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## A videogame intervention for tobacco product use prevention in adolescents

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## HIGHLIGHTS

- Adolescents showed high engagement in the videogame and the game characters.
- Beliefs mediated the relationship between knowledge/intentions to use e-cigarettes.
- The videogame changed knowledge of e-cigarettes and other tobacco products.
- Age and gender affected the videogame's impact on tobacco product-related outcomes.

## ARTICLE INFO

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## ABSTRACT

**Purpose:** This pilot study evaluated the short-term effects of an interactive videogame on changing adolescent knowledge, beliefs and risk perceptions, and intentions to use e-cigarettes, cigarettes, and other tobacco products. A secondary aim was to evaluate players' game experience.

**Methods:** Participants (N = 80 11–14 year olds) were recruited from 7 community-based afterschool programs in New Haven, Connecticut and Los Angeles, California. The design was a single group pre-post design with replication. A pre-test survey was administered that included demographic variables and knowledge, risk perceptions, beliefs, and intentions to use e-cigarettes, cigarettes, and other tobacco products. An interactive videogame focusing on risky tobacco use situations was subsequently played in four 60-min sessions over a four-week period, followed by a post-test survey. Analyses included paired *t*-tests of pre-post videogame change, regression analyses, and path analyses testing mediational effects of beliefs and risk perceptions on the relationship between knowledge and intentions.

**Results:** The videogame changed knowledge of e-cigarettes and other tobacco products ( $p$ 's < 0.001), risk perceptions of cigarettes and e-cigarettes ( $p$  < .01 and  $p$  < .001, respectively), and beliefs about e-cigarettes and other tobacco products ( $p$ 's < 0.05), but not intentions. Older adolescents reported greater e-cigarette knowledge and risk perceptions ( $p$ 's < 0.05), and females reported greater risk perception of cigarettes ( $p$  < .05). Beliefs mediated the relationship between knowledge and intentions to use e-cigarettes (indirect effect  $p$  < .05).

**Conclusion:** Results suggest that brief exposure (4 h over 4 weeks) to a videogame focused on changing knowledge and attitudes towards tobacco products may have a promising effect on preventing risk for early adolescent tobacco product use, particularly for e-cigarettes.

## 1. Introduction

In 2016, 3.9 million American high school and middle school students used one of the following tobacco products in the past 30 days:

cigarettes, cigars, smokeless tobacco, e-cigarettes, hookahs, pipe tobacco, and bidis (Jamal et al., 2017). Smoking uptake in adolescence is particularly concerning because the majority of adult daily smokers began using cigarettes before the age of 18 (US Department of Health

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and Human Services, 2014). While cigarette use in adolescents has been decreasing, adolescent use of electronic cigarettes (e-cigarettes) has been increasing in the past several years (US Department of Health and Human Services, 2016), and is now the most commonly initiated tobacco product in this age group (Jamal et al., 2017). Adolescents cite flavors as the top reason for using e-cigarettes (Bold, Kong, Cavallo, Camenga, & Krishnan-Sarin, 2016), and perceive e-cigarettes and other vaping products to be safer than conventional cigarettes (Feirman, Lock, Cohen, Holtgrave, & Li, 2016; Harrell et al., 2017; Kowitz et al., 2017; Pokhrel, Fagan, Kehl, & Herzog, 2015; Villanti et al., 2017). However, adolescent e-cigarette use has been linked to subsequent cigarette use (Bold, Kong, Cavallo, Camenga, & Krishnan-Sarin, 2017; Soneji et al., 2017), and emerging data suggest that e-cigarettes and other vaping products are themselves harmful (El-Zaatari, Chami, & Zaatari, 2015; McConnell et al., 2017; Schweitzer, Wills, Tam, Pagano, & Choi, 2017; Tierney, Karpinski, Brown, Luo, & Pankow, 2016). Thus, interventions for preventing adolescent tobacco product use should address knowledge, beliefs, and risk perceptions, including information about product safety.

Videogames are a promising way to promote tobacco use prevention in adolescents, as they integrate entertainment with education and/or behavior change (Baranowski et al., 2016; Charsky, 2010). Videogames may have several advantages over traditional in-person interventions (Truth Initiative, 2015), including the flexibility to incorporate strategies that encourage health behavior change, such as role-play and opportunities for repeated skill-building, and engagement (Fleming et al., 2017). These advantages have translated to a range of videogames that promote key outcomes as precursors to behavior change, including knowledge, risk perceptions, beliefs, and intentions (Hieftje, Edelman, Camenga, & Fiellin, 2013; Primack et al., 2012; Stapinski et al., 2018). Thus, a brief videogame intervention to change behavioral precursors may help to prevent future tobacco product use in adolescents.

The major aim of this study was to evaluate the short-term impact of a videogame on adolescent change in knowledge, risk perceptions, beliefs (including about flavors), and intentions related to the use tobacco products. A secondary aim was to evaluate self-reported game experiences and satisfaction to ensure player engagement.

## 2. Methods

### 2.1. Study design

This pilot study was a single-group design with cross-replication of a videogame intervention played by adolescents in 7 afterschool settings in two regions (New Haven, Connecticut and Los Angeles, California). The measurement design was a survey administered to each participant before and after playing the game. The average length of time between pre and post-test for each afterschool setting was 4 weeks. All procedures were approved by the Institutional Review Boards at Yale University and the University of Southern California.

### 2.2. Participants

English-speaking adolescents aged 11–14 years were recruited from community afterschool programs. Eligibility included regular program participation and familiarity with videogames. Participants obtained parental permission and were assented by the local research team. Participants were provided an unidentifiable ID number for the study,  $N = 80$  (100% response rate).

### 2.3. Videogame intervention

*PlayForward: smokeSCREEN (smokeSCREEN)* is a tablet-based videogame offering a potential 4 h of gameplay. This intervention is an adaptation of a videogame, *PlayForward: Elm City Stories*, an evidence-based and theory-based videogame that improved adolescents' sexual

health knowledge and increased their positive attitudes towards their sexual health (Fiellin et al., 2017). In *smokeSCREEN*, players help their virtual character navigate school by choosing how their character makes decisions that may put them in situations where tobacco product use is occurring, such as whether or not to throw a party while the character's parents are not home, encountering a character who says e-cigarettes are safe, or should be tried because of a great flavor. Through a set of integrated mini-games, players work on specific skills that could transfer to the real world to help them avoid risky behaviors, such as refusing offers by peers to use e-cigarettes. Focus groups were conducted with adolescents to generate the situations and skills relevant to tobacco product use, which were then used for the adaptation (Camenga et al., 2018). Approximately half of the game situations involve combustible and other tobacco use, 25% e-cigarettes, and 25% flavored products. For the present pilot study, with a short time frame, participants played *smokeSCREEN* on an iPad in 60-min sessions delivered once weekly in their afterschool setting for four weeks.

### 2.4. Measures

Before initial gameplay and after gameplay was completed, participants completed a survey with questions adapted from national surveys (Global Youth Tobacco Survey Collaborative Group, 2002; National Youth Tobacco Survey (NYTS), 2018) on: knowledge, risk perceptions, personal beliefs about use and intentions about cigarettes, e-cigarettes, and other tobacco use. Questions had 3–5 response choices (e.g., risk perceptions, “How much do you think people harm themselves when they use e-cigarettes” 1 = no harm, 4 = a lot) personal beliefs (e.g., “I think I might enjoy using an e-cigarette,” 1 = strongly agree, 4 = strongly disagree). Other questions were used as covariates in analyses: having received education in school (in the last 12 months) and at home (ever) about tobacco products (5 items total, each scored yes or no), frequency of exposure to product marketing through advertising (8 items total, 5 response choices scored never to always), and lifetime use of cigarettes, e-cigarettes, and other tobacco products (each scored yes or no). The pre-test survey also included 5 questions about demographic characteristics (age, gender, race, ethnicity, and grade). The post-test survey also included 10 items on game experience and satisfaction (e.g., “I felt connected to my character in the game,” 4 response choices, ranging from strongly disagree to strongly agree).

### 2.5. Procedures

Yale and USC staff co-trained and followed the same protocol for recruitment, measurement, and game instruction as used in a previous randomized trial (Fiellin et al., 2016). The pilot study was implemented across all 7 settings within the same three-month period.

### 2.6. Statistical analysis

Descriptive analyses were conducted to summarize demographic characteristics across the total sample as well as compare the relative proportion of each characteristic by region (New Haven, Los Angeles) and location (afterschool program), using a two-sample test of proportions. Pre-test scores for each of the outcomes were then generated two ways. Items theorized to represent a specific outcome (e.g., risk perceptions) were factor analyzed by tobacco product. Items within a theorized outcome were summed and averaged by product. The two methods were then compared for consistency between region and from pre- to post-test. The average sum score method yielded the highest reliability across both regions and was used for all subsequent analyses. Average sum scores for knowledge, risk perceptions, personal beliefs, and intentions to use each product (cigarettes, e-cigarettes, other tobacco products) were treated as the primary outcomes of gameplay.

To analyze changes in outcomes from pre- to post-test, paired-samples *t*-tests were conducted. Regression analyses of game effects on

change scores and pre-test adjusted post-test scores were conducted, with and without adjustment for demographic variables and with and without multi-level adjustment for region and afterschool program site. Results did not differ by pre-test lifetime product use, ethnicity, location, or type of afterschool program, entered one at time as covariates, and thus were not entered in subsequent regression analyses. Effects of whether risk perceptions or personal beliefs mediated the effect between knowledge and intentions on post-test intentions were also conducted, adjusting for pre-test values and other covariates. Significance was set at  $p < .05$  based on two-tailed tests. Bonferroni correlations were used to reduce potential Type I error. Forward selection (entry significance level = 0.05) was used in regression analyses to retain only those covariates that had significant effects on changes in averaged scores. Only sex and age were significantly related to outcomes in regression analyses and thus were retained as covariates in final analyses. The 10 variables representing game experience were factor analyzed, yielding one factor with 7 items loading  $> 0.45$  (CFA = 0.955, RMSEA = 0.093), scores were then summed to create an overall satisfaction score. Proportions of game players who reported high satisfaction (either agree or highly agree) were also tabulated for each of the 7 items. All analyses were done using SAS V9.2 (SAS Institute, Cary, NC) and Mplus 7.4.

### 3. Results

#### 3.1. Descriptive characteristics

Sample characteristics by region and for the total sample, are shown in Table 1. There were no differences by region, except for race and ethnicity, where there were more African-American and Hispanic adolescents in the New Haven region, and more Asians in the Los Angeles region. Fewer than half of the adolescents reported having received tobacco product education at school or at home, and most adolescents reported that they had never or rarely been exposed to tobacco product marketing (not shown in the table).

#### 3.2. Short-term effect of videogame intervention on outcomes

After gameplay, adolescents increased their scores on measures of knowledge, risk perceptions, and personal health beliefs (see Table 2). *t*-Tests on change scores showed that players' knowledge about both e-cigarettes and other tobacco products increased ( $t = 4.70, p < .001, t = 4.27, p < .001$  respectively), but not about cigarettes. Risk perceptions related to e-cigarettes ( $t = 3.49, p < .001$ ) and cigarettes

**Table 1**  
Sample characteristics.

Characteristics	Yale (n = 41)		USC (n = 39)		Total Sample (n = 80)	
	N	(%)	N	(%)	N	(%)
Females	23	(56.1)	26	(66.7)	49	(61.13)
White	6	(14.6)	10	(25.6)	16	(20.0)
African American	26	(63.4)	3	(7.7)**	29	(36.3)
Asian	0	(0.0)	12	(30.8)**	12	(15.0)
Other	2	(4.9)	2	(5.1)	4	(5.0)
Missing Ethnicity	7	(17.1)	12	(30.8)	19	(23.7)
Hispanic	29	(72.5)	18	(28.9)**	47	(51.3)
Lifetime use						
E-cigarettes	2	(4.9)	1	(2.6)	3	(3.8)
Cigarettes	1	(2.4)	0	(0.0)	1	(1.3)
Other tobacco	0	(0.0)	1	(2.6)	1	(1.3)

Note that Hispanic ethnicity difference between regions is based on participants who reported ethnicity.

\*  $p < .05$ .

\*\*  $p < .01$ .

\*\*\*  $p < .001$ .

( $t = 2.74, p < .01$ ) increased after adolescents played the game. After gameplay, players increased their negative health beliefs pertaining to e-cigarettes ( $t = 2.56, p < .05$ ) and other tobacco products ( $t = 2.74, p < .05$ ), while health belief changes pertaining to cigarettes approximated significance ( $t = 1.96, p = .054$ ).

When entered as a predictor in a covariate-adjusted linear regression model, female gender was significantly associated with greater observed increases in cigarette use risk perception relative to male gender ( $p < .05$ ), as assessed by pre-post change scores. Similarly, older age was associated with greater increases in e-cigarette use risk perception ( $p = .033$ ). Subsequent regression analyses showed that age was positively associated with greater knowledge ( $p < .02$ ) and personal beliefs ( $p < .05$ ) about e-cigarettes, controlling for pre-test values and sex. Mediation path analyses showed a good fit to the model of personal beliefs mediating the effect of knowledge on e-cigarette use intentions at post-test (CFI  $> 0.950$ , RMSEA  $< 0.05$ , effect of knowledge on beliefs 0.34,  $p < .01$ , effect of beliefs on intentions  $-0.43, p < .001$ , effect of knowledge on intentions NS, indirect effect =  $-0.15, p < .05$ ). There were no mediational effects of either beliefs or risk perceptions on intentions to use either cigarettes or other tobacco products.

#### 3.3. Game experience and satisfaction

The mean average satisfaction score was high ( $M(SD) = 3.20 (0.56)$  out of a possible 4). The proportion of players who rated high satisfaction on individual items ranged from  $> 60 - > 90\%$ . Of these, 92.4% reported taking personal responsibility for game choices, and 87.3% reported that they were likely to make decisions in life based on the game.

### 4. Discussion

#### 4.1. Strengths

The data collected from this pilot study suggest that short-term videogame playing may have a positive effect on changing risk factors that have been associated with adolescent tobacco product use, including personal beliefs, knowledge, and intentions. Effects were found primarily for e-cigarette outcomes, secondarily, on tobacco products other than cigarettes, and none on cigarette outcomes. One potential explanation for lack of effects related to cigarette use is that conventional tobacco products have been available longer than alternative products and have been addressed in prevention programs, suggesting that adolescents may have already achieved a “ceiling effect” in knowledge, risk perceptions, and beliefs about cigarettes prior to game-playing. In summary, the findings of the present study suggest that brief videogames may be a useful tool for changing risk factors that can promote prevention of future e-cigarette use among adolescents.

#### 4.2. Limitations

Several study limitations should be noted. First, this pilot study was not designed to have control comparison groups. However, the study replication in two diverse locations, using the same protocol, and yielding the same findings, suggests that results from this study are valid, reliable, and reproducible. Second, while sufficient for a pilot study, the small sample size of 80 and short timeframe for pre-post game assessment (4 weeks) may have yielded different effects on longitudinal outcomes if the sample size was larger and the timeframe was longer. Third, the lifetime tobacco product use level of participants was low relative to prevalence rates reported in other recent studies on early adolescent e-cigarette and cigarette use (Pentz et al., 2015). We used the same types of program sites that were used in a previous randomized trial for a risk reduction videogame intervention (Fiellin et al., 2017). However, it is possible that the low prevalence of tobacco

**Table 2**  
Comparison of pre and post averaged change scores by product in each domain (N = 80).

Score	Product (N items)	Pre test	Post test	Changes	T statistics (p-values)
		M (SD)	M (SD)	M (SD)	
Knowledge	Cigarette (Baranowski et al., 2016)	2.41 (0.63)	2.32 (0.73)	−0.09 (0.91)	−0.87 (0.39)
	e-Cigarette (N = 5)	2.26 (0.38)	2.50 (0.42)	0.23 (0.46)	4.59 (< 0.0001)*
	other tobacco product (N = 14)	2.51 (0.26)	2.63 (0.28)	0.12 (0.25)	4.27 (< 0.0001)*
Intentions	Cigarette (N = 2)	1.12 (0.32)	1.17 (0.40)	0.05 (0.31)	1.42 (0.16)
	e-Cigarette (N = 2)	1.21 (0.46)	1.23 (0.49)	0.02 (0.37)	0.46 (0.65)
	other tobacco product (N = 2)	1.08 (0.23)	1.11 (0.32)	0.03 (0.21)	1.07 (0.29)
Risk perception	Cigarette (N = 14)	3.47 (0.39)	3.62 (0.40)	0.15 (0.49)	2.74 (0.01)*
	e-Cigarette (N = 14)	3.25 (0.36)	3.40 (0.40)	0.15 (0.41)	3.41 (0.001)*
Beliefs	Cigarette (N = 3)	2.97 (0.51)	3.05 (0.41)	0.08 (0.38)	1.96 (0.05)
	e-Cigarette (N = 12)	2.57 (0.33)	2.66 (0.32)	0.09 (0.32)	2.56 (0.01)*
	Other tobacco product (N = 11)	2.76 (0.25)	2.83(0.27)	0.06 (0.26)	2.25 (0.03)*

Note: Risk perception questions for tobacco products were not included in the survey.

\* Significant at  $\alpha = 0.05$ .

use in our study is related to the characteristics of adolescents who regularly participate in afterschool programs (Boys and Girls Clubs of America, 2017; Eisenberg & Hutton, 2015). Consequently, follow-up studies in larger, more nationally-representative samples are warranted to determine the generalizability of the present findings to other groups.

#### 4.3. Future directions

Future research should evaluate the potential of videogames for multiple tobacco product use prevention with larger and different samples, e.g., youth from schools who exhibit higher rates of use at baseline, and in different settings such as recreational clubs or homes. Since videogames carry high appeal for adolescents and can be administered individually in flexible settings and at flexible times, the potential for large-scale dissemination may exceed the current limitations faced by current in-school classroom-based prevention programs.

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#### Contributors

Dr. Pentz contributed to study design conceptualization and data analysis and writing of the manuscript.

Dr. Fiellin contributed to study design conceptualization and writing of the manuscript.

Dr. Hieftje contributed to study design conceptualization, game development and writing of the manuscript.

Ms. Arora contributed through assisting in writing the manuscript.

Ms. Brito and Ms. Pendergrass contributed to participant recruitment, data collection, coding, and descriptive analyses.

Dr. Tindle collaborated with Drs. Fiellin and Hieftje in the initial design of the game, including providing the initial focus on electronic cigarettes in the game content and selection of survey questions related

to electronic cigarettes and other tobacco products.

Dr. Krishnan-Sarin contributed to study design conceptualization and writing of the manuscript.

Ms. Liu conducted the statistical analysis for this paper.

All authors have reviewed and approved the final manuscript.

#### Conflict of interest

All authors declare that they have no conflict of interest.

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