



Published in final edited form as:

Curr Addict Rep. 2017 December ; 4(4): 422–430. doi:10.1007/s40429-017-0176-5.

Gender Differences in U.S. Adolescent E-Cigarette Use

Grace Kong¹, Karissa E. Kuguru¹, and Suchitra Krishnan-Sarin¹

¹Yale School of Medicine, 34 Park Street, Room S-211, New Haven, CT 06519, USA

Abstract

Purpose of Review—This study aims to review the recent (2012–2017) available gender difference data on e-cigarette use among adolescents.

Recent Findings—E-cigarettes are the most commonly used tobacco product among adolescents, and recent study findings showed that e-cigarette use can lead to cigarette smoking. However, gender differences in e-cigarette use among adolescents are relatively unknown.

Summary—We used the search terms “adolescents” and “e-cigarettes” on PubMed and identified 652 articles. Of these, 16 articles (2.5%) examined gender differences in adolescent e-cigarette use. Boys appear to have greater use of e-cigarettes, but girls may be at increased risk if e-cigarettes are targeted to them, as it has been for cigarettes. Data on gender differences are limited, and future research should continue to examine gender differences in e-cigarette use. Trends in use rates could evolve with new regulations and innovations in e-cigarette marketing and product features.

Keywords

E-cigarette; Youth; Adolescents; Gender

Introduction

E-Cigarettes Are Popular Among Adolescents

Electronic cigarettes (e-cigarettes), also referred to as electronic nicotine delivery system (ENDS), are battery-operated electronic devices that produce visible aerosol (i.e., vapor) when a liquid solution (also known as e-liquid or e-juice), which may contain flavoring, nicotine, and other chemicals, such as propylene glycol (PG) and vegetable glycerin (VG), are heated. Since their introduction to the USA and the global market around 2007, e-cigarettes have rapidly become popular among adolescents. The recent National Youth Tobacco Survey showed that past-month e-cigarette use among US adolescents increased eightfold between 2011 and 2016 (1.5 to 11.3%), while cigarette smoking decreased (15.8 to

Correspondence to: Grace Kong.

Compliance with Ethical Standards

Conflict of Interest G.K., K.E.K., and S.K.-S. declare they have no conflict of interest.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

This article is part of the Topical Collection on *Women and Addictions*

8.0%) during this same time period [1•]. E-cigarettes are now the most commonly used nicotine/tobacco product among adolescents.

The growing popularity of e-cigarettes has stimulated a heated debate among health professionals, with some viewing e-cigarettes as a valuable harm reduction tool for current cigarette smokers [2], while others take a pre-cautionary view by warning the public of the potential harm of exposing youth to nicotine through e-cigarettes [3]. Of note, many recent studies suggest that youth who start using e-cigarettes are more likely to progress on to using other combustible tobacco products like cigarettes [4•]. In fact, based on this evidence, the recent US Surgeon General's Report on e-cigarette use among youth recommends a development of a comprehensive strategy to protect youth from e-cigarettes [5•].

Gender Differences in the Effects of Nicotine and Tobacco Use

While e-cigarette use among youth has been well-documented using national [1•, 6] and local data [7–10], there is limited evidence on gender differences in use rates. Gender differences need examination considering the extensive existing research on gender differences in the effects of nicotine and tobacco use behaviors [11].

Historically, cigarette smoking has been higher among males; however, there has been a narrowing of this gap in the USA and around the world [12, 13]. It has been proposed that the narrowing of gender differences may be in part due to extensive targeting of females through the use of tobacco marketing that normalizes and glamorizes smoking through the use of themes on how cigarettes could curb appetite, promote weight loss, and make females thin and independent [14, 15]. Even the shape of cigarettes and the packaging through the use of slim, long packs, with pink and pastel colors are specifically designed to appeal to females [16, 17]. The increase in smoking among females is a serious public health problem and has led to two US Surgeon General's Report dedicated to setting the national priority on reducing and preventing smoking among females [18, 19].

There are also well-established gender differences in nicotine effects. Females metabolize nicotine and cotinine (a metabolite of nicotine) faster than males due to the presence of estrogen [20]. The quicker metabolism of nicotine and cotinine may be related to worse smoking cessation outcomes among females [21–23]. Females are also less sensitive to the rewarding effects of nicotine (i.e., they find it less rewarding) [24] and experience greater adverse subjective sensitivity (i.e., greater strength, head rush, bad effects) [25]. However, females have greater sensitivity to the non-pharmacological components (e.g., visual, olfactory cues, mood) of cigarette smoking, which may contribute to difficulties in quitting [24].

The path to developing nicotine dependence and eventually achieving cessation appears to vary between males and females. First, early age of onset of cigarette smoking is associated with negative outcomes, such as greater nicotine dependence [26]. Although males are more likely to initiate at an earlier age than females [27], evidence indicates that males are more likely than females to forward telescope (recall their age of onset for regular cigarette smoking to be a younger age) [28]. The forward telescoping among males suggests that females could face similar risks as males in developing nicotine dependence. Second,

adolescent females and males have different reasons for maintaining smoking behavior. Female adolescents smoke to control weight [29, 30]; conversely, male adolescents report smoking because of the taste and smell of cigarettes and the “buzz” they feel from smoking [30]. Third, female smokers have lower smoking cessation rates relative to male smokers [21–23, 31, 32]. The gender smoking cessation could be related to concerns about gaining weight [33], negative mood when trying to quit [34], and greater reinforcement for smoking from behavioral and non-pharmacological factors (also described above) [32].

Finally, female smokers appear to experience worse health outcomes than male smokers. Although not consistently observed, studies have shown that the risk of lung cancer and other lung diseases appear to be greater in females than males [35, 36]. Female smokers also experience greater respiratory symptoms and lower ratings of overall health compared to male smokers [37]. The few published studies on health outcomes among adolescent smokers have shown that adolescent girls who smoke experience greater deficits in lung growth [38] and more respiratory symptoms than boys who smoke [39].

Much of the literature on gender differences in tobacco use has focused on cigarettes. With the growing popularity of e-cigarettes among youth [6, 40], potential gender differences in e-cigarette use needs examination. Thus, we conducted a review of the recent (2012–2017) available literature to identify gender differences in e-cigarette use among adolescents.

Methods

We searched the terms “adolescents” and “e-cigarettes” on PubMed in May 2017. The search was limited to publication years between 2012 and 2017 in the USA. To be included in this review, the articles had to report e-cigarette use rates for each gender among youth up to 18 years old accompanied by an appropriate statistical test and/or *p* values or confidence intervals to assess gender differences in use rates. Articles that reported dual use of e-cigarettes and other tobacco products were excluded.

In this review, we reported e-cigarette use by gender and study characteristics, such as the year that the survey was conducted, study location, type of survey, and sample characteristics, such as age and sample size (Table 1). We also examined the questions used to define and assess e-cigarette use (Table 2).

Results

The search terms identified 652 studies, and 2.5% (*N* = 16) of the studies met the inclusion criteria. Of the 16 studies, 2 studies reported use rates separated by age group (i.e., middle school versus high school) and 1 study reported use rates separated by 2 years of survey administration (i.e., 2011 vs. 2012). These rates were counted as separate rates despite being from the same studies.

Of the included studies, 81.3% reported “ever use” rates and 75% reported “current use” rates. E-cigarette use was **defined** consistently across the studies: “ever use” was defined as ever trying an e-cigarette and “current use” was defined as using an e-cigarette in the past 30 days. Specific brands and terms referring to e-cigarettes varied slightly. When the e-cigarette

brand name was provided as an example, the brands used were “Ruyan” and “NJOY.” Some also used the terms “e-cigarettes” and “electronic cigarettes” to refer to the product. Only one study used terms such as “vape pen” and “e-hookah” to refer to the product.

The surveys were conducted around 2013 ($SD = 1.31$), and the sample sizes ranged from $N = 298$ to $N = 36,993$; larger sample sizes came from national surveys and small sample sizes came from surveys of a subset of a cohort study. Five studies (26%) used the national survey, National Youth Tobacco Survey (NYTS), and 73.7% used surveys from specific states (i.e., CA, CT, FL, NC, NY, OR, TX). Approximately 16% were data derived from middle school students, 47% from high school students, and 32% from both.

Ever e-cigarette use rates ranged from 2 to 48.9% among boys and 1.2 to 49.2% among girls; current use rates ranged from 1.6 to 16.2% among boys and 0.6 to 16.8% among girls. Significant gender differences were observed among 53.8% ($n = 7$) of studies that reported ever e-cigarette use rates ($n = 13$) and 66.7% ($n = 8$) of studies that reported current use rates ($n = 12$). All studies that reported gender differences observed higher use rates among boys than girls. All gender comparisons, with the exception of three studies, were bivariate comparisons. The three studies that did not provide bivariate comparisons examined gender differences adjusting for other covariates.

Discussion

E-cigarettes have been available in the market for about a decade. Their use has grown rapidly, surpassing cigarette smoking to become the most commonly used tobacco product among adolescents [1•, 6]. However, little is known about gender differences in adolescent e-cigarette use. Our review of the literature published between 2012 and 2017 showed that about half (when examining “ever e-cigarette use”) and two thirds (when examining “current e-cigarette use”) of the studies reported significant differences in e-cigarette use between boys and girls. All studies that observed gender differences showed that boys had higher use rates than girls. Higher e-cigarette use among adolescent boys is perhaps not surprising given the well-documented research findings showing higher tobacco use among both adolescent [40] and adult males [55], as well as the greater nicotine-related subjective reward experienced by males relative to females and the subjective adverse effects of nicotine experienced by females relative to males (as reviewed in the “Introduction” section).

Interestingly, unlike with cigarettes, e-cigarette marketing seems to be targeted toward males [56, 57]. Although specific studies of gender differences in e-cigarette marketing have yet to be conducted, existing studies have identified that e-cigarette marketing have focused on sporting events [56] and have emphasized sex appeal (e.g., sexy women surrounding male users) [57], which may make these products more enticing to adolescent males. Additionally, relative to boys, adolescent girls are more likely to obtain their e-cigarettes from their peers, while boys are more likely than girls to purchase e-cigarettes from online sources [58], suggesting that purchase and use of e-cigarettes among boys may be influenced by e-cigarette marketing. Boys who purchase their own e-cigarettes could be also using them more frequently due to greater, easier access from owning their own e-cigarettes, whereas

girls who depend on their peers for e-cigarettes may be using them more infrequently due to limited access. Although current trends point to boys being more likely to use e-cigarettes, about half of the studies did not observe significant differences in use rates by gender. Therefore, future studies need to assess gender differences in e-cigarette use, especially considering that e-cigarette marketing strategies and innovations in product features (e.g., packaging and device design, appealing flavors) are expected to evolve rapidly. Future studies should also assess other subgroup differences in e-cigarette use, such as socioeconomic status (SES) and racial/ethnic and sexual minority groups. These subgroups have been traditionally targeted by the tobacco industry [59–61].

It is important to note that e-cigarette use rates varied depending on the age of the sample and the questions used to assess e-cigarette use. Generally, use rates were lower among younger adolescents and higher among older adolescents. When interpreting use rates, it is important to determine how adolescents are grouped together (e.g., middle school and high school together or separately). The measurement of e-cigarette use should also be taken into consideration. The studies included in this review examined “ever use” or “current use,” defined as past-30-day use of e-cigarettes. The use rates were higher for “ever use” than for “current use.” Future studies should use more nuanced measurement of e-cigarette use that better captures the use patterns such as frequency and quantity of use.

Although there have been many research studies on e-cigarettes (our study identified 652 between 2012 and 2017 using search terms e-cigarettes and adolescents), research on e-cigarettes is still at a nascent stage and future studies are needed to assess whether subgroup differences in e-cigarette use exist. Our research shows that very few studies (2.5%) presented adolescent e-cigarette use rates by gender. Furthermore, even the studies that examined gender differences have not explicitly examined gender differences as the main focal point, but rather, examined gender as a covariate in examining use rates. In addition to identifying gender differences in use rates, future studies should also examine the context in which gender differences could occur.

Our examination of the existing literature also identified several areas for future research. Even though most of the studies we reviewed were published between 2012 and 2017, the questions used to assess the brands of e-cigarettes used were in many cases outdated and potentially unfamiliar to adolescents (e.g., Ruyan, which is the first e-cigarette brand to be marketed in the USA). Currently, there are many varieties of e-cigarette devices available with thousands of flavors [62]. Furthermore, a recent study indicates that the use of disposable/cigalike devices are less common among adolescents, whereas later generation devices, such as rechargeable, pen-like devices, mods/mech-modes are more common [63]. Thus, future research needs to consider the use of different device types and focus on later generation devices that adolescents may be more familiar with to obtain more accurate estimates of use.

Future research on gender differences in e-cigarette use should consider the fact that e-cigarettes are different from other tobacco products because they have various constituents that can be manipulated (e.g., nicotine, flavors, PG/VG levels). It is particularly important to determine the level of nicotine used in the e-liquids, considering the known gender

differences in nicotine metabolism and reactivity. One study [64] has examined nicotine concentrations used by adolescents in e-cigarettes. This study observed that 28.5% of adolescent e-cigarette users used nicotine-free e-liquid, 37.5% used nicotine e-liquid, and 34.1% did not know the levels of nicotine in their e-liquids. Furthermore, girls were more likely to report not knowing the content of the nicotine level being used in their e-cigarettes, perhaps because they are more likely to use their friends' e-cigarettes [58]. Therefore, future research also needs to focus on examining gender differences in the use of nicotine by quantifying the nicotine in e-cigarettes being used by youth, and other appealing constituents like flavors in e-cigarettes to understand if girls and boys use e-cigarettes for different reasons.

Conclusion

Very few studies have examined gender differences in e-cigarette use among adolescents. Of the studies that have examined gender differences, gender differences were not the focal point of the study, and only about half observed that boys were more likely to use e-cigarettes than girls and the other half did not observe gender differences in e-cigarette use. As the regulation and marketing of e-cigarettes are quickly evolving, future studies should continue to assess gender differences in adolescent e-cigarette use while also assessing quantity and frequency of use, nicotine levels and other constituents used in e-liquids, and the device type. Furthermore, studies should also assess e-cigarette use among subpopulations of adolescents who have been traditionally targeted by the tobacco industry, such as adolescents from low SES backgrounds and ethnic/racial and sexual minority adolescents.

Acknowledgments

This study was supported in part by the National Institutes of Health (NIH) and Food and Drug Administration (FDA) grant P50DA036151, awarded to the Yale Tobacco Center of Regulatory Science (TCORS). The content is solely the responsibility of the authors and does not necessarily represent the official views of the NIH or the FDA.

References

Papers of particular interest, published recently, have been highlighted as:

- Of importance

1. Jamal A, Gentzke A, Hu SS, Cullen KA, Apelberg BJ, Homa DM, et al. Tobacco use among middle and high school students—United States, 2011–2016. *MMWR*. 2017; 66(23):597–603. Provides the most recent national rates of e-cigarette use among youth. [PubMed: 28617771]
2. Nitzkin JL. The case in favor of E-cigarettes for tobacco harm reduction. *Int J Environ Res Public Health*. 2014; 11(6):6459–71. [PubMed: 25003176]
3. Kong G, Krishnan-Sarin S. A call to end the growing epidemic of adolescent e-cigarette use. *Drug Alcohol Depend*. 2017; 174:215–21. [PubMed: 29350618]
4. 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. Most recent review of the association between e-cigarette and cigarette use among youth. 2017
5. USDHHS. A Report of the Surgeon General. Atlanta, GA: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease

- Prevention and Health Promotion, Office on Smoking and Health; 2016. E-Cigarette Use Among Youth and Young Adults. US Surgeon General report of e-cigarette use among youth
6. Johnston, LD., O'Malley, PM., Miech, RA., Bachman, JG., Schulenberg, JE. Monitoring the future national survey results on drug use, 1975–2015: overview, key findings on adolescent drug use. Ann Arbor: Institute for Social Research, The University of Michigan; 2016.
 7. Barrington-Trimis JL, Berhane K, Unger JB, Cruz TB, Huh J, Leventhal AM, et al. Psychosocial factors associated with adolescent electronic cigarette and cigarette use. *Pediatr.* 2015; 136(2):308–17.
 8. Krishnan-Sarin S, Morean ME, Camenga DR, Cavallo DA, Kong G. E-cigarette use among high school and middle school students. *Nic Tob Res.* 2015; 17:810–8.
 9. 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. [PubMed: 26284721]
 10. Wills TA, Knight R, Williams RJ, Pagano I, Sargent JD. Risk factors for exclusive e-cigarette use and dual e-cigarette use and tobacco use in adolescents. *Pediatr.* 2014; 135(1):43–51.
 11. Perkins KA, Donny EC, Caggiula AR. Sex differences in nicotine effects and self-administration: review of human and animal evidence. *Nic Tob Res.* 1999; 1:301–15.
 12. Warren CW, Jones NR, Eriksen MP, Asma S. Patterns of global tobacco use in young people and implications for future chronic disease burden in adults. *Lancet.* 2006; 367:749–53. [PubMed: 16517275]
 13. Greaves, L. *Sifting the evidence: gender and tobacco control.* Geneva: 2007.
 14. Barbeau EM, Leavy-Sperounis A, Balbach ED. Smoking, social class, and gender: what can public health learn from the tobacco industry about disparities in smoking? *Tob Control.* 2004; 13(2):115. [PubMed: 15175523]
 15. Amos A, Haglund M. From social taboo to “torch of freedom”: the marketing of cigarettes to women. *Tob Control.* 2000; 9(1):3. [PubMed: 10691743]
 16. Wakefield M, Morley C, Horan JK, Cummings KM. The cigarette pack as image: new evidence from tobacco industry documents. *Tob Control.* 2002; 11(suppl 1):i73. [PubMed: 11893817]
 17. Doxey J, Hammond D. Deadly in pink: the impact of cigarette packaging among young women. *Tob Control.* 2011; 20(5):353–60. [PubMed: 21478476]
 18. USDHHS. Women and smoking: a report of the surgeon general. *MMWR Morb Mortal Wkly Rep.* 2002; 51:1–30.
 19. USDHHS. A report of the Surgeon General. Washington D.C: U.S. Department of Health and Human Services, Public Health Service, Office of the Assistant Secretary for Health, Office on Smoking and Health; 1980. *The Health Consequences of Smoking for Women.*
 20. Benowitz NL, Lessov-Schlaggar CN, Swan GE, Jacob P III. Female sex and oral contraceptive use accelerate nicotine metabolism. *Clinical Pharmacology & Therapeutics.* 2006; 79:480–8. [PubMed: 16678549]
 21. Piper ME, Cook JW, Schlam TR, Jorenby DE, Smith SS, Bolt DM, et al. Gender, race, and education differences in abstinence rates among participants in two randomized smoking cessation trials. *Nic Tob Res.* 2010; 12(6):647–57.
 22. Scharf D, Shiffman S. Are there gender differences in smoking cessation, with and without bupropion? Pooled- and meta-analyses of clinical trials of bupropion SR. *Addiction.* 2004; 99(11):1462–9. [PubMed: 15500599]
 23. Cepeda-Benito A, Reynoso JT, Erath S. Meta-analysis of the efficacy of nicotine replacement therapy for smoking cessation: differences between men and women. *Journal of Consulting and Clinical Psychology.* 2004; 74:712–22.
 24. Perkins KA. Acute responses to nicotine and smoking: implications for prevention and treatment of smoking in lower SES women. *Drug Alcohol Depend.* 2009; 104:S79–86. [PubMed: 19084357]
 25. Sofuoglu M, Mooney M. Subjective responses to intravenous nicotine: greater sensitivity in women than men. *Exp Clin Psychopharmacol.* 2009; 17(2):63–9. [PubMed: 19331482]
 26. Hu M, Davies M, Kandel DB. Epidemiology and correlates of daily smoking and nicotine dependence among young adults in the United States. *Am J Public Health.* 2006; 96(2):299–308. [PubMed: 16380569]

27. Thompson AB, Tebes JK, McKee SA. Gender differences in age of smoking initiation and its association with health. *Addiction research & theory*. 2015; 23(5):413–20. [PubMed: 27499723]
28. Bright BC, Soulakova JN. Evidence of telescoping in regular smoking onset age. *Nic Tob Res*. 2014; 16(6):717–24.
29. Fulkerson JA, French SA. Cigarette smoking for weight loss or control among adolescents: gender and racial/ethnic differences. *J Adolesc Health*. 2003; 32(4):306–13. [PubMed: 12667735]
30. Vidrine JI, Anderson CB, Pollak KI, Wetter DW. Gender differences in adolescent smoking: mediator and moderator effects of self-generated expected smoking outcomes. *Am J Health Promot*. 2006; 20(6):383–7. [PubMed: 16871816]
31. Smith PH, Bessette AJ, Weinberger AH, Sheffer CE, McKee SA. Sex/gender differences in smoking cessation: a review. *Prev Med*. 2016; 92(Supplement C):135–40. [PubMed: 27471021]
32. Bohadana A, Nilsson F, Rasmussen T, Martinet Y. Gender differences in quit rates following smoking cessation with combination nicotine therapy: influence of baseline smoking behavior. *Nicotine Tob Res*. 2003; 5(1):111–6. [PubMed: 12745512]
33. Pisinger C, Jorgensen T. Weight concerns and smoking in a general population: the Inter99 study. *Prev Med*. 2007; 44(4):283–9. [PubMed: 17222451]
34. Perkins KA, Giedgowd GE, Karelitz JL, Conklin CA, Lerman C. Smoking in response to negative mood in men versus women as a function of distress tolerance. *Nic Tob Res*. 2012; 14(12):1418–25.
35. Zang EA, Wynder EL. Differences in lung cancer risk between men and women: examination of the evidence. *JNCI: Journal of the National Cancer Institute*. 1996; 88(3–4):183–92. [PubMed: 8632492]
36. Siegfried JM. Women and lung cancer: does oestrogen play a role? *Lancet Oncol*. 2001; 2(8):506–13. [PubMed: 11905727]
37. Langhammer A, Johnsen R, Gulsvik A, Holmen TL, Bjermer L. Sex differences in lung vulnerability to tobacco smoking. *Eur Respir J*. 2003; 23:1017–23.
38. Gold DR, Wang X, Wypij D, Speizer FE, Ware JH, Dockery DW. Effects of cigarette smoking on lung function in adolescent boys and girls. *N Engl J Med*. 1996; 335:931–7. [PubMed: 8782500]
39. Holmen TL, Barrett-Connor E, Clausen J, Langhammer A, Holmen J, Bjermer L. Gender differences in the impact of adolescent smoking on lung function and respiratory symptoms. The Nord-Trøndelag health study, Norway, 1995–1997. *Respir Med*. 2002; 96(10):796–804. [PubMed: 12412979]
40. Singh T, Arrazola RA, Corey CG. Tobacco use among middle and high school students—United States, 2011–2015. *MMWR*. 2016; 65:361–7. [PubMed: 27077789]
41. Camenga DR, Kong G, Cavallo DA, Liss AK, Hyland A, Delmerico J, et al. Alternate tobacco product and drug use among adolescents who use electronic cigarettes, cigarettes only, and never smokers. *J Adolesc Health*. 2014; 55(4):588–91. [PubMed: 25085648]
42. Lippert AM. Do adolescent smokers use e-cigarettes to help them quit? The sociodemographic correlates and cessation motivations of U.S. adolescent e-cigarette use. *Am J Health Promot*. 2015; 29(6):374–9. [PubMed: 24968185]
43. Dutra LM, Glantz SA. Electronic cigarettes and conventional cigarette use among us adolescents: a cross-sectional study. *JAMA Pediatr*. 2014; 168(7):610–7. [PubMed: 24604023]
44. Cardenas VM, Breen PJ, Compadre CM, Delongchamp RR, Barone CP, Phillips MM, et al. The smoking habits of the family influence the uptake of e-cigarettes in US children. *Ann Epidemiol*. 2015; 25(1):60–2. [PubMed: 25453726]
45. 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. [PubMed: 25840880]
46. Corsi DJ, Lippert AM. An examination of the shift in school-level clustering of US adolescent electronic cigarette use and its multilevel correlates, 2011–2013. *Health Place*. 2016; 38:30–8. [PubMed: 26796326]
47. Huang L, Kowitt SD, Sutfin EL, Patel T, Ranney LM, Goldstein AO. Electronic cigarette use among high school students and its association with cigarette use and smoking cessation, North Carolina youth tobacco surveys, 2011 and 2013. *Prev Chronic Dis*. 2016; 13:150564.

48. Alcalá HE, Albert SL, Ortega AN. E-cigarette use and disparities by race, citizenship status and language among adolescents. *Addict Behav.* 2016; 57:30–4. [PubMed: 26835605]
49. Barrington-Trimis JL, Urman R, Berhane K, Unger JB, Cruz TB, Pentz MA, et al. E-cigarettes and future cigarette use. *Pediatr.* 2016; 138(1) <https://doi.org/10.1542/peds.2016-0379>.
50. Cooper M, Case KR, Loukas A. E-cigarette use among Texas youth: results from the 2014 Texas youth tobacco survey. *Addict Behav.* 2015; 50:173–7. [PubMed: 26151581]
51. Gilreath TD, Leventhal A, Barrington-Trimis JL, Unger JB, Cruz TB, Berhane K, et al. Patterns of alternative tobacco product use: emergence of hookah and e-cigarettes as preferred products amongst youth. *J Adolesc Health.* 2016; 58(2):181–5. [PubMed: 26598059]
52. Porter L, Duke J, Hennon M, Dekevich D, Crankshaw E, Homsy G, et al. Electronic cigarette and traditional cigarette use among middle and high school students in Florida, 2011–2014. *PLoS One.* 2015; 10:e0124385. [PubMed: 25969979]
53. Westling E, Rusby JC, Crowley R, Light JM. Electronic cigarette use by youth: prevalence, correlates, and use trajectories from middle to high school. *J Adolesc Health.* 2017; 60:660–6. [PubMed: 28242187]
54. Giovacchini CX, Pacek L, McClernon FJ, Que LG. Use and perceived risk of electronic cigarettes among North Carolina middle and high school students. *N C Med J.* 2017; 78(1):7–13. [PubMed: 28115555]
55. Jamal A, King BA, Neff LJ, Whitmill J, Babb SD, Graffunder CM. Current cigarette smoking among adults—United States, 2005–2015. *MMWR Morb Mortal Wkly Rep.* 2016; 65:1205–11. [PubMed: 27832052]
56. Andrade MD, Hastings G, Angus K. Promotion of electronic cigarettes: tobacco marketing reinvented? *Brit Med J.* 2013:347.
57. Grana RA, Ling PM. “Smoking revolution”: a content analysis of electronic cigarette retail websites. *Am J Prev Med.* 2014; 46:395–403. [PubMed: 24650842]
58. Kong G, Morean ME, Cavallo DA, Camenga DR, Krishnan-Sarin S. Sources of electronic cigarette acquisition among adolescents in Connecticut. *Tob Regul Sci.* 2017; 3(1):10–6. [PubMed: 29082300]
59. Smith EA, Thomson K, Offen N, Malone RE. “If you know you exist, it’s just marketing poison”: meanings of tobacco industry targeting in the lesbian, gay, bisexual, and transgender community. *Am J Public Health.* 2008; 98(6):996–1003. [PubMed: 18445800]
60. Lee JGL, Henriksen L, Rose SW, Moreland-Russell S, Ribisl KM. A systematic review of neighborhood disparities in point-of-sale tobacco marketing. *Am J Public Health.* 2015; 105(9):e8–e18.
61. Lee JGL, Landrine H, Torres E, Gregory KR. Inequities in tobacco retailer sales to minors by neighbourhood racial/ethnic composition, poverty and segregation, USA, 2015. *Tob Control.* 2016; 25:e142–5. [PubMed: 27609780]
62. Zhu S, Sun JY, Bonnevie E, Cummins SE, Gamst A, Yin L, et al. Four hundred and sixty brands of e-cigarettes and counting: implications for product regulation. *Tob Control.* 2014; 23(suppl 3):iii3–9. [PubMed: 24935895]
63. Barrington-Trimis, JL., Gibson, LA., Halpern-Felsher, B., Harrell, MB., Kong, G., Krishnan-Sarin, S., et al. Type of e-cigarette device used among adolescents and young adults: findings from a pooled analysis of 8 studies of 2,166 vapers. *Nic Tob Res.* 2017. <https://doi.org/10.1093/ntr/ntx069>
64. Morean ME, Kong G, Cavallo DA, Camenga DR, Krishnan-Sarin S. Nicotine concentration of e-cigarettes used by adolescents. *Drug Alcohol Depend.* 2016; 167:224–7. [PubMed: 27592270]

Table 1

Studies reporting e-cigarette use rates among adolescents separated by gender (2012–2017)

Author (year)	Survey year	Sample/location	Survey type	Age or grade	Sample size	Ever use		Current use		
						Male %	Female %	Male %	Female %	OR (95% CI) or <i>p</i> value
1. Camenga et al. (2014) [41]	2010–11	4 HS/New York, Connecticut	School-wide survey	9th grade: 27.2% 10th grade: 25.0% 11th grade 25.1% 12th grade 22.7%	<i>N</i> = 3102	n/a	n/a	n/a	n/a	3.2% / 1.8% / $p = 0.01^2$
2. Lippert (2015) [42]	2011	MS, HS/USA	National Youth Tobacco Survey (NYTS)	n/a	<i>N</i> = 15,264	2.0% /	1.2% /	n/a	n/a	n/a
3. Dutra and Glantz (2014) [43]	2011	MS, HS/USA	NYTS	$M = 14.7$, $SD = 0.1$	<i>N</i> = 17,353	3.9%	2.4%	$p < 0.01$	0.6%	$p < 0.01$
4. Cardenas et al. (2015) [44]	2012	MS, HS, USA	NYTS	$M = 14.6$ $SD = 0.1$	<i>N</i> = 22,529	7.7%	5.3%	$p < 0.01$	1.4%	$p < 0.01$
5. Barnett et al. (2015) [45]	2012	MS, HS, USA	NYTS	n/a	n/a	8.1%	5.5%	1.5 (1.2–1.7)	n/a	n/a
6. Corsi and Lippert (2016) [46]	2013	172 MS, HS/Florida	Florida Youth Tobacco Survey (FYTS)	MSs (age/grade not provided)	<i>N</i> = 6175	4.5%	4.0%	$p > 0.05$	1.8%	1.7% $p > 0.05$
7. Huang et al. (2016) [47]	2013	178–187 MS, HS/USA	NYTS	HSs (age/grade not provided)	<i>N</i> = 6440	14.2%	9.7%	$p < 0.05$	6.8%	3.9% $p < 0.05$
8. Leventhal et al. (2015) [9]	2013	83 HS/North Carolina	North Carolina Youth Tobacco Survey (NCYTS)	$M = 14.7$, SD not provided	<i>N</i> = 17,013	6.5%	4.6%	1.21 ⁵ (1.08, 1.36)	2.6%	1.5% n/a
9. Alcalá et al. (2016) [48]	2014	9th grade in 10 HS/California	School-wide survey	9th grade: 29.9% 10th grade: 26% 11th grade 23.3% 12th grade 20.8%	<i>N</i> = 4092	n/a	n/a	n/a	8.7% /	3.8% /
10. Barrington-Trimis et al. (2015) [7]	2014	Telephone survey of adolescents, ages 12–17/California	Adolescent California Health Interview Survey (CHIS)	$M = 14.1$ (95% CI 14.0, 14.1)	<i>N</i> = 2530	10.9% /	6.8% /	$p < 0.001$	n/a	n/a
11. Barrington-Trimis et al. (2016) [49]	2014	11th–12th grades/California	Children's Health Study (CHS), cohort study	$M = 14.5$, SD not provided	<i>N</i> = 1052	12.3%	8.21%	$p > 0.05$	n/a	n/a
12. Cooper et al. (2015) [50]	2014	11th–12th grades/California	CHS	$M = 17.3$, $SD = 0.6$	<i>N</i> = 2084	n/a	n/a	n/a	11.6% /	7.6% /
13. Gilreath et al. (2016) [51]	2014	6–12th grades/Texas	Texas Youth Tobacco Survey	Median age = 17.4 (interquartile range 16.8–17.9)	<i>N</i> = 298	48.9%	49.2%	0.96 (0.60–1.55)	n/a	n/a
14. Porter et al. (2015) [52]	2014	11–12th grades/California	CHS	$M = 14.49$, $SD = 1.98$	<i>N</i> = 13,602	n/a	n/a	n/a	12.6% /	8.0% /
	2014	MS, HS/Florida	FYTS	$M = 17.3$, $SD = 0.6$	<i>N</i> = 2097	16.2%	12.6%	$p > 0.05$	11.6%	7.6% $p > 0.05$
	2014	MS, HS/Florida	FYTS	6th grade = 36.5% 7th grade = 38.0% 8th grade = 36.5% 9th grade = 26.9% 10th grade = 23.0%	<i>N</i> = 32,930	n/a	n/a	n/a	4.2%	3.6% $p > 0.05$
	2014	MS, HS/Florida	FYTS		<i>N</i> = 36,993	n/a	n/a	n/a	12.6%	8.8% $p < 0.001$

Author (year)	Survey year	Sample/location	Survey type	Age or grade	Sample size	Ever use		Current use		OR (95% CI) or <i>p</i> value
						Male %	Female %	Male %	Female %	
15. Westling et al. (2017) [53]	2014–16	8th grades, 11 MS/Oregon	School-based survey	11th grade = 20.6% 12th grade = 17.3%	N = 1091	26.1% ¹	28.8% ¹	16.2% ¹	16.8% ¹	0.95 (0.69, 1.31)
16. Giovacchini et al. (2017) [54]	2015	4 MS, 3 HS/North Carolina	North Carolina Youth Risk Behavior Survey (NCYRBS), school-based survey	9th grade: 30.2% 10th grade: 23.4% 11th grade: 20.6% 12th grade: 25.8%	N = 444 (HS only)	22.3% ¹	14.9% ¹	n/a	n/a	<i>p</i> = 0.247

Studies are presented in the order of the survey year and then by author name. All reference groups are non-users of e-cigarettes, unless otherwise stated. All statistics and *p* values presented are bivariate comparisons, unless otherwise stated. Bold font indicates statistically significant difference at *p* < .05

OR odds ratio, 95% CI 95% confidence interval, MS middle school, HS high school, n/a not available

- ¹The percentages were recalculated to reflect the percentages based on the total number of male/female participants, respectively
- ²The reference groups are never e-cigarette users stratified by cigarette smoking status
- ³Adjusted odds ratio, with age, race/ethnicity, income, living with a smoker, being friends with a smoker, own smoking, having tried to quit smoking (among smokers)
- ⁴E-cigarette use data from other waves are presented in the paper, but only data from the survey wave reporting e-cigarette use rates by gender are presented here
- ⁵Adjusted odds ratio, with school, e-cigarette use, age, race, cigarette smoking in the model
- ⁶Adjusted odds ratio, with community, ethnicity, income, and highest parental education in the model
- ⁷The reference group is non-current e-cigarette users
- ⁸E-cigarette use data from only HS students are reported because gender differences for middle school students are missing

Table 2

Questions used to assess e-cigarette use

Author (year)	Questions used to assess e-cigarette use	
	Ever use	Current use
1. Camenga et al. (2014) [41]	n/a	"In the past 30 days, have you used any of the following tobacco products?" Current users responded using "e-cigarettes (an electronic cigarette that is filled with liquid nicotine and emits "smoke" vapor)"
2. Lippert (2015) [42]	Specific question was not provided in the manuscript. Participants were asked whether they had ever tried e-cigarettes and were presented with some brands as examples.	n/a
3. Dutra and Glantz (2014) [43]	"Which of the following tobacco products have you ever tried, even just 1 time?" Ever users responded, "electronic cigarettes or e-cigarettes, such as Ruyan or NJOY."	"During the past 30 days, which of the following tobacco products did you use on at least 1 day?" Current users responded, "e-cigarettes."
4. Cardenas et al. (2015) [44]	"Which of the following tobacco products have you ever tried, even just one time?" Ever users responded, "Electronic Cigarettes or E-cigarettes such as Ruyan or NJOY."	n/a
5. Barnett et al. (2015) [45]	Ever users responded "yes" to, "using an electronic cigarette" to the question, "Have you ever tried, even once..."	Current users responded "yes" to "During the past 30 days, have you used an electronic cigarette?"
6. Corsi and Lippert (2016) [46]	"Which of the following tobacco products have you ever tried, even just one time?" Ever users endorsed "electronic cigarette or e-cigarettes, such as Ruyan or NJOY."	"Which of the following tobacco products have you ever tried, 1 or more times in the past 30 days?" Current users endorsed using e-cigarettes.
7. Huang et al. (2016) [47]	n/a	"In the past 30 days, which of the following tobacco products have you used on at least 1 day?" Current users endorsed trying at least 1 of the past 30 days of "electronic cigarette or e-cigarettes, such as Ruyan or NJOY."
8. Leventhal et al. (2015) [9]	Specific question was not provided in the manuscript. Ever users endorsed ever using an e-cigarette.	n/a
9. Alcalá et al. (2016) [48]	Specific question was not provided in the manuscript. Ever users endorsed ever using an e-cigarette.	
10. Barrington-Trimis et al. (2015) [7]	n/a	"During the past 30 days, on how many days did you use these products?" Participants who had "never tried" tried "electronic or e-cigarette, even one or two puffs" were classified as "never users." Those who had used e-cigarettes but not in the past 30 days were classified as "past users." Participants who had used the product on at least 1 of the past 30 days were classified as "current users."
11. Barrington-Trimis et al. (2016) [49]	Specific question was not provided in the manuscript. Participants who had "never tried" the product (not "even 1 or 2 puffs") were classified as "never users." Those reporting an age at first use of the tobacco product were classified as "ever users" of that product.	n/a
12. Cooper et al. (2015) [50]	n/a	"During the past 30 days, on how many days did you use electronic cigarettes or e-cigarettes, such as Ruyan or NJOY?" Participants reporting at least 1 day of e-cigarette use in the past 30 days were classified as current users, while those reporting zero days of e-cigarette use in the past 30 days were classified as non-current users.
13. Gilreath et al. (2016) [51]	Specific question was not provided in the manuscript. Participants who provided an age of onset were considered ever users.	Specific question was not provided in the manuscript. Endorsement of past-30-day use was considered current users.
14. Porter et al. (2015) [52]	n/a	Current users responded "yes" to, "During the past 30 days have you used an electronic cigarette?"

Author (year)	Questions used to assess e-cigarette use	
	Ever use	Current use
15. Westling et al. (2017) [53]	Ever users endorsed using at least once to, "In your whole life, how many different times have you ever smoked an e-cigarette ['vape pen'] or an e-hookah, even a puff?"	Current users endorsed using at least once to, "In the last 30 days, on how many days would you say you have smoked an e-cigarette ['vape pen'] or an e-hookah, even a puff?"
16. Giovacchini et al. (2017) [54]	Specific question was not provided in the manuscript. Ever users endorsed ever using an e-cigarette.	Current users endorsed at least once to, "How many of the past 30 days they had used an e-cigarette or electronic vapor product (1–30)."

Studies are presented in the order of the survey year and then by author name. Only the questions used to provide separate rates by gender are included in this table

n/a not available