



Mixed methods evaluation of vaping and tobacco product use prevention interventions among youth in the Florida 4-H program

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ABSTRACT

Introduction: Novel prevention programs are developed to address the increase in e-cigarette use (vaping) among children. However, it remains paramount to test their feasibility in rural settings. This pilot study implemented and evaluated the feasibility and outcomes of two innovative programs, *CATCH My Breath* and *smokeSCREEN*, among youth in rural settings in Florida.

Methods: We conducted four focus groups with youth aged 11–17 recruited from 4-H rural clubs in Florida. In a subsequent randomized trial, we recruited 82 youth participants and assigned them to one of three arms: *CATCH My Breath*, *smokeSCREEN*, or control. *CATCH My Breath* and *smokeSCREEN* participants attended online group intervention sessions while the control group received educational material. Pre- and post-surveys were administered to all participants to assess knowledge, susceptibility, perceived positive outcomes and risk perceptions related to tobacco and e-cigarette use. Other feasibility parameters were also assessed.

Results: Focus group discussions provided insights about feasibility and informed the implementation of both interventions in terms of delivery format, scheduling of sessions and incentives. After the intervention, *CATCH My Breath* participants significantly improved their general tobacco-related knowledge (post-pre = 16.21–12.92 = 3.3, $p < .01$) and risk perceptions towards other flavored tobacco products (post-pre = 19.29–17.71 = 1.6, $p < .05$). *smokeSCREEN* participants significantly improved their general tobacco knowledge (post-pre = 18.77–13.77 = 5.0, $p < .01$), knowledge about e-cigarettes (post-pre = 9.08–6.31 = 2.8, $p < .01$) and risk perception towards e-cigarettes (post-pre = 24.69–21.92 = 2.8, $p < .05$).

Conclusions: This study demonstrated feasibility of delivering the interventions via participant engagement, participants' willingness to be randomized, assessment of outcome measures, and exploration of different recruitment methods. Despite the potential positive influence of *CATCH My Breath* and *smokeSCREEN* on youth participants, further evaluation with larger samples is needed.

1. Introduction

Despite significant progress in reducing cigarette smoking among youth in the US, tobacco use remains the leading preventable cause of

premature disease and death in the US (US Department of Health and Human Services, 2014). The tobacco product landscape continues to evolve as the industry introduces an increasingly wide array of novel tobacco products, including electronic nicotine delivery systems

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(ENDS), commonly referred to as electronic cigarettes or e-cigarettes (Cobb, Byron, Abrams, & Shields, 2010). E-cigarettes became available on the US market in 2007 (Regan, Promoff, Dube, & Arrazola, 2013). Since then, e-cigarettes have become an appealing tobacco product among youth. Considerable research has recognized a dramatic rise in vaping among US youth that has reached an epidemic level and emerged into an urgent public health concern (Arrazola et al., 2015; Venkata, Palagiri, & Vaithilingam, 2021). Since 2014, e-cigarettes have been the most commonly used tobacco product among youth in the US (Wang et al., 2019). Factors that have contributed to the rise in e-cigarettes use among youth include the use of characterizing flavors (Cullen et al., 2019; Hoffman, Salgado, Dresler, Faller, & Bartlett, 2016), perception of reduced risk (Amrock, Lee, & Weitzman, 2016; Arrazola et al., 2015), exposure to youth-targeted advertising campaigns (Padon, Maloney, & Cappella, 2017; Pu & Zhang, 2017; Singh et al., 2016) and innovations in vaping devices (Venkata et al., 2021).

Nationally representative estimates from the 2022 National Youth Tobacco Survey (NYTS) indicated that 9.4% of surveyed students from grades 6–12 reported current e-cigarette use, representing 14.1% of high school students and 3.3% of middle school students (Cooper et al., 2022). Research has documented the harmful toxicant components of e-cigarettes (Logue et al., 2017; Tierney, Karpinski, Brown, Luo, & Pankow, 2016), and the serious short- and long-term health consequences of vaping (Chadi, Hadland, & Harris, 2019; US Department of Health and Human Services, 2016; Venkata et al., 2021). Additionally, given that e-cigarettes typically contain nicotine – a highly addictive psychoactive component, the initiation of vaping during adolescence can lead to addiction (Hamidullah, Thorpe, Frie, Mccurdy, & Khokhar, 2020; Sapru et al., 2020). In particular, youth exposure to nicotine is worrisome knowing that human brain development continues through adolescence (England, Bunnell, Pechacek, Tong, & McAfee, 2015). A review by Sapru et al. (2020) concluded that the adolescent brain is highly sensitive to the impact of nicotine and that there is an inverse relationship between age and the overall effect of nicotine on the brain and body (Sapru et al., 2020). Chronic nicotine exposure during adolescence has been consistently associated with smoking-induced cognitive deficits, psychopathological outcomes, and future substance use (Hamidullah et al., 2020). This evidence points to adolescence as a crucial time for tobacco prevention efforts and highlights the critical need for adolescent-tailored preventative efforts to mitigate the threat of vaping among youth in the US.

Generally, there are considerable regional variations in tobacco use, with residents in many rural areas having disproportionately higher rates of tobacco use compared to residents in large metropolitan areas, specifically with respect to the use of cigarettes and smokeless tobacco (Buettner-Schmidt, Miller, & Maack, 2019; CDC, 2022; Talbot et al., 2019). In Florida, there are large disparities in cigarette smoking rates among rural and non-rural counties, especially in the northern part of the state, where 2019 adult smoking rates were above 25% in 9 rural counties, according to the Behavioral Risk Factor Surveillance System (2022). Youth in these rural settings represent a particularly vulnerable population. Causes of urban-rural disparities are complex, but can be attributed to socioeconomic factors, such as lower income and education levels and higher unemployment in rural areas, and other factors that are more specific to rural cultures and communities, such as the economic dependence on tobacco growing and greater social acceptance of smoking (Association, 2012). Policy-level tobacco control and regulatory factors that disproportionately benefit urban areas, including enforcement of regulations around the sale and marketing of tobacco products and treatment availability, also contribute to this disparity (Doogan et al., 2017). When examining ENDS use specifically, initial studies did not find a clear distinction between rural and urban users in the U.S. (Buettner-Schmidt et al., 2019; Mumford et al., 2019). However, one recent study found that rural youth are particularly vulnerable to e-cigarette initiation in comparison to their urban counterparts (Dai et al., 2021).

Although the US has experienced a decades-long decline in adult smoking rates, rural populations have not benefited equally from this progress (Doogan et al., 2017). Youth smoking declined from 1975 to 2018 (Johnston et al., 2019). However, a much greater reduction has benefited urban youth, widening the rural–urban gap in youth tobacco use (Ziller, Lenardson, Paluso, Talbot, & Daley, 2019). Data from the 2012 Florida Youth Tobacco Survey showed that the prevalence of ever and past-30-day use of e-cigarettes among high school students in non-metropolitan and rural Florida counties were 11% and 4.8% respectively, significantly higher than their counterparts residing in metropolitan counties (8% and 3.2% respectively) (Choi & Bernat, 2016). Although novel programs have been developed to address the vaping epidemic among children (Liu, Gaiha, & Halpern-Felsher, 2020; Substance Abuse and Mental Health Services Administration (SAMHSA), 2020), a challenge remains in adapting and deploying these programs for youth in rural settings, taking into consideration the unique context of rural cultures and communities that influence the use of e-cigarette by youth.

CATCH My Breath and *smokeSCREEN* are two innovative prevention interventions that focus on promoting healthy behaviors and increasing awareness about vaping and tobacco use among youth (Hieftje, Fernandes, Lin, & Fiellin, 2021; Kelder et al., 2020; Liu et al., 2020; Pentz et al., 2019; Substance Abuse and Mental Health Services Administration (SAMHSA), 2020). *CATCH My Breath* is an evidence-based youth vaping prevention program that consists of four in-class modules and utilizes a peer-led teaching approach (CATCH, n.d.). These modules feature interactive activities that deliver knowledge and develop skills, aiming to empower youth and enable them to make informed decisions about vaping (CATCH, n.d.; Kelder et al., 2020). *CATCH My Breath* is a school-based program that was designed for students in grades 5–12 (aged 10–18 years), informed by best practices from prior tobacco prevention interventions and rooted in social cognitive theory (Kelder et al., 2021). The only published evaluation of *CATCH My Breath* is a pilot study among 6th and 7th grade students across 12 middle schools in Texas which provided preliminary support for the effectiveness of *CATCH My Breath*: from baseline to 16-month follow-up, intervention schools had significantly lower increases in ever e-cigarette and greater improvements in e-cigarette knowledge and perceived positive outcomes compared to control schools (Kelder et al., 2020).

smokeSCREEN is an evidence-based smoking and vaping prevention videogame delivered at the individual level and designed for adolescents aged 10–16 years (play2PREVENT, n.d.; smokeSCREEN, n.d.). *smokeSCREEN* addresses various challenges teens face with a dedicated focus on youth decision-making around smoking and vaping and includes strategies for both tobacco use prevention and cessation (play2PREVENT, n.d.; smokeSCREEN, n.d.), informed by earlier videogame interventions (Camenga et al., 2018; Duncan, Hieftje, Pendergrass, Sawyer, & Fiellin, 2018), and guided by social cognitive theory and theory of planned behavior (Hieftje et al., 2021). A pre-post evaluation of *smokeSCREEN* among 560 participants aged 10–16 years demonstrated a significant positive impact on both beliefs and knowledge about electronic cigarettes and vaping (Hieftje et al., 2021). Earlier preliminary studies of *smokeSCREEN* have also shown promising results (Duncan et al., 2018; Pentz et al., 2019).

These programs recognize that smoking behavior is shaped by the interaction of environmental factors (e.g., peer role models, health messaging, social reinforcement) and intrapersonal factors (e.g., knowledge, outcome expectations, perceived susceptibility/severity) (Kelder, Hoelscher, & Perry, 2015). Consistent with this conceptual model, the programs' sessions address a range of issues that are known to influence e-cigarette use behavior. The ultimate aim is to prevent its future use among adolescents by acting upon key measures that are precursors to behavior change, including knowledge, perceived positive outcomes, risk perceptions, and susceptibility.

CATCH My Breath and *smokeSCREEN* have been featured in the Substance Abuse and Mental Health Services Administration (SAMHSA)

Evidence-Based Resource Guide Series (2020). Although both programs were developed based on best practices and are being individually evaluated, data about their effectiveness in real-world settings are limited. Additionally, their feasibility in various populations or among individuals within different population groups, including among rural youth has not been established. In an attempt to fill this gap, the purpose of our study is to evaluate the feasibility and outcomes of implementing *CATCH My Breath* and *smokeSCREEN* among youth in rural settings in Florida, consistent with guidance on measures to be used in feasibility studies (Eldridge et al. (2016).

2. Methods

2.1. Study design

This study used a sequential mixed-methods approach. First, we conducted four focus groups with youth from rural settings to obtain their feedback and recommendations on implementing *CATCH My Breath* and *smokeSCREEN* in a rural context. We used findings of the focus group to inform the implementation of both interventions. Then, we evaluated both interventions through a pilot, three-arm randomized controlled trial with baseline and immediate follow-up assessments.

2.2. Participants and procedures

The study was conducted between November 2021 and February 2022, in collaboration with the University of Florida (UF) Cooperative Extension, a partnership of state, federal, and county governments that aims to provide scientific knowledge and expertise to the public (UF/IFAS Extension, n.d.). Extension oversees the Florida 4-H Youth Development Program, a practical educational program that serves youth through 4-H clubs, with a focus on rural youth (UF/IFAS Extension, n.d.). Youth Development Program coordinators emailed 4-H members and their parents/legal guardians information on the study. Virtual meetings were conducted to confirm eligibility and complete the informed consent and assent process. Participants were eligible if they were aged 11–17 years, regardless of their e-cigarette use status.

In the first phase of the study, we conducted virtual focus groups via Zoom videoconferencing technology, whereby study staff demonstrated selected materials from *CATCH My Breath* and *smokeSCREEN* programs to the groups of youth and sought their feedback and recommendations about how to best customize the implementation strategies of the programs to meet the contextual local needs of youth in rural settings. We also assessed implementation barriers and facilitators. A total of 4 focus groups were conducted with 34 participants and were divided by age group: two 14–17-year-old groups (N = 16), and two 11–13-year-old groups (N = 18). Focus groups lasted for 45–75 min and were audio-recorded and transcribed verbatim. After focus groups were analyzed,

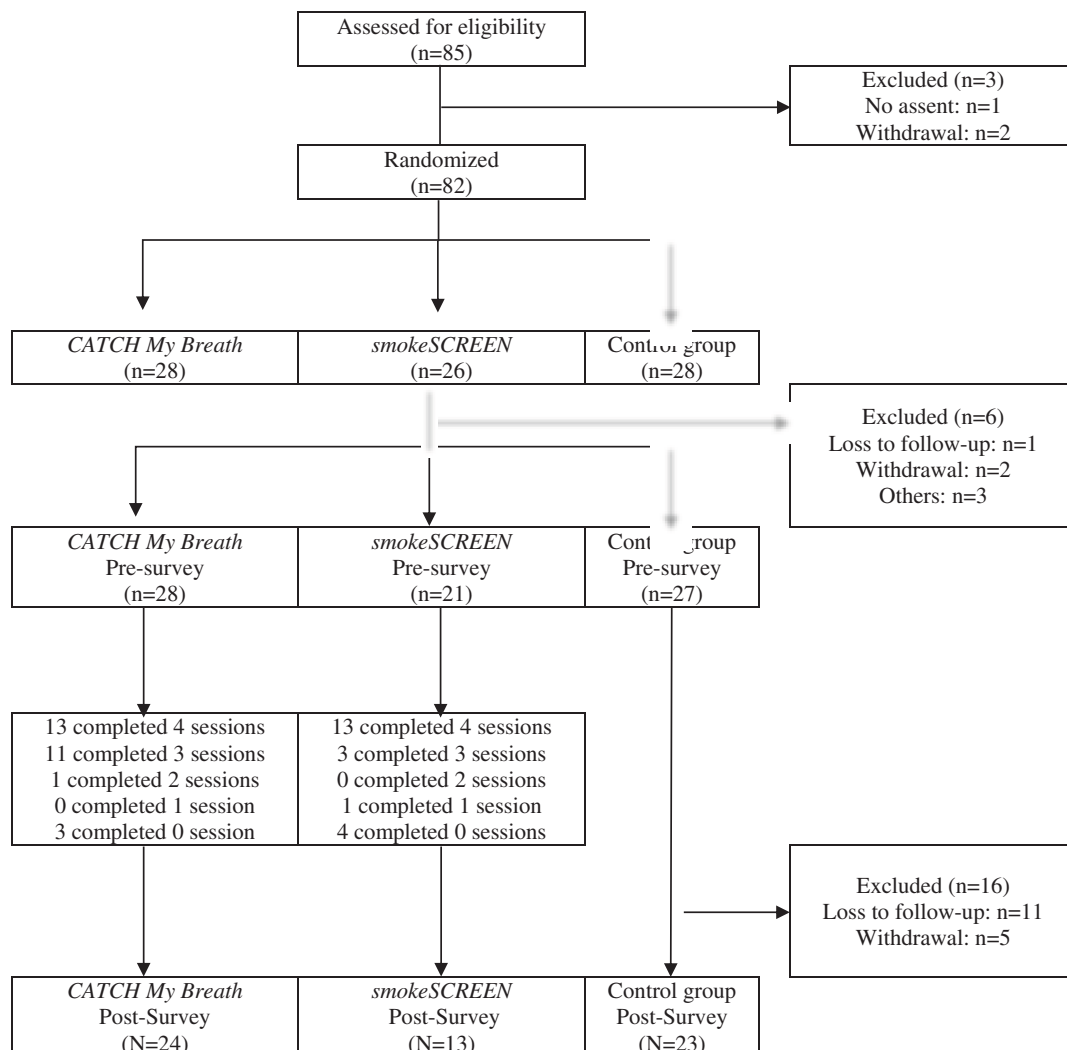


Fig. 1. CONSORT diagram.

the research team examined key findings and used participant feedback and recommendations to inform the delivery of the programs to youth in rural settings. Focus group participants did not participate in the trial phase.

In the second phase, a total of 85 parents were consented, and 82 youth participants assented and were randomized, using the REDCap randomization tool, to one of three arms (Fig. 1): *CATCH My Breath*, *smokeSCREEN*, or the control group at the completion of the meeting consenting participants. Following, saliva cotinine test kits (iScreen Oral Fluid Nicotine test) were mailed to participants, with cotinine being commonly used as a biomarker to validate self-reported smoking status (Ramdzan, Almeida, McCullough, Segundo, & Kolev, 2018). Participants completed an online survey at baseline and the noninvasive cotinine saliva test in a subsequent virtual meeting. Participants in the two intervention arms attended the intervention sessions as per their age subgroups (sessions for 11–13 and 14–17 years old were held separately). Participation was in a group format, and each of the two intervention arms included six groups. Participants in the control arm were directed to review information about vaping and tobacco on their own.

Participants completed an online post-intervention survey and the saliva cotinine test during a final virtual meeting, which was completed at any time after completing the intervention sessions for *CATCH My Breath* or *smokeSCREEN* and after referral to the control material. The average length of time between baseline and post-intervention survey was 17 weeks. Data collection was completed electronically via REDCap.

2.3. Interventions for the trial phase

Arm 1 – *CATCH My Breath*: Sessions include interactive activities allowing active group participation and discussion (e.g., interview, true or false questions, role-play). A summary of the session content is provided in Table 1. For this study, *CATCH My Breath* curriculum was delivered once per week over four weeks via Zoom group sessions. Each session lasted 30–60 min and was facilitated by two trained research team members using PowerPoint presentations for each session, made available by the program developers.

Arm 2 – *smokeSCREEN*: In this videogame, players assist their virtual character in navigating school by making choices during social encounters involving tobacco product use. The game involves 7 unique stories addressing different themes. Our research team provided the participants with usernames, passwords and instructions on how to play the videogame. Participants played *smokeSCREEN* individually then met in groups with the research team once-a-week over a four-week period, via Zoom, to discuss the game. *smokeSCREEN* sessions lasted about 30–60 min and were facilitated by two trained research team members. A summary of the *smokeSCREEN* session content is provided in Table 2.

Arm 3 – control: participants in the control arm were directed to review the Youth Tobacco Prevention web page on the CDC website which includes information about vaping and tobacco (CDC, 2021).

Table 1
Content of *CATCH My Breath* sessions.

Session number	Content
Session 1	Knowledge to enable informed decisions about e-cigarettes (e-cigarettes content and health consequences, school policies and age-of-sale restrictions).
Session 2	Data on e-cigarette prevalence among peer school students; Nicotine addiction; Pressures for e-cigarette use by social (e.g., peer/adult role models) and environmental influences (e.g., advertising or promoting tobacco products).
Session 3	Refusal skills to resist social influences to use e-cigarettes; Media critical analysis with a focus on how big tobacco industry targets young people.
Session 4	Anti-vaping social media campaign prepared by students; Public commitment by students to abstain from e-cigarette use.

Table 2
Content of *smokeSCREEN* sessions.

Session number	Content
Session 1	Story 1: E-cigarettes content and health consequences; Addiction.
Session 2	Stories 2 and 3: Refusal skills and peer pressure; Consequences of smoking.
Session 3	Stories 4 and 5: Secondhand smoking; Media analysis.
Session 4	Stories 6 and 7: Marketing strategies by tobacco companies; Smoking cessation resources.

2.4. Ethical considerations

The study was approved by the UF Institutional Review Board (IRB202000797). Adolescents were offered incentives for participation in the study: electronic gift cards were provided to the participants after completing the focus group, the baseline survey and the post-survey (\$20, \$10 and \$10 respectively).

2.5. Outcome measures

We administered a 67-item questionnaire organized into six sections (*number of items per section*): socio-demographic (5); smoking and vaping behavior (10); thoughts and beliefs towards tobacco (24); intentions (6); social norms (6); and knowledge (16). Most tobacco related sections included general items and items on cigarette, e-cigarette and other flavored tobacco products (e.g., cigarillo, hookah, and pipe). All items were based on prior tobacco surveys (CDC, 2020; Hieftje et al., 2021; Pentz et al., 2019). The primary outcomes of the intervention were: knowledge, susceptibility, perceived positive outcomes and risk perceptions. Knowledge was assessed by asking questions about smoking generally and about e-cigarettes specifically in relation to the content delivered during the intervention sessions (true, false, and not sure). We used an adapted measure of susceptibility (Pierce, Choi, Gilpin, Farkas, & Merritt, 1996; Pierce et al., 2017) with two questions on each of the three tobacco products: whether they would use the tobacco product if one of their best friends offered them one and whether they think they will use it at any time during the next 12 months (definitely not, probably not, probably yes, and definitely yes). Perceived positive outcomes was measured through assessing the participants' self-evaluations of two likely consequences of a tobacco product use. We asked participants how much they agreed with the following statement "I think I might enjoy using an e-cigarette" (strongly agree, agree, disagree and strongly disagree), and whether they think young people who use e-cigarettes have more or less friends compared to non-smokers (more friends, no difference, and less friends). Risk perception was assessed through 18 items which had a variety of response options (4–6 response choices). Items asked about the perceived harm caused by using a tobacco product in terms of general harm, ability to quit, future hypothetical outcomes and addiction.

2.6. Data analysis

2.6.1. Qualitative data analysis

Transcripts were initially open coded by three research staff members (AA, AK and JL). A codebook was developed based on the open coding. In-depth team-based analysis was conducted through iterative stages of deductive and inductive coding. To ensure higher inter-rater reliability, each transcript was coded independently by two research staff members. The coded interviews were compared and discussed in team meetings during which any discrepancies were resolved by consensus and/or a third coder. Decisions made during team meetings informed revisions to the codebook. Codes added to the codebook during the coding effort were then back coded.

2.6.2. Statistical data analysis

Descriptive analyses were conducted to summarize demographics and other characteristics at baseline, across the total sample as well as the three intervention arms, and to compare the three groups on all characteristics. To analyze the impact of the intervention on outcome measures, items were first grouped to represent a specific outcome, then Likert-type responses were scored such that a higher score represents anti-smoking profile (higher risk perception, better knowledge, lower susceptibility, and lower perceived positive outcomes). Then, the following analyses were performed: i) items within each outcome measure were summed and averaged by product to generate scores for each outcome; For this analysis, mean average scores at each time (pre-and-post) and mean change and SD are reported for all outcomes across the three intervention arms. ii) single items within each outcome measure were averaged individually (except for knowledge outcome). Mean change and 95% CI for this analysis are reported in the form of forest plots; To analyze changes in outcomes from pre- to post-survey, paired-samples t-tests were conducted. iii) For knowledge-related questions, paired responses for pre- and post-surveys were compared for each group using McNemar's exact test. The three groups were also compared at baseline using Fisher's exact test. To make comparisons between pre- and post-intervention measures, we only included those participants who completed the post-intervention survey. No missing data were observed. All statistical analysis were completed using SAS 9.4.

3. Results

3.1. Focus group discussions

Four primary themes resulted from analysis of focus group discussions, namely: the value of interactive components, feasibility of completing the programs, effectiveness of the programs and recommendations. More details, along with illustrative quotes, are presented in [Appendix 1](#). In terms of feasibility, participants expressed concerns about completing both programs. For *smokeSCREEN*, participants noted the tradeoff between accountability and independence. Although the ability to complete *smokeSCREEN* at their own pace was appealing to the participants, some expressed concern that youth may not remember or may be demotivated to complete the program. For both programs, participants discussed how other activities (e.g., work, extracurriculars) could interfere with their ability to complete the programs. This issue was somewhat more salient for *CATCH My Breath* as it requires working the program into their schedules, though the overall time required to complete *smokeSCREEN* was also a concern for some.

Participants recommended that programs should acknowledge youths' autonomy and decision-making ability rather than "telling them what to do". Other recommendations included incorporating information about how stress and mental health issues contribute to vaping, providing visuals that demonstrate the consequences of vaping on the body and appearance, and having peers deliver intervention messages to increase effectiveness. Participants also recommended the delivery of vaping prevention programs to younger age groups (i.e., elementary school students), the dissemination of programs through social media, and the provision of incentives (e.g., gift cards, recognition of volunteer hours) for completion.

Based on the participants' feedback and recommendations, the following changes were made before implementing each program: 1) In the *smokeSCREEN* arm, virtual group sessions were organized to discuss knowledge and gameplay experiences between participants and facilitators in addition to independent gameplay; 2) Scheduling flexibility and communication with participants was increased to find times that worked with participant schedules; and 3) Participants were offered rewards, in addition to the gift cards, for participating through the end of the study, including letters confirming volunteer service and a \$25 credit towards 4-H state event registration fees.

3.2. Descriptive characteristics of study participants in the trial phase

A total of 76 participants completed the baseline survey out of all randomized participants ($n = 82$), yielding a response rate equal to 92.7%. Out of all participants, 28, 21 and 27 participants were randomized to the *CATCH My Breath* group, the *smokeSCREEN* group, and the CDC group respectively. Out of the participants randomized to either of the two intervention arms ($n = 49$), 83.7% attended at least half of the intervention sessions ($n = 41$). A total of 60 participants completed the post-survey, indicating a follow-up rate equals to 78.9%.

Descriptive statistics for the demographic and smoking variables of the baseline sample are presented in [Table 3](#) by intervention arm and for the total sample. Half of the participants were aged 11–13 years; the mean age was 13.62 (SD: 1.79); slightly more than half were females (54%); around half were in middle school (51.3%), the majority were white (73.7%) and non-Hispanic (86.8%). Among participants, 2.6%, 6.6%, and 1.3% reported ever use of cigarettes, e-cigarettes and other flavored tobacco products respectively. In terms of susceptibility, 19.7% were considered susceptible to e-cigarettes use, and equal percentages (15.8%) were susceptible to cigarettes and other flavored tobacco products. There were no significant differences between the trial groups.

3.3. Effects of *CATCH My Breath* and *smokeSCREEN*

After *CATCH My Breath* sessions, youth increased their scores, indicating improvement, on all outcome measures: susceptibility, knowledge, risk perceptions, and perceived positive outcomes ([Table 4](#)). The only significant increase was in terms of general tobacco related knowledge (post-pre = 16.21–12.92 = 3.3, $p < .01$) and risk perceptions towards other tobacco products (post-pre = 19.29–17.71 = 1.6, $p < .05$).

After *smokeSCREEN* gameplay, adolescents increased their scores on knowledge, risk perception and perceived positive outcomes. Significant changes were only established in their general knowledge (post-pre = 18.77–13.77 = 5.0, $p < .01$), knowledge about e-cigarettes (post-pre = 9.08–6.31 = 2.8, $p < .01$) and risk perception towards e-cigarettes (post-pre = 24.69–21.92 = 2.8, $p < .05$). In the *smokeSCREEN* group, participants' score on susceptibility to use other tobacco products increased, indicating lower susceptibility, while their scores on susceptibility to use cigarettes and e-cigarettes decreased, indicating higher susceptibility. However, none of these changes was significant. Change in scores of risk perception to cigarettes among the control group was significant (post-pre = 19.39–18.26 = 1.1, $p < .01$).

Additional data for single items of risk perceptions, perceived positive outcomes and susceptibility are presented in [Appendix 2](#). To report corresponding results, we used the forest plots to display the mean change of impact of intervention, by group, using mean change and 95% CI. In all groups, the mean change for each item of the outcome measures was mostly in the positive direction, except for few cases, while some of the items didn't change. Figures are displayed in [Appendix 3](#).

For knowledge, there were significant differences in the proportions of correct answers between pre- and post-survey for only 2 out of 16 knowledge questions among the *CATCH My Breath* group, and for only 1 out of 16 among the *smokeSCREEN* group ($p < .05$). The control group had significant improvement in answers to 1 question ([Table 5](#)). We also compared the improved knowledge among the three groups for all knowledge questions. The difference between groups was significant for only 1 question.

4. Discussion

This study aim is to evaluate the feasibility and outcomes of implementing *CATCH My Breath* and *smokeSCREEN* among youth in rural settings in Florida. The adolescents' feedback provided during the focus groups that preceded the randomized controlled trial contributed to insights on feasibility of the programs, informed their implementation and identified opportunities for adaptations in program delivery.

Table 3
Participants' baseline characteristics.

Characteristics	Participants, N (%)				Three-group P-value
	CATCH My Breath (n = 28)	smokeSCREEN (n = 21)	Control (n = 27)	Total (N = 76)	
Demographics					
Age, in years					1.000
11–13	14 (50.0)	10 (47.6)	14 (51.9)	38 (50.0)	
14–17	14 (50.0)	11 (52.4)	13 (48.2)	38 (50.0)	
Mean age (SD)	13.86 ± 1.86	13.57 ± 1.94	13.41 ± 1.62	13.62 ± 1.79	0.674*
Gender					0.833
Male	11 (39.3)	11 (52.4)	12 (44.4)	34 (44.7)	
Female	16 (57.1)	10 (47.6)	15 (55.6)	41 (54)	
Other	1 (3.6)	0 (0.0)	0 (0.0)	1 (1.3)	
School level					0.828
Elementary (Grade 5)	2 (7.1)	0 (0.0)	2 (7.4)	4 (5.3)	
Middle (Grades 6–8)	14 (50.0)	12 (57.1)	13 (48.2)	39 (51.3)	
High (Grades 9–12)	12 (42.9)	9 (42.9)	12 (44.4)	33 (43.4)	
Race					0.593
Asian or Asian American	3 (10.7)	1 (4.8)	1 (3.7)	5 (6.6)	
Black or African American	3 (10.7)	1 (4.8)	0 (0.0)	4 (5.3)	
White	19 (67.9)	15 (71.4)	22 (81.2)	56 (73.7)	
Multi-Racial	3 (10.7)	4 (19.0)	4 (14.8)	11 (14.5)	
Ethnicity					0.361
Hispanic	4 (14.3)	1 (4.8)	5 (18.5)	10 (13.2)	
Non-Hispanic	24 (85.7)	20 (95.2)	22 (81.5)	66 (86.8)	
Tobacco-related Variables					
Cigarettes ever use	1 (3.6)	1 (4.8)	0 (0.0)	2 (2.6)	0.735
E-Cigarettes ever use	2 (7.1)	1 (4.8)	2 (7.4)	5 (6.6)	1.000
Flavored tobacco products ever use	0 (0.0)	0 (0.0)	1 (3.7)	1 (1.3)	0.632
Cigarettes susceptibility	5 (17.9)	2 (9.5)	5 (18.5)	12 (15.8)	0.730
E-cigarettes susceptibility	5 (17.9)	4 (19.1)	6 (22.2)	15 (19.7)	0.936
Flavored tobacco products susceptibility	1 (3.6)	5 (23.8)	6 (22.2)	12 (15.8)	0.069
Cigarette smoking by four closest friends					0.744
None	24 (85.7)	20 (95.2)	21 (77.8)	65 (85.5)	
1–2	0 (0.0)	0 (0.0)	1 (3.7)	1 (1.3)	
3–4	1 (3.6)	0 (0.0)	1 (3.7)	2 (2.6)	
Don't know	3 (10.7)	1 (4.8)	4 (14.8)	8 (10.5)	
E-cigarette use by four closest friends					0.872
None	22 (78.6)	16 (76.2)	18 (66.7)	56 (73.7)	
1–2	4 (14.3)	2 (9.5)	4 (14.8)	10 (13.2)	
3–4	0 (0.0)	1 (4.8)	2 (7.4)	3 (3.95)	

Table 3 (continued)

Characteristics	Participants, N (%)				Three-group P-value
	CATCH My Breath (n = 28)	smokeSCREEN (n = 21)	Control (n = 27)	Total (N = 76)	
Don't know	2 (7.1)	2 (9.5)	3 (11.1)	7 (9.2)	0.891
Flavored tobacco products use by four closest friends					
None	22 (78.6)	19 (90.5)	22 (81.5)	63 (82.9)	
1–2	2 (7.1)	1 (4.8)	2 (7.4)	5 (6.6)	
3–4	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	
Don't know	4 (14.3)	1 (4.8)	3 (11.1)	8 (10.5)	
Friends' reaction if respondent smoked cigarette					0.676
Very Unfriendly	4 (14.3)	7 (33.3)	5 (18.5)	16 (21.1)	
Unfriendly	12 (42.9)	8 (38.1)	13 (48.2)	33 (43.4)	
Friendly	10 (35.7)	6 (28.6)	7 (25.9)	23 (30.3)	
Very Friendly	2 (7.1)	0 (0.0)	2 (7.4)	4 (5.3)	
Friends' reaction if respondent used e-cigarette					0.752
Very Unfriendly	4 (14.3)	7 (33.3)	5 (18.5)	16 (21.1)	
Unfriendly	11 (39.3)	7 (33.3)	11 (40.7)	29 (38.2)	
Friendly	11 (39.3)	7 (33.3)	10 (37)	28 (36.8)	
Very Friendly	2 (7.1)	0 (0.0)	1 (3.7)	3 (4)	
Friends' reaction if respondent used flavored tobacco products					0.826
Very Unfriendly	5 (17.9)	6 (28.6)	7 (25.9)	18 (23.7)	
Unfriendly	11 (39.3)	8 (38.1)	11 (40.7)	30 (39.5)	
Friendly	9 (32.1)	7 (33.3)	7 (25.9)	23 (30.3)	
Very Friendly	3 (10.7)	0 (0.0)	2 (7.4)	5 (6.6)	

**p-value from Kruskal Wallis test; Others from Fisher's Exact test.

Feasibility-related knowledge and experience have also been gained by assessing several attributes, as specified below. These attributes are comparable to the list of parameters suggested by the National Institute for Health Research (NIHR, 2019) for feasibility studies to estimate. The general pattern of findings appears to be promising in terms of the potential positive influence of the two interventions on vaping and tobacco use prevention. Still, our findings call for further evaluation with larger samples of youth participants, given the lack of statistically significant results for many of the outcomes.

4.1. Strengths and implications

After completing the program, youth in both intervention groups had improved knowledge, higher perception of risks associated with tobacco use and lower perception of positive outcomes. Youth who completed CATCH My Breath also had lower susceptibility to using any tobacco product while youth who completed smokeSCREEN had lower susceptibility to using other tobacco products only.

Our findings were consistent with prior studies. In a prior pilot study of CATCH My Breath among middle school students in Texas,

Table 4

Comparison of pre- and post-intervention scores in susceptibility, knowledge, risk perception and perceived positive outcomes.

	CATCH My Breath group				smokeSCREEN group				Control group			
	Pre M (SD)	Post M (SD)	Change M (SD)	P- value	Pre M (SD)	Post M (SD)	Change M (SD)	P- value	Pre M (SD)	Post M (SD)	Change M (SD)	P- value
Susceptibility												
Cigarettes	7.75 (0.53)	7.92 (0.28)	0.17 (0.48)	0.219	8.00 (0.00)	7.85 (0.55)	-0.15 (0.55)	1.000	7.70 (0.70)	7.65 (0.71)	-0.04 (0.47)	1.000
E-cigarettes	7.83 (0.38)	7.88 (0.34)	0.04 (0.36)	1.000	7.85 (0.55)	7.46 (1.45)	-0.38 (0.96)	0.500	7.61 (0.84)	7.61 (0.89)	0.00 (0.60)	1.000
Flavored tobacco products	7.96 (0.20)	8.00 (0.00)	0.04 (0.20)	1.000	7.85 (0.38)	7.92 (0.28)	0.08 (0.49)	1.000	7.65 (0.71)	7.74 (0.62)	0.09 (0.29)	0.500
Knowledge												
E-cigarettes	6.71 (2.93)	7.79 (2.38)	1.08 (2.70)	0.071	6.31 (2.25)	9.08 (1.04)	2.77 (2.39)	0.001	7.00 (3.26)	8.04 (2.65)	1.04 (2.90)	0.126
General	12.92 (5.63)	16.21 (5.06)	3.29 (4.81)	0.001	13.77 (3.17)	18.77 (3.14)	5.00 (4.00)	0.002	14.61 (5.06)	16.65 (4.24)	2.04 (5.44)	0.085
Risk perception												
Cigarettes	18.58 (2.21)	19.13 (1.75)	0.54 (2.73)	0.473	19.08 (1.04)	19.46 (1.56)	0.38 (1.89)	0.445	18.26 (2.56)	19.39 (1.50)	1.13 (1.94)	0.009
E-cigarettes	22.04 (4.64)	23.75 (2.83)	1.71 (4.24)	0.110	21.92 (3.25)	24.69 (1.80)	2.77 (4.23)	0.049	23.00 (3.68)	24.18 (3.10)	1.14 (3.04)	0.052
Flavored tobacco products	17.71 (3.01)	19.29 (1.92)	1.58 (3.22)	0.036	18.23 (2.09)	19.62 (1.71)	1.38 (2.69)	0.106	17.70 (2.69)	18.74 (2.26)	1.04 (2.50)	0.055
Perceived positive outcomes												
Cigarettes	5.92 (0.97)	6.13 (1.03)	0.21 (1.06)	0.343	6.15 (0.69)	6.23 (0.83)	0.08 (1.19)	0.883	5.87 (0.87)	5.91 (1.00)	0.04 (0.88)	0.965
E-cigarettes	5.96 (1.04)	6.00 (1.10)	0.04 (1.04)	0.965	6.00 (0.82)	6.25 (0.87)	0.25 (0.97)	0.438	5.74 (0.92)	5.65 (1.03)	-0.09 (0.90)	0.796
Flavored tobacco products	5.88 (0.90)	6.17 (1.01)	0.29 (0.95)	0.210	6.15 (0.80)	6.31 (0.85)	0.15 (0.99)	0.531	5.78 (0.90)	5.70 (1.02)	-0.09 (0.67)	0.766

intervention schools had significantly greater improvements in e-cigarette knowledge and perceived positive outcomes compared to control schools (Kelder et al., 2020). In that study, *CATCH My Breath* was collaboratively facilitated by teachers and student-peer leaders in classrooms. A pilot study that evaluated *smokeSCREEN* among youth recruited from community-based afterschool programs in New Haven, Connecticut and Los Angeles, California showed significant improvement in their beliefs and knowledge about tobacco product use, and risk perception (Pentz et al., 2019). Similar findings in terms of change in adolescent beliefs and knowledge about e-cigarettes and vaping associated with *smokeSCREEN* were drawn from a larger study of participants recruited from schools and afterschool programs in Rhode Island, Massachusetts, California, and Arizona (Hieftje et al., 2021).

To our knowledge, this is the first study to implement and evaluate these two vaping prevention interventions among a population of youth in rural settings. One strength of this study is the use of a randomized controlled trial to compare more than one prevention program with a control condition.

In terms of feasibility, figures provided above indicate promising rates of response, follow-up and attendance. Also, participants showed willingness to be randomized, as part of the assent process. Besides, the fact that no missing data were observed among the subgroup used for analysis envisioned that the questions/measures were acceptable. On the other hand, this study exposed the need to assess additional measures, in particular for the *smokeSCREEN* arm. Other feasibility-related insights gained throughout this study include the need to explore i) additional more successful methods of recruiting participants, and ii) ways to minimize the overall time required to implement the various components of the intervention, knowing that the average length of time between baseline and post-intervention survey was 17 weeks.

Another major contribution by this study related to feasibility is with respect to the setting and context. The study was conducted in a setting that is different from the original studies which evaluated the two intervention programs. We delivered the programs entirely online, while the other studies were implemented in-person either in classrooms, during school or afterschool programs. The online implementation has

been pragmatic and allowed for more flexibility in scheduling and delivery, and averted limitations associated with in-school classroom-based prevention programs, but also contributed to subsequent challenges as presented below. Another notable difference is in the targeted population; we implemented the programs among youth in rural settings, who were exclusively recruited from 4-H clubs, whereas prior programs focused on youth from non-rural settings. These two differences might have also contributed to the lack of statistically significant results. Accordingly, this pilot study should be interpreted in light of these factors. The COVID-19 pandemic necessitated that the interaction with youth be strictly online, and results demonstrate that the online delivery was feasible and resulted in generally similar outcomes to more traditional dissemination of these programs. Another added value of this study is its timely relevance to the ongoing efforts to evaluate the two programs and other appropriate interventions to address rural health disparities.

4.2. Challenges and limitations

This study has potential limitations that should be acknowledged. First, the relatively small sample size does not allow for meaningful effect size estimates and the findings should be interpreted with caution (Leon, Davis, & Kraemer, 2011). Second, the study sample was primarily recruited from youth actively participating in youth-focused programs within 4-H clubs. Accordingly, findings from this study may not be comparable to the wider rural population. The absence of any means to assess the long-term effect of the interventions on the participants' knowledge and behavior is another limitation. We were also limited by the inability to use the findings of the focus groups to change the content of the programs, and changes were only applied to program delivery components. In addition, most of the participants who were lost to follow up were in the *smokeSCREEN* group. Although the recorded reasons were non-specific to the intervention (e.g., lack of time to engage with the program, change of contact phone number, no reply to e-mails), and nothing could be directly attributed to the game, it is plausible that participants in this group could not commit to the

Table 5
Impact of the interventions on knowledge related to tobacco use.

	CATCH My Breath group					smokeSCREEN group					Control group					Three-group P-value**
	PreN (%)	PostN (%)	Improved [†] N (%)	Dis-improved [‡] N (%)	Pre vs Post p-value*	PreN (%)	PostN (%)	Improved [†] N (%)	Dis-improved [‡] N (%)	Pre vs Post p-value*	PreN (%)	PostN (%)	Improved [†] N (%)	Dis-improved [‡] N (%)	Pre vs Post p-value*	
1. Smoking causes damage to almost every organ in your body.	15 (62.50)	21 (87.50)	6 (25.00)	0	0.031	10 (76.92)	12 (92.31)	3 (23.08)	1 (7.69)	0.625	14 (60.85)	19 (82.61)	5 (21.74)	0	0.063	1.000
2. Smokers have a greater chance of having higher blood pressure, heart attacks, and strokes.	21 (87.50)	24 (100)	3 (12.50)	0	0.250	13 (100)	13 (100)	0	0	–	22 (95.65)	22 (95.65)	1 (4.35)	1 (4.35)	1.000	0.526
3. People need to smoke more than five cigarettes a day to have early signs of heart disease.	11 (45.83)	11 (45.83)	5 (20.83)	5 (20.83)	1.000	5 (38.46)	8 (61.54)	5 (38.46)	2 (15.38)	0.453	12 (52.17)	11 (47.83)	3 (13.04)	4 (17.39)	1.000	0.220
4. Smoking and breathing in other people's smoke can increase your risk of getting heart disease and cancer.	16 (66.67)	20 (83.33)	5 (20.83)	1 (4.17)	0.219	8 (61.54)	13 (100)	5 (38.46)	0	0.063	19 (82.61)	16 (69.57)	3 (13.04)	6 (26.09)	0.508	0.220
5. You are more likely to get coughs, colds, and pneumonia if you smoke	17 (70.83)	21 (87.50)	5 (20.83)	1 (4.17)	0.219	8 (61.54)	10 (76.92)	3 (23.08)	1 (7.69)	0.625	16 (69.57)	21 (91.30)	7 (30.43)	2 (8.70)	0.180	0.746
6. Addiction to tobacco products can happen quickly in teens because their brains are more vulnerable to nicotine.	12 (50.00)	20 (83.33)	9 (37.50)	1 (4.17)	0.022	9 (69.23)	13 (100)	4 (30.77)	0	0.125	16 (69.57)	21 (91.30)	5 (21.74)	0	0.063	0.548
7. Candy and fruit flavors mask the bad taste of tobacco, making it easier for teens to start using.	19 (79.17)	22 (91.67)	4 (16.67)	1 (4.17)	0.375	8 (61.54)	12 (92.31)	4 (30.77)	0	0.125	21 (91.30)	20 (86.96)	2 (8.70)	3 (13.04)	1.000	0.238
8. Most flavored tobacco products, such as hookah or cigarillos, are less dangerous to your health than cigarettes.	10 (41.67)	15 (62.50)	7 (29.17)	2 (8.33)	0.180	8 (61.54)	12 (92.31)	5 (38.46)	1 (7.69)	0.219	11 (47.83)	11 (47.83)	5 (21.74)	5 (21.74)	1.000	0.618
9. Tobacco use in the media gives teens a realistic idea that a lot of people use tobacco products and usually show the consequences of smoking.	7 (29.17)	7 (29.17)	4 (16.67)	4 (16.67)	1.000	2 (15.38)	8 (61.54)	7 (53.85)	1 (7.69)	0.070	5 (21.74)	8 (34.78)	4 (17.39)	1 (4.35)	0.375	0.042
10. Water vapor from e-cigarettes, such as JUULs, don't contain any toxic chemicals in them known to cause certain cancers and diseases.	12 (50.00)	13 (54.17)	6 (25.00)	5 (20.83)	1.000	6 (46.15)	9 (69.23)	5 (38.46)	2 (15.38)	0.453	16 (69.57)	18 (78.26)	3 (13.04)	1 (4.35)	0.625	0.205
11. E-cigarettes, like JUULs, rarely have nicotine in them, even if the packaging says it does.	14 (58.33)	19 (79.17)	6 (25.00)	1 (4.17)	0.125	9 (69.23)	13 (100)	4 (30.77)	0	0.125	16 (69.57)	17 (73.91)	4 (17.39)	3 (13.04)	1.000	0.632
12. Companies that sell tobacco products, including e-	9 (37.50)	8 (33.33)	3 (12.50)	4 (16.67)	1.000	2 (15.38)	8 (61.54)	6 (46.15)	0	0.031	10 (43.48)	11 (47.83)	5 (21.74)	4 (17.39)	1.000	0.089

(continued on next page)

Table 5 (continued)

	CATCH My Breath group					smokeSCREEN group					Control group					Three-group p-value**
	PreN (%)	PostN (%)	Improved [†] N (%)	Dis-improved [‡] N (%)	Pre vs Post p-value*	PreN (%)	PostN (%)	Improved [†] N (%)	Dis-improved [‡] N (%)	Pre vs Post p-value*	PreN (%)	PostN (%)	Improved [†] N (%)	Dis-improved [‡] N (%)	Pre vs Post p-value*	
cigarettes, target adults using candy flavors.																
13. Teens that use e-cigarettes, like JUULs, are much more likely to use other tobacco products, like cigarettes.	21 (87.50)	22 (91.67)	3 (12.50)	2 (8.33)	1.000	8 (61.54)	11 (84.62)	4 (30.77)	1 (7.69)	0.375	16 (69.57)	21 (91.30)	5 (21.74)	0	0.063	0.385
14. The nicotine found in e-cigarettes, like JUULs, won't damage a teenager's brain.	18 (75.00)	22 (91.67)	6 (25.00)	2 (8.33)	0.289	12 (92.31)	13 (100)	1 (7.69)	0	1.000	17 (73.91)	21 (91.30)	4 (17.39)	0	0.125	0.480
15. Many health risks and appearance changes from tobacco product use can reverse soon after quitting.	12 (50.00)	10 (41.67)	3 (12.50)	5 (20.83)	0.727	8 (61.54)	8 (61.54)	3 (23.08)	3 (23.08)	1.000	10 (43.48)	12 (52.17)	5 (21.74)	3 (13.04)	0.727	0.692
16. Withdrawal symptoms from nicotine are at their worst the first few days to a week after stopping.	6 (25.00)	10 (41.67)	5 (20.83)	1 (4.17)	0.219	2 (15.38)	8 (61.54)	7 (53.85)	1 (7.69)	0.070	11 (47.83)	18 (78.26)	7 (30.43)	0	0.016	0.138

Response items: "false", "true", "not sure".

† Improved knowledge: change from incorrect answer/not sure at pre-test to correct answer at post-test.

‡ Disimproved knowledge: change from correct answer at pre-test to incorrect answer/not sure at post-test.

*Pre vs Post p-values from Exact McNemar's test.

**Three-group p-values from Fisher's Exact test.

required gameplay component, in addition to their participation in the online group sessions, which is not the case for the *CATCH My Breath*. Not having data on outcomes from participants who were lost to follow-up might have biased the results and its interpretation, potentially in a direction that showed improved results. Another limitation that is specific for the *smokeSCREEN* group is the lack of uniformity regarding duration of game play, time of day, or number of times played among participants, which limits the utility of the findings.

Additionally, the transition to virtual program delivery due to the COVID-19 pandemic was coupled with unique challenges, which other researchers have encountered as well (Boland et al.; Kienle et al., 2021; Mitchell et al., 2020; Ozernov-Palchik et al., 2022). Logistically, it was highly demanding for the research team to schedule the group sessions in a way that accommodated participant schedules, which resulted in hosting more groups and organizing participating youth into groups of limited number. This planning process may have been simplified if interventions were implemented in a place where all participants could be physically available at the same time, as in a school setting. Facilitating the group sessions via video conference may have limited the interaction of participants in the planned activities and discussions. Other associated challenges include concerns with technical difficulties resulting from video-conference delivery as well as privacy concerns. In addition, recruitment of participants was challenging despite using alternate recruitment methods (e.g., promoting the study via social media). Pandemic-related delays were also evident in other research activities (e.g., mailing the Salivary kits), which caused a subsequent delay in the overall project timeline.

4.3. Recommendations

Recommendations for future work include conducting studies with a longer follow-up period and enrolling larger and more representative samples to expand the generalizability of our findings to other youth groups and to establish a stronger evidence base. Involving participants who are not already part of other youth programs is one possible direction. Future research should also consider alternative and innovative recruitment strategies that could overcome the challenges faced by our team. For the *smokeSCREEN* group, we suggest recording the time spent playing the game, and examining if play duration has differential impact on outcomes. Assessing participants' experiences and satisfaction with the program post implementation is also recommended to identify strengths of the program, and areas for improvement. Also, we recommend following up with participants who did not complete the program, to assess their feedback and reasons behind dropout, which could provide additional insight into feasibility of intervention delivery. Additionally, we suggest using the findings from the focus groups to further develop the content of the programs, by expanding on stress and mental health issues that were highlighted by the youth participants, which might eventually contribute to more improvements in outcomes.

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Dima S. Bteddini: Writing – review & editing. **Jennifer H. LeLaurin:** Methodology, Writing – review & editing. **Xiaofei Chi:** Methodology, Formal analysis, Writing – review & editing. **Jaelyn M. Hall:** Funding acquisition, Writing – review & editing. **Ryan P. Theis:** Methodology, Formal analysis, Writing – review & editing. **Matthew J. Gurka:** Writing – review & editing. **Ji-Hyun Lee:** Methodology, Writing – review & editing. **Erin M. Mobley:** Writing – review & editing. **George E. Khalil:** Writing – review & editing. **Caroline J. Polansky:** Writing – review & editing. **Allie M. Kellner:** Formal analysis, Writing – review &

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The data that has been used is confidential.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.addbeh.2023.107637>.

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