Prevalence of electronic nicotine delivery systems (ENDS) use among youth globally: a systematic review and meta-analysis of country level data

Sze Lin Yoong,[1,2] Emily Stockings,[3] Li Kheng Chai,[1,4] Flora Tzelepis,[1,2,4] John Wiggers,[1,2,4] Christopher Oldmeadow,[1,4] Christine Paul,[1,4] Armando Peruga,[5] Melanie Kingsland,[1,2,4] John Attia,[1,4] Luke Wolfenden[1,2,4]

Abstract

Objective: To describe the prevalence and change in prevalence of electronic nicotine delivery systems (ENDS) use in youth by country and combustible smoking status.

Methods: Databases and the grey literature were systematically searched to December 2015. Studies describing the prevalence of ENDS use in the general population aged ≤20 years in a defined geographical region were included. Where multiple estimates were available within countries, prevalence estimates of ENDS use were pooled for each country separately.

Results: Data from 27 publications (36 surveys) from 13 countries were included. The prevalence of ENDS ever use in 2013–2015 among youth were highest in Poland (62.1%; 95%CI: 59.9-64.2%), and lowest in Italy (5.9%; 95%CI: 3.3-9.2%). Among non-smoking youth, the prevalence of ENDS ever use in 2013–2015 varied, ranging from 4.2% (95%CI: 3.8-4.6%) in the US to 14.0% in New Zealand (95%CI: 12.7-15.4%). The prevalence of ENDS ever use among current tobacco smoking youth was the highest in Canada (71.9%, 95%CI: 70.9-72.8%) and lowest in Italy (29.9%, 95%CI: 18.5-42.5%). Between 2008 and 2015, ENDS ever use among youth increased in Poland, Korea, New Zealand and the US; decreased in Italy and Canada; and remained stable in the UK.

Conclusions: There is considerable heterogeneity in ENDS use among youth globally across countries and also between current smokers and non-smokers.

Implications for public health: Population-level survey data on ENDS use is needed to inform public health policy and messaging globally.

Key words: electronic nicotine delivery systems, smoking, youth

Electronic nicotine delivery systems (henceforth referred to as ENDS), are handheld battery-operated devices that aim to simulate conventional cigarettes by delivering a solution typically comprising nicotine, propylene glycol, glycerine and flavouring agents, which is heated and inhaled as an aerosol by users.[1] Since being introduced into markets in the mid-to-late 2000s, ENDS use has risen significantly among adults in many countries.[2,3] At the same time, there has been considerable public health debate regarding the potential benefits and harms of ENDS use.[4-6] ENDS have been marketed as an aid to reduce or cease tobacco smoking,[7] and are endorsed as such by the Royal Society for Public Health, the Royal College of Physicians, and Public Health England in the UK.[8-10] However, many other organisations including the World Health Organization (WHO), American Lung Association and Australian Medical Association do not support the use of ENDS as a cessation aid in youth, citing concerns regarding product safety and the potential that experimentation with ENDS could lead to nicotine dependence and subsequent tobacco use.[11-13] Evidence supporting such concerns was also documented in the recent US Surgeon General Report.[14]

As experimentation with cigarettes primarily occurs in youth (ages 10–24 years),[15,16] and the developing brain is particularly sensitive to nicotine,[17] the use of ENDS during youth has received considerable attention.[8,18] In many jurisdictions, ENDS products are actively marketed in ways that appeal to young people, including the use of celebrity product endorsements and promotion of flavoured products (e.g. 'candy' flavour), and via social media.[19] Although many jurisdictions where ENDS can be legally purchased have bans on sales to minors when the e-liquid contains nicotine,[20-22] ENDS are often easily obtained through informal social sources, such as friends and family members.[23] Further, few countries enforce age restrictions on the purchase of e-liquids that do not contain nicotine.[22] Recent meta-analyses of youth cohort studies published by the WHO[24] and others[69] suggest that use of ENDS by non-smoking young people can as much as quadruple the odds of later tobacco use.[25] Given the availability and promotion of ENDS in many countries, and their potential to influence tobacco use in youth, an understanding of the prevalence

1. School of Medicine and Public Health, University of Newcastle, New South Wales
2. Hunter New England Population Health, Hunter New England Local Health District, New South Wales
3. National Drug and Alcohol Research Centre, UNSW Australia, New South Wales
4. Hunter Medical Research Institute, New South Wales
5. Centro de Epidemiología y Políticas de Salud (Center for Epidemiology and Health Policies), Facultad de Medicina/CAS, Universidad del Desarrollo, Región Metropolitana, Chile
Correspondence to: Dr Emily Stockings, National Drug and Alcohol Centre, UNSW Australia, 22–32 King Street, Randwick, NSW 2031; e-mail: e.stockings@unsw.edu.au
Submitted: July 2017; Revision requested: November 2017; Accepted: January 2018
The authors have stated they have no conflict of interest.

Aust NZ J Public Health. 2018; 42:303-8; doi: 10.1111/1753-6405.12777

of ENDS use in young people generally, and among smokers and non-smokers, is needed to assess their potential impact on population health.

To our knowledge, just three systematic reviews have described the prevalence of ENDS use in young people,[26-28] none of which synthesised findings via meta-analysis, or considered the non-English literature,[26-28] thus limiting their ability to provide global estimates of the prevalence of ENDS use in youth. Given the documented increase in ENDS use among young people in recent years,[29-31] a comprehensive review and meta-analyses of the prevalence of ENDS use is needed. In view of the differences across countries in the timing of the introduction of ENDS, and of the implementation of regulations regarding their availability, purchase, and use,[32,33] it is crucial to examine the differences in the prevalence of ENDS use across countries, and to examine changes in prevalence within countries over time. Such data are required to better inform future tobacco control efforts, and public health policy as evidence regarding the potential benefits and harms of ENDS use continues to advance.

Objectives

The aims of this review are to: 1) describe the prevalence of ENDS use ('ever' and 'current') in young people aged ≤20 years by country and combustible tobacco smoking status (non-smokers and current smokers) during the 2013-2015 period; and 2) describe the changes in ENDS use (ever and current) in youth over time (2008–2015) by country.

Methods

The study reports data from a review undertaken on behalf of the WHO. A full description of the review methods is provided elsewhere.[24]

Search strategy and study eligibility

EMBASE, MEDLINE, PsycInfo, CINAHL and the Cochrane library were searched from database conception to December 2015 to identify cross-sectional, repeat-cross-sectional or longitudinal studies reporting on prevalence of ENDS use among young people in the general population, and within a defined geographical region. Eligible studies employed a probability sampling method, and recruited general population samples of young people aged ≤20 years. For studies that included samples aged more than 20 years, the study was included if outcomes among those aged ≤20 years was reported separately, or if the authors provided such results separately. For inclusion in analyses to address Aim 1, studies had to report prevalence of ENDS of samples between (and including) years 2013–2015. For inclusion in analyses of Aim 2, studies could include data on prevalence of ENDS in any year. Studies where participants were recruited based on a specific health condition or as members of particular socioeconomic groups were excluded. There were no restrictions regarding the location of the study, peer review status or language.

Broadly, the search terms included e-cig*, electronic nicotine*, electronic hookah* and e-hookah* as MESH terms (see Appendix A of the online supplementary file). A screen of the first 750 hits of a 'Google.com' search including the terms 'electronic cigarette' and 'e-cigarette' was also undertaken by one reviewer (FT) to capture the grey literature.

Information on potentially eligible studies was also sought from 30 experts recommended by the Tobacco Unit of the WHO, and from selected authors who had published two or more relevant studies in the field.

All studies identified in the searches were exported into EndNote X6 for screening by two reviewers (SY, LW). 'Google translate' was used to assist with assessing the eligibility of non-English language manuscripts.

Data extraction and study quality assessment

SLY and LW or LKC extracted the study characteristics, and prevalence of ENDS use by smoking statuses using a standardised form. Where prevalence of ENDS use by current smokers and non-smokers were not reported, estimates of use were calculated using the following information provided in the original publications: number in total sample, prevalence of ENDS users, prevalence of smokers, and prevalence of concurrent ENDS and tobacco users. A consensus process was used to resolve any differences in extraction. For the included studies, other supporting publications or reports were also sought to obtain relevant information where the data from the primary study was absent or unclear.

Two reviewers (MK and FT) independently undertook an assessment of study quality using the Joanna Briggs Institute Critical Appraisal Checklist for Studies Reporting Prevalence Data.[34-35] Any discrepancies were resolved via discussion with a third reviewer (SY).

Data synthesis and analyses

All analyses were undertaken using Stata version 14 software[36] and the METAPROP package. 'Ever' users were defined as those who had ever used ENDS in their lifetime (including studies that described participants as 'occasional' users), and 'current' use was defined as use in past 30 days, or where studies described participants as being 'current' or 'regular' users. Non-smokers were defined as those not currently smoking (including ex-smokers and never smokers) and smokers were defined as those currently smoking (including experimental, occasional or current users).

For Aim 1, where multiple studies provided estimates of ENDS prevalence between 2013 and 2015 for a single country, data were pooled using a random effects meta-analysis, weighted according to the inverse variance method. The Freeman-Tukey double arcsine transformation of prevalence was also used to allow for studies with prevalence that was close to zero and to account for data skewness. Exact 95% confidence intervals for the individual studies were computed, and stratified by country (where available). Pooled estimates of prevalence are reported as an absolute percent with 95% confidence intervals. For Aim 2, data were pooled where multiple studies reported prevalence estimates for the same country for the same year, and produced estimates for each year of data available. Heterogeneity was assessed using the I-squared statistic and reported for each point estimate, together with estimates of the between study variance, and corresponding *p*-values.

Results

Study characteristics and study quality assessment

Overall, 27 studies that reported findings from 36 individual surveys were included (see Figure S1, online supplementary Appendix for PRISMA flowchart). The included studies were conducted in 13 countries: the US (national and subnational) (*n*=10);[34-43] Korea (*n*=2);[44,45] New Zealand (*n*=2);[46,47] UK, including Scotland and Wales (*n*=2);[48,49] Poland (*n*=2);[50,51] Canada

(*n*=2);[52,53] Hungary (*n*=1),[54] China, including Hong Kong (*n*=1);[55] France (*n*=1);[56] Ireland (*n*=1);[57] Italy (*n*=1);[58] Iceland (*n*=1);[59] and Greece (*n*=1).[60] The studies were conducted between 2008 and 2015,[44,58] with sample sizes ranging from 99[47] to 75,643.[45] Two studies included both youth and adults and provided findings separately for youth (*n*=99 and *n*=160–163).[46,58] ENDS use was assessed as 'ever' use in 22 studies[34,35,37,38,41-53,56-60] and/or 'current use' in 22 studies.[34-43,45,46,48-52,54,55,57,58,60] Four publications also reported 'regular' or 'occasional use'.[46,48,57,58] Of all the included studies, only two[53,58] reported the type of ENDS (i.e. with or without nicotine) used among youth. One study[58] conducted in Italy reported that the majority of regular ENDS users (96%) used ENDS containing nicotine; while the other study,[53] conducted in Canada, reported that the majority (72%) of ENDS ever users used ENDS without nicotine. However, these results were only presented for regular users[58] or ever users[53] in the studies, respectively. All study characteristics are reported in Table S1 (online supplementary file). When evaluated using the Joanna Briggs Institute Critical Appraisal Checklist, most studies used samples that were representative of the target population (*n*=18); conducted appropriate participant recruitment (*n*=26); and had an adequate sample size (*n*=23). Most (*n*=19) described the subjects and setting in detail; however, eight did not. The objectivity and reliability of the measures of ENDS use were mostly unclear, as data were collected via self-report. Important confounders or subgroup differences were accounted for in 18 studies. All 27 studies conducted appropriate statistical analyses (see Figures S2 and S3 in online supplementary Appendix C).

Current prevalence of ENDS use among adolescents

Prevalence of ENDS use among all youth

Estimates of the prevalence of ENDS use from studies conducted in nine countries between 2013 and 2015 are presented in Figures 1 and 2. Rates of ever use among youth were highest in Poland (one data point, 62.1%; 95%CI: 59.9-64.2%), and lowest in Italy (three data points, 5.9%; 95%CI: 3.3-9.2%). Rates of current use among youth were highest in Poland (one data point, 29.9%, 95%CI: 27.9-32.0%) and lowest in New Zealand (one data point, 0.0%; 95%CI: 0.0-3.7%), see Figure 2.

Prevalence of ENDS use among non-smoking youth

Estimates of the prevalence of ever ENDS use among non-smoking youth was available from 13 surveys conducted in eight countries between 2013 and 2015. Prevalence was highest in New Zealand (one data point, 14.0%, 95%CI: 12.7-15.4%) and lowest in the US (one data point, 4.2%, 95%CI: 3.8-4.6%). The prevalence of current ENDS use among non-smoking youth was reported in 10 surveys conducted in six countries between 2013 and 2015. Prevalence was highest in Poland (13.0%; 95%CI: 11.2-15.0%) and lowest in Italy (0.0%, 95%CI: 0.0-0.5%), see supplementary Figure S5.

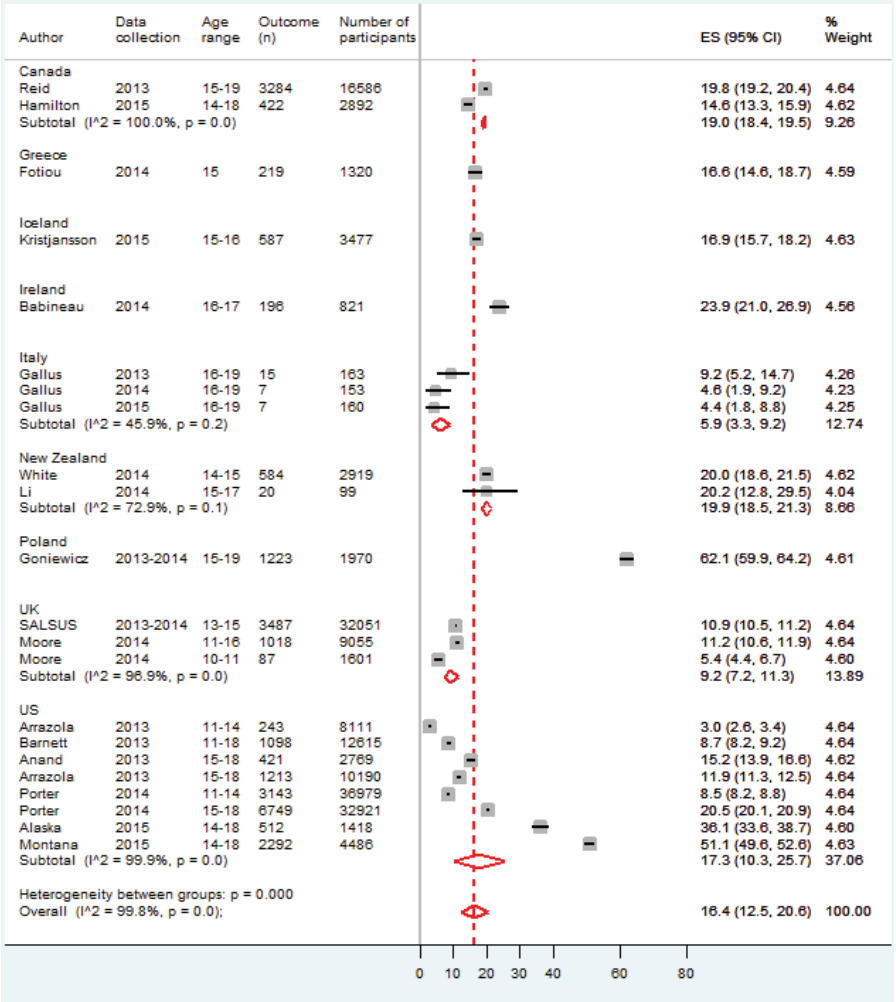
Prevalence of ENDS use among youth who are current smokers

From the 13 surveys conducted between 2013 and 2015 in eight countries, the prevalence of ENDS ever use among current tobacco-smoking youth was highest in Canada (71.9%, 95%CI: 70.9-72.8%) and lowest in Italy (29.9%, 95%CI: 18.5-42.5%), see supplementary Figure S6. The prevalence of current ENDS use among current cigarette-smoking youth was reported in 10 surveys conducted in six countries between 2013 and 2015, and ranged from 57.4% (95%CI: 53.8-61.0%) in Poland to 2.0% (95%CI: 0.7-4.7%) in Greece (see supplementary Figure S7).

Change in ENDS use among youth over time

Seven countries (US, UK, Poland, New Zealand, Korea, Canada and Italy) provided more than one comparable estimate of prevalence of ever use of ENDS among youth between 2008 and 2015. Overall, it appeared that prevalence of ever use increased in four countries: Poland (20.9% in 2010 to 62.1% in 2013); Korea (0.5% in 2008 to 9.4% in 2011); New Zealand (7.0% in 2012 to 20.0% in 2014); and the US (2.7% in 2011 to 47.3% in 2013), decreased in Italy and Canada, and remained stable in the UK. The estimates for Poland, New Zealand, the US and Italy were

Figure 1: Prevalence of ENDS ever use among youth, by country for all respondents (smokers and non-smokers).



drawn from studies with repeated samples of the same participants over time; however, estimates for Korea, Canada and the UK comprised different samples over time (see supplementary Table S2).

Five countries (US, UK, Poland, Italy and Hungary) provided more than one comparable estimate of prevalence of current use of ENDS among youth between 2010 and 2015. Prevalence of current use appeared to increase in three countries: Poland (8.2% in 2010 to 29.9% in 2013); the UK (0.9% in 2013 to 1.4% in 2014); and the US (1.1% to 25.8% in 2015). Estimates from Poland and the US were drawn from studies with repeated samples of the same participants over time; however, estimates for the UK comprised different samples over time. Prevalence of current use decreased in Hungary and remained stable in Italy (see supplementary Table S3), and both estimates were drawn from studies with repeated samples of the same participants over time.

Discussion

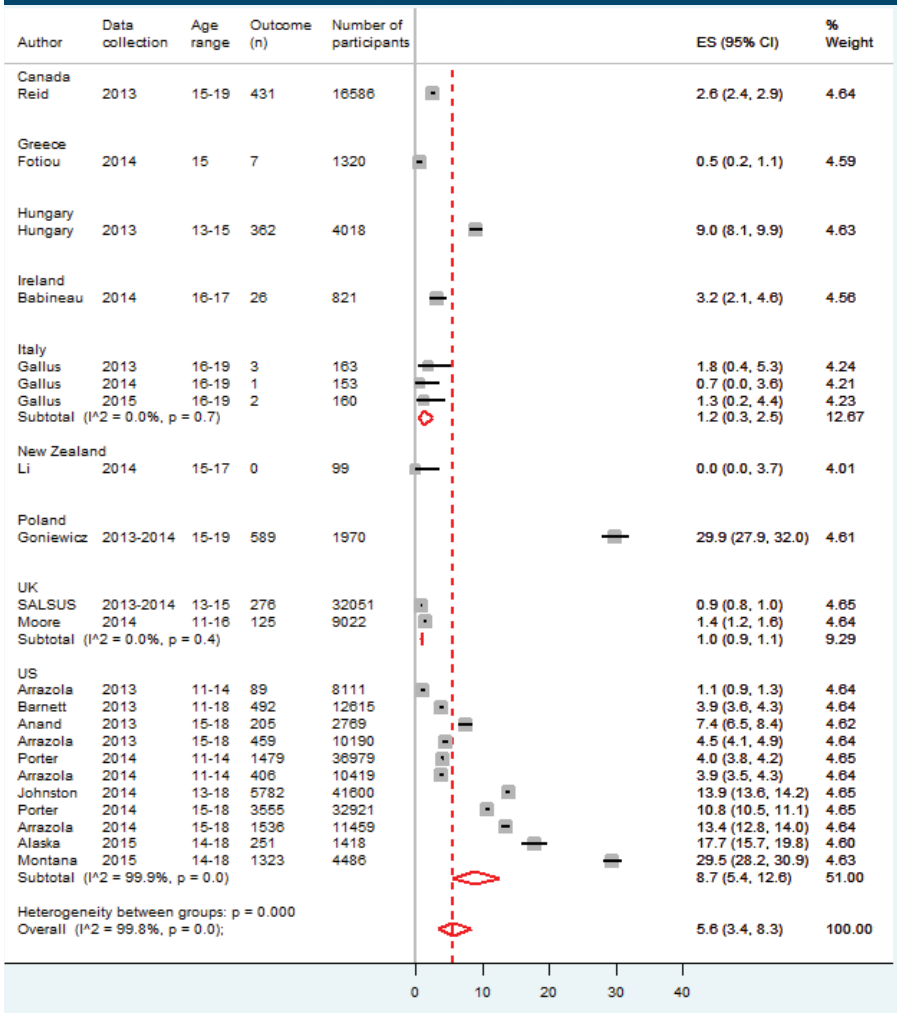
The findings are consistent with previous reviews that found that current smokers were more likely to use ENDS,[61] and that ENDS ever and current use was increasing in the majority of countries with multiple prevalence estimates.[25] While considerable heterogeneity in prevalence estimates were reported across countries, ENDS use appeared to be increasing in most countries among young people. Such findings provide useful information for policy makers who are responsible for implementing tobacco control initiatives.

In interpreting these study results, it is important to consider that data were only available in 13 countries, with 10 of 27 included studies from the US. Systematically and consistently collected population-level survey data on ENDS use is needed in other countries. As such, items assessing ENDS use in youth should be considered for inclusion in regular national and international data collection efforts, such as the Framework Convention on Tobacco Control (FCTC) Global Youth Tobacco Surveys. As data collection regarding ENDS use in youth progresses, researchers may consider including survey items that capture greater detail regarding the quantity and frequency of ENDS use to provide a clearer distinction between current and regular ENDS users, and use patterns that may be occasional, opportunistic or sporadic. This may be achieved by developing validated tools or common standards for assessing ENDS use, as have been established for combustible tobacco use.[62,63]

Several limitations of this review need to be considered. First, the review pooled a variety of measures for assessment of current use, including 'regular' use and 'use in the past 30 days', which may have influenced prevalence estimates for some countries and comparisons across countries. Second, this study examined ENDS use among current non-smokers rather than never smokers. While it is possible that individuals with previous nicotine dependence may have been included, estimates of tobacco use among youth indicate that the majority of non-smoking youth (>80%) have never smoked.[39,48,64] Third, the majority of included studies (93%) did not record whether the ENDS use included nicotine and/or non-nicotine e-liquids. This is an important distinction to consider in future studies of ENDS use in young people, given that concerns have been raised regarding the susceptibility of the adolescent brain to early exposure to nicotine, and the possibility that ENDS experimentation could lead to nicotine dependence in adulthood. Finally, although several studies conducted repeated measures of ENDS use on the same population using the same survey methods, other studies did not and, as such, the country-level changes in ENDS prevalence should be interpreted with caution and validated with longitudinal cohort studies when they become available.

While prevalence of current ENDS use was typically low among non-smokers, increasing use among this group may be a concern in light of recent longitudinal studies reporting a positive association between ENDS ever use and subsequent uptake of cigarette smoking at 12-month follow-up.[21,66-69] Future studies should continue to monitor prevalence of ENDS ever and current use among youth, particularly among non-smokers, to enable pooling and comparisons between countries. Given the marked differences observed between countries in the prevalence of ENDS

Figure 2: Prevalence of ENDS current use among youth, by country for all respondents (smokers and non-smokers).



use, and given that more than 55 countries have already introduced legislation restricting the sale of ENDS to youth,[70] further studies are required to determine the association between prevalence of ENDS use and the ENDS regulatory environment.

Conclusions

This review identified variability in changes in the prevalence of ENDS use among youth by country, smoking status and over time. There is a need to develop validated measures of ENDS use to allow for accurate and comparable assessments and ongoing monitoring of the prevalence of ENDS use among youth, particularly non-smokers. Further research assessing the prevalence of ENDS use in other countries, and the potential impact of policies regulating the availability of ENDS use among youth, is needed.

References

1. German Cancer Research Center. *Electronic Cigarettes - An Overview*. Heidelberg (DE): German Cancer Research Center (DKFZ) Unit Cancer Prevention and WHO Collaborating Centre for Tobacco Control; 2013.
2. Action on Smoking and Health. *Fact Sheet: Use of Electronic Cigarettes (Vapourisers) among Adults in Great Britain* [Internet]. London (UK): Action on Smoking and Health; 2016 [cited 2017 Feb 9]. Available from: http://ash.org.uk/information-and-resources/fact-sheets/use-of-electronic-cigarettes-vapourisers-among-adults-in-great-britain/
3. Agaku IT, King BA, Husten CG, Bunnell R, Ambrose BK, Hu SS, et al. Tobacco product use among adults — United States, 2012-2013. *MMWR Morb Mortal Wkly Rep*. 2014;63(25):542-7.
4. Berridge V. Electronic cigarettes and history. *Lancet*. 383(9936):2204-5.
5. Green SH, Bayer R, Fairchild AL. Evidence, Policy, and E-Cigarettes — Will England Reframe the Debate? *N Engl J Med*. 2016;374(14):1301-3.
6. Mendelsohn CP. Electronic cigarettes: What can we learn from the UK experience? *Med J Aust*. 2016;204(1):14-5.
7. McRobbie H, Bullen C, Hartmann-Boyce J, Hajek P. Electronic cigarettes for smoking cessation and reduction (Cochrane Review). In: *The Cochrane Database Systematic Reviews*; 2014; 12; CD010216.
8. McNeill A, Brose L, Calder R, Hitchman S, Hajek P, McRobbie H. *E-cigarettes: An Evidence Update* [Internet]. A report commissioned by Public Health England. 2015 [cited 2017 Dec 23]. Available from: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/457102/Ecigarettes_an_evidence_update_A_report_commissioned_by_Public_Health_England_FINAL.pdf
9. Royal College of Psychiatrists. *Nicotine without Smoke: Tobacco Harm Reduction*. London (UK): RCP; 2016.
10. Royal Society for Public Health. *Stopping Smoking by Using other Sources of Nicotine*. London (UK): RSPH; 2015.
11. Rigotti N. E-cigarette use and subsequent tobacco use by adolescents: New evidence about the potential risk of e-cigarettes. *JAMA*. 2015;314(7):673-4.
12. Australian Institute of Health and Welfare. *National Drug Strategy Household Survey Detailed Report 2013*. Drug Statistics Series No.: 28. Canberra (AUST): AIHW; 2014.
13. Centres for Disease Control and Prevention. *Smoking and Tobacco Use: National Youth Tobacco Survey (NYTS)* [Internet]. Atlanta (GA): CDC; 2015 [cited 2016 Jul 11]. Available from: http://www.cdc.gov/tobacco/data_statistics/surveys/nyts/
14. U.S. Department of Health and Human Services. *The Health Consequences of Smoking - 50 Years of Progress*. A Report of the Surgeon General. Rockville (MD): Office of the Surgeon General; 2014.
15. U.S. Department of Health and Human Services. *E-cigarette Use among Youth and Young Adults*. A report of the US Surgeon General. Atlanta (GA): Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Office of Smoking and Health; 2016.
16. Grana R, Benowitz N, Glantz SA. E-cigarettes: A scientific review. *Circulation*. 2014;129(19):1972-86.
17. Department of Health. *Rules about Tobacco, E-cigarettes and Smoking: 1 October 2015* [Internet]. London (UK): Department of Health and Social Care; 2015 [cited 2017 Jun 23]. Available from: https://www.gov.uk/government/publications/new-rules-about-tobacco-e-cigarettes-and-smoking-1-october-2015/new-rules-about-tobacco-e-cigarettes-and-smoking-1-october-2015
18. U.S Food and Drug Administration. *FDA Takes Significant Steps to Protect Americans from Dangers of Tobacco through New Regulation* [Internet]. Silver Spring (MD): U.S. Department of Health and Human Services; 2016 [cited 2017 Jun 23]. Available from: https://www.fda.gov/NewsEvents/Newsroom/PressAnnouncements/UCM499234.htm
19. Global Tobacco Control. *Country Laws Regulating E-cigarettes* [Internet]. Baltimore (MD): Johns Hopkins Bloomberg School of Public Health, Institute for Global Tobacco Control; 22017 [cited 2017 Jul 14]. Available from: http://globaltobaccocontrol.org/e-cigarette/policy-domains
20. Krishnan-Sarin S, Morean ME, Camenga DR, Cavallo DA, Kong G. E-cigarette use among high school and middle school adolescents in Connecticut. *Nicotine Tob Res*. 2015;17(7):810-18.
21. Yoong SL, Tzelepis F, Wiggers J, Oldmeadow C, Chai LK, Paul C, et al. *Prevalence of Smoking-proxy Electronic Inhaling System (SEIS) Use and its Association with Tobacco Initiation in Youths: A Systematic Review*. Geneva (CHE): World Health Organisation; 2016.
22. Alawsi F, Nour R, Prabhu S. Are e-cigarettes a gateway to smoking or a pathway to quitting? *Br Dent J*. 2015;219(3):111-15.
23. Schneider S, Diehl K. Vaping as a catalyst for smoking? an initial model on the initiation of electronic cigarette use and the transition to tobacco smoking among adolescents. *Nicotine Tob Res*. 2016;18(5):647-53.
24. Zhong J, Cao S, Gong W, Fei F, Wang M. Electronic cigarettes use and intention to cigarette smoking among never-smoking adolescents and young adults: A meta-analysis. *Int J Environ Res Public Health*. 2016;13(5). pii: E465.
25. Chapman SLC, Wu L-T. E-Cigarette prevalence and correlates of use among adolescents versus adults: A review and comparison. *J Psychiatr Res*. 2014;54:43-54.
26. Durmowicz EL. The impact of electronic cigarettes on the paediatric population. *Tob Control*. 2014;23 Suppl 2:ii41.
27. Greenhill R, Dawkins L, Notley C, Finn MD, Turner JJD. Adolescent awareness and use of electronic cigarettes: A review of emerging trends and findings. *J Adolesc Health*. 2016;59(6):612-19.
28. Conference of the Parties to the WHO Framework Convention on Tobacco Control. Electronic *Nicotine Delivery Systems, Including Electronic Cigarettes*. Report by the Convention Secretariat (FCTC/COP/5/13) [Internet]. Geneva (CHE): World Health Organization; 2012 [cited 2017 Jan 23]. Available from: http://apps.who.int/gb/fctc/PDF/cop5/FCTC_COP5_13-en.pdf
29. Legal Resource Center for Maryland. *State Electronic Smoking Device Legislation* [Internet]. Baltimore (MD): University of Maryland Francis King Carey School of Law Legal Resource Center for Public Health Policy; 2013 [cited 2017 2 Feb]. Available from: http://publichealthlawcenter.org/sites/default/files/resources/UofMaryland-fs-state-e-smokingdevice-legislation-9-2013.pdf
30. The Joanna Briggs Institute. *Joanna Briggs Institute Reviewers' Manual 2014 Edition/Supplementation: The Systematic Review of Prevalence and Incidence Data*. Adelaide (AUST): The Joanna Briggs Institute; 2014.
31. Munn Z, Moola S, Riitano D, Lisy K. The development of a critical appraisal tool for use in systematic reviews addressing questions of prevalence. *Int J Health Policy Manag*. 2014;3(3):123-8.
32. *STATA*: statistical software. Release 14. College Station (TX): Stata Corporation; 2015.
33. World Health Organization. *Report on the Global Tobacco Epidemic, 2008: The MPOWER Package*. Geneva (CHE): WHO; 2008.
34. Anand V, McGinty KL, O'Brien K, Guenthner G, Hahn E, Martin CA. E-cigarette use and beliefs among urban public high school students in North Carolina. *J Adolesc Health*. 2015;57(1):46-51.
35. Arrazola RA, Neff LJ, Kennedy SM, Holder-Hayes E, Jones CD, Centers for Disease C, et al. Tobacco use among middle and high school students--United States, 2013. *MMWR Morb Mortal Wkly Rep*. 2014;63(45):1021-6.
36. Arrazola RA, Singh T, Corey CG, Husten CG, Neff LJ, Apelberg BJ, et al. Tobacco use among middle and high school students - United States, 2011-2014. *MMWR Morb Mortal Wkly Rep*. 2015;64(14):381-5.
37. Barnett TE, Soule EK, Forrest JR, Porter L, Tomar SL. Adolescent electronic cigarette use: Associations with conventional cigarette and hookah smoking. *Am J Prev Med*. 2015;49(2):199-206.
38. Corey C, Baoguang W, Johnson SE, Apelberg B, Husten C, King BA, et al. Electronic Cigarette Use Among Middle and High School Students - reprinted (slightly edited) from Morbidity and Mortality Weekly Report 2013;62:729-730. *Oncol Times*. 2013;35(19):36.
39. Dutra LM, Glantz SA. Electronic cigarettes and conventional cigarette use among U.S. adolescents: A cross-sectional study.[Erratum appears in JAMA Pediatr. 2014 Jul;168(7):684]. *JAMA Pediatr*. 2014;168(7):610-17.
40. Johnston LD, O'Malley PM, Miech RA, Bachman JG, Schulenberg JE. *Monitoring the Future National Survey Results on Drug Use: 1975-2014: Overview, Key Findings on Adolescent Drug Use*. Ann Arbor (MI): University of Michigan Institute for Social Research; 2015.
41. Porter L, Duke J, Hennon M, Dekevich D, Crankshaw E, Homsi G, et al. Electronic cigarette and traditional cigarette use among middle and high school students in Florida, 2011-2014. *PLoS One*. 2015;10(5):e0124385.
42. Alaska Department of Health and Social Services. *2015 Alaska Youth Risk Behavior Survey Results* [Internet]. Anchorage (AK): State of Alaska; 2015 [cited 2016 Apr 29]. Available from: http://dhss.alaska.gov/dph/Chronic/Pages/yrbs/yrbsresults.aspx
43. Montana Office of Public Instruction. *2015 Montana Youth Risk Behaviour Survey High School Results* [Internet]. Helena (MT): Government State Montana; 2015 [2016 Apr 29]. Available from: http://opi.mt.gov/pdf/YRBS/15/15MT_YRBS_FullReport.pdf
44. Cho JH, Shin E, Moon SS. Electronic-cigarette smoking experience among adolescents. *J Adolesc Health*. 2011;49(5):542-6.
45. Lee S, Grana RA, Glantz SA. Electronic cigarette use among Korean adolescents: A cross-sectional study of market penetration, dual use, and relationship to quit attempts and former smoking. *J Adolesc Health*. 2014;54(6):684-90.
46. Li J, Newcombe R, Walton D. The prevalence, correlates and reasons for using electronic cigarettes among New Zealand adults. *Addict Behav*. 2015;45:245-51.
47. White J, Li J, Newcombe R, Walton D. Tripling use of electronic cigarettes among New Zealand adolescents between 2012 and 2014. *J Adolesc Health*. 2015;56(5):522-8.
48. Moore G, Hewitt G, Evans J, Littlecott HJ, Holliday J, Ahmed N, et al. Electronic-cigarette use among young people in Wales: Evidence from two cross-sectional surveys. *BMJ Open*. 2015;15;5(4):e007072.
49. National Services Scotland. *Scottish Schools Adolescent Lifestyle and Substance Use Survey (SALSUS): SMOKING among 13 and 15 Year Olds in Scotland 2013*. Edinburgh (SCO): National Services Scotland; 2014.
50. Goniewicz ML, Gawron M, Nadolska J, Balwicki L, Sobczak A. Rise in electronic cigarette use among adolescents in Poland. *J Adolesc Health*. 2014;55(5):713-15.
51. Goniewicz ML, Zielinska-Danch W. Electronic cigarette use among teenagers and young adults in Poland. *Pediatrics*. 2012;130(4):e879-85.

52. Reid JL, Hammond D, Rynard VL, Burkhalter R. *Tobacco Use in Canada: Patterns and Trends*. 2015 ed. Ontario (CAN): University of Waterloo Propel Centre for Population Health Impact; 2015.
53. Hamilton HA, Ferrence R, Boak A, Schwartz R, Mann RE, O'Connor S, et al. Ever use of nicotine and nonnicotine electronic cigarettes among high school students in Ontario, Canada. *Nicotine Tob Res*. 2015;17(10):1212-8.
54. Hungarian Focal Point for Tobacco Control. *Hungarian and Foreign Data & Statistics: Global Youth Tobacco Surveys* [Internet]. Budapest (HUN): National Institute for Health Development; 2014 [cited 2015 Oct 2]. Available from: http://www.fokuszpont.dohanyzasvisszaszoritasa.hu/en/content/hungarian-and-foreign-data-statistics
55. Wang MP, Ho SY, Leung LT, Lam TH. Electronic cigarette use and its association with smoking in Hong Kong Chinese adolescents. *Addict Behav*. 2015;50:124-7.
56. Dautzenberg B, Birkui P, Noel M, Corsett J, Osman M, Dautzenberg M. E-cigarette: A new tobacco product for schoolchildren in Paris. *Open J Respir Dis*. 2013;3(1):21-4.
57. Babineau K, Taylor K, Clancy L. Electronic cigarette use among irish youth: A cross sectional study of prevalence and associated factors. *PLoS One*. 2015;10(5):e0126419.
58. Gallus S, Lugo A, Pacifici R, Pichini S, Colombo P, Garattini S, et al. E-cigarette awareness, use, and harm perceptions in Italy: A national representative survey. *Nicotine Tob Res*. 2014;16(12):1541-8.
59. Kristjansson AL, Mann MJ, Sigfusdottir ID. Licit and illicit substance use by adolescent e-cigarette users compared with conventional cigarette smokers, dual users, and nonusers. *J Adolesc Health*. 2015;57(5):562-4.
60. Fotiou A, Kanavou E, Stavrou M, Richardson C, Kokkevi A. Prevalence and correlates of electronic cigarette use among adolescents in Greece: A preliminary cross-sectional analysis of nationwide survey data. *Addict Behav*. 2015;51:88-92.
61. Wang M, Wang J-W, Cao S-S, Wang H-Q, Hu R-Y. Cigarette smoking and electronic cigarettes use: A meta-analysis. *Int J Environ Res Public Health*. 2016;13(1):120.
62. West R, Hajek P, Stead L, Stapleton J. Outcome criteria in smoking cessation trials: Proposal for a common standard. *Addiction*. 2005;100(3):299-303.
63. Global Adult Tobacco Survey Collaborative Group. *Tobacco Questions for Surveys: A Subset of Key Questions from the Global Adult Tobacco Survey (GATS)*. 2nd ed. Atlanta (GA): Centers for Disease Control and Prevention; 2011.
64. Centers for Disease Control and Prevention. *Youth and Tobacco Use* [Internet]. Atlanta (GA): CDC; 2016 [cited 2016 Jul 11]. Available from: http://www.cdc.gov/tobacco/data_statistics/fact_sheets/youth_data/tobacco_use/
65. Kong G, Morean ME, Cavallo DA, Camenga DR, Krishnan-Sarin S. Reasons for electronic cigarette experimentation and discontinuation among adolescents and young adults. *Nicotine Tob Res*. 2015;17(7):847-54.
66. Wills TA, Knight R, Sargent JD, Gibbons FX, Pagano I, Williams RJ. Longitudinal study of e-cigarette use and onset of cigarette smoking among high school students in Hawaii. *Tob Control*. 2017;26(1):34-39.
67. Primack BA, Soneji S, Stoolmiller M, Fine MJ, Sargent J. Initiation of cigarette smoking after electronic cigarette use: A national study of young adults. *J Gen Intern Med*. 2015;30:S193.
68. Leventhal AM, Strong DR, Kirkpatrick MG, Unger JB, Sussman S, Riggs NR, et al. Association of electronic cigarette use with initiation of combustible tobacco product smoking in early adolescence. *JAMA*. 2015;314(7):700-7.
69. Soneji S, Barrington-Trimis JL, Wills TA, Leventhal AM, Unger JB, Gibson LA, et al. Association between initial use of e-cigarettes and subsequent cigarette smoking among adolescents and young adults: A systematic review and meta-analysis. *JAMA Pediatr*. 20171;171(8):788-797.
70. Institute for Global Tobacco Control. *Country Laws Regulating E-cigarettes: A Policy Scan*. Baltimore (MD): Johns Hopkins Bloomberg School of Public Health; 2015.

Supporting Information

Additional supporting information may be found in the online version of this article:

Supplementary Appendix A: Search terms employed in the electronic databases.

Supplementary Appendix B: PRISMA Flowchart.

Supplementary Appendix C: Risk of bias in included studies.

Supplementary Appendix D: Supplementary results figures and tables.