, R., & Wongkongdech, R. (2026). Psychosocial correlates of adolescent e-cigarette preventive behavior among Thai secondary school students. *Healthcare*, 14(12), 1664. <https://doi.org/10.3390/healthcare14121664>
27. Ollila, H., Tarasenko, Y., Ciobanu, A., Lebedeva, E., & Raitasalo, K. (2024). Exclusive and dual use of electronic cigarettes among European youth in 32 countries with different regulatory landscapes. *Tobacco Control*, 33, 622–627. <https://doi.org/10.1136/tc-2022-057749>
28. Patanavanich, R., Aekplakorn, W., Glantz, S. A., & Kalayasiri, R. (2021). Use of e-cigarettes and associated factors among youth in Thailand. *Asian Pacific Journal of Cancer Prevention*, 22(7), 2199–2207. <https://doi.org/10.31557/APJCP.2021.22.7.2199>

29. Razali, M. F., Riyadzi, M. R., Abd Hamid, H. A., Wan-Fei, K., & Yusoff, U. N. (2025). Prevalence of adolescent dual tobacco use and its associated factors: Findings from a cross-sectional study. *BMJ Open*, 15(7), e097974. <https://doi.org/10.1136/bmjopen-2024-097974>
30. Sreeramareddy, C. T., Acharya, K., & Manoharan, A. (2022). Electronic cigarettes use and 'dual use' among the youth in 75 countries: Estimates from Global Youth Tobacco Surveys (2014–2019). *Scientific Reports*, 12(1), 20967. <https://doi.org/10.1038/s41598-022-25594-4>
31. Sreeramareddy, C. T., Acharya, K., & Manoharan, A. (2024). Changes in e-cigarette use, cigarette smoking, and dual-use among the youth (13–15 years) in 10 countries (2013–2019). *Nicotine & Tobacco Research*, 26(2), 142–150. <https://doi.org/10.1093/ntr/ntad124>
32. Sun, R., Méndez, D., & Warner, K. E. (2023). Association of electronic cigarette use by US adolescents with subsequent persistent cigarette smoking. *JAMA Network Open*, 6(3), e234885. <https://doi.org/10.1001/jamanetworkopen.2023.4885>
33. Soneji, S., Barrington-Trimis, J. L., Wills, T. A., Leventhal, A. M., Unger, J. B., Gibson, L. A., Yang, J., Primack, B. A., Andrews, J. A., Miech, R. A., Spindle, T. R., Weaver, S. R., Eissenberg, T., Hornik, R. C., Dick, D. M., & Sargent, J. D. (2017). Association between initial use of e-cigarettes and subsequent cigarette smoking among adolescents and young adults: A systematic review and meta-analysis. *JAMA Pediatrics*, 171(8), 788–797. <https://doi.org/10.1001/jamapediatrics.2017.1488>
34. Thepthien, B. O., Tinn, C. S., Ofuchi, T., & Kim, B. (2021). An analysis of e-cigarette and polysubstance use patterns of adolescents in Bangkok, Thailand. *Tobacco Induced Diseases*, 19, 88. <https://doi.org/10.18332/tid/142894>
35. Van Minh, H., Long, K. Q., Van Vuong, D., Hung, N. M., & Park, K. (2022). Tobacco and electronic cigarette smoking among in-school adolescents in Vietnam between 2013 and 2019. *Global Health Action*, 15(1), 2114616. <https://doi.org/10.1080/16549716.2022.2114616>
36. Wang, J. W., Cao, S. S., & Hu, R. Y. (2018). Smoking by family members and friends and electronic-cigarette use in adolescence: A systematic review and meta-analysis. *Tobacco Induced Diseases*, 16, 5. <https://doi.org/10.18332/tid/84864>
37. Wang, Y., Duan, Z., Weaver, S. R., Self-Brown, S. R., Ashley, D. L., Emery, S. L., & Huang, J. (2022). Association of e-cigarette advertising, parental influence, and peer influence with US adolescent e-cigarette use. *JAMA Network Open*, 5(9), e2233938. <https://doi.org/10.1001/jamanetworkopen.2022.33938>
38. Wibowo, R., Weinmann, T., Nowak, D., & Prabandari, Y. S. (2025). Exploring e-cigarette use among Indonesian youth: Prevalence, determinants and policy implications. *Journal of Community Health*, 50(4), 585–595. <https://doi.org/10.1007/s10900-025-01442-0>
39. World Health Organization. (2023). WHO report on the global tobacco epidemic, 2023: Protect people from tobacco smoke. Geneva: World Health Organization.
40. Yinpraphan, N., Hansang, N., Sukcharoen, N., & Poommin, P. (2026). Prevalence and associated factors of e-cigarette use tendency among adolescents in a rural community, Thailand. *Tobacco Induced Diseases*, 24. <https://doi.org/10.18332/tid/218288>