



Review Article

Factors associated with child and adolescent electronic nicotine and non-nicotine delivery systems use: A scoping review

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ARTICLE INFO

Keywords:

Electronic nicotine delivery systems

Vaping

Youth

Child

Adolescent

ABSTRACT

Objectives: To identify, characterise and broadly synthesise factors associated with child and adolescent electronic nicotine delivery systems (ENDS) and/or electronic non-nicotine delivery systems (ENNDS) ever-use and/or current use.

Methods: Four electronic databases were searched from inception to 3rd June 2022. Non-experimental studies that provided quantitative factors associated with adolescent and/or child ENDS or ENNDS ever-use and/or current use were included. Factors associated with ever-use (any lifetime use) and/or current use (use in past 30 days) were included. All screening and data extraction was conducted independently by paired review authors. Frequencies for country, study design, sample size, measure of ENDS/ENNDS use and factors examined were calculated. Factors were categorised according to the Theory of Triadic Influence domains and sub-domains.

Results: The search of electronic databases identified 4756 records, 240 of which were included. The majority of studies examined factors categorised within the Biology and Personality domain of the Theory of Triadic Influence (89.2%; 95%CI 84.6, 82.5), followed by the Social Context (50.8%; 95%CI 44.5, 57.2) and Broader Environment domains (30.4%; 95%CI 24.6, 36.3). The proportion of factors significantly associated with ENDS/ENNDS use was >75% for the Behavioural (78.0%; factors included use of tobacco, other drugs and alcohol), Peer Attitudes and Behaviours (80.0%; factors included peer use of ENDS/ENNDS and tobacco), and Legislation/Policy sub-domains (78.6%; factors included accessibility and advertising).

Conclusions: The evidence base on factors associated with ENDS/ENNDS use in children and adolescents is rapidly developing, predominately by research concentrated in high income regions and focused on behavioural and personality-related factors.

1. Introduction

Electronic nicotine delivery systems (ENDS) and electronic non-nicotine delivery systems (ENNDS) are aerosol devices which work by heating a liquid that users breathe in. This liquid usually contains a combination of toxic chemicals, including those that add flavour, and nicotine (i.e. ENDS). (*World Health Organization, 2020*) There are many forms of ENDS and ENNDS available, including e-hookahs, e-cigars and

e-pipes, with e-cigarettes being the most common. (*World Health Organization, 2020*) Systematic review evidence suggests that nicotine-containing e-cigarettes (i.e. ENDS) can be a useful smoking cessation aid among adults, with meta-analyses indicating that such devices increase quit rates compared to nicotine replacement therapy or ENNDS. (*Hartmann-Boyce et al., 2021*)

Since ENDS and ENNDS were first introduced, the prevalence of their use has risen globally, including among children and adolescents who do

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<https://doi.org/10.1016/j.ypmed.2024.107895>

Received 14 September 2023; Received in revised form 9 February 2024; Accepted 10 February 2024

Available online 12 February 2024

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not use tobacco. A recent systematic review synthesising the prevalence of ENDS and ENNDS use in children and adolescents (aged 8 to 20 years) across 69 countries and territories reported the pooled prevalence for ever-use (defined as any lifetime use) was 17.2% and current use (use in the last 30 days) was 7.8% across these age groups. (Yoong et al., 2021) Prevalence of ENDS and ENNDS use is highest in high-income countries, including Poland, Spain and France, where current use exceeds 40%. (Yoong et al., 2021) E-cigarette use among non-smoking adolescents can more than double the risk of subsequent tobacco use. (Berry et al., 2019) Detrimental health effects of ENDS and ENNDS include acute lung injury known as EVALI (e-cigarette or vaping product use associated lung injury), poisoning, burns and toxicity through inhalation potentially causing seizures. (Banks et al., 2022) Among non-smokers in particular, the use of ENDS/ENNDS offers no benefits and can result in multiple serious adverse health effects. (Banks et al., 2022)

In response to this emerging public health issue, leading public health organisations, including the World Health Organization (WHO), have developed recommendations to address child and adolescent ENDS and ENNDS use. (World Health Organization, 2019) The WHO Report on the Global Tobacco Epidemic recommends for numerous government and public health actions to address the increased prevalence of ENDS and ENNDS use in children and adolescents. (World Health Organization, 2019) This includes policy and legislative action to restrict the supply of ENDS and ENNDS to this age group, (World Health Organization, 2019) which is now implemented in several countries. For example, it is illegal in several states in the United States of America (USA) to sell ENDS to individuals under 18 years of age, (Centre for Disease Control and Prevention, 2021) whilst in Australia, it is illegal to sell or supply ENDS or ENNDS to individuals under 18 years of age. (NSW Government, 2021)

The implementation of health promotion programmes targeting children and adolescents to prevent and/or reduce ENDS and ENNDS use is recommended by national health agencies to supplement policy and legislative approaches. (Substance Abuse and Mental Health Services Administration (SAMHSA), 2020; U.S. Department of Health and Human Services, 2016) However, the factors associated with child and adolescent ENDS and ENNDS use must first be identified in order to inform the development and implementation of such health promotion programmes. Substantial research has been conducted to identify causal pathways and factors associated with child and adolescent tobacco use, which may also be relevant to adolescents behaviours related to initiation and use of ENDS and ENNDS. (Institute of Medicine (US), 2001; Topa and Moriano, 2010; Aghdam et al., 2021; Thomas et al., 2015) For example, the Theory of Triadic Influence, a model used for describing and understanding the interrelated influences on youth uptake of tobacco smoking, suggests that the combined effect of biology and personality, social context and broader environment leads to youth's decision whether to commence tobacco use or not. (Flay et al., 1999; Flay, 1999; Turner et al., 2004) While these factors may similarly influence child and adolescent use of ENDS/ENNDS, research is needed to confirm if the tobacco-use factors in children and adolescents do indeed translate to ENDS and ENNDS. Such research is integral to determine what factors should be targeted during the development and implementation of health promotion programmes to prevent the initiation of ENDS and ENNDS use.

2. Objectives

The primary objective of this scoping review was to identify, characterise and broadly synthesise factors associated with child and adolescent ENDS and/or ENNDS ever-use and/or current use. Specifically, we sought to characterise the modifiable factors for which an association with child and adolescent ENDS/ENNDS use has been examined and describe where such associations have been established. The scoping review was undertaken to map the literature and identify research gaps using the Theory of Triadic Influence. (Munn et al., 2018)

3. Methods

This review was conducted in accordance with the best practice guidance for scoping review protocols outlined in the JBI Manual. (Peters et al., 2022) Reporting of the scoping review aligns with guidelines specified within the 2018 PRISMA Extension for Scoping Reviews (PRISMA-ScR). (Tricco et al., 2018)

A protocol was prospectively deposited with the Open Science Framework (OSF) on 17 June 2022 (doi:10.17605/OSF.IO/NSFWT). As this is review is secondary analysis on publicly available data, ethical approval was not required.

3.1. Inclusion and exclusion criteria

3.1.1. Types of studies

Non-experimental studies of any design that provide quantitative (i.e. prospective cohort studies, cross-sectional surveys) descriptions of factors associated with either child and/or adolescent ENDS or ENNDS ever-use and/or current use were included.

We included studies which reported modifiable factors associated with ENDS/ENNDS use as a whole study sample (i.e. they did not split the sample into subgroups for the primary analysis). Studies that solely reported non-modifiable factors associated with either child and/or adolescent ENDS or ENNDS use were excluded. There was no restriction on language of publication or study sample size.

3.1.2. Types of participants

Our analysis included studies that investigated ENDS/ENNDS use among children and/or adolescents, incorporating both self-reported data and other measures such as observations or reports from other sources (e.g. parents). This includes children and adolescents (defined here as those aged ≤ 19 years) (World Health Organization, 2019) who were ever-users (defined as any lifetime use, including current use) or non-users (defined as never having used) of ENDS or ENNDS. Parents, guardians and families responsible for the care of children and adolescents aged ≤ 19 years were also included if they reported on their child's behaviour.

3.1.3. Types of measures

Any modifiable factors reported to be associated with child and/or adolescent ENDS or ENNDS ever-use (defined as any lifetime use) and/or current use (defined as use in past 30 days) were included. These definitions are consistent with those used in previous reviews of ENDS and ENNDS. (Yoong et al., 2021) Data could be collected via a variety of methods, including interviews, questionnaires or surveys completed by children and adolescents, parents and/or guardians. Where studies reported data split by sub-groups (e.g. synthesised factors for male and females separately), studies needed to report data for the whole sample (e.g. males and females combined) in order to be included in the review. Studies that reported data split by sub-groups but did not provide overall data were excluded to ensure there was no duplication in calculating associations.

3.1.4. Types of evidence sources

Non-data-based papers such as letters to the editor, commentaries, studies describing conceptual frameworks or models, and studies describing measures were excluded, as were effectiveness trials and reviews.

3.1.5. Search strategy

A search of four electronic databases (MEDLINE, EMBASE, CINAHL and PsycInfo) was conducted on 3rd June 2022 to identify potentially eligible studies, using a list of keywords and MeSH terms from each database (inception to June 2022) (Supplementary File 1). Terms for the search strategy were adapted from a previous review (Yoong et al., 2021) and included published search filters for "electronic nicotine

Table 1
Theory of Triadic Influence domains and sub-domains.

Domain	Definition	Sub-domains (example)
Biology and personality	Including individual demographic, physiological, psychological and behavioural factors. These factors include self-efficacy (broadly defined as an individual's sense of self), social competence and self-determination.	<ul style="list-style-type: none"> • Demographic (e.g. age, socioeconomic status, gender, race and ethnicity) • Physiological (e.g. genetics, biology or positive/negative bodily sensations) • Psychological (e.g. mental health) • Behavioural (e.g. use of cigarettes, alcohol or other drugs) • Personality (e.g. own beliefs, knowledge and attitudes)
Social context	Including the influence of peers, including family and friends, through their attitudes and behaviour towards ENDS or ENNDS which results in the development of a perception of what constitutes normative behaviour regarding ENDS/ENNDS.	<ul style="list-style-type: none"> • Peer attitudes/Behaviours (e.g. values, beliefs, attitudes or behaviours of peers regarding e-cigarettes) • Family attitudes/Behaviours (e.g. values, beliefs, attitudes or behaviours of family regarding e-cigarettes)
Broader environment	Including cultural contexts and legislative/policy issues that impact the pricing and availability of ENDS/ENNDS. These factors influence knowledge, expectations, values and evaluations, leading to specific attitudes and beliefs towards ENDS or ENNDS.	<ul style="list-style-type: none"> • Cultural contexts (e.g. religion) • Informational environment (e.g. exposure to e-cigarette advertising and information) • Accessibility (e.g. proximity to e-cigarette sale stores) • Legislation/policy (e.g. policies and laws influencing access and supply to e-cigarettes)

delivery systems (ENDS) OR electronic non-nicotine delivery systems (ENNDS)" AND "children OR adolescents".

In addition to electronic database searches, a search of Google Scholar (first 100 results) for relevant unpublished or grey literature publications using the search terms: adolescent OR child OR teen OR youth AND Electronic Nicotine Delivery Systems OR Vaping was conducted. A hand search of reference lists of relevant systematic reviews was conducted to identify any other relevant studies.

3.2. Evidence selection

Title and abstract screening for eligible studies was conducted independently by review authors (CB, HT, SMc, CBi, AB, ML, CL, JDo) in pairs using Covidence software. (Innovation, 2024) Review authors were not blinded to study information. For potentially eligible studies, full texts of manuscripts were examined for eligibility by a pair of review authors independently (CB, HT, SMc, CBi, AB, ML, CL, JDo). Reasons for exclusion were documented for all studies and recorded in a PRISMA diagram. Disagreements between review authors were resolved via consensus or, when required, by a third author.

3.3. Data extraction

Data extraction was completed independently by review authors (CB, CBi, HT, SMc, JDr) using a data extraction form piloted by the review team. To ensure standardisation in approaches, the author team piloted data extraction and then discussed any potential discrepancies in approaches or in the data extracted.

The following data was extracted from each study:

- General information: author name, title, publication date, country;
- Study methods: study design, setting, sample size;
- Participant characteristics: age, gender, ENDS and/or ENNDS use;
- Data collection method;
- Factors examined, categorised according to the Theory of Triadic Influence (described below), and statistical significance of randomly selected factors in each Theory of Triadic Influence sub-domain.

3.4. Data synthesis

Consistent with JBI guidance for data analysis of scoping reviews, (Aromataris and Munn, 2020) we calculated frequencies for country, study design, sample size, age, gender and ENDS/ENNDS use of

participants, measure of ENDS/ENNDS use, data collection method, and factors examined.

We classified factors examined within each study according to the domains within the Theory of Triadic Influence: a model developed by Flay and colleagues (Flay, 1999) for understanding the interrelated influences on youth uptake of smoking (applied here to ENDS/ENNDS). The model encompasses the interrelated personal, social and environmental influences on youth behaviour (i.e. ENDS/ENNDS use), separating them into three domains: Biology and Personality; Social Context; and Broader Environment. Whilst several frameworks and theories have been developed to describe and categorise potential influences of adolescent use or uptake of cigarettes, the Theory of Triadic Influence was selected for use within this review as it is comprehensive and incorporates components of 14 different human behaviour theories. (Flay, 1999).

Each factor examined in the included studies was first categorised within one of the three broad domains, and then categorised into the relevant sub-domains developed by the review team and described in Table 1. Each factor was categorised based on how it was assessed and reported by the authors of the included studies. For example, this may have consisted of self-report (e.g. adolescents completing a questionnaire to assess their attitudes towards ENDS/ENNDS and use behaviours), researcher observation, and audits (e.g. researchers using the publicly available data and reports to measure the implementation of ENDS/ENNDS control measures, such as policies and taxation). For studies where there were factors that examined associations of both ever and current ENDS/ENNDS use, we extracted and reported data regarding associations for current use only. For studies that only examined one factor within each sub-domain (e.g. age was the only factor examined from the demographic sub-domain), we extracted information pertaining to that factor and reported whether or not the association with measures of current or ever ENDS/ENNDS use was statistically significant. We used statistical significance thresholds as defined by the authors of included studies; although varied, alpha values were typically either 0.05 or 0.01. Where a study examined multiple factors within the one sub-domain (e.g. age and gender within the demographic sub-domain were both examined), we extracted each factor but only reported the statistical significance of any association with ENDS/ENNDS for one randomly selected factor per sub-domain (e.g. age or gender). Factors were randomly selected using the random number function in Microsoft Excel. We did not characterise the direction of the association or its strength.

We reported study characteristics and statistical significance of factors overall and in subgroups based on the study design using descriptive statistics and 95% confidence intervals. Specifically, we grouped studies according to whether they employed cross-sectional or prospective

cohort designs. We did so given that prospective designs, unlike cross-sectional studies, are recommended for observational studies identifying factors causally related to ENDS or ENNDS use. (Elwood and Elwood, 2017)

4. Results

4.1. Study selection

The search of electronic databases identified 4756 non-duplicate records (Fig. 1). Following screening of titles and abstracts, we obtained the full texts of 776 manuscripts for further review. A total of 536 studies were excluded following the review of full texts for the following reasons: inappropriate aim or objective ($n = 199$); inappropriate outcomes ($n = 89$); inappropriate participants ($n = 98$); abstract or erratum only (i.e. no full text could be located, $n = 66$); studies solely reporting non-modifiable factors ($n = 40$); inappropriate study design ($n = 16$); systematic review ($n = 16$); and studies did not report whole population analysis ($n = 12$). A total of 240 studies were included in this scoping review.

4.2. Study characteristics

The included studies were predominately conducted in North America ($n = 176$, 73%, Table 2). Studies were conducted between 2011 and 2022. The number of studies increased over time, with 67% ($n = 161$) of the included studies conducted in the past three years. The majority of included studies were single-point cross-sectional studies (61%, $n = 140$), with an additional 24 studies (10%) repeat cross-

sectional. Sixty-nine studies used prospective cohort designs. The majority of studies (93%, $n = 224$) included samples of >500 participants. Ninety-nine percent of studies ($n = 239$) measured both current and ever-use of ENDS/ENNDS. The mean sample size of the included studies was 16,738 (range 69–736,158).

4.3. Factors examined with child and adolescent ENDS and ENNDS use

The majority of studies examined factors which were categorised within the Biology and Personality domain of the Theory of Triadic Influence (89.2% of studies; 95% CI 84.6, 92.5), followed by the Social Context (50.8% of studies, 95% CI 44.5, 57.2) and Broader Environment domains (30.4% of studies, 95% CI 24.6, 36.3) (Table 3).

4.3.1. Biology and personality

Of the 214 studies that examined Biology and Personality factors associated with child and adolescent ENDS/ENNDS use, 68.8% examined factors in the Demographics sub-domain, followed by Behavioural (62.5%) and Personality sub-domains (34.6%) (Table 3). Just 7.1% of reported factors were classified within the Physiological sub-domain. There was little difference in the proportion of factors classified in each sub-domain between cross-sectional and prospective cohort study designs. Supplementary File 2 describes the most common reported factors for each sub-domain. Within the Demographic sub-domain the most common factors examined were gender/sex (157 studies); race/ethnicity (112 studies); and age (95 studies). Within the Behavioural sub-domain, the most common factors were smoking status (105 studies); alcohol (55 studies) and marijuana use (39 studies); whilst perceived harms of ENDS/ENNDS (37 studies) was the most common

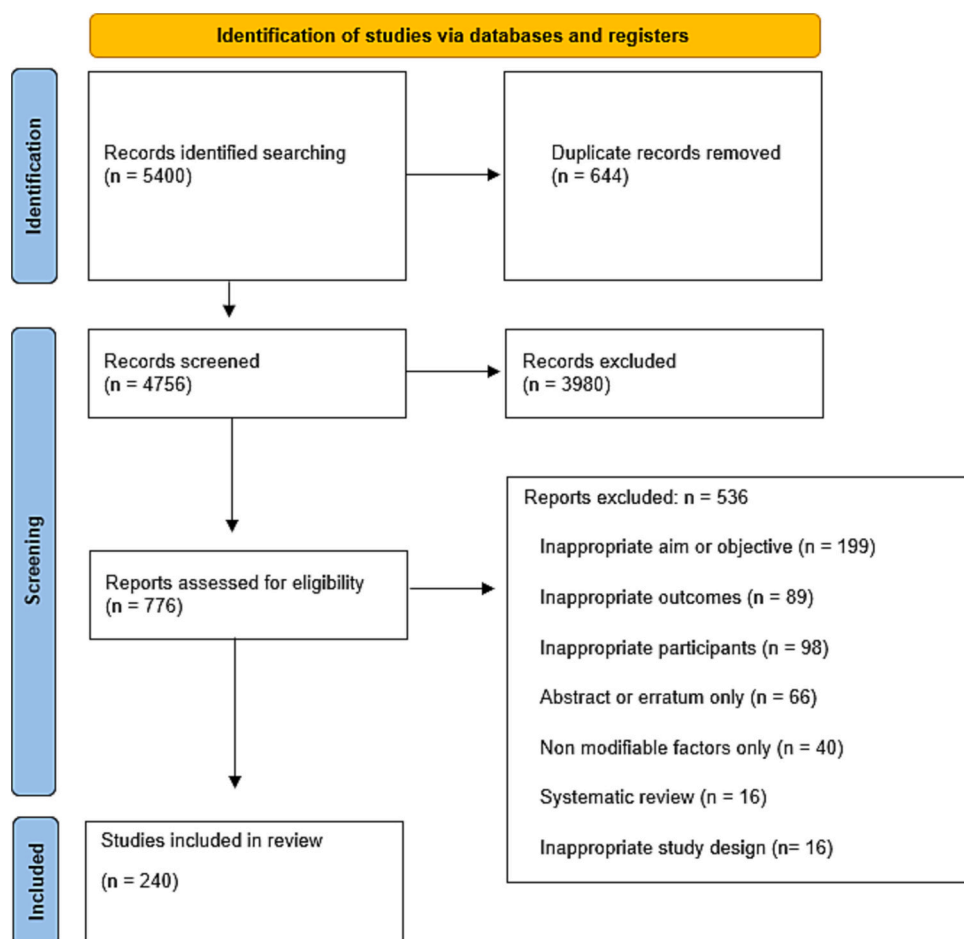


Fig. 1. PRISMA diagram showing the flow of potentially eligible studies through screening stages.

Table 2
Summary of included studies and demographics of participants.

Characteristics of included studies	Total studies n (%) n = 240
Study region	
North America	176 (73)
Europe	30 (13)
Asia	21 (9)
Oceania	3 (1)
South America	4 (2)
Other	6 (2)
Year published	
2011–2013	1 (0)
2014–2016	28 (12)
2017–2019	75 (31)
2020–2022	136 (57)
Study design	
Single-point cross-sectional studies	147 (61)
Repeat cross-sectional	24 (10)
Prospective cohort studies	69 (29)
Sample size	
≤250 participants	7 (3)
251–499 participants	8 (3)
≥500 participants	224 (93)
No sample size reported	1 (<1)
Mean sample size (range)	16,768 (69–736,158)
Participants characteristics	
Children only (<10 years)	0 (0)
Adolescents only (10–19 years)	236 (98)
Both adolescents and children (<10 years)	3 (1)
Not reported	1 (<1)
Male, female, other	7 (3)
Male, other	1 (<1)
Males and females	227 (94)
Men	1 (<1)
Not reported	4 (2)
Outcome measures	
Current-use (use in past 30 days) only	1 (<1)
Both current- and ever-use	239 (99)

factor in the Personality sub-domain.

4.3.2. Social context

Of the 122 studies that examined Social Context factors associated with child and adolescent ENDS/ENNDS use, 33.3% were categorised within the Peer Attitudes and Behaviours sub-domain, and 41.3% within the Family Attitudes and Behaviours sub-domain (Table 3). Within these two sub-domains, the most frequently reported factors were friend or peer use of ENDS/ENNDS or tobacco (57 studies); use of tobacco by other household members (66 studies); household composition (13 studies); family connectedness or parents talking about or monitoring ENDS/ENNDS use (11 studies); friends or peer use of cannabis or other

Table 3
Proportion of studies examining factors associated with ENDS/ENNDS use by sub-domains of the Theory of Triadic Influence domains and study design.

	Cross-sectional studies (n = 171) n (%) [95% CIs]	Prospective cohort studies (n = 69) n (%) [95% CIs]	All studies (n = 240) n (%) [95% CIs]
Biology and personality	155 (90.6) [85.3; 94.2]	59 (85.5) [75.3; 91.9]	214 (89.2) [84.6; 92.5]
Demographics	123 (71.9) [65.1; 78.7]	42 (60.9) [49.1; 72.7]	165 (68.8) [62.8; 74.7]
Physiological	16 (9.4) [5.8; 14.7]	1 (1.4) [0.3; 7.8]	17 (7.1) [4.5; 11.0]
Psychological	37 (21.6) [16.1; 28.4]	17 (24.6) [16.0; 36.0]	54 (22.5) [17.7; 28.2]
Behavioural	107 (62.6) [55.2; 69.9]	43 (62.3) [50.6; 74.0]	150 (62.5) [56.3; 68.7]
Personality	61 (35.7) [28.4; 42.9]	22 (31.9) [20.6; 43.2]	83 (34.6) [28.5; 40.6]
Social context	89 (52.0) [44.5; 59.6]	33 (47.8) [35.7; 59.9]	122 (50.8) [44.5; 57.2]
Peer attitudes/Behaviours	57 (33.3) [26.2; 40.5]	23 (33.3) [21.9; 44.7]	80 (33.3) [27.3; 39.3]
Family attitudes/Behaviours	71 (41.5) [34.1; 49.0]	28 (40.6) [28.7; 52.5]	99 (41.3) [35.0; 47.5]
Broader environment	50 (29.2) [22.4; 36.1]	23 (33.3) [21.9; 44.7]	73 (30.4) [24.6; 36.3]
Cultural contexts	4 (2.3) [0.9; 5.9]	0 (0.0) [0.0; 4.3]	4 (1.7) [0.6; 4.2]
Informational environment	35 (20.5) [15.1; 27.1]	18 (26.1) [15.5; 36.7]	53 (22.1) [17.3; 27.7]
Accessibility	18 (10.5) [6.8; 16.0]	2 (2.9) [0.8; 10.0]	20 (8.3) [5.5; 12.5]
Legislation/policy	9 (5.3) [2.8; 9.7]	5 (7.2) [3.1; 15.9]	14 (5.8) [3.5; 9.6]

substances (10 studies); and social comparison (five studies).

4.3.3. Broader environment

Of the 73 studies that examined Broader Environment factors associated with child and adolescent ENDS/ENNDS use, 22.1% were categorised within the Informational Environment sub-domain; 8.3% in the Accessibility sub-domain, 5.8% in the Legislation/Policy sub-domain; and 1.7% in the Cultural Context sub-domain. Within the Informational Environment sub-domain, the proportion of prospective cohort studies (26.1%) was higher than cross-sectional studies (20.5%) though the 95% confidence intervals around these estimates overlap. Within the Accessibility domain, the proportion of cross-sectional studies (10.5%) was higher than prospective cohort studies (2.9%), though confidence intervals were wide and also overlapping.

4.4. Factors significantly associated with ENDS/ENNDS use

The proportion of factors significantly associated with ENDS/ENNDS use was >75% for the Behavioural (78%), Peer Attitudes and Behaviours (80.0%), and Legislation/Policy sub-domains (78.6%). It was lowest among factors within the Demographic, Physiological and Cultural Context sub-domains (<50%) (Table 4).

There were large differences in the proportion of significant associations for factors in the Physiological and Cultural sub-domains between cross-sectional and prospective cohort designs owing to a lack of studies (n ≤ 2) employing prospective designs. There were little differences in the proportion of significant associations of factors in other sub-domains by study design.

5. Discussion

This scoping review aimed to identify, characterise and broadly synthesise factors associated with child and adolescent ENDS and/or ENNDS ever-use and/or current use. Through a comprehensive search of four electronic databases, Google scholar and grey literature, our review identified 240 studies that were eligible for inclusion. The review found research examining factors associated with ENDS/ENNDS use has accelerated markedly over the past decade; such studies were typically large (>500 participants) and examined factors across the domains of the Theory of Triadic Influence, though not uniformly. Furthermore, >50% of factors examined within most sub-domains were significantly associated with ENDS/ENNDS use. The findings provide a comprehensive map of the research in the field and important information to guide future research.

We found almost 90% of research to date has been undertaken in two global regions: North America (73%) and Europe (13%). While we did not restrict eligibility to English language publications, the findings may

Table 4
Statistical significance of factors for each sub-domain by study design.

Domains	Number of cross-sectional studies with significant outcome n (%) [95%CI]	Number of prospective cohort studies with significant outcome n (%) [95%CI]	All studies with significant outcome n (%) [95%CI]
Biology and Personality			
Demographic	62 (50.4) [41.4;59.4]	16 (38.1) [22.8;53.4]	78 (47.3) [39.6;55.0]
Physiological	6 (37.5) [10.9;64.1]	1 (100.0) [0.0;100.0]	7 (41.2) [15.1;67.3]
Psychological	19 (51.4) [34.5;68.2]	9 (52.9) [26.5;79.4]	28 (51.9) [38.1;65.6]
Behavioural	83 (77.6) [68.8;84.4]	34 (79.1) [64.8;88.6]	117 (78.0) [70.7;83.9]
Personality	39 (63.9) [51.5;76.3]	15 (68.2) [47.0;89.3]	54 (65.1) [54.6;75.5]
Social Context			
Peer Attitudes/Behaviours	45 (78.9) [66.7;87.5]	19 (82.6) [62.9;93.0]	64 (80.0) [70.0;87.3]
Family Attitudes/Behaviours	47 (66.2) [54.9;77.5]	17 (60.7) [41.4;80.0]	64 (64.6) [55.1;74.2]
Broader Environment			
Cultural Contexts	1 (25.0) [4.6;69.9]	-	1 (25.0) [4.6;69.9]
Informational Environment	19 (54.3) [36.9;71.6]	10 (55.6) [30.1;81.0]	29 (54.7) [40.9;68.6]
Accessibility	12 (66.7) [42.5;90.8]	2 (100.0) [0.0;100.0]	14 (70.0) [48.0;92.0]
Legislation/policy	6 (66.7) [28.2;100.0]	5 (100.0) [40.0;100.0]	11 (78.6) [52.4;92.4]

Green = $\geq 75\%$, Yellow = 60–74% and Red = 50–59%.

be attributable, in part, to the databases and broader search methods of the review. However, reviews in tobacco or substance use and public health more broadly have similarly reported a dominance of research output from these regions (Mannocci et al., 2019). While prevalence of ENDS/ENNDS use in adolescents is highest in high-income countries and regions, it is increasing globally (Yoong et al., 2021). As the patterns and determinants of ENDS/ENNDS use are likely to vary cross-culturally, the lack of eligible studies for inclusion from other global regions does restrict the utility of the current evidence base to support the development of effective prevention initiatives. Strategies to support research in countries and regions outside of North America and Europe appear warranted. We also identified that most included studies examined cross-sectional associations of factors with ENDS/ENNDS use. This is also consistent with bibliographic studies of research output (Wolfenden et al., 2016). However, cross-sectional studies provide limited evidence regarding the direction of the association and the causal relationship between factors and ENDS/ENNDS use. Greater investment in prospective studies would strengthen the evidence-base to support the development of strategies to address ENDS/ENNDS use in this population group.

We identified studies that examined factors associated with the ENDS/ENNDS across all domains and sub-domains of the Theory of Triadic Influence. However, most included studies examined factors aligned to the Biology and Personality domain (89.2%) and relatively few studies examined factors aligned to the Broader Environment domain (30.4%). A relatively small number of studies examined factors categorised within the Broader Environment domain particular those within the Cultural Context, Accessibility, Legislation/policy sub-

domains. These differences in prevalence may be reflective of the different levels of ease in researching sub-domain factors. For example, biology and personality factors such as demographics and behaviour may be easily captured, and their measurement integrated into existing health surveillance systems or cohort studies such as routine school-based surveys. Conversely, research examining broader environment factors may face more opportunity, resource and logistical constraints; for example, national-level policies are infrequent and may be implemented quickly, providing little time to examine changes in ENDS/ENNDS behaviours. Given policy and legislative and other environmental initiatives may have the greatest potential to impact ENDS/ENNDS behaviour, future research focused on the broader environment may be of particular value.

There were differences in the frequency of significant associations of factors with ENDS/ENNDS across sub-domains. Within the Biology and Personality domain, significant associations were most common within the Behavioural and Personality sub-domains where 78.0% and 65.1% of associations were statistically significant, respectively. The factors most reported within these sub-domains (Behavioural sub-domain: use of cigarettes, other drugs and alcohol; Personality sub-domain: perceived harms and benefits of use, sensation seeking), have also been identified in previous literature as influential factors of youth tobacco use. For example, reviews have suggested factors such as ever-smoking or drinking, rebelliousness and thrill seeking are predictors of adolescent tobacco smoking uptake (Wellman et al., 2016). Within the Social Context domain, the Peer Attitudes and Behaviours sub-domain was frequently reported to be significantly associated with ENDS/ENNDS use (80.0%), with peer use of ENDS/ENNDS and tobacco

identified as the most reported factor (63 studies). Such findings are consistent with the adolescent tobacco literature (Wellman et al., 2016; Lund et al., 2022). Finally, within the Broader Environment domain, factors within the Accessibility (70.0%) and Legislation/policy (78.6%) sub-domains were reported as statistically significant.

While the aim of this scoping review was not to examine the direction and strength of the association, the findings provide important indicators that such factors may be particularly salient to ENDS/ENNDS use in children and adolescents and guide the focus of interventions to curb use in this population. Targeting factors within the sub-domains found to frequently be significantly associated with ENDS/ENNDS use, including perceived harms and benefits of ENDS/ENNDS, use of alcohol and tobacco, and the influence of peers, may be a valuable foundation for interventions to address adolescent ENDS/ENNDS use. Additionally, supplementing these behavioural-type interventions with broader environmental approaches, such as legislative and policy action to limit youth accessibility to these devices and exposure to advertising (i.e. factors that were also categorised within statistically significant sub-domains), may further enhance efforts to combat use. A multi-level approach would align with current guidance from leading public health organisations (Substance Abuse and Mental Health Services Administration (SAMHSA), 2020; U.S. Department of Health and Human Services, 2016), who recommend the implementation of health promotion programmes targeting children and adolescents to prevent and/or reduce ENDS/ENNDS use to enhance policy and legislative measures.

6. Limitations

This scoping review has several strengths, including the use of methods that align with best practice recommendations, such as the prospective registration of the review protocol, comprehensive search of electronic databases, and screening and data extraction conducted in pairs. However, the scoping review is not without its limitations. Whilst the review identified factors associated with child and adolescent ENDS/ENNDS use, we did not characterise the nature of the relationship. There were also a number of deviations from the methods pre-specified in the protocol, including the decision to only include studies that examined modifiable factors associated with ENDS/ENNDS use. Whilst non-modifiable factors were still extracted from those studies that also reported modifiable, this deviation from the protocol is likely to have resulted in the review not providing a thorough insight into the types of non-modifiable factors associated with ENDS/ENNDS use. Additionally, no information on the study funding or conflicts of interest, which may have influenced what was reported within the included studies, was extracted.

7. Conclusions

Child and adolescent e-cigarette use is an increasing concern globally. Public health action to mitigate the harm associated with ENDS/ENNDS use must be informed by a thorough understanding of the behaviour and its determinants. This review found an evidence base that is rapidly developing, dominated by research concentrated in high income regions of the globe, and predominantly examining factors related to behaviour and personality. The findings provide important guidance on the types of factors that should potentially be targeted in future interventions to curb ENDS/ENNDS use in this population. Behavioural-type interventions targeting child and adolescent perceived harms and benefits of ENDS/ENNDS, their use of alcohol and tobacco, and the influence of peers, employed in combination with legislative and policy measures may be particularly salient in addressing this emerging public health issue.

Patient consent for publication

Not required.

Ethics approval

This study does not involve human participants.

Disclosure of funding

This work was supported by funding from a NHMRC Centre for Research Excellence (APP1153479) - 'the National Centre of Implementation Science'. Courtney Barnes and Cassandra Lane receive salary support from a NSW Ministry of Health PRSP Research Fellowship. Luke Wolfenden is supported by an NHMRC Investigator Grant (APP11960419) and NSW Cardiovascular Research Capacity Program (H20/28248). The contents of this manuscript are the responsibility of authors and do not reflect the views of NSW Ministry of Health or NHMRC.

CRediT authorship contribution statement

Courtney Barnes: Writing – review & editing, Writing – original draft, Methodology, Formal analysis, Data curation, Conceptualization. **Sam McCrabb:** Writing – review & editing, Writing – original draft, Methodology, Data curation, Conceptualization. **Caitlin Bialek:** Writing – review & editing, Writing – original draft, Methodology, Data curation. **Heidi Turon:** Writing – review & editing, Writing – original draft, Methodology, Conceptualization. **Julia Dray:** Writing – review & editing, Writing – original draft, Data curation. **Megan Duffy:** Writing – review & editing, Writing – original draft, Data curation. **Cassandra Lane:** Writing – review & editing, Writing – original draft, Data curation. **Melanie Lum:** Writing – review & editing, Writing – original draft, Data curation. **Alison Brown:** Writing – review & editing, Writing – original draft, Data curation. **Jodie Doyle:** Writing – review & editing, Writing – original draft, Data curation. **Luke Wolfenden:** Writing – review & editing, Writing – original draft, Data curation.

Declaration of competing interest

The authors have no conflicts of interest to declare.

Data availability

Data will be made available on request.

Acknowledgments

The authors would like to thank Jacob Morrison and Stephanie Mantach for assistance with conducting title/abstract and full text screening, and Christophe Lecathelinais for his support with the analysis.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.ypmed.2024.107895>.

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