

Original Investigation

Characterizing Heated Tobacco Product Use Among Adult Cigarette Smokers and Nicotine Vaping Product Users in the 2018 ITC Four Country Smoking & Vaping Survey

Connor R. Miller MS^{1,*}, Edward Sutaranto MD^{1,*}, Danielle M. Smith PhD¹, Sara C. Hitchman PhD², Shannon Gravely PhD³, Hua-Hie Yong PhD^{4,5}, Ron Borland PhD^{5,6}, Richard J. O'Connor PhD¹, K. Michael Cummings PhD⁷, Geoffrey T. Fong PhD^{3,8,9}, Andrew Hyland PhD¹, Anne C.K. Quah PhD³, Maciej L. Goniewicz PhD¹

¹Department of Health Behavior, Roswell Park Comprehensive Cancer Center, Buffalo, NY, USA; ²Department of Addictions, Institute of Psychiatry, Psychology & Neuroscience, King's College London, London, UK; ³Department of Psychology, University of Waterloo, Waterloo, ON, Canada; ⁴School of Psychology, Deakin University, Geelong, VI, Australia; ⁵Cancer Council Victoria, Melbourne, VI, Australia; ⁶School of Psychological Sciences, University of Melbourne, Melbourne, VI, Australia; ⁷Department of Psychiatry and Behavioral Sciences, Medical University of South Carolina, Charleston, SC, USA; ⁸School of Public Health and Health Systems, University of Waterloo, Waterloo, ON, Canada; ⁹Ontario Institute for Cancer Research, Toronto, ON, Canada

Corresponding Author: Connor R. Miller, MS, Department of Health Behavior, Division of Cancer Prevention and Population Sciences, Roswell Park Comprehensive Cancer Center, Elm and Carlton Streets, Buffalo, NY 14263, USA. Telephone: 716-645-1300 ext. 4278; E-mail: connor.miller@roswellpark.org

*These authors have contributed equally to this work.

Abstract

Introduction: Heated tobacco products (HTP) have diversified global tobacco markets, and user characteristics remain understudied. This study evaluated sociodemographic characteristics, nicotine-related perceptions, and behaviors of current HTP users within a sample of adult (18+ years) nicotine users across four countries.

Aims and Methods: Data were from current smokers or nicotine vaping product (NVP; known as “e-cigarettes”) users from Canada, England, the United States, and Australia ($n = 11\,421$) who participated in the 2018 ITC Four Country Smoking and Vaping Survey. Current (at-least-monthly) HTP users were characterized ($n = 441$), and weighted multivariable logistic regressions examined correlates of HTP use.

Results: Compared to nonusers, current HTP users were younger (mean age: 44.4 vs 31.0 years; $p < .001$) and had higher socioeconomic status ($p < .001$). A majority of current HTP users used HTPs nondaily (daily: 40.3% vs nondaily: 59.7%). Most HTP users concurrently used both cigarettes and NVPs (90.5%). Among concurrent cigarette-HTP-NVP users, 36.2% used all three products daily. Use of other combusted tobacco products (cigars, cigarillos, pipe, waterpipe/hookah), cannabis, and binge drinking were each associated with current HTP use. HTP use was more common among smokers intending to quit within 6 months or reporting a quit attempt in the past 18 months, and vapers who had experienced negative side effects.

Conclusion: HTP users in this sample tended to be younger and more affluent. Most reported concurrent use of multiple nicotine products and other substances. Those cigarette smokers who used HTPs appeared more interested in smoking cessation, while some characteristics of concurrent HTP-NVP users were suggestive of dissatisfaction with NVPs.

Implications: Few studies have scrutinized characteristics of HTP early adopters in emerging markets. Our results indicate that in 2018, characteristics of established nicotine users who adopted HTP use in four high-income Western countries mirror those of HTP users in East Asian markets (South Korea and Japan) where HTPs are popular. HTP users reported high levels of concurrent use of noncigarette-combusted tobacco products (e.g., cigars, pipe tobacco). These findings point to the need for future longitudinal studies of HTP use given the implications of those use patterns on the harm reduction potential of HTPs. HTP user characteristics may yield important information to consider in regulation of these products.

Introduction

Heated tobacco products (HTPs) are electronic devices that heat tobacco to produce a nicotine-containing aerosol. HTPs differ from conventional cigarettes, which combust tobacco at higher temperatures, and from nicotine vaping products (NVPs; commonly known as e-cigarettes), which aerosolize liquids that contain nicotine but no tobacco.¹ While contemporary HTP brands are thought of as novel tobacco products, HTP technology dates back decades to products such as Accord (Philip Morris) and Eclipse (RJ Reynolds). Early-generation HTPs were commercially unsuccessful due to a number of factors, including poor nicotine delivery, lack of positive sensory experience, relatively high price, and difficulty of use.²

Marked by the launch of IQOS by Philip Morris International in 2014, a new generation of HTPs have emerged in numerous tobacco markets.^{3–6} IQOS was followed by competing HTPs from British American Tobacco (glo), Japan Tobacco International (Ploom/Ploom TECH), and Korean Tobacco & Ginseng (lil). Since their introduction, contemporary HTPs have increased in popularity in East Asian markets such as South Korea and Japan, where HTPs comprised 11% (South Korea) and 23% (Japan) of national tobacco sales in 2019.^{7,8} HTPs have yet to capture significant market share in many other regions, although recent upticks in awareness of HTPs have been observed in less-established markets such as the United States (US), England, and several European Union countries.^{9,10}

Manufacturers have marketed HTPs as less harmful alternatives to cigarettes due to a lack of combustion, although there is evidence of partial pyrolysis during IQOS operation.^{11,12} Independent reviews of research studies have concluded that HTPs emit lower toxicant concentrations than cigarettes,^{13,14} and industry-funded studies have reported reduced serum levels of biomarkers of exposure in cigarette smokers who switched completely to HTPs.^{15–17} In July 2020, the US Food and Drug Administration authorized Philip Morris International to market IQOS as a modified-exposure product relative to conventional cigarettes.¹⁸ However, risk-benefit assessments should not only consider relative risks versus cigarettes but also NVPs, as NVPs produce less toxic emissions than HTPs.^{19–21}

Any potential harm reduction role for HTPs hinges on the characteristics of users in the real world. There are concerns that HTPs may appeal to tobacco-naïve individuals, as has been the case with NVPs in some countries.^{22,23} Studies from Japan have observed higher levels of HTP use among younger adults.²⁴ Japanese adults who use HTPs tend to be those who are male, of higher socioeconomic status, and those who also consume alcohol.^{24,25} Whereas past 30-day HTP use by youth appears nominal (less than 1.0%) in Japan thus far,²⁶

some concerns have arisen in South Korea, where an estimated 7.8% of 12th-grade males reported past 30-day HTP use in 2019.²⁷ Poly-tobacco use patterns also differ between the countries based on product availability in the retail marketplace. Concurrent use of HTPs and cigarettes is common in Japan, where NVPs are rare due to stringent regulations,^{28,29} while concurrent use of cigarettes, HTPs, and NVPs is common in South Korea.³⁰

Detailed assessments of HTP user characteristics and use behaviors have been limited outside of Japan and South Korea. Previously, we examined prevalence of awareness, trial, and current use of HTPs in 2018 among adult cigarette and/or NVP users in Canada, England, US, and Australia, observing high prevalence of poly-tobacco use among those using HTPs.³¹ In this paper, we extend our prior work by examining sociodemographic characteristics (age, sex, ethnicity, country of residence, and socioeconomic status) and product/substance use patterns of current (at-least-monthly) HTP users from the same 2018 study cohort. We also explore associations between current HTP use and smoking-specific characteristics (e.g., cigarettes consumption pattern, quit intentions, opinions toward cigarettes) among the subsample of current cigarette smokers and vaping-specific characteristics (e.g., NVP consumption pattern, NVP device subtype preferences, NVP harm perceptions) among the subsample of current NVP users (vapers).

Methods

Survey Participants

The International Tobacco Control (ITC) Four Country Smoking and Vaping Survey is an ongoing cohort study designed to be representative of adult (18+ years) current smokers, former smokers, and current vapers in Canada, England, US, and Australia.³² The Wave 1 (2016) sample consisted of some continuing participants from the precursor ITC Four Country cohort studies (22%),³³ while the rest were newly-recruited as current smokers (100+ cigarettes smoked lifetime, currently smoke on a monthly basis), recent former smokers (100+ cigarettes smoked lifetime, quit in the past 24 months), and/or current weekly vapers. At Wave 2 (2018), HTP-related questions were added to the survey. Data collection for Wave 2 occurred between February and July 2018, with 45.2% retention of Wave 1 respondents (those lost to follow-up were replenished using similar criteria as Wave 1). Additional methodological details can be found in the technical report.³⁴ Results reported in this manuscript are from cross-sectional analyses of Wave 2 data.

The sampling strategy for Wave 2 did not target exclusive HTP users, and there were only two respondents who met our definition for current HTP use (described below) that were not also using cigarettes and/or NVPs at-least-monthly. Therefore, we excluded respondents who were neither current (at-least-monthly) cigarette smokers nor current (at-least-monthly) vapers from our analytic sample ($n = 1566$). Contemporary HTPs, such as IQOS, have been retailed in England since December 2016 and Canada since April 2017, while IQOS only entered the US in April 2019 and is effectively banned in Australia.³¹ Thus, at the time of survey, HTPs were available for purchase (primarily in metropolitan regions) in Canada and England, while they were not yet formally marketed in the US nor Australia.

Measures

Current HTP Use

Respondents were classified as current HTP users if they self-reported current HTP use at-least-monthly and selected a known HTP device brand from a subsequent dropdown list. The second criterion was designed to reclassify respondents who may have confused HTPs with other products (i.e., NVPs, cannabis vaporizers). Among the 11 421 respondents comprising the main sample, 501 self-reported current-at-least-monthly HTP use, of whom 60 selected “do not know”, “other”, or refused to provide the HTP device brand that they used, leaving 441 respondents who selected a listed HTP device brand (Supplementary Figure S1).

Sociodemographic Factors & Non-HTP Substance Use

Sociodemographic factors included age, sex, ethnicity, country of residence, and socioeconomic status (SES). Ethnicity was dichotomized as “majority” (Canada/US/England = white; Australia = English speaking) or “minority”. SES was derived from three-level education and income variables (low, moderate, high) that accounted for country-specific differences in currency and education systems.³⁵ Respondents in the “high” category for either education or income were classified as having “high” SES; remaining respondents in the “low” category for either education or income were classified as having “low” SES, and the rest were classified as having “moderate” SES (those who responded “do not know” or “refused” for both variables were coded as missing).

Current cigarette and NVP use status (defined as at-least-monthly current product use) were classified as a composite variable into three mutually exclusive groups (“current smoker [not current vaper]”, “current vaper [not current smoker]”, “concurrent cigarette-NVP user”). Past 30-day use of noncigarette-combusted tobacco was ascertained for cigars, cigarillos, pipe tobacco, and waterpipe/hookah/shisha. Those who responded affirmatively for any combusted tobacco product other than cigarettes were classified as past 30-day non-cigarette combusted tobacco users, and a numeric variable was derived for the number of non-cigarette combusted tobacco products used. Past 30-day cannabis use was further classified into smoking cannabis and vaping cannabis (Supplementary Table S1 presents these categories of cannabis use). Those who reported having 6 or more alcoholic drinks on a single occasion on an at-least-monthly basis were classified as monthly binge drinkers.

Smoking-Specific Characteristics

We examined smoking-specific characteristics in three categories:

1. Cigarette consumption and dependence were examined by evaluating smoking intensity among daily smokers (cigarettes per day), time-to-first cigarette among weekly smokers (“How soon after waking do you usually smoke your first cigarette?”) and urges to smoke in the past 24 hours among all current smokers (“In general, how strong have urges to smoke been in the last 24 hours?”). Time-to-first cigarette was dichotomized to “ ≤ 5 minutes” or “ > 5 minutes”.³⁶
2. Quit intentions and efficacy were assessed with responses to the questions “Are you planning to quit smoking cigarettes...in the next 6 months?” and “If you decided to give up smoking completely in the next 6 months, how sure are you that you would succeed?” among current smokers, who were also dichotomized according to whether they reported a smoking quit attempt in the past 18 months.
3. Attitudes and experiences of current smokers were examined with “What is your overall opinion of smoking cigarettes?”, “To what extent, if at all, has smoking cigarettes damaged your health?”, and “How worried are you, if at all, that smoking cigarettes WILL damage your health in the future?”. Supplementary Table S1 contains further details regarding variable operationalization.

Vaping-Specific Characteristics

We examined vaping-specific characteristics in two categories:

1. NVP consumption and dependence were examined by evaluating time-to-first vape among daily vapers by the question “How soon after waking do you usually have your first vape (i.e. puff on your e-cigarette)?”, while all current vapers were asked “Do you plan to keep on vaping, or do you plan to stop using sometime in the foreseeable future?”.
2. User preferences and satisfaction among current vapers was assessed with “How much do you enjoy using e-cigarettes or vaping devices?” and “How satisfying is vaping (using e-cigarettes), compared to smoking ordinary cigarettes”. Harm perceptions were assessed with “Compared to smoking cigarettes, how harmful do you think vaping (using e-cigarettes) is?” and “How worried are you that using e-cigarettes or vaping devices WILL damage your health in the future?”. We also evaluated responses to the question “Have you experienced any negative side effects of using e-cigarettes that concerned you?”, and current vapers indicated their preferred vaping device subtype (refillable tank; disposable; prefilled cartridges). Supplementary Table S1 contains further details regarding variable operationalization.

Statistical Analyses

Sociodemographic and non-HTP substance use characteristics were presented as frequencies and unweighted percentages or mean and standard deviation. Analyses were stratified by current HTP use status and further examined the current HTP user subsample according to [1] daily and nondaily HTP use, [2] country of residence, [3] sex, and [4] age (18–24 versus 25+ years). Comparisons using unweighted data across groups utilized independent t-tests or ANOVA for continuous variables and the Pearson χ^2 test or Fisher's exact test for categorical variables. To scrutinize those current HTP users who were also current smokers and current vapers (concurrent cigarette-HTP-NVP users), we derived an 8-category variable according to the frequency of using each of the three products (daily versus non-daily).

Weighted multinomial logistic regression analyses were used to compare sociodemographic characteristics of distinct patterns of current cigarette, NVP, and HTP use. An initial model classified those respondents who were not current HTP users as (1) exclusive cigarette smokers, (2) exclusive vapers, or (3) concurrent cigarette-NVP users, while the remaining respondents (i.e., all of the current HTP users) were classified according to frequency of HTP use as (4a) non-daily HTP users or (5a) daily HTP users. A second model maintained the categories for respondents who were not current HTP users, but re-classified current HTP users as either (4b) “HTP+NVP/HTP+cigarette users” (current-at-least-monthly users of HTPs and either cigarettes or NVPs, but not all three products) or (5b) concurrent cigarette-HTP-NVP users.

Weighted multivariable logistic regression models were used to evaluate associations between current HTP use and smoking-specific characteristics among the subsample of current cigarette smokers (irrespective of other product use [i.e., the analytic sample included those cigarette smokers who also used NVPs]). Similarly, associations between current HTP use and vaping-specific characteristics were evaluated among the subsample of current vapers (irrespective of other product use [i.e., the analytic sample included those vapers who also smoked cigarettes]). Individual explanatory variables of interest were introduced into separate models predicting current HTP use that controlled for sociodemographic factors and either current NVP use (in the “smoking-specific characteristic” models) or current cigarette smoking (in the “vaping-specific characteristic” models). Analyses were repeated among the subset of HTP-aware respondents (those who answered “yes” to the question “Have you heard about new electronic products that heat tobacco instead of burning it? These products use battery power to heat capsules, pods, or cigarette-like sticks that contain tobacco. These include products such as “IQOS”) and among HTP ever users (those HTP-aware respondents who answered “yes” to the question “Have you ever used one of these “heat-not-burn” products, even one time?” and selected a known HTP device brand [Supplementary Figure S1]). Stratified multivariable analyses were also conducted according to country of residence, sex, and age.

Regression models were weighted to extend generalizability of the sample to smoker and vaper populations in each of the four countries. Weights were calibrated using raking techniques in accordance with distributions of smoking and vaping status, geographic region, and sociodemographic characteristics of adult populations in the four countries, as per benchmarks from respective national surveillance systems.^{32,37} All analyses were conducted in SAS version 9.4 (SAS Institute Inc. 2013, Cary, NC). All tests were two-tailed and considered significant at $p < .05$. Missing data were handled as listwise deletions; neither the overall analytic sample nor the current HTP user subsample had more than 5% missingness for variables used in analyses.

Results

Sociodemographic Characteristics

The overall sample had a mean age of 43.9 years (interquartile range: 28.0–58.0 years), 51.2% were female, and 49.9% had high SES (Table 1). Among the 441 current HTP users, 39.9% resided in England, 27.1% in Canada, 21.4% in US, and 11.7% in Australia. Current HTP users tended to be younger (31.0 vs. 44.4 years; $p < .001$), male (67.6% vs. 48.1%; $p < .001$), of minority ethnicity (32.6% vs. 14.7%; $p < .001$), and of high SES (67.5% vs. 49.3%; $p <$

.001). More than half of current HTP users used non-daily (59.7%). No significant sociodemographic differences were observed between daily and non-daily HTP users. The mean age of current HTP users in Canada (35.6 years; interquartile range: 26.0–44.0 years) was higher than in England (29.6 years; interquartile range: 22.0–34.0 years) or US (29.4 years; interquartile range: 22.0–31.5 years), and the proportion of current HTP users who were of minority ethnicity differed across countries (Canada = 45.2%; US = 41.3%; England = 25.7%) (Supplementary Table S2).

In the multinomial analyses, compared to exclusive cigarette smokers and exclusive vapers, HTP users were more likely to be younger (Table 2 and Supplementary Table S3). This was true of both daily and non-daily HTP users and of those who used HTPs with other nicotine products (cigarettes, vaping products). Compared to exclusive cigarette smokers, HTP users were also more likely to be higher SES. But compared to exclusive vapers, only daily HTP users were more likely to be higher SES.

Non-HTP Substance Use

In the overall sample, 58.3% currently smoked but did not vape, 10.0% currently vaped but did not smoke, and 31.7% concurrently smoked and vaped (Table 1). By contrast, 5.2% of current HTP users currently smoked but did not vape, 4.3% currently vaped but did not smoke, and 90.5% concurrently smoked and vaped. Of those current HTP users that concurrently smoked and vaped ($n = 399$), 80.9% were self-reported daily smokers, 67.1% daily vapers, and 42.0% daily HTP users (Figure 1). Approximately one-third (36.2%) of concurrent cigarette-HTP-NVP users reported using all three products daily.

Among all current HTP users ($n = 441$), more than three-quarters (78.4%) were past 30-day noncigarette-combusted tobacco users, and on average HTP users reported using more than one non-cigarette combusted tobacco product type (Table 1). Around one-third (34.7%) of current HTP users reported past 30-day cannabis use in general, 27.6% reported smoking cannabis, and 15.9% reported vaping cannabis (e.g., cannabis e-liquids or dry herb vaporizers). More than half (53.5%) of current HTP users were at-least-monthly binge drinkers. Current HTP users used the above products and substances more frequently compared to non-HTP users (all $p < .001$).

Smoking-Specific Characteristics

Among current smokers ($n = 10\,281$), measures of cigarette consumption and dependence did not differ according to current HTP use status (Table 3). Intentions to quit smoking within 6 months (aOR = 2.54 [1.74–3.71]) and reporting a failed quit attempt in the last 18 months (aOR = 1.60 [1.08–2.36]) were positively associated with current HTP use. Those who concurrently used HTPs have lower odds to have a negative opinion of smoking (aOR = 0.33 [0.22–0.50]) or be worried about future health damage from cigarette smoking (aOR = 0.64 [0.44–0.94]), but more likely to believe smoking had already damaged their health a great deal (aOR = 1.72 [1.06–2.78]). For both intentions to quit smoking within 6 months and reporting a failed quit attempt in the last 18 months, associations with current HTP use were significant only in the England subsample (Supplementary Table S4).

Vaping-Specific Characteristics

Among current vapers ($n = 4615$), current HTP use was positively associated with daily vaping (aOR = 2.41 [1.66–3.49]), and planning to continue to vape in the future (aOR = 1.99 [1.14–3.48]) (Table 3).

Table 1. Sociodemographic Characteristics and Substance Use Patterns of the Overall Analytic Sample and Among Current HTP Users

Characteristics	Current HTP use status*				Current HTP users		
	Overall	No	Yes	p	Non-daily	Daily	p
	(<i>n</i> = 11 421)	(<i>n</i> = 10 967)	(<i>n</i> = 441)		(<i>n</i> = 263)	(<i>n</i> = 178)	
Sociodemographics							
Age (years)	43.9 ± 16.8	44.4 ± 16.7	31.0 ± 11.8	<.001	31.8 ± 12.7	29.9 ± 10.2	.111
Sex (% female)	5844 (51.2)	5694 (51.9)	143 (32.4)	<.001	87 (33.1)	56 (31.5)	.722
Ethnicity(% minority)	1728 (15.4)	1583 (14.7)	141 (32.6)	<.001	86 (33.3)	55 (31.4)	.678
Country of residence							
Canada	3094 (27.1)	2999 (27.4)	93 (21.1)	<.001	66 (25.1)	27 (15.2)	.092
United States	2441 (21.4)	2368 (21.6)	68 (15.4)		39 (14.8)	29 (16.3)	
England	4555 (39.9)	4277 (39.0)	272 (61.7)		153 (58.2)	119 (66.9)	
Australia	1331 (11.7)	1323 (12.1)	8 (1.8)		5 (1.9)	3 (1.7)	
Socioeconomic status							
Low	3935 (34.6)	3835 (35.1)	94 (21.4)	<.001	64 (24.4)	30 (16.9)	.076
Moderate	1758 (15.5)	1706 (15.6)	49 (11.1)		32 (12.2)	17 (9.6)	
High	5681 (49.9)	5380 (49.3)	297 (67.5)		166 (63.4)	131 (73.6)	
Non-HTP substance use							
Cigarettes & NVPs†							
Current vaper (not current smoker)	1140 (10.0)	1120 (10.2)	19 (4.3)	<.001	13 (4.9)	6 (3.4)	.046
Current smoker (not current vaper)	6659 (58.3)	6628 (60.4)	23 (5.2)		19 (7.2)	4 (2.3)	
Concurrent cigarette-NVP user	3622 (31.7)	3219 (29.4)	399 (90.5)		231 (87.8)	168 (94.4)	
Non-cigarette combusted tobacco							
Used NCT in P30D (% yes)	2341 (20.7)	1997 (18.4)	341 (78.4)	<.001	194 (74.6)	147 (84.0)	.020
Number of NCT products used in P30D	0.3 ± 0.7	0.3 ± 0.6	1.4 ± 1.1	<.001	1.2 ± 1.0	1.6 ± 1.2	.002
Cannabis							
Used cannabis in P30D (% yes)	2,324 (20.9)	2171 (20.3)	149 (34.7)	<.001	80 (31.4)	69 (39.7)	.077
Smoked cannabis in P30D (% yes)	2,043 (18.4)	1921 (18.0)	118 (27.6)	<.001	64 (25.2)	54 (31.0)	.184
Vaped/vaporized cannabis in P30D (% yes)	484 (4.4)	414 (3.9)	68 (15.9)	<.001	35 (13.8)	33 (19.0)	.149
Alcohol							
At-least-monthly binge drinking (% yes)	2962 (26.6)	2726 (25.5)	230 (53.5)	<.001	129 (50.4)	101 (58.1)	.118

Data presented as *n* (%) or mean ± standard deviation, unless otherwise specified.

p values are from independent *t*-tests for continuous variables; Pearson χ^2 tests for categorical variables where all cells *n* ≥ 5; Fisher's exact test for categorical variables where any cell *n* < 5.

**n* = 13 respondents had missing data for current HTP use status.

†current use defined as currently using the product on an at-least-monthly basis.

HTP: heated tobacco product; NVP: nicotine vaping product; NCT: non-cigarette combusted tobacco; P30D: past 30 days.

Vapers who used HTPs were less likely to prefer tank vaping systems (aOR = 0.20 [0.13–0.31]). Vapers who used HTPs were more likely to find vaping equally or more satisfying than smoking (aOR = 1.53 [1.01–2.31]), less likely to perceive vaping as less harmful than smoking (aOR = 0.51 [0.35–0.74]), more likely to worry about future health damage from vaping (aOR = 2.19 [1.57–3.05]), and more likely to have experienced negative side effects of vaping (aOR = 6.52 [4.55–9.36]). The association between current HTP use and having experienced negative side effects of vaping was strongest among current vapers in England (aOR = 8.68 [5.20–14.48]), followed by the US (aOR = 6.29 [2.49–15.84]) and Canada (aOR = 3.49 [1.90–6.40]) (Supplementary Table S4). The positive association between current HTP use and vaping satisfaction relative to smoking was stronger among female vapers (Supplementary Table S5), while positive associations of current HTP use with daily vaping and planning to vape in the future were stronger among respondents 25 years and older (Supplementary Table S6).

After restricting analytic samples to respondents who had heard of HTPs, measures of association were similar but generally attenuated compared to those from the non-restricted samples (Table 3). When analytic samples were restricted to HTP ever users, the majority of associations were not statistically significant.

Discussion

Understanding who is using HTPs and how they are being used is important in forecasting the public health impact of these products for smoking harm reduction. In our sample of adult current smokers and vapers across four high-income western countries, those reporting the use of HTPs tended to be younger and more affluent, mirroring findings from established markets such as Japan and South Korea.^{24,30} Several user characteristics, such as age and SES, were also reminiscent of NVP early adopters in these four countries 7–8 years prior.³⁸ The association of HTPs with affluence may be driven by the relative expense of HTPs. For instance, the IQOS device cost upwards of USD\$100 when first rolled out in the US in fall 2019,³⁹ and users must also purchase tobacco inserts at similar prices to that of ordinary cigarettes (though a free carton of tobacco inserts are often included with the initial device purchase⁴⁰). Whether this barrier to entry declines over time in a similar fashion to NVPs⁴¹ will be important to track.

A striking observation was that the vast majority (90.5%) of current HTP users reported both smoking cigarettes and using NVPs on a monthly basis, approximately one-third of which reported using all three products daily. Current HTP users also used more than one type of noncigarette-combusted tobacco product on average. These are

Table 2. Adjusted Multinomial Odds Ratios Comparing Several Patterns of HTP, Cigarette and NVP Use Versus Exclusive Cigarette Smokers.

Characteristics	Model 1				Model 2*	
	ExclusiveNVP (n = 1120)	Cigarette +NVP (n = 3219)	Non-daily HTP (n = 263)	Daily HTP (n = 178)	HTP + cigarette or HTP + NVP (n = 42)	HTP + cigarette + NVP (n = 399)
Age	aOR (95% CI)	aOR (95% CI)	aOR (95% CI)	aOR (95% CI)	aOR (95% CI)	aOR (95% CI)
18–24 years	2.99 (2.18–4.11)	1.59 (1.34–1.87)	12.09 (5.34–27.38)	10.30 (3.07–34.61)	18.14 (4.85–67.90)	8.89 (4.22–18.75)
25–34 years	1.55 (1.11–2.17)	1.21 (1.00–1.45)	5.87 (2.43–14.21)	8.65 (2.49–30.07)	4.63 (0.74–29.08)	7.60 (3.52–16.39)
35–44 years	1.28 (0.93–1.75)	1.22 (1.02–1.45)	4.57 (2.02–10.32)	3.72 (0.95–14.62)	4.43 (1.01–19.38)	4.20 (1.93–9.13)
45–54 years	0.88 (0.66–1.18)	1.35 (1.14–1.60)	3.39 (1.42–8.06)	4.90 (1.15–20.96)	5.89 (1.45–23.99)	2.96 (1.26–6.95)
55+ years	ref	ref	ref	ref	ref	ref
Sex						
Male	1.21 (0.97–1.52)	1.08 (0.96–1.21)	1.60 (1.03–2.49)	2.03 (1.14–3.63)	1.25 (0.56–2.82)	2.08 (1.48–2.91)
Female	ref	ref	ref	ref	ref	ref
Ethnicity						
Majority	ref	ref	ref	ref	ref	ref
Minority	1.07 (0.77–1.48)	0.93 (0.79–1.10)	1.30 (0.82–2.04)	1.33 (0.79–2.24)	0.63 (0.25–1.63)	1.74 (1.25–2.42)
Country of residence						
Canada	ref	ref	ref	ref	ref	ref
England	3.95 (3.01–5.17)	1.96 (1.71–2.25)	1.52 (0.91–2.53)	1.96 (0.97–3.97)	1.15 (0.44–3.04)	2.04 (1.40–2.95)
United States	2.31 (1.79–2.97)	1.36 (1.15–1.60)	0.92 (0.48–1.76)	0.92 (0.41–2.05)	0.83 (0.30–2.33)	0.99 (0.59–1.66)
Australia	2.75 (1.95–3.89)	0.44 (0.34–0.57)	0.25 (0.08–0.78)	0.09 (0.02–0.39)	0.08 (0.01–0.66)	0.28 (0.10–0.80)
Socioeconomic status						
Low	ref	ref	ref	ref	ref	ref
Moderate	1.46 (1.04–2.04)	1.27 (1.07–1.51)	1.00 (0.52–1.91)	0.88 (0.36–2.16)	0.52 (0.12–2.32)	1.13 (0.65–1.95)
High	1.60 (1.23–2.07)	1.34 (1.18–1.53)	1.81 (1.09–2.99)	3.24 (1.71–6.13)	2.88 (1.23–6.76)	1.87 (1.24–2.81)

Bolded values indicate an aOR with 95% CI that does not span the null value.

Base referent = exclusive cigarette smokers.

All reported statistics other than frequencies are weighted estimates.

*In addition to utilizing the same “exclusive cigarette” base referent group, Model 2 maintained the “exclusive NVP” and “cigarette + NVP” categories, therefore the aOR (95% CI) were identical to those reported in respective Model 1 columns.

HTP: heated tobacco product; NVP: nicotine vaping product; aOR: adjusted odds ratio; CI: confidence interval.

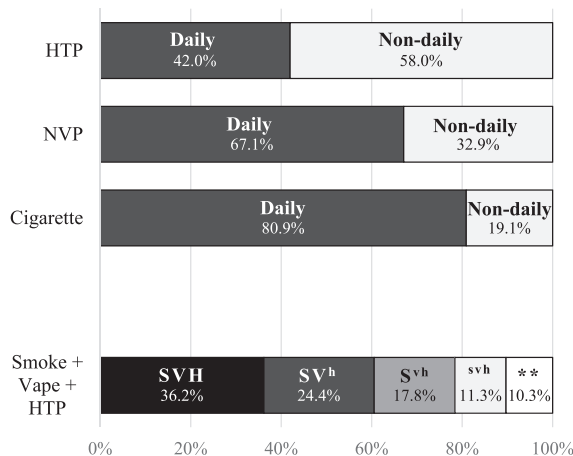


Figure 1. Frequency of tobacco product use among concurrent users of HTPs, NVPs, and cigarettes (n = 399). Data represents unweighted percentages. Capital letter indicates daily product use, superscript letter indicates non-daily (i.e., weekly or monthly) product use. S: smoking (cigarette); V: vaping (NVP); H: heated tobacco product. **other categories: ^sV^h = 4.5%; S^hH = 2.5%; V^hH = 2.0%; ^sH = 1.3%.

important findings, as any public health benefit from authorizing HTPs to the market centers around their utility for displacing more harmful forms of tobacco use. Current HTP users were also more likely to be

past 30-day cannabis users, and a strong association was observed with using cannabis-containing e-liquid or dry herb cannabis vaporizer modalities. Prospective cohort studies will offer insight towards HTP poly-use patterns over time, including whether concurrent cigarette-HTP-NVP use is associated with smoking cessation in the future.

Consistent with previous studies,^{29,30} we did not observe significant differences in cigarette consumption (frequency and intensity) between current HTP users and nonusers. These findings suggest that, instead of smoking reduction or cessation, HTPs may be used to complement cigarette smoking at the moment. Yet, past cigarette quit attempts and future quit intentions were significantly more common among those current cigarette smokers who used HTPs, particularly in the England subsample. Notably, prior analyses of early adopters of NVPs in the US-based PATH Study found significant interest in using NVPs to help quit smoking,⁴² yet almost 90% of concurrent cigarette-NVP users were still smoking one year later.⁴³ Such evidence for NVPs tempers expectations that *interest* in quitting via HTPs might by itself be a strong predictor of smoking cessation in real-world settings. That said, a number of factors differentiate contemporary HTPs from early-model NVPs, most notably a superior nicotine delivery profile⁴⁴ and the presence of actual tobacco, each of which influence the potential for HTPs to displace cigarettes.

Concurrent NVP and HTP Use

One group of a priori interest were current HTP users that also vaped, who comprised 94.8% of current HTP users. Compared with

Table 3. Associations of Current HTP Use with Smoking-Related and Vaping-Related Characteristics Among Current Smokers and Current Vapers

Characteristics	Current HTP use:No % (95% CI)/ M ± SD	Current HTP use:Yes % (95% CI)/ M ± SD	Multivariable odds of current HTP use		
			All aOR (95% CI)	HTP-aware aOR (95% CI)	HTP ever users aOR (95% CI)
Current smokers	<i>n</i> = 9847	<i>n</i> = 422	<i>n</i> = 10 281	<i>n</i> = 3526	<i>n</i> = 639
Cigarette consumption and dependence					
Daily smoker	87.0 (86.1–87.8)	77.5 (68.2–86.8)	1.05 (0.53–2.07)	0.82 (0.39–1.72)	0.76 (0.27–2.11)
Cigarettes per day†	14.6 ± 8.1	13.0 ± 4.4	1.01 (0.99–1.03)	1.01 (0.99–1.04)	1.02 (0.98–1.07)
Time to first cigarette: ≤ 5 minutes‡	18.1 (17.0–19.2)	18.2 (11.5–24.9)	1.53 (0.93–2.53)	1.54 (0.89–2.67)	2.55 (0.86–7.51)
P24H urge to smoke: none or slight	21.4 (20.3–22.5)	19.2 (13.0–25.3)	0.73 (0.47–1.12)	0.81 (0.51–1.29)	0.74 (0.34–1.61)
Quit intentions					
Planning to quit smoking within 6 months	33.7 (32.5–35.0)	65.1 (57.3–72.8)	2.54 (1.74–3.71)	2.76 (1.83–4.15)	4.06 (2.07–7.97)
Reported a failed quit attempt in the last 18 months	38.2 (37.0–39.5)	59.2 (50.1–68.3)	1.60 (1.08–2.36)	1.60 (1.03–2.47)	1.39 (0.66–2.93)
Very confident would succeed in quitting	15.9 (14.9–16.8)	21.9 (15.4–28.3)	1.22 (0.80–1.87)	1.28 (0.80–2.04)	1.62 (0.60–4.36)
Smoking attitudes and experiences					
Negative opinion of smoking	50.1 (48.7–51.4)	24.5 (17.6–31.5)	0.33 (0.22–0.50)	0.34 (0.22–0.53)	0.53 (0.26–1.11)
Believes smoking has already damaged health a great deal	9.4 (8.7–10.2)	16.7 (10.9–22.6)	1.72 (1.06–2.78)	1.71 (1.01–2.90)	1.08 (0.40–2.90)
Moderately or very worried smoking will damage health in the future	60.9 (59.6–62.2)	54.5 (45.6–63.4)	0.64 (0.44–0.94)	0.58 (0.37–0.91)	0.64 (0.32–1.29)
Current vapers	<i>n</i> = 4194	<i>n</i> = 417	<i>n</i> = 4615	<i>n</i> = 1892	<i>n</i> = 564
Vaping consumption and dependence					
Daily vaper	64.5 (61.8–67.2)	65.5 (58.1–72.9)	2.41 (1.66–3.49)	2.27 (1.49–3.47)	2.78 (1.44–5.39)
Time to first vape: ≤ 5 minutes†	15.7 (12.4–18.9)	13.0 (6.8–19.2)	1.08 (0.56–2.07)	1.06 (0.52–2.14)	0.27 (0.06–1.28)
Probably or definitely plans to vape in the future	61.7 (58.6–64.9)	78.6 (70.3–87.0)	1.99 (1.14–3.48)	1.43 (0.78–2.64)	0.95 (0.39–2.36)
Vaping preferences, perceptions, and experiences					
Preferred model: tank vaping system	71.3 (68.8–73.9)	24.9 (18.3–31.4)	0.20 (0.13–0.31)	0.24 (0.15–0.38)	0.30 (0.15–0.57)
Very much or extremely enjoys vaping	45.5 (42.2–48.7)	41.6 (34.1–49.1)	1.19 (0.81–1.73)	0.93 (0.60–1.45)	0.63 (0.32–1.25)
Vaping is as satisfying or more satisfying than smoking§	53.5 (50.3–56.7)	59.3 (51.2–67.5)	1.53 (1.01–2.31)	1.24 (0.79–1.93)	1.34 (0.69–2.61)
Vaping is less harmful than smoking	81.5 (79.2–83.7)	53.8 (45.9–61.6)	0.51 (0.35–0.74)	0.48 (0.32–0.72)	0.59 (0.30–1.16)
Moderately or very worried vaping will damage health in the future	25.7 (22.9–28.6)	55.8 (47.6–63.9)	2.19 (1.57–3.05)	2.16 (1.54–3.04)	1.58 (0.83–3.01)
Have experienced negative side effects of vaping	11.9 (10.2–13.5)	61.1 (52.7–69.5)	6.52 (4.55–9.36)	5.43 (3.66–8.06)	3.27 (1.67–6.44)

Bolded values indicate an aOR with 95% CI that does not span the null value.

All reported statistics other than frequencies are weighted estimates.

Each row represents results for the specified variable from individual logistic regression models controlling for a covariate set (see below).

All regression models were adjusted for age, sex, ethnicity, SES, and country of residence.

Unless specified otherwise: “current smoker” models were further adjusted for current vaping status; “current vaper” models were further adjusted for current smoking status.

Analytic sample restricted to: †current DAILY users of the specified product; ‡current WEEKLY users of the specified product; § current vapers who have EVER smoked.

HTP: heated tobacco product; M: mean; SD: standard deviation; aOR: adjusted odds ratio; CI: confidence interval; NVP: nicotine vaping product; SES: socioeconomic status; P24H: past 24 hours.

HTPs, NVPs produce less toxic emissions,^{19–21} suggesting they may pose lower health risks. If true, HTPs could undermine harm reduction efforts if these products appealed to smokers who, in the

absence of HTPs, would use an NVP to aid smoking cessation. Alternatively, HTPs may attract smokers who have tried using NVPs but find them inadequate as a replacement for cigarettes, which

could have positive public health implications if these individuals completely switch away from smoking cigarettes.

We found that current vapers who also used HTPs were more likely to report negative experiences with NVPs, more likely to worry about future health consequences of vaping, and more likely to think vaping is equally or more harmful than cigarette smoking, each of which aligns with the hypothetical “unsatisfied with NVPs” user group. Yet HTP use among vapers was also associated with more frequent (daily) vaping and with planning to vape in the future. A possible explanation for these conflicting findings is that verbs to describe HTP use (explicitly referred to as *using* in this paper) and NVP use (generally referred to as *vaping* throughout this paper) are not necessarily mutually exclusive. While it is simple enough to differentiate the act of *smoking* a cigarette from *vaping* a NVP, there are marked similarities between how one produces and inhales an aerosol from NVPs and HTPs. Qualitative study of HTP users will be crucial for informing population surveys of how to better differentiate questions about HTP use from other products.

Strengths and Limitations

In addition to confusion around verbs describing product use, some respondents may fail to distinguish HTPs from other product classes altogether (e.g., NVPs, cannabis vaporizers). The survey incorporated multiple items regarding HTPs, including an item about device brands used/preferred (additional details in Supplementary Figures S1 and S2). We reclassified respondents who did not know the HTP brand they supposedly used or whose written responses were definitively not HTP brands, increasing confidence in the measurement validity of the current HTP use variable. Altogether, 12.0% of self-reported current HTP users were reclassified. The survey also included HTP device images alongside the initial HTP awareness question to aid respondents in differentiating HTPs from other product classes.

As this study focused on established nicotine-using adults (current smokers or vapers), our results are not generalizable to exclusive HTP users, tobacco-naïve adults, or youth. Since the timeframe of data collection aligns with capturing early adopters of HTPs, it will be important to track uptake among varied demographic groups if HTPs become more commonplace. User characteristics may also shift over time due to numerous factors, including regulatory decisions such as the US Food and Drug Administration’s July 2020 authorization of IQOS being marketed as a modified-exposure tobacco product.¹⁸ Future research is needed to assess differences in HTP user characteristics due to regulatory changes. We also had aimed to scrutinize characteristics of concurrent cigarette-HTP-NVP users according to product use frequency, however the small subsample size limited ability to detect differences (Supplementary Table S7). The study’s cross-sectional nature is an inherent limitation, and longitudinal studies are needed prior to drawing strong conclusions about patterns of concurrent tobacco and other substance use we observed.

Conclusions

This study of 2018 data examined HTP user characteristics among current smokers and/or vapers in four high-income countries where HTPs were brand new or not yet available in mainstream nicotine markets. Sociodemographic characteristics of current HTP users were similar to those in established markets such as Japan and South Korea. A majority of current HTP users used both NVPs and cigarettes, along with some other form(s) of combusted tobacco. Those cigarette smokers who also used HTPs appeared more interested in smoking cessation, while certain characteristics

of NVP users who concurrently used HTPs were suggestive of dissatisfaction with NVPs.

Supplementary Material

A Contributorship Form detailing each author’s specific involvement with this content, as well as any supplementary data, are available online at <https://academic.oup.com/ntr>.

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Author Contributions

CRM: Conceptualization, Data curation, Formal analysis, Methodology, Visualization, Writing—original draft, Writing—review & editing. ES: Conceptualization, Methodology, Visualization, Writing—original draft, Writing—review & editing. DMS: Conceptualization, Methodology, Supervision, Writing—review & editing. SCH: Writing—review & editing. SG: Writing—review & editing. HY: Writing—review & editing. RB: Funding acquisition, Investigation, Writing—review & editing. RJO: Writing—review & editing. KMC: Funding acquisition, Investigation, Writing—review & editing. GTF: Funding acquisition, Investigation, Supervision, Writing—review & editing. AH: Funding acquisition, Writing—review & editing. AM: Investigation, Writing—review & editing. ACKQ: Project administration, Writing—review & editing. MLG: Conceptualization, Methodology, Supervision, Writing—review & editing.

Ethics Approval

Study questionnaires and materials were reviewed and provided clearance by Research Ethics Committees at the following institutions: University of Waterloo (Canada, ORE#20803/30570, ORE#21609/30878), King’s College London, UK (RESCM-17/18-2240), Cancer Council Victoria, Australia (HREC1603), University of Queensland, Australia (2016000330/HREC1603); and Medical University of South Carolina (waived due to minimal risk). All participants provided consent to participate.

Declaration of Interests

KMC has received payment as a consultant to Pfizer, Inc., for service on an external advisory panel to assess ways to improve smoking cessation delivery in health care settings. KMC also has served as paid expert witness in litigation filed against cigarette manufacturers. GTF has served as expert witnesses on behalf of governments in litigation involving the tobacco industry. AM is a UK National Institute for Health Research (NIHR) Senior Investigator. The views expressed in this article are hers and not necessarily those of the NIHR, or the UK Department of Health and Social Care. MLG received research grant from Pfizer, Inc. and served as a member of scientific advisory board to Johnson&Johnson. All other authors have no conflicts of interest to declare.

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