



BMJ Open Association between socioecological factors and electronic cigarette use among Thai youth: an institution-based cross-sectional study

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ABSTRACT

Objectives This study aimed to examine cigarette use distribution, pattern of e-cigarette use and to determine socioecological model (SEM) factors associated with e-cigarette use among Thai youth (aged 15–24).

Design An institution-based cross-sectional study.

Participants The study conducted in five regions: the north, south, central, northeast and Bangkok area of Thailand from May to October 2021. An internet-based, self-administered questionnaire was developed based on the SEM. We enrolled 13 139 students who understood Thai and voluntarily consented to participate in the study. Hierarchical generalised estimating equations identified the related factors to e-cigarette use consistent with the SEM.

Results Of 12 948 respondents (95.5%), 181 were excluded due to a lack of cigarette use status. Of 12 767, the prevalence of cigarette use was 4.3%, e-cigarette use was 3.5% and dual-use was 2.4%. E-cigarettes were a much more favourable choice among female youth than cigarettes. E-cigarette users tended to express more positive beliefs towards e-cigarettes than non-users. Although the use of e-cigarettes is illegal in Thailand, 66% of users obtained e-cigarettes from online markets and 4% from grocery stores. We found that having a girlfriend or boyfriend who uses e-cigarettes increased the odds of e-cigarette use by 3.239 times. Interestingly, higher odds of e-cigarette use were associated with peer use than with sibling use among e-cigarette users. (Adjusted OR 2.786, 95% CI 1.844 to 4.208 and 2.485, 95% CI 1.402 to 4.404, respectively). Exposure to e-cigarette use in school increased the odds of e-cigarette use by four times.

Conclusion This institution-based cross-sectional study revealed that youth e-cigarette use is a significant problem. To prevent the increasing rate of e-cigarette use, health literacy about e-cigarette use, including media and information literacy, should be launched across all levels of the school environment to enlist youth to stand against the negative impacts of e-cigarette use among all those of school age.

STRENGTHS AND LIMITATIONS OF THIS STUDY

- ⇒ This investigation is a large institution-based cross-sectional study examining the prevalence of e-cigarette use covering both public and private institutions and a wide range of ages (15–24 years).
- ⇒ This study uses an internet-based anonymous self-administered questionnaire to encourage student frankness in reporting their current cigarette use.
- ⇒ The prevalence of e-cigarette use reported may be underestimated because this study occurred during the COVID-19 pandemic when many public places were closed.

BACKGROUND

Tobacco-attributed morbidity and mortality have raised public health concerns worldwide due to the significant loss of human life and the enormous economic cost.^{1–5} One-fourth of deaths worldwide are caused by ischaemic heart disease, stroke and chronic obstructive pulmonary disease; more than 8 million are attributed to tobacco use.² The global economic cost of tobacco use is around US\$1.85 trillion (1.8% of gross domestic product, GDP).³ However, the economic country cost varies globally, ranging from 0.65% of GDP⁴ to 2.59% of GDP.⁵

Due to the tremendous efforts of all countries, the global prevalence of tobacco use declined from 22.7% to 17.5% in 15 years. However, the significant challenges for public health professionals worldwide are new forms and products from tobacco companies, such as electronic nicotine delivery systems, commonly known as e-cigarettes, and the attractive promotion of these products as healthier alternatives to smoking.⁶ Although the full risks of e-cigarettes to humans are unknown, the health risks of nicotine in these products are well recognised.⁷ Nicotine

is highly addictive and affects youth brain development which occurs sequentially until the mid-20s.¹⁸ Therefore, tobacco use among youth (age 15–24 years) has drawn global and public health attention.

Despite many countries expanding their control measures on conventional cigarettes to e-cigarettes, the estimated number of worldwide e-cigarette users has sharply increased.⁹ The prevalence of e-cigarette use in 15–24-year-olds in 14 countries varied from 0.02% to 9.7%.^{10–15} In 2021, a survey of US middle and high school students found the past 30-day use of e-cigarettes higher than for cigarettes (2.8% vs 1.0% and 11.3% vs 1.9%, respectively).^{11 12} The situation in the USA differs from that for Korean adolescents, who had a lower percentage of e-cigarette use than cigarettes, 0.6% vs 3.4%, respectively.¹³

Thailand is a country that the WHO has recognised for its best practices in fighting against tobacco. However, e-cigarettes have become a current challenge in reducing nicotine addiction.^{15–17} The previous school-based surveys in Thailand found the prevalence of current e-cigarette use ranged from 3.3% to 3.7%,^{15 16} with a higher prevalence among boys than girls, 5.5% and 1.3%, respectively.¹⁶ However, another community-based study reported e-cigarette use at 6.8%.¹⁷ Previous studies found that e-cigarette use among family members and peers influenced e-cigarette use among adolescents and youth.^{16 17} Also, the types of educational institutions, the location of the school and the availability of e-cigarettes in neighbourhoods were all associated with e-cigarette use among the younger generation in the USA and Asian countries.^{14 16–18} Youth are unaware of e-cigarette risks, perceive e-cigarettes as non-addictive, and consider e-cigarette use as reflecting a modern self-image.^{13–18}

It is necessary to examine the relationships between interpersonal, intrapersonal, school and community factors to understand youth e-cigarette usage. This study examines cigarette use distribution, describes e-cigarette use patterns and identifies factors associated with the socioecological model of e-cigarette use among Thai youth (aged 15–24).

METHODS

Study design and settings

An institution-based cross-sectional study was conducted in five regions of Thailand, including the north, south, central, northeast and Bangkok area, from May to October 2021. An anonymous, internet-based self-administered questionnaire was used and accessed via QR code for the student respondents' privacy and encouragement to report the truth. Due to the educational system in Thailand, about 90% of Thai youth aged 15–24 years commonly study in high schools, vocational schools and universities or colleges. Our study settings covered these three types of education and public and private educational institutions to ensure our sample included all youth 15–24 years of age.

Study samples and sampling techniques

We included students studying in the selected educational institutions who understand Thai. We excluded students who selected 'no' on the consent page of the internet-based anonymous self-administered questionnaire. A sample size of 12900 students was determined adequate for a single proportion (proportion of e-cigarette use=0.286) with a margin of error (0.05), compensated for cluster sampling (design effect= 1.5) and non-response rate (30%) at 95% CI.

A two-stage stratified cluster sampling method selected a sample of youth. In Thailand, not all provinces have universities or colleges. Therefore, we chose two provinces from each region with universities or colleges in the first step. Then, we randomly selected two high schools, two vocational schools and one university or college (if there were more than one university or college in the province) from the selected provinces. Finally, we randomly selected one class from each grade of the chosen educational institution and included all students in that class. For college and university, we randomly selected one non-health science faculty and included all students of that faculty. We obtained consent from the parents or guardians of all students aged <18 years chosen before sending the internet-based anonymous self-administered questionnaire to the students. The QR code of the internet-based anonymous self-administered questionnaire was disseminated to all students to ensure all students voluntarily agreed to participate.

Research instruments and their performance

The internet-based anonymous self-administered questionnaire was collaboratively developed by authors consistent with Tobacco Questions for Surveys of Youth,¹⁹ and the socioecological model composed of four sections: (1) current cigarette use, (2) intrapersonal level including personal characteristics, attitude and belief towards e-cigarette use, (3) interpersonal level including e-cigarette use among youth's connections and (4) school and community level.

Section 1: Current cigarette use is this study's dependent variable, measured by the question, 'During the past 30 days, did you use cigarettes?'. Four responses were provided: cigarette use only, e-cigarette use only (nicotine-containing e-cigarette),²⁰ cigarette and e-cigarette use (dual-use) and never used. Only e-cigarettes and dual-use were later categorised as current e-cigarette use and used in generalised estimating equations as a binary response (GEEs).²¹

Sections 2–4 include the independent variables of this study. Section 2: Intrapersonal level had age, sex identity with three responses: male, female, LGBTQ+, knowledge of e-cigarette legislation, attitude and beliefs about e-cigarette use. Knowledge of e-cigarette legislation was assessed through five yes-no questions. Attitude and beliefs used 17 five-scale questions ranked 1–5 from strongly disagree, disagree, neutral, agree and strongly agree. The questions in section 2 were scored and summed for a total

Table 1 Prevalence of cigarette, e-cigarette and dual-use by respondent characteristics

Factors	Cig.	95% CI	E-cig.	95% CI	Dual	95% CI	N	%
Overall	4.3	3.9 to 4.6	3.5	3.2 to 3.8	2.4	2.1 to 2.6	12 767	100
Region								
North	6.1	5.1 to 7.0	4.7	3.9 to 5.5	3.5	2.9 to 4.4	2472	19.4
Northeast	3.9	3.2 to 4.7	3.6	2.9 to 4.4	3.2	2.5 to 3.9	2475	19.4
Central	4.7	3.8 to 5.6	2.5	1.8 to 3.4	1.0	0.5 to 1.3	2295	18.0
South	3.1	2.4 to 3.8	2.1	1.5 to 2.7	1.3	0.8 to 1.7	2235	17.5
Bangkok	3.7	3.1 to 4.4	4.1	3.5 to 4.8	2.6	2.0 to 3.1	3290	25.8
Types of educational institutions (n=12 699)								
High school	1.3	0.9 to 1.0	1.6	1.2 to 1.9	1.3	0.9 to 1.6	4258	32.1
Vocational school	7.9	7.1 to 8.6	4.2	3.6 to 4.8	2.5	2.0 to 2.9	4366	33.4
College/university	3.6	3.0 to 4.1	4.6	3.9 to 5.2	3.4	2.8 to 3.9	4075	31.9
Age (year)								
15–17	2.9	2.3 to 3.3	1.9	1.6 to 2.3	1.6	1.2 to 1.9	5034	39.4
18–21	5.4	4.8 to 5.9	4.2	3.6 to 4.6	2.4	2.0 to 2.7	6533	51.2
22–24	4.6	3.3 to 5.6	6.1	4.7 to 7.4	5.5	4.2 to 6.7	1200	9.4
Sex identification								
Male	7.4	6.8 to 8.1	4.9	4.4 to 5.4	3.5	3.0 to 3.9	5983	47.0
Female	1.4	1.1 to 1.6	2.2	1.9 to 2.6	1.3	1.1 to 1.6	6512	51.2
LGBTQ+	3.8	1.4 to 6.3	2.5	0.5 to 4.5	2.6	0.5 to 4.5	234	1.8

Dual is the dual-use of cigarettes and e-cigarettes. 95% CI is a 95% CI for the percentage. Cig, cigarettes; LGBTQ+, lesbian, gay, bisexual, transgender, queer and other sexual identities.

score on attitude, belief and knowledge of e-cigarette legislation. A higher score on attitude and belief reflected higher favourability towards e-cigarettes. A higher score on knowledge of e-cigarette legislation reflected a higher correct understanding of e-cigarettes.

Section 3: Interpersonal level included e-cigarette use among youth's social connections, such as siblings, boyfriend or girlfriend, and close friends. Lastly, in section 4, the school and community level comprised three items: types of education institutions, signs prohibiting e-cigarettes in school and exposure to e-cigarette use.

The questionnaire was internally checked for its content and readability by the academic team of the Thailand Tobacco Control Research and Knowledge Management Centre before sending the questionnaire to the respondents. Then, we examined the reliability of the internet questionnaire and found that the novel measures of e-cigarette knowledge and awareness of e-cigarette legislation had a Cronbach's alpha from 0.79 to 0.85. The complete questionnaire is provided in online supplemental file 1.

Data collection and data analysis

Data collection was conducted during the semester from May to October 2021. The electronic questionnaire with informed consent on the first page was sent to all selected class students asking for voluntary participation. For students <18 years old, the electronic questionnaire

was sent to students after receiving parental consent from the student's parents or guardians. About 12 948 students consented and continued responding to the questionnaire. After cleaning the data, we excluded students who did not report their current cigarette use (181 persons) and included 12 767 students for data analysis.

Cigarette use included cigarette use, e-cigarette use and never use. We estimated the prevalence of e-cigarette use by an unweighted technique due to the lack of a reference population size. We used the GEEs for binary outcomes to determine the association between independent variables and current e-cigarette use (use of a nicotine-containing e-cigarette within 30 days) and calculated a 95% CI. Due to the small number of youth identifying as LGBTQ+ (234 persons), we decided to exclude this group from the GEE analysis. Finally, we added 12 495 respondents to the GEE analysis. To comply with the socioecological framework, we identified the effects of factors at each socioecological level. We hierarchically added variables into the model in the following steps: model 1: age, sex identity, knowledge of e-cigarette legislation, attitude and belief.

Model 2: We added e-cigarette use among respondent connections such as siblings, close friends, boyfriend or girlfriend, neighbours and teachers. Model 3: we added the availability of signs banning e-cigarettes in school, exposure to e-cigarette use in school and types of educational institutions.

Table 2 Types and pattern of e-cigarette use among current e-cigarette users (n=753)

Factors	No	Percentage
Type of e-cigarette		
Pod mod model	595	80.5
(multiple responses)		
VAPE model	326	44.1
DIY	60	8.1
Smartwatch	15	2.0
Tobacco heating products	20	2.7
Time to use E-cigarettes		
After waking up	201	27.5
Before meal	267	36.5
During break time	437	59.8
After class	299	40.9
Before bedtime	272	37.2
Source of E-cigarette		
Online market	489	66.4
Friend	233	31.6
Referral market	198	26.9
Family	39	5.3
Grocery store	32	4.3
Others	37	5.0
Substances consumed with E-cigarettes		
Alcoholic beverage	604	68.5
Energy drink	168	19.0
Sleeping pills	76	8.6
Illicit drugs	34	3.9
Cannabis	7	0.9
Mitragynine	11	1.5
Desire to quit e-cigarettes		
Never	238	33.2
Once but failed	240	33.5
Think but never try	205	28.6
Think but do not know how	34	4.7
Effect of e-cigarette use on cigarette use		
Stopped using cigarettes	227	31.1
Cut down cigarette consumption	232	31.8
Never use cigarettes	173	23.7
Nothing changes	78	10.7
Increase cigarette consumption	19	2.6
VAPE, vaporizers or Vaping devices.		

Three models were used to identify the related factors consistent with the socioecological model after controlling for the effects of elements at different levels; GEE calculated a 95% CI.

Patient and public involvement

There were no patients involved in this research. The youth participants were recruited not as patients but as

populations at risk of nicotine-containing e-cigarettes and citizens. Hence, the development of the research question and outcome measures were not informed by patient priorities, experiences and preferences. No patients were involved in the research design. This study is neither clinical research nor a randomised control trial.

RESULTS

Prevalence of cigarette use and pattern of e-cigarette use among Thai youth

We obtained parental consent from 13 139 students, and 12 948 (98.5%) met the inclusion criteria (age 15–24 years). The electronic questionnaire was sent to 12 948 youth from 54 academic institutions in the north, north-east, central, south and Bangkok area of Thailand. We excluded 181 students due to a lack of variable outcome status. Of 12 767 respondents, 47% were male and 1.8% were LGBTQ+. The prevalence of cigarette use was 4.3% (95% CI 3.9% to 4.6%), followed by e-cigarette use (3.5%, 95% CI 3.2% to 3.8%) and dual-use (2.4%, 95% CI 2.12% to 2.6%) (table 1).

Youth in the northern region reported higher usage of cigarettes, as well as e-cigarette usage (6.1%, 95% CI 5.1% to 7.0% and 4.7%, 95% CI 3.9% to 5.5%, respectively) compared with other regions (table 1). We found cigarette usage more prevalent among vocational schools (7.9%, 95% CI 7.1% to 8.6%), but e-cigarette usage was much more frequent in colleges and universities (4.6%, 95% CI 3.9% to 5.2%). Cigarette use is most prevalent among 18–21 years old, while e-cigarette prevalence increases with age. Current cigarette and e-cigarette use among males was the highest used (7.4%, 95% CI 6.8% to 8.1% and 4.9%, 95% CI 4.4% to 5.4%). However, female youth reported higher use of e-cigarettes compared with cigarette or dual-use (table 1).

Our study found higher e-cigarette use among male versus female youth in the north (5.8% vs 3.1%), Bangkok (5.5% vs 3.0%) and the northeast (4.3% vs 3.0%) (online supplemental table 1). E-cigarette use is most frequent among college/university students (male 6.6% vs female 3.4% vs LGBTQ 5.3%), while cigarette use is most frequent among vocational students (male 11.2% vs female 2.4% vs LGBTQ+4.1%). Not surprisingly, dual-use is most common among college/university students (male 5.5% vs female 1.9% vs LGBTQ+6.4%) (online supplemental table 1).

We found that 5.0% of 15–17 male youth reported cigarette use, and those 18–21 had the highest cigarette use (9.0%). The trend of e-cigarette use increased by age in males, females and LGBTQ youth, ranging from 2.8% to 8.0% in males, from 1.3% to 4.8% in females, and 1.0%–4.0% in LGBTQ+ (online supplemental table 1).

Types and patterns of e-cigarette use

Among 753 respondents who reported using e-cigarettes in the last 30 days, 80% used the Pod Mod system, and 44% used the VAPE model. About 66% bought

Table 3 Mean (SD) score of positive attitude and belief towards e-cigarettes and correct knowledge of e-cigarette legislation

Score	Non-user		User		P value
	Mean	(SD)	Mean	(SD)	
Positive attitude towards e-cigarettes	13.57	(5.65)	17.25	(4.66)	<0.001
Positive belief towards e-cigarette	31.67	(9.56)	38.24	(8.17)	<0.001
Correct knowledge of e-cigarette legislation	5.01	(2.87)	5.58	(2.55)	<0.001

e-cigarettes from the online market, and 31% got e-cigarettes from friends. Almost two-thirds of e-cigarette users (68%) consumed e-cigarettes with an alcoholic drink and 19% with an energy drink. Among e-cigarette users, 33.2% never considered quitting, and 33.5% tried to quit but failed. Interestingly, among e-cigarette users, 31.1% of them reported stopping using conventional cigarettes, and 31.8% cut down on cigarette consumption (table 2).

Knowledge of e-cigarette legislation and attitude and belief towards e-cigarettes

E-cigarette users have significantly higher mean scores related to knowledge about e-cigarette legislation than non-users (mean=5.58, SD=2.55 vs mean=5.01, SD=2.87, respectively), but have a significantly greater positive attitude and belief towards e-cigarettes than non-users (table 3).

Related factors to e-cigarettes among Thai youth

In the first step, all variables at the intrapersonal level are significantly related to e-cigarette use. After adding variables related to e-cigarette use among the respondents' connection, the factors at the intrapersonal level remained significant except for attitude towards e-cigarettes. However, e-cigarette use among respondents' social relations is strongly associated with e-cigarette use among youth. Next, variables at the school and community levels were added to the model. The final model found that males had higher odds of using e-cigarettes than female youth (adjusted (Adj.) OR 1.727, 95% CI 1.160 to 2.570). Interestingly, higher knowledge of e-cigarette legislation produced higher odds of e-cigarette use (adj. OR 1.116, 95% CI 1.049 to 1.186) (table 4).

E-cigarette use among respondents' social connections was significantly associated with e-cigarette use. We found

Table 4 Related factors to e-cigarette use by generalised estimation equation (GEE) for binary outcome (n=12 495)

Factors	Model 1		Model 2		Model 3	
	adj. OR	95% CI	adj. OR	95% CI	adj. OR	95% CI
Intrapersonal level						
Age	1.165	1.121 to 1.211	1.228	1.116 to 1.351	1.080	0.938 to 1.244
Male	1.995	1.688 to 2.357	1.687	1.173 to 2.426	1.727	1.160 to 2.570
Positive belief towards e-cigarettes	1.049	1.039 to 1.059	1.043	1.017 to 1.069	1.051	1.024 to 1.079
Positive attitude towards e-cigarettes	1.076	1.058 to 1.094	1.007	0.969 to 1.047	0.984	0.947 to 1.023
Knowledge of e-cigarette legislation	1.150	1.118 to 1.184	1.175	1.107 to 1.248	1.116	1.049 to 1.186
Inter-personal level						
E-cigarette users in a relationship				0.949 to 2.636		
Siblings			1.582		2.485	1.402 to 4.404
Girlfriend or boyfriend			3.568	2.248 to 5.663	3.239	2.017 to 5.199
Close friend			2.729	1.818 to 4.095	2.786	1.844 to 4.208
School and community level						
Signs prohibiting e-cigarettes in school					0.737	0.484 to 1.124
Exposure to e-cigarette use in school					4.040	2.827 to 5.775
Types of educational institutions						
High school					1	
Vocational school					2.386	1.177 to 4.837
College/university					2.295	1.129 to 4.665

Model 1 GEE considers factors at intra-personal factors.

Model 2 GEE considers factors at intrapersonal and interpersonal levels.

Model 3 GEE considers factors at the intrapersonal, interpersonal, and school and community levels.

adj. OR, adjusted OR.



that having a girlfriend or boyfriend who uses e-cigarettes increased the odds of e-cigarette use by 3.239 times, while use by close friends increased the odds of e-cigarette use by 2.786 times. Interestingly, use by peers resulted in more significant effects on e-cigarette use in youth than sibling use of e-cigarettes (adj. OR 2.485, 95% CI 1.402 to 4.404). Exposure to e-cigarette use at high school, vocational school or university/college produced higher odds of using e-cigarettes by four times, 2.4 times and 2.3 times, respectively (table 4).

Discussion

This institution-based cross-sectional study found that the prevalence of current use of exclusive cigarettes was 4.3%, exclusive e-cigarette use was 3.4% and dual-use was 2.4%. E-cigarette use in this study was lower than in previous studies in Thailand^{16 17} and the USA.^{12 18} The lower overall prevalence of current e-cigarette use by youth in this study is likely related to the continual cigarette prevention and control measures and the prohibition of selling and marketing e-cigarettes in Thailand.^{22 23} During data collection, Thailand had COVID-19 lockdown measures, with youth at every level of education studying at home to maintain distancing. The lockdown situation probably decreased the prevalence of cigarette use in this population. A previous study found that younger age and light smokers decreased smoking consumption during the lockdown to prevent COVID-19 outbreaks.²⁴

In contrast to lower e-cigarette use, this study found a higher prevalence of e-cigarette use among female students than in previous Thai studies.^{16 17} The higher prevalence of e-cigarette use than cigarettes reflects more acceptance of e-cigarettes than cigarettes among Thai female youth. Most online e-cigarette vendors sell nicotine-based e-cigarette liquids, reflecting Thailand's high demand for this product. Not surprisingly, e-cigarette users in our study reported likely e-cigarette addiction, such as trying to quit but failing and using e-cigarettes after a long period without using. This descriptive information suggests the need for an enhanced e-cigarette risk communication programme.

Our study found that youth e-cigarette use was related to factors at all levels of the socioecological model. We found higher odds of e-cigarette use among youth with a better knowledge of e-cigarette legislation and a favourable view of e-cigarettes. This situation is likely related to the advertisement of the tobacco industry. About 50% of respondents believed that e-cigarettes contained less nicotine than conventional cigarettes and intended to use e-cigarettes to assist in quitting smoking. This finding is consistent with previous studies.^{16 25 26} Earlier studies in Qatar²⁵ and Thailand^{16 26} found that fewer e-cigarette users believed in the health harm caused by e-cigarettes than non-users.^{16 25-27}

Similar to previous studies, our study found that e-cigarette users have higher odds of having e-cigarette users be a girlfriend, boyfriend or close friends than

those who did not.^{14 15 25 26} Peers influencing practices among youth have been well documented.^{28 29} The first experimental study by Gardner and Steinberg in 2004 revealed that adolescents and youth were more strongly influenced by their peers in risky decision-making.²⁸ Adolescents and youth are likely concerned about social values and eager to accommodate the behaviours of their peer group.³⁰

Surprisingly, more than 70% of respondents accepted that e-smoking in public spaces is illegal, but e-cigarette use in schools was still reported. This situation affected higher odds of e-cigarette use among those who reported the availability of e-cigarettes in schools. This finding is consistent with previous studies, which found higher odds of e-cigarette users who live in areas with the availability of e-cigarettes.^{10 14} The higher prevalence of current e-cigarette use in college/university students in this study may relate to the autonomy among college and university students. In Thailand, college and university students are considered adults; therefore, their families do not strictly monitor their daily-life practices. This finding implies that these groups would benefit from future e-cigarette control measures to prevent increased use. Although the protective effect of signs warning that e-cigarettes are banned was not statistically significant, it draws attention to the need to reinforce institution-based policy for e-cigarette bans.

This institution-based cross-sectional study revealed that vocational schools, colleges and universities have a high prevalence of e-cigarette use, likely related to the institutional social context and norm. The institution-based policy of e-cigarette bans should be reinforced, especially in vocational schools, universities and colleges.

The odds of e-cigarette use increase among youth closely connected with current e-cigarette users. The need to prevent increasing e-cigarette use among early-age youth is crucial. E-cigarette literacy programmes should be integrated into all ecological levels that impact e-cigarette use, including the intrapersonal, interpersonal, school and community levels. Additionally, this study found that the online market is the primary source of e-cigarettes among youth. Media, information and digital literacy should be enhanced among youth early on. Finally, the government should provide online innovative health risk communications about e-cigarettes to counter misinformation that e-cigarette use is harmless and to reinforce Thailand's e-cigarette regulations that ban online marketing and sales.

This study had several strengths, such as the sizeable institution-based survey covering public and private school students from three main educational types in Thailand. Additionally, we used an internet-based anonymous self-administered questionnaire that encouraged students to report their current cigarette use.

This study had some limitations. First, we did not identify a temporal-causal relationship between

e-cigarette use and related factors. Second, we conducted this study during the COVID-19 pandemic; the prevalence of e-cigarette use may be underestimated because most social places were closed. One limitation was the prevalence estimation because we needed more population information to use inverse-weight probability to compensate for cluster sampling. Although cluster sampling might reduce the variability of the samples in each region, the combination of 54 clusters from various regions generated national-level results. Additionally, Thailand's formal education institutions comply with the standard educational framework of the Ministry of Education that produce similar context of educational institution in certain types across the region. Moreover, we used GEE to determine related factors to e-cigarette use that provide less bias with less bias estimation of ORs for cluster sampling.³¹

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