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Heat-not-burn tobacco product use in Japan: its prevalence, predictors and perceived symptoms from exposure to secondhand heat-not-burn tobacco aerosol

Takahiro Tabuchi,[1] Silvano Gallus,[2] Tomohiro Shinozaki,[3] Tomoki Nakaya,[4] Naoki Kunugita,[5] Brian Colwell[6]

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[1]Cancer Control Center, Osaka International Cancer Institute, Osaka, Japan
[2]Department of Epidemiology, Laboratory of Lifestyle Epidemiology, Istituto di Ricerche Farmacologiche 'Mario Negri', Milan, Italy
[3]Department of Biostatistics, School of Public Health, The University of Tokyo, Bunkyo-ku, Tokyo, Japan
[4]Department of Geography, College of Letters, Ritsumeikan University, Kita-ku, Kyoto, Japan
[5]Department of Environmental Health, National Institute of Public Health, Wako City, Saitama, Japan
[6]School of Public Health, Texas A&M University, College Station, Texas, USA

Correspondence to
Dr Takahiro Tabuchi, Cancer Control Center, Osaka International Cancer Institute, Chuo-ku, Osaka 541-8567, Japan;
tabuti-ta@mc.pref.osaka.jp

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ABSTRACT

Objectives A heat-not-burn (HNB) tobacco product, IQOS, was first launched in Japan and Italy as test markets and is currently in commerce in 30 countries. Using two data sources, we examined interest in HNB tobacco (IQOS, Ploom and glo), its prevalence, predictors of its use and symptoms from exposure to secondhand HNB tobacco aerosol in Japan, where HNB tobacco has been sold since 2014.

Methods Population interest in HNB tobacco was explored using Google search query data. Prevalence of HNB tobacco current use (ie, use in the previous 30 days) was calculated using a longitudinal internet survey of 8240 individuals (15–69 years old in 2015) followed up to 2017. Rates of perceived symptoms from exposure to exhaled aerosol of others' HNB tobacco were also calculated.

Results The largest internet search volume for IQOS occurred in April 2016 in the week after a popular national entertainment TV show introduced IQOS. For Ploom and glo, search volumes have remained limited since their launch. Prevalence of IQOS users increased from 0.3% in January–February 2015 to 0.6% in January–February 2016 and up to 3.6% in January–February 2017, while estimated rates of use of other HNB tobacco products remained low in 2017. Respondents who had seen the TV programme in 2016 were more likely to have used IQOS than those who had not seen it (10.3% vs 2.7%). Among never-smokers who had been exposed to secondhand HNB tobacco aerosol, nearly half reported at least one acute symptom, although these symptoms were not serious.

Conclusions A popular TV programme triggered IQOS diffusion in Japan. Extrapolating from survey results to the general population, around 3.1 million people currently use IQOS in Japan. Tobacco control organisations and governments should closely monitor HNB tobacco and consider how to regulate it.

INTRODUCTION

Heat-not-burn (HNB) tobacco products are electronic devices that heat tobacco leaf and resemble electronic cigarettes (e-cigarettes) in terms of producing aerosol.[1] In 2014, Philip Morris International (PMI) introduced the IQOS, a novel HNB tobacco product in Japan and Italy only. As of October 2017, IQOS is currently being test-marketed in 30 countries, that is, Canada, Colombia, Czech Republic, Denmark, France, Germany, Greece, Guatemala, Italy, Israel, Japan, Kazakhstan, Korea, Lithuania, Monaco, the Netherlands, New Zealand, Palestine, Poland, Portugal, Romania, Russia, Serbia, Slovak Republic, Slovenia, South Africa, Spain, Switzerland, Ukraine and the UK.[2] IQOS is intended to compete with available electronic nicotine delivery systems, or e-cigarettes,[3 4] and other HNB tobacco products. Japan is the only country where a national roll-out of IQOS has occurred, and Japan's worldwide share of IQOS was 98% in October 2016.[5] Japan Tobacco began 'Ploom' sales online in December 2013 and launched a new product 'Ploom Tech' in March 2016 in Japan. British American Tobacco also began to sell an HNB tobacco product 'glo' in December 2016 in Japan. During recent decades, smoking prevalence in Japan has declined from 48% in 2001 to 31% in 2016 among men, and from 14% in 2001 to 10% in 2016 among women.[6] In this circumstance, tobacco company executives are counting on HNB tobacco for significant revenue growth worldwide.[7]

In December 2016, PMI applied to the US Food and Drug Administration (FDA) for IQOS to be considered a modified risk tobacco product (MRTP).[8] MRTPs are 'tobacco products that are sold or distributed for use to reduce harm or the risk of tobacco-related disease associated with commercially marketed tobacco products'.[9] This move was followed in March 2017 by a Premarket Tobacco Product Application to the FDA; this is the mechanism through which new tobacco products are authorised to be marketed in the USA.

Mass media influence people's behaviour through direct and indirect product marketing.[10 11] In Japan, HNB tobacco IQOS was picked up on a popular TV programme *Ame-talk* in April 2016, in which many popular Japanese comedians discussed their IQOS use, which seems to have led to interest in the product by viewers. The market share of IQOS-specific tobacco sticks has increased in Japan, reaching 4.9% of all tobacco products, including combustible cigarettes, by October 2016.[5] In an earlier study of HNB/e-cigarette use in Japan,[12] 6.6% had ever used the product(s) and 1.3% had used in the previous 30 days. Among electronic smoking device ever-users, e-cigarettes accounted for the majority; Ploom and IQOS only accounted for 7.8% and 8.4%, respectively, in 2015.[12]

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This study examined the present state of HNB tobacco and e-cigarette use in Japan—population interest, rate of use, predictors of use and effects of use on others—based on data from two sources: Google Trends and a longitudinal internet survey in Japan.

METHODS AND DATA SOURCES

Google Trends

Google Trends (www.google.com/trends), a publicly available, objectively evaluable record of search activity, calculates relative search volume (RSV) for specific search terms and has been used to assess e-cigarettes' popularity by measuring the fraction of searches that include a specific search term or terms in a user-chosen location[13 14] (in the case of the present study, Japan, where 83% of the population had internet access in 2015 and Google had the top share of desktop searches of 67% in 2016[15 16]) during a set period (the 4 years from 1 April 2013 to 1 April 2017) relative to total searches in that period, normalised to a 0–100 scale. Weekly aggregated search query trends originating in Japan were analysed to examine population interest in HNB tobacco/e-cigarettes. The search terms used included 'e-cigarettes', 'Ploom', 'IQOS' and 'glo' (irrespective of capitalisation). Because both Japanese characters and Roman letters were used to write search terms, RSVs from both were combined for given terms and normalised; that is, Japanese 'アイコス(IQOS)' was combined with Roman 'IQOS'.[13] Similarly, the terms 'プルーム(Ploom)' and 'グロー(glo)' were used. Three Japanese terms '電子タバコ(e-cigarette)', '電子たばこ(e-cigarette)' and 'ベイパー(vaping)' were used for e-cigarettes. We did not use search terms of specific brand names such as Blu, because e-cigarettes with nicotine are illegal and uncommon in Japan. To examine trends over time, we focused on RSV values as the impact point[13]; high spikes were detected by visual inspection, and RSVs ranging from 0 to 100 were evaluated as continuous values.[14] Using those values, we looked for possible relationships between the RSVs (assumed to represent population interest in specific search terms) and tobacco-related events in Japan.

Longitudinal internet survey

We conducted a baseline internet survey between 31 January and 17 February 2015, randomly sampling members from a large panel with a major Japanese internet research agency, Rakuten Research.[17] The overall size of the survey panel was 2 278 733 people in 2015. The panel members covered all social categories (such as education, housing tenure and marital status) defined by the census in Japan. The survey panel consisted of people recruited initially through services managed by the research agency group. At the time of registration, they were required to provide information such as sex, age, occupation and residence and to agree that they would participate in different research surveys. The 2015 baseline survey recruited 8240 eligible respondents aged 15–69 years (4084 men and 4156 women) using inverse probability weighting (IPW) for 'being a respondent in an internet survey', approximating a nationally representative sample; weighting accounted for baseline characteristics such as sociodemographic, health-related and tobacco-related factors.[12 18] Details were given in a previous report.[12]

One-year and 2-year follow-up surveys were conducted from 29 January to 15 February 2016 and from 27 January to 27 February 2017, respectively, using the 2015 baseline survey respondents. In all, 5403 and 4304 respondents answered the follow-up surveys, for response rates of 65.6% and 52.2%, respectively. After exclusion of those whose responses showed unnatural discrepancies (eg, respondents who chose the same number in all of a set of questions; other examples are shown in the online supplementary data), we analysed the remaining 5366 and 4217 individuals (respectively), using IPW adjustment to account for both 'being an internet survey respondent' and 'non-response in the follow-up survey' (details in online supplementary data).[12 18 19]

Measures: current use (use in the previous 30 days)

Panellists were asked about their current use (use in the previous 30 days) of each product (e-cigarettes, Ploom, IQOS and glo) in the 2015, 2016 and 2017 surveys (glo was included in 2017 only, because it only entered the market in December 2016). The term 'Ploom Tech' was used instead of Ploom in 2017, following the product change. Respondents who answered 'yes' to the question, 'Have you used the following products in the previous 30 days?' (options: e-cigarette, Ploom, IQOS and glo) were defined as current users of the designated product(s).[20 21] Current combustible cigarette smokers who had concurrently used any HNB tobacco or e-cigarette in the previous 30 days were defined as dual users.

Measures: exposure to tobacco-related media information

We examined whether people had seen the *Ame-talk* programme that introduced IQOS in the 2017 survey, using the question 'Have you seen the TV program "Ame Talk: The Latest Comedians' Tobacco Use", which aired in April 2016? (yes or no)' with some capture images of the TV programme. *Ame-talk* is a popular programme that occasionally introduces new products such as home electrical goods, comic books and delicious foods, and broadcasts every Thursday night in Japan. A 1-hour episode broadcast on 28 April 2016, discussed comedians' tobacco use, focusing on IQOS (eg, what is IQOS, how to use tobacco including IQOS, smoking history and preferred brands). In the programme, a famous comedian said that residents in his apartment complex complained about him smoking on his veranda; to cope with this complaint, he had to change from cigarettes to IQOS. Other comedians discussed their dual use of IQOS and combustible cigarettes, and visually demonstrated its use, indicating a specific method to charge its battery. This programme introduced IQOS but did not mention Ploom or e-cigarettes.

Awareness of tobacco company promotions was also measured in the 2017 survey, using the question: 'How often have you noticed things that promote smoking?' Options included never, rarely, sometimes, often and very often.[22]

Measures: symptoms from exposure to secondhand HNB tobacco aerosol

Self-reported experience of, and symptoms due to, inhaling the aerosol produced by HNB tobacco devices used by other people were examined in the 2017 survey, using the questions: 'Have you ever inhaled the aerosol of HNB tobacco (Ploom Tech, IQOS and/or glo) that other people were using?' (yes or no) and 'Have you ever experienced symptoms due to the aerosol of HNB tobacco that other people were producing?'. Options included sore throat, eye pain, feeling ill and other injuries or symptoms (yes or no).

Baseline characteristics in 2015

Variables were grouped into demographics (age, sex, education, marital status and income), combustible and HNB tobacco/e-cigarette use history, use and intentions to quit, electronic smoking

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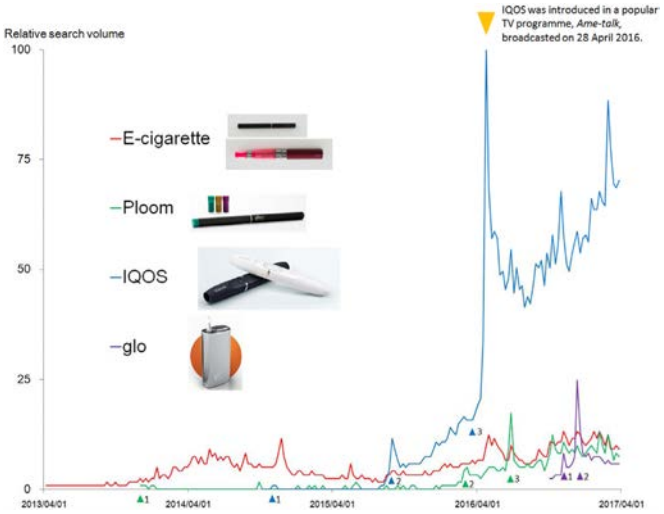


Figure 1 Weekly Google search volume for HNB tobacco/e-cigarette from 2013 to 2017 (past 4 years) in Japan. Note: Ploom sales began online in December 2013 (▲green triangle no. 1) and Ploom Tech sales began in March 2016 (▲green triangle no. 2), but both soon stopped because of product shortages. Ploom Tech sales restarted in June 2016 (▲green triangle no. 3). IQOS was sold only in Nagoya city as of November 2014 (▲blue triangle no. 1), with expanded sales to 12 prefectures in September 2015 (▲blue triangle no. 2), and further expansion to 35 prefectures in April 2016 (▲blue triangle no. 3). IQOS's results before November 2014 were omitted. British American Tobacco announced on 9 November 2016 (▲purple triangle no. 1) that glo would be sold from 12 December 2016 (▲purple triangle no. 2). glo's results before October 2016 were omitted. The above-mentioned information was reported by various news media, such as newspapers, television news and internet news. ※pictures were obtained from official websites except for the e-cigarette. Ame-talk: http://www.tvasahi.co.jp/ametalk/; Ploom: https://www.ploom.jp; IQOS: https://www.iqos.jp; glo: https://www.discoverglo.com/jp. HNB, heat-not-burn.

device use history and intent, and worksite rules on tobacco use. Variables are described in the online supplementary data.

Statistical analyses

Weighted percentages and 95% CIs for product use (e-cigarette, Ploom, IQOS and glo) in each of 2015, 2016 and 2017 were calculated, with IPW adjustments. Similarly, weighted percentages for self-reported symptoms from exposure to secondhand HNB tobacco aerosol in 2017 were calculated. Adjusted odds ratios (AORs) and 95% CIs for HNB tobacco/e-cigarette use were calculated by multivariable logistic regression models with robust variance estimators to explore predictors of product use, using tobacco-related, sociodemographic and all other factors indicated in the above as covariates. Predictors of IQOS use in 2017 were examined, because considerable IQOS uptake was seen that year. Sex-stratified rates with 95% CIs of use are shown in the online supplementary data. Probability values for statistical tests were two tailed; $P<0.05$ was considered statistically significant. All analyses were performed using SAS V.9.3.

RESULTS

Google Trends

The weekly Google search volume for words related to HNB tobacco/e-cigarettes in Japan from 2013 to 2017 is shown in figure 1. Over this period, the highest RSV spike for IQOS (ie, RSV=100) was observed in the week of 24–30 April 2016, when IQOS was introduced in *Ame-talk*; after the spike, IQOS RSVs maintained high values. The second highest spike for IQOS (RSV=88) was observed in the week between 26 February 26 and 4 March 2017. This may be due to PMIs application in the USA, but this information was hardly reported as news. Therefore, cause of this spike is uncertain. For e-cigarettes, small spikes were occasionally seen, particularly around 2014, but there was no conspicuous upward trend. Also, small spikes corresponding to release time periods were observed for Ploom (RSV=17, 26 June to 2 July 2016) and glo (RSV=25, 11–17 December 2016). Aside from these spikes, IQOS had a markedly higher RSV than the other products (see online supplementary figure S1), which shows an RSV validation check using the stable term 'alcohol'.

Longitudinal internet survey

Characteristics of study participants are shown in table 1 (for all three waves in online supplementary table S1). Of total baseline subjects, 50% were male, 59% were never-smokers and 6% were ever-users of HNB tobacco/e-cigarette in 2015. Distribution of respondents in follow-up surveys was adjusted close to baseline distribution, using IPWs.

Estimated rates of current use (use in the previous 30 days) of HNB tobacco/e-cigarette in 2015, 2016 and 2017 are shown in table 2 and figure 1. In 2015, 1.3% of respondents (both sexes) were current e-cigarette users, while 0.3% were current IQOS users (and similarly 0.3% for Ploom). One year later, in 2016, these levels had not changed greatly. In 2017, the e-cigarette current user rate had increased to 1.9%, while the IQOS current user rate had increased more than 10-fold to 3.6% (increased absolute value=3.3%). The Ploom Tech current user rate also increased, but only to 1.2%, and the glo current user rate was 0.8% in 2017.

Men were more likely to use tobacco products than women (table 2 and see online supplementary tables S2–8). Baseline current smokers with intention to quit were significantly more likely to use IQOS than current smokers with no intention to quit (18.8% vs 10.3%). Respondents who had seen the IQOS episode of *Ame-talk* in April 2016 were significantly more likely to use it than those who had not (10.3% vs 2.7%); this tendency was also seen in dual users. In 2017, 4.7% of respondents currently used at least one type of HNB tobacco or e-cigarette; of them, 72% also currently smoked combustible cigarettes—a 3.4% overall dual use rate.

Predictors of IQOS current use (use in the previous 30 days) in 2017 are shown in table 3. AOR of baseline current smokers with intention to quit was significantly higher than that of those with no intention to quit (13.3 vs 6.7). AOR of respondents who had seen the TV programme was significantly higher (3.1) than that of those who had not. Women, aged 60 years or more, and current drinkers showed significantly lower AOR than reference categories. Ever-use or no use with preference of e-cigarette use, most deprived area of living place and experience of awareness of tobacco promotion were associated with greater odds of using IQOS.

We also examined and rejected the hypothesis that 'people who often watch TV may be more curious and therefore more likely to use new products'. Two sensitivity analyses, the first adjusting for everyday TV viewing and the second using subgroup analysis among those watching commercial TV programmes every day, did not change the results (data not shown; rather higher AORs were observed in those who saw the TV programme in these sensitivity analyses).

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Table 1 Characteristics of the study subjects (internet survey), both sexes, n=8240

Characteristics at baseline 2015	n*	%
Total	8240	100.0
Sex		
Men	4084	49.6
Women	4156	50.4
Age groups, years		
15–19	881	10.7
20–29	1462	17.7
30–39	1465	17.8
40–49	1487	18.1
50–59	1461	17.7
60–69	1484	18.0
Smoking status		
Never-smoker	4839	58.7
Former smoker	1582	19.2
Current smoker with intention to quit	281	3.4
Current smoker with no intention to quit	1538	18.7
Workplace indoor smoking ban status		
No ban (including smoking room/corner)	2699	32.8
Complete ban	3256	39.5
Not working/did not know	2285	27.7
HNB tobacco/e-cigarette use status		
Never used with no preference for e-cigarette use	7369	89.4
Never used but would like to try e-cigarette in future	353	4.3
Ever-user	518	6.3
Equivalent household income		
1st quartile (lowest)	2079	25.2
2nd quartile	1646	20.0
3rd quartile	1531	18.6
4th quartile (highest)	1256	15.2
Did not know/did not want to answer	1729	21.0
Housing tenure		
Does not own housing	2237	27.2
Owns housing	6003	72.9
Education		
Junior high school/high school	4905	59.5
University/technical school/college or more	3335	40.5
Marital status		
Married	4970	60.3
Never married	2802	34.0
Divorced/widowed	468	5.7
Alcohol consumption		
Never-drinker	3360	40.8
Former drinker	473	5.8
Current drinker	4406	53.5
Self-rated health		
Good (excellent/very good/good)	7356	89.3
Poor (fair/poor)	884	10.7
Area-level deprivation index of living place		
1st quartile (least deprived)	1109	13.5
2nd quartile	1645	20.0
3rd quartile	2404	29.2
4th quartile (most deprived)	2862	34.7
Missing/unknown	219	2.7
Experience of having seen the TV programme†‡		
Had not seen	3756	45.6
Had seen	438	5.3
Did not respond to 2017 survey	4046	49.1
Awareness of tobacco company promotion†		
Never, seldom or sometimes seen	3846	46.7
Often or very often seen	153	1.9
Did not respond to 2017 survey/responded to reduced version§	4240	51.5

*Adjusted for 'being a respondent in an internet survey' using a nationally representative sample in Japan.
†Information collected in 2017 survey.
‡An episode of a popular entertainment TV show introducing IQOS, broadcasted on 28 April 2016, in Japan (see methods section for detail).
§'Responded to reduced version' means responders who answered the question-reduced version that did not included some questions, such as on awareness of tobacco company promotion (n=194).Trends in current use of HNB tobacco/e-cigarette, both sexes, in Japan. Longitudinal internet survey, 2015, 2016 and 2017. Note: rate of glo use in 2015 and 2016 (before glo's sales start) was 0%. HNB, heat-not-burn.
HNB, heat-not-burn.

In all, 12% of respondents (n=997) had been exposed to secondhand HNB tobacco aerosol (table 4). Of them, 37% had experienced at least one symptom as a result, with the most common complaint being generally feeling ill, followed by eye discomfort and then a sore throat. Only 26% of current users reported having experienced at least one symptom, in comparison with 41% of former users and 49% of never-users of any tobacco product.

DISCUSSION

IQOS diffusion in Japan

Interest in, and use of, IQOS among the Japanese rapidly increased from 2015 to 2017, triggered by its appearance on a popular national entertainment TV show, *Ame-talk*. Among viewers of the programme, IQOS use was nearly four times higher than non-viewers (10.3% vs 2.7%). Although a substantial degree of influence from a popular TV show devoted to a product is to be expected from a marketing perspective,[23] the impact of this single episode was nevertheless surprisingly large. This effect was confirmed by multivariable regression analyses (table 3) and Google Trends data (figure 2). Consistently, a recent study reported that number of Google searches for NHB tobacco in Japan exceeded that for e-cigarette in the USA.[24] HNB tobacco are getting very popular. Previous literature shows that a new product or behaviour often has initial widespread popularity, as (1) influential 'early adopters' use the product and (2) more people are exposed to the product and find it compelling and that (3) the physical and social environment can be enormously influential in this regard.[23 25] In Japan, (1) popular comedians played the role of early adopters, (2) IQOS was made by a well-known tobacco company with the ability to promote it widely[26] and (3) the spread of smoke-free environments in Japan might be influential.[27] Several previous studies on e-cigarettes have shown that tobacco marketing and advertisement exposure may promote e-cigarette uptake,[4] and the *Ame-talk* episode may thus have worked this way too. It is not known why only IQOS was introduced on television in this way.[28]

Dual use is common

Seventy-two per cent of HNB tobacco/e-cigarette current users also concurrently used combustibles. There is controversy over

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Table 2 Rate of current use (use in the previous 30 days) of electronic tobacco products

	e-Cigarette			IQOS			Ploom/Ploom Tech			glo	Any product			Dual use*		
Characteristics at 2015 baseline	**2015**	**2016**	**2017**	**2015**	**2016**	**2017**	**2015**	**2016**	**2017**	**2017**	**2015**	**2016**	**2017**	**2015**	**2016**	**2017**
Overall	1.3	1.4	1.9	0.3	0.6	3.6	0.3	0.3	1.2	0.8	1.4	1.8	4.7	0.8	1.2	3.4
Sex																
Men	1.9	1.8	2.9	0.4	1.0	5.4	0.3	0.5	1.9	1.3	1.9	2.2	7.0	1.3	1.8	5.3
Women	0.8	1.1	0.8	0.2	0.3	1.8	0.2	0.0	0.4	0.4	0.8	1.4	2.4	0.4	0.6	1.5
Age groups, years																
15–19	1.5	4.0	1.8	0.6	2.3	2.0	0.6	0.1	1.3	1.8	1.5	4.1	2.0	0.8	4.0	1.5
20–29	3.6	3.2	3.7	1.0	0.6	5.8	1.1	0.4	1.5	1.0	3.7	3.9	8.7	2.4	1.9	4.4
30–39	1.5	1.2	1.7	0.3	0.9	5.4	0.2	0.6	1.2	1.2	1.5	2.0	6.1	0.8	1.5	4.7
40–49	0.9	0.7	1.2	0.0	0.1	3.9	0.0	0.3	1.2	1.0	0.9	0.8	4.8	0.6	0.4	3.9
50–59	0.2	0.2	2.4	0.0	0.4	3.7	0.0	0.0	0.9	0.2	0.3	0.5	4.2	0.2	0.2	3.7
60–69	0.4	0.1	0.4	0.0	0.1	0.0	0.0	0.0	0.7	0.0	0.4	0.2	1.2	0.2	0.1	1.2
Smoking status																
Never-smoker	0.4	0.5	0.9	0.1	0.1	1.3	0.1	0.1	0.6	0.6	0.4	0.7	1.5	-	0.4	1.1
Former smoker	1.5	3.5	1.5	1.1	1.7	2.1	1.0	0.5	0.9	0.9	1.6	4.0	2.8	-	2.2	1.6
Current smoker with intention to quit	2.1	5.1	10.0	1.2	0.2	18.8	0.7	0.6	6.4	1.6	2.6	5.5	25.4	2.6	5.5	23.4
Current smoker with no intention to quit	4.0	1.5	3.9	0.2	1.1	10.3	0.2	0.4	2.2	1.3	4.1	2.2	13.6	4.1	2.0	9.6
Workplace indoor smoking ban status																
No ban (including smoking room/corner)	2.3	1.7	2.0	0.4	0.5	3.6	0.4	0.1	1.2	0.6	2.4	2.2	5.7	1.7	1.9	4.4
Complete ban	1.0	1.9	2.0	0.3	1.2	5.0	0.3	0.5	1.2	0.9	1.0	2.4	5.7	0.4	1.2	3.7
Not working/did not know	0.7	0.5	1.4	0.1	0.0	1.7	0.1	0.0	1.0	1.0	0.7	0.6	2.0	0.4	0.5	1.8
HNB tobacco/e-cigarette use status																
Never used with no preference for e-cigarette use	0.0	0.8	1.3	0.0	0.2	2.1	0.0	0.1	0.9	0.5	0.0	1.0	2.9	0.0	0.5	2.2
Never used but would like to use e-cigarette in future	0.0	0.2	1.6	0.0	1.0	17.8	0.0	0.1	1.4	0.3	0.0	1.4	19.1	0.0	0.4	18.4
Ever-user	21.1	12.2	11.4	4.9	8.0	15.0	4.6	3.3	5.3	6.2	21.6	16.0	21.3	13.5	12.9	10.3
Equivalent household income																
1st quartile (lowest)	2.5	2.1	1.7	0.4	1.4	3.6	0.4	0.0	1.1	1.1	2.6	2.4	4.6	1.9	2.2	3.9
2nd quartile	0.7	1.1	2.2	0.2	0.0	2.5	0.1	0.0	1.3	1.3	0.7	1.2	3.2	0.4	1.0	2.1
3rd quartile	1.3	1.4	2.0	0.3	0.9	5.1	0.4	0.7	1.4	0.6	1.3	2.1	5.9	0.7	1.3	5.1
4th quartile (highest)	1.7	1.2	1.2	0.7	0.6	4.4	0.6	0.7	1.4	0.5	1.7	2.1	6.5	0.8	1.5	4.5
Did not know/did not want to answer	0.3	1.3	2.1	0.0	0.1	2.6	0.0	0.0	0.6	0.5	0.3	1.3	3.9	0.3	0.0	1.7
Housing tenure																
Does not own housing	1.5	1.1	4.2	0.3	0.7	5.1	0.3	0.5	3.1	2.2	1.6	1.8	7.6	1.0	1.5	5.5
Owns housing	1.3	1.6	1.0	0.3	0.6	3.1	0.3	0.1	0.4	0.3	1.3	1.8	3.7	0.8	1.1	2.6
Education																
Junior high school/high school	1.6	1.5	2.2	0.3	0.9	3.7	0.3	0.2	1.2	0.8	1.6	1.8	4.8	0.9	1.6	3.7
University/technical school/college or more	1.0	1.4	1.4	0.4	0.3	3.5	0.3	0.3	1.1	0.9	1.1	1.9	4.6	0.7	0.8	3.0

Continued

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Table 2 Continued

Characteristics at 2015 baseline	e-Cigarette			IQOS			Ploom/Ploom Tech			glo	Any product			Dual use*		
	2015	2016	2017	2015	2016	2017	2015	2016	2017	2017	2015	2016	2017	2015	2016	2017
Marital status																
Married	0.7	0.9	1.8	0.2	0.6	3.4	0.2	0.3	0.9	0.6	0.8	1.3	4.5	0.3	0.8	3.6
Never married	2.5	2.4	2.1	0.5	0.6	4.3	0.5	0.3	1.7	1.3	2.5	2.8	5.4	1.9	1.9	3.4
Divorced/widowed	0.8	0.4	0.7	0.3	0.9	1.7	0.3	0.0	0.6	0.6	0.8	1.3	1.8	0.4	1.1	1.0
Alcohol consumption																
Never-drinker	1.0	1.5	1.5	0.4	0.9	3.8	0.4	0.4	1.1	0.8	1.0	1.7	4.3	0.5	1.5	3.4
Former drinker	2.0	1.6	4.0	0.9	0.7	3.6	0.8	0.0	1.2	1.9	2.1	2.3	5.3	0.6	2.1	3.8
Current drinker	1.5	1.4	1.9	0.2	0.4	3.5	0.1	0.1	1.2	0.7	1.5	1.8	4.9	1.1	0.9	3.4
Self-rated health																
Good (excellent/very good/good)	1.2	1.5	1.8	0.3	0.7	3.6	0.3	0.3	1.0	0.7	1.2	2.0	4.8	0.8	1.3	3.3
Poor (fair/poor)	2.6	0.5	2.1	0.3	0.2	4.0	0.3	0.0	2.1	2.0	2.6	0.7	4.2	1.5	0.3	4.0
Area-level deprivation index of living place																
1st quartile (least deprived)	1.3	1.1	2.4	0.7	1.0	2.4	0.7	0.2	1.5	1.1	1.5	2.0	5.0	0.9	1.5	3.8
2nd quartile	1.2	1.5	3.1	0.3	0.3	3.7	0.2	0.2	1.1	1.0	1.2	1.9	4.3	0.9	1.3	3.5
3rd quartile	1.7	0.8	0.8	0.0	0.4	2.5	0.1	0.0	0.8	0.4	1.7	1.1	3.4	1.4	0.9	2.3
4th quartile (most deprived)	0.9	1.3	2.1	0.2	0.2	4.6	0.2	0.5	1.2	1.1	0.9	1.7	5.5	0.4	0.7	4.2
Missing/unknown	3.6	8.4	0.0	2.8	8.4	8.1	2.8	0.0	2.3	0.0	3.6	8.4	10.4	0.1	8.4	3.6
Experience of having seen the TV programme†‡																
Had not seen	0.8	0.5	1.3	0.2	0.1	2.7	0.2	0.2	0.8	0.5	0.9	0.8	3.5	0.6	0.5	2.7
Had seen	2.4	2.4	5.5	1.5	1.9	10.3	1.5	0.9	3.9	3.3	2.5	3.4	13.3	1.3	3.2	8.3
Did not respond to 2017 survey	1.7	3.4	–	0.2	1.4	–	0.2	0.1	–	–	1.7	3.8	–	1.1	2.2	–
Awareness of tobacco company promotion§																
Never, seldom or sometimes seen	0.9	0.6	1.7	0.4	0.3	3.6	0.3	0.2	1.0	0.6	1.0	1.0	4.8	0.6	0.8	3.4
Often or very often seen	2.3	2.5	6.2	0.0	2.4	6.9	0.0	2.3	6.1	6.1	2.3	2.6	7.1	2.0	2.6	7.1
Did not respond to 2017 survey/responded to reduced version§	1.6	3.1	0.8	0.3	1.3	1.3	0.3	0.1	0.0	0.0	1.7	3.5	1.4	1.0	2.0	1.0

Both sexes and years 2015, 2016 and 2017, in Japan.
Note: glo was sold in 12 December 2016.
*Dual use means use of both combustible cigarette and at least one new tobacco products (IQOS, Ploom, glo and e-cigarette with nicotine or e-cigarette without nicotine).
†Information collected in 2017 survey.
‡A programme of a popular entertainment TV show introducing IQOS was broadcasted on 28 April 2016 in Japan (see methods section for detail).
§Responded to reduced version means responders who answered question-reduced version that did not included some questions such as awareness of tobacco company promotion (n=194).
HNB, heat-not-burn.

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Table 3 Predictors of IQOS current use (IQOS use in the previous 30 days) in 2017 in Japan

	Among total sample	Among HNB tobacco/e-cigarette never-users at baseline
Characteristics at 2015 baseline	Adjusted ORs* (95% CI)	Adjusted ORs* (95% CI)
Sex		
Men	1 (reference)	1 (reference)
Women	0.48 (0.21 to 1.05)	**0.28 (0.10 to 0.77)**
Age groups, years		
15–19	1 (reference)	1 (reference)
20–29	1.88 (0.53 to 6.60)	2.76 (0.76 to 10.06)
30–39	1.53 (0.36 to 6.59)	1.58 (0.32 to 7.91)
40–49	0.81 (0.20 to 3.34)	1.20 (0.29 to 4.99)
50–59	1.25 (0.25 to 6.17)	1.36 (0.24 to 7.66)
60–69	**0.01 (0.00 to 0.10)**	**0.00 (0.00 to 0.05)**
Smoking status		
Never-smoker	1 (reference)	1 (reference)
Former smoker	1.79 (0.70 to 4.60)	1.02 (0.34 to 3.03)
Current smoker with intention to quit	**13.3 (3.08 to 57.4)**	**18.5 (3.37 to 102.0)**
Current smoker with no intention to quit	**6.74 (2.52 to 18.0)**	**11.4 (3.98 to 32.8)**
Workplace indoor smoking ban status		
No ban (including smoking room/corner)	1 (reference)	1 (reference)
Complete ban	1.58 (0.65 to 3.86)	1.76 (0.63 to 4.91)
Not working/did not know	1.27 (0.45 to 3.55)	1.54 (0.46 to 5.19)
HNB tobacco/e-cigarette use status		
Never used with no preference for e-cigarette use	1 (reference)	1 (reference)
Never used but would like to use e-cigarette in future	**4.16 (1.44 to 12.0)**	**3.58 (1.26 to 10.2)**
Ever-user	**3.85 (1.42 to 10.5)**	–
Equivalent household income		
1st quartile (lowest)	1 (reference)	1 (reference)
2nd quartile	0.89 (0.30 to 2.62)	0.48 (0.12 to 1.85)
3rd quartile	1.79 (0.70 to 4.58)	1.69 (0.64 to 4.41)
4th quartile (highest)	2.09 (0.83 to 5.24)	1.72 (0.63 to 4.70)
Did not know/did not want to answer	1.11 (0.27 to 4.52)	1.36 (0.38 to 4.89)
Housing tenure		
Does not own housing	1 (reference)	1 (reference)
Owns housing	0.58 (0.28 to 1.19)	0.60 (0.27 to 1.33)
Education		
Junior high school/high school	1 (reference)	1 (reference)
University/technical school/college or more	0.95 (0.41 to 2.23)	1.13 (0.43 to 2.95)
Marital status		
Married	1 (reference)	1 (reference)
Never married	0.99 (0.47 to 2.10)	0.88 (0.38 to 2.07)
Divorced/widowed	0.34 (0.05 to 2.27)	0.58 (0.08 to 3.99)
Alcohol consumption		
Never-drinker	1 (reference)	1 (reference)
Former drinker	0.72 (0.20 to 2.57)	0.50 (0.11 to 2.35)
Current drinker	0.44 (0.18 to 1.10)	**0.34 (0.13 to 0.88)**
Self-rated health		
Good (excellent/very good/good)	1 (reference)	1 (reference)
Poor (fair/poor)	1.42 (0.53 to 3.85)	1.95 (0.65 to 5.88)
Areal deprivation index of living place		
1st quartile (least deprived)	1 (reference)	1 (reference)
2nd quartile	2.09 (0.77 to 5.70)	**3.76 (1.31 to 10.8)**
3rd quartile	1.38 (0.52 to 3.64)	1.32 (0.39 to 4.42)
4th quartile (most deprived)	**2.79 (1.17 to 6.68)**	**3.41 (1.17 to 9.94)**
Missing/unknown	**4.57 (1.14 to 18.3)**	1.32 (0.15 to 11.37)
Experience of having seen the TV programme†‡		
Had not seen	1 (reference)	1 (reference)
Had seen	**3.08 (1.41 to 6.70)**	**3.66 (1.65 to 8.08)**
Awareness of tobacco company promotion†		
Never, seldom or sometimes seen	1 (reference)	1 (reference)
Often or very often seen	2.44 (0.75 to 7.97)	**3.03 (1.00 to 9.17)**
Responded to reduced version§	0.63 (0.16 to 2.48)	0.76 (0.16 to 3.57)

*Adjusted for all listed variables.
†Information collected in 2017 survey.
‡An episode of a popular entertainment TV show introducing IQOS, broadcasted on 28 April 2016, in Japan (see methods section for detail).
§'Responded to reduced version' refers to responders who answered a question-reduced version that did not included some questions, such as on awareness of tobacco company promotion (n=194).
HNB, heat-not-burn.

whether dual use of e-cigarettes can assist with smoking cessation or not,[29–31] and there is no evidence that HNB tobacco products like IQOS currently play a role in cessation. We will examine this question using future follow-up survey data.

Regulation of HNB tobacco/e-cigarettes

Several regulatory issues are raised by the present findings. First, a significant portion of those exposed to secondhand HNB tobacco aerosol reported symptoms as a result. While the reported symptoms were mild, their frequency indicates that appropriate regulation will still be needed. Electronic tobacco products are regulated differently in Japan depending on whether they use tobacco leaf. The sale of nicotine-containing e-cigarettes as a pharmaceutical product in Japan was banned in 2010. Non-nicotine e-cigarettes, however, are unregulated and available to the public, even to minors. In contrast, Ploom, IQOS and glo are sold as tobacco products and regulated by the *Tobacco Business Act*, because components of these products are made of tobacco leaf. HNB tobacco products have been marketed to consumers as a less harmful alternative to conventional cigarettes, for both users and bystanders[26]; however, HNB tobacco aerosol does include various harmful constituents, although at lower levels than smoke from combustibles.[32 33] Nicotine levels of HNB tobacco aerosol are approximately equal to those released by conventional cigarettes.[1 32 33] Moreover, their actual health effects on users and their overall impact on public health are still not fully known.[34] Regulatory strategies for HNB tobacco should thus be carefully formulated with an eye towards the future. Regulators, however, are already far behind,

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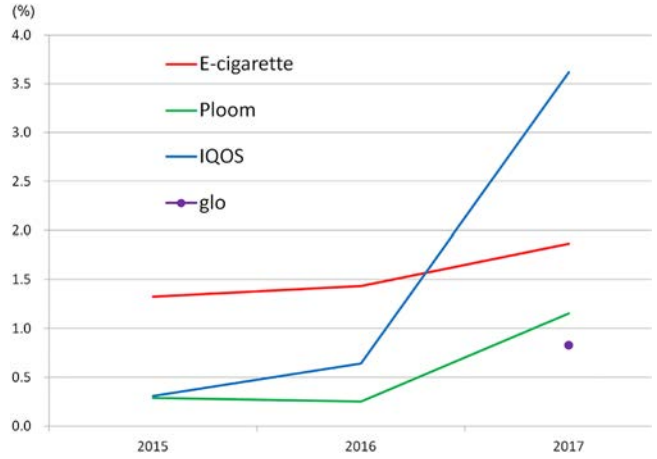


Figure 2 Trends in current use of HNB tobacco/e-cigarette, both sexes, in Japan. Longitudinal internet survey, 2015, 2016 and 2017. Note: rate of glo use in 2015 and 2016 (before glo's sales start) was 0%. HNB, heat-not-burn.

because, as the present findings show, IQOS is already being widely used. If PMI gains FDA approval for IQOS in the USA, the company will assert that it poses reduced risk compared with combustibles and seek similar approvals worldwide.[8]

Limitations and strengths

Although the polling company seeks to ensure representativeness, the distribution is always imperfect; we adjusted for 'being an internet survey respondent' using nationally representative data.[18] Additionally, self-reported information was used, and we excluded respondents with discrepancies or inconsistencies in the answers; however, since the true effects and implications of HNB tobacco/e-cigarette use are unknown, we could not confirm the validity of the exclusion and IPW adjustments in the study. Third, as HNB tobacco products looked like e-cigarettes, some people might categorise HNB tobacco, such as IQOS, as an e-cigarette. Therefore, some might have selected both e-cigarette and HNB tobacco, and this may have led to overestimation. Fourth, use in the previous 30 days was defined as current use in the present study as well as in previous studies.[20 21] Because use in the previous 30 days can include 1 day-only trials, cautious interpretation of the data is necessary. However, prevalence of 1 day-only use within 30 days was relatively small. In the present study, participants were asked 'For the previous 30 days, how many days did you use each tobacco product? (0 to 30 days)'. Of 298 users who reported IQOS use in the previous 30 days in 2017, 52% used on 28 days or more, 22% used on 10–27 days and 14% used on 1 day. As these figures may differ by products and periods, we will report these details in the future. Fifth, Google Trends analysis showed its highest spike in the weekly data for 24–30 April 2016, when the *Ame-talk* episode on IQOS was broadcast in most areas. However, in some localities, it was not broadcast until May 2016; moreover, many people might have recorded the programme and watched it later, which may mean the spike was underestimated. Additional consideration of marketing efforts by the tobacco industry may be necessary.

Despite these limitations, this study garnered consistent results from two independent datasets—from Google Trends and a longitudinal internet survey. As this is the first study to report on the dissemination of IQOS, we need further monitoring and analysis of its impact in Japan.

CONCLUSIONS

A 1-hour entertainment TV programme triggered IQOS diffusion in Japan. In 2017, it was estimated that 3.6% of people currently used IQOS, while 4.7% currently used any HNB or e-cigarette product and 3.4% were dual users. If these estimates are extrapolated straightforwardly to the 86 million Japanese adults aged 17–71 years, approximately 3.1 million currently use IQOS, 4.0 million currently use any HNB or e-cigarette product and 2.9 million are dual users. Tobacco control organisations and governments should continue to monitor HNB tobacco and consider how to regulate it, given its impending, likely rapid global diffusion.

Table 4 Symptoms caused by HNB tobacco aerosol produced by others

	Among total sample, n=8240	Among those exposed to aerosol of HNB tobacco, n=977				
Characteristics	Exposed to aerosol of HNB tobacco, n (%)	Sore throat, %	Eye pain, %	Feeling ill, %	Other injury or symptom, %	Any symptom, %
Total	977 (11.9)	20.6	22.3	25.1	13.4	37.0
Sex						
Men	582 (14.1)	19.7	24.0	24.3	18.6	31.4
Women	395 (9.6)	21.9	19.9	26.3	5.7	45.3
Age groups, years*						
17–29	179 (10.6)	27.9	37.3	39.7	14.5	56.3
30–39	310 (18.5)	22.3	25.0	24.0	13.6	42.1
40–49	227 (12.0)	22.4	22.3	25.1	11.0	28.8
50–59	169 (12.2)	11.6	5.7	12.0	18.8	24.4
60–71	93 (5.8)	13.0	14.9	24.8	6.6	26.1
Combustible cigarette and HNB tobacco/e-cigarette use*						
Never/never†	294 (6.9)	23.1	28.7	38.0	9.6	49.2
At least one former and no current‡	272 (13.1)	21.1	20.9	22.9	10.6	41.2
At least one current§	412 (21.5)	18.6	18.7	17.4	18.0	25.6

*Status in 2017.
†Never/never means persons who never smoke (combustible tobacco) and never use HNB tobacco/e-cigarette.
‡Former/former, former/never or never/former.
§Current/never, current/former, current/current, former/current or never/current.
HNB, heat-not-burn.

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What this paper adds

- In 2016, Philip Morris International applied for US Food and Drug Administration approval of the heat-not-burn tobacco product 'IQOS' as a modified risk tobacco product.
- Multiple heat-not-burn tobacco products (IQOS, Ploom Tech and glo) are currently sold in Japan, but prevalence of use for the products is unknown.
- To date, no studies have observed symptoms from exposure to secondhand heat-not-burn tobacco aerosol.
- Using Google search data and a longitudinal internet survey in Japan, we found that interest in, and use of, IQOS rapidly increased from 2015 to 2017 (use in the previous 30 days: 0.3% to 3.6%), triggered by a 1-hour popular entertainment TV show that introduced IQOS.
- Of participants who had been exposed to others' heat-not-burn tobacco aerosol, 37% had reported at least one symptom because of it.
- As heat-not-burn tobacco use rapidly increases, tobacco control organisations and governments should closely monitor the use of heat-not-burn tobacco and consider how to regulate it.

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Competing interests None declared.

Ethics approval The study was reviewed and approved by the Research Ethics Committee of the Osaka International Cancer Institute (no. 1412175183).

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Data sharing statement Our rule for data sharing of raw data is under consideration.

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