

Review

E-cigarette use among adolescents: Controversies and challenges for future research

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Abstract

As e-cigarette use increases rapidly, it is important to examine its appeal, influence and effects among adolescents. Evidence shows that adolescents using e-cigarettes are at higher risk to initiate and/or continue using tobacco and cannabis. E-cigarettes have been promoted in multiple ways by the media as a healthier alternative to smoking and some studies present benefits of its use when compared to combustible cigarette smoking. On the other hand, numerous studies on adolescent populations point out the negative biological effects of e-cigarettes due to chemical substances that some of their products contain, as well as its sociological and emotional effects. In 2012, the United States Centre of Disease Control and Prevention estimated that e-cigarette use doubled among middle and high school students. In Greece, significant changes in smoking behaviors have been observed during the past few years, possibly as a combined result of the implemented tobacco control and austerity measures. A study among Greek adolescents reported that in 2015 39% of 16 year-old high school pupils nationwide had smoked cigarettes at least once in their lifetime, while 13% were regular smokers (1). Another study reported that half of the population of 15 year-old Greek pupils who have used combustible cigarettes have also tried e-cigarettes (2). In the present paper we review literature regarding e-cigarette use during adolescence and discuss some key issues, such as probable reasons for the initiation and/or continuation of its use, as well as its physical, emotional and social effects. Finally, we present some public health measures that have been proposed aiming at controlling e-cigarette use among adolescents.

Key words: adolescents, smoking, e-cigarette, vaporizer, vaping.

Introduction

It has been estimated that approximately 25 million 13–15 years old boys and 13 million girls of the same age smoke cigarettes or use smokeless tobacco products worldwide. Regarding the prevalence of the phenomenon, significant differences occur between countries. In 2014 9.2% of United States high-school students smoked cigarettes, while at the same year the “2014 Health Behavior in School-aged Children Study” conducted among 15-year-old pupils in Greece reported 36.9% lifetime smoking of conventional cigarettes and 16.6% lifetime use of e-cigarettes, mostly experimenting (0.5% reported current e-cigarette use) (3). According to the “Global Youth Tobacco Survey” conducted in 108 countries between 1999 and 2016, the countries with the highest prevalence of tobacco use among youth are generally non-very-high HDI (Human Development Index) countries. In several of these countries tobacco use among adolescent girls is now more common than among adult women, while in some countries tobacco is now more commonly used by youth than by adults (4).

Adolescent smoking has been known to be a major issue for health systems and the public health of the entire population. Apart from the profound adverse effects of nicotine on the developing brain, the issue of transition appears to be also rather significant, since 60-90% of adult smokers started smoking before the age of 18 years. At the same time the duration of tobacco use is more likely to be longer among those who start tobacco use at an earlier age than those who start it later in life (5). However, during the last decade a new public health issue has emerged. Since its introduction in the market (2007 in the United States) e-cigarette has been increasingly used by adolescents worldwide. According to the Centre of Disease Control and Prevention, 1.78 million students reported having ever used e-cigarettes as of 2012, while in 2014 13.4% of high-school students in the United States reported having used e-cigarettes in the past 30 days. E-cigarette use in many countries remains unregulated by national or international organizations with no restrictions on its sale to children and adolescents. What is more, the overall impact of e-cigarette on public health is still uncertain, raising serious concerns and an urgent need for systematic and extensive research on the field.

Method

In the present paper we investigated existing evidence regarding e-cigarette use among adolescents. We conducted a literature review on PubMed and Google Scholar using the key words: “adolescents”, “e-cigarette”, “teenagers”, “vaping”. Studies using adult population or investigating tobacco use, cannabis or other drug abuse were excluded. Our research resulted in 57 results. Articles should be published in English and included both original researches and literature reviews. It should be noted that we found only a small number of studies investigating the issue in the Greek adolescent population.

Psychosocial factors related to e-cigarette use

Relevant literature shows that adolescent groups with e-cigarette users often include also combustible cigarette smokers (6). This may mean that combustible cigarette smokers may act as a potential risk factor for their peers not only by providing cigarettes, but also by presenting patterns and attitudes of smoking related behavior and thus familiarize smoke-free adolescents with the image of a smoker (6,7). According to the “problem behavior theory” adolescents who reject mainstream values are susceptible to adopt several types of deviating behavior (8).

On the other hand, adolescents who are considered to be at “lower risk” may initiate the use of e-cigarettes and prefer it to combustible cigarettes, because of the perception that the e-cigarette is more socially acceptable and not as damaging to health, as the combustible cigarette (9). Evidence also indicates that adolescents who start e-cigarette use, become more prone to attitudinal changes that could lead to a growing interest to experiment with or even initiate marijuana or other substance use as well (6,7). This may be also facilitated through the availability of several types of marijuana that can be inhaled through a device similar to the e-cigarette or even through the e-cigarette itself, by using marijuana liquids that contain the hallucinatory THC substance instead of the regular e-cigarette liquids, which may or may not contain nicotine.

Adolescents, who are already familiar with the inhalation of e-cigarette liquids, may thus perceive the THC liquid inhalation as something not as harmful (6).

Evidence shows that some adolescents might not even know that the e-cigarette contains nicotine, thus they might be inhaling nicotine without even realizing it. Among these adolescents, previous combustible cigarette use did not correlate to the initiation of the use of e-cigarettes containing nicotine (10). Furthermore, Dutra's findings suggest that the e-cigarette was not associated with the decline of combustible smoking, as far as the adolescents are concerned (11).

The electronic cigarette is becoming a trend, replacing to some extent combustible cigarettes and gaining appeal among adolescents, who may experience feelings of empowerment, rebelliousness or edginess through e-cigarette use. Adolescents may even enjoy the variety of e-cigarettes and their flavors, which may also act as status symbols, depending on their price, quality and style.

According to a recent literature review of 25 research articles the most significant variables associated with e-cigarette use among adolescents were male gender, older age, conventional smoking, peer influence, as well as daily and heavier smoking (12).

A study conducted in Germany with a sample of 2,693 adolescents (mean age = 12.5 years, SD = 0.6), shows that 126 students (4.7%) had tried e-cigarettes, 76.2% (n = 96) of whom had also tried conventional cigarettes and thus were considered as dual users. E-cigarette use was associated with parental, family members' or friends' combustible cigarette smoking, male gender, older age, lower academic achievement and higher sensation seeking scores. Interestingly enough, lifetime use of conventional cigarettes at baseline was associated neither with e-cigarette nor with dual use at the follow up measurement (13). Another study investigating the temporal regularity of e-cigarette use found a decrease during the past 30 days, a finding which may indicate that adolescents are not using the e-cigarette on a regular basis (10).

A further study conducted in 27 European countries has shown that: "the perception that e-cigarettes are harmful increased from 27.1% in 2012 to 51.6% in 2014, but there were major differences in prevalence and trends between member states. Among those who reported that they had tried using an e-cigarette in the 2014 survey, 15.3% defined themselves as current users" (14). Another interesting finding of the study was that those who had tried an e-cigarette in order to quit smoking were more likely to be current users (14).

A study of 2084 11th- and 12th-grade students in Southern California found that 499 (24.0%) students had used an e-cigarette, 200 of whom (9.6%) were current users (among the past 30 days), 390 (18.7%) students had tried a combustible cigarette and 119 (5.7%) were current cigarette smokers. The majority of the students agreed on the fact that cigarettes (98.6%) and e-cigarettes (86.0%) are harmful for one's health, but almost half of current e-cigarette users disagreed on the harmfulness of e-cigarettes. 40.5% (n = 81) of current e-cigarette users had never tried combustible cigarettes. This study's findings regarding the association between adolescent's e-cigarette use and family members' and/or friends' e-cigarette use or combustible smoking are in concordance with the findings of many other similar studies(15).

Leventhal et al conducted a study, which included two follow-up assessments (after 6 and 12 months), studying a sample of 2,530 high school students in California and found that e-cigarette use was positively associated with the use of combustible tobacco products. E-cigarette use was also associated with male gender, native Hawaiian/Pacific islander ethnicity, lower parental education level, peer smoking, impulsivity, use of non-nicotine or tobacco substances and delinquent behavior. Positive associations were also found between e-cigarette use and other types of smoking, such as combustible cigarette, hookah and cigar smoking (16).

According to Morean et al, factors such as using nicotine e-liquid or purchasing e-cigarettes from tobacco shops, gas stations and online retailers were all associated with combustible cigarette smoking (p-values < .01). Adolescents using e-cigarettes that contain nicotine were also found to be heavier e-cigarette

users ($p < .01$). Thus, the main finding of this study is that it is more likely adolescents who use e-cigarettes containing nicotine not only smoke other types of cigarettes as well, but are also heavier users. It was reported that a significant number of adolescents did not know the levels of nicotine concentration in the e-cigarettes that they used. This finding combined with the lack of adequate evidence on nicotine concentration in e-cigarettes used by adolescents raises serious concerns about the levels and consequences of youth exposure to nicotine (17).

According to Leventhal et al's study, adolescents using only e-cigarettes reported lower levels of internalizing syndromes, such as generalized anxiety disorder, obsessive-compulsive disorder, panic, depression, social phobia in comparison to adolescents using combustible cigarettes only, but higher levels of panic disorder, anhedonia and depression when compared to non smokers. As far as externalizing syndromes (rash action during positive affect, alcohol drug use/abuse, mania) are concerned, dual users presented the highest levels of psychiatric comorbidity, followed by single product users (combustible or e-cigarette users only) and non smokers who presented the lowest levels (18).

E-cigarette and tobacco products use in Greece among adolescents

In Greece, significant changes in smoking behaviors have been observed during the past few years, possibly as a combined result of the implemented tobacco control and austerity measures. A study about smoking, alcohol and drug use among Greek adolescents reported that in 2015 39,2% of 16-year-old high school pupils nationwide had smoked cigarettes at least once in their lifetime, while 13% were regular smokers, predominantly males (1). Another study in Greece reported that half of the population of 15-year-old pupils who have used combustible cigarettes, have also tried e-cigarettes (2).

Male adolescents were 7 times more likely to use e-cigarettes, while female gender was associated with lifetime tobacco use. E-cigarette use was associated with current not heavy smoking

(1). Alcohol and low parental monitoring correlated with tobacco, but not with e-cigarette use. Cannabis and peer smoking showed a stronger correlation with tobacco, than with e-cigarette use (2).

According to Farsalinos's study conducted in 2017, e-cigarette users in Greece tend to be current or former smokers. The authors argue that it's highly unlikely for people that have never smoked before to prefer e-cigarettes that contain nicotine or to even start using e-cigarettes. Finally, another interesting finding of the same study was that "most participants overestimated the harmfulness of e-cigarettes relative to smoking" (19).

Discussion

Adolescence is considered to be the critical age of starting and establishing tobacco use (20). Adolescents prefer using multiple and flavored tobacco products (21) and this preference could cause susceptibility to nicotine dependence and continuance of tobacco use (22). According to the "gateway theory", early initiation of alcohol or tobacco use during adolescence can increase the risk of initiating cannabis use or other illegal-harmful substances (1). E-cigarette use can be also viewed as a gateway to combustible cigarette smoking (23).

According to the Centre of Disease and Control, e-cigarette use increased about 8 times from 2011 to 2016 among middle and high school students (24). A substantial number of adolescents who use e-cigarettes also smoke combustible cigarettes (25, 9) and tend to associate themselves with other e-cigarette/combustible cigarette users (6). On the other hand, because of the more negative perceptions associated with combustible cigarette smoking (26), adolescents who use e-cigarettes may view themselves in a different light when compared to the image they have for combustible cigarette smokers (27). Furthermore and given the higher sensitivity of the adolescent brain to nicotine, the biological and physiological effects of nicotine contained in e-cigarettes are thought to contribute significantly to the overall phenomenon of nicotine addiction (5, 28).

Conclusion

Various measures have been proposed aiming at reducing or controlling the increase of tobacco and e-cigarette use among adolescents. Some of the proposed measures to include increasing the costs of tobacco/ e-cigarette products (for example, by increasing taxes) while making the e-cigarette and its products unavailable to minors, for example by raising the minimum age of sale for tobacco/ e-cigarette products to 21 years old (29). Other measures could be the promotion of healthy habits by the media, the reduction of tobacco/e-cigarette advertising, promotion and availability, the implementation of community, school and university policies and interventions that promote tobacco-free environments and lifestyles, as well as the prohibition of smoking in public, work related, school and university areas (20, 22, 30). Maintaining a strong racial identity, as well as ethnic pride or being part of productive groups (such as art, gymnastics, dance groups) and focusing the attention on higher academic achievement is also considered a way to prohibit adolescents from initiating e-cigarette use, as well as tobacco or combustible cigarette use (20). In conclusion, evidence indicates that specific measures, such as public health monitoring and health awareness programs, could help adolescents acquire relevant knowledge and finally change their smoking behavior.

References

1. Kokkevi A, Fotiou A, Kanavou E, Stavrou M, Richardson C. Smoking, alcohol, and drug use among adolescents in Greece – 2015 update and secular trends 1984–2015. *Archives of Hellenic Medicine* 2016, 33(2):249-257
2. 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. doi:10.1016/j.addbeh.2015.07.021
3. 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):381-385. PMID: 25879896
4. Drope J, Schluger N, Cahn Z, Drope J, Hamill S, Islami F, et al. *The Tobacco Atlas*. American Cancer Society and Vital Strategies. Atlanta, 2018.
5. England LJ, Bunnell RE, Pechacek TF, McAfee TA. Nicotine and the developing human: A neglected element in the electronic cigarette debate. *American Journal of Preventive Medicine* 2015, 49:286–293 doi:10.1016/j.amepre.2015.01.015
6. Wills, T. A., Gibbons, F. X., Sargent, J. D., & Schweitzer, R. J. How Is the Effect of Adolescent E-Cigarette Use on Smoking Onset Mediated: A Longitudinal Analysis. *Psychology of Addictive Behaviors* 2016, 30(8):876-886. doi:10.1037/adb0000213
7. Wills TA, Sargent JD, Gibbons FX, Pagano I, Schweitzer R. e-Cigarette use is differentially related to smoking onset among lower risk adolescents. *Tob Control* 2016, 26(5): 534–539. doi:10.1136/tobaccocontrol-2016-053116
8. Jessor R, Jessor S.-L. Problem behavior and psychosocial development: A longitudinal study of youth. 1977
9. 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. *Pediatrics* 2015, 135(1):e43-e51. doi:10.1542/peds.2014-0760
10. 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):612-619. doi:10.1016/j.jadohealth.2016.08.005.
11. Dutra LM and Glantz SA. E-cigarettes and National Adolescent Cigarette Use: 2004–2014. *Pediatrics* 2017, 139(2):e20162450 doi:10.1542/peds.2016-2450
12. Perikleous EP, Steiropoulos P, Paraskakis E, Constantinidis TC and Nena E. E-Cigarette Use Among Adolescents: An Overview of the Literature and Future Perspectives. *Front Public Health* 2018, 6:86. doi:10.3389/fpubh.2018.00086

13. Hanewinkel R., Isensee B. Risk factors for e-cigarette, conventional cigarette, and dual use in German adolescents: A cohort study. *Preventive Medicine* 2015, 74:59–62. doi:10.1016/j.ypmed.2015.03.006
14. Filippidis FT, Lavery AA, Gerovasili V, et al Two-year trends and predictors of e-cigarette use in 27 European Union member states. *Tobacco Control* 2017, 26:98-104. doi:10.1136/tobaccocontrol-2015-052771
15. 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. *Pediatrics* 2015, 136:308–317. doi: 10.1542/peds.2015-0639
16. Leventhal AM, Strong DR, Kirkpatrick MG, et al. Association of Electronic Cigarette Use With Initiation of Combustible Tobacco Product Smoking in Early Adolescence. *JAMA* 2015, 314(7):700–707. doi:10.1001/jama.2015.8950
17. Morean ME, Kong G, Cavallo DA, Camenga DR, Krishnan-Sarin S. Nicotine concentration of e-cigarettes used by adolescents. *Drug Alcohol Depend* 2016, 1;167:224-7. doi: 10.1016/j.drugalcdep.2016.06.031.
18. Leventhal AM, Strong DR, Sussman S, Kirkpatrick MG, Unger JB, Barrington-Trimis JL, Audrain-McGovern J. Psychiatric comorbidity in adolescent e-cigarette and cigarette use. *Journal of Psychiatric Research* 2016, 73:71–78. doi: 10.1016/j.jpsychires.2015.11.008.
19. Farsalinos K, Tomaselli V, Polosa R. Frequency of Use and Smoking Status of U.S. Adolescent E-Cigarette Users in 2015. *American Journal of Preventive Medicine* 2018, 54(6):814-820. doi:10.1016/j.amepre.2018.03.003.
20. U.S. Department of Health and Human Services. Preventing Tobacco Use Among Youth and Young Adults: A Report of the Surgeon General. 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, Atlanta GA, 2012.
21. Centers for Disease Control and Prevention. Flavored Tobacco Product Use Among Middle and High School Students—United States, 2014. *Morbidity and Mortality Weekly Report* 2015, 64(38):1066–70
22. U.S. Department of Health and Human Services. Reducing Tobacco Use: A Report of the Surgeon General. 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, Atlanta GA, 2000.
23. Etter J.-F. Gateway effects and electronic cigarettes. *Addiction* 2017. doi:10.1111/add.13924
24. Centers for Disease Control and Prevention. Tobacco Use Among Middle and High School Students—United States, 2011–2017. *Morbidity and Mortality Weekly Report* 2018, 67(22):629-33.
25. Dutra LM, Glantz SA. Electronic cigarettes and conventional cigarette use among us adolescents: a cross-sectional study. *JAMA Pediatr* 2014, 168:610–17. doi:10.1001/jamapediatrics.2013.5488
26. Johnston LD, O'Malley PM, Bachman JG, Schulenberg JE, Miech RA. Monitoring the Future national survey results on drug use, 1975–2013: Volume 1: Secondary school students. Ann Arbor, MI: Institute for Social Research, University of Michigan, 2014.
27. Hertel AW, Mermelstein RJ. Smoker identity and smoking escalation among adolescents. *Health Psychology* 2012, 31:467–475. doi: 10.1037/a0028923
28. Yuan M, Cross SJ, Loughlin SE, Leslie FM. Nicotine and the adolescent brain. *Journal of Physiology* 2015, 593:3397–3412. doi: 10.1113/JP270492
29. King BA, Jama AO, Marynak KL, Promoff GR. Attitudes Toward Raising the Minimum Age of Sale for Tobacco Among U.S. Adults. *American Journal of Preventive Medicine* 2015, 49(4):583-8. doi: 10.1016/j.amepre.2015.05.012
30. Centers for Disease Control and Prevention. Best Practices for Comprehensive Tobacco Control Programs—2014. 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, Atlanta, 2014.