

## Electronic cigarette survey characteristics

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### ABSTRACT

**Introduction:** Electronic cigarettes (EC) remain a controversial topic with uncertainty about harm reduction in current smokers, their efficacy in smoking cessation, their potential for addiction, the need for regulation, and the type of information needed to educate the public about the benefits and hazards of EC. Multiple medical institutions and organizations have conducted surveys to investigate the demographics and perceptions of EC consumers in adult and youth populations. However, it is unknown whether these surveys use consistent, reliable, or accurate measures for EC use.

**Methods:** We analyzed 13 survey articles identified during a review of the use of EC during smoking cessation programs to determine the characteristic features of the surveys and to determine how frequently they satisfied the measurement of important core items suggested by recent articles.

**Results:** Our analysis focused on 13 studies. These studies represented the work of 13 separate research groups and were published in 10 different biomedical journals with a median impact factor score of 4.1. The median number of participants in the studies was 2,624 (Q1-Q3: 662–6,356); the number of participants ranged from 179 to 19,414. The median number of e-cigarette users in the surveys was 840 (Q1-Q3: 256–3,849). All studies provided clear study goals in their introduction. Five surveys used on-line methods to collect information; four studies provided limited information about the reliability of their data. All studies reported study outcomes and considered limitations. Five studies had limited external validity. None of the surveys collected a complete set of core information recommended by recent authorities on survey methodology for EC.

**Conclusions:** The surveys reviewed in this project had significant variability in study design, survey population, and study goals. Consequently, comparisons across studies become difficult and limit the external validity of survey studies on EC.

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## 1. Introduction

For centuries, cigarettes have remained a highly effective and simple method to administer nicotine [1]. However, burning tobacco generates carcinogens, oxidizing agents, and other toxins, which damage organs and increase the risk for several cardiopulmonary disorders [1]. In response to these concerns, the tobacco industry has aggressively marketed electronic cigarettes (EC) in Western markets as safer and cheaper alternatives to traditional cigarettes [1]. Electronic cigarettes use a battery-powered aerosolizer to disperse ultra-fine particulates containing propylene glycol, vegetable glycerin, nicotine, and other flavoring agents without producing combustion products [1]. Several Western countries, e.g., England, have approved EC as a safer and effective method for smoking cessation, and some countries have approved EC use in pregnant women [1].

Despite their wide acceptance and increasing sales, EC remain a controversial topic with uncertainty about harm reduction in current smokers, their efficacy in smoking

cessation, their potential for addiction, their potential for long-term harm, the need for regulation and policies, and the type information needed to educate the public about the benefits and hazards of EC [2]. Several meta-analyses and clinical studies showed that EC increase endothelial dysfunction, arterial stiffness, and the long-term risk for coronary events [2–5]. A recent high profile case series report and editorial highlight the growing epidemiological phenomenon of EC-related lung injury and hospitalization in the USA, noting further a current lack of attribution on the exact precipitating cause of these illnesses [6,7]. At the time of this writing, six state or city health departments in the USA have reported deaths associated with e-cigarette use [8–11]. The World Health Organization has rejected EC use for smoking cessation and adopted an abstinence-only approach along with government policies focused on tax increases, advertising bans, and media campaigns against EC products [12]. The FDA has increased their efforts to regulate EC by restricting youth access, conducting retailer and

manufacture checks, increasing requirements for electronic cigarette manufactures, requiring pre-marking reviews, and preventing youth tobacco use with enforcement actions, policy, and education [13].

Hammond et al. recently reported the prevalence of vaping and smoking among adolescents from 16 to 19 years of age in Canada, England, and the USA using repeat cross-sectional surveys in 2017 and 2018. This study reported that the prevalence of vaping during the last 30 days prior to the survey increased in Canada from 8.4% to 14.6% and in the USA from 11.1% to 16.2% but not in England [13]. Companies that make EC have expanded their marketing efforts toward these younger users who often perceive EC as novel and harmless [1]. This change in marketing strategy has important implications for the health of adolescents and young adults and has raised concerns that EC will function as gateway drugs to the use of conventional cigarettes and other illicit drugs. Therefore, information about the number of EC users, their characteristics, their use pattern, and their perceptions about these devices becomes essential to establish use regulation and develop information to inform the public.

Multiple medical institutions and organizations have conducted surveys to investigate the demographics and perceptions of EC consumers in adult and youth populations [14]. Surveys about EC use can provide information to the public, to health authorities, to regulatory agencies, and to practicing clinicians. The utility of these surveys depends on multiple factors, including the study population, sample collection, survey questions, and reliability, which potentially limits the interpretation and application of the surveys to inform public policy [14]. Recent publications have outlined core items that are potentially important in these surveys [14–16]. Pearson and coauthors recommended eight core items to assess e-cigarette use in population-based surveys to allow accurate comparisons across different jurisdictions [16]. Their conclusions were based on a series of meetings sponsored by the Robert Wood Johnson Foundation which included 65 individuals from 15 countries. Weaver et al. reviewed national tobacco use surveys and projects supported by the federally funded Tobacco Centers of Regulatory Science to identify important measures of electronic cigarette use patterns to use in surveys by tobacco researchers [14]. These included ever use, frequency, device type, flavors, and nicotine content. Important publications used in this study were published between 2014 and 2016. Gibson et al. collected and reviewed 371 survey items on electronic cigarette perceptions from 7 of the 14 Tobacco Centers of Regulatory Science sites [15]. Their analysis resulted in four specific categories of perception, including benefit, harm, addiction, and social norm.

We analyzed a small set of research articles reporting surveys of EC use to determine the characteristic features of the surveys and to determine how frequently they satisfied the core measurement requirements suggested by the three review articles discussed above. We also determine how frequently these surveys provided the key information about the central elements of any survey project. These elements would include survey design, survey reliability, internal validity, external validity, and construct validity (an overview of a project goals and outcomes).

## 2. Methods

A PubMed search was performed for articles with publication dates between 1/1/2007 and 1/31/2015 using the following search term within title/abstract: ‘Electronic cigarette\*’, ‘e-cig\*’, ‘electronic nicotine delivery’, ‘electronic nicotine delivery device\*’, ‘ENDD’, ‘Electric cigarette\*’, ‘Electric nicotine delivery’, ‘Electric nicotine delivery device\*’. A total of 721 articles were recovered, and the titles were reviewed to identify potentially relevant articles. The titles and abstracts were then reviewed to identify articles that considered the use of EC as cessation aids for conventional cigarette smoking. This review was restricted to articles published in English. Information collected from these articles was used to create a narrative review of EC and to do a meta-analysis on the use of EC in smoking cessation [17,18]. A subset of these articles was also used to develop a presentation at the Southern Society of Clinical Investigation meeting in 2016 (Pane JD, Orellana-Barrios MA, Payne D, Nugent K, Nugent R. The Use of Electronic Cigarettes as Cessation Aids and in Conjunction with Conventional Cigarettes in Adults: A review of the Survey Evidence (SSCI Regional Meeting, New Orleans LA, Feb 2016; 10.1136/jim-2015-000035.402). The articles used in this meeting presentation were used to develop this project [19–31]. No other criteria were used to select articles used in the current analysis, and these selections were not based on research group or publication year.

Analysis of survey design includes four core elements: reliability, internal validity, external validity, and construct validity [32,33]. Reliability measures the consistency of survey results. This can be determined by including 2–3 questions in the survey which should give the same result or answer. This can also be measured by test/retest protocols. Internal validity measures the degree to which the questions in the survey measure what they are designed to measure. External validity measures the degree to which survey results can be extrapolated to other groups at different locations, in different timeframes,

or with different demographics. Construct validity measures the degree to which the survey provides interpretable information about the underlying question, as, for example, *Why do you use electronic cigarettes?* Each article reviewed in this study was analyzed by two authors (JK, KN) for content and by one author (JD) for study design. Ideally, the survey authors should report their assessment of the core elements in their publication. In the absence of these conclusions, the authors of this review made decisions about these core elements based on their reading of the manuscript and analysis of study outcomes in relationship to the study goals.

### 3. Results

Our analysis focused on 13 studies. These studies represented the work of 13 separate research groups and were published in 10 different biomedical journals with a median impact factor score of 4.1 (Quartile 1 < Q1/>-Quartile 3 < Q3/>: 2.5–4.6). The median number of participants in the studies was 2,624 (Q1–Q3: 662–6,356); the number of participants ranged from 179 to 19,414. The median number of e-cigarette users in the surveys was 840 (Q1–Q3: 256–3,849). Based on information from seven surveys, the median number of participants in the

age range of 26 to 50 years was 51% (Q1–Q3: 38.2–62.4%); more participants were males (median: 53.0%; Q1–Q3: 45.1–55.1%; 9 surveys). The median percentage of Caucasian participants was 75.8% (Q1–Q3: 65.7–86.7%; 6 surveys). Slightly less than one half of the participants were in college or had a college degree (median: 48.8%; Q1–Q3: 34.2–64.5%, 10 surveys); the median percentage of participants with incomes greater than 60,000 dollars per year was 27.1% (Q1–Q3: 24.5–50.1%; 6 surveys).

The study goals for the surveys are summarized in Table 1. The first authors for these publications had advanced terminal degrees and worked either in universities or at research centers. Survey participants were from multiple countries; six surveys were exclusively from the USA. The surveys focused on interests in and beliefs about e-cigarette (7 surveys), or on their use (3 surveys), or on potential benefit in smoking cessation (3 surveys).

The survey design and study population, study location, contact method and language, and answer formats are reported in Tables 2 and 3. Six surveys provided information on the response rate. The surveys used short answer questions in clear language that could either be answered with a yes or no or on a Likert scale. Only four surveys reported any information relevant to reliability testing (Table 4). None of the surveys directly

**Table 1.** Study goals of surveys analyzed in this project.

Berg [19] <sup>a</sup> . How often are current smokers interested in using or switching to e-cigarettes and what are the correlates of interest in using or switching to e-cigarettes? PhD <sup>b</sup> , University <sup>c</sup> , JS-nicotine, drug, tobacco research, IF-4.6
Brown [30]. How effective are e-cigarettes compared to nicotine replacement therapy bought over-the-counter in smokers attempting to stop smoking? PhD, University, JS-nicotine, drug, tobacco research, IF-6.9
Christensen [21]. What is the profile of the e-cigarettes users in adults in Kansas and is there an association with quit attempts and abstinence? Masters Public Health, State Depart Health, JS-environmental, public, preventive health, IF-3.4
Coleman [22]. Is the use of e-cigarettes in young non-smokers associated with being open to future conventional cigarette smoking? Masters Public Health, US Food Drug Administration, JS-nicotine, drug, tobacco research, IF-4.6
Farsalinos [23]. What are the characteristics of e-cigarettes use and the perceived benefits? MD, Research Center, JS- Environmental, public, preventive health, IF-1.5
Goniewicz [24]. What are the reasons and patterns of use of electronic cigarettes among users in Poland and what are their attitudes towards e-cigarettes? PhD, Research Center, JS-nicotine, drug, tobacco research, IF-2.9
Hiscock [25]. How often do clinicians involved in the smoking cessation programs receive questions about e-cigarettes? Do these clinicians consider e-cigarettes a positive or negative development? PhD, Research Center, JS-nicotine, drug, tobacco research, IF-2.1
Hummel [29]. What is the prevalence of e-cigarettes awareness and use and what are the characteristics of tobacco smokers who have used e-cigarettes in the Netherlands? PhD, University, JS-nicotine, drug, tobacco research, IF-4.2
Kasza [26]. What are the demographics and smoking-related predictors of the use of unconventional tobacco products, including e-cigarettes, in cigarette smokers? What are the predictors of the use of these products as an alternative to quit smoking? MA, Research Center, JS-nicotine, drug, tobacco research, IF-4.6 MA, Research center
Lechne [27]. What is the effect of the duration of e-cigarettes use on current cigarette smoking, the dependence on e-cigarettes, the frequency of use of e-cigarettes, and the strength of nicotine solution? Masters of Science, University, JS-nicotine, drug, tobacco research, IF-4.6
Li [28]. What is the use, perception, and acceptability of e-cigarettes in New Zealand? PhD, Government agency, JS- broad coverage, IF-0.7
Martinez-Sanchez [31]. What is the support for and the correlates of the use of e-cigarettes and indoor work places and selected public and private places? PhD, Research Center, JS-broad coverage, IF-2.8
Choi [20]. What are the characteristics associated with awareness and use of e-cigarettes among young adults? What are the characteristics associated with selective perceptions of electronic cigarettes? PhD, University, JS-environmental, public, preventive health, IF-4.1

<sup>a</sup>Reference number.

<sup>b</sup>Terminal degree of first author.

<sup>c</sup>Organization employing first author.

JS, journal scope; IF, journal impact factor.

**Table 2.** Study design.

Author, reference	Study population # responses	Age/gender Race/ethnicity	Location
Berg [19] 2015	Cross sectional survey of online panel 2,501	Y, Y Y	USA, oversample Southeast USA
Brown [30] 2014	Cross sectional representative sample 5,863	Y, Y N	England
Christensen [21] 2014	Population-based random sample 9656	Y, Y Y	Kansas, USA
Coleman [22] 2015	Nat Adult Tobacco Survey, nationally representative, subgroup 18–29 4,310	Y, Y Y	USA
Farsalinos [23] 2014	E-cig users, current, former, never cig smokers 19,414	Y, Y Translation into 10 languages	Europe, Americas, Asia, Australia, Africa
Goniewicz [24] 2013	E-cig smokers 179	Y, Y N	Poland
Hiscock [25] 2014	Smoking cessation advisers 587	N, N N	England
Hummel [29] 2015	Current smokers 6,602	Y, Y N	Netherlands
Kasza [26] 2014	Adult smokers 6,110	Y, Y Y	USA
Lechner [27] 2015	Customers – E-cig retail locations 159	Y, Y Y	Oklahoma, USA
Li [28] 2013	Current and recent quitters 840	Y, Y Y	New Zealand
Martinez-Sanchez [31] 2014	Representative sample of adults in Barcelona 736	Y, Y NR	Barcelona, Spain
Choi [20] 2013	Population-based prospective cohort 2,624	Y, Y Y	Minnesota and surrounding states, USA

Y, yes; N, no; NR, not reported.

addressed internal validity, but all summarized study outcomes and limitations (Table 5). Based on study goals (Table 1) and study outcomes (Table 5), the authors of this review reached conclusions regarding external validity of the various studies, and these are summarized in Table 4. Information in Table 6 outlines our analysis of the completion rates for the core items identified in three recent articles which provided recommendations for survey studies on EC. Most studies did not collect a complete set of information relevant to these recommendations, and the percent completion based on one point per item summed for all 13 surveys was 43%.

#### 4. Discussion

Our analysis indicates that the surveys in our sample had different designs, different objectives, and varying numbers of participants and did not always report information relevant to reliability and validity. The lack of

**Table 3.** Study contact method and answer format.

Author, year Reference #	Contact method; Response rate [8]	Language	Answer reporting format
Berg [19]	On line survey; 32% participation rate overall	English	Y, N, Likert
Brown [30]	Face-to-face interviews; NR	English	Y, N
Christensen [21]	Telephone – landline, cell NR	English	Y, N, Likert
Coleman [22]	Telephone; 44.9%	English	Y, N, Likert
Farsalinos [23] Y, N, Likert	Web site for EC advocates; NR	10 different languages	languages
Goniewicz [24]	Internet – 16 discussion forums, retail outlets – 5; NR	Polish	Multiple short answers
Hiscock [25]	2 on line surveys in 2011 and 2013; 5.6%	English	Multiple choice, free text
Hummel [29]	Web database interview NR	Dutch	Y, N, Likert
Kasza [26]	Interview by telephone; 21–35%	English	Y, N, how often
Lechner [27]	Direct contact NR	English	Usually single answer
Li [28]	Random digit dialing, interviews; NR	English	Y, N, Likert
Martinez-Sanchez [31]	Face-to-face interviews; 72.9%	Spanish	Y, N, Likert
Choi [20]	Computer-assisted telephone interview; 68.9%	English	Y, N, Likert

<sup>a</sup>Response rate calculations were not uniform and depended on the study.

Y, yes; N, no; NR, not reported.

consistent and reliable methodology for EC survey research potentially limits our understanding about the safety of EC and their effectiveness in smoking cessation and limits the comparison of important information in different geographical locations, cultures, and economies. [34,35]. Overall, research on EC users and EC use patterns trails the rapid development of new products and the increasing prevalence of EC use in the public [34,35]. Little research has investigated the differences in the craving and addiction levels associated with traditional cigarettes and EC [34,35]. The popular belief that EC reduce craving and increase cigarette cessation is largely unsubstantiated [34,35] and requires randomized controlled studies. Furthermore, most EC survey research does not have a reliable method to compare addiction and dependence between traditional cigarette and EC users [34,35]. Therefore, many policy makers, health educators, clinicians, and members of the public have a poor understanding of EC and their risks and benefits [5,36–41].

Although closely associated with conventional cigarette use, EC consumption patterns may present qualitative measurement difficulties secondary to differing quantifiable units (e.g., number of cigarettes vs. amount of EC use or cartridges consumed). Further, the varia-

**Table 4.** Study analysis and quality.

Author, reference	Reliability testing	Internal validity	External validity	Descriptive statistics	Modeling statistics
Berg [19]	Yes	ND	Yes, at country level	Y	Logistic regression, cluster analysis
Brown [30]	NR	ND	Limited to smokers trying to quit	y	Logistic regression
Christensen [21]	NR	ND	Yes, at state level	Y	Logistic regression
Coleman [22]	Reported some missing data	ND	Yes, young adults at country level	Y	Logistic regression
Farsalinos [23]	NR	ND	Yes, E-cig users world wide	Y	Logistic regression
Goniewicz [24]	Eliminated surveys with inconsistent answers	ND	Limited, small sample size	Y	N
Hiscock [25]	Did a limited pilot study	ND	Limited, unique survey group	Y	N
Hummel [29]	Reported some missing data	ND	Yes, at country level	Y	Logistic regression
Kasza [26]	NR	ND	Yes, at country level	Y	Logistic regression
Lechner [27]	NR	ND	Limited, unique survey group	Y	Linear & logistic regression
Li [28]	NR	ND	Yes, at country level	Y	Logistic regression
Martinez-Sanchez [31]	NR	ND	Limited, at city level	Y	Logistic regression
Choi [20]	NR	ND	Yes, young adults	Y	Linear models

Y, yes; N,no; NR, not reported; ND, not discussed.

**Table 5.** Study conclusions and limitations.

Berg [19]. Current smokers have a higher interest in using e-cigarettes than smokeless tobacco for smoking cessation, harm reduction, and novelty. Limitations include sample from a consumer panel, cross-sectional study design, and self-reporting.
Brown [30]. Smokers trying to stop smoking without professional support are more likely to report abstinence if they use e-cigarettes than smokers who use a nicotine replacement product or no aid. Limitations include abstinence not verified, recall data, multiple products available for nicotine replacement therapy and electronic cigarettes.
Christensen [21]. Electronic cigarette use is associated with cessation attempts but not with cigarette abstinence. Limitations include cross-sectional study design, self-reporting, underreporting.
Coleman [22]. This study demonstrates that the 'ever use' of e-cigarettes is associated with being 'open' to smoking cigarettes. Limitations include cross-sectional survey design, observational data, self-reporting, limited sample size of young adults who have never tried cigarette smoking.
Farsalinos [23]. Electronic cigarettes are used as long-term substitutes for smoking. Limitations include convenience sample of dedicated users.
Goniewicz [24]. Electronic cigarette users in Poland primarily use these products as an aid to smoking cessation and to reduce harm. Limitations include no control group to evaluate adverse effects, small sample size.
Hiscock [25]. There is substantial interest in using e-cigarettes to support quit attempts by smokers seeking smoking cessation services. There is no consensus among advisers as to whether or not e-cigarettes are a positive or negative development. Limitations include small sample size, recall needed to describe clients' experiences, uncertain basis for practitioners' opinions.
Hummel [29]. Over time e-cigarettes are increasingly used by Dutch smokers. Common motivations include to reduce tobacco smoking and to use alternative less harmful nicotine products. Limitations include cross-sectional data, small sample size, a limited number of reasons available to choose for use, uncertain timing for use of smoking cessation pharmacology.
Kasza [26]. Fewer than 15% of cigarette smokers reported using unconventional tobacco products. The use of these products was more prevalent in adults aged 18–24. Limitations include survey response rates.
Lechner [27]. The daily consumption of traditional cigarettes decreased with increasing duration of e-cigarette use. Limitations include the following: The participants were identified at the retail e-cigarette stores, cross-sectional design, retrospective reporting of behavior, self-reporting.
Li [28]. The use of e-cigarettes by smokers and recent smokers is uncommon in New Zealand. Limitations include use of the question on "ever-purchase" instead of "ever-use", asked about the acceptability of e-cigarettes as a cheaper alternative to tobacco cigarettes and a cessation product but not about other purposes, general lack of knowledge of e-cigarettes in survey population.
Martinez-Sanchez [31]. One half of the general population in Barcelona did not support the use of e-cigarettes in work places or public places. Limitations include overestimation of older participants in the survey, non-uniform information regarding of e-cigarettes.
Choi [20]. More than two thirds of young adults in this sample were aware of e-cigarettes. Perceptions included help with smoking cessation, less harm, and less addiction. Limitations included cross-sectional not longitudinal design, regional sample, self-reporting.

tion in EC delivery devices and products, including differing levels of nicotine and other additives, presents a challenge for measuring precise differences across a large sample of users who may pay minimal attention to such details [42,43]. A recent case series report suggests that EC-related pulmonary disease may be associated with the use of EC devices for the delivery of tetrahydrocannabinol and cannabidiol [6]. This finding suggests that future surveys on EC use will need to ask about use of non-nicotine EC products. However,

determining the use patterns may be complicated by the variable legal status of cannabis products across study locations.

In the USA, the lack of information about EC and public health has resulted in EC regulatory policies that vary significantly across state and local jurisdictions [44]. This variation reflects the controversy concerning whether EC could increase the rates of smoking cessation, sustain smoking cessation, and improve public health [44]. Different clinical studies have shown contradictory

**Table 6.** Study analysis based on current recommendations.

Core items in population surveys – Pearson et al. (8 core items) [16]						
Studies	Ever use	Frequency <sup>a</sup>	Harm	Former use	Device	Nicotine
13 Total	13	6	9	10	1	4
<b>Survey measures – Weaver et al. (5 core items) [14]</b>						
Studies	Ever use	Frequency <sup>b</sup>	Flavors	Device	Nicotine	
13 Total	13	5	0	1	4	
<b>Perceptions – Gibson et al. (4 core items) [15]</b>						
Studies	Benefit	Harm	Addiction	Social norm		
13 Total	8	6	3	3		

<sup>a</sup>Frequency was defined as how often do you currently use EC (daily, weekly, monthly, etc.).

<sup>b</sup>The suggested definition was the number of days EC were used in the last 30 days.

results concerning EC and smoking cessation. A study examining daily EC users found that 22% quit smoking after one month and 46% after one year [45]. However, a similar study in California suggested EC smokers were less likely to quit tobacco or smoking-related products [46]. Furthermore, there is little research on whether EC smoking adversely affects public health through either direct consumption or second-hand smoke from EC combustion products [44]. This has further compounded the confusion and uncertainty among patients whether EC pose a significant risk to their families' health or themselves. Marks et al. surveyed pregnant women and found that more than half did not know whether EC contained nicotine, were addictive, or posed a significant health risk to their fetus [38]. Even medical professionals have inadequate basic knowledge about the use and perceptions of EC on patient health [36]. A study including 853 medical, nursing, pharmacy, public health, or allied health students found that they were likely to try or regularly use EC and that many perceived EC as less expensive, less addictive, and less dangerous than traditional tobacco products [36]. Interestingly, medical students had less education about the epidemiology and health effects of EC than other health profession students [36]. Therefore, the uncertainty of scientific and clinical studies on EC use has prevented policy makers, health professionals, and the general public from establishing a cohesive response to both regulate EC use and understand their risks and benefits.

Overall, more research is required to understand the use patterns, the addiction potential, perceptions, and basic knowledge about EC in health professionals and the public. Several investigators have argued for the development of reliable and valid measures of EC dependence to inform public health officials of the long-term impact and potential costs of EC [2,47–49]. In response, researchers have developed alternatives to or modifications of existing tobacco addiction instruments for EC research [34,35]. The studies found that the Fagerström Test of Cigarette Dependence (e-FTCD), the e-cigarette Wisconsin Inventory of Smoking Dependence Motives (e-WISDM), and the Penn State Electronic Cigarette Dependence Index (PS-ECDI) had better reliability for assessing the addiction potential of EC than traditional nicotine addiction scales [34,35]. Specifically, modifications in the use of EC terminology and phrasing allowed

researchers to identify participants with a higher risk of addiction based on whether participants reported increased usage of EC daily or within the last month or if they had lower confidence in their ability to quit EC [34,35]. Pilot testing of EC questionnaires accompanied by qualitative interviews could help assess the reliability and validity of the measurement EC consumption [50]. Further, researchers need to stay current with terminologies associated with EC devices and use patterns, which can change over time and may differ by demographic group [51].

The lack of internal reliability or external validity in the survey studies reduces their utility for providing information to patients about the risk and benefits of EC for smoking cessation and overall health. Internal reliability in surveys can be increased through improved quality control and ensuring adequate recruitment strategies, data collection, data analysis, and sample size [52]. Electronic cigarette surveys need direct interviews with patients and more analysis of the quantity of nicotine consumed by EC users. Similarly, external validity can be improved through a broader inclusion of study population criteria resembling the general population [52]. In most of the surveys we analyzed, the survey participants were young Caucasian men with moderate affluence and college education. Future surveys should include participants in different social, ethnic, and economic groups to identify gaps in knowledge, use, and perceptions about EC. Finally, it remains unknown how physician perception and knowledge concerning EC could affect patient use of EC for smoking cessation. Future studies should try to determine whether improvement in physician knowledge of EC and informed discussion with patients changes public perception and possibly government policy towards EC.

**Limitations** This review involved a relatively small number of studies, and our conclusions necessarily reflect the information collected from these studies. But these surveys report information from several countries using participants with different demographic characteristics. Consequently, the survey results provide an overview of EC studies. These studies were published in 2013–2015, and it is possible that current approaches to survey studies have improved and meet the criteria outlined by the experts better. However, these core elements probably

represent basic information required in surveys and do not necessarily include all elements related to EC, especially information related to long-term health effects. It is possible that information regarding validity was omitted by the authors because of word restrictions in manuscript preparation and because information about study goals, outcomes, and limitations provides the details necessary to consider study validity. The target cohort or the questions in some studies were fairly specific (i.e., unique) and would not support generalization (external validity) to other survey populations.

## 5. Conclusion

In summary, some surveys on the public perception and use of EC frequently have design deficiencies. Most surveys cannot provide comprehensive information on the relevant public health concerns related to the use of EC. Therefore, investigators need to ask very precise questions, develop surveys that have construct validity, do pilot tests to determine whether or not the surveys have internal reliability, and organize the study so that the response rate is adequate to have external validity for the particular question posed and the population of interest. Important questions include *Do you use e-cigarettes? If yes, how often? If yes, for how long? If yes, do they contain nicotine? If you use e-cigarettes, have you quit using conventional tobacco cigarettes? If you use e-cigarettes, do you have side effects possibly related to them?* Questions about awareness seem less important given the widespread publicity about lung toxicity associated with electronic cigarette use. Finally, longitudinal studies are needed to identify chronic toxicity, changes in lung function, and sustained abstinence from conventional tobacco products.

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## Authors' contributions

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