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Heated tobacco product use and associated factors among U.S. youth, 2019

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ABSTRACT

Background: In April 2019, the U.S. Food and Drug Administration authorized the marketing of IQOS Heated Tobacco Products (HTPs) in the United States. This study sought to assess self-reported awareness and use of HTPs among U.S. students in 2019.

Methods: This study analyzed the 2019 National Youth Tobacco Survey (NYTS), a cross-sectional, school-based, nationally representative survey ($n = 19,018$). Weighted estimates of the prevalence of self-reported awareness, ever use, and current use (past 30-day) of HTPs were reported and multivariable logistic regression models were performed to examine the factors associated with HTPs awareness and use.

Results: In 2019, 12.8 % (a population estimate of 3,438,000), 2.4 % (632,000), and 1.6 % (425,000) of U.S. students reported awareness, ever use, and current use of HTPs, respectively. In the multivariate analysis, high school students were less likely than middle school students to report awareness (AOR = 0.7 [0.6–0.8]) of HTPs. Females (vs. males) had a lower odd of reporting ever use of HTPs (AOR = 0.5 [0.4–0.8]), while Hispanics (vs. non-Hispanic Whites) had higher odds of reporting current use of HTPs (AOR = 1.6 [1.1–2.5]). Current cigarette smoking, e-cigarette use, and other tobacco use are associated with higher odds of HTPs ever and current use than non-users.

Conclusions: HTP use is emerging among U.S. adolescents. This study identified an elevated risk of HTP use among middle school students, Hispanics, current tobacco users, and those who live with a household member using HTPs. Continuous surveillance and educational campaigns on the harmfulness of HTPs are warranted.

1. Introduction

As the global sales of combustible cigarettes have been declining since 2000 (Campaign for Tobacco-Free Kids, 2020), the tobacco industry is rapidly marketing new products, including heated tobacco products (HTPs), to generate new revenues (Bialous and Glantz, 2018). HTPs, also called heat-not-burn products, generally heats dry tobacco to produce nicotine-containing aerosols for users to inhale (Auer et al., 2017). Tobacco companies, including Philip Morris International (PMI), British American Tobacco (BAT), and Japan Tobacco International (JTI), has been using “harm reduction” and product innovation as marketing strategies to promote HTPs across many countries (Bialous and Glantz, 2018). For instance, since the launch of IQOS in December 2014, PMI has been heavily marketing HTPs in an increasing number of countries, including Canada, Japan, Korea, Italy, France, and Germany (Philip Morris International, 2020).

In April 2019, the Food and Drug Administration (FDA) authorized the marketing of IQOS HTPs in the United States (The Food and Drug

Administration, 2019). Given the recent introduction of IQOS in the US market, the knowledge on the awareness and use of HTPs in the US is very limited. Nyman et al. (Nyman et al., 2018) reported that the awareness of HTPs was 12.4 % among US adults, and the ever use and current use of HTPs were 2.4 % and 1.1 % in 2017, respectively. Czoli et al. (Czoli et al., 2020) analyzed the 2017 International Tobacco Control Youth Tobacco and E-cigarette survey to estimate that 9.4 % of U.S. youths aged 16–19 years old reported awareness of IQOS. However, to the best of our knowledge, no studies have reported the prevalence of HTP use among U.S. adolescents. Since a key component in claiming harm reduction is to measure the impact of new tobacco products on adolescents and to assess whether the new product will influence the initiation of that product among youth (The Food and Drug Administration, 2009), it is important to monitor the HTPs awareness and use among U.S. adolescents.

Since HTP use heat to vaporize tobacco below the combustion point to produce nicotine-containing aerosols, these products are in the line between combustible cigarettes and e-cigarettes. HTPs contain toxic

Abbreviations: HTPs, heated tobacco products; CI, confidence interval; AOR, adjusted odds ratio; NYTS, National Youth Tobacco Survey; NH, non-hispanic

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constituents that resemble those in traditional cigarettes, while the delivery mechanism through aerosol resembles that of e-cigarettes (Czoli et al., 2020). Therefore, HTPs may be appealing to current cigarette smokers and e-cigarette users. Furthermore, tobacco marketing and social context (e.g., family members using tobacco products) are causally related to youth tobacco use (U.S. Department of Health and Human Services, 2012, 2016). It is critically needed to understand HTP use by tobacco use status and other correlates so that strategies could be developed to prevent youth from using HTPs.

To address these gaps in knowledge, this study used data from the 2019 National Youth Tobacco Survey (NYTS) to assess self-reported awareness and use of HTPs among U.S. middle and high students in 2019. I further reported the population estimates of HTP use and examined the risk factors associated with HTPs awareness and use.

2. Data and methods

2.1. Data

The National Youth Tobacco Survey (NYTS) is a cross-sectional, school-based survey conducted annually since 2011 to provide national data on estimates of youth tobacco product use. The 2019 NYTS was conducted using a stratified, 3-stage cluster sampling procedure to produce a nationally representative sample of U.S. middle school (6–8 grades) and high school (9–12 grades) students. Primary sampling units (PSU), defined as a county, a group of small counties, or part of a very large county, were randomly selected within each stratum. Secondary sampling units including schools within each selected PSU, were randomly selected within each PSU (The Centers for Disease Control and Prevention, June 2019). Classes within each school were randomly selected at the final sampling stage. Parental consent and student assent were required for NYTS participation. Student participation was anonymous and voluntary.

In 2019, the final sample consisted of 325 schools, of which 251 participated, yielding a school response rate of 77.2 % (or refusal rate of 22.8 %). A total of 19,018 student questionnaires were completed out of a sample of 22,153 students, yielding a student response rate of 85.8 %. The overall response rate was 66.3 %. A detailed description of the 2019 NYTS survey design, questionnaire, and data collection can be found on the NYTS website (The Centers for Disease Control and Prevention, June 2019). Given the use of public data with de-identified information, this study is exempt by the University of Nebraska Institutional Review Board (IRB).

2.2. Measures

2.2.1. HTPs awareness and use

Students were provided instruction that “The next section is about “heated tobacco products”. Some people refer to these products as “heat-not-burn” tobacco products. “Heated tobacco products” heat tobacco sticks or capsules to produce a vapor. They are different from e-cigarettes, which heat a liquid to produce a vapor. Some brands of “heated tobacco products” include iQOS, glo, and Eclipse.” Self-reported awareness of heated tobacco products was defined as an affirmative response to the question “Before today, have you heard of “heated tobacco products”?” with the response options “Yes,” “No,” and “Don’t know/Not Sure.” Ever use of heated tobacco products was defined as an affirmative response to the question “Have you ever tried a “heated tobacco product”, even just one time?” with the response options “Yes,” “No,” and “Don’t know/Not Sure.” Current use of heated tobacco products was defined as those who responded ≥ 1 day to the question “During the past 30 days, on how many days did you use a heated tobacco product?”

2.2.2. Tobacco use status

E-cigarette use status was defined as *never* (students who reported having never tried an e-cigarette), *former* (students who reported

having ever tried an e-cigarette but having not used it in the last 30 days), and *current* (students who reported having used an e-cigarette ≥ 1 day in the past 30 days) (Dai and Hao, 2016). Similarly, I defined the status of cigarette smoking and other tobacco use as *never*, *former* and *current*. Other tobacco products include cigars (cigars, little cigars, and cigarillos), smokeless tobacco (chewing tobacco, snuff, dip, snus, and dissolvable tobacco), hookahs, pipe tobacco, or bidis and those who reported currently using any of these products were defined as current other tobacco users.

2.2.3. Exposure to tobacco marketing and tobacco use by household members

Exposure to e-cigarette marketing was measured by four items: “When you are using the Internet, how often do you see ads or promotions for e-cigarettes?” “When you read newspapers or magazines, how often do you see ads or promotions for e-cigarettes?” “When you go to a convenience store, supermarket, or gas station, how often do you see ads or promotions for e-cigarettes?” and “When you watch TV, or streaming services (such as Netflix, Hulu, or Amazon Prime), or go to the movies, how often do you see actors and actresses using e-cigarettes?” Four dichotomous variables were created to measure the channels of exposure to e-cigarette advertising: the Internet, newspapers/magazines, stores, and TV/streaming services/movies with 0 including response options of “I don’t use,” “Never,” “Rarely,” and 1 including response options of “Sometimes,” “Most of the time,” and “Always.” The number of exposures from multiple channels was further summed as exposure from 0, 1, 2+ types of channels. I also created a similar variable to measure the exposure to cigarette and other tobacco marketing.

Tobacco use by other household members was defined as “none,” “other tobacco product use” (non-HTPs tobacco use) and “HTPs” by the multiple-choice question “Does anyone who live with you now...? (CHOOSE ALL THAT APPLY)” with the following response options: “Smoke cigarettes,” “Smoke cigars, cigarillos, or little cigars,” “Use chewing tobacco, snuff, or dip,” “Use electronic cigarettes or e-cigarettes,” “Smoke tobacco from a hookah or waterpipe,” “Smoke pipes filled with tobacco (not waterpipes),” “Use snus,” “Use dissolvable tobacco products,” “Smoke bidis (small brown cigarettes wrapped in a leaf),” “Use heated tobacco products,” and “No one who lives with me now uses any form of tobacco.”

2.2.4. Covariates

Several demographic variables were included in the analysis, such as age categorized as 9–12, 13–15, 16–17, and 18+, sex (male or female), race/ethnicity (non-Hispanic white, non-Hispanic black, Hispanic, or non-Hispanic others), and school level (middle or high school).

2.2.5. Statistical methods

Weighted estimates and 95 % confidence intervals (CI) of the prevalence of awareness, ever use, and current use (past 30-day) HTPs were reported using the Taylor series variance estimation, overall and stratified by demographic factors and tobacco use status. Rao-Scott Chi-Square test was used to detect significant differences among groups. Sampling weights and survey strata were included in the analyses to account for the complex survey design. Population estimates of the number of youth reporting awareness, ever and current use of HTPs were calculated at the national level. Separate multivariable logistic regression models were performed to examine the factors associated with HTPs awareness and use (dependent variables), where independent variables included demographics (sex, grade, race/ethnicity), tobacco use status (cigarettes, e-cigarettes, other tobacco), exposure to cigarette/other tobacco marketing, exposure to e-cigarette marketing, and tobacco use by a household member. Adjusted ORs (AOR) were calculated in the multivariable analysis. Statistical analyses were performed using SAS 9.4 (Cary, NC) and p-values < 0.05 were

Table 1

Heated Tobacco Product (HTP) Use among U.S. Middle and High School Students, 2019 National Youth Tobacco Survey (n = 19,018).

	2019		Awareness of HTPs		Ever Use of HTPs		Current Use of HTPs	
			% (95% CI) ^a	P-value ^b	% (95% CI) ^a	P-value ^b	% (95% CI) ^a	P-value ^b
Overall	19,018	100	12.8 (11.6 to 14.0) ^c		2.4 (1.5 to 3.2) ^d		1.6 (1.2 to 1.9)	
Sex				0.1134				0.2595
Male	9,803	52.0 (50.4 to 53.7)	13.6 (11.6 to 15.5)		3.0 (1.5 to 4.6)		1.7 (1.3 to 2.1)	
Female	9,099	48.0 (46.3 to 49.6)	11.9 (11.1 to 12.8)		1.6 (1.3 to 2.0)		1.4 (1.0 to 1.8)	
Age Group				< .0001				0.066
9-12	3,951	19.2 (17.2 to 21.2)	14.9 (13.6 to 16.2)		1.2 (0.7 to 1.7)		1.1 (0.7 to 1.5)	
13-15	8,481	44.4 (42.7 to 46.2)	13.1 (12.0 to 14.2)		2.2 (1.7 to 2.8)		1.6 (1.2 to 1.9)	
16-17	5,050	27.9 (25.5 to 30.3)	12.2 (9.7 to 14.8)		3.4 (1.2 to 5.7)		1.8 (1.2 to 2.5)	
18+	1,498	8.5 (7.5 to 9.5)	8.6 (6.4 to 10.8)		2.2 (1.4 to 3.1)		2.1 (1.3 to 2.9)	
School Level				< .0001		0.0002		0.1487
Middle School	8,837	44.1 (39.8 to 48.3)	14.2 (13.2 to 15.2)		1.7 (1.3 to 2.0)		1.4 (1.0 to 1.8)	
High School	10,097	55.9 (51.7 to 60.2)	11.7 (9.8 to 13.6)		2.9 (1.5 to 4.3)		1.7 (1.3 to 2.2)	
Race / Ethnicity				< .0001				0.0354
NH-white ^e	9,351	56.2 (51.7 to 60.7)	12.8 (11.5 to 14.0)		2.3 (1.5 to 3.2)		1.3 (1.0 to 1.7)	
NH-black	2,430	13.3 (10.5 to 16.2)	12.2 (10.8 to 13.5)		2.0 (1.2 to 2.8)		1.8 (1.2 to 2.4)	
Hispanic	5,564	25.0 (21.8 to 28.1)	13.0 (10.8 to 15.2)		2.9 (1.4 to 4.3)		2.1 (1.5 to 2.7)	
Others	1,227	5.5 (4.4 to 6.6)	12.4 (10.1 to 14.8)		1.4 (0.6 to 2.3)		1.2 (0.3 to 2.1)	
Any Tobacco Use				0.1268				< .0001
Never	11,516	59.5 (57.1 to 61.9)	11.9 (11.1 to 12.8)		0.3 (0.2 to 0.4)		0.3 (0.2 to 0.4)	
Former	3,304	17.5 (16.2 to 18.9)	13.7 (9.9 to 17.5)		3.4 (0.4 to 6.4)		0.2 (0.0 to 0.3)	
Current	4,198	23.0 (21.4 to 24.6)	14.4 (12.3 to 16.4)		6.8 (5.2 to 8.4)		6.0 (4.6 to 7.4)	
Cigarette Smoking				< .0001				< .0001
Never	16,061	83.7 (81.5 to 86.0)	11.6 (10.9 to 12.3)		0.9 (0.7 to 1.0)		0.8 (0.6 to 1.0)	
Former	2,161	12.0 (10.4 to 13.5)	17.1 (12.3 to 21.8)		7.4 (3.2 to 11.6)		2.0 (1.3 to 2.7)	
Current	748	4.3 (3.4 to 5.2)	24.3 (18.1 to 30.5)		17.4 (11.3 to 23.4)		16.0 (10.7 to 21.4)	
E-cigarette Use				0.5702				< .0001
Never	12,563	65.2 (63.0 to 67.3)	12.3 (11.5 to 13.2)		0.5 (0.4 to 0.7)		0.5 (0.4 to 0.7)	
Former	2,720	14.8 (13.5 to 16.1)	13.2 (8.6 to 17.8)		4.3 (0.5 to 8.0)		0.3 (0.1 to 0.4)	
Current	3,627	20.0 (18.5 to 21.5)	14.1 (12.1 to 16.1)		6.8 (5.2 to 8.4)		6.0 (4.4 to 7.5)	
Other Tobacco Use				< .0001				< .0001
Never	15,220	79.1 (76.7 to 81.4)	11.5 (10.9 to 12.2)		0.7 (0.5 to 0.8)		0.6 (0.4 to 0.7)	
Former	2,219	12.1 (10.7 to 13.6)	16.7 (11.8 to 21.7)		6.8 (2.6 to 11.0)		1.7 (1.0 to 2.5)	
Current	1,579	8.8 (7.7 to 9.9)	18.9 (15.3 to 22.5)		11.5 (8.7 to 14.4)		10.7 (8 to 13.4)	
Exposure to Cig/Tobacco Marketing				< .0001				0.0005
No	3,391	18.3 (17.2 to 19.3)	8.9 (7.6 to 10.1)		2.2 (1.4 to 3.0)		1.2 (0.8 to 1.7)	
1	6,392	34.8 (33.6 to 36.0)	10.9 (9.8 to 11.9)		1.3 (1.0 to 1.6)		0.9 (0.6 to 1.2)	
2+	8,417	46.9 (45.2 to 48.5)	15.7 (13.8 to 17.5)		2.9 (1.4 to 4.4)		1.8 (1.3 to 2.3)	
Exposure to E-cigarette Marketing				< .0001				< .0001
No	5,830	31.0 (29.5 to 32.5)	9.3 (8.0 to 10.5)		1.8 (1.2 to 2.5)		1.1 (0.7 to 1.4)	
1	4,778	25.8 (24.9 to 26.8)	11.4 (10.2 to 12.5)		1.7 (1.1 to 2.2)		1.1 (0.7 to 1.5)	
2+	7,721	43.1 (41.8 to 44.4)	16.1 (14.2 to 18.0)		2.9 (1.5 to 4.4)		2.0 (1.5 to 2.6)	
Tobacco Use by Household Members				< .0001				< .0001
None	11,265	59.7 (57.2 to 62.2)	11.6 (10.5 to 12.8)		1.4 (0.8 to 1.9)		0.9 (0.7 to 1.1)	
Other Tobacco Products	6,963	39.2 (36.7 to 41.6)	13.5 (12.2 to 14.9)		3.0 (1.9 to 4.0)		2.0 (1.5 to 2.5)	
Heated Tobacco Products	204	1.1 (0.9 to 1.4)	43.1 (32.2 to 54.1)		28.2 (17.3 to 39.2)		22.2 (14.0 to 30.5)	

^a Weighted estimates and 95 % CI were reported by taking the complex survey design (sampling weight and stratum) into account using the Taylor series variance estimation.

^b Rao-Scott Chi-Square test was used to detect significant differences among groups.

^c Awareness of HTPs was measured by a three-level category variable with “Don’t know/Not Sure” (22.5 %), “No” (64.7 %), and “Yes” (12.8 %).

^d Ever use of HTPs was measured by a three-level category variable with “Don’t know/Not Sure” (10.0 %), “No” (87.7 %), and “Yes” (2.4 %).

^e NH: non-Hispanic.

considered statistically significant.

3. Results

Table 1 presents the sample characteristics of the 2019 NYTS data as well as HTPs awareness and use among U.S. middle and high school students. This study (n = 19,018) included 48.0 % female, 55.9 % high school students, 56.2 % non-Hispanic (NH) Whites, 13.3 % NH Blacks, and 25.0 % Hispanics, 23.0 % current any tobacco users, 20.0 % current e-cigarette users, 4.3 % current cigarette smokers, and 8.8 % other tobacco users. Exposure to tobacco marketing was common among adolescents with 81.7 % of respondents reporting exposure to cigarette/other tobacco marketing (1 or 2+) and 69.0 % reporting exposure to e-cigarette marketing. There were 1.1 % of students living with a household member who uses HTPs and 39.2 % living with someone who uses other tobacco products.

As shown in Table 1, 12.8 % (95 %CI [11.6 %–14.0 %]) of U.S. students reported awareness of HTPs in 2019. Older adolescents were less likely than younger adolescents to report having heard of HTPs. For instance, 11.7 % [9.8 %–13.6 %] of high school students reported awareness of HTPs comparing to 14.2 % [13.2 %–15.2 %] of middle school students. Current tobacco users were more likely to report awareness of HTPs than never users. Those who reported multiple channels of exposure to tobacco marketing (vs. no exposure) were more likely to have heard of HTPs than those who reported no exposure.

Overall, 2.4 % [1.5 %–3.2 %], and 1.6 % [1.2 %–1.9 %] of U.S. students reported ever use and current use of HTPs, respectively. Males (vs. females) and high school (vs. middle school) were more likely to report ever use but not current use of HTPs. Current tobacco users were more likely than former or never users to report HTP use. For instance, 17.4 % [11.3 %–23.4 %] of current cigarette smokers reported ever use of HTPs, in comparison with 7.4 % [3.2 %–11.6 %] of former smokers

Table 2Population Estimates of Heated Tobacco Product (HTP) Use among U.S. Middle and High School Students, 2019 National Youth Tobacco Survey (n = 19,018)^a.

Characteristics	Weighted N (,000)	Awareness of HTPs		Ever Use of HTPs		Current Use of HTPs	
		Weighted N (,000)	%	Weighted N (,000)	%	Weighted N (,000)	%
Overall	27,011	3,438	100%	632	100%	425	100%
School Level							
Middle School	11,860	1,679	49%	195	31%	165	39%
High School	15,045	1,751	51%	434	69%	258	61%
Cigarette Smoking							
Never	22,562	2,608	76%	195	31%	178	42%
Former	3,229	549	16%	237	38%	65	15%
Current	1,152	276	8%	198	31%	181	43%
E-cigarette Use							
Never	17,512	2,149	63%	94	15%	94	22%
Former	3,980	525	15%	170	27%	10	2%
Current	5,377	754	22%	365	58%	317	75%

^a Population estimates of the number of youth reporting awareness, ever and current use of HTPs were calculated at the national level.

and 0.9 % [0.7 %–1.0 %] of never smokers. There were 6.0 % [4.4 %–7.5 %] of current e-cigarette users who reported current use of HTPs, in comparison with 0.3 % [0.1 %–0.4 %] of former users and 0.5 % [0.4 %–0.7 %] of never users. Students who live with a household member using HTPs reported the highest prevalence of ever (28.2 % [17.3 %–39.2 %]) and current (22.2 % [14.0 %–30.5 %]) use of HTPs.

Table 2 presents the population estimates of youth awareness and use of HTPs in the United States in 2019. Overall, about 3438,000 U.S. middle and high students reported awareness of HTPs, including 1679,000 middle school students, 2608,000 never cigarette smokers, and 2149,000 never e-cigarette users. Approximately 632,000 and 425,000 U.S. students reported ever and current use of HTPs, respectively. The number of current HTP users were similarly distributed across never vs. current cigarette smokers (178,000 vs. 181,000) but predominantly among current e-cigarette users (75 % of total HTP users).

The factors associated with HTPs awareness and use in the multi-variable models were presented in Table 3. High school students were less likely than middle school students to report awareness (AOR = 0.7[0.6–0.8]) and current use (AOR = 0.5[0.4–0.7]) of HTPs. Females (vs. males) had lower odds of reporting ever use of HTPs (AOR = 0.5[0.4–0.8]), while Hispanics (vs. non-Hispanic Whites) had higher odds of reporting current use of HTPs (AOR = 1.6[1.1–2.5]).

Current tobacco use is associated with higher odds of HTPs ever and current use. For instance, current cigarette smokers (AOR = 2.9[1.6–4.9]) and current e-cigarette users (AOR = 5.5[3.0–9.9]) were more likely to report current use of HTPs, in contrast to never users.

4. Discussion

In recent years, a new generation of HTPs, including IQOS, has been developed with a sleek design and the claim of harm reduction. After a debut with new marketing and promotion strategies, IQOS has generated extensive consumer interest and market growth (Bialous and Glantz, 2018). For instance, since the launch of IQOS in Japan in November 2014, it had quickly captured 2.4 % of Tokyo's market share for tobacco over 6 months (Jenssen et al., 2018). 19.5 % of Italian respondents aged ≥15 years reported awareness of IQOS in a 2017 survey where IQOS has been available since 2014 (Liu et al., 2019) and 2.8 % of South Korean adolescents reported ever use of HTPs one year after IQOS was launched in 2017 (Kang and Cho, 2019). This study reported that 12.8 % of U.S. adolescents were aware of HTPs in 2019 and the awareness was slightly higher than that reported in 2017 (9.1 %) (Czoli et al., 2020), suggesting that HTPs continue to gain awareness among U.S. adolescents. Though IQOS was only authorized to market in the U.S. during the survey period (February 15, 2019 – May 24, 2019

(The Centers for Disease Control and Prevention, 2020) and it was not launched until October 2019 in the U.S. market (Churchill et al., 2019), RJ Reynolds received a substantial equivalence approval by the FDA for their HTP, Eclipse in 2018 (The Food and Drug Administration, 2018). Other HTPs may have influenced the estimates of awareness and use of HTPs reported in this study. Concerns have been raised that IQOS packaging resembles iPhones and other popular smartphones, and HTPs were released in sleek flagship stores that appear similar to high-end technology brand stores (Jenssen et al., 2018; McKelvey et al., 2018). This study found that the awareness of HTPs was higher among middle school students (14.2 %) than high school students (11.7 %). One plausible reason is that the similarity in appearance of HTPs to the popular electronic device may increase appeal to adolescents, especially among younger teens. Another possible reason is that HTPs are new tobacco products that have been recently introduced in the United States, there is the potential for adolescents to misclassify HTPs with other tobacco products like e-cigarettes, especially among younger adolescents. Future surveys may consider including product images in instructions provided to participants and continuous surveillance of youth awareness of this emerging tobacco product is warranted.

This study is the first to report the prevalence of HTP use among U.S. adolescents in a nationally representative sample, with 2.4 % and 1.6 % of U.S. students reporting ever and current use of HTPs in 2019, respectively. These statistics are as high as those reported in a 2017 U.S. adult study (2.2 % and 1.1 %, respectively) (Nyman et al., 2018). Though the use of HTPs was still uncommon among U.S. adolescents, our prevalence estimates translate to 425,000 adolescents currently using HTPs in 2019, including 178,000 never smokers and 65,000 former smokers. Given that youth are traditionally targeted by tobacco marketing (U.S. Department of Health and Human Services, 2012) and the prevalence of current IQOS use increased dramatically from 0.6 % in 2015 to 2.0 % in 2017 among Japanese youths aged 15–19 years old following a popular TV show in April 2016 (Tabuchi et al., 2018), the use of HTPs among U.S. youth could increase rapidly with IQOS now becoming commercially available. HTPs contain many toxic constituents and cause nicotine addiction (Bialous and Glantz, 2018). It is concerning that the early adopters of HTPs in this study sample included a similar proportion of never cigarette smokers and current smokers. Educational campaigns on the harmfulness of HTPs and evidence-based strategies to prevent youth use of HTPs are needed.

This study further identified risk factors associated with HTP use with elevated risks among middle school students, Hispanics, current tobacco users, and those who live with a household member using HTPs. For instance, Hispanic students were 1.6 times more likely than non-Hispanic youths to report current use of HTPs and current e-cigarette users were over 5 times more likely to be current HTP users than never e-cigarette users. Nicotine exposure in adolescence can harm

Table 3

Factors Associated with Heated Tobacco Product (HTP) Use among U.S. Middle and High School Students, 2019 National Youth Tobacco Survey (n = 19,018).

Characteristics	Awareness of HTPs		Ever Use of HTPs		Current Use of HTPs	
	AOR ^a	P-value	AOR ^a	P-value	AOR ^a	P-value
Sex						
Male	Reference		Reference		Reference	
Female	0.8 (0.7–1.0)	0.0178	0.5 (0.4–0.8)	0.0040	1.0 (0.7–1.5)	0.9725
School Level						
Middle School	Reference		Reference		Reference	
High School	0.7 (0.6–0.8)	< .0001	0.7 (0.5–1.0) ^b	0.0683	0.5 (0.4–0.7) ^c	0.0002
Race/Ethnicity						
NH-white ^d	Reference		Reference		Reference	
NH-black	1.0 (0.8–1.2)	0.7631	1.1 (0.7–1.7)	0.7704	1.4 (0.9–2.2)	0.1485
Hispanic	1.1 (0.9–1.3)	0.3144	1.2 (0.9–1.7)	0.2611	1.6 (1.1–2.5)	0.0213
Others	1.1 (0.9–1.4)	0.3035	1.0 (0.5–2.2)	0.9705	1.7 (0.6–4.3)	0.2950
Cigarette Smoking						
Never	Reference		Reference		Reference	
Former	1.5 (1.1–1.9)	0.0073	2.6 (1.4–4.6)	0.0023	0.9 (0.5–1.5)	0.6789
Current	2.2 (1.4–3.2)	0.0003	4.3 (1.9–9.8)	0.0007	2.9 (1.6–4.9)	0.0003
E-cigarette Use						
Never	Reference		Reference		Reference	
Former	0.9 (0.7–1.1)	0.2587	4.1 (2.6–6.5)	< .0001	0.4 (0.1–1.0)	0.0570
Current	0.7 (0.5–0.9)	0.0074	4.0 (2.2–7.0)	< .0001	5.5 (3.0–9.9)	< .0001
Other Tobacco Use						
Never	Reference		Reference		Reference	
Former	1.5 (1.2–2.0)	0.0036	4.0 (2.6–6.3)	< .0001	1.9 (1.0–3.5)	0.0461
Current	1.5 (1.1–2.0)	0.0045	4.3 (2.7–6.7)	< .0001	5.2 (2.8–9.5)	< .0001
Exposure to Cigarette and OtherTobacco Marketing						
No	Reference		Reference		Reference	
1	1.1 (0.9–1.3)	0.5183	0.6 (0.4–0.9)	0.0110	0.9 (0.5–1.6)	0.6238
2+	1.4 (1.1–1.7)	0.0019	1.2 (0.7–2.0)	0.5130	1.2 (0.7–1.9)	0.5363
Exposure to E-cigarette Marketing						
No	Reference		Reference		Reference	
1	1.1 (0.9–1.4)	0.1851	0.7 (0.5–1.1)	0.1250	1.0 (0.6–1.7)	0.9112
2+	1.7 (1.4–2.0)	< .0001	1.1 (0.7–1.5)	0.7791	1.5 (0.9–2.4)	0.1123
Tobacco Use by Household Members						
None	Reference		Reference		Reference	
Other Tobacco Products	1.0 (0.9–1.2)	0.6811	1.0 (0.8–1.3)	0.8548	1.0 (0.7–1.5)	0.8325
Heated Tobacco Products	5.8 (3.5–9.8)	< .0001	11.7 (6.3–21.5)	< .0001	6.0 (3.2–11.2)	< .0001

^a Multivariable logistic regressions were performed to assess the factors associated with awareness, ever use, and current use of heated tobacco products, where all listed factors, including demographics (sex, grade, race/ethnicity), tobacco use status (cigarettes, e-cigarettes, other tobacco), exposure to cigarette/other tobacco marketing, exposure to e-cigarette marketing, and tobacco use by household member were covariates. For the awareness and ever use of heated tobacco products, those who responded “No” served as the reference group.

^b OR = 1.8 95 % CI (1.2–1.8). Due to the multicollinearity of school level and e-cigarette use as well as the overlapping between HTP use and e-cigarette use, the direction was inverted and AOR became insignificant after adjusted for e-cigarette use.

^c OR = 1.2 95 % CI (0.9–1.7). Due to the multicollinearity of school level and e-cigarette use as well as the overlapping between HTP use and e-cigarette use, the direction was inverted after adjusted for e-cigarette use.

^d NH: non-Hispanic.

brain development and tobacco use at an early age is associated with increased risk of addiction and use of marijuana and other substances (Taioli and Wynder, 1991; U.S. Department of Health and Human Services, 2012, 2014). It worth noting that current HTP users were predominantly among current e-cigarette users. Future studies are needed to assess whether the dual use of HTPs and e-cigarettes in adolescence could increase the risk of cigarette smoking and other substance use.

This study is subject to several limitations. First, the 2019 NYTS data are cross-sectional, thus the causal inference cannot be established. Second, the awareness and use of HTPs were self-reported, thus they are subject to recall and social desirability biases, especially for younger respondents (Brener et al., 2003). However, previous studies have confirmed the validity of self-reported tobacco use (Boykan et al., 2019; Caraballo et al., 2004). Third, the 2019 NYTS is a school-based survey collected from students who attended either public or private schools. The results might not be generalizable to all school-aged youths. Finally, due to a small sample size of current HTP use, I did not report the frequency of HTPs. Future studies should examine the correlates of HTP use frequency.

5. Conclusion

Despite these limitations, this study reported an emerging trend of HTPs awareness and use among U.S. middle and high school students. As the tobacco industry projects a rapid increase in marketing and production of HTPs, marketing regulations and comprehensive tobacco control strategies are needed to prevent HTPs from enticing a new generation of youth users.

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This is not a clinical trial.

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HD had full access to all the data in the study and takes responsibility for the integrity of the data. HD conceptualized the study, acquired the data, performed the analyses, interpreted the results, drafted the manuscript, critically reviewed and revised the manuscript.

Declaration of Competing Interest

The author has no conflicts of interest to disclose.

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