



A Breath of Knowledge: Overview of Current Adolescent E-cigarette Prevention and Cessation Programs

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Abstract

Purpose Adolescent use of electronic cigarettes (e-cigarettes) has risen rapidly, which is concerning given the health effects of e-cigarettes and youth susceptibility to nicotine addiction. It is critical that efforts to educate, prevent, and reduce adolescent use of e-cigarettes are developed and evaluated. The purpose of this paper is to review available current prevention and cessation programs.

Findings A web-based search of currently available e-cigarette prevention and cessation/treatment programs was conducted using Google in May of 2020. Programs were then reviewed on whether they included theory- and evidence-based practices of effective adolescent prevention and cessation programs. Eight prevention programs, seven cessation programs, and one program that addressed both prevention and cessation were identified and included in this review. Most prevention programs included the importance of understanding flavored e-cigarette products, addressed industry-targeted marketing, included social learning activities to develop refusal skills, delivered free-of-cost, available online, and explicitly stated their incorporation of theory. Five prevention programs and two cessation programs had empirically evaluated their e-cigarette-related components.

Conclusions Although the programs reviewed largely incorporated theory and included key components known to be effective, there are some gaps in the programs' overall ability to prevent and stop adolescents from using e-cigarettes, such as lack of dedicated e-cigarette materials. More evidence-based tools, resources, and evaluations are needed to best inform adolescent e-cigarette cessation. Addressing the gaps that existing prevention and cessation programs present requires intervening at multiple systematic levels, conducting more rigorous program evaluations, and bolstering the availability of cessation programs.

Keywords E-cigarette · Prevention · Cessation · Education · Youth

Introduction

Although the prevalence of adolescent combustible cigarette use has declined greatly, adolescents' use of alternative tobacco products has risen rapidly, owing largely to their use of electronic cigarettes (e-cigarettes) [1]. The 2019 Youth Risk Behavior Survey found that a total of 50.1% of US high school students had ever used an e-cigarette product, and 32.7% were past 30-day e-cigarette product users [2]. In the past 5 years, there has been an enormous proliferation of new

types of e-cigarettes on the market, likely contributing to this surge in e-cigarette use. Since Juul came on the market in 2015, which comprised nearly three quarters of the US e-cigarette market share in 2018 [3], many pod-based e-cigarette products have been developed and marketed. In 2019, a new group of e-cigarette products, disposables such as Puff Bar, came on the market. All of these newer products have high amounts of nicotine, with an average of about 60 mg of nicotine per pod/device [4]. These newer products contain salt-based nicotine, a type of nicotine that is combined with benzoic acid to change the PH balance of the nicotine, making it less acidic and harsh and therefore easier to use especially among nicotine naïve adolescents [5]. These patterns of use, newer products, and high concentrations of nicotine are concerning given the health effects of e-cigarettes and that adolescents are highly susceptible to nicotine addiction [6,7].

Given the high rates of use and known health consequences of using e-cigarettes, it is critical now more than ever that

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adolescents are educated about e-cigarettes so that they can make informed decisions regarding their health, and that efforts to prevent and reduce adolescent use of e-cigarettes are developed, implemented, disseminated, and evaluated. In this paper, we elaborate on the health effects and reasons for youth use as the rationale for prevention and cessation programs, and importance of theory-based programs, and then discuss in detail the various prevention and cessation programs available to prevent and reduce adolescent use of e-cigarettes.

Health Effects

Studies have shown that adolescent use of e-cigarettes has deleterious health effects, such as resulting in cardiac and respiratory problems, secondhand aerosol exposure, and impacts on brain development and nicotine addiction [8]. A study found that a validated nicotine dependence scale for e-cigarettes (PROMIS-E) identified more than half of the study sample of adolescents as experiencing some level of nicotine dependence from using e-cigarettes [9]. Nicotine's impact on adolescent brain development can lead to additional mental health-related negative outcomes, such as depression and substance use disorder [10]. Furthermore, recent research shows a relationship between adolescent e-cigarette ever-use, dual-ever-use and past 30-day dual-use of e-cigarettes and cigarettes and COVID-19-related outcomes [11, 12••]. In light of recent attention brought to youth e-cigarette, or vaping, product use-associated lung injury (EVALI) [13] and associations between youth e-cigarette use and COVID-19-related outcomes [12••], it is important that public health efforts continue to inform adolescents about emerging health harms and prevent or stop adolescent e-cigarette use.

Why Adolescents Use E-cigarettes

Despite e-cigarette health risks, adolescents are susceptible to using e-cigarettes for a number of reasons, including the appeal of flavors, social influences, marketing, and perceptions of reduced harm of e-cigarettes [14•, 15–17]. Here, we briefly discuss some of these well-researched factors about why adolescents use e-cigarettes.

A primary reason for youth appeal of e-cigarettes is the numerous available flavors. Adolescents have reported that they think flavors, especially fruity, candy or sweet, menthol, and mint, are for them, and this direct appeal of flavors leads to increased acceptability and use of e-cigarettes [15].

In addition to flavors driving youth e-cigarette use, adolescence is a particularly unique time in the developmental process, as youth are transitioning to adulthood and learning to discover and develop their personal identities [18]. During this developmental phase, adolescents are particularly influenced

by social pressures and the rapidly evolving world of social media and technology [19, 20]. Studies have found that peer pressure is an important reason why youth use e-cigarettes [21, 22]. Adolescents are constantly being exposed to both messaging around the flavors and positive aspects of e-cigarettes, both from social media and official advertising from the tobacco industry itself [23, 24]. Adolescents have reported feeling targeted by such content and e-cigarette advertising [25].

E-cigarette messaging results in perceptions of reduced risk and greater social acceptability of these products [20, 25]. Data show that adolescents think e-cigarettes are safer than combustible cigarettes, with some adolescents believing that e-cigarettes contain just water vapor without nicotine or other chemicals [14•, 26–28]. Several qualitative studies have found that adolescents do not fully understand the severity and negative consequences of nicotine addiction, compared with other types of addictions [29, 30]. Coupled with these perceptions, recent studies show other proximal levels of influence, whereby adolescents are using e-cigarettes as a means to manage stress, anxiety, and depression [31–33].

Flavors, social influences, marketing, and misperceptions of the true risk of e-cigarettes as well as the misinformation that they are exposed to by social media and marketing have driven this widespread epidemic of adolescent e-cigarette use. As such, these critical components for adolescent e-cigarette use should be considered when designing, implementing, and evaluating any e-cigarette prevention and cessation program.

Importance of E-cigarette Prevention and Cessation Programs

E-cigarette prevention and cessation programs are important to help educate adolescents on how to make the best decisions for themselves as they navigate through their adolescence and the social pressures that come with it. It is important to continually adapt tobacco prevention and cessation programs to include and address emerging novel products that can quickly become popularized by adolescents, such as e-cigarettes. Given that e-cigarette prevention and cessation programs are relatively new, we have drawn upon the cigarette prevention and cessation program theories and best practices as a framework for evaluating e-cigarette prevention and cessation programs. However, it is important to address e-cigarettes separately from tobacco and combustible cigarette education, as adolescents do perceive e-cigarettes as new and different products [34, 35], which is why there is a currently urgent need to expand e-cigarette prevention and cessation programs for adolescents.

Schools and classrooms have traditionally been the settings for delivering tobacco prevention efforts because a large part of adolescents' social lives take place in and revolve around a

school setting and with their peers [36–38]. When taught in a classroom or other group setting, these prevention curricula help adolescents with decision-making around using tobacco, help teach and learn refusal skills strategies, and help adolescents develop a sense of collective confidence in learning these skills alongside their peers [39]. The evidence on effectiveness of school-based tobacco prevention programs is mixed in regard to helping change the norms around tobacco use and addressing the misperceptions that exist about tobacco products, and mixed results in changing actual behavior [37, 40–43]. However, effective components of such school-based tobacco prevention programs include interactive curricula, activities around refusal skills, and content addressing targeted marketing and health effects [44, 45•], which if applied collectively in prevention curriculum may lead to decreases in youth intentions to use and actual use.

In addition to needing effective e-cigarette prevention programs, evidence-based e-cigarette cessation programs are needed to help youth who are experiencing addictive behavior with respect to e-cigarettes [46]. Unfortunately, there are few validated cessation programs for adolescents experiencing nicotine dependence or addiction to e-cigarettes. The scientific literature is currently lacking in studies on nicotine replacement therapies for adolescents trying to quit e-cigarettes, and there are only a few studies on cognitive behavioral therapy and other therapies for adolescent cessation [47, 48]. Alternative-to-suspension programs, designed for students caught using e-cigarettes in school, are increasingly being used in school settings to address e-cigarette use among adolescents in a more supportive way, rather than through punishment [49]. Text messaging and other online chat-based cessation platforms are also becoming popular [50]; however, additional research is needed on the efficacy of this form of text-based counseling and intervention. Although evaluated e-cigarette cessation programs for adolescents are lacking, addressing nicotine addiction early is important in preventing adolescent occasional e-cigarette-users from escalating to more frequent use, as well as preventing adolescent e-cigarette users from later using combustible cigarettes.

We next review theories and best practices for prevention and cessation programs, then review specific programs, discussing what these programs are doing well and illustrating the gaps that still exist.

Importance of Theory

Prevention and cessation programs are most effective when based on valid theories of youth development, behavior change models, and how youth learn [51]. Theory lays the foundation to understanding why risk behaviors,

such as e-cigarette use, happen and how to design better resources with strategies that have been validated through past programs. The most commonly used and cited theories for tobacco prevention and cessation programs include the Theory of Planned Behavior, Social Cognitive Theory, and the Transtheoretical Model of Behavior Change [52–54]. The Optimal Health Framework and Positive Youth Development are frameworks that are now being applied in many tobacco prevention programs to build engagement and foster participatory learning [51]. The following presents further information on the core components of these theories and frameworks that are most effective in prevention and cessation programs.

The Theory of Planned Behavior explains how variables such as intention, attitudes, subjective norms, and perceived behavioral control can influence behavior, and has been widely used in understanding tobacco use intentions and designing interventions [52, 55]. Self-efficacy is an important aspect of the theory of planned behavior, to help build confidence to feel personally empowered to make decisions and resist risk behaviors, such as e-cigarette use [39]. Social Cognitive Theory explains how individuals imitate modeled behaviors and highlights how educating adolescents about social norms can help build refusal skills, resist peer pressure, and shape behavior change [52]. The Transtheoretical Model of behavior change posits that health behavior changes progress through a number of stages and has been used in many tobacco interventions, especially smoking cessation [54, 56].

The Optimal Health Framework posits that influences of physical and social environments, such as parents, peers, schools, communities, and media can increase and reduce the likelihood of adolescents engaging in unhealthy risk behaviors [57••]. The Optimal Health Framework also explains how risk-taking behavior results from neurobiological development during adolescence, which is why adolescents tend to seek novel experiences and experimentation to help develop independence and self-identity [57••]. The Optimal Health Framework can help inform programs in understanding why adolescents use e-cigarettes and how to best address this issue in the environments adolescents find themselves in.

Positive Youth Development is another approach that encourages educators to engage adolescents in learning about the process of development and decision-making during the journey into adulthood [51]. Elements of Positive Youth Development in tobacco prevention programs include supportive environments with adult mentorship and encouraging community involvement and leadership [51], such as through youth-led projects [51, 58, 59]. Core components of e-cigarette programs and interventions should thus include elements of social-emotional learning, Positive Youth Development, and involve adolescents' families and communities [51, 57••].

Best Practices in Prevention and Cessation

Effective tobacco prevention programs include normative education and interactive content. Normative education is defined as informational and behavioral interventions aimed at addressing beliefs around a certain behavior, such as decreasing e-cigarette use among adolescents [60]. Overall, it is important for prevention programs to address reasons why adolescents use e-cigarettes and beliefs around what constitutes nicotine addiction or susceptibility to marketing as a means to enable youth to reflect on perceptions underlying their decisions to use e-cigarettes. Thus, in preventing adolescent e-cigarette use, programs should address flavors, peer influences, perceptions of harm, and other key reasons why adolescents are particularly attracted to these more novel tobacco products. Specifically for school-based tobacco prevention, programs with the potential for long-term impact also include education around commitments and intentions not to use, training around refusal skills, and use of peer leaders [61]. Interactive content is defined as curricula that encourage discussions and activities, and fosters games, role playing, and practicing of refusal and other skills [61]. Under no circumstances should any youth tobacco prevention program be developed and implemented by the tobacco or e-cigarette industry, as such program content and delivery can be adversely affected by bias towards commercial interests [44, 62].

Unfortunately, there is less scientific literature around best practices for tobacco cessation programs for adolescents. Research has evaluated the efficacy of overall strategies of adolescent cessation, such as individual or group counseling, messaging interventions, and pharmacological interventions, but have not identified what aspects of such programs or specific components were effective at a more granular or content level [47, 63, 64]. Thus, we do not have as exhaustive of a list of best practices for adolescent tobacco cessation programs as we do for prevention programs.

Overall, programs that are adaptable and accessible, ideally being fully online or web-based and completely free-of-cost, help with wider dissemination and implementation of programs. Effective programs address both middle and high school levels, which is around the age when most adolescents are known to try e-cigarettes for the first time [65].

Next, we review the current landscape of e-cigarette prevention and cessation programs available and assess whether or not they are theory-informed and meeting the identified best practices.

Review of Programs: Methods

To identify available e-cigarette prevention and cessation programs, we conducted a web-based search of currently available e-cigarette prevention and cessation programs

using Google in May of 2020. The Google Boolean search terms used were “e-cigarette prevention program,” “e-cigarette prevention,” “e-cigarette education,” “vaping prevention,” “e-cigarette cessation,” “youth e-cigarette cessation,” “e-cigarette treatment,” and “e-cigarette alternative-to-suspension.” The purpose of using Google as the main search platform was to identify programs that were more widely known and searchable not just by an academic audience but also by parents, adolescents, and educators. This is especially important since many e-cigarette prevention and cessation programs have likely not yet been evaluated and therefore might not show up in searches on PubMed, PsychLit, or other academic search sites. The results of these Google searches were reviewed to identify programs that focused on adolescent e-cigarette prevention or cessation.

Inclusion criteria for both prevention and cessation programs were that the program included content addressing e-cigarettes was created and used in the USA, and that the stated intended audience was adolescents or educators who delivered program content to adolescents. Exclusion criteria for both prevention and cessation programs were not having working webpages and/or evidence of not having been updated within the last 5 years, when e-cigarettes became most popular among youth. Programs around vaping marijuana were not included to focus this review on nicotine e-cigarette prevention and cessation.

Inclusion criteria specific for prevention programs were school-based education curricula, mass media campaigns, and educational games. Inclusion criteria specific for cessation programs were websites with quitting resources, quitlines, text messaging services, and alternative-to-suspension programs.

With this inclusion and exclusion criteria, eight prevention programs [59, 66–72], seven cessation programs [73–79], and one program combining prevention and cessation [72] were identified as focusing on adolescents and included in this review. Table 1 provides detailed information on each of the nine prevention programs and Table 2 provides detailed information on each of the eight cessation programs. Data in both tables are presented to summarize information on the following program aspects: source of the program, duration of exposure, component of program dedicated to e-cigarettes, date the program was created, date of last update of the program, intended audience, cost, channel of delivery, whether or not the program explicitly uses theory, and whether the program has been empirically evaluated. Additional components evaluated for prevention and cessation programs differ, as the prevention programs identified were mostly educational or media campaigns, whereas the cessation programs were mostly individual counseling or alternative-to-suspension programs, and thus these prevention and cessation programs are not directly comparable to one another.

Table 1 Details of identified e-cigarette prevention programs for adolescents, organized by most recently created

Program	Affiliation	Type of program	Duration of education exposure	Component of program dedicated to e-cigarettes	Original date created (not when e-cigarette component added)	Intended audience	Fully accessible online	Price	Date of last update of program
The Rise of Vaping Video	Campaign for Tobacco-free Kids	Educational video	20 min	Entire program/video	2019	Middle and high School	Yes	Free	2020
smokeSCREEN	Yale Center for Health and Learning Games	Online game	2–3 h	Incorporates e-cigarette use along with tobacco use in general	2018	Age 10–16	Yes	Free	2020
The Real Cost of Vaping	Collaboration between FDA and Scholastic	Resources for educators (infographics)	N/A	Entire program	2018	Grades 6–12	Yes	Free	2020
Stanford Tobacco Prevention Toolkit	Stanford School of Medicine/Department of Pediatrics	School-based education	1, 5, 8, 10 sessions where the minimum exposure is 45 min	Part of a tobacco prevention program with a dedicated module for e-cigarettes	2016	Middle and High School (program specific for each school level)	Yes	Free	2020
MSP (Model Smoking Prevention Program)	Formerly the Minnesota Smoking Prevention Program	School-based education	6 sessions, 45–50 min each	Incorporates e-cigarette use along with tobacco use in general; supplemental section	2016	Grades 5–8	No	Cost	2016
CATCH My Breath (Coordinated Approach to Child Health) E-cigarette and Juul Prevention Program	University of Texas, Health School of Public Health	School-based education	4 sessions, 30–40 min each	Entire program	2014	Middle and High School (program specific for each school level)	Need to enroll	Free	2016
“The Real Cost” Youth E-cigarette Prevention Campaign	Food and Drug Administration (FDA)	Counter-marketing campaign	N/A	Entire campaign	2014	Youth age 12–17	Yes	Free	2018
truth Campaign	Truth Initiative	Counter-marketing campaign	N/A	Entire campaign	2000	Youth and young adults	Yes	Free	2020
Project Alert (Adolescent Learning Experiences Resistance Training)	RAND Corporation	School-based education	11 sessions, 45 min each, with 3 booster sessions	Incorporates e-cigarette use along with tobacco use in general; supplemental section	1995	Grades 7 and 8	Yes	Free	2018

Table 1 (continued)

Program	Theories explicitly stated	Who delivers program	Address flavors	Address marketing	Includes refusal skills activities	Includes content on disposables	Empirically evaluated for e-cigarette component
The Rise of Vaping Video	No	Video	Yes	Yes	Yes	No	No
smokeSCREEN	Social cognitive theory, theory of planned behavior	Online game	Yes	Yes	Yes	No	Yes ¹
The Real Cost of Vaping	No	Educator/infographics	Yes	Yes	N/A	No	No
Stanford Tobacco Prevention Toolkit	Positive Youth Development; Theory of Planned Behavior	Educator	Yes	Yes	Yes	Yes	Yes ^{*2}
MSPP (Model Smoking Prevention Program)	Social Influences Theory	Educator and peer	Yes	Yes	Yes	No	No
CATCH My Breath (Coordinated Approach to Child Health) E-cigarette and Juul Prevention Program	Social Cognitive Theory	Peer	Yes	Yes	Yes	No	Yes ^{*3}
“The Real Cost” Youth E-cigarette Prevention Campaign	Behavior Change Theory	Television and online advertisements	Yes	Yes	N/A	No	Yes ^{γ4}
truth Campaign	Behavior Change Theory	Mass media	Yes	Yes	N/A	No	Yes ^{α5}
Project Alert (Adolescent Learning Experiences Resistance Training)	Theory-informed, but exact theories used not stated	Educator and peer	Yes	Yes	Yes	No	No

*Single-group pre-post study (on adolescent intent/use of e-cigarettes); ^controlled repeat cross-sectional; γ randomized copy testing and focus group discussions for program development; α national cohort study

¹ Hiefije KD, Fernandes CSF, Lin IH, Fiellin LE. Effectiveness of a web-based tobacco product use prevention videogame intervention on young adolescents’ beliefs and knowledge. *Subst Abuse*. 2019. doi:<https://doi.org/10.1080/08897077.2019.1691128>

² Gaiha S.M., Duemler A, Silverwood L, Razo A, Halpern-Felsher B, Walley SC. School-based e-cigarette education in Alabama: Impact on knowledge of e-cigarettes, perceptions and intent to try. *Addict Behav*. June 2020:106519. doi:<https://doi.org/10.1016/j.addbeh.2020.106519>

³ Kelder SH, Mantey DS, Van Dusen D, Case K, Haas A, Springer AE. A Middle School Program to Prevent E-Cigarette Use: A Pilot Study of “CATCH My Breath.” *Public Health Rep*. 2020;135 [2]:220–229. doi:<https://doi.org/10.1177/0033354919900887>

⁴ Huang LL, Lazard AJ, Pepper JK, Noar SM, Ranney LM, Goldstein AO. Impact of The real cost campaign on adolescents’ recall, attitudes, and risk perceptions about tobacco use: A national study. *Int J Environ Res Public Health*. 2017;14 [1]. doi:<https://doi.org/10.3390/ijerph14010042>

⁵ Vallone D, Greenberg M, Xiao H, et al. The effect of branding to promote healthy behavior: Reducing tobacco use among youth and young adults. *Int J Environ Res Public Health*. 2017;14 [12]. doi:<https://doi.org/10.3390/ijerph14121517>

Table 2 Details of identified e-cigarette cessation programs for adolescents, organized by most recently created

Program	Affiliation	Type of program	Duration of program exposure	Component of program dedicated to e-cigarettes	Original date created (not when e-cigarette component added)	Intended audience	Fully accessible online	Price	Date of last update of Program	Theories explicitly stated	Who delivers program	Empirically evaluated for e-cigarette component
My Life, My Quit	National Jewish Health	Texting/quitting support	5 1:1 coaching sessions ~ every 7–10 days	Entire program	2019	Youth	Yes	Free	2020	No	Counselor (one-on-one)	No
This is Quitting	Truth Initiative	Texting intervention	N/A	Entire program	2019	Youth	Yes	Free	2019	No	Text messages	Yes* ¹
Healthy Futures/Tobacco Prevention Toolkit	Stanford School of Medicine/Department of Pediatrics	Alternative-to-suspension	1-, 2- and 4-h sessions	Incorporates e-cigarette use along with tobacco use in general	2019	Middle and High School	Yes	Free	2020	Positive Youth Development	Educator	No
Not on Tobacco (N-O-T)	American Lung Association	School-based education	10, 50-min sessions	Incorporates e-cigarette use along with tobacco use in general	1999	Ages 14–19	No	Free	2020	Social Cognitive Theory	Educator	No
Project Alert (Adolescent Learning Experiences Resistance Training)	RAND Corporation	School-based education	1 session on e-cigarettes/-tobacco	One session addressing tobacco and e-cigarette cessation	1995	Grades 7 and 8	Yes	Free	2018	Theory-informed, but exact theories used not stated	Educator and peer	No
Smokefree.gov/SmokefreeTXT for teens	National Cancer Institute (NIH)	Cessation tools such as texting, app, counselors, info sheets	N/A	Some tools specific to e-cigarettes	N/A	Ages 13–19	Yes	Free	2020	No	Counselors and online resources	No
INDEPTH	American Lung Association	Alternative-to-suspension	4, 50-min sessions	Incorporates e-cigarette use along with tobacco use in general	N/A	Youth	No	Free	2019	No	Educator	Yes ²
1-800-QUIT-NOW/State-Level quitlines	Centers for Disease Control (CDC)	Quitline	N/A	Incorporates e-cigarette use along with tobacco use in general	N/A	All ages	Yes	Free	2020	Theories of behavior change	Counselor (one-on-one)	No

*Yes (engagement and commitment to quit); impact evaluation on reducing e-cigarette use ongoing

¹ Graham AL, Jacobs MA, Amato MS, Graham A. Engagement and 3-Month Outcomes From a Digital E-Cigarette Cessation Program in a Cohort of 27, 000 Teens and Young Adults. *Nicotine Tob Res.* 2020;2020 [5]:859–860. doi:<https://doi.org/10.1093/ntr/nz097>

² American Lung Association. *INDEPTH Pilot Evaluation Overview*

What Programs Are Doing Well

As shown in Table 1, all of the prevention programs discuss the importance of understanding flavored e-cigarette products, and all but one [80] of the prevention programs address industry-targeted marketing and advertising to adolescents. Six of the prevention programs [59, 66, 68, 69, 72, 81] included social learning activities to develop refusal skills, and the three programs that did not include refusal skills were mass media campaigns [67, 70, 71].

Of the nine prevention programs examined, all but one program [68] was free-of-cost, and all but one program [68] was fully available online or required a simple enrollment process by individual educators/professionals. Seven of the prevention programs [59, 66–71] explicitly stated incorporation of theory in their program descriptions and published materials. Of the prevention programs, two explicitly cited Social Cognitive Theory [66, 69], two explicitly cited Behavior Change Theory [70, 71], one explicitly cited Positive Youth Development [59], one explicitly cited Social Influences Theory [68], and one explicitly cited Theory of Planned Behavior [66].

Of the eight cessation programs examined, all were free-of-cost, and all but two programs were fully available and accessible online [75, 79]. Two of the cessation programs explicitly stated their incorporation of theory in their program descriptions and materials [76, 79]. Three of the cessation programs included texting features, which indicated that these programs were trying direct-to-youth strategies using platforms and technologies that adolescents frequent [73, 74, 77]. Four of the cessation programs explicitly stated incorporation of theory in their program descriptions and published materials [72, 76, 78, 79]. Of the cessation programs, one explicitly cited Positive Youth Development [76], one explicitly cited Social Cognitive Theory [79], and one explicitly cited Theories of Behavior Change [78].

Overall, studies show that some programs have been evaluated and show promising results. Of the nine prevention programs, five programs have evaluated and published their content containing e-cigarette education [59, 66, 69–71]. These evaluated prevention programs show that the programs are successful at changing adolescent perceptions and behavior, including reducing e-cigarette use and increasing knowledge around these products [45, 82–86]. Of the eight cessation programs, two have evaluated and published their content regarding e-cigarette cessation [73, 75]. These evaluated cessation programs have promising results showing youth engagement with the program content and motivating adolescents to quit e-cigarettes [87, 88]. Many programs also included normative education and interactive content around how e-cigarettes are not completely harmless, such as the four messaging campaigns [67, 70, 71, 81].

Gaps in Programs

Despite the prevention and cessation programs largely including key components known to be effective, there are some gaps in the programs. There were only a few programs solely dedicated to or with separate modules on e-cigarettes. Three programs combined the topic of e-cigarettes with their general tobacco curricula [66, 68, 72]. Overall, we found eight programs with separate modules or stand-alone programs for e-cigarettes [59, 67, 69–71, 73, 77, 81]. Thus, varying durations of exposure to prevention content make it challenging to compare the efficacy of programs with one another.

Ideally, e-cigarette prevention and cessation should be separated from general tobacco prevention and cessation. What works to reduce the use of other tobacco products may not work for e-cigarettes due to differences in social norms and social desirability by peers, ability to use e-cigarettes discreetly and without odor, an overwhelmingly aggressive advertising and social media landscape, appealing flavors, and perceived lower health risk of e-cigarettes compared to combustible cigarettes [14, 89, 90]. E-cigarette product types and components are also fast-evolving, unlike other traditional tobacco products. Our review showed that several programs were not up to date or did not include the latest products that youth are using. Only one prevention program [59] includes education around newer disposables like Puff Bar and add-on flavor-enhancers like Puff Krush.

Specifically for prevention programs, components of all programs should include a discussion of contents of e-cigarette flavors, explanation of negative health effects, exposure and identification of targeted marketing, and practicing refusal skills to understand social influences and allow greater resistance to use. It was also unclear whether the level of interactivity and esthetic appeal of prevention content achieved is what adolescents are used to seeing in other marketing content from the industry, which presents a potential gap in appeal and engagement. Only one prevention program was designed as an interactive game platform to educate an adolescent audience about tobacco and e-cigarette prevention [66].

Our search identified more prevention than cessation programs, and there is less information specifically around e-cigarette cessation programs. More effective and evidence-based tools, resources, and programs are needed for adolescent e-cigarette cessation. Most e-cigarette specific cessation programs were started an average of 2 years ago. This could be due to the fact that e-cigarettes are evolving rapidly in the market and there is growing evidence of adolescent addiction to e-cigarettes, resulting in cessation programs being developed more recently, and older tobacco prevention programs needing to adapt e-cigarette content into their materials and models. Of these e-cigarette specific cessation programs that have only been developed in the past year or two, only one

alternative-to-suspension program has published pilot data on their outcomes and found that the program did influence students to make a plan to stop using e-cigarette products [88], and one texting program has published 3-month observational outcomes and found promising results for using texting to reduce the barriers of accessing a cessation intervention [87]. Furthermore, there are no FDA-approved nicotine replacement therapies identified for adolescent e-cigarette use. Additional research is needed to assess psychosocial needs and particular withdrawal symptoms related to e-cigarette cessation. More physiological studies are also needed to design nicotine titration plans for varying levels of e-cigarette use by adolescents of different ages for pharmacological treatments and to test effective strategies to enable medication adherence, acceptability, and sustained cessation.

Ultimately, more evaluation is needed to move from evidence-informed to evidence-based practices in e-cigarette prevention and cessation. Some prevention programs have evaluated their entire curricula or tobacco prevention efforts, but not specifically their e-cigarette components. Our review of e-cigarette programs showed a dearth of published studies evaluating existing prevention and cessation programs for adolescent e-cigarette use with pre-post data or randomized controlled trials. When studies are conducted, we rarely know the long-term impact of the program or unintended consequences such as e-cigarette education leading to decreased youth e-cigarette use but increased use of other products. Published data across programs are inconsistent with regard to information about program development, formative research, theoretical foundations, key principals and aims, modes of delivery, qualitative justification, reach, partnerships, evidence used in designing and updating content, measures of success, implementation research on acceptability and feasibility, and emphasis placed on the e-cigarette content. On the contrary, e-cigarette counter-marketing campaigns set a good example of publishing details on how they are developed and designed [91, 92]. Few educational programs describe the details of how they were developed, and thus it is difficult to distinguish which are most rigorous with respect to one another. Due to wide variations in content, duration of exposure, and mode of delivery, it is also difficult to tease apart which are the crucial components that work from each of these programs. There is also a need for program implementation research on barriers and facilitators in the school context that influence the probability of greater reach, impact, acceptability, and scalability.

Recommendations

Addressing the gaps in the existing prevention and cessation programs requires incorporating a theory-based approach, expanding focused interactive content, and conducting more rigorous program evaluations, in order to develop effective

and successful long-term programs. Overall, current programs are supported by theory and follow best practices, but some gaps still exist. Programs should strive for a holistic approach or multi-modal approach involving schools, parents, teachers, and the greater community, which a systematic review of prevention education suggested is the way forward [93]. Programs should continue to bolster their digital accessibility and interactive components in order to keep up with the advancing technology and media that surround adolescents. Most importantly, programs need to focus on addressing the factors most likely to influence adolescent use of e-cigarettes, include more information around e-cigarettes' impact on mental health, describe their programs for ease of replication, and evaluate their programs.

Conclusion

Unabated adolescent use of e-cigarettes, misinformation about the harms of e-cigarettes fueled by marketing, appealing flavors, other product characteristics such as their sleek design, high nicotine content causing adolescents to become addicted, and other health effects of e-cigarettes are why both e-cigarette prevention and cessation programs for adolescents are critical [94]. This review highlighted that there are few adolescent-focused e-cigarette prevention programs and very few cessation programs. Furthermore, few have been evaluated to determine the most effective components for helping adolescents to make informed decisions regarding their health. Most programs are available online, with many free and few requiring cost. Few programs contain an updated stand-alone e-cigarette curriculum, not all programs utilize a theoretical framework, and not all programs address key influences on adolescent e-cigarette use: marketing, flavors, nicotine addiction, and peer pressure. The development, evaluation, and dissemination of prevention and in particular cessation programs is needed in order to mitigate adolescent use of e-cigarettes.

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Compliance with Ethical Standards

Conflict of Interest Dr. Halpern-Felsher is the Founder and Executive Director of the Tobacco Prevention Toolkit. She is also a paid expert scientist in some e-cigarette litigation and an unpaid scientific advisor and expert witness regarding some tobacco-related policies. Ms. Liu and Dr. Mathur Gaiha have no conflicts of interest to disclose.

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- Of major importance

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