Tobacco Control

Recommended core items to assess e-cigarette use in population-based surveys

Journal:	*Tobacco Control*
Manuscript ID	tobaccocontrol-2016-053541.R1
Article Type:	Special communication
Date Submitted by the Author:	n/a
Complete List of Authors:	Pearson, Jennifer; Truth Initiative, Schroeder Institute for Tobacco Research and Policy Studies; Johns Hopkins University Bloomberg School of Public Health, Department of Health, Behavior, and Society Hitchman, Sara; King's College London, UK Centre for Tobacco Control Studies, National Addiction Centre, Institute of Psychiatry Brose, Leonie ; King's College London, UK Centre for Tobacco and Alcohol Studies, Addictions Bauld, Linda; University of Stirling, Stirling Management School Glasser, Allison; Truth Initiative, The Schroeder Institute for Tobacco Research and Policy Studies Villanti, Andrea; Schroeder Institute for Tobacco Research and Policy Studies at Truth Initiative, ; Johns Hopkins Bloomberg School of Public Health, Department of Health, Behavior & Society McNeill, Ann; King's College London, UK Centre for Tobacco Control Studies, National Addiction Centre, Institute of Psychiatry Abrams, David; Truth Initiative, Schroeder Institute for Tobacco Research and Policy Studies; Johns Hopkins University Bloomberg School of Public Health, Department of Health, Behavior, and Society Cohen, Joanna; Johns Hopkins University Bloomberg School of Public Health, Department of Health, Behavior, and Society
Keywords:	Electronic nicotine delivery devices, Public policy, Surveillance and monitoring

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Jennifer L. Pearson, PhD, MPH[1, 2]
Sara C. Hitchman, PhD [3,4]
Leonie S. Brose, PhD [3,4]
Linda Bauld, PhD[5,4]
Allison M. Glasser, MPH[1]
Andrea C. Villanti, PhD, MPH[1,2]
Ann McNeill, PhD[3,4]
David B. Abrams, PhD[1,2]
Joanna E. Cohen, PhD[2]

[1] Schroeder Institute for Tobacco Research & Policy Studies at Truth Initiative, Washington, DC, USA
[2] Department of Health, Behavior, and Society, Johns Hopkins Bloomberg School of Public Health, Baltimore, MD, USA
[3] Department of Addictions, Institute of Psychiatry, Psychology and Neuroscience, King's College London, London, England, UK
[4] UK Centre for Tobacco and Alcohol Studies, London, England, UK
[5] Institute for Social Marketing, School of Health Sciences, University of Stirling, Stirling, Scotland, UK

Corresponding author:
Jennifer L. Pearson, PhD, MPH
The Schroeder Institute for Tobacco Research and Policy Studies at Truth Initiative
900 G Street NW, Fourth Floor
Washington, DC 20001
Phone 202-454-5768
Email: jpearson@truthinitiative.org

Number of tables & figures: 1
Word count: 3,657

ABSTRACT

Background: A consistent approach using standardized items to assess e-cigarette use in both youth and adult populations will aid cross-survey and cross-national comparisons of the effect of e-cigarette (and tobacco) policies and improve our understanding of the population health impact of e-cigarette use. Focusing on adult behavior, we propose a set of e-cigarette use items, discuss their utility and potential adaptation, and highlight e-cigarette constructs that researchers should avoid without further item development. Reliable and valid items will strengthen the emerging science and inform knowledge synthesis for policymaking.

Methods: Building on informal discussions at a series of international meetings of 65 experts from 15 countries, the authors provide recommendations for assessing e-cigarette use behavior, relative perceived harm, device type, presence of nicotine, flavors, and reasons for use.

Results: We recommend items assessing eight core constructs: e-cigarette ever use, frequency of use, and former daily use; relative perceived harm; device type; primary flavor preference; presence of nicotine; and primary reason for use. These items should be standardized or minimally adapted for the policy context and target population. Researchers should be prepared to update items as e-cigarette device characteristics change.

Conclusions: A minimum set of e-cigarette items is proposed to encourage consensus around items to allow for cross-survey and cross-jurisdictional comparisons of e-cigarette use behavior. These proposed items are a starting point. We recognize room for continued improvement, and welcome input from e-cigarette users and scientific colleagues.

What this paper adds:

Jurisdictions have taken different approaches to regulating e-cigarette devices and e-cigarette use. These different approaches present an opportunity to evaluate the effect of e-cigarette policies and regulation on e-cigarette and tobacco product use. However, for cross-jurisdictional comparisons to be useful, approaches to assessing e-cigarette use must be similar. The recommended set of eight e-cigarette measures for surveillance includes two core items to distinguish ever use from more frequent use and six items to assess former use, relative perceived harm, primary device type, primary flavour preference, nicotine content, and primary reason for use.

INTRODUCTION

E-cigarette use has grown in many high- and middle- income countries,[1-12] resulting in a rapidly evolving e-cigarette marketplace. As e-cigarette use is still a relatively new behavior, researchers have taken a variety of approaches to measuring use, often adapting cigarette smoking items to assess e-cigarette use. The lack of a consistent approach to assessing e-cigarette use is a barrier to knowledge synthesis [13, 14] and to conducting meaningful cross-national comparisons of the effect of e-cigarette policies on population tobacco use patterns. It has been recommended that monitoring, evaluation, and research use standardized approaches and definitions of e-cigarette use for trial, occasional, and regular users and among youth and adult populations.[13, 15]

As evidenced by at least 139 countries' adoption[16, 17] of the Global Adult and Global Youth Tobacco Surveys (GATS & GYTS), researchers, governments, and funders are aware of the power of common items for understanding the effect of policy on behavior. The following suggested core e-cigarette items are the result of a Robert Wood Johnson Foundation-funded (RWJF) project ('Harvesting Global Learning on Alternative Nicotine Delivery Systems (ANDS) to Inform U.S. Policy Action, Policy Research, and Surveillance') that brought together researchers and government representatives to identify existing needs to support cross-national e-cigarette research and learning. While no formal Delphi method was employed, the following recommendations are based on input from the 65 individuals from 15 countries included in the RWJF meeting series, as well as the authors' own experiences developing questions, analyzing responses, and/or interpreting findings for the International Tobacco Control (ITC) 4-Country Study,[18] Smoking Toolkit (STS),[19] Population Assessment of Tobacco and Health (PATH) Study,[20] Online Panel Survey in Great Britain[27-29], Truth Initiative Young Adult Cohort Study [21], National Health Interview Survey,[3] and National Youth Tobacco Study[22, 23] surveys, providing unique insight into the strengths and limitations of various e-cigarette items.

Focusing on adults, the purpose of this paper is to propose an efficient set of e-cigarette use items to enable accurate cross-jurisdictional comparisons of e-cigarette use behavior and to allow systematic evaluation of the effects of policy on e-cigarette and tobacco product use. While they still need to undergo systematic evaluation, we hope that these proposed items will promote open dialogue and further development of rigorous items for national and sub-national e-cigarette surveillance research.

ASSESSING E-CIGARETTE USE

There are several general issues that need to be considered when developing a survey with e-cigarette items. These include the survey's target population, the policy setting, and the mix of tobacco products and e-cigarette devices available to the target population. It is also important to take into account e-cigarette terminology and to accurately differentiate between e-cigarettes, other emerging products, and traditional tobacco products. We describe these issues here before introducing a core set of recommended items.

E-cigarette terminology

E-cigarettes are known by a variety of names, with terms varying by region, age group, tobacco use status, or reason for use.[24, 25] Terms that have been used include electronic cigarettes, e-cigarettes, electronic nicotine delivery systems (ENDS), alternative nicotine delivery systems (ANDS), electronic vapor products, e-cigars, e-pipes, e-hookahs, e-shishas, personal vaporizers, vape pens, and hookah pens. The meaning of these terms is not standardized, and the same term may be employed to refer to different sub-types of devices. The researcher-generated terms 'ENDS' and 'ANDS' inaccurately imply that these devices always contain nicotine. These are academic terms and should be avoided in public-facing documents and presentations.[25] Currently, it is likely that the most universally

understood terms are 'electronic cigarettes,' 'e-cigarettes,' or the phrase 'e-cigarettes or other vaping devices.'

A helpful way to introduce the relevant terminology in surveys is to include a 'preamble,' or a brief introduction at the start of the e-cigarette section. For example, the Wave 1 survey instrument for the PATH Study used this preamble:

> 'The next questions are about e-cigarettes. Some e-cigarettes can be bought as one-time, disposable products, while others can be bought as reusable kits with a cartridge or tank system. Some people refill their own e-cigarettes with nicotine fluid, sometimes called 'e- liquid.' Disposable e-cigarettes, e-cigarette cartridges and e-liquid come in many different flavors and nicotine concentrations. Some common brands include Fin, NJOY, Blu, e-Go and Vuse.'

This preamble was developed for use in the United States in 2014, and has been updated in each PATH Study survey wave. Researchers should be aware that introductory text such as this preamble will need to be modified as products change and the public develops familiarity with e-cigarettes. In markets where 'heat-not-burn' products, such as iQos, have been introduced, the preamble could note that respondents should not consider these products when answering e-cigarette items. We strongly suggest pilot research to assess the appropriate e-cigarette terms in surveys, and if possible, we suggest including both the standard (e.g., e-cigarette) and colloquial (e.g., vaping device) names. Future research should include regular cognitive testing of terminology used to identify e-cigarette native terms used by the survey's target population. Surveys with appropriate modes may consider using pictures of devices. These pictures should also be cognitively tested and updated as e-cigarettes evolve in the target population's setting.

Differentiating e-cigarettes from cigarettes and new emerging products

An additional challenge in e-cigarette survey item development is clearly differentiating cigarette items from e-cigarette items. As these devices do not produce smoke, it is not appropriate to refer to 'smoking' or 'smoker' when describing e-cigarette use, nor are these terms generally employed among established e-cigarette users.[26] The scientifically accurate term for e-cigarette emissions is 'aerosol'; however, the popular term for e-cigarette emissions understood by the public is 'vapor.' E-cigarette use behavior should be described as 'use' or 'vaping.' We recommend differentiating e-cigarette use from 'smoking' when smoking is first mentioned in the survey. For example, the 2016 Online Panel Survey in Great Britain[27-29] used the following text at the beginning of its tobacco use section: "When we refer to cigarettes, pipes, cigars, or other tobacco products, we are not referring to electronic cigarettes or vaping devices (because these do not contain tobacco)." In the case of vaping devices that could be used for nicotine or cannabis consumption, researchers could consider an additional item about the substance most commonly consumed with the device, which could then be used as a basis for skip patterns or form fills. We also strongly recommend that heat-not burn products be assessed separately from e-cigarette products. As heat-not-burn products continue to spread within and beyond the European Union and Japan, the research community will need to seriously consider how to assess use of these products so that they are differentiated from traditional combusted tobacco and vaping products.

Recommended e-cigarette items

Table 1 presents a minimum set of e-cigarette items that, in the experience of the authors, are essential to assessing the role of policy on e-cigarette and tobacco use behavior. The items cover eight constructs: ever use, frequency of use, former daily use, relative perceived harm, device type, presence of nicotine, flavor preference, and reasons for use. The first two constructs, ever use and frequency of

use, are further identified as minimum core e-cigarette items when survey space is limited. It should be noted that this minimum set of items is insufficient for surveys of tobacco users or vapers.

E-cigarette ever use: Ever use of e-cigarettes captures initiation or trial. While this construct is useful for quantifying the proportion of initiates in a population and constructing skip patterns within surveys, it is minimally useful in analyses, as most ever use is limited to 1 or 2 instances.[3, 15] Researchers should use caution when employing this item as a measure of exposure to e-cigarettes.[30] Prior research has employed ever use as a measure of e-cigarette exposure among adult smokers;[31-33] however, this weak measure yields uninterpretable estimates of the effect of e-cigarette use on smoking. It should be noted that 'ever e-cigarette use' (i.e., trial) is different than 'former daily use,' which we present below.

We recommend assessing e-cigarette ever use with an item from the ITC 4-Country Survey.[34] This item should be asked of all survey respondents and allow a 'Don't know' response. Additionally, e-cigarette ever use should be asked on its own rather than as part of a list of tobacco products, as the list approach is likely to underestimate use.[3]

Frequency of e-cigarette use: It is still not known what levels of e-cigarette use are relevant to behavioral and health outcomes. Frequency of e-cigarette use is commonly assessed by asking the participant about the number of days he or she has used an e-cigarette in the past 30 days. However, due to the transience of e-cigarette use in some populations (i.e., smokers or young adults), we do not recommend this approach for estimating frequency of use for two reasons. First, this item encourages equating *any* level of use in the past 30 days with 'current' use, conflating recent initiates or experimental users who may be unlikely to progress to daily use with current, established e-cigarette users.[10, 12, 15, 35] Second, this item is most useful in combination with a subsequent item assessing the length of time the use pattern has endured, which increases the number of items in our core set of items.

Our proposed item, adapted from the ITC 4-Country Survey,[34] allows for flexibility in defining a meaningful level of e-cigarette use. In addition to surveillance surveys, this item is also appropriate to assess within-person changes in cohort studies and could be used alone when only one or two questions on e-cigarettes are possible due to space restrictions. Researchers should include parallel items assessing frequency of e-cigarette use and cigarette smoking so that co-use of these products (i.e., 'dual use') can be compared.

Former daily use: Assessing patterns of former daily use is important for understanding the impact of e-cigarette use on uptake or reduction of smoking, as well as e-cigarette-related health outcomes. PATH Waves 1-2 and the ITC surveys ask whether respondents who do not currently use e-cigarettes have ever used e-cigarettes 'fairly regularly.' Rather than leaving the definition of 'fairly regularly' to respondents, we suggest asking about at least daily use over a month or more, which would indicate that the user had vaped for an extended period and may be relevant for behavioral outcomes.

Relative perceived harm: Common theories of health behavior posit that harm perceptions influence tobacco use behavior, with lower perceived harm encouraging higher levels of experimentation and current use. PATH, ITC, STS, GATS, and the Truth Initiative Young Adult Cohort ask about absolute or relative perceived harm. We suggest assessing perceived harm relative to cigarettes (rather than absolute perceived harm) among all survey respondents due to their common use as a smoking cessation or harm reduction tools.[36, 37] Using an item adapted from PATH and the ITC 4-Country survey, we suggest assessing relative perceived harm to understand how tobacco use prevention and health communication campaigns, as well as media coverage, affect the perceptions of non-, former, and current tobacco users, and how these perceptions affect e-cigarette use.

Device type: E-cigarettes are a diverse product class and must not be treated as a single product. With the wide variation in design, content, function, nicotine delivery, price, and availability of these products, different types of e-cigarette devices may have different behavioral and health effects. A

growing body of work suggests that device characteristics such as nicotine content and type of battery are correlated with e-cigarette use behaviors and may affect smoking cessation.[28, 38-41] Given the diversity of the products, it is unsurprising that surveys vary widely in their approach to capturing device type. Some surveys (e.g. PATH Wave 2) split questions about devices into two parts: a first question about the size/shape of the device, and a second question about whether the device is disposable, uses pre-filled cartridges, or is refillable with liquids. Some studies (e.g. PATH Waves 1-2 and ITC) also use pictures of e-cigarette types.

The wording and response options for our suggested device type item are driven by battery size, which has been shown to affect nicotine delivery[42, 43] and smoking cessation.[38] Our proposed response options identify four mutually exclusive types of devices (Table 1). For analyses, these items may be collapsed into Groups 1 and 2, likely to have less powerful batteries (often called “cigalikes”), and Groups 3 and 4, likely to have more powerful batteries, often called “second generation” and “mods.” Devices with larger batteries are normally refillable with e-liquid (e.g., a liquid containing some mix of propylene glycol, glycerin, water, flavoring, impurities, and often nicotine), which may be associated with a risk of unintentional poisoning and is a relevant data point in estimating population harms.[44, 45] While we have found this approach useful in understanding device characteristics in the UK and US, items assessing device characteristics will need to be adapted according to availability of e-cigarettes in different jurisdictions and the evolution of the devices. The utility of this approach may diminish as devices with more powerful batteries and pre-filled cartridges or sealed tanks are made available

Nicotine content: Similar to understanding device characteristics, assessing e-cigarette nicotine content has no direct parallel cigarette survey item. Few of the first national and international surveys of e-cigarettes asked if the device contained nicotine. As countries banned nicotine-containing e-cigarettes, more surveys asked about whether devices used contained nicotine.[12, 46-49] These items

often ask about nicotine concentration by percent, milligrams per milliliter (mg/mL), or by an ordinal descriptive term (e.g., “low,” “medium,” and “high”). Each of these approaches, however, has serious drawbacks. Asking about nicotine concentration by percent or mg/mL is difficult for inexperienced users, yielding a number of ‘don’t know’ responses (e.g., 12% ‘don’t know’ in a recent Action on Smoking and Health survey).[50, 51] Using terms that correspond to manufacturers’ descriptions (e.g. ‘low’) is also problematic because these labels do not necessarily capture similar ranges of nicotine concentrations across brands or jurisdictions.

Our proposed nicotine content item requires some respondent knowledge and is similar to an item used in PATH Wave 2. Our item asks about ‘the vaping device you use most often’ because sophisticated users may use multiple nicotine concentrations, employing different strengths of nicotine in different situations or over time. It may be possible to collect more reliable information on e-liquid nicotine concentration among experienced users; however, the ultimate amount of nicotine delivered to the user depends on the device, the nicotine concentration, and the user’s experience with e-cigarettes, among other variables.[42, 52-55] Assessing nicotine fluid concentration is of limited application until we have refined items to accurately assess device characteristics such as battery wattage and coil resistance. In jurisdictions where certain nicotine concentrations are banned, it may be useful to adapt our suggested item to assess use of the banned e-liquid nicotine concentrations.

Flavors: Most e-cigarettes, even those that taste like traditional cigarettes, are flavored because their main constituents (e.g., nicotine, propylene glycol) have little flavor. However, truly unflavored e-liquids (e.g., those that contain only propylene glycol, glycerin, water, and nicotine) are also available. Most existing surveys of e-cigarette use ask about flavors, but their approach differs. PATH Waves 1-2 and ITC ask about flavors that are available in cigarettes (e.g., traditional tobacco, menthol or mint), as well as several other flavor categories (e.g. chocolate, fruit, clove or spice, alcoholic drink, dessert). While understanding the prevalence of different e-cigarette flavor preferences may shed light on the

behavioral and public health impact of flavor use, this is a difficult behavior to accurately assess. First, respondents may find describing their preferred flavor using a list of generic terms challenging if their preferred flavor fits into multiple categories. For example, is “piña colada” an alcoholic drink or a fruit flavor? Second, like nicotine concentration, e-cigarette users may vape a variety of e-cigarette flavors. Respondents to the PATH Wave 2 and the 2016 ITC survey were provided a list of individual flavors and asked to “select all that apply” to describe their flavor use in the past 30 days. With this approach, however, it is unclear whether the respondents are describing one preferred e-liquid flavor, or a range of preferred flavors.

Ultimately, the flavor response options should be dependent on the current situation in the target population’s jurisdiction and the purpose of the research. In the US, for example, menthol cigarettes are legal and prevalent, but other flavored cigarettes are banned. Thus, it makes sense to ask about menthol e-liquid use separately from other flavors. In different policy contexts, it may make sense to ask about other flavors. Our recommended item focuses on the most common flavor because some users may consume multiple flavors in a day or week. The proposed response options avoid the problem of multiple categorization of a flavor and decrease response burden. While switching between flavors is an important construct that should be assessed in surveys with large sample of daily vapers, this item is of limited use in a general population survey in settings where daily e-cigarette use is uncommon, which describes nearly all current settings.

Reasons for use: Given the opportunity, e-cigarette users will nominate multiple reasons for e-cigarette use.[36, 56] While allowing respondents to choose multiple reasons for use reflects complex motivations for the behavior, it has limited utility for understanding the role of e-cigarette use and behavioral intention in e-cigarette and tobacco use behavior. It could be argued that qualitative research may be more appropriate for in-depth explorations of reasons for use. However, where survey space allows, a single question on the main reason why e-cigarettes or vaping products are/were used

may be relevant for policy and practice. If the survey mode allows, researchers may also consider asking respondents to rank their reasons for use, which would still allow for comparisons of top reasons across jurisdictions. If the purpose of a survey is to measure the effectiveness of e-cigarettes for smoking cessation, we recommend including 'e-cigarette or vaping device' in a list of questions that assess what approach, support, or aids were used during a specific attempt to stop smoking (e.g., in the last attempt).[57]

E-cigarette items of limited utility

In addition to our eight recommended items, we highlight three constructs which we believe are of limited utility in most jurisdictions: e-cigarette awareness, e-cigarette or e-liquid quantity of consumption, and e-cigarette or e-liquid brands.

E-cigarette awareness: Until recently, most national surveys asked about awareness of e-cigarettes. In 2014 and 2015, the US National Adult Tobacco Survey (NATS) and STS in England did not assess awareness because previous surveys had shown e-cigarette awareness was near universal (93% in the UK as early as 2012[58] and 86.4% in the US in 2013[59]). We recommend dropping the awareness item in jurisdictions where awareness has reached saturation.

E-cigarette or e-liquid quantity of consumption: One complex issue in e-cigarette research is evaluating how much e-liquid users consume. Research suggests that frequency of e-cigarette use is relevant to smoking cessation effectiveness.[28, 29, 60] Many surveys follow approaches similar to those assessing heaviness of smoking among cigarette smokers,[61] asking about consumption of cartridges or disposable e-cigarettes per day, or number of e-cigarette puffs per day. For users of refillable e-cigarettes, items ask how long it takes to use a specific amount of e-liquid (i.e., 10ml) or the size (in ml) of the last bottle purchased and how long it usually lasts. Interestingly, this is similar to methods that have been developed for assessing cannabis consumption. [62] PATH, ITC, and STS all ask

questions about the daily quantity of e-cigarette use. PATH and ITC ask about daily consumption in product units, and how long one's last purchase of liquid will last (ITC), while STS asks about number of times per day the e-cigarette is used. However, e-liquid bottles and e-cigarette refillable reservoirs are of varying sizes, so time to depletion is of limited utility without reliable information about the respondent's device. Additionally, e-liquid consumption as a function of puffs per day will vary by the user's puff topography and device settings. Similar to frequency of use, the field is in its infancy and we are only beginning to accurately measure and understand how heaviness of use/daily quantity may predict public health outcomes. Without item testing, we recommend including these items with caution and ask that researchers share their lessons learned and publish formative work to advance the field.

E-cigarette and e-liquid brands: It is common practice in surveys of smoking behavior to include questions about the respondent's preferred brand; this practice has been applied to brand varieties of devices and e-liquid. Assessing e-cigarette device brands is challenging, as there are thousands of varieties, and it is unclear how brand loyal e-cigarette users are to device and e-liquid makers. Experienced e-cigarette users may have more than one device, or may combine components from multiple brands. Casual e-cigarette users may not know the brand of their device or e-liquid. Despite these challenges, brand is a worthwhile construct for understanding the effect of marketing on e-cigarette use behavior.

CONCLUSION

Using the combined experience of an international group of researchers, we have proposed a minimum set of e-cigarette items to encourage consensus around items and allow for cross-jurisdictional comparisons and surveillance of e-cigarette use. These proposed items are meant to open

a dialogue on meaningful items for national e-cigarette surveillance and should be updated as measurement of e-cigarette use behavior evolves. We recognize that there is room for continued improvement of these items, and we welcome input from e-cigarette users and academic/public health colleagues. We also encourage discussion of how common definitions of e-cigarette use and consistency in reporting of results could advance the field. Additionally, this paper focuses on items for surveys and studies with adults only; future recommendations are needed for youth surveys, although some of the same items are applicable to youth. Standardized, reliable, and valid surveillance items will speed knowledge synthesis both within and across countries, will place patterns and reasons for e-cigarette use in the context of the emerging complexity of poly-tobacco/nicotine product use, and will better inform policymaking and regulation and the overall public health impact of e-cigarettes and related products.[63]

Ethics Approval Statement: This manuscript does not include human subjects research, so ethics approval was not obtained.

Research Reporting Statement: As this is a Special Communication that does not report results from research, we have not included a research reporting statement.

Acknowledgements: The authors would like to thank the Robert Wood Johnson Foundation for funding "Harvesting Global Learning on Alternative Nicotine Delivery Systems (ANDS) to Inform U.S. Policy Action, Policy Research, and Surveillance," during which the idea for this manuscript was formed. We would also like to thank the authors of relevant surveys whose work has contributed to the survey items recommended in this manuscript. Effort on this manuscript for AMG, ACV, and DBA was also supported by Truth Initiative. JLP's time was supported by the National Institute On Drug Abuse of the National

Institutes of Health under Award Number K01DA037950. The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health. LSB is funded by a Cancer Research UK (CRUK)/BUPA Foundation Cancer Prevention Fellowship (C52999/A19748). LSB, SCH and AM are members of the UK Centre for Tobacco and Alcohol Studies, a UK Clinical Research Collaboration Public Health Research: Centre of Excellence with funding from the Medical Research Council, British Heart Foundation, Cancer Research UK, Economic and Social Research Council and the National Institute for Health Research under the auspices of the UK Clinical Research Collaboration (MR/K023195/1).

Contributorship: All authors conceived the manuscript topic. JLP wrote the first draft of the paper and led the writing team. SCH, LSB, LB, AMG, ACV, AM, DBA, and JEC contributed to manuscript writing. JEC and ACV were project leads on "Harvesting Global Learning on Alternative Nicotine Delivery Systems (ANDS) to Inform U.S. Policy Action, Policy Research, and Surveillance."

Competing interests: None declared.

REFERENCES

1. Singh T, Arrazola RA, Corey CG, et al. Tobacco Use Among Middle and High School Students - United States, 2011-2015. *MMWR Morb Mortal Wkly Rep* 2016;65(14):361-7.
2. Caraballo RS, Jamal A, Nguyen KH, et al. Electronic Nicotine Delivery System Use Among U.S. Adults, 2014. *American journal of preventive medicine* 2016;50(2):226-9.
3. Delnevo CD, Giovenco DP, Steinberg MB, et al. Patterns of electronic cigarette use among adults in the United States. *Nicotine & Tobacco Research* 2015;In Press.
4. Schoenborn CA, Gindi RM. Electronic Cigarette Use Among Adults: United States, 2014: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Health Statistics, 2015.
5. Czoli CD, Hammond D, White CM. Electronic cigarettes in Canada: prevalence of use and perceptions among youth and young adults. *Can J Public Health* 2014;105(2):e97-e102.
6. Action on Smoking and Health. Use of electronic cigarettes among children in Great Britain, 2015.
7. Action on Smoking and Health. Use of electronic cigarettes (vapourisers) among adults in Great Britain, 2015.
8. Eastwood B, Dockrell MJ, Arnott D, et al. Electronic cigarette use in young people in Great Britain 2013-2014. *Public Health* 2015.
9. Filippidis FT, Laverty AA, Gerovasili V, et al. Two-year trends and predictors of e-cigarette use in 27 European Union member states. *Tobacco control* 2017;26(1):98-104.
10. Gravely S, Fong GT, Cummings KM, et al. Awareness, Trial, and Current Use of Electronic Cigarettes in 10 Countries: Findings from the ITC Project. *Int J Environ Res Public Health* 2014;11(11):11691-704.
11. La Torre G, Mipatrini D. Country-level correlates of e-cigarette use in the European Union. *Int J Public Health* 2016;61(2):269-75.
12. Yong HH, Borland R, Balmford J, et al. Trends in E-Cigarette Awareness, Trial, and Use Under the Different Regulatory Environments of Australia and the United Kingdom. *Nicotine & tobacco research : official journal of the Society for Research on Nicotine and Tobacco* 2015;17(10):1203-11.
13. McNeill A, Brose LS, Calder R, et al. E-cigarettes: an evidence update -- A report commissioned by Public Health England. London, England: Public Health England, 2015.
14. Malas M, van der Tempel J, Schwartz R, et al. Electronic Cigarettes for Smoking Cessation: A Systematic Review. *Nicotine & tobacco research : official journal of the Society for Research on Nicotine and Tobacco* 2016;18(10):1926-36.
15. Amato MS, Boyle RG, Levy D. How to define e-cigarette prevalence? Finding clues in the use frequency distribution. *Tobacco control* 2016;25(e1):e24-9.
16. Organization WH. Tobacco Free Initative (TFI): Global Adult Tobacco Survey (GATS). Secondary Tobacco Free Initative (TFI): Global Adult Tobacco Survey (GATS) 2017. http://www.who.int/tobacco/surveillance/survey/gats/en/.
17. Centers for Disease Control and Prevention. Global Tobacco Surveillance System Data (GTSSData): Country Reports. Secondary Global Tobacco Surveillance System Data (GTSSData): Country Reports 2017. https://nccd.cdc.gov/GTSSDataSurveyResources/Ancillary/DataReports.aspx?CAID=3.
18. International Tobacco Control Policy Evaluation Project. Promoting Evidence-Based Strategies to Fight the Global Tobacco Epidemic. Secondary Promoting Evidence-Based Strategies to Fight the Global Tobacco Epidemic 2017. http://www.itcproject.org/.
19. Fidler JA, Shahab L, West O, et al. 'The smoking toolkit study': a national study of smoking and smoking cessation in England. *BMC public health* 2011;11:479.

20. Hyland A, Ambrose BK, Conway KP, et al. Design and methods of the Population Assessment of Tobacco and Health (PATH) Study. *Tobacco control* 2016.
21. Rath JM, Villanti AC, Abrams DB, et al. Patterns of tobacco use and dual use in US young adults: the missing link between youth prevention and adult cessation. *Journal of Environmental and Public Health* 2012;2012.
22. Villanti AC, Pearson JL, Glasser AM, et al. Frequency of youth e-cigarette and tobacco use patterns in the U.S.: Measurement precision is critical to inform public health. *Nicotine & tobacco research : official journal of the Society for Research on Nicotine and Tobacco* 2016.
23. Collins LK, Villanti AC, Pearson JL, et al. Frequency of Youth E-Cigarette, Tobacco, and Poly-Use in the United States, 2015: Update to Villanti et al., "Frequency of Youth E-Cigarette and Tobacco Use Patterns in the United States: Measurement Precision Is Critical to Inform Public Health". *Nicotine & Tobacco Research* In Press.
24. Ayers JW, Althouse BM, Allem JP, et al. Revisiting the Rise of Electronic Nicotine Delivery Systems Using Search Query Surveillance. *American journal of preventive medicine* 2016.
25. Pearson JL, Amato MS, Wang X, et al. How US Smokers Refer to E-cigarettes: An Examination of User-Generated Posts From a Web-Based Smoking Cessation Intervention, 2008-2015. *Nicotine & tobacco research : official journal of the Society for Research on Nicotine and Tobacco* 2016.
26. McQueen A, Tower S, Sumner W. Interviews with "vapers": implications for future research with electronic cigarettes. *Nicotine & tobacco research : official journal of the Society for Research on Nicotine and Tobacco* 2011;13(9):860-7.
27. Brose LS, Partos TR, Hitchman SC, et al. Support for e-cigarette policies: a survey of smokers and ex-smokers in Great Britain. *Tobacco control* 2016.
28. Hitchman SC, Brose LS, Brown J, et al. Associations Between E-Cigarette Type, Frequency of Use, and Quitting Smoking: Findings From a Longitudinal Online Panel Survey in Great Britain. *Nicotine & tobacco research : official journal of the Society for Research on Nicotine and Tobacco* 2015;17(10):1187-94.
29. Brose LS, Hitchman SC, Brown J, et al. Is the use of electronic cigarettes while smoking associated with smoking cessation attempts, cessation and reduced cigarette consumption? A survey with a 1-year follow-up. *Addiction* 2015;110(7):1160-8.
30. Pearson JL, Stanton CA, Cha S, et al. E-Cigarettes and Smoking Cessation: Insights and Cautions From a Secondary Analysis of Data From a Study of Online Treatment-Seeking Smokers. *Nicotine & tobacco research : official journal of the Society for Research on Nicotine and Tobacco* 2015;17(10):1219-27.
31. Al-Delaimy WK, Myers MG, Leas EC, et al. E-cigarette use in the past and quitting behavior in the future: a population-based study. *Am J Public Health* 2015;105(6):1213-9.
32. Popova L, Ling PM. Alternative tobacco product use and smoking cessation: a national study. *Am J Public Health* 2013;103(5):923-30.
33. Christensen T, Welsh E, Faseru B. Profile of e-cigarette use and its relationship with cigarette quit attempts and abstinence in Kansas adults. *Prev Med* 2014;69C:90-94.
34. International Tobacco Control Policy Evaluation Project. 4-Country E-cig W1 Survey. Secondary 4-Country E-cig W1 Survey 2017. http://www.itcproject.org/files/ITC_4CE1__web_Eng.pdf.
35. Pepper JK, Brewer NT. Electronic nicotine delivery system (electronic cigarette) awareness, use, reactions and beliefs: a systematic review. *Tobacco control* 2014;23(5):375-84.
36. Patel D, Davis KC, Cox S, et al. Reasons for current E-cigarette use among U.S. adults. *Prev Med* 2016;93:14-20.
37. Berg CJ, Haardoerfer R, Escoffery C, et al. Cigarette users' interest in using or switching to electronic nicotine delivery systems for smokeless tobacco for harm reduction, cessation, or novelty: a

cross-sectional survey of US adults. *Nicotine & tobacco research : official journal of the Society for Research on Nicotine and Tobacco* 2015;17(2):245-55.
38. Chen C, Zhuang YL, Zhu SH. E-Cigarette Design Preference and Smoking Cessation: A U.S. Population Study. *American journal of preventive medicine* 2016.
39. Farsalinos KE, Romagna G, Voudris V. Factors associated with dual use of tobacco and electronic cigarettes: A case control study. *The International journal on drug policy* 2015;26(6):595-600.
40. Foulds J, Veldheer S, Yingst J, et al. Development of a questionnaire for assessing dependence on electronic cigarettes among a large sample of ex-smoking E-cigarette users. *Nicotine & tobacco research : official journal of the Society for Research on Nicotine and Tobacco* 2015;17(2):186-92.
41. Yingst JM, Veldheer S, Hrabovsky S, et al. Factors Associated With Electronic Cigarette Users' Device Preferences and Transition From First Generation to Advanced Generation Devices. *Nicotine & tobacco research : official journal of the Society for Research on Nicotine and Tobacco* 2015;17(10):1242-6.
42. Farsalinos KE, Spyrou A, Tsimopoulou K, et al. Nicotine absorption from electronic cigarette use: comparison between first and new-generation devices. *Sci Rep* 2014;4:4133.
43. Wagener TL, Floyd EL, Stepanov I, et al. Have combustible cigarettes met their match? The nicotine delivery profiles and harmful constituent exposures of second-generation and third-generation electronic cigarette users. *Tobacco control* 2016.
44. Liber AC, Drope JM, Stoklosa M. Combustible cigarettes cost less to use than e-cigarettes: global evidence and tax policy implications. *Tobacco control* 2016.
45. Chatham-Stephens K, Law R, Taylor E, et al. Notes from the field: calls to poison centers for exposures to electronic cigarettes--United States, September 2010-February 2014. *MMWR Morb Mortal Wkly Rep* 2014;63(13):292-3.
46. Kinnunen JM, Ollila H, El-Amin Sel T, et al. Awareness and determinants of electronic cigarette use among Finnish adolescents in 2013: a population-based study. *Tobacco control* 2015;24(e4):e264-70.
47. Gallus S, Lugo A, Pacifici R, et al. E-cigarette awareness, use, and harm perceptions in Italy: a national representative survey. *Nicotine & tobacco research : official journal of the Society for Research on Nicotine and Tobacco* 2014;16(12):1541-8.
48. Shiplo S, Czoli CD, Hammond D. E-cigarette use in Canada: prevalence and patterns of use in a regulated market. *BMJ Open* 2015;5(8):e007971.
49. Tabuchi T, Kiyohara K, Hoshino T, et al. Awareness and use of electronic cigarettes and heat-not-burn tobacco products in Japan. *Addiction* 2016;111(4):706-13.
50. Coleman BN, Johnson SE, Tessman GK, et al. "It's not smoke. It's not tar. It's not 4000 chemicals. Case closed": Exploring attitudes, beliefs, and perceived social norms of e-cigarette use among adult users. *Drug and alcohol dependence* 2016;159:80-5.
51. Action on Smoking and Health. Use of electronic cigarettes (vapourisers) among adults in Great Britain. Secondary Use of electronic cigarettes (vapourisers) among adults in Great Britain 2016. file:///C:/Users/aglasser/Downloads/ASH_891.pdf.
52. Ramoa CP, Hiler MM, Spindle TR, et al. Electronic cigarette nicotine delivery can exceed that of combustible cigarettes: a preliminary report. *Tobacco control* 2016;25(e1):e6-9.
53. Vansickel AR, Eissenberg T. Electronic Cigarettes: Effective Nicotine Delivery After Acute Administration. *Nicotine & Tobacco Research* 2013;15(1):267-70.
54. St Helen G, Havel C, Dempsey DA, et al. Nicotine delivery, retention and pharmacokinetics from various electronic cigarettes. *Addiction* 2016;111(3):535-44.
55. Lopez AA, Hiler MM, Soule EK, et al. Effects of Electronic Cigarette Liquid Nicotine Concentration on Plasma Nicotine and Puff Topography in Tobacco Cigarette Smokers: A Preliminary Report.

Nicotine & tobacco research : official journal of the Society for Research on Nicotine and Tobacco 2016;18(5):720-3.
56. Pepper JK, Ribisl KM, Emery SL, et al. Reasons for starting and stopping electronic cigarette use. *Int J Environ Res Public Health* 2014;11(10):10345-61.
57. Brown J, Beard E, Kotz D, et al. Real-world effectiveness of e-cigarettes when used to aid smoking cessation: a cross-sectional population study. *Addiction* 2014;109(9):1531-40.
58. Brown J, West R, Beard E, et al. Prevalence and characteristics of e-cigarette users in Great Britain: Findings from a general population survey of smokers. *Addictive Behaviors* 2014;39(6):1120-5.
59. Huang J, Kim Y, Vera L, et al. Electronic Cigarettes Among Priority Populations: Role of Smoking Cessation and Tobacco Control Policies. *American journal of preventive medicine* 2016;50(2):199-209.
60. Biener L, Hargraves JL. A longitudinal study of electronic cigarette use among a population-based sample of adult smokers: association with smoking cessation and motivation to quit. *Nicotine & tobacco research : official journal of the Society for Research on Nicotine and Tobacco* 2015;17(2):127-33.
61. Heatherton TF, Kozlowski LT, Frecker RC, et al. Measuring the heaviness of smoking: using self-reported time to the first cigarette of the day and number of cigarettes smoked per day. *Br J Addict* 1989;84(7):791-9.
62. Freeman TP, Morgan CJ, Hindocha C, et al. Just say 'know': how do cannabinoid concentrations influence users' estimates of cannabis potency and the amount they roll in joints? *Addiction* 2014;109(10):1686-94.
63. Levy DT, Cummings KM, Villanti AC, et al. A framework for evaluating the public health impact of e-cigarettes and other vaporized nicotine products. *Addiction* 2016.

Table 1. Recommended minimum core items to assess e-cigarette use in national surveys.

Construct	Item	Response options	Population/Respondents
CORE ITEM **Ever use**	Have you ever tried an e-cigarette or vaping device?	a) Yes b) No c) Don't know	All
CORE ITEM **Frequency of Use**	How often do you currently use an e-cigarette or vaping device?	a) Daily or almost daily b) Less than daily, but at least once a week c) Less than weekly, but at least once a month d) Less than monthly e) Not at all f) Don't know	Those who respond 'yes' to 'ever use' question
Relative harm	Compared to cigarettes, how harmful are e-cigarettes to a person' health?	a) Much less harmful than cigarettes b) Somewhat less harmful than cigarettes c) About the same as cigarettes d) Somewhat more harmful than cigarettes e) Much more harmful than cigarettes f) Don't know	All
Former daily use	Have you ever used an e-cigarette or vaping device daily for a month or more?	a) Yes b) No c) Don't know	Those who responded (a) 'yes' to the 'ever use' question but (b) 'less than daily, but at least once a week', (c) 'less than weekly, but at least once a month,' (d) 'less than monthly, or (e) 'not at all' to the frequency of use question. [Some further filtering may be needed depending on the frequency of use response option chosen and the target population.]
Device type	What e-cigarette or vaping device [do/did] you use (the most)?	a) A disposable e-cigarette or vaping device (non-rechargeable) b) An e-cigarette or vaping device that uses	Those who respond (a) 'yes' to 'ever use' question

		replaceable pre-filled cartridges (rechargeable) c) An e-cigarette or vaping device with a tank that you refill with liquids (rechargeable) d) A modular system that you refill with liquids (you use your own combination of separate devices: batteries, atomizers etc...) (rechargeable) e) Don't know	
Presence of nicotine	Does the e-cigarette or vaping device that you use most often contain nicotine?	a) Yes b) No c) Don't know	Those who responded 'daily', 'less than daily, but at least once a week,' 'less than weekly, but at least once a month,' or 'less than monthly' to the frequency of use question.
Flavor preference	What flavor [do/did] you use most when vaping/using an e-cigarette or vaping device? (select one) [randomize list of response options]	a) Tobacco b) Tobacco menthol, menthol, or mint c) Some other flavour like fruit, candy, alcohol, coffee, vanilla, etc. d) No flavour e) Don't know	Those who respond 'yes' to 'ever use' question Note: List of flavours depending on policy context and research question
Reasons for use	What is (was) your primary reason for using an e-cigarette or vaping device? (select one) [randomize list of response options]	a) To quit smoking b) To cut down smoking c) To use when I cannot or am not allowed to smoke d) To avoid returning to smoking e) Because I enjoy(ed) it f) Curiosity/just wanted to try them g) Some other reason h) Don't know	For those who are at least once a month users

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