

Electronic cigarettes and subsequent use of cigarettes in young people: An evidence and gap map

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Funding information

Cancer Research UK, Grant/Award Number: PPRCTAGPJ\100002

Abstract

Background and aims: The use of e-cigarettes may influence later smoking uptake in young people. Evidence and gap maps (EGMs) are interactive on-line tools that display the evidence and gaps in a specific area of policy or research. The aim of this study was to map clusters and gaps in evidence exploring the relationship between e-cigarette use or availability and subsequent combustible tobacco use in people aged < 30 years.

Methods: We conducted an EGM of primary studies and systematic reviews. A framework and an interactive EGM was developed in consultation with an expert advisory group. A systematic search of five databases retrieved 9057 records, from which 134 studies were included. Systematic reviews were appraised using AMSTAR-2, and all included studies were coded into the EGM framework resulting in the interactive web-based EGM. A descriptive analysis of key characteristics of the identified evidence clusters and gaps resulted in this report.

Results: Studies were completed between 2015 and 2023, with the first systematic reviews being published in 2017. Most studies were conducted in western high-income countries, predominantly the United States. Cohort studies were the most frequently used study design. The evidence is clustered on e-cigarette use as an exposure, with an absolute gap identified for evidence looking into the availability of e-cigarettes and subsequent cessation of cigarette smoking. We also found little evidence analysing equity factors, and little exploring characteristics of e-cigarette devices.

Conclusions: This evidence and gap map (EGM) offers a tool to explore the available evidence regarding the e-cigarette use/availability and later cigarette smoking in people under the age of 30 years at the time of the search. The majority of the 134 reports is from high-income countries, with an uneven geographic distribution. Most of the systematic reviews are of lower quality, suggesting the need for higher-quality reviews. The evidence is clustered around e-cigarette use as an exposure and subsequent frequency/intensity of current combustible tobacco use. Gaps in evidence focusing on e-cigarette availability, as well as on the influence of equity factors may warrant further research.

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This EGM can support funders and researchers in identifying future research priorities, while guiding practitioners and policymakers to the current evidence base.

KEYWORDS

Cigarettes, electronic cigarettes, evidence and gap map, smoking, vaping, young people, youth

INTRODUCTION

Evidence and gap maps (EGMs) first emerged in 2003 and have seen significant growth over recent years [1]. They are interactive web-based tools that provide a visual overview of the existing evidence and gaps in a domain-specific area of research or policy, existing within the evidence synthesis ecosystem [1–3]. Developing an EGM involves following rigorous and systematic methods, resulting in a framework (a matrix with columns and rows, referred to as ‘primary dimensions’) and filters (‘secondary dimensions’), allowing users to explore the map through a specific lens according to their interests (e.g. focusing on countries or study designs) [2, 3].

To the best of our knowledge, an EGM on electronic cigarettes (e-cigarettes) has yet to be published. E-cigarettes are defined as ‘electronic vaping devices that are handheld and produce for inhalation an aerosol formed by heating an e-liquid using a battery-powered heating coil’ [4]. While they are primarily marketed and promoted as an alternative to cigarettes for adults who smoke, they have also become popular among young people. In the United Kingdom, the proportion of young people (aged 11–17 years) trying these products rose from 7.7% in 2022 to 11.6% in 2023 alone [4]. This trend has also been observed on a global scale [5, 6].

The available evidence points towards vaping being substantially less harmful than smoking, with toxicant levels considerably lower in regulated e-cigarettes than in combustible tobacco [7, 8]. Evidence also shows that vaping can promote smoking cessation [9]. However, there is still uncertainty regarding the life-course implications of the uptake of e-cigarettes by adolescents and young people. The unfeasibility of randomized controlled trials with non-smokers (for ethical reasons) contributes to this challenging scenario.

Systematic reviews have reported a positive association between e-cigarette use and later cigarette smoking in young people [10–14]. The causality of this relationship remains highly disputed [10, 12]; most natural experiments suggest the opposite relationship [9–12]. It has also been theorized that e-cigarettes may act as a substitute for combustible cigarettes in young people, hence preventing young people from combustible cigarette smoking who would have otherwise used cigarettes [13].

This continues to be an area of prolific scientific debate and development, with an increasing volume of research published worldwide. Stakeholder input has emphasized the importance of mapping current available primary research and systematic reviews on this topic to inform future research and decision-making. Therefore, we aimed to systematically identify and map primary studies and systematic reviews exploring the association between the use or availability of e-cigarettes and subsequent combustible tobacco use behaviour in

people under the age of 30 years. This resulted in an EGM that offers an overview and visual representation of the available evidence and gaps in this complex field.

METHODS

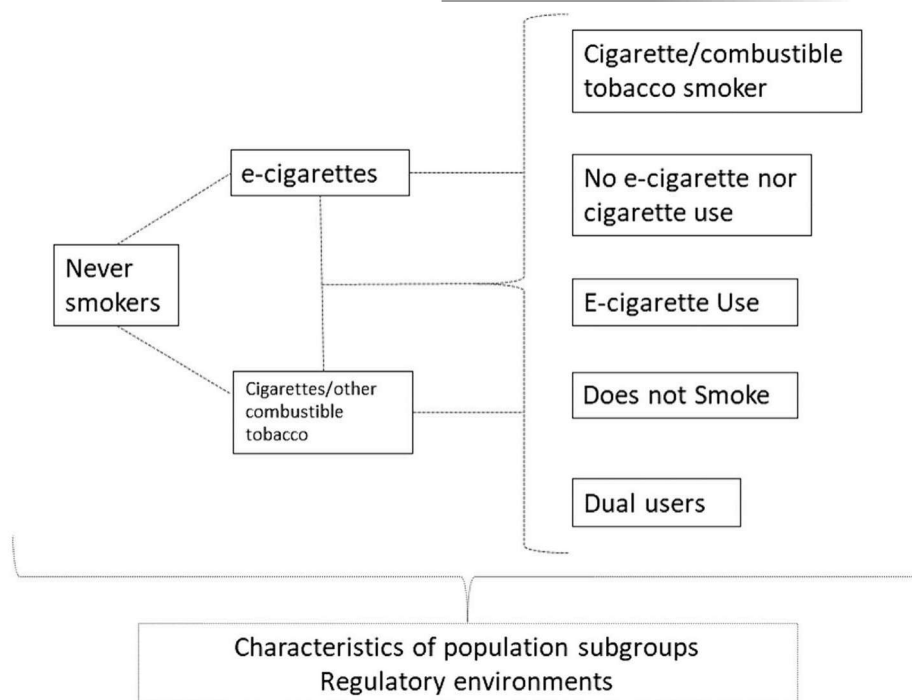
The protocol for this EGM was pre-registered (<https://osf.io/khj7z>) and is part of a wider research project, which at the time of writing includes a published Cochrane protocol [14]. EGMs share some methodological similarities with systematic reviews, but are different products [2,3]. They do not aim to produce a synthesis, but rather an interactive overview of evidence [2, 3]. We adapted EGM methods from the Campbell Collaboration Guidance [2] explaining any deviations from the original protocol in this report. We used the same search strategy and eligibility criteria for primary studies as in our linked Cochrane protocol [14]. Screening differed, as we included both primary studies and systematic reviews in this EGM. We appraised the quality of systematic reviews. The development of the conceptual framework and consultation exercises were unique to this EGM. The descriptive overview of the identified literature and gaps is also specific to this EGM, as is the interactive EGM itself.

Developing the EGM framework

The original draft framework was developed by the core research team, informed by previous and concurrent research [14]. We focused upon four main causal hypotheses when originally developing our framework. The original ‘gateway hypothesis’ describes a sequential pathway of drug involvement where the uptake of soft/licit substances (e.g. tobacco, alcohol) precedes the use of hard/illicit substances (e.g. cocaine) in the general population [15]. This theory was later transferred to temporal progression from e-cigarettes (‘less harmful’) to combustible tobacco use (‘more harmful’) in tobacco control [16].

Another hypothesis in addiction research is the ‘common liability’ hypothesis which postulates non-specific liability to psychoactive substances irrespective of order of consumption initiation [17]. In the context of tobacco control, this translates into the assumption that any relationships between e-cigarettes and combustible tobacco use derive from the individual’s ‘liability’ to nicotine products, reflecting a range of shared risk factors which may facilitate substance use onset [13, 18]. Any type of use of nicotine products appears to predict cigarette smoking initiation [18]. Natural experiments, such as those evaluating legislative changes designed to restrict e-cigarette accessibility, have been proposed as a strategy to eliminate common liabilities and

FIGURE 1 Evidence and gap map framework.



causally identify the relationship between e-cigarettes use and combustible tobacco use [11, 12].

When observing the decline in smoking rates that followed the e-cigarettes market introduction [19] and other e-cigarette accessibility restrictions [11, 12], it has also been theorized that e-cigarettes may have a preventive role regarding smoking behaviour. This is known as the 'diversion hypothesis', where young people who have a propensity to nicotine are diverted from combustible tobacco by using e-cigarettes instead.

Schneider & Dehl proposed the 'catalyst model', bringing together the above-cited hypotheses and other dispersed hypotheses found in the literature [20]. E-cigarettes could lead to desensitization and reduced harm perceptions of cigarettes, dual use and nicotine dependence [20]. Phenomena such as social renormalization—where e-cigarettes are perceived as sufficiently similar to combustible cigarettes to normalize the other—have also been theorized to contribute to this [20]. However, Hallingberg and colleagues were unable to confirm this in their segmented regression analysis of e-cigarette use data from Great Britain [21].

Given that all these hypotheses lack definitive empirical support, our framework was broad to allow for the potential of these mechanisms to coexist and underlie consumption trajectories from abstinence to e-cigarettes and/or combustible tobacco use in young people. It was also assumed that some could occur simultaneously and act on different variables, subject to influence from individual and environmental factors. Regulatory environments can influence accessibility to e-cigarettes, as well as shape other aspects that may influence the uptake of such products (e.g. flavours, sales, nicotine content) at a population-level [20]. However, policies regarding e-cigarette regulation vary greatly between jurisdictions [22]. Not only do epidemiological profiles of e-cigarettes and combustible tobacco

use influence how countries decide to regulate these products, but contextual factors also play a major role [20]. We have integrated regulatory environments into our framework as they can influence e-cigarettes and combustible tobacco trajectories and outcomes.

Tobacco-related disparities are well documented [23]. Cigarette smoking is influenced by social determinants [24]. It is plausible that these determinants also influence vaping–smoking trajectories. Even though the evidence regarding the impact of e-cigarettes on health equity is limited, capturing and mapping data that capture differences and intersections across socio-economic status (SES), race/ethnicity, age, education, gender and geography have been identified as a priority [23, 25]. Therefore, we included PROGRESS-Plus characteristics [26] in our framework, grouping them under 'characteristics of population subgroups'. PROGRESS-Plus is an acronym developed to identify characteristics that differentiate health opportunities and outcomes and is used in evidence synthesis to explore and report equity factors [26]. Framework development was refined through consultation with stakeholders with expertise in the field of tobacco control, as detailed in the stakeholder involvement section. The resulting framework is shown in Fig. 1. Supporting information, Appendix A contains a descriptive list of exposures, outcome categories and filters of the EGM.

Search strategy

An information specialist searched MEDLINE, Embase, PsycINFO and the Cochrane Tobacco Addiction Group's Specialized Register on 3 April 2023. The Register is populated by searches of the Cochrane Central Register of Controlled trials (CENTRAL), MEDLINE, Embase, PsycINFO and two on-line trial registries: ClinicalTrials.gov and the World Health Organization (WHO) International Clinical Trials Registry Platform

(ICTRP). The search strategy combined terms relevant for exposures, outcomes and study designs (Supporting information, Appendix B). It was the same search strategy used for our linked Cochrane protocol [14].

We also asked the advisory group for additional relevant references through a call for evidence integrated in one of our consultation exercises (see stakeholder involvement section for details). Two records were referred for screening by one of the authors. Another three records were identified by experts.

Inclusion and exclusion criteria

Inclusion criteria for participants, exposures/comparators, and outcomes were as per the Cochrane protocol [14]:

- Participants: aged ≤ 29 years or with extractable data on this subgroup (as per [14])
- Exposures/comparators: e-cigarette use, with or without nicotine; e-cigarette availability (encompassing interventions designed to affect accessibility and appeal)
- Outcomes: combustible tobacco use behaviours (including current use, initiation and cessation)

Three types of study were eligible for inclusion in this EGM:

1. Cohort studies that prospectively collected data on e-cigarettes and combustible tobacco smoking from the same individuals at a minimum of two time-points (we term these individual-level studies) [14].
2. Studies with repeated cross-sectional measures that evaluated combustible tobacco use in young people in relation to e-cigarette use or availability (or both) in a given population (we term these population-level studies) [14].
3. Systematic reviews defined according to the existence of the following: research question; replicable search strategy; screening methods and eligibility criteria; quality appraisal methods; and reporting of data synthesis [27].

Systematic reviews were not eligible for inclusion in the Cochrane protocol. We included systematic reviews published from 2015 onwards. The publication of the PRISMA-P checklist in 2015 brought significant methodological developments for systematic reviews [28]. This year also carried the introduction of technologically advanced e-cigarettes globally, concurring to a sharp rise in the use of e-cigarettes among young people in certain countries (e.g. the United States) [29]. Primary studies were considered from inception. We excluded studies that did not meet the above criteria.

Screening and selection of studies

Two researchers independently screened the titles and abstracts of all retrieved papers according to the inclusion criteria. Full texts were

subsequently screened by two independent researchers. We used Covidence© software for screening [30]. Any discrepancies were resolved through discussion, with a third reviewer when needed.

Primary studies were included irrespective of being included in a selected systematic review. The study selection process and reasons for exclusion for full texts are presented in the PRISMA flow-chart [31].

Assessment of study quality

We assessed the quality of eligible systematic reviews using a modified scoring of AMSTAR-2 (A *Mea*Surement Tool to Assess systematic Reviews) [32] based on its critical domains [33]. A rating of 'higher' or 'lower quality' was assigned to each review based on whether they had received 'yes' or a 'partial yes' to at least six of the seven critical domains of AMSTAR-2 (namely: the existence of and adherence to a protocol, a comprehensive search strategy, a list of excluded studies, an adequate risk of bias assessment technique, appropriate meta-analytical methods where necessary, the contemplation of risk of bias in discussing the results of the review and investigation of publication bias; see Supporting information, Appendix C) [32]. We had originally planned that quality appraisal would be completed by one reviewer and checked by a second, but were subsequently able to allocate resources to conduct the quality appraisal in duplicate. Discrepancies were resolved through discussion. We did not appraise the quality of primary studies as part of this EGM; this follows standard practice for EGM as per 3ies guidelines [1].

Data coding

We developed the coding form and code set and piloted it with 10 included studies [2]. We used Addict-O, an addiction ontology, to inform the vaping and smoking-related definitions of our EGM [34]. We used the PROGRESS-Plus framework to assess the extent to which outcomes addressed equity factors including place of residence (rural versus urban), race/ethnicity, occupation, gender, religion, education, socio-economic status and social capital, age and LBGQTIA+, mental health and health status (e.g. chronic condition). The categories were informed by the input of our advisory group.

Studies were also classified according to the 2022 World Bank Country Classification of income [35] and the regional grouping of member states of the WHO [36].

The coding procedures were further refined by interactive discussion between the core research team and after the consultation exercises with the advisory group.

Data coding was conducted in full by one researcher and a second researcher checked the coding of a random sample of 10% of studies and systematic reviews. The random sample of papers was selected by applying a RANDOM formula to the full list of records on MS Excel™. Any discrepancies were discussed, and refinements were made to coding in full. No specific data-checking approach was specified in the protocol, but this was selected by the core research team. Coding took place in EPPI-reviewer version 4 [37].

Developing the interactive EGM

All studies meeting the inclusion criteria were mapped into the EGM. We generated our interactive EGM using the EPPI-Mapper software© [38]. The EGM matrix represents e-cigarette exposures as rows and combustible tobacco use outcomes as columns. Each cell of the matrix displays included studies pertaining to that combination of exposure–outcome as circles or gaps where no studies were found. The size of the circles is proportional to the number of included studies and the colour represents the study type and quality of systematic reviews. Empty cells represent an absolute gap in evidence.

Users can refine their searches of relevant evidence on the map by using the filters based on key characteristics (e.g. country). Clicking on any given circle opens a tab with the corresponding list of references. Clicking on a reference allows the user to access its summary information and URL.

Stakeholder involvement

Our advisory group included stakeholders with expertise in the field of tobacco control and policy [policy officers, representatives of Cancer Research UK (CRUK), practitioners and researchers] from the United Kingdom, Canada and the United States. Members were identified from existing networks and through the CRUK E-cigarette Research Forum. An initial consultation helped inform the EGM framework, in particular key exposures and outcome categories, as well as filters. A preliminary version of the EGM was populated with a small sample of study data, and the advisory group had a chance to trial it and provide further

feedback. We integrated input from all stages of consultation to ensure that the EGM provided useful information to the target audience.

Patient and public involvement

Members of the public provided input on the original funding application for the project in which this EGM is integrated. We also conducted PPI activities to ascertain the usability of EGMs by members of the public.

Data analysis

We analysed the included studies descriptively across study design, time, geographical and economic distributions, populations, distribution by exposures and outcomes, distribution by equity factors and other characteristics.

RESULTS

Interactive evidence and gap map

The interactive EGM can be accessed in Supporting information, Appendix D and instructions on how to use it here. Figure 2 exemplifies a visualization of the interactive EGM, with the exposures and outcome categories displayed as the rows and column headings, respectively.

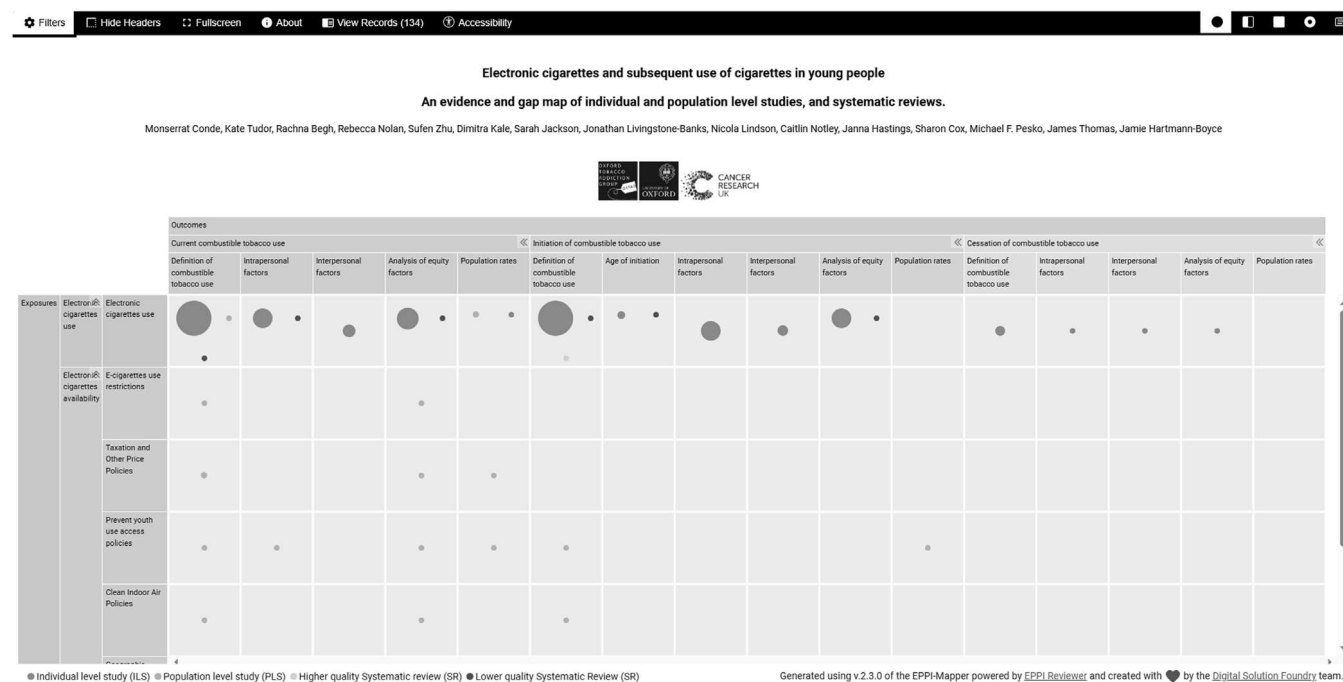


FIGURE 2 Interactive evidence and gap map (EGM) of included studies, displaying exposures and outcome categories and colour-coded study design (orange: individual-level studies, yellow: population-level studies, light blue: higher-quality systematic reviews, dark blue: lower-quality systematic reviews).

Search yield and included studies

After removing duplicates, 9060 records were screened at the title and abstract stage, with 126 being screened at full text. A total of 134 studies were included: eight systematic reviews and 126 primary studies. See Fig. 3 for the PRISMA flow diagram. Of the 126 primary studies, 24 looked at changes in smoking prevalence based on e-cigarette use prevalence and/or e-cigarette availability/regulations (population-level studies, which did not necessarily follow the same individuals over time) and 99 were cohort studies where individuals' e-cigarette use at baseline was analysed in relation to their smoking status at follow-up (individual-level studies).

Our included systematic reviews were published between 2017 and 2022. Individual-level studies and population-level studies were published between 2015 and 2023. Overall, 2021 was the year with most studies ($n = 23$), reflecting the relative recency of available research in this field.

Populations

Seventy-six studies used data originating from adolescents (aged 18 years), whereas 47 included young adult populations (aged 18–29 years). Eighteen included both people under and over the age of 18 years in their analyses. The EGM linked to this paper is segmented by these three age group filters.

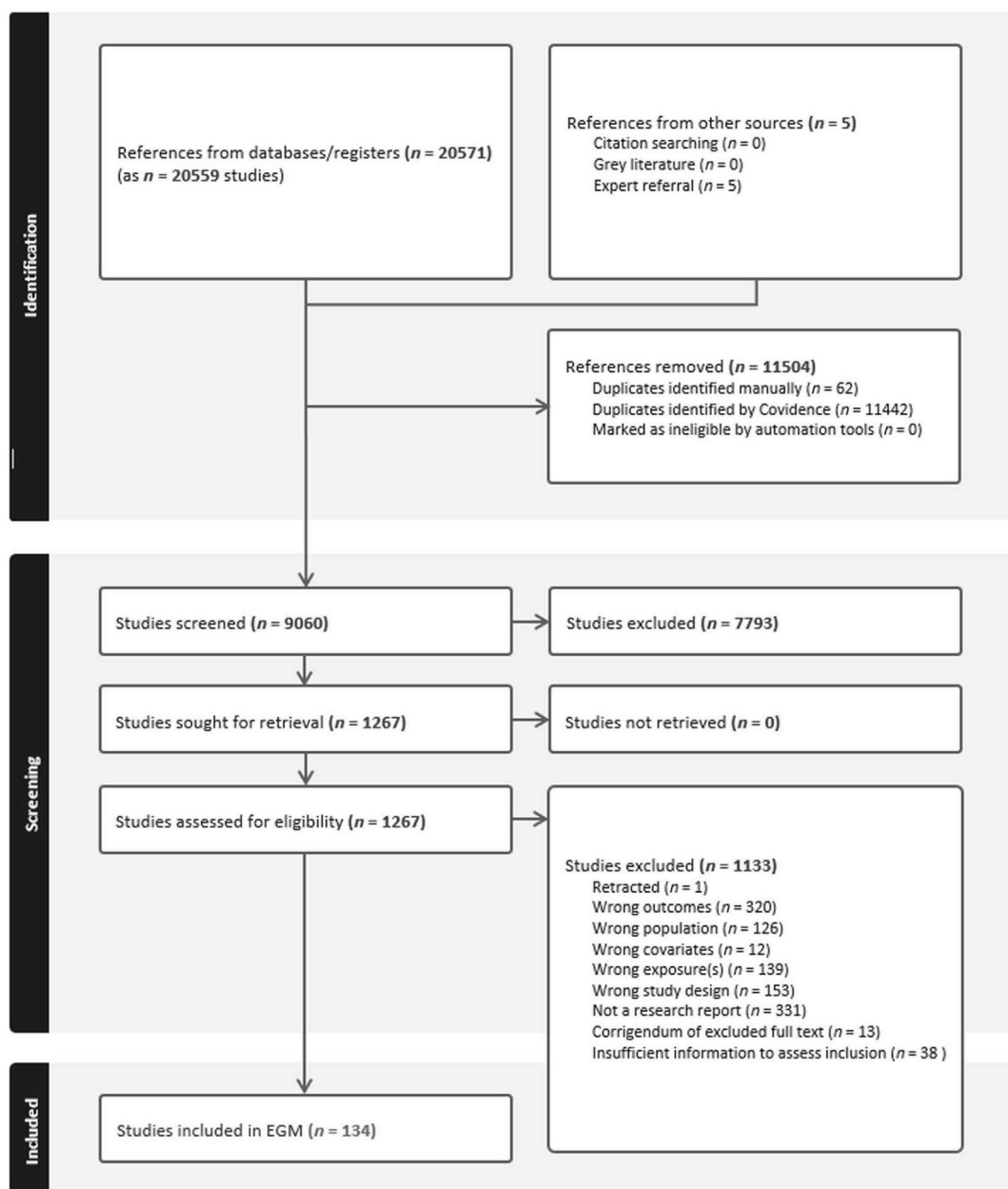


FIGURE 3 Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow-chart of search and screening process.

Distribution by exposures

Seven of the population-level studies, 99 individual-level studies and all systematic reviews explored e-cigarette use as the exposure.

Regarding e-cigarette availability, population-level studies were distributed among different regulatory measures. Eight studies pertained to policies to prevent youth e-cigarette use or access. Three population-level studies were mapped onto e-cigarette use restrictions, seven studies onto taxation and other price policies and two population-level studies onto clean indoor air policies. No studies focused upon geographic measures. Five population-level studies referred to other tobacco/nicotine policies.

Distribution by outcomes

Most studies assessed current combustible tobacco use ($n = 70$) followed by initiation of combustible tobacco use ($n = 56$) and cessation of combustible tobacco use ($n = 9$). No population-level studies were mapped into cessation of combustible tobacco use, and only three population-level studies addressed initiation of tobacco use outcomes. Individual-level studies were mapped across all three main outcomes.

The most frequently assessed category among all main outcomes was the definition of combustible tobacco use, followed by analysis of equity factors. Eleven population-level studies and one individual-level study reported population rates. Age of initiation was reported by seven individual-level studies and one systematic review.

Distribution by exposure–outcome combinations

E-cigarette use and definition of current combustible tobacco use was the most frequent exposure–outcome combination ($n = 67$). This was followed by e-cigarette use and frequency/intensity of combustible

tobacco use as a measure of initiation of combustible tobacco use ($n = 55$). Conversely, an absolute gap of evidence regarding the exposure–outcome combinations between e-cigarette availability categories and subsequent cessation of combustible tobacco use was detected. Most studies pertaining to e-cigarette availability as an exposure displayed combinations with measures of current combustible tobacco use, with three exploring initiation of combustible tobacco use.

Geographic and economic distribution

One hundred and six studies were set in the Region of the Americas, 14 studies in the European region and five studies in the south-east Asia region. There were no primary studies exploring five or more countries across regions. Six of the included systematic reviews addressed multiple regions. Most studies ($n = 99$) were set in the United States, with 11 and seven studies in the United Kingdom and Canada, respectively. The geographic distribution of studies is displayed on the choropleth map in Fig. 4.

Most studies only used data from high-income economies ($n = 126$). No studies were conducted using data from low-income countries, and only one study was set in a lower-middle-income country. Four studies were conducted in upper-middle-income economies. Three systematic reviews used studies from economies with different income levels. Countries, WHO regions and economies are filters in our EGM.

Distribution by equity factors

We assessed whether studies analysed the relationship between e-cigarette use or availability and subsequent cigarette use by PROGRESS-Plus characteristics. These are displayed as filters in our EGM. Even though most studies reported adjusting their statistical

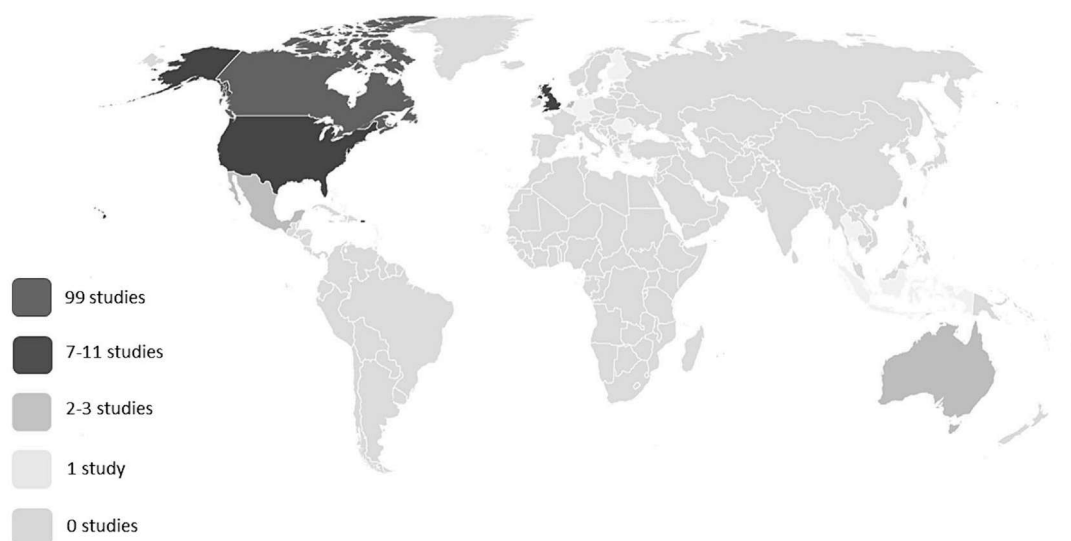


FIGURE 4 Choropleth map with distribution of studies by country.

BOX 1 Absolute evidence gaps identified in the EGM

- Geographic restrictions on e-cigarettes and their association with current combustible tobacco use, initiation of combustible tobacco use and cessation of combustible tobacco use
- E-cigarette use and its association with population rates of initiation of combustible tobacco use.
- E-cigarette use and its association with population rates of cessation of combustible tobacco use
- How associations between e-cigarette use/availability and subsequent combustible tobacco use vary based on social stratifying characteristics, including occupation, religion and LBGTQIA+.

models by equity factors, 80 studies did not report any equity-specific results. Thirty-nine studies analysed gender, 34 studies race/ethnicity and 25 studies did so for age. This was followed by 22 studies analysing socio-economic factors. Health status (e.g. chronic condition) was analysed in three studies and mental health in one study. Three studies analysed education, three analysed place of residence and two analysed social capital. We identified a gap regarding occupation, religion and LBGTQIA+. Box 1 summarizes the absolute evidence gaps identified.

Other characteristics

We mapped included studies according to other characteristics coded as separate filters in the EGM. We assessed whether studies reported the type of e-cigarette devices, using the Addict-O ontology as a classification system [34]. Five studies focused upon nicotine-containing e-cigarettes, three studies referred to closed-system e-cigarettes, two studies on e-cigarettes with an open system, one study on flavoured e-cigarettes and one study on an e-cigarette pod device. One hundred and fourteen studies did not report data on e-cigarette device type. We also ascertained the longitudinal data sets from which the study data originated. Twenty-eight records used data from the Population Assessment of Tobacco and Health—PATH study (USA), 11 from the National Tobacco Survey—NYTS (USA), five from the Truth Longitudinal Cohort—TLC (USA), Monitoring the Future Study—MTFS (USA) and Project M-PACT (USA), respectively. Four studies used data from COMPASS (Canada). The rest of the records, where applicable, used data from various other longitudinal data sets, multiple data sets ($n = 15$) or collected original data ($n = 25$).

Quality of included systematic reviews

We assessed the risk of bias of all included systematic reviews ($n = 8$). Using AMSTAR-2 ratings, two reviews were judged to be of 'low'

quality and six reviews of 'critically low' quality. When applying the adapted rating system [33], each of the reviews were classified either as 'higher' ($n = 3$) or 'lower' ($n = 5$) quality based on whether they scored a 'yes' or 'partial yes' to at least six of the critical domains of AMSTAR-2. None of the eight reviews provided a justified list of excluded papers, which downgraded their overall ratings, and many did not report the sources of funding of included primary studies. Please see Supporting information, Appendix C.

DISCUSSION

This is the first EGM, to our knowledge, to report on e-cigarette use/availability and subsequent combustible tobacco smoking in people aged 29 years and under. Our EGM can be used in multiple ways by selecting and describing the available evidence and gaps in this topic area. We mapped 134 studies, providing a visualization of this ever-evolving field of research and highlighting the nature of the existing literature which is predominantly composed of observational studies. We mapped the studies into exposure–outcome combinations defined by our EGM framework, which builds upon existing research, and was developed through consultation exercises with our advisory group of experts in the field of e-cigarettes and tobacco control. The EGM filters allow users to narrow their focus upon each intersection of exposures and outcomes by selecting characteristics of interest. E-cigarette use and subsequent frequency/intensity of current combustible tobacco use or initiation of combustible tobacco use were the most frequent exposure–outcome combinations. It is important to highlight that these clusters merely suggest that these exposure–outcome combinations have been explored more frequently, irrespective of the strength of the available evidence. Moreover, clusters of studies in one cell may still warrant further research. Not only may there be opportunities to conduct systematic reviews and other syntheses of the identified clusters of primary studies; the lower quality of most of the systematic reviews also emphasizes opportunities to replicate these following more rigorous methods. It is also important to consider the real-world significance of future research initiatives when analysing relative gaps (intersections with a lower number of studies). For example, conducting further studies exploring the influence of e-cigarette availability measures in various contexts (e.g. in areas with high or low levels of existing e-cigarette usage) could prove particularly valuable from a policy viewpoint.

When considering geographical distribution, studies with data from the United States led the evidence, followed by the United Kingdom and Canada. Thus, nearly all evidence emerged from western high-income countries. The absolute gap regarding low-income countries is stark. The low diversity of overall geographical clusters of evidence also represents a gap in further reflecting the influence of different regulatory landscapes in e-cigarette use and subsequent combustible tobacco use in young people. The geographic distribution of the available evidence does not reflect the areas of the world with the greatest burden of tobacco related diseases and death [39, 40]. A more comprehensive geographic distribution could

contribute to a clearer understanding of the role of global health disparities in this phenomenon. It would also facilitate a clearer understanding of underlying socio-cultural aspects related to young people's patterns of use and transitions. Interactions between exposures, intersectionality (e.g. race/ethnicity, gender, SES) and contextual factors in a country may result in unique patterns of outcomes, which may not be fully transferrable to other international contexts.

The existence of large nationally representative longitudinal study databases (e.g. PATH), which are openly accessible for secondary research with minimal cost and resource burden, may also contribute to this over-representation of evidence from the United States; consequently, the dearth of these data sources contributes to under-representation from other countries. Cross-sectional studies tend to be more common in middle- and low-income settings. The use of the same waves of data with different analytical approaches, and various standards of reporting, among multiple independent studies may pose challenges when interpreting the existing body of evidence. The value of the information arising from longitudinal studies builds up over time, granting a deeper exploration of use transitions and underlying factors. Similarly, cohort studies—which comprise a significant number of the included individual-level studies—also present limits to representativity. Future planning of primary research should take these aspects into consideration.

Previous research has shown that e-cigarette awareness, ever use and current use may be more prevalent among male adolescents, younger adults of white ethnicity and people who attained intermediate to higher levels of education [41]. These groups are also more exposed to e-cigarette products and advertising [25]. However, most mapped studies did not assess possible differences in outcomes among PROGRESS-Plus indicators (see Box 1). Sex (male/female), race/ethnicity, age and socio-demographic status were the indicators most often considered in analyses. Being a member of the LGBTQIA+ community has been linked with higher rates of e-cigarette use [25, 41]. Therefore, the absence of analyses focusing upon this indicator in our included studies was noteworthy. Health equity considerations should be addressed in detail in future studies exploring vaping–smoking transitions in young people. This will promote a better understanding of how such phenomena interact with tobacco-related disparities to adequately inform policy and decision-making.

Furthermore, we also identified that most studies do not report e-cigarette characteristics, including nicotine content. Future primary studies should assess this, as such characteristics may influence the appeal of these products and pose different levels of risk of addictive behaviours [42].

We applied rigorous literature searching, screening and coding methods following the latest guidance on developing EGMs [1, 2]. Co-creating our EGM framework with an advisory group is also a major strength and unique feature of this work. To the best of our knowledge, this EGM is one of the first to be conducted of exposures, which may play a role in expanding and illustrating the applicability of these versatile tools. We have also contributed to developing new taxonomical definitions regarding e-cigarette availability for Addict-O in the process.

However, there were some limitations. Beyond trial registries, our search strategy did not include grey literature repositories which may have introduced some bias, particularly considering potential working documents and reports from low- and middle-income settings. We have also limited our search to international databases primarily indexed in English; however we did not limit our inclusion criteria by language of publication, so will have included non-English language records where we have found them. E-cigarettes were first developed in China, so it could be expected to find more evidence arising from this nation. We acknowledge that there are various Chinese literature databases which could contain relevant studies conducted in China. While searching non-English language databases was outside the scope of our project, through our search of CENTRAL (via the CTAG Specialised Register) we covered the ICTRP, which covers a range of non-English language trial registries, including the Chinese Clinical Trial Registry (ChiCTR), which may help to partially mitigate this. Despite the potential limitations of our searches, we designed and conducted them in line with Cochrane best practice and are confident that the identified literature can serve as a representative basis to characterize trends, gaps and other characteristics of the available evidence on e-cigarette use/availability and subsequent combustible tobacco use in young people.

We only appraised the quality of the included systematic reviews, as these studies can be arguably more useful to support decision-making [1]. Therefore, no conclusions regarding the quality of the population- and individual-level studies can be drawn based on this EGM. Appraising the quality of these studies was outside the scope of this EGM, but users will be able to access this information on a linked upcoming review [14]. These resources will be linked on the project webpage.

We did not perform data coding in duplicate, but conducted a coding checking exercise which mitigated any biases arising from this. Categorizing exposures and outcomes was challenging, due to the wide variation in reporting and taxonomical approaches in this topic area. However, our coding approach was preceded by robust piloting and consensus among the core research team. In addition, the included studies evaluate a heterogenous range of exposures relating to accessibility, availability, appeal and use, and often to more than one of these constructs simultaneously. We used a coding framework co-developed with our advisory group, but a different group may have opted for different language and descriptors.

This is a rapidly evolving field of research and practice with new products being constantly introduced in the market, generating substantial concern about young people's use, and a continuous need for policy measures to tackle these issues. We suggest that this EGM works as an interactive tool to consult key literature, according to the evidence needs and interests of the user. This EGM can be used to inform future primary research and evidence syntheses, as well as funding priorities and policies.

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ACKNOWLEDGEMENTS

This research work was funded by Cancer Research UK under Grant Number PPRCTAGPJT\100002. The content is solely the responsibility of the authors and does not necessarily represent the official views of the funder. The authors would like to acknowledge the contributions of Dr Teteh Champion, Social and Behavioural Research, Cancer Research UK, Camille Guertin, PhD, Tobacco Control Directorate, Health Canada, Ottawa, ON K1A 0 K9, Canada; Christine Czoli, PhD, Tobacco Control Directorate, Health Canada, Ottawa, ON K1A 0 K9, Canada and members of the advisory group and public contributors.

DECLARATION OF INTERESTS

M.C., J.H., S.Z., R.N., J.L.B., K.T., R.B. and J.T. declare no competing interests. J.H.B. declares current funding from the Food and Drug Administration; no other competing interests. C.N. is an associate editor at *Addiction* and the first author of an included study. C.N. was not involved in the screening, coding or quality appraisal of this study; no

other competing interests. S.C. is a senior editor at *Addiction* and the co-author of an included study. S.C. was not involved in the screening, coding or quality appraisal of this study; no other competing interests. S.J. is a senior editor at *Addiction*; no other competing interests. D.K. is an associate editor at *Addiction*, no other competing interests. N.L. is an associate editor at *Addiction*; no other competing interests. M.P.'s research is supported by the National Institute on Drug Abuse of the National Institutes of Health under Award Number R01DA045016. M.P. declares current funding from the Food and Drug Administration, the American Cancer Society, University of Kentucky Institute for the Study of Free Enterprise and Health Canada. M.P. is the first author and co-author of included studies and was not involved in the screening or coding of these studies; no other competing interests.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

How to cite this article: Conde M, Tudor K, Begh R, Nolan R, Zhu S, Kale D, et al. Electronic cigarettes and subsequent use of cigarettes in young people: An evidence and gap map. *Addiction*. 2024. <https://doi.org/10.1111/add.16583>