

Heated tobacco product use and combustible cigarette smoking relapse/initiation among former/never smokers in Japan: the JASTIS 2019 study with 1-year follow-up

Yusuke Matsuyama ,¹ Takahiro Tabuchi²

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¹Global Health Promotion, Tokyo Medical and Dental University, Bunkyo, Japan

²Cancer Control Center, Osaka International Cancer Institute, Osaka, Japan

Correspondence to

Dr Yusuke Matsuyama, Global Health Promotion, Tokyo Medical and Dental University, Bunkyo 113-8510, Japan; matsuyama-thk@umin.org

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ABSTRACT

Background Use of heated tobacco products (HTPs), which were first launched in Japan, has been rapidly spreading worldwide. The present study aimed to investigate whether HTP use was associated with combustible cigarette smoking relapse/initiation among former/never combustible cigarette smokers.

Methods A prospective cohort study was conducted by analysing two waves of data from the Japan 'Society and New Tobacco' Internet Survey. Among the 7766 never/former combustible cigarette smokers who answered the baseline survey in 2019, 5947 (follow-up rate: 76.6%) responded to the follow-up survey in 2020 (age range 18–73 years old; 50.5% men). The association between HTP use and combustible smoking after 1 year was investigated by multivariable logistic regression analysis adjusting for potential confounders.

Results Of the respondents, 308 (5.2%) used HTPs at baseline. One year later, 97 (1.7%) non-HTP users and 39 (12.7%) HTP users were smoking combustible cigarettes. Among former smokers who had quit for 1 year or more and among never smokers, HTP use was significantly associated with combustible cigarette smoking 1 year later (OR=2.80, 95% CI 1.42 to 5.52 and OR=9.95, 95% CI 3.39 to 29.16, respectively), while the association was not significant among former smokers who recently quit.

Conclusion HTP use was associated with relapse/initiation of combustible cigarette smoking after 1 year. The risks of HTP use, including subsequent combustible smoking, should be carefully monitored.

INTRODUCTION

Cigarette smoking remains one of the most significant health threats in the world despite declines in prevalence in some countries.¹ More than six million people die due to tobacco use across the globe every year.² In recent years tobacco industries have been promoting new tobacco products, that is, heated tobacco products (HTPs)—devices that heat-process tobacco rather than combust it to deliver a nicotine aerosol for inhalation.³ Japan was one of the first countries to introduce HTPs such as IQOS and Ploom.⁴ In Japan, HTPs and electronic cigarettes (e-cigarettes) are regulated differently depending on whether they use liquid or tobacco leaf. The sale of nicotine e-cigarettes is banned by the Pharmaceutical and Medical Device Act, whereas non-nicotine e-cigarettes are not regulated and are publicly available, even to

minors. On the other hand, HTPs are regulated by the Tobacco Industries Act, which legalised the sale of HTPs in Japan. Following their launch in 2014, the number of people using HTPs in the previous 30 days has been increasing in Japan: from 2015 to 2017, the prevalence of IQOS users increased from 0.3% to 3.6%; Ploom/Ploom Tech users increased from 0.3% to 1.2%; and the percentage of glo users in 2017 was 0.8% (glo was released in 2016).⁴ Recently HTPs have been advertised as 'personalized-gadgets' in Japan. For example, the IQOS online store promotes that customers can select colours and accessories from 960 combinations, and there is an option to engrave a name or favourite message on the front cover. Also, situations such as outdoor, business and weekends with the products are suggested, thereby advertising each customer according to their lifestyle. In 2019, 11% of individuals aged 15–69 years old in Japan were estimated to have used some form of HTP in the previous 30 days.⁵ Another HTP brand, PULZE, was released in May 2019. As of 2020, there are four major HTP brands sold in Japan.

While IQOS and other HTPs have been shown to expose users to lower amounts of toxicants than conventional cigarettes, it is unknown whether and what extent of this reduction in exposure is associated with lower health risks.⁴ HTP delivers harmful and potentially harmful toxicants,⁶ and a considerable portion of people who have been exposed to an HTP aerosol reported mild symptoms such as eye discomfort and sore throat.⁴ It has been reported that more than half of HTP users are concurrently using combustible cigarettes in Japan⁷ and Korea.⁸ Importantly, e-cigarettes, another new tobacco product, have been reported to be a potential gateway to combustible cigarette smoking among young people and adults^{9 10} and also to lead to a relapse of combustible cigarette smoking.¹¹ It would be informative to investigate whether there are similar associations between HTP use and relapse or initiation of smoking. The present study aimed to investigate the association between HTP use and relapse/initiation of combustible cigarette smoking among former/never combustible cigarette smokers in Japan.

METHODS

Internet survey

We used data from the Japan 'Society and New Tobacco' Internet Survey (JASTIS), a longitudinal



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internet cohort study about perception, attitude and prevalence of using HTPs, e-cigarettes and conventional tobacco products in Japan.¹² Details of the survey have been reported in the cohort profile paper¹² and elsewhere.^{13–15} The participants were randomly selected from panellists at Rakuten Insight, one of the largest internet research companies that covers all of Japan. On registration, the panellists provided web-based written informed consent and agreed that they would participate in different research surveys. Minors provided their consent with approval from their parents or guardians. The initial survey of JASTIS was conducted from January to February 2015, and the present study used two waves of longitudinal data from February 2019 (baseline) to February 2020 (follow-up). The 2019 survey comprised five cohorts: (1) those enrolled in 2015 through a stratified sampling by sex and age (15–69 years in 2015); (2) those enrolled in 2015 through a restricted sampling of e-cigarette and HTP users; (3) those enrolled in 2015 through a restricted sampling of combustible cigarette users who do not use e-cigarettes or HTPs; (4) those enrolled in 2017 through a stratified sampling by sex and age (15–69 years in 2017); and (5) those enrolled in 2019 through a stratified sampling by sex and age (15–24 years in 2019). Participation was voluntary but panellists were required to answer all the questions to finish the survey; thus, there was no missing information in the survey questionnaire.

Of the 10 781 respondents to the 2019 survey, we excluded those who we suspected had responded to the questionnaire inaccurately. These included those who chose every option in a list of 15 diseases, those who chose every item in a list of 7 substances, or those who, when asked to choose the second item from the bottom of a list, failed to do so (n=482). We also excluded respondents aged 17 years or less (n=334) and those who smoked combustible cigarettes at baseline (n=2199), resulting in 7766 respondents for follow-up. Of these, 5947 (age in 2019 ranged from 18 to 73, with a mean of 46.5 years; 50.5% were men) answered questions about their combustible cigarette smoking status in the follow-up survey in 2020 (follow-up rate: 76.6%).

Measurement: HTP use and combustible cigarette smoking

In the 2019 survey, respondents were asked about their current use of HTPs (Ploom Tech, Ploom Tech+, Ploom S, IQOS and glo), e-cigarettes and combustible cigarettes. Panellists who were newly enrolled in the survey in 2019 were asked if they used tobacco products with the following question: 'Do you use the following tobacco products? Please choose your current status for each product: Ploom Tech, Ploom Tech+, Ploom S, IQOS, glo, e-cigarettes, and combustible tobacco', with the following response options: 'never used', 'used several times but not regularly', 'had used regularly but quit', 'use sometimes' and 'use almost every day'. Respondents who answered 'use sometimes' and 'use almost every day' were defined as users of that product. Panellists who had participated in the previous waves had already answered similar questions at their first enrolment. In the 2019 survey, they were asked whether they used each of the products in the previous 30 days. Those who answered 'yes' were defined as current users of that product. The brand names were provided for HTPs, whereas those of e-cigarettes were not. Photos of the products were not shown with the question.

Regarding combustible cigarette smoking, respondents were asked whether they had ever used cigarettes, and respondents who answered yes were further asked if they had used them within the previous year. Respondents were classified into four

categories: never smoker, long-term-quit smoker (ie, former smoker who has quit for 1 year or more), recently quit smoker (ie, former smoker who quit less than a year ago) and current smoker. The definition of long-term-quit smoker and recently quit smoker followed a previous study which reported a high risk of smoking relapse within 1 year among those who had quit for 1 year or less,¹⁶ and has been used in other studies.^{11 17} Those who were categorised as 'current smokers' in the 2019 survey were excluded because the present study focused on relapse/initiation of combustible smoking after HTP use.

Measurement: covariates

The following variables at baseline were adjusted as covariates: age, sex, educational attainment, equivalent household income, housing tenure, marital status, having a household member who smokes tobacco, alcohol consumption, use of marijuana within the year and self-rated health.

Statistical analysis

Multivariable logistic regression analysis was performed to investigate the association between HTP use and relapse/initiation of combustible cigarette smoking after 1 year among former/never smokers. Two models were constructed by sequentially adding covariates: model 1, adjusting for age, sex, educational attainment, equivalent household income, housing tenure, marital status, having a household member who smokes tobacco, alcohol consumption, use of marijuana within the year and self-rated health; and model 2, further adjusting for combustible smoking experience in 2019. Stratification analysis by combustible cigarette smoking experience in 2019 was also performed because it was expected that this experience, that is, being never smokers, recently quit smokers and longer-quit smokers, would strongly correlate with relapse of combustible cigarette smoking, $P < 0.05$ was considered statistically significant. All statistical analyses were performed using Stata V.16.1.

RESULTS

Table 1 describes the demographic characteristics of the study participants. The participant group comprised 3903 never smokers and 2044 former smokers (1850 long-term-quit smokers and 194 recently quit smokers). Of these, 308 (5.2%) used HTPs at baseline. More specifically, 39 (1.0%) never smokers, 170 (9.2%) long-term-quit smokers and 99 (51.0%) recently quit smokers used HTPs. Participants who were middle aged, men, with high income, married or divorced/widowed, having a household member who smokes tobacco, alcohol drinkers and recently quit smokers were more likely to use HTPs. One year later, 97 (1.7%) non-HTP users and 39 (12.6%) HTP users smoked combustible cigarettes. In the 2020 survey, 283 (4.8%) used HTPs; of these, 235 (83.0%) had also used HTPs in 2019. Demographic characteristics by smoking relapse/initiation at the 2020 survey are presented in online supplemental table S1.

Table 2 reports the association between HTP use and relapse/initiation of combustible cigarette smoking after 1 year. After adjusting for covariates except for combustible cigarette smoking status, HTP users were more likely to relapse/initiate combustible cigarette smoking (model 1: OR=5.54, 95% CI 3.62 to 8.48). The association was explained mostly by combustible cigarette smoking status in 2019 but remained significant (model 2: OR=1.658, 95% CI 1.003 to 2.742). Former smokers were more likely to smoke combustible cigarettes 1 year later than never smokers (OR=4.33, 95% CI 2.56 to 7.30 for long-term-quit smokers; OR=28.53, 95% CI 15.06 to 54.03 for recently

Table 1 Demographic characteristics of study participants (N=5947)

	HTP use at baseline			P value
	Total (N=5947)	No (n=5639, 94.8%)	Yes (n=308, 5.2%)	
	n (column%)	n (row%)	n (row%)	
Age (years)				<0.001
18–29	1110 (18.7)	1077 (97.0)	33 (3.0)	
30–39	926 (15.6)	863 (93.2)	63 (6.8)	
40–49	1220 (20.5)	1142 (93.6)	78 (6.4)	
50–59	1167 (19.6)	1078 (92.4)	89 (7.6)	
60–73	1524 (25.6)	1479 (97.0)	45 (3.0)	
Sex				<0.001
Male	3003 (50.5)	2763 (92.0)	240 (8.0)	
Female	2944 (49.5)	2876 (97.7)	68 (2.3)	
Educational attainment				0.430
High school or less	1565 (26.3)	1477 (94.4)	88 (5.6)	
2-year college or more	4366 (73.4)	4146 (95.0)	220 (5.0)	
Other	16 (0.3)	16 (100.0)	0 (0.0)	
Equivalent household income				<0.001
First quartile (lowest)	1164 (19.6)	1124 (96.6)	40 (3.4)	
Second quartile	1337 (22.5)	1269 (94.9)	68 (5.1)	
Third quartile	1080 (18.2)	1020 (94.4)	60 (5.6)	
Fourth quartile (highest)	1121 (18.8)	1031 (92.0)	90 (8.0)	
Do not want to answer/do not know	1245 (20.9)	1195 (96.0)	50 (4.0)	
Housing tenure				0.170
Does not own housing	1854 (31.2)	1747 (94.2)	107 (5.8)	
Owns housing	4093 (68.8)	3892 (95.1)	201 (4.9)	
Marital status				<0.001
Married	3357 (56.4)	3146 (93.7)	211 (6.3)	
Never married	2175 (36.6)	2107 (96.9)	68 (3.1)	
Divorced/widowed	415 (7.0)	386 (93.0)	29 (7.0)	
Household member smoking tobacco				<0.001
No	5073 (85.3)	4847 (95.5)	226 (4.5)	
Yes	874 (14.7)	792 (90.6)	82 (9.4)	
Alcohol consumption				<0.001
Never drinker	1031 (17.3)	1008 (97.8)	23 (2.2)	
Former drinker	1722 (29.0)	1645 (95.5)	77 (4.5)	
Current drinker	3194 (53.7)	2986 (93.5)	208 (6.5)	
Marijuana use within the year				0.300
No	5854 (98.4)	5553 (94.9)	301 (5.1)	
Yes	93 (1.6)	86 (92.5)	7 (7.5)	
Self-rated health				0.810
Good (excellent/very good/good)	5206 (87.5)	4935 (94.8)	271 (5.2)	
Poor (fair/poor)	741 (12.5)	704 (95.0)	37 (5.0)	
Smoking status				<0.001
Never smoker	3903 (65.6)	3864 (99.0)	39 (1.0)	
Long-term-quit smoker*	1850 (31.1)	1680 (90.8)	170 (9.2)	
Recently quit smoker†	194 (3.3)	95 (49.0)	99 (51.0)	
Combustible smoking at follow-up				<0.001
No	5811 (97.7)	5542 (95.4)	269 (4.6)	
Yes	136 (2.3)	97 (71.3)	39 (28.7)	
HTP use at follow-up				<0.001
No	5664 (95.2)	5591 (98.7)	73 (1.3)	
Yes	283 (4.8)	48 (17.0)	235 (83.0)	

*Former smokers who have quit smoking for 1 year or more.

†Former smokers who have quit smoking for less than 1 year.

HTP, heated tobacco product.

quit smokers). Younger age, men, lower educational attainment and divorced/widowed were also associated with relapse/initiation of combustible cigarette smoking.

Table 3 shows the results of the stratification analysis. Among recently quit smokers, HTP use was not associated with relapse/initiation of combustible smoking 1 year later (OR=0.59, 95% CI 0.28 to 1.26). On the other hand, among long-term-quit

Original research

Table 2 Association between heated tobacco product use and relapse/initiation of combustible cigarette smoking 1 year later (n=5931)

	n (%)*	Model 1† OR (95% CI)	Model 2‡ OR (95% CI)
Heated tobacco product use at baseline			
No	97 (1.7)	Ref	Ref
Yes	39 (12.7)	5.54 (3.62 to 8.48)	1.658 (1.003 to 2.742)
Age (years)			
18–29	34 (3.1)	Ref	Ref
30–39	29 (3.1)	0.65 (0.37 to 1.13)	0.37 (0.20 to 0.69)
40–49	24 (2.0)	0.35 (0.19 to 0.64)	0.18 (0.09 to 0.36)
50–59	32 (2.7)	0.41 (0.22 to 0.76)	0.18 (0.09 to 0.36)
60–73	17 (1.1)	0.22 (0.11 to 0.45)	0.10 (0.05 to 0.22)
Sex			
Male	92 (3.1)	1.91 (1.28 to 2.86)	1.34 (0.87 to 2.05)
Female	44 (1.5)	Ref	Ref
Educational attainment			
High school or less	50 (3.2)	2.00 (1.37 to 2.92)	2.05 (1.38 to 3.04)
2-year college or more	86 (2.0)	Ref	Ref
Other	0 (0.0)	–§	–§
Equivalent household income			
First quartile (lowest)	25 (2.1)	Ref	Ref
Second quartile	28 (2.1)	0.89 (0.50 to 1.55)	0.89 (0.50 to 1.59)
Third quartile	27 (2.5)	1.09 (0.61 to 1.95)	1.12 (0.62 to 2.03)
Fourth quartile (highest)	42 (3.7)	1.54 (0.89 to 2.66)	1.52 (0.86 to 2.68)
Do not want to answer/do not know	14 (1.1)	0.55 (0.28 to 1.08)	0.59 (0.30 to 1.18)
Housing tenure			
Does not own housing	54 (2.9)	Ref	Ref
Owns housing	82 (2.0)	0.89 (0.61 to 1.30)	1.03 (0.69 to 1.53)
Marital status			
Married	73 (2.2)	Ref	Ref
Never married	48 (2.2)	0.83 (0.52 to 1.33)	1.00 (0.62 to 1.62)
Divorced/widowed	15 (3.6)	2.08 (1.14 to 3.81)	2.01 (1.07 to 3.78)
Household member smoking tobacco			
No	108 (2.1)	Ref	Ref
Yes	28 (3.2)	1.33 (0.84 to 2.11)	1.26 (0.78 to 2.02)
Alcohol consumption			
Never drinker	10 (1.0)	Ref	Ref
Former drinker	38 (2.2)	2.28 (1.10 to 4.69)	1.82 (0.85 to 3.87)
Current drinker	88 (2.8)	2.60 (1.31 to 5.19)	1.92 (0.93 to 3.97)
Marijuana use within the year			
No	132 (2.3)	Ref	Ref
Yes	4 (4.3)	1.48 (0.49 to 4.43)	1.48 (0.46 to 4.77)
Self-rated health			
Good (excellent/very good/good)	122 (2.3)	Ref	Ref
Poor (fair/poor)	14 (1.9)	0.84 (0.47 to 1.50)	0.80 (0.44 to 1.45)
Smoking status			
Never smoker	39 (1.0)	–	Ref
Long-term-quit smoker¶	53 (2.9)	–	4.33 (2.56 to 7.30)
Recently quit smoker**	44 (22.7)	–	28.53 (15.06 to 54.03)

*Number (%) of combustible cigarette smokers at follow-up.

†Adjusted for all listed variables except combustible cigarette smoking status at baseline.

‡Adjusted for all listed variables.

§People who chose 'other' for their educational status were excluded because it predicted the outcome completely.

¶Former smokers who have quit smoking for 1 year or more.

**Former smokers who have quit smoking for less than 1 year.

Ref, reference.

smokers and never smokers, those who used HTPs were more likely to relapse/initiate combustible cigarette smoking (OR=2.80, 95% CI 1.42 to 5.52 and OR=9.95, 95% CI 3.39 to 29.16, respectively). Apart from HTP use, lower educational attainment was associated with combustible smoking relapse,

while younger age and using marijuana within the year were associated with combustible smoking initiation.

Table 3 Association between heated tobacco product use and relapse/initiation of combustible smoking 1 year later: stratification analysis by combustible cigarette smoking status at baseline

	Recently quit smokers* (n=193)		Long-term-quit smokers† (n=1843)		Never smokers (n=3895)	
	n (%)‡	OR (95% CI)§	n (%)‡	OR (95% CI)§	n (%)‡	OR (95% CI)§
Heated tobacco product use at baseline						
No	25 (26)	Ref	39 (2.3)	Ref	33 (0.9)	Ref
Yes	19 (19)	0.59 (0.28 to 1.26)	14 (8.2)	2.80 (1.42 to 5.52)	6 (15.4)	9.95 (3.39 to 29.16)
Age (years)						
18–29	3 (27)	Ref	1 (2.3)	Ref	30 (2.8)	Ref
30–39	9 (26)	0.81 (0.14 to 4.75)	17 (7.5)	3.08 (0.39 to 24.53)	3 (0.5)	0.13 (0.03 to 0.46)
40–49	7 (16)	0.35 (0.05 to 2.19)	16 (3.8)	1.49 (0.18 to 12.02)	1 (0.1)	0.03 (0.00 to 0.26)
50–59	16 (26)	0.62 (0.11 to 3.52)	12 (2.6)	0.97 (0.11 to 8.24)	4 (0.6)	0.13 (0.04 to 0.50)
60–73	9 (21)	0.62 (0.09 to 4.23)	7 (1.0)	0.45 (0.05 to 4.11)	1 (0.1)	0.030 (0.003 to 0.269)
Sex						
Male	35 (22.6)	1.07 (0.38 to 3.01)	40 (3.0)	1.42 (0.70 to 2.90)	17 (1.1)	1.32 (0.66 to 2.65)
Female	9 (23.1)	Ref	13 (2.6)	Ref	22 (0.9)	Ref
Educational attainment						
High school or less	17 (34.7)	2.68 (1.14 to 6.29)	19 (4.0)	1.8515 (1.0003 to 3.4271)	14 (1.3)	1.58 (0.77 to 3.23)
2-year college or more	27 (18.8)	Ref	34 (2.5)	Ref	25 (0.9)	Ref
Other	0 (0.0)	—¶	0 (0.0)	—¶	0 (0.0)	—¶
Equivalent household income						
First quartile (lowest)	7 (26)	Ref	8 (2.5)	Ref	10 (1.2)	Ref
Second quartile	10 (24)	0.74 (0.22 to 2.53)	11 (2.6)	1.03 (0.40 to 2.66)	7 (0.8)	0.63 (0.22 to 1.78)
Third quartile	4 (11)	0.34 (0.08 to 1.41)	16 (4.1)	1.71 (0.69 to 4.25)	7 (1.1)	0.91 (0.32 to 2.61)
Fourth quartile (highest)	19 (31)	1.74 (0.55 to 5.51)	15 (3.6)	1.40 (0.55 to 3.61)	8 (1.2)	1.37 (0.51 to 3.73)
Do not want to answer/do not know	4 (15)	0.42 (0.09 to 1.90)	3 (1.0)	0.41 (0.11 to 1.59)	7 (0.8)	0.64 (0.23 to 1.76)
Housing tenure						
Does not own housing	15 (21.7)	Ref	23 (4.8)	Ref	16 (1.2)	Ref
Owns housing	29 (23.2)	1.19 (0.50 to 2.83)	30 (2.2)	0.68 (0.37 to 1.26)	23 (0.9)	1.02 (0.50 to 2.09)
Marital status						
Married	29 (21.6)	Ref	33 (2.5)	Ref	11 (0.6)	Ref
Never married	9 (23.1)	1.14 (0.40 to 3.21)	13 (3.4)	0.85 (0.41 to 1.76)	26 (1.5)	0.65 (0.25 to 1.66)
Divorced/widowed	6 (28.6)	1.54 (0.46 to 5.17)	7 (4.7)	2.03 (0.82 to 5.01)	2 (0.8)	2.45 (0.50 to 12.04)
Household member smoking tobacco						
No	37 (24.0)	Ref	46 (2.9)	Ref	25 (0.8)	Ref
Yes	7 (17.5)	0.73 (0.26 to 2.03)	7 (2.8)	0.77 (0.31 to 1.89)	14 (2.4)	2.095 (0.996 to 4.409)
Alcohol consumption						
Never drinker	1 (12.5)	Ref	2 (2.9)	Ref	7 (0.7)	Ref
Former drinker	13 (28.9)	6.87 (0.62 to 75.62)	16 (3.2)	1.12 (0.23 to 5.37)	9 (0.8)	1.24 (0.44 to 3.53)
Current drinker	30 (21.3)	4.64 (0.44 to 49.25)	35 (2.7)	1.07 (0.23 to 4.89)	23 (1.3)	2.09 (0.84 to 5.23)
Marijuana use within the year						
No	43 (22.5)	Ref	52 (2.9)	Ref	37 (1.0)	Ref
Yes	1 (33.3)	0.40 (0.03 to 5.53)	1 (2.6)	0.85 (0.11 to 6.75)	2 (3.9)	5.86 (1.17 to 29.35)
Self-rated health						
Good (excellent/very good/good)	37 (22.2)	Ref	48 (3.0)	Ref	37 (1.1)	Ref
Poor (fair/poor)	7 (25.9)	1.63 (0.57 to 4.66)	5 (1.9)	0.73 (0.28 to 1.90)	2 (0.4)	0.42 (0.10 to 1.84)

*Former smokers who have quit smoking for 1 year or more.

†Former smokers who have quit smoking for less than 1 year.

‡Number (%) of combustible cigarette smokers at follow-up.

§Models were adjusted for all listed variables.

¶People who chose 'other' for their educational status were excluded because it predicted the outcome completely.

Ref, reference.

DISCUSSION

The present study found that 5.2% of participants used HTPs: 51.0%, 9.2% and 1.0% of recently quit smokers, long-term-quit smokers and never smokers used HTPs, respectively. Former/never combustible cigarette smokers who used HTPs were more likely to relapse/initiate combustible cigarette smoking than non-HTP users. A strong association was observed among never smokers and long-term-quit smokers. The association among recently quit smokers was not significant, which may reflect the

small number of recently quit smokers among the study participants and their extremely high likelihood of smoking relapse. The findings also confirmed other factors associated with relapse/initiation of smoking that were reported in previous literature.^{9 11 18}

To the best of our knowledge, the present study is the first to report the association between HTP use and relapse/initiation of combustible cigarette smoking, while several studies have described the association of awareness and prevalence of HTP

use with combustible smoking behaviours.^{8 19–22} For example, in 2017, 19.5% of the Italian population aged 15 years or more were aware of HTPs and 1.4% had tried them,¹⁹ while 9.3% of British adults were aware of HTPs and 1.7% had used them in 2017.²¹ These studies consistently reported that awareness and prevalence were higher among current or former smokers and people with higher socioeconomic status,^{8 19–22} as was observed in the present study regarding prevalence. Smartphone-style packaging and HTP stores designed to resemble high-end technology brand stores such as Apple or Microsoft stores²³ might be attractive to them. Those who like ‘new gadgets’ might be more likely to use HTPs, especially at this early stage of increasing HTP use. Former smokers might use them to quit combustible smoking, but the present study found such users were more likely to relapse. A cross-sectional study conducted in Korea reported that combustible smokers were more likely to use HTPs, but HTP use among smokers was not associated with their intention to quit smoking within a month.⁸ Further longitudinal studies are needed to evaluate whether HTPs work as complements to, or substitutes for, combustible cigarettes.

The present study did not evaluate the pathway linking HTP use and smoking relapse/initiation; however, the potential pathways linking e-cigarettes and smoking relapse/initiation¹⁰ might be partly applicable. More specifically, HTPs may work as behavioural scripts so that people become familiar with cigarette smoking-related behavioural scripts, that is, moving a hand towards the mouth, inhalation and exhalation; HTPs may provide positive cognitive or behavioural expectation, such as a sense of belonging with cigarette-smoking peers; and HTP users may become addicted to nicotine. These pathways need to be investigated in future research.

The association between HTP use and subsequent combustible smoking was prominent among long-term-quit smokers as well as never smokers, while the association was not significant among recently quit smokers, that is, those who had quit smoking less than a year ago. The findings among recently quit and long-term-quit smokers are in line with previous studies on e-cigarettes. Although they are different in terms of products, policy regulation and societal perceptions of tobacco use, it would be useful to compare the two. Dai and Leventhal¹⁷ reported that e-cigarette use was associated with subsequent smoking relapse in former smokers, but it was not significant in those who quit less than a year before. Everard *et al*¹¹ reported that the association between e-cigarette use and subsequent smoking relapse was greater in former smokers who had quit for a year or more than those who quit for within a year. HTP users who quit smoking less than a year previously would have started using HTPs before or just after quitting combustible cigarette smoking. This might reflect their high nicotine dependency, and such people are less likely to quit smoking successfully.²⁴ HTP use might not influence the risk of smoking relapse among these people.

On the other hand, the results among never smokers need to be carefully interpreted because the proportion of HTP users was small (1.0%). The notably high OR with a wide 95% CI for initiation of cigarette smoking among them might partly reflect their curiosity or risk-taking behaviour leading to smoking initiation. Evaluating the reason for HTP use among never smokers is warranted.

Although they contain harmful and potentially harmful toxicants,⁶ HTPs are widely available to the public. The law on secondhand smoke prevention in public places finally came into force in Japan in April 2020, far behind other countries.²⁵ However, the law permits restaurants and workplaces to have rooms for combustible cigarette smoking or HTP use. HTP use

is widely promoted by new social media²⁶ and targets a different population from combustible cigarette smokers,²⁷ such as younger and more affluent individuals.²⁸ In addition to regulation similar to that for combustible cigarette smoking, different approaches need to be employed to reduce the dangers of HTP use, for example, undermining the idea that using HTPs looks attractive.

The present study has several limitations. First, as we used internet-based survey data, the study participants might not be fully representative of the general population. Second, both exposure and outcome are self-reported. However, the self-reported combustible smoking status has been previously validated,²⁹ yet the question on HTP use has not. We reduced the misclassification of HTP use by including the name of the products in the questionnaire. As we excluded the participants whose responses lacked internal consistency, the internal validity of the findings has improved. Third, information on e-cigarette use was not included in the analysis because misclassification was likely; that is, some participants could answer ‘yes’ to both e-cigarette and HTP use even though they only use HTPs because it might be difficult to differentiate between them. Fourth, there might be residual confounding, such as risk-taking behaviour. We did not directly measure risk-taking behaviour in the survey, but alcohol drinking and marijuana use within the year were adjusted. Lastly, the findings from Japan, one of the first countries to introduce HTPs, would be informative, but might not be directly applicable to other countries due to differences in availability and regulation of HTPs.

CONCLUSIONS

The present study is the first to show the high risk of combustible cigarette smoking relapse/initiation among current HTP users in Japan, which is one of the biggest HTP markets in the world. Further research is needed to investigate the mechanism through which HTP users are led to combustible cigarette smoking. The risks of HTP use, including subsequent combustible cigarette smoking, should be carefully evaluated.

What this paper adds

What is already known on this subject

- ▶ The prevalence of heated tobacco product (HTP) use has been increasing in Japan, the country where HTP was first introduced in 2014.
- ▶ HTP use might be associated with relapse/initiation of combustible cigarette smoking among former/never smokers.
- ▶ Few studies have investigated this possibility.

What this paper adds

- ▶ A longitudinal internet cohort study in Japan found that using HTPs was significantly associated with combustible cigarette smoking 1 year later among former smokers who had quit for 1 year or more, as well as never smokers, while the association was not significant among recently quit smokers.

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ORCID iD

Yusuke Matsuyama <http://orcid.org/0000-0002-6114-5604>

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