

Adolescent Use of and Susceptibility to Heated Tobacco Products

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abstract

BACKGROUND AND OBJECTIVES: A leading brand of heated tobacco products (HTPs), IQOS, was authorized to be sold in the United States in 2019. Researchers have examined the awareness and use of HTPs among US adults. In this study, we examined high school students' awareness, use, and susceptibility pertaining to HTPs.

METHODS: A large, cross-sectional population survey of randomly sampled 10th- and 12th-graders in California ($N = 150\,516$) was conducted online during school hours from September 2019 to March 2020.

RESULTS: Overall, 8.9% (95% confidence interval [CI], 8.7%–9.1%) of California high school students had heard of HTPs. Approximately 0.67% (95% CI, 0.61%–0.73%) had ever tried HTPs, and 0.20% (95% CI, 0.17%–0.23%) were current users (ie, ~30% of ever users continued to use HTPs at the time of survey). Among those who never tried HTPs, 18.3% (95% CI, 17.9%–18.8%) were susceptible to future use. The susceptibility to HTP use was greater among users of cigarettes or e-cigarettes than among nonusers.

CONCLUSIONS: The awareness of HTPs among adolescents was remarkable given the low availability of products at the time of survey. Only a small percentage of adolescents experimented with HTPs. However, almost a third of those who had experimented with HTPs continued to use them. This high ratio and the fact that almost 1 out of 5 never users were susceptible to future HTP use should put the public health community on high alert as more HTP products are coming into the market, with promotion of these products likely to increase.

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WHAT'S KNOWN ON THIS SUBJECT: The awareness and use of heated tobacco products (HTPs) among US adults have been studied both before and after a leading brand, IQOS, received premarket tobacco product application authorization in 2019. Little is known about its impact on adolescents.

WHAT THIS STUDY ADDS: Approximately 9% of California high school students had heard of HTPs. Among those who had tried HTPs, 30% continued to use HTPs at the time of survey. Among those who had not tried HTPs, 18% were susceptible to future use.

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Cigarette smoking among US adolescents has declined significantly in the last decade.¹ However, the decrease in smoking has been accompanied by a dramatic increase in e-cigarette use.² The use of e-cigarettes among US high school students increased from 1% in 2011 to 27.5% in 2019.^{3,4} The product design for e-cigarettes has gone through several generations but always with a plethora of flavors.⁵ E-cigarettes are now the most prevalent tobacco product used by adolescents,⁶ although their popularity seems to have declined in 2020.^{7,8}

A new line of tobacco products, however, is ready to compete for adolescents' attention: heated tobacco products (HTPs).^{7,9} HTPs, which generate nicotine-containing aerosols by heating tobacco instead of burning it, have already gained some recognition among US adults.^{10–12} With novel and slick exterior designs, many HTPs are also flavored.^{13,14} Currently, only 1 brand of HTPs, IQOS, has obtained premarket tobacco product application (PMTA) authorization from the US Food and Drug Administration (FDA).¹⁵ With its PMTA authorization, IQOS can be legally sold in the United States. The distribution of IQOS so far is still limited, mainly in 2 municipalities: Atlanta, Georgia, and Richmond, Virginia.^{16,17} However, there are online outlets and resellers that sell IQOS to US residents. HTPs have been successful in several markets outside of the United States.^{18–20} Three tobacco companies dominate these markets: Philip Morris International (PMI), Japan Tobacco International (JTI), and British American Tobacco (BAT).^{20,21} In addition to IQOS, BAT's Glo and JTI's Ploom Tech (known as Logic Vapeleaf in the United States.)²² have been found in the United

States, although they have no PMTA authorization from the FDA.

Researchers have found that 5% to 12% of American adults were aware of HTPs and that some adults have tried them.^{10–12} The level of awareness of HTPs among adolescents appeared to be similar to that of adults before IQOS' PMTA authorization.^{23,24} No study, however, has examined the awareness or usage of HTPs among adolescents after IQOS received its PMTA authorization.

The current study investigated the awareness and usage of HTPs among adolescents after IQOS' PMTA authorization. For students who had tried HTPs, the study assessed the proportion who continued to use these products. For those who had not tried them, it examined their susceptibility to using HTPs in the future. Susceptibility to trying particular tobacco products has been shown to be a useful monitoring strategy.²⁵ Because HTPs have not yet become widely available in the United States, the susceptibility measure could serve as a warning sign. Toward these objectives, we analyzed the data from the most recent California Student Tobacco Survey (CSTS) (2019–2020), a survey with >150 000 high school student participants.

METHODS

Design and Participants

This study used data from the 2019–2020 cycle of the CSTS, an ongoing school-based survey that provides statewide estimates of tobacco use among middle and high school students in California. The CSTS used a two-stage cluster sampling design, in which school was the primary sampling unit and classroom was the secondary sampling unit. The high schools and

middle schools (eighth-graders) were sampled separately. This study included high schools only. The sampling design for high schools first divided the state into 35 regions. Eligible schools in each region were then randomly sampled. Public and nonsectarian schools were eligible. Special education, juvenile court, district and/or county community, continuation, or other alternative schools were not sampled. Within each high school, only 10th- and 12th-graders were sampled.

The 2019–2020 CSTS approached a random sample of 608 schools, and 482 agreed to participate (79.3%). Among these, 358 schools completed the survey (74.3%) between September 2019 and March 2020. A total of 162 675 students in 8th, 10th, and 12th grades participated, with an overall student response rate of 68.3%. The current analyses included data from 311 high schools (47 middle schools were excluded). A total of 150 516 10th- and 12th-graders answered the HTP-related questions in the survey (Table 1). The CSTS was administered online during class time. Participation was voluntary. The study was approved by the University of California San Diego Human Research Protections Program, Institutional Review Board 170787.

Measures

To add clarity, pictures and descriptions of all tobacco products were presented before any question was asked. Students who answered yes to having ever smoked cigarettes were considered ever smokers. Students who answered yes to vaping nicotine or just flavoring were considered ever e-cigarette users.

For HTPs, the questionnaire used the term “heat-not-burn,” which is another common name for these

TABLE 1 Prevalence of Having Heard of HTPs Among High School Students, 2019–2020 CSTS

	Total <i>N</i> = 150 516 % (95% CI)	Never Used Cigarettes or E-cigarettes <i>n</i> = 110 880 % (95% CI)	Ever Used E-cigarettes Only <i>n</i> = 29 857 % (95% CI)	Ever Used Cigarettes <i>n</i> = 9369 % (95% CI)
Overall	8.9 (8.7–9.1)	8.4 (8.2–8.6)	8.3 (7.9–8.8)	16.6 (15.5–17.7)
Sex				
Male	9.2 (8.8–9.5)	8.5 (8.1–8.8)	9.2 (8.6–9.8)	16.8 (15.3–18.4)
Female	8.3 (8.0–8.6)	8.3 (8.0–8.7)	7.2 (6.6–7.7)	12.3 (10.9–13.7)
Other	13.5 (12.2–14.9)	9.7 (8.1–11.2)	15.4 (12.8–18.0)	28.7 (24.4–33.1)
Undisclosed	10.3 (9.1–11.4)	7.5 (6.3–8.6)	10.2 (8.0–12.5)	29.6 (23.3–35.9)
Race and/or ethnicity				
NH-white	9.6 (9.2–10.0)	9.3 (8.8–9.7)	7.8 (7.1–8.5)	17.1 (15.0–19.2)
NH-Black	7.9 (6.9–9.0)	7.2 (6.1–8.3)	9.5 (6.6–12.4)	17.3 (11.0–23.5)
Hispanic	8.9 (8.6–9.2)	8.5 (8.1–8.8)	8.5 (7.8–9.1)	15.5 (14.2–16.9)
NH-Asian	7.2 (6.8–7.7)	7.0 (6.5–7.5)	7.3 (6.4–8.2)	15.2 (11.7–18.7)
NH-other	9.1 (8.0–10.1)	7.7 (6.4–9.0)	8.5 (6.7–10.2)	20.9 (16.8–25.0)
NH-multiple	10.1 (9.4–10.7)	9.6 (8.8–10.3)	8.8 (7.6–10.1)	18.2 (15.4–21.0)
Grade				
Grade 10	9.4 (9.1–9.7)	8.9 (8.6–9.2)	9.5 (8.8–10.1)	18.2 (16.3–20.0)
Grade 12	8.3 (8.0–8.6)	7.8 (7.4–8.1)	7.4 (6.9–7.9)	15.6 (14.4–16.8)

NH-white, non-Hispanic white; NH-Black, non-Hispanic Black or African American; NH-Asian, non-Hispanic Asian; NH-other, non-Hispanic other (including American Indian or Alaskan native, Native Hawaiian, or other Pacific Islander); NH-multiple, non-Hispanic multiple race and/or ethnicity.

products. The students were first presented with a picture of one HTP, with the following description: “Heat-not-burn tobacco products use an electronic device to heat tobacco sticks (heat-sticks) or capsules instead of burning it. They may also be called heated tobacco products. They are different from vapes. Popular brands include IQOS, Glo, and Ploom Tech.” Then, students were asked, “Before today, have you heard of heat-not-burn tobacco products?”

Those who answered yes were asked, “Where did you last hear about heat-not-burn tobacco products?” Eight

response options were presented (see [Table 2](#)). The use of HTP was assessed with 2 questions, starting with “Have you ever used a heat-not-burn tobacco product?” Those who answered yes were then asked, “Have you used a heat-not-burn tobacco product in the last 30 days?” Students who had used HTPs in the last 30 days were asked, “What brand of heat-not-burn tobacco product do you use most often?” Students could choose 1 of 9 options: Glo, iFuse, IQOS, Jouz, Lil, Logic Vapeleaf, Pax, Ploom Tech, and other.

To reduce false-positives, only those current users who identified a

known HTP brand were considered to have used HTP. Those who chose brand Pax (8% of self-reported current HTP users) were excluded because Pax is a vaporizer designed for vaping marijuana only. Those who chose other were also excluded (~30% of self-reported current HTP users).

The susceptibility of HTPs was assessed with a single question, “If one of your best friends offered you a heat-not-burn tobacco product, would you use it?” Responses were on a 4-point Likert scale, from “definitely yes” to “definitely not.” Any response other than definitely

TABLE 2 Sources From Which High School Students Have Heard of HTPs, 2019–2020 CSTS

Source of Information	Total <i>N</i> = 13 549 % (95% CI)	Never Used Cigarettes or E-cigarettes <i>n</i> = 9396 % (95% CI)	Ever Used E-cigarettes Only <i>n</i> = 2512 % (95% CI)	Ever Used Cigarettes <i>n</i> = 1615 % (95% CI)
Internet or social media (eg, Snapchat, Instagram, or YouTube)	39.1 (38.1–40.1)	41.7 (40.4–42.9)	35.9 (33.8–38.0)	28.8 (25.8–31.8)
A friend or someone else	32.5 (31.4–33.6)	29.1 (27.9–30.3)	40.4 (37.7–43.2)	40.4 (36.8–43.9)
Television or streaming service (eg, Netflix, Hulu, or Amazon Prime)	9.3 (8.4–10.3)	10.3 (9.2–11.3)	8.2 (6.3–10.1)	5.6 (3.7–7.6)
Other	7.0 (6.4–7.6)	6.8 (6.1–7.5)	5.2 (4.2–6.3)	10.3 (8.6–12.0)
Store (eg, convenience store, smoke shop, or vape shop)	5.8 (5.3–6.2)	5.8 (5.2–6.4)	5.1 (4.2–5.9)	6.6 (5.3–7.9)
Bus stop or billboard	2.9 (2.5–3.3)	3.0 (2.5–3.6)	2.3 (1.7–2.9)	3.0 (2.2–3.8)
Radio or music streaming service (eg, Spotify, Pandora, or SoundCloud)	1.9 (1.6–2.2)	1.9 (1.5–2.3)	1.6 (1.0–2.2)	2.6 (1.7–3.5)
Magazine	1.6 (1.3–1.8)	1.4 (1.1–1.7)	1.3 (0.7–1.8)	2.7 (1.9–3.5)

not was defined as susceptible in this analysis.²⁵

Analyses

All estimates were weighted by the school enrollment data from the California Department of Education. Point estimates and their 95% confidence intervals (CIs) were computed.²⁶ We also calculated the proportion of HTP “continued use” given that participants had tried it. All analyses were performed by using SAS software version 9.4 (SAS Institute, Inc, Cary, NC).²⁷ The estimates for prevalence are presented with 2 decimal points because these values are small (Table 3).

RESULTS

Table 1 presents the awareness of HTPs among 150 516 high school student survey participants. Overall, 8.9% of students reported having heard of HTPs. Awareness differed by whether the participants had smoked cigarettes. Those who had never used cigarettes or e-cigarettes (8.4%) and those who had only used e-cigarettes (8.3%) had heard of HTPs. For those who had tried cigarettes, approximately twice as many (16.6%) had heard of HTP.

Students who identified their sex as other than male or female (13.5%) were more likely to have heard of HTPs than those who identified as

male (9.2%) or female (8.3%). White students and students of multiple ethnicities had the highest awareness, with Asian students having the lowest (7.2%). Students in 10th grade (9.4%) were more likely to have heard of HTPs than 12th-graders (8.3%). Within each demographic dimension, those who had tried cigarettes consistently had greater awareness than those who had not.

Table 2 shows the sources from which students last heard about HTPs. Overall, Internet or social media (39.1%) was the most frequently mentioned source of having heard of HTPs. A friend or

TABLE 3 Prevalence of Ever and Current Use of HTPs Among High School Students, 2019–2020 CSTS

	Total % (95% CI)	Never Used Cigarettes or E-cigarettes % (95% CI)	Ever Used E-cigarettes Only % (95% CI)	Ever Used Cigarettes % (95% CI)
Ever use	<i>N</i> = 150 560	<i>n</i> = 110 909	<i>n</i> = 29 862	<i>n</i> = 9374
Overall	0.67 (0.61–0.73)	0.11 (0.08–0.14)	1.30 (1.13–1.47)	5.22 (4.65–5.80)
Sex				
Male	0.59 (0.51–0.67)	0.10 (0.07–0.12)	1.19 (0.96–1.41)	4.63 (3.74–5.51)
Female	0.48 (0.42–0.53)	0.09 (0.05–0.13)	1.11 (0.93–1.29)	3.34 (2.70–3.98)
Other	3.30 (2.63–3.97)	0.52 (0.00–1.04)	4.96 (3.34–6.58)	13.54 (10.38–16.69)
Undisclosed	1.81 (1.37–2.25)	0.22 (0.03–0.41)	2.28 (1.15–3.40)	12.52 (8.98–16.06)
Race and ethnicity				
NH-white	0.65 (0.54–0.75)	0.07 (0.03–0.10)	0.94 (0.72–1.16)	4.58 (3.58–5.57)
NH-Black	0.72 (0.41–1.02)	0.19 (0.00–0.44)	1.33 (0.52–2.14)	9.34 (4.08–14.60)
Hispanic	0.67 (0.59–0.75)	0.13 (0.09–0.16)	1.39 (1.13–1.65)	4.94 (4.15–5.73)
NH-Asian	0.37 (0.27–0.46)	0.08 (0.02–0.13)	1.12 (0.71–1.53)	4.94 (2.76–7.12)
NH-other	1.09 (0.80–1.39)	0.05 (0.00–0.12)	1.49 (0.78–2.20)	8.19 (5.64–10.75)
NH-multiple	0.70 (0.54–0.87)	0.07 (0.02–0.12)	1.39 (0.94–1.84)	5.10 (3.48–6.71)
Grade				
Grade 10	0.58 (0.51–0.66)	0.08 (0.06–0.11)	1.43 (1.19–1.68)	5.74 (4.60–6.89)
Grade 12	0.76 (0.68–0.84)	0.14 (0.10–0.18)	1.18 (1.00–1.37)	4.90 (4.21–5.59)
Current use	<i>n</i> = 15 0551	<i>n</i> = 11 0908	<i>n</i> = 29 858	<i>n</i> = 9370
Overall	0.20 (0.17–0.23)	0.01 (0.00–0.02)	0.26 (0.20–0.32)	2.24 (1.82–2.65)
Sex				
Male	0.14 (0.09–0.20)	0.00 (0.00–0.00)	0.20 (0.11–0.28)	1.58 (0.84–2.32)
Female	0.09 (0.07–0.12)	0.01 (0.00–0.03)	0.16 (0.10–0.22)	0.93 (0.56–1.29)
Other	1.89 (1.46–2.32)	0.06 (0.00–0.15)	1.83 (0.99–2.67)	10.19 (7.64–12.73)
Undisclosed	0.94 (0.64–1.23)	0.04 (0.00–0.10)	1.14 (0.18–2.09)	7.10 (4.62–9.57)
Race and ethnicity				
NH-white	0.12 (0.08–0.16)	0.00 (0.00–0.01)	0.15 (0.05–0.25)	1.01 (0.59–1.44)
NH-Black	0.32 (0.15–0.48)	0.02 (0.00–0.06)	0.53 (0.00–1.06)	5.86 (2.25–9.48)
Hispanic	0.21 (0.16–0.26)	0.01 (0.00–0.03)	0.26 (0.19–0.34)	2.40 (1.73–3.07)
NH-Asian	0.06 (0.03–0.10)	0.01 (0.00–0.02)	0.12 (0.01–0.23)	1.48 (0.63–2.34)
NH-other	0.44 (0.26–0.63)	—	0.35 (0.00–0.70)	3.99 (2.24–5.74)
NH-multiple	0.25 (0.16–0.35)	—	0.39 (0.16–0.61)	2.47 (1.30–3.63)
Grade				
Grade 10	0.19 (0.14–0.25)	0.01 (0.00–0.03)	0.33 (0.23–0.43)	2.71 (1.75–3.68)
Grade 12	0.21 (0.17–0.25)	0.01 (0.00–0.02)	0.20 (0.13–0.27)	1.94 (1.53–2.35)

NH-white, non-Hispanic white; NH-Black, non-Hispanic Black or African American; NH-Asian, non-Hispanic Asian; NH-other, non-Hispanic other (including American Indian or Alaskan native, Native Hawaiian, or other Pacific Islander); NH-multiple, non-Hispanic multiple race and/or ethnicity; —, not applicable.

someone else (32.5%) was the second. When these categories are combined, more than two-thirds (71.6% = 39.1% + 32.5%) of students reported having heard of HTPs from the Internet or from someone they knew. The remaining one-third had heard of HTPs from various sources: television (9.3%), store (5.8%), bus stop or billboard (2.9%), radio or music streaming (1.9%), magazine (1.6%), and other (7.0%).

The source of information appears to differ by students' tobacco use status. Internet or social media was the number one source mentioned by students who had never used cigarettes or e-cigarettes (41.7%). Among those who had used e-cigarettes or cigarettes, however, the most frequently mentioned source of information was a friend or someone else (40.4%), whereas Internet or social media ranked second.

Table 3 presents the prevalence of ever use and current use of HTPs. The top half shows the results on ever use. Overall, 0.67% of students reported having ever used an HTP. Among those who had never used cigarettes or e-cigarettes, only 0.11% had tried HTPs. However, among students who had tried e-cigarettes (but not cigarettes), 1.30% had tried HTPs. For those who had ever smoked cigarettes, 5.22% had tried HTPs.

The prevalence of ever use of HTPs varies by demographic variables. However, the variation across demographic variables is much smaller than the variation across tobacco use status (ie, whether the students had already tried e-cigarettes or cigarettes).

The bottom half of Table 3 shows the current use of HTPs. Overall, 0.20% of students reported having used an HTP in the last 30 days.

Among those who had never smoked cigarettes or used e-cigarettes, only 0.01% had used an HTP in the last 30 days. However, among students who had ever used e-cigarettes (but not cigarettes), 0.26% were current users. Among those who had ever smoked cigarettes, 2.24% were current users. Again, these differences across tobacco use status are much greater than the variation across demographic variables.

Students who reported having used HTPs in the last 30 days were asked about the brands they used most often. Among the students who were able to identify a known HTP brand, the top 3 brands were Logic Vapeleaf, iFuse, and Jouz (see Table 4). Logic Vapeleaf (name used in the United States) and Ploom Tech (name used in Japan) are identical products²²; both are owned by JTI.²⁸ If they were combined, the proportion would be 31.6% (24.8% + 6.8%). Similarly, iFuse is a modified version of Glo,²⁹ with both owned by BAT. The combined proportion is 29.1% (19.1% + 10.0%). Jouz and IQOS are devices that use Marlboro HeatSticks^{30,31} owned by PMI. Thus, their combined proportion is 25.8% (17.0% + 8.8%). Finally, 13.5% of students who used HTPs in the last 30 days indicated they used Lil, owned by Korea Tobacco & Ginseng Corporation.³²

Table 5 presents 2 statistics. The first row shows the continuation ratio (the proportion of those who

were still using HTPs at the time of survey among those who had ever tried one). Overall, 30.2% of students who had ever used HTPs were current users (ie, had used HTPs in the last 30 days). The ratio was 9.9% among those who had never tried cigarettes or e-cigarettes. It increased to 20.0% among those who had ever used e-cigarettes (but not cigarettes) and 42.8% among those had ever tried cigarettes.

The second row showed susceptibility among those who had never tried HTPs but were susceptible to it. Overall, 18.3% of never-using HTP participants were susceptible to future HTP use. Approximately 11.2% of those who had never tried cigarettes or e-cigarettes were susceptible. Susceptibility increased to 35.5% among students who had ever used e-cigarettes only. For those who had ever tried cigarettes, almost half (49.4%) were susceptible to future HTP use.

DISCUSSION

In this study, we found that ~9% of California high school students reported having heard of HTPs. Some (~0.67%) had even tried HTPs. Among the brands reported by the current users, 87% were affiliated with the top 3 tobacco companies: PMI, BAT, and JTI.

The limited number of brands for HTP contrasts with the large number of brands for

TABLE 4 Brands of Current Use of HTPs Among High School Students, 2019–2020 CSTS

Tobacco Company	Brand	Total, N = 314 % (95% CI)
JTI	Logic Vapeleaf	24.8 (3.0–18.9)
	Ploom Tech	6.8 (1.8–3.2)
BAT	Glo	10.0 (1.8–6.5)
	iFuse	19.1 (2.3–14.6)
PMI	iQOS	8.8 (1.7–5.4)
	Jouz ^a	17.0 (5.0–7.1)
Korea Tobacco & Ginseng Corporation	Lil	13.5 (2.1–9.3)

^aJouz uses Marlboro HeatSticks owned by PMI, but Jouz is not owned by PMI.

TABLE 5 Continuation Ratio Among Ever Users and Susceptibility Among Never Users, 2019–2020 CSTS

	Total % (95% CI)	Never Used Cigarettes or E-cigarettes % (95% CI)	Ever Used E-cigarettes Only % (95% CI)	Ever Used Cigarettes % (95% CI)
HTP ever user	<i>N</i> = 1031	<i>n</i> = 109	<i>n</i> = 395	<i>n</i> = 526
Continuation ratio	30.2 (26.3–34.1)	9.9 (3.2–16.6)	20.0 (15.5–24.5)	42.8 (36.8–48.8)
HTP never user	<i>N</i> = 149 464	<i>n</i> = 110 761	<i>n</i> = 29 454	<i>n</i> = 8837
Susceptibility	18.3 (17.9–18.8)	11.2 (10.9–11.6)	35.5 (34.8–36.3)	49.4 (47.5–51.4)

e-cigarettes.^{5,33} Compared with e-cigarettes, HTPs are more difficult to manufacture and are owned mainly by large tobacco companies. These companies have released HTPs under a small number of brands.²⁰ Early generations of HTPs (such as Eclipse) were sold sporadically in the 1990s and 2000s.^{34–36} New HTPs introduced after August 8, 2016, the date of FDA's deeming regulations for tobacco products,³⁷ can only be legally sold in the United States after receiving their PMTA authorization from the FDA. To date, only iQOS had received its PMTA authorization (in April 2019). The other brands reported by users had no PMTA authorization.

The current survey was conducted from September 2019 to March 2020. This was after IQOS received PMTA authorization. However, the authorization did not seem to have an immediate impact on the awareness of HTPs among adolescents. Surveys that preceded the PMTA authorization revealed that 9% to 13% of adolescents were aware of HTPs.^{23,24} This study found 9% awareness. In fact, the prevalence of HTP use (0.67%) found in this study was lower than that reported in an earlier 2019 National Youth Tobacco Survey (2.4%).²⁴ One explanation is that the current study had a stricter definition of HTP use: this survey asked respondents for the brands they used; those whose reported brands mismatched with known HTP products were coded as non-HTP users.

Given that promotion for HTP was still limited to date, the fact that 9% of high school students had already heard about HTPs is remarkable. Social media were a key source of information. Promotion on social media was likely initiated by HTP users themselves, although some content might have been sponsored.^{14,38}

Interestingly, the levels of HTP awareness and use among California high school students in this 2019–2020 survey were similar to those for US adults found in a recent national survey, conducted from November 2019 to February 2020.¹² The cited study revealed that 8% of American adults had heard of HTPs, 0.55% had tried HTPs, and 0.10% were current users.¹² In other words, ~7% of the adults who had heard of HTPs experimented with them (0.55/8 = 6.8%). The current study found a similar percentage: among those who had heard of HTPs, 7.4% (0.67/9 = 7.4%) reported having experimented with these products.

However, the adolescents appeared to differ from the adults in the likelihood of continuing to use the products once they had experimented with them. For adults, the cited study revealed that 18% of those who had tried HTPs were still current users at the time of survey.¹² For adolescents in the current study, ~30% of experimenters continued to use the products at the time of survey (Table 5). This continuation ratio for HTPs among adolescent

experimenters resembles the continuation ratio for adolescent e-cigarette experimenters, 36%, as shown from another CSTS.³⁹

It appears, therefore, that HTP could be attractive to adolescents. Similarity to e-cigarette is concerning given the recent dramatic uptake of e-cigarettes among adolescents. Currently, the promotion of HTPs is still limited. With more advertising for HTPs, more adolescents will learn of these new products and may experiment with them.^{40–42} A new product, IQOS3, received its PMTA authorization in December 2020.⁴³ As such, promotion for a series of IQOS products may increase significantly in the near future.

A subgroup of adolescents may be particularly at risk if advertising of HTPs or the availability of new products increases. Nearly 1 in 5 (18%) students who had never used an HTP were susceptible to future use, as measured by openness to a friend's offering of the product (Table 5). Given the strong peer influence on adolescents' tobacco use,⁴⁴ the risk of increased HTP initiation could be high if these products become widely promoted.

Not surprisingly, the susceptibility to HTPs was even higher among those students who had already experimented with e-cigarettes or cigarettes. For those who had experimented with cigarettes, almost half of them were susceptible to using HTPs (Table 5). There are

personal characteristics that render certain subgroups more liable for drug use than others.⁴⁵ The students who have already used some tobacco products, such as e-cigarettes or cigarettes, are more likely to possess those characteristics associated with a higher propensity to use similar tobacco products, such as HTPs, in the future.⁴⁶ In previous studies, researchers have found that tobacco users are more interested in a novel tobacco product compared with nontobacco users.² With this study, we confirm previous research in finding that students who have used e-cigarettes or cigarettes are much more susceptible to using HTPs.

Although those who had never tried e-cigarettes or cigarettes were less susceptible to future HTP use, the risk was still substantial at 11%. Moreover, this group is the largest subgroup, consisting of 74% of all students. Prevention strategies need to be developed to reduce adolescents' chance of experimenting with HTPs because the risk of becoming regular users is substantial once the students have experimented with them.

This study is limited in that it only inquired about HTPs with a few questions. For example, the relative

risk perception of these new products compared with e-cigarettes was not assessed. The study is also limited in that it is a cross-sectional survey, making it difficult to assess the time course of behavior change. For example, although it is logically clear that students have to be aware of the products before they will experiment with them and that they will first have to experiment before becoming regular users, it is difficult to accurately assess the timing of these transitions without a longitudinal design. It is possible that some of the current HTP users only started to experiment with the product in the last 30 days before the survey, which would have inflated the computation of the continuation ratio. Finally, the survey was conducted with students in the state of California. The results may not generalize to other states.

CONCLUSIONS

This study, based on a large representative sample, found that 9% of high school students were aware of HTPs despite their restricted market availability. A small number of students had even experimented with HTPs. More importantly, 30% of experimenters

continued to use HTPs. In addition, a significant proportion of students appear to be susceptible to using these attractively designed products in the future. The public health community needs to monitor HTP developments, especially related promotional activities, and the impact they may have on youth.

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ABBREVIATIONS

BAT: British American Tobacco
CI: confidence interval
CSTS: California Student Tobacco Survey
FDA: Food and Drug Administration
HTP: heated tobacco product
PMTA: premarket tobacco product application
PMI: Philip Morris International
JTI: Japan Tobacco International

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