



More support needed: Evaluating the impact of school e-cigarette prevention and cessation programs on e-cigarette initiation among a sample of Canadian secondary school students

Gillian C. Williams^{a,b,*}, Adam G. Cole^c, Margaret de Groh^b, Ying Jiang^b, Scott T. Leatherdale^a

^a School of Public Health Sciences, University of Waterloo, Waterloo, ON, Canada

^b Applied Research Division, Public Health Agency of Canada, Ottawa, ON, Canada

^c Faculty of Health Sciences, Ontario Tech University, Oshawa, ON, Canada

ARTICLE INFO

Keywords:

Vaping
Adolescent
School
Quasi-experimental study

ABSTRACT

Given the recent increase in e-cigarette use among adolescents, there is a need to further explore how school programs are associated with e-cigarette initiation. The objective of this quasi-experimental study was to evaluate the impact of multiple school-based e-cigarette prevention and cessation programs on e-cigarette initiation among Canadian adolescents. This study used data from Year 6 (2017/18) and Year 7 (2018/19) of the COM-PASS study in British Columbia, Alberta, Ontario, and Quebec, Canada. Students in grades 9 to 11 who had never tried e-cigarettes at baseline were included ($n = 13,269$). Schools ($n = 88$) reported whether they added programming that addressed e-cigarette or tobacco prevention or cessation. Generalized estimating equations were used to identify how added programs were associated with e-cigarette initiation at follow-up. At one-year follow-up (2018/19), 23% of schools added programs. Our evaluation results suggest that none of the activities taken by schools to prevent or reduce vaping among students significantly prevented vaping onset. In fact, female students at schools that reported adding a theme week had higher odds of e-cigarette initiation (OR 1.68 [95% CI 1.31–2.16]) and male students at schools that reported a cessation program had higher odds of e-cigarette initiation (OR 1.20 [95% CI 1.01–1.44]). These results suggest that schools may not know how to address e-cigarette use and that there can be risks to students if programs are not carefully implemented. Results point to the need for additional support to ensure that schools are taking evidence-based approaches that support all students.

1. Introduction

E-cigarette use, or vaping, has increased rapidly among youth in Canada and the US in recent years (Cole et al., 2020; Cullen et al., 2018; Government of Canada, 2019; Hammond et al., 2019). In the US, 20% of high school students reported past 30-day e-cigarette use in 2020 (Wang et al., 2021). In Canada, e-cigarette use among adolescents aged 15–19 years doubled from 10% in 2016 to 20% in 2018 (Government of Canada, 2019). Schools are an ideal environment to implement interventions to target this behaviour as they comprise a large population of youth irrespective of socioeconomic background (Benningfield et al., 2015), students are in the school environment for the majority of the day, and schools have previously been shown to influence youth behaviours (Cole et al., 2019; Corsi and Lippert, 2016; Denny et al., 2011;

Lippert et al., 2019; Thomas et al., 2015).

There is evidence that policies, programs, and other school characteristics influence adolescents' cigarette smoking behaviours (Cole et al., 2017; Lovato et al., 2010; Murnaghan et al., 2008; Thomas et al., 2015), but similar evidence for the influence of the school environment on adolescents' e-cigarette use is lacking. The limited available evidence indicates that school environments play a role in adolescent e-cigarette use (Cole et al., 2019; Corsi and Lippert, 2016; Lippert et al., 2019). For example, seeing e-cigarette use on school property is associated with greater e-cigarette use and susceptibility to future use (Mantey et al., 2021). Evidence from published and grey literature indicates that schools are implementing e-cigarette interventions but there is currently a lack of evaluation data for school-based programs (Liu et al., 2020; Milicic et al., 2018; O'Connor et al., 2019). Furthermore, since evidence

* Corresponding author at: School of Public Health and Health Systems, University of Waterloo, 200 University Ave W, Waterloo, ON N2L 3G1, Canada.

E-mail address: gillian.williams@uwaterloo.ca (G.C. Williams).

<https://doi.org/10.1016/j.ypmed.2021.106924>

Received 25 June 2021; Received in revised form 1 December 2021; Accepted 13 December 2021

Available online 18 December 2021

0091-7435/© 2021 The Authors.

Published by Elsevier Inc.

This is an open access article under the CC BY-NC-ND license

(<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

suggests that boys are more likely to use e-cigarettes than girls and reasons for e-cigarette use and products of choice vary by gender (Cole et al., 2020; Kong et al., 2017; Yimsaard et al., 2021), studies should investigate the potential differential impact of school-based programs by gender.

Evidence from a recent review indicates that the content and format of e-cigarette prevention programs in the United States varies greatly (Liu et al., 2020). Program formats range from a one-time 20 min video to multi-session school-based interactive lessons based on theory (Liu et al., 2020). A common format is the provision of curriculum and posters for teachers to implement in their schools (Liu et al., 2020; O'Connor et al., 2019). Programs typically address topics such as health effects, flavours, and marketing and include refusal skills (Liu et al., 2020). Some programming focuses exclusively on e-cigarettes (Huang et al., 2017; Kelder et al., 2020; Vallone et al., 2017) while others include a wider range of tobacco products (Gaiha et al., 2021; Hieftje et al., 2021).

Evaluations of e-cigarette prevention programs to-date have typically focused on changes in knowledge (Gaiha et al., 2021; Hieftje et al., 2021). To our knowledge, only one program (CATCH My Breath) has evaluated differences in e-cigarette behaviours pre- and post-intervention and found that the prevalence of ever e-cigarette use was significantly lower in the intervention schools relative to control schools (Kelder et al., 2020). There is a need for evidence on whether other types of school programs influence e-cigarette behaviours, including initiation.

E-cigarette cessation programs have also been implemented (American Lung Association, 2019; Graham et al., 2020). These programs aim to reduce the number of students vaping and therefore help reduce non-users' social exposure to e-cigarette use which has been associated with increased susceptibility and use among youth (Agaku et al., 2020; Dai, 2021; Etim et al., 2020; Mantey et al., 2021). Studies have indicated that some youth are interested in quitting e-cigarettes and there is promise for low-cost quit aids such as text (SMS)-based programs (Graham et al., 2020).

Given the rapid increase in e-cigarette use among adolescents in recent years, there is a need to further explore how school programs are associated with e-cigarette initiation. While many programs have been implemented, the majority have not been evaluated (O'Connor et al., 2019). Natural experiment studies provide the opportunity to evaluate these programs using quasi-experimental research methods (Leatherdale, 2018). The Smoke Free Ontario (SFO) four pillars of tobacco control (industry, prevention, protection, and cessation) provide a framework for categorizing tobacco and e-cigarette interventions based on the main purpose of the intervention (Smoke-Free Ontario Scientific Advisory Committee, 2010; Smoke-Free Ontario Scientific Advisory Committee and Ontario Agency for Health Protection and Promotion (Public Health Ontario), 2017). The objective of this quasi-experimental study was to evaluate the impact by gender of adding a range of school-based e-cigarette prevention and cessation programs, categorized based on the SFO pillars of tobacco control, on e-cigarette initiation among a sample of Canadian youth.

2. Methods

The COMPASS study is a prospective cohort study that collects data from students in grades 9 to 12 (ages 13–18) in British Columbia, Alberta, and Ontario, and in Secondary I–V (ages 12–17) in Quebec, Canada (Leatherdale et al., 2014). All procedures were approved by the University of Waterloo Office of Research Ethics (# 30118) and appropriate school board committees. This secondary data analysis received ethics approval from the REB at Ontario Tech University (#15884). A full description of the COMPASS study methods can be found in print (Leatherdale et al., 2014) or online (www.compass.uwaterloo.ca).

2.1. Participants

This longitudinal pre-post quasi-experimental study used data from Year 6 (2017/18, baseline) and Year 7 (2018/19, follow-up) of the COMPASS Study. Given the focus of the current analysis on evaluating the impact of adding new e-cigarette prevention and cessation programs on e-cigarette initiation, we excluded schools ($n = 20$) who indicated they had an e-cigarette prevention/cessation program in place at baseline but not at follow-up (i.e., a program was removed). Among remaining schools, a total of 34,090 students in grades 9–11 (Secondary III–IV in Quebec) from 88 schools participated at baseline (81.5% participation rate). Students who had ever tried e-cigarettes or did not respond at baseline were removed ($n = 12,897$, 38%), leaving 21,193 students at baseline. 13,339 (63%) students were then linked from baseline to follow up. Students with missing data on covariates were also removed ($n = 70$, 0.5%). The final sample included 13,269 students in grades 9–11 (Secondary III–IV in Quebec) from 88 schools (British Columbia $n = 11$; Alberta $n = 7$; Ontario $n = 47$; Quebec $n = 23$) who were linked from baseline to follow-up and reported never having tried e-cigarettes at baseline. The sample was approximately half female (56%) and the majority were White (64%).

2.2. Measures

Student responses were captured using the COMPASS questionnaire, a paper-based survey completed during class time. Students reported their grade (9, 10, 11), gender (Female, Male), ethnicity (White, non-White), and weekly spending money (Zero, \$1–\$20, \$21–\$100, \$100+, Don't know/missing) at baseline.

To identify e-cigarette initiation, students were asked "Have you ever tried an electronic cigarette, also known as an e-cigarette?" Students who indicated no at baseline and yes at follow-up were considered to have initiated e-cigarette use.

School-level variables were collected using the School Policies and Programs (SPP) questionnaire, which is completed annually by a school contact knowledgeable about the school's health-related programs and policies (typically a principal, guidance counsellor, or physical education teacher). School contacts were asked if the school offered any programs outside of curriculum that addressed tobacco use prevention ("Other than classes/curriculum, does your school offer any programs that address tobacco use prevention?"), tobacco use cessation ("Other than classes/curriculum, does your school offer any programs that address tobacco use cessation?"), or e-cigarette use prevention ("Other than classes/curriculum, does your school offer any programs that address e-cigarette use prevention?") and whether these programs were new or continuing ("Are these programs new this year, or continuing from previous years?"). We included responses to tobacco use prevention and cessation programs to be as comprehensive as possible since some respondents may consider e-cigarette prevention or cessation programs as part of tobacco programming. School contacts were also asked to describe these programs. We did not follow up with schools who did not provide adequate detail about their programs due to lack of reliability of collecting this information retrospectively.

We also calculated a senior e-cigarette use measure for each school to control for the baseline school e-cigarette environment. Consistent with previous tobacco literature, we calculated the percent of grade 12 students (grade 11 in Quebec) who reported past 30-day e-cigarette use at each school (Cole and Leatherdale, 2014).

Finally, additional data on school neighbourhood median income (\$25,001–\$50,000, \$50,001–\$75,000, \$75,001–\$100,000, \$100,000+) and urbanicity (Rural, Small Urban, Medium Urban, Large Urban) were collected from the 2016 census.

2.3. Analysis

This is a natural experiment study that makes use of a quasi-

experimental design to evaluate the impact of e-cigarette and tobacco programs on e-cigarette initiation (Leatherdale, 2018). Natural experiment studies provide the opportunity to evaluate interventions that are not able to be evaluated using a Randomized Controlled Trial because implementation of the intervention is outside of the control of the researcher. In a quasi-experimental research design, data are still collected pre- and post-intervention, but the comparison is between non-randomized intervention and control groups (Leatherdale, 2018). In the case of this study, schools implemented tobacco/e-cigarette prevention or cessation programs on their own, without input or direction from the researchers.

We first identified schools that added new programs to ensure that our baseline data captured students who had not yet initiated e-cigarette use pre-intervention. Program descriptions were evaluated by two reviewers (GW and AC) and discrepancies were resolved by consensus. Similar to a previous evaluation of school-based tobacco programs (Leatherdale and Cole, 2015), new programs were categorized based on the SFO four pillars of tobacco control (industry, prevention, protection, and cessation) (Smoke-Free Ontario Scientific Advisory Committee, 2010; Smoke-Free Ontario Scientific Advisory Committee and Ontario Agency for Health Protection and Promotion (Public Health Ontario), 2017). Industry refers to interventions to counter the tobacco industry's efforts to promote and sell their products. Prevention interventions aim to prevent tobacco use initiation and prevent the progression of further tobacco use. Protection interventions seek to enhance protections from second-hand smoke and from social exposure to smoking, vaping, and other tobacco products. Finally, cessation interventions motivate, encourage, and support efforts to quit smoking or e-cigarette use (Smoke-Free Ontario Scientific Advisory Committee and Ontario Agency for Health Protection and Promotion (Public Health Ontario), 2017). Prevention programs were then grouped based on similar types of interventions (e.g., posters, presentations). Schools that did not add a new program in 2018/19 were categorized as control schools consistent with recommendations for evaluating natural experiments (Leatherdale, 2018).

Descriptive statistics identified the proportion of students who initiated e-cigarette use in intervention schools relative to control schools; significant differences between intervention schools and control schools were identified through a *t*-test. Generalized estimating equations (GEE) via PROC GENMOD with an exchangeable correlation structure were used to identify how added program types were associated with e-cigarette initiation at follow-up while accounting for the nesting of students within schools. Separate models were conducted for male and female students and controlled for student grade, ethnicity, and weekly spending money at baseline, the school's senior e-cigarette use rate, as well as school neighbourhood median income, urbanicity, the presence of baseline tobacco/e-cigarette prevention or cessation programs, and province. A sensitivity analysis was conducted to compare schools with and without interventions at baseline.

3. Results

Among the 13,269 students who had not tried e-cigarettes at baseline, 3864 (29%) reported initiating e-cigarette use the following year. At baseline, 25 schools (28% of total schools) reported having programming that addressed e-cigarette or tobacco prevention or cessation. At one-year follow-up, 20 schools (23%) added a tobacco use prevention, tobacco use cessation, or e-cigarette use prevention program, and 4 of these schools reported adding more than one program (e.g., both prevention and cessation programs). There was overlap between schools that had a program at baseline and schools that added a program at follow-up. Of the 20 schools that added a new program/policy, 13 (65%) had a pre-existing program/policy at baseline.

Based on the descriptions of interventions provided (Table 1), no schools identified interventions designed to counter the tobacco industry's efforts to promote and sell their product (SFO Pillar: Industry). The

Table 1

Descriptions and classifications of school-based e-cigarette prevention and cessation programs added at follow-up, 2018/19 COMPASS study.

School	Intervention classification(s) ^a	Program description
1	Cessation;	The school ran a vaping focus group and a vaping information and cessation program was developed and offered this year.
2	Cessation	The school brought in the Tobacco Enforcement Officers to speak with small groups of students to discuss cessation. Additionally, the school nurse set up displays from a variety of agencies to assist in smoking cessation.
3	Cessation;	The school implemented activities related to "I stop, I win" and a policy for a tobacco-free generation (CQLT). Additionally, awareness activities were done in the classroom.
4	Cessation; Prevention - NEI	The school indicated a new tobacco prevention program, cessation program, and vaping prevention program but no details were provided.
5	Cessation; Prevention - NEI	The school indicated a new tobacco prevention program, cessation program, and vaping prevention program but no details were provided.
6	Cessation; Prevention - theme week	The school hired a new school nurse to help with cessation. The school nurse also implemented a tobacco-free week.
7	Prevention - interactive display	An external organization presented interactive stations to illustrate the results of e-cigarette/vaping use.
8	Prevention - interactive display	The school had Health Canada come present their vaping workshop and display.
9	Prevention - interactive display	The school had Health Canada come do a class presentation and activity.
10	Prevention - interactive display	The school put up posters and had students participate in a vaping maze.
11	Prevention - NEI	The school worked with their public health nurse and unit to deliver programming to students and parents, but no other details were provided.
12	Prevention - NEI	The school psychoeducator implemented prevention programs against vaping, but no other details were provided.
13	Prevention - NEI	The school increased promotion and vigilance around anti-vaping messages.
14	Prevention - NEI	The school indicated a new vaping prevention program, but no details were provided.
15	Prevention - NEI	The school indicated a new vaping prevention program, but no details were provided.
16	Prevention - NEI	The school indicated a new vaping prevention program, but no details were provided.
17	Prevention - theme week	The school implemented an Addiction Prevention Week.
18	Prevention - presentation	The school had a group of teachers who lead classroom sessions using videos, guest speakers, and Tobacco Enforcement Officers to discuss the harmful effects of vaping.
19	Prevention - presentation	The school invited police officers to come in and talk about substance abuse and related issues.
20	Prevention - presentation	The school held various sessions including spotlights, community education, parent information nights, and round table discussions.
21	Prevention - presentation	The school implemented workshops with the help of a special education technician.
22	Prevention - Presentation; Protection	The school had prevention workers discuss the laws around vaping.
23	Protection	The school implemented a mandatory online awareness program and quiz about vaping. The school also implemented a suspension re-entry program for vaping.
24	Protection;	The school had their community School Resource Officer and a Tobacco Enforcement Officer speak to students and staff about fines for vaping and smoking on school property.

NEI: not enough information.

^a classification based on smoke-free Ontario pillars of tobacco control;

most popular type of program added was prevention programs (SFO Pillar: Prevention) which discouraged youth from trying tobacco products/e-cigarettes ($n = 19$ schools). This category was further divided into “interactive displays”, “presentations”, “theme weeks”, and “not enough information”. Among schools that indicated an interactive display ($n = 4$), two specified that Health Canada came to present a workshop and display (CBC News, 2019) while the other two indicated interactive stations or a “vaping maze.” Among schools that offered

presentations ($n = 5$), two had police officers do the presentations, two had prevention workers, and one did not specify. Two schools implemented theme weeks; one was a tobacco-free week and the other an addiction prevention week. Among schools that did not provide enough information ($n = 8$), five did not provide any additional information and 3 did not specify the nature of the prevention program implemented. Few schools reported either interventions designed to reduce exposure to second-hand smoke/vapour (SFO Pillar: Protection, $n = 3$ schools) or interventions to motivate, encourage, and support efforts to quit smoking/vaping (SFO Pillar: Cessation, $n = 6$ schools).

At follow-up, mean school-level e-cigarette initiation rates were significantly higher in schools that implemented a theme week

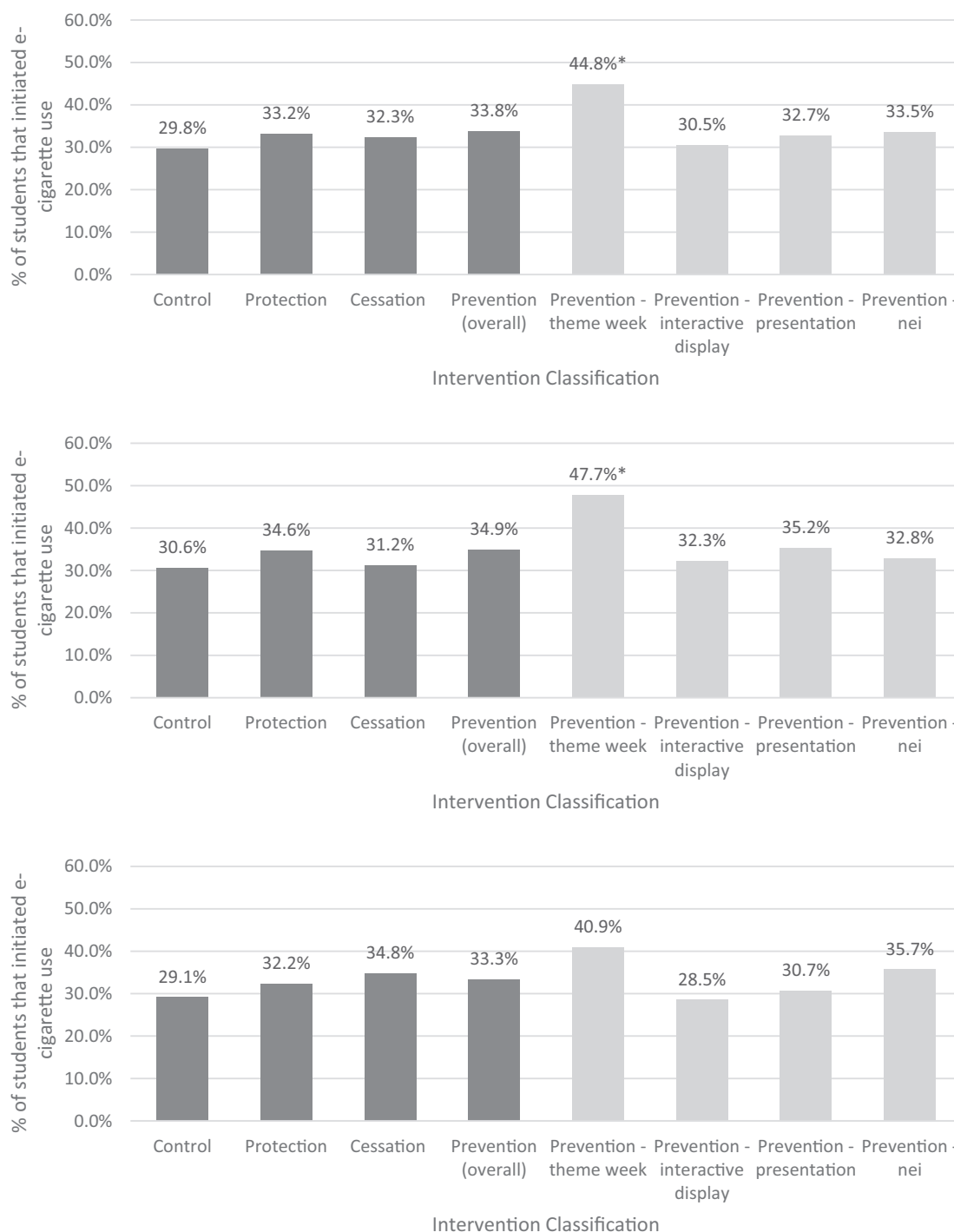


Fig. 1. E-cigarette initiation rates at follow-up in intervention and control schools among the full sample (top), females (middle), and males (bottom); * $p < .05$.

compared to control schools (Fig. 1). No other significant effects were identified.

GEE regression results suggest that none of the activities taken by schools to prevent or reduce vaping prevented vaping onset (Table 2). In fact, after controlling for covariates, students at schools that reported adding a theme week had higher odds of e-cigarette initiation (OR 1.49 [95%CI 1.30–1.72]). We also examined results stratified by gender. After controlling for covariates, female students at schools that reported adding a theme week had higher odds of e-cigarette initiation (OR 1.68 [95% CI 1.31–2.16]), and male students at schools that reported a cessation program had higher odds of e-cigarette initiation (OR 1.20 [95% CI 1.01–1.44]). We hypothesized that baseline programming might mute the effects of new programming but a sensitivity analysis that compared the impact of e-cigarette interventions on e-cigarette initiation at follow-up between schools with and without interventions at baseline produced similar results (Supplementary Table S1).

4. Discussion

This evaluation of school-based natural experiments identified the impact of multiple e-cigarette prevention and cessation programs on e-cigarette initiation among Canadian high school students. Despite rising rates of e-cigarette use among adolescents in this time period (Cole et al., 2020; Cullen et al., 2018; Government of Canada, 2019; Hammond et al., 2019), the majority of schools did not add an e-cigarette or tobacco prevention or cessation program between baseline and follow-up. We identified programs that fit into three of the four SFO pillars of tobacco control: prevention, protection, and cessation. Overall, most of the added programming had no impact on e-cigarette initiation. We also found that students at schools that implemented a prevention “theme week” were negatively impacted and had higher odds of e-cigarette initiation. It appears there could be differential impacts by gender, but more research is needed to determine what these differences are and what program components are needed to address gender differences. When designing evaluations, gender should be taken into consideration and sample size should be adequate to address potential differences.

Overall, most of the added programming had no impact on e-

Table 2

GEE logistic regression analyses evaluating the impact of categories of school e-cigarette interventions implemented between baseline and follow-up among baseline never e-cigarette users relative to no change in programming, 2017/18–2018/19 COMPASS study, $n = 13,269$.

Intervention classification	Odds of e-cigarette initiation, overall sample ($n = 13,269$) (95% CI)	Odds of e-cigarette initiation, female students ($n = 7518$) (95% CI)	Odds of e-cigarette initiation, male students ($n = 5818$) (95% CI)
Control (reference)	1.00	1.00	1.00
Protection	0.97 (0.75–1.24)	0.93 (0.74–1.16)	0.99 (0.71–1.37)
Cessation	0.96 (0.80–1.16)	0.85 (0.61–1.17)	1.20 (1.01–1.44)
Prevention – Theme week	1.49 (1.30–1.72)	1.68 (1.31–2.16)	1.27 (0.75–2.17)
Prevention – Interactive display	1.12 (0.94–1.34)	1.12 (0.90–1.40)	1.14 (0.90–1.44)
Prevention – Presentation	1.00 (0.89–1.11)	1.01 (0.80–1.28)	0.97 (0.78–1.21)
Prevention – Not enough information	1.09 (0.92–1.29)	1.04 (0.82–1.31)	1.18 (1.00–1.38)

Models controlled for student gender (when applicable), grade, ethnicity, weekly spending money, and school baseline urbanicity, school baseline neighbourhood median income, province, baseline tobacco and/or e-cigarette programming, and baseline school-level senior e-cigarette use rate. Bold $p < 0.05$.

cigarette initiation. This could have been since many of the programs appeared to be single events (i.e., presentations, vape maze). Given the rapidly changing e-cigarette landscape, schools might need to provide programming more than once a year to keep up with these changes. Many prevention programs include multiple sessions and there is some limited evidence for the benefit of additional booster sessions (Kelder et al., 2020; Liu et al., 2020; Thomas et al., 2015). There was also a notable lack of programming targeting the SFO “Industry” pillar. This is a component that should be added to school prevention programs as there is evidence that exposure to e-cigarette marketing is associated with susceptibility to and ever use of e-cigarettes (Mantey et al., 2016). Based on these results, it appears as though schools lack capacity to independently implement evidence-based programming and may need additional support in designing, implementing, and evaluating e-cigarette prevention interventions. It is well known that comprehensive approaches are the most effective in preventing and reducing substance use (Griffin and Botvin, 2010). Based on what we know from tobacco prevention programs, elements of successful e-cigarette programming include discussing e-cigarette specific topics (e.g., flavours, marketing, and specific health risks), including normative education, helping students develop social competence and refusal skills, and incorporating theory in the development of the program (Kelder et al., 2020; Liu et al., 2020; Mantey et al., 2016; Thomas et al., 2015; U.S. Department of Health and Human Services, 2012; Unger and Bartsch, 2018). Supporting schools in implementing evidence-based programming, and making use of robust evaluation systems such as the COMPASS study will help ensure schools are maximizing students' time and school resources (Leatherdale, 2018; Leatherdale et al., 2014).

The overall results and those stratified by gender indicate that female students at schools that implemented a prevention “theme week” had higher odds of e-cigarette initiation. Based on the descriptions provided by the schools, these programs were broad, and it is not clear how much of the intervention focused on e-cigarette use. It is possible that these interventions resulted in a “boomerang effect,” where the health message backfired and resulted in an increase in the targeted behaviour (Byrne and Hart, 2009). Evidence from the cigarette smoking prevention literature has identified that fostering social competence and refusal skills is an important part of successful school-based intervention programs (Thomas et al., 2015). In the current study, due to lack of detail, it is difficult to know how programs were implemented, what the components were, to what extent they were evidence informed, and why there were different results among females and males. Future research should also examine the differential impact of e-cigarette programming among racial/ethnic groups and by socioeconomic status.

We also identified that a quarter of schools implemented cessation programs. This is encouraging as other research has identified that students are interested in quitting e-cigarettes (American Lung Association, 2019; Graham et al., 2020). Cessation programs have the potential to help reduce substance use initiation through a reduction in social exposure to use, which has been identified in the cigarette smoking literature (Bellatorre et al., 2016). However, in stratified analyses cessation programs were associated with increased odds of initiation among males. The lack of positive findings in the current study indicate that cessation programs at these schools did not likely shift social norms and that these schools could potentially benefit from additional guidance to make sure they are implementing evidence-based cessation programs that are appealing to both male and female students. Additionally, future studies might use a longer follow-up time as it typically takes multiple attempts to quit smoking (Chaiton et al., 2016), which is likely similar for quitting e-cigarette use, and changing school norms could take more time.

5. Strengths and limitations

The strengths of this study include the use of a large longitudinal sample to evaluate natural experiments. To conduct a rigorous

evaluation, we included both intervention and control schools in our analyses and explored differential impacts by gender to evaluate differences in e-cigarette behaviours. However, this study is not without limitations. The biggest study limitation was the lack of program detail provided for implemented programs. It is difficult to know how programs were implemented, what the components were, and to what extent they were evidence informed, which may introduce heterogeneity in our intervention categories. Future studies are needed to evaluate specific intervention components both individually and in combination. Additionally, some schools may have been incorrectly categorized as control schools if a change happened and they forgot to report it in the SPP. But given the number of control schools included, we expect this would have a minimal effect. Next, the COMPASS study does not ask about additional variables such as exposure to e-cigarette marketing or peer and family use, all of which could influence e-cigarette initiation (D'Angelo et al., 2021; Etim et al., 2020). However, we did include the senior vaping rate for each school to account for the baseline school e-cigarette environment. Additionally, due to the lack of a definition of an e-cigarette or listing of brands on the questionnaire and the changing language used by youth to refer to e-cigarette devices (e.g., vaping, Juuling), this study may underreport e-cigarette use. Finally, participant drop-out may have resulted in an underestimation of e-cigarette initiation and its association with interventions.

6. Conclusion

While 23% of schools added an e-cigarette or tobacco prevention or cessation program, we did not identify any positive impacts on e-cigarette initiation. Two types of interventions (prevention “theme weeks” among females and cessation programs among males) had a negative impact and increased the risk of e-cigarette initiation. Results point to the need for more evidence-based guidelines and tools for schools to use to assist them in preventing e-cigarette use among adolescents.

Author contributions

GCW collaborated on the study methodology, conducted statistical analysis, interpreted the results, and drafted the original manuscript. AGC conceived of the study research questions, collaborated on the study methodology, interpreted study results, contributed the original manuscript draft, and reviewed the manuscript for important intellectual content. MdG, YJ, and STL collaborated on the study methodology, interpreted study results, and revised the manuscript for important intellectual content. STL is the principal investigator of the COMPASS study, wrote the funding proposal, developed the tools, and lead study implementation and coordination. All authors read and approved the final manuscript.

Funding acknowledgement

The COMPASS study has been supported by a bridge grant from the CIHR Institute of Nutrition, Metabolism and Diabetes (INMD) through the “Obesity – Interventions to Prevent or Treat” priority funding awards (OOP-110788; awarded to SL), an operating grant from the CIHR Institute of Population and Public Health (IPPH) (MOP-114875; awarded to SL), a CIHR project grant (PJT-148562; awarded to SL), a CIHR bridge grant (PJT-149092; awarded to KP/SL), a CIHR project grant (PJT-159693; awarded to KP), and by a research funding arrangement with Health Canada (#1617-HQ-000012; contract awarded to SL), and a CIHR-Canadian Centre on Substance Abuse (CCSA) team grant (OF7 B1-PCPEGT 410-10-9633; awarded to SL). The COMPASS-Quebec project additionally benefits from funding from the Ministère de la Santé et des Services sociaux of the province of Québec, and the Direction régionale de santé publique du CIUSSS de la Capitale-Nationale. This work was supported by an operating grant from CIHR (#170256; grant awarded to AC). GW is supported by the Ontario Graduate Scholarship (OGS) and by

the Public Health Agency of Canada through the Federal Student Work Experience Program.

Declaration of Competing Interest

The authors have no conflicts of interest to declare.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.ypmed.2021.106924>.

References

- Agaku, I.T., Perks, S.N., Odani, S., Glover-Kudon, R., 2020. Associations between public e-cigarette use and tobacco-related social norms among youth. *Tob. Control.* 29, 332–340. <https://doi.org/10.1136/tobaccocontrol-2018-054728>.
- American Lung Association, 2019. *INDEPTH Pilot Evaluation Overview*.
- Bellatorre, A., Choi, K., Bernat, D., 2016. The influence of the social environment on youth smoking status. *Physiol. Behav.* 176, 100–106. <https://doi.org/10.1016/j.ypmed.2015.09.017>.
- Benningfield, M.M., Riggs, P., Stephan, S.H., 2015. The role of schools in substance use prevention and intervention. *Child Adolesc. Psychiatr. Clin. N. Am.* 24, 291–303. <https://doi.org/10.1016/j.chc.2014.12.004>.
- Byrne, S., Hart, P.S., 2009. The boomerang effect: a synthesis of findings and a preliminary theoretical framework. *Ann. Int. Commun. Assoc.* 33, 3–37. <https://doi.org/10.1080/23808985.2009.11679083>.
- Chaiton, M., Diemert, L., Cohen, J.E., Bondy, S.J., Selby, P., Philipneri, A., Schwartz, R., 2016. Estimating the number of quit attempts it takes to quit smoking successfully in a longitudinal cohort of smokers. *BMJ Open* 6. <https://doi.org/10.1136/bmjopen-2016-011045>.
- Cole, A.G., Leatherdale, S.T., 2014. The association between senior student tobacco use rate at school and alternative tobacco product use among junior students in Canadian secondary schools. *Tob. Induc. Dis.* 12.
- Cole, A.G., Qian, W., Leatherdale, S.T., 2017. Changing the smoking trajectory: evaluating the impact of school-based tobacco interventions on changes to susceptibility to future smoking. *Int. J. Environ. Res. Public Health* 14. <https://doi.org/10.3390/ijerph14101182>.
- Cole, A.G., Aleyan, S., Leatherdale, S.T., 2019. Exploring the association between E-cigarette retailer proximity and density to schools and youth E-cigarette use. *Prev. Med. Rep.* 15, 100912. <https://doi.org/10.1016/j.pmedr.2019.100912>.
- Cole, A.G., Aleyan, S., Battista, K., Leatherdale, S.T., 2020. Trends in youth e-cigarette and cigarette use between 2013 and 2019: insights from repeat cross-sectional data from the COMPASS study. *Can. J. Public Health* 112, 60–69. <https://doi.org/10.17269/s41997-020-00389-0>.
- Corsi, D.J., Lippert, A.M., 2016. An examination of the shift in school-level clustering of US adolescent electronic cigarette use and its multilevel correlates, 2011–2013. *Health Place* 38, 30–38. <https://doi.org/10.1016/j.healthplace.2015.12.007>.
- Cullen, K.A., Ambrose, B.K., Gentzke, A.S., Apelberg, B.J., Jamal, A., King, B.A., 2018. Notes from the field use of electronic cigarettes and any tobacco product among middle and high school students — United States, 2011–2018. *Morb. Mortal. Wkly. Rep. Notes* 67, 1276–1277.
- Dai, H., 2021. Youth observation of E-cigarette use in or around school, 2019. *Am. J. Prev. Med.* 60, 241–249. <https://doi.org/10.1016/j.amepre.2020.07.022>.
- D'Angelo, H., Patel, M., Rose, S.W., 2021. Convenience store access and E-cigarette advertising exposure is associated with future E-cigarette initiation among tobacco-naïve youth in the PATH study (2013–2016). *J. Adolesc. Health* 68, 794–800. <https://doi.org/10.1016/j.jadohealth.2020.08.030>.
- Denny, S.J., Robinson, E.M., Utter, J., Fleming, T.M., Grant, S., Milfont, T.L., Clark, T., 2011. Do schools influence student risk-taking behaviors and emotional health symptoms? *J. Adolesc. Health* 48, 259–267. <https://doi.org/10.1016/j.jadohealth.2010.06.020>.
- Etim, N., Pike, J., Xie, B., 2020. Age-varying associations between e-cigarette use and peer use, household use, and exposure to e-cigarette commercials among alternative high school students in Southern California. *Tob. Induc. Dis.* 18, 1–9. <https://doi.org/10.18332/tid/116412>.
- Gaiha, S.M., Duemler, A., Silverwood, L., Razo, A., Halpern-felsher, B., Walley, S.C., 2021. School-based e-cigarette education in Alabama: Impact on knowledge of e-cigarettes, perceptions and intent to try. *Addict. Behav.* 112, 106519. <https://doi.org/10.1016/j.addbeh.2020.106519>.
- Government of Canada, 2019. Summary of results for the Canadian Student Tobacco, Alcohol and Drugs Survey 2018–19 [WWW Document]. URL: <https://www.canada.ca/en/health-canada/services/canadian-student-tobacco-alcohol-drugs-survey/2018-2019-summary.html>.
- Graham, A.L., Jacobs, M.A., Amato, M.S., 2020. 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.* 859–860. <https://doi.org/10.1093/ntr/ntz097>.
- Griffin, K.W., Botvin, G.J., 2010. Evidence-based interventions for preventing substance use disorders in adolescents. *Child Adolesc. Psychiatr. Clin. N. Am.* 19, 505–526. <https://doi.org/10.1016/j.chc.2010.03.005>.
- Hammond, D., Reid, J.L., Rynard, V.L., Fong, G.T., Cummings, K.M., McNeill, A., Hitchman, S., Thrasher, J.F., Goniewicz, M.L., Bansal-travers, M., Connor, R.O.,

- Levy, D., Borland, R., White, C.M., 2019. Prevalence of vaping and smoking among adolescents in Canada, England, and the United States: repeat national cross sectional surveys. *BMJ*. <https://doi.org/10.1136/bmj.l2219>.
- Hieftje, K.D., Fernandes, C.F., Lin, I., 2021. Effectiveness of a web-based tobacco product use prevention videogame intervention on young adolescents' beliefs and knowledge. *Subst. Abuse*. 42, 47–53. <https://doi.org/10.1080/08897077.2019.1691128>.
- Huang, L., Lazard, A.J., Pepper, J.K., Noar, S.M., Ranney, L.M., Goldstein, A.O., 2017. 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* 14, 42. <https://doi.org/10.3390/ijerph14010042>.
- Kelder, S.H., Mantey, D.S., Van Dusen, D., Case, K., Haas, A., Springer, A.E., 2020. A Middle School Program to Prevent E-Cigarette Use: A Pilot Study of "CATCH My Breath". *Public Health Rep.* 135, 220–229. <https://doi.org/10.1177/0033354919900887>.
- Kong, G., Kuguru, K.E., Krishnan-Sarin, S., 2017. Gender Differences in U.S. Adolescent E-Cigarette Use. *Curr. Addict. Reports* 4, 422–430. <https://doi.org/10.1007/s40429-017-0176-5.Gender>.
- Leatherdale, S.T., 2018. Natural experiment methodology for research: a review of how different methods can support real-world research. *Int. J. Soc. Res. Methodol.* 1–17. <https://doi.org/10.1080/13645579.2018.1488449>.
- Leatherdale, S.T., Cole, A., 2015. Examining the impact of changes in school tobacco control policies and programs on current smoking and susceptibility to future smoking among youth in the first two years of the COMPASS study: looking back to move forward. *Tob. Induc. Dis.* 13. <https://doi.org/10.1186/s12971-015-0031-1>.
- Leatherdale, S.T., Brown, K.S., Carson, V., Childs, R.A., Dubin, J.A., Elliott, S.J., Faulkner, G., Hammond, D., Manske, S., Sabiston, C.M., Laxer, R.E., Bredin, C., Thompson-Haile, A., 2014. The COMPASS study: a longitudinal hierarchical research platform for evaluating natural experiments related to changes in school-level programs, policies and built environment resources. *BMC Public Health* 14. <https://doi.org/10.1186/1471-2458-14-331>.
- Lippert, A.M., Corsi, D.J., Venechuk, G.E., 2019. Schools influence adolescent E-cigarette use, but when? Examining the interdependent association between school context and teen vaping over time. *J. Youth Adolesc.* 48, 1899–1911. <https://doi.org/10.1007/s10964-019-01106-y>.
- Liu, J., Gaiha, S.M., Halpern-Felsher, B., 2020. A Breath of Knowledge: Overview of Current Adolescent E-Cigarette Prevention and Cessation Programs. *Curr. Addict. Reports*. <https://doi.org/10.1007/s40429-020-00345-5>.
- Lovato, C.Y., Pullman, A.W., Halpin, P., Zeisser, C., Candace, I.J., Best, F., Diener, A., Manske, S., 2010. The influence of school policies on smoking prevalence among students in. *Prev. Chronic Dis. Public Health Res. Pract. Policy* 7.
- Mantey, D.S., Cooper, M.R., Clendennen, S., Pasch, K., Perry, C.L., 2016. E-cigarette marketing exposure is associated with E-cigarette use among U.S. Youth. *J. Adolesc. Health* 58, 686–690. <https://doi.org/10.1016/j.jadohealth.2016.03.003.E-Cigarette>.
- Mantey, D.S., Omega-Njemnobi, O., Ruiz, F.A., Vaughn, T.L., Kelder, S.H., Springer, A.E., 2021. Association between observing peers vaping on campus and E-cigarette use and susceptibility in middle and high school students. *Drug Alcohol Depend.* 219, 108476. <https://doi.org/10.1016/j.drugalcdep.2020.108476>.
- Milicic, S., Decicca, P., Pierard, E., Leatherdale, S.T., 2018. An evaluation of school-based e-cigarette control policies' impact on the use of vaping products. *Tob. Induc. Dis.* 16, 35.
- Murnaghan, D.A., Leatherdale, S.T., Sihvonen, M., Kekki, P., 2008. A multilevel analysis examining the association between school-based smoking policies, prevention programs and youth smoking behavior: evaluating a provincial tobacco control strategy. *Health Educ. Res.* 23, 1016–1028. <https://doi.org/10.1093/her/cyn034>.
- News, C.B.C., 2019. Teens Navigating a Maze when it Comes to Vaping Myths — But this Exhibit Tries to Clear the Air. CBC Newfoundland, Labrador.
- O'Connor, S., Pelletier, H., Bayoumy, D., Schwartz, 2019. Interventions to Prevent Harms from Vaping [WWW Document]. URL. https://www.otru.org/wp-content/uploads/2019/05/special_vape_interventions.pdf.
- Smoke-Free Ontario Scientific Advisory Committee, 2010. Evidence to Guide Action: Comprehensive Tobacco Control in Ontario [WWW Document]. URL. <https://www.publichealthontario.ca/-/media/documents/C/2012/comprehensive-tobacco-control-2010.pdf?la=en> (accessed 4.27.20).
- Smoke-Free Ontario Scientific Advisory Committee, Ontario Agency for Health Protection and Promotion (Public Health Ontario), 2017. Evidence to Guide Action: Comprehensive tobacco control in Ontario [WWW Document]. URL. <https://www.publichealthontario.ca/-/media/documents/C/2017/comprehensive-tobacco-control-2016.pdf?la=en> (accessed 4.27.20).
- Thomas, R.E., McLellan, J., Perera, R., 2015. Effectiveness of school-based smoking prevention curricula: systematic review and meta-analysis. *BMJ Open* 5, e006976. <https://doi.org/10.1136/bmjopen-2014-006976>.
- U.S. Department of Health and Human Services, 2012. Preventing Tobacco Use Among Youth and Young Adults: A Report of the Surgeon General.
- Unger, J.B., Bartsch, L., 2018. Exposure to tobacco websites: associations with cigarette and e-cigarette use and susceptibility among adolescents. *Addict. Behav.* 78, 120–123. <https://doi.org/10.1016/j.addbeh.2017.11.012>.
- Vallone, D., Greenberg, M., Xiao, H., Bennett, M., Cantrell, J., Rath, J., Hair, E., 2017. The effect of branding to promote healthy behavior: reducing tobacco use among youth and young adults. *Int. J. Environ. Res. Public Health* 14, 1517. <https://doi.org/10.3390/ijerph14121517>.
- Wang, T.W., Gentzke, A.S., Neff, L.J., Glidden, E.V., Jamal, A., Park-Lee, E., Ren, C., Cullen, K.A., King, B.A., Hacker, K.A., 2021. Characteristics of e-cigarette use behaviors among US youth, 2020. *JAMA Netw. Open* 4, 1–13. <https://doi.org/10.1001/jamanetworkopen.2021.11336>.
- Yimsaard, P., McNeill, A., Yong, H., Cummings, K.M., Chung-hall, J., Hawkins, S.S., Quah, A.C.K., Fong, G.T., Connor, R.J.O., Hitchman, S.C., 2021. Gender differences in reasons for using electronic cigarettes and product characteristics: findings from the 2018 ITC four country smoking and vaping survey. *Nicotine Tob. Res.* 678–686. <https://doi.org/10.1093/ntr/ntaa196>.