BMJ Open

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Journal:	*BMJ Open*
Manuscript ID	bmjopen-2021-049395
Article Type:	Original research
Date Submitted by the Author:	26-Jan-2021
Complete List of Authors:	Myagmar-Ochir, Enkhtuguldur; Dokkyo Medical University, Department of Public Health Kaneko, Makiko; Department Store Health Insurance Association, Division of Health Support Tomiyama, Kiyomi; Department Store Health Insurance Association, Division of Health Support Zaitsu, Masayoshi ; Dokkyo Medical University, Department of Public Health Watanabe, Shuichi; Department Store Health Insurance Associatio, Division of Health Support Nishino, Yoshitaka; Dokkyo Medical University, Department of Public Health Takahashi, Kyo; Dokkyo Medical University, Department of Public Health Haruyama, Yasuo; Dokkyo Medical University Kobashi, Gen; Dokkyo Medical University, Department of Public Health
Keywords:	PUBLIC HEALTH, PREVENTIVE MEDICINE, Health policy < HEALTH SERVICES ADMINISTRATION & MANAGEMENT, EPIDEMIOLOGY

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Positive occupational gradient in use of heated tobacco products: Analysis of retail workers in Japan

Enkhtuguldur Myagmar-Ochir,[1] Makiko Kaneko,[2] Kiyomi Tomiyama,[2] Masayoshi Zaitsu,[1] Shuichi Watanabe,[2] Yoshitaka Nishino,[1] Kyo Takahashi,[1] Yasuo Haruyama,[3] Gen Kobashi[1]

[1] Department of Public Health, School of Medicine, Dokkyo Medical University, Mibu, Tochigi, Japan

[2] Division of Health Support, Department Store Health Insurance Association, Tokyo, Japan

[3] Integrated Research Faculty for Advanced Medical Sciences, School of Medicine, Dokkyo Medical University, Mibu, Tochigi, Japan

Corresponding to: Masayoshi Zaitsu, MD, PhD

Department of Public Health, School of Medicine, Dokkyo Medical University

880 Kitakobayashi, Mibu, Shimotsuga-gun, Tochigi, 321-00293 Japan

Tel: +81-282-87-2133; Fax: +81-282-86-2935

Email: m-zaitsu@dokkyomed.ac.jp: ORCID: orcid.org/0000-0001-7616-355X

Word count: 3,372

Abstract

Objective: Although heated tobacco products (HTPs) have become popular worldwide, research on occupational gradients in smoking HTPs remains scarce.

Setting and participants: In 2018, we conducted a cross-sectional study comprised of 7,714 retail business workers in the service industry in Japan.

Primary and secondary outcome measures: For the definition of smoking HTPs, we identified current HTP smokers who only smoked HTPs, using five mutual categories of current smoking status (never, former, HTPs only, combustible cigarettes only, and dual smokers who smoked both combustible cigarettes and HTPs). Occupational classes were classified into higher occupational class workers (e.g., upper non-manual workers) and other workers. Odds ratios (ORs) and 95% confidence interval (CIs) of higher occupational class workers were estimated for HTP usage, adjusted for age, sex, employment type, and cigarette smoking-related health knowledge.

Results: The overall prevalence of smoking HTPs was 3.0% (male 5.0%, female 2.2%). The prevalence of HTP smokers differed across occupational classes (5.6% in higher occupational class workers vs. 2.5% in others; $P < 0.05$). The odds of higher occupational class workers remained elevated even after controlling for smoking-related health knowledge (OR 1.97, 95% CI 1.40 to 2.77), while health knowledge was generally insufficient. Sensitivity analyses with workers of all smoking status showed the same pattern. When stratified by sex, the

occupational gradient only remained significant in male workers.

Conclusions: We found a positive occupational gradient in smoking HTPs, particularly among male workers in the retail sector in Japan. National tobacco control should explicitly address this occupational gap and further encourage individuals to quit smoking.

Key words: heated tobacco products, occupation, smoking, socioeconomic status

Strengths and limitations of this study

- This study examined occupational gradients in heated tobacco products (HTPs) smoking prevalence, which remains unclear under the widespread use of HTPs worldwide.
- Higher occupational class workers have higher prevalence of HTPs usage, while cigarette smoking-related health knowledge was insufficient.
- This positive occupational gradient remained significant in male workers when stratified by sex.
- The cross-sectional design does not allow firm conclusions regarding the causal mechanisms underlying the relationship between occupation and HTP usage.

Introduction

Heated tobacco products (HTPs) are smoking devices that heat tobacco sticks to produce aerosols containing nicotine and other chemicals for inhalation [1, 2]. The widespread use of HTPs represents an emerging public health concern. After the initial marketing of IQOS (a brand of HTPs) in Japan and Italy in 2014, HTP usage rapidly spread to more than 30 countries [2]. In Japan, HTP brands IQOS, Glo, and Ploom Tech are currently available, and the prevalence of HTP usage was found to have reached approximately 8% in men and 2% in women in 2018 [3]. In addition, the prevalence has begun to increase in Europe (approximately 1.4% in Italy in 2017) [4]. In some Asian countries, the market for HTPs remains relatively small, and HTPs are not officially retailed in China and Hong Kong [5]. Although the impression of HTPs as a healthy alternative is promoted by direct- and indirect-to-consumer advertising of HTPs compared with conventional combustible cigarettes (e.g., reduced harmfulness and a smoke-free image) [6], there is accumulating evidence for HTP-related adverse effects on health, including acute respiratory diseases and cardiovascular events [7, 8]. In addition, the long-term safety of HTPs has not been proven.

In Japan, the use of HTPs may be related to social patterning. For instance, the distribution of HTP usage has been found to differ across sex and age: men and younger people in their 20s and 30s were found to be more likely to smoke HTPs compared with their female and older counterparts [9-11], which has been proposed to be partly attributable to a

popular television program [2]. Furthermore, several studies have suggested that a socioeconomic gradient for the use of HTPs should be investigated [3, 9, 11, 12]. A recent online cross-sectional survey suggested a potential "positive" socioeconomic gradient in HTP usage [9]. In that study, individuals with higher socioeconomic status (SES), in terms of educational attainment and household income, were more likely to smoke HTPs compared with their lower SES counterparts. This pattern implies that affluent individuals in Japan still have a tendency to prefer higher-risk behaviors for health, representing a potential exception of the fundamental cause theory advocated by Link and Phelan, which proposes that no matter the specific disease pattern in society at any particular point in time, higher SES groups manage to enjoy an overall health advantage [13]. However, the occupational gradient, one of three fundamental SES indicators (education, income, and occupation), remains unclear in relation to the use of HTPs.

Currently, higher occupational class workers in Japan (e.g., workers in managerial and professional positions) do not always enjoy favorable health benefits. For instance, higher occupational workers are reported to have poorer overall mortality and higher cardiovascular risk [14-16]. In addition, because of the Japanese tradition of emphasizing hospitality and customer satisfaction, workers in the service industry may be more vulnerable to psychological stress and more likely to smoke than those in other industries [16-19]. In that occupational stratum, the risk of coronary heart disease has been reported to exhibit a positive

occupational gradient (i.e., a higher risk observed in higher occupational classes) [16]. Thus, it is possible that a positive occupational gradient exists in HTP usage. However, few studies have investigated the overall and sex-specific occupational gradient of smoking HTPs in large working cohorts in service industry sectors such as the retail sector. In addition, because of HTP advertisements promoting a clean image associated with reduced harmfulness [6], cigarette smokers in higher occupational classes (but not limited to those classes) might be unintentionally attracted to HTPs because high SES people tend to choose healthier behaviors [13]. However, little is known about the occupational gradient for smoking HTPs after controlling for cigarette smoking-related health knowledge (e.g., smoking-related lung cancer risks), which may function as a surrogate indicator for the achievement of contemporary public education for tobacco control in Japan.

The present study aimed to examine the overall and sex-specific prevalence of smoking HTPs among a sizable working cohort in the retail sector, a common service industry sector in Japan. We sought to examine whether higher occupational class is associated with higher prevalence of smoking HTPs.

Methods

Data setting

Among a working cohort of the Department Store Health Insurance Association, a typical working population in the retail sector, we conducted a cross-sectional survey about smoking and related health knowledge in August 2018. As a baseline survey, this cross-sectional study was intended to capture a broad overview of occupational factors associated with smoking HTPs. The survey instrument was a self-report questionnaire about smoking behaviors (smoking status and duration of smoking) and HTPs. The survey also asked respondents about their knowledge of smoking-related adverse effects such as cancer and cardiovascular risks. We distributed 8,638 questionnaires to all workers in the working cohort of department stores; 7,837 self-reported questionnaires were collected (response rate, 90.7%). The collected data were mutually linked to individual basic demographics (age and sex) and current job information, including occupational class (e.g., managerial and clerical workers) and employment type (full-time or part-time workers). We obtained a de-identified dataset from the Department Store Health Insurance Association. Written informed consent was obtained and participants received a prepaid card with a value of 300 Japanese yen (approximately US $3) after the survey for their cooperation. The ethical committee of Dokkyo Medical University approved this study (Protocol Number, 30007).

This cross-sectional study included 7,837 current workers who responded to the

questionnaire. We excluded data from participants with missing information (n = 123, 1.6%), which gave a total of 7,714 study participants (2,215 men and 5,499 women; mean age, 46.6 [SD 12.8] years) for analysis.

Main outcome of HTP usage

The primary outcome was to assess the prevalence of smoking HTPs in the retail sector in Japan.

In the questionnaire, HTPs were described as "tobacco", in accord with the Tobacco Business Act in Japan. We cited the IQOS, Glo, and Ploom Tech as HTPs with pictures because these products were commercially available in Japan in 2018. The study participants chose one status for smoking (never, former, sometimes, or every day) from the question, "Do you currently smoke?" If they answered "sometimes" or "every day," we defined them as current smokers. For current smokers, we distinguished between smoking combustible cigarettes, HTPs, or both, using the following question: "Which type(s) of tobacco do you smoke? Please choose all options that apply from the following: combustible cigarettes, IQOS, Glo, or Ploom Tech." Based on this protocol, we classified participants into three current smoking status categories (never, former, and current). We also divided current smokers using HTPs, ultimately identifying five mutually exclusive groups, as follows.

1. Never smokers

2. Former smokers

3. HTP smokers, who currently smoke HTPs only

4. Combustible cigarette smokers, who currently smoke combustible cigarettes only

5. Dual smokers, who currently smoke both combustible cigarettes and HTPs

Because of the limitations of our dataset, the specific duration (years) and amount (number of heat sticks/cartridge per day) for using HTPs were not available. To clarify and simplify the context of using HTPs, we defined smoking HTPs by identifying HTPs smokers only (but excluding dual smokers). Following the rapid rise in prevalence of HTPs after 2016 in Japan [2], most HTP smokers were found to have switched from combustible cigarettes, after a long history of smoking (≥15 years of smoking history, 140 of 229 participants, 61.1%).

Occupational information, smoking-related health knowledge, and other variables

We hypothesized that higher occupational class, a proxy for SES, would be associated with a higher prevalence of smoking HTPs. According to the Erikson–Goldthorpe–Portocarero scheme, an internationally valid occupational class measurement for SES [20] and previous studies that adapted the Erikson–Goldthorpe–Portocarero scheme for Japanese occupational classes [9, 14, 15], we defined two groups of occupational classes: a higher occupational

class group (upper non-manual workers [managerial and professional workers], 5.2% [n=399] and clerical workers, 9.4% [n=723]) and other workers (including service workers, 78.4% [n=6,047] and manual workers, 7.1% [n=545]). Because clerical workers tended to have more favorable health outcomes compared with upper non-manual workers in Japan [14], we classified clerical workers into the higher occupational class group.

For a broad indicator of health knowledge that might affect risky behavior of smoking HTPs (because the long-term safety of HTPs has not been proven), study participants were asked whether they knew about the link between cigarette smoking and each of five common diseases: asthma (yes/no), lung cancer (yes/no), stroke (yes/no), angina/myocardial infarction (yes/no), and periodontal disease (yes/no). By calculating how many links they knew about, we obtained a total sum score of smoking-related health knowledge, a continuous variable ranging from 0 (did not know about any links to diseases) to 5 (knew about all links to diseases). Because the study participants may have learned about all of the links to diseases through public education provided by the government [21], we handled all diseases equally without using different weights.

In our analytical model for explaining the association between occupational class and smoking HTPs, potential confounding variables included basic demographics (age and sex) and employment type (full-time or part-time workers) [9]. As a potential mediating variable that could explain the association (but not be a confounding factor), we included the

total sum score of smoking-related health knowledge as an explanatory variable in our regression model. Although HTP-related risks for common chronic diseases have not been established and health-related knowledge regarding cigarette smoking might not provide a complete substitute for the potential motivations for smoking HTPs, we empirically employed this indicator as a potential behavioral mediator.

Statistical analysis

Descriptive analyses were used to report the background characteristics of the study participants and the prevalence of HTP usage.

Next, we assessed the association between HTPs and occupational class, with never smokers (the control group) and HTP smokers (the case group). Odds ratios (ORs) and 95% confidence intervals (CIs) of higher occupational class workers were estimated for HTP usage using logistic regression. The reference group was the other workers group. In multivariable regression analyses, we adjusted for age, sex, and employment type (full-time/part-time) (model 1). In model 2, we additionally adjusted for smoking-related health knowledge as a continuous variable. Analyses were also stratified by sex. In a priori analysis, we combined dual smokers (both cigarettes and HTPs) and HTPs smokers (only HTPs), and the estimated ORs and 95% CIs of higher occupational class workers for HTP usage were 1.41 (1.09 to 1.83, model 2). However, we distinguished HTP smokers from dual smokers in

the final analytical model.

Furthermore, we used all 7,714 study participants, which also included former smokers, combustible cigarette smokers, and dual smokers. To examine the association for each smoking status against occupational classes, we estimated multinomial odds ratios using multinomial logistic regression [9]. Again, we adjusted for age, sex, and employment type in model 1 and additionally adjusted for smoking-related health knowledge in model 2. Analyses were also stratified by sex. For a supplementary analysis within HTP smokers, we explored potential reasons for smoking HTPs and health attitudes regarding HTPs.

All P-values were both sided and the alpha level was set at 0.05. Data were analyzed using SPSS version 26.0 (SPSS Inc., Chicago, IL., USA).

Patient and Public Involvement

No patients or the public involved.

Results

Of the total 7,714 study participants, the prevalence of combustible cigarettes, HTPs, and dual smokers was 15.8%, 3.0%, and 3.4%, respectively (Table 1). The sex-specific prevalence of combustible cigarettes, HTPs, and dual smokers was 22.8%, 5.0%, and 5.6% in male workers, and 12.9%, 2.2%, and 2.5% in female workers, respectively (Table 1). The prevalence of HTPs smokers was greater in a younger population aged in their 30s and 40s and differed across occupational classes (5.6% in higher occupational class workers vs. 2.5% in other workers) and employment types (5.5% in full-time workers vs. 2.2% in part-time workers), respectively (all $P < 0.05$, Figure 1). Occupational differences only remained significant in male workers when stratified by sex (Figure 1).

The percentage of never smokers among higher occupational class workers was smaller than that among other workers (46.2% vs 61.6%, $P < 0.001$), which indicates that higher occupational class workers were more likely to have ever smoked in this cohort (Table 2). Among male workers in those higher occupational classes, the prevalence of individuals who had ever smoked or were HTP smokers was again greater, and the prevalence of current smokers tended to be greater (Table 2). However, the percentage of combustible cigarette smokers did not differ between occupational classes (Table 2), which suggests possible switching from combustible cigarettes to HTPs in that occupational group. Meanwhile, none of the smoking status groups differed across occupational classes among female workers.

Overall, most of the specific disease knowledge was insufficient, except for lung cancer, and most of the study participants did not know about the link between smoking and cardiovascular diseases (Table 2). Although the gap was small, health knowledge differed across occupational classes: the total sum scores in higher occupational class and other workers were 2.9 (SD 1.4) and 2.7 (SD 1.3), respectively (P < .001, Table 2).

In regression analyses, although the background characteristics differed across occupation and smoking status (Table 2 and Table S1), a positive occupational gradient for HTP usage was observed in multivariable logistic regression: the OR of higher occupational class workers was 1.99 (95% CI 1.42 to 2.78) in model 1 (Table 3). Even after controlling for smoking-related health knowledge (model 2), the elevated odds remained significant (OR 1.97, 95% CI 1.40 to 2.77, Table 3), which suggests that this association was not fully explained by health knowledge of common smoking-related risks. In addition, the odds of full-time employment and smoking-related health knowledge were significantly elevated (model 2, Table 3). However, for the sex-specific association, the occupational gradient only remained significant in male workers (Table 3).

In addition, in a sensitivity analysis including all types of smokers, higher occupational class workers were more likely to smoke HTPs (Table 4), and the observed patterns were almost identical to the main results. Additionally, occupational differences were not observed in combustible cigarette smokers, supporting the possible switching from

cigarettes to HTPs in high occupational strata.

Among HTP smokers, the dominant reason for smoking HTPs was reduced odor and smoke, rather than taking care of others (i.e., not to bother others) or considering health-related aspects (Table S2).

Discussion

Using a large working cohort in the retail sector in Japan, we first found that the prevalence of HTP usage was at least 5% in male workers and 2% in female workers, with a positive occupational gradient for smoking HTPs. Male workers in the higher occupational class in this population were more likely to be ever smokers, with a higher prevalence of smoking HTPs. In addition, no significant occupational gradient was observed in current smoking status among female workers. Public awareness was generally insufficient regarding tobacco-induced health disadvantages, despite contemporary public education.

The short-term and long-term safety of HTPs has not been established, and the World Health Organization warned that HTPs currently contain the same harmful substances as combustible cigarettes [9]. Thus, it has been proposed that HTPs should not be used to improve health [22]. In addition, cigarette smokers, particularly those in high occupational classes, should fundamentally be encouraged to quit smoking, and not to use HTPs [13]. However, in our study, the results suggested that higher occupational class workers might be unintentionally attracted to HTPs because of insufficient health knowledge. The majority of HTP smokers in the current study (> 60%) were former combustible cigarette smokers, and higher occupational class workers were more likely to have ever been smokers than their occupational counterparts, consistent with a well-known contemporary pattern in Japan [23, 24]. Additionally, among HTP smokers, the dominant reason for smoking HTPs was reduced

odor or reduced smoke.

Behavioral and environmental aspects associated with the workplace in Japan may also play a role in the pattern of results we observed. In contrast to the contemporary pattern seen in Western countries, higher occupational class workers are likely to experience greater job stress, potentially stemming from overtime work, hierarchical corporate culture in Japanese companies, and a strongly emphasized concept of hospitality to meet customers' expectations [16]. Previous studies suggest that male full-time workers experience higher levels of job stress [25], and occupational stress has long been assumed to lead to the development of stress coping responses, such as smoking [26]. In the current study, it might be expected that male workers in higher occupational positions, particularly those in the service sector [16-18], are more likely to smoke, irrespective of tobacco products.

In addition to HTP product advertisements promoting a clean image of reduced harmfulness [6], economic dimensions of HTPs may also support the positive occupational gradient we observed. For instance, the price of an HTP device was reported to be 6–18 times more expensive than a pack of cigarettes in 2018, [27] and the prevalence of HTP smokers was higher among full-time workers (i.e., affluent workers) in the present study. In addition, the higher price might be related to subjective impressions of high-quality products, which could act as another potential driver for using HTPs.

Several limitations of the current study should be noted. First, our cross-sectional

design does not allow firm conclusions regarding the causal mechanisms underlying the relationship between occupation and HTP usage. Additionally, we were not able to assess other relevant SES indicators (i.e., educational attainment and income) in this working cohort. However, reverse causality appears to be unlikely because occupational classes are a fundamental SES indicator, and studies suggest a potential SES gap in smoking HTPs [9]. Second, although our data were extracted from a sizable working cohort in the retail sector, the numbers of male and female workers were not balanced. In addition, the study participants only included workers in department stores, thereby limiting the generalizability of our findings. Despite these limitations, the current study is one of the most extensive investigations of the use of HTPs in Japan. Third, our self-reported questionnaires may have been subject to under-reporting of HTP usage. Smoking duration and intensity were not separately available for combustible cigarettes and HTPs. In addition, data regarding passive smoking were not collected. Thus, these limitations might have introduced potential misclassifications in smoking categories. However, previous studies have supported the validity of self-reported smoking status and tobacco use [28]. Fourth, as the baseline survey, we intended to capture a broad overview of the relationship between occupation and HTPs. Thus, data for potential acute and chronic clinical outcomes are not yet available. In addition, due to the limitations of our data set, we were unable to completely assess how health knowledge related to HTPs is associated with smoking HTPs. To address these issues, we

plan to collect more comprehensive data in the future. Additionally, it remains unclear whether the observed positive occupational gradient for HTP usage is associated with overall mortality and cardiovascular risk, combined with inflammatory and oxidative stress (e.g., C-reactive protein and urinary 8-hydroxydeoxyguanosine) [19, 29]. Despite these limitations, the strengths of the current study included a large sample size, providing the first report of an occupational gradient in smoking HTPs even after controlling for health knowledge, with a robust occupational indicator [9, 14, 15].

Finally, our results suggest that HTP smoking is highly prevalent, particularly among higher-SES males in Japan. In this group, challenges include unfavorable health outcomes [9, 14-16]. However, for the five smoking-related diseases listed on the government website in Japan, we found unfavorable results regarding health knowledge, except for lung cancer. Additionally, participants who knew about the link between cigarette smoking and lung cancer did not quit smoking, even though they were aware of the adverse health outcomes involved. Overall, our findings suggest that health education about tobacco control is currently insufficient in Japan. Among HTP smokers, the dominant reason for smoking HTPs was reduced odor or reduced smoke, rather than taking care of others or considering health-related factors. Therefore, further public education on tobacco control with both population and high-risk approaches should remain a high priority.

In conclusion, the current findings indicated that higher occupational class is

associated with a higher prevalence of smoking HTPs, particularly among male retail workers in the service industry in Japan. Public awareness of tobacco-related health impacts is currently insufficient. Hence, national tobacco control should explicitly address this occupational gap and further encourage individuals to quit smoking.

Acknowledgments: We thank Benjamin Knight, MSc., from Edanz Group (https://en-author-services.edanzgroup.com/ac) for editing a draft of this manuscript.

Author contribution: EM, MZ, and YH designed the study. MK, KT and SW created the dataset. EM, YN, and MZ analyzed the data. EM wrote the first draft of the manuscript. MK, KT, MZ, SW, YN, KT, YH and GK commented on the manuscript. All authors read and approved the final manuscript.

Funding: This work was supported in part by Health, Labour and Welfare Sciences Research Grants (20FA1005) and Japan Society for the Promotion of Science (JSPS KAKENHI JP18K17351).

Conflict of interest: The authors declare no potential conflicts of interest.

Data availability statement: No additional data available.

Ethics approval: The study was approved by the Ethics Committee of Dokkyo Medical University (Protocol Number 30007).

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Figure legends

Figure 1. Prevalence of heated tobacco smokers across various background characteristics in the cohort. Each bar shows the prevalence of heated tobacco smokers within specific background characteristics. Abbreviation: HTP, heated tobacco products.

Table1. Background characteristics of a large working cohort of department stores in Japan

Characteristics	N (%) or mean (SD)[a]		
	Total (n=7,714)	Male (n=2,215)	Female (n=5,499)
Age, mean (SD)	46.6 (12.8)	40.2 (13.7)	49.2 (11.4)
Higher occupational class	1,122 (14.5)	797 (36.0)	325 (5.9)
Full time employment	1,800 (23.3)	1,349 (60.9)	451 (8.2)
Current smoking status			
Never smokers	4,580 (59.4)	1,011 (45.6)	3,569 (64.9)
Former smokers	1,428 (18.5)	466 (21.0)	962 (17.5)
Current smoker	1,706 (22.1)	738 (33.3)	968 (17.6)
Combustible cigarette smokers	1,217 (15.8)	505 (22.8)	712 (12.9)
HTPs smokers	229 (3.0)	110 (5.0)	119 (2.2)
Dual smokers[b]	260 (3.4)	123 (5.6)	137 (2.5)

Abbreviation: HTPs, heated tobacco products.

[a] Percentage may not total 100 due to rounding.

[b] Dual smokers are those who currently smoke both combustible cigarettes and HTPs.

Table 2. Background differences across occupational classes

Characteristics	N (%) or mean (SD)		P[a]
	Higher occupational class workers	Others	
Total	*n=1,122*	*n=6,592*	
Age, mean (SD)	45.5 (11.8)	46.8 (12.9)	0.001
Female	325 (29.0)	5,174 (78.5)	<0.001
Full time employment	466 (41.5)	1,334 (20.2)	<0.001
Current smoking status			
Never smokers	518 (46.2)	4,062 (61.6)	<0.001
Former smokers	273 (24.3)	1,155 (17.5)	<0.001
Current smoker	331 (29.5)	1,375 (20.9)	<0.001
Combustible cigarette smokers	222 (19.8)	995 (15.1)	<0.001
Dual smokers	46 (4.1)	214 (3.2)	0.143
HTPs smokers	63 (5.6)	166 (2.5)	<0.001
Total score, mean (SD)[b]	2.9 (1.4)	2.7 (1.3)	<0.001
Asthma	794 (70.8)	4,581 (69.5)	0.391
Lung cancer	1,042 (92.9)	6,150 (93.3)	0.600
Stroke	509 (45.4)	2,671 (40.5)	0.002
Angina/myocardial infarction	540 (48.1)	2,707 (41.1)	<0.001
Periodontal disease	342 (30.5)	1,789 (27.1)	0.021
Male	*n=797*	*n=1,418*	
Age, mean (SD)	45.4 (11.8)	37.4 (13.9)	<0.001
Full time employment	426 (53.5)	923 (65.1)	<0.001
Current smoking status			
Never smokers	304 (38.1)	707 (49.9)	<0.001
Former smokers	219 (27.5)	247 (17.4)	<0.001
Current smoker	274 (34.4)	464 (32.7)	0.427
Combustible cigarette smokers	178 (22.3)	327 (23.1)	0.696
Dual smokers	41 (5.1)	82 (5.8)	0.529
HTPs smokers	55 (6.9)	55 (3.9)	0.002
Total score, mean (SD)	3.0 (1.4)	2.6 (1.4)	<0.001
Asthma	574 (72.0)	908 (64.0)	<0.001
Lung cancer	752 (94.4)	1,286 (90.7)	0.002
Stroke	385 (48.3)	589 (41.5)	0.002
Angina/myocardial infarction	411 (51.6)	507 (35.8)	<0.001
Periodontal disease	261 (32.7)	453 (31.9)	0.699

Female	*n=325*	*n=5,174*	
Age, mean (SD)	45.7 (11.8)	49.4 (11.4)	<0.001
Full time employment	40 (12.3)	411 (7.9)	0.005
Current smoking status			
Never smokers	214 (65.8)	3,355 (64.8)	0.713
Former smokers	54 (16.6)	908 (17.5)	0.667
Current smoker	57 (17.5)	911 (17.6)	0.975
Combustible cigarette smokers	44 (13.5)	668 (12.9)	0.744
Dual smokers	5 (1.5)	132 (2.6)	0.256
HTPs smokers	8 (2.5)	111 (2.1)	0.704
Total score, mean (SD)	2.6 (1.4)	2.7 (1.3)	0.069
Asthma	220 (67.7)	3,673 (71.0)	0.205
Lung cancer	290 (89.2)	4,864 (94.0)	0.001
Stroke	124 (38.2)	2,082 (40.2)	0.457
Angina/myocardial infarction	129 (39.7)	2,200 (42.5)	0.317
Periodontal disease	81 (24.9)	1,336 (25.8)	0.719

Abbreviation: HTPs, heated tobacco products.

[a] P-values for t-test or chi-squared test.

[b] Total scores were created by summing up each link known.

Table 3. Odds ratios for heated tobacco smokers against occupational class and other factors

Characteristics	N (%) or mean (SD)		Odds ratio (95% confidence interval)		
	Never	HTPs	Crude	Model 1[a]	Model 2[b]
Total	*n=4,580*	*n=229*			
Higher occupational class	518 (11.3%)	63 (27.5%)	2.98 (2.20 to 4.03)	1.99 (1.42 to 2.78)	1.97 (1.40 to 2.77)
Full time employment	988 (21.6%)	99 (43.2%)	2.77 (2.11 to 3.63)	1.75 (1.21 to 2.53)	1.73 (1.20 to 2.50)
Age	45.8 (13.5)	42.4 (11.1)	0.98 (0.97 to 0.99)	1.00 (0.99 to 1.02)	1.00 (0.99 to 1.01)
Female	3,569 (77.9%)	119 (52.0%)	0.31 (0.23 to 0.40)	0.50 (0.34 to 0.72)	0.50 (0.35 to 0.73)
Total knowledge	2.5 (1.3)	3.0 (1.4)	1.33 (1.20 to 1.47)		1.34 (1.21 to 1.48)
Male	*n=1,011*	*n=110*			
Higher occupational class	304 (30.1%)	55 (50.0%)	2.33 (1.56 to 3.46)	2.15 (1.37 to 3.36)	2.09 (1.33 to 3.28)
Full time employment	658 (65.1%)	90 (81.8%)	2.41 (1.46 to 3.99)	3.52 (2.05 to 6.04)	3.48 (2.02 to 5.99)
Age	34.9(11.9)	38.3 (9.9)	1.02 (1.01 to 1.04)	1.03 (1.01 to 1.05)	1.03 (1.004 to 1.05)
Total knowledge	2.4 (1.4)	3.0 (1.4)	1.35 (1.17 to 1.55)		1.31 (1.13 to 1.53)
Female	*n=3,569*	*n=119*			
Higher occupational class	214 (6.0%)	8 (6.7%)	1.13 (0.54 to 2.35)	1.04 (0.50 to 2.17)	1.11 (0.53 to 2.32)
Full time employment	330 (9.2%)	9 (7.6%)	0.80 (0.40 to 1.60)	0.51 (0.24 to 1.08)	0.51 (0.24 to 1.09)
Age	48.9 (12.2)	46.1 (10.7)	0.98 (0.97 to 0.997)	0.98 (0.96 to 0.99)	0.98 (0.96 to 0.99)
Total knowledge	2.6 (1.3)	3.1 (1.4)	1.34 (1.17 to 1.54)		1.35 (1.18 to 1.55)

Abbreviation: HTPs, heated tobacco products.

[a]Odds ratios for heated tobacco smokers against occupational class were estimated with unconditional logistic regression, adjusted for age, sex, and employment type.

[b]Additional adjustment for smoking-related health knowledge.

Table 4. Multinomial odds ratios for each smoking status in high occupational class workers

Characteristics	Multinominal odds ratio (95% confidence interval)	
	Model 1[a]	Model 2[b]
HTPs smokers		
Higher occupational class	1.99 (1.42 to 2.79)	1.94 (1.38 to 2.72)
Full time employment	1.62 (1.12 to 2.33)	1.58 (1.09 to 2.29)
Age, continuous	0.997 (0.99 to 1.01)	0.99 (0.98 to 1.01)
Female	0.51 (0.36 to 0.73)	0.51 (0.35 to 0.73)
Total knowledge		1.34 (1.22 to 1.48)
Combustible cigarette smokers		
Higher occupational class	1.02 (0.84 to 1.23)	0.99 (0.81 to 1.20)
Full time employment	0.89 (0.73 to 1.09)	0.88 (0.72 to 1.07)
Age, continuous	1.03 (1.02 to 1.03)	1.03 (1.02 to 1.03)
Female	0.29 (0.24 to 0.35)	0.29 (0.24 to 0.34)
Total knowledge		1.31 (1.24 to 1.37)
Dual smokers		
Higher occupational class	1.01 (0.71 to 1.45)	0.97 (0.67 to 1.40)
Full time employment	1.83 (1.27 to 2.62)	1.79 (1.24 to 2.57)
Age, continuous	1.01 (0.99 to 1.02)	1.00 (0.99 to 1.01)
Female	0.43 (0.31 to 0.60)	0.42 (0.30 to 0.60)
Total knowledge		1.44 (1.31 to 1.59)
Former smokers		
Higher occupational class	1.38 (1.15 to 1.65)	1.34 (1.12 to 1.61)
Full time employment	0.82 (0.67 to 1.00)	0.81 (0.66 to 0.99)
Age, continuous	1.03 (1.03 to 1.04)	1.03 (1.02 to 1.03)
Female	0.44 (0.37 to 0.53)	0.44 (0.37 to 0.53)
Total knowledge		1.30 (1.24 to 1.36)

Abbreviation: HTP, heated tobacco product.

[a] Adjusted for age, sex, and employment type.

[b] Additional adjustment for smoking-related health knowledge.15

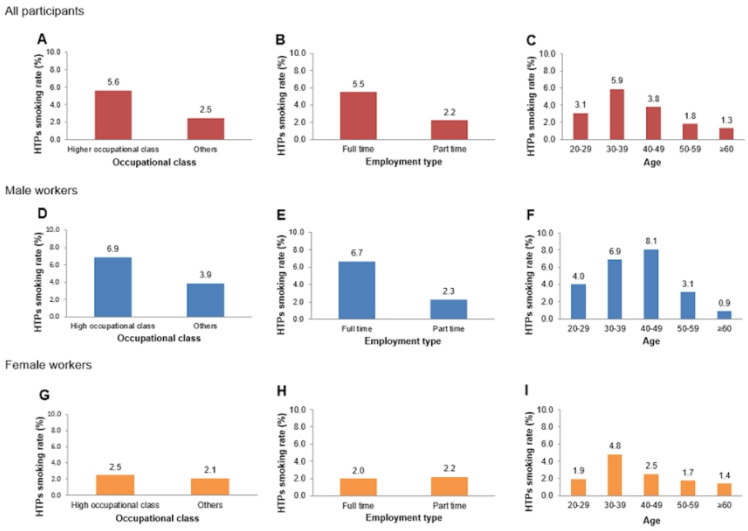

Figure 1. Prevalence of heated tobacco smokers across various background characteristics in the cohort. Each bar shows the prevalence of heated tobacco smokers within specific background characteristics. Abbreviation: HTP, heated tobacco products.

160x90mm (300 x 300 DPI)

Table S1. Background characteristics across each current smoking status group

Characteristics	N (%) or mean (SD)[a]				
	Never	Former	Combustible cigarette	Dual	HTPs
Total (n=7,714)	n=4,580	n=1,428	n=1,217	n=260	n=229
Age, mean (SD)	**45.8 (13.5)**	**49.4 (10.8)**	**48.0 (11.9)**	**42.7 (12.4)**	**42.4 (11.1)**
Female	**3,569 (77.9)**	**962 (67.4)**	**712 (58.5)**	**137 (52.7)**	**119 (52.0)**
Higher occupational class	**518 (11.3)**	**273 (19.1)**	**222 (18.2)**	**46 (17.7)**	**63 (27.5)**
Full time employment	**988 (21.6)**	**285 (20.0)**	**314 (25.8)**	**114 (43.8)**	**99 (43.2)**
Smoking-related health knowledge					
Total score, mean (SD)	**2.5 (1.3)**	**3.0 (1.3)**	**3.0 (1.4)**	**3.2 (1.3)**	**3.0 (1.4)**
Asthma	**3,121 (68.1)**	**1,088 (76.2)**	**824 (67.7)**	**184 (70.8)**	**158 (69.0)**
Lung cancer	4,260 (93.0)	1,352 (94.7)	1,125 (92.4)	244 (93.8)	211 (92.1)
Stroke	**1,540 (33.6)**	**672 (47.1)**	**688 (56.5)**	**160 (61.5)**	**120 (52.4)**
Angina/myocardial infarction	**1,607 (35.1)**	**747 (52.3)**	**630 (51.8)**	**147 (56.5)**	**116 (50.7)**
Periodontal disease	**1,056 (23.1)**	**476 (33.3)**	**421 (34.6)**	**87 (33.5)**	**91 (39.7)**
Men (n=2,215)	n=1,011	n=466	n=505	n=123	n=110
Age, mean (SD)	**34.9 (11.9)**	**48.5 (13.0)**	**44.4 (13.7)**	**38.0 (12.6)**	**38.3 (9.9)**
Higher occupational class	**304 (30.1)**	**219 (47.0)**	**178 (35.2)**	**41 (33.3)**	**55 (50.0)**
Full time employment	**658 (65.1)**	**231 (49.6)**	**273 (54.1)**	**97 (78.9)**	**90 (81.8)**
Smoking-related health knowledge					
Total score, mean (SD)	**2.4 (1.4)**	**3.1 (1.3)**	**3.0 (1.4)**	**3.1 (1.3)**	**3.0 (1.4)**
Asthma	**648 (64.1)**	**346 (74.2)**	**329 (65.1)**	**86 (69.9)**	**73 (66.4)**
Lung cancer	**913 (90.3)**	**435 (93.3)**	**467 (92.5)**	**120 (97.6)**	**103 (93.6)**
Stroke	**317 (31.4)**	**243 (52.1)**	**278 (55.0)**	**75 (61.0)**	**61 (55.5)**
Angina/myocardial infarction	**295 (29.2)**	**258 (55.4)**	**248 (49.1)**	**62 (50.4)**	**55 (50.0)**
Periodontal disease	297 (29.4)	159 (34.1)	179 (35.4)	40 (32.5)	39 (35.5)
Women (n=5,499)	n=3,569	n=962	n=712	n=137	n=119
Age, mean (SD)	**48.9 (12.2)**	**49.9 (9.6)**	**50.6 (9.6)**	**47.0 (10.7)**	**46.1 (10.7)**
Higher occupational class	214 (6.0)	54 (5.6)	44 (6.2)	5 (3.6)	8 (6.7)
Full time employment	**330 (9.2)**	**54 (5.6)**	**41 (5.8)**	**17 (12.4)**	**9 (7.6)**
Smoking-related health knowledge					
Total score, mean (SD)	**2.6 (1.3)**	**3.0 (1.3)**	**3.1 (1.4)**	**3.2 (1.3)**	**3.1 (1.4)**
Asthma	**2,473 (69.3)**	**742 (77.1)**	**495 (69.5)**	**98 (71.5)**	**85 (71.4)**
Lung cancer	**3,347 (93.8)**	**917 (95.3)**	**658 (92.4)**	**124 (90.5)**	**108 (90.8)**
Stroke	**1,223 (34.3)**	**429 (44.6)**	**410 (57.6)**	**85 (62.0)**	**59 (49.6)**
Angina/myocardial infarction	**1.312 (36.8)**	**489 (50.8)**	**382 (53.7)**	**85 (62.0)**	**61 (51.3)**
Periodontal disease	**759 (21.3)**	**317 (33.0)**	**242 (34.0)**	**47 (34.3)**	**52 (43.7)**

Abbreviation: HTPs, heated tobacco products. Bold numbers indicate $P < 0.05$ (ANOVA or chi-squared test).

Table S2. Reasons for smoking heated tobacco products

Characteristics	**Reason 1** "Smoking HTPs reduce the odor and smoke."	**Reason 2** "Smoking HTPs do not bother others."	**Reason 3** "Smoking HTPs was healthier."
	n (%)	n (%)	n (%)
HTPs smokers[a]			
Total, n=229			
Occupational class			
Higher occupational class workers (n=63)	57 (90.5)	15 (23.8)	25 (39.7)
Others (n=166)	137 (82.5)	54 (32.5)	59 (35.5)
Employment type			
Full time (n=99)	82 (82.8)	34 (34.3)	36 (36.4)
Part time (n=130)	112 (86.2)	35 (26.9)	48 (36.9)
Sex			
Male (n=110)	94 (85.5)	34 (30.9)	43 (39.1)
Female (n=119)	100 (84.0)	35 (29.4)	41 (34.5)
Male, n=110			
Occupational class			
Higher occupational class workers (n=55)	49 (89.1)	13 (23.6)	22 (40.0)
Others (n=55)	45 (81.8)	21 (38.2)	21 (38.2)
Employment type			
Full time (n=90)	77 (85.6)	31 (34.4)	34 (37.8)
Part time (n=20)	17 (85.0)	3 (15.0)	9 (45.0)
Female, n=119			
Occupational class			
Higher occupational class workers (n=8)	8 (100)	2 (25.0)	3 (37.5)
Others (n=111)	92 (82.9)	33 (29.1)	38 (34.2)
Employment group			
Full time (n=9)	5 (55.6)	3 (33.3)	2 (22.2)
Part time (n=110)	95 (86.4)	32 (29.1)	39 (35.5)
HTPs smokers plus dual smokers[b]			
Total, n=489			
Occupational class			
Higher occupational class workers (n=109)	89 (81.7)	23 (21.1)	31 (28.4)
Others (n=380)	291 (76.6)	105 (27.6)	107 (28.2)
Employment type			
Full time (n=213)	170(79.8)	60 (28.2)	52 (24.4)
Part time (n=276)	210 (76.1)	68 (24.6)	86 (31.2)
Sex			
Male (n=233)	185 (79.4)	63 (27.0)	64 (27.5)
Female (n=256)	195 (76.2)	65 (25.4)	74 (28.9)
Male, n=233			
Occupational class			
Higher occupational class workers (n=96)	80 (83.3)	21 (21.9)	28 (29.2)
Others (n=137)	105 (76.6)	42 (30.7)	36 (26.3)
Employment type			
Full time (n=187)	152 (81.3)	55 (29.4)	48 (25.7)
Part time (n=46)	33 (71.7)	8 (17.4)	16 (34.8)
Female, n=256			
Occupational class			
Higher occupational class workers (n=13)	9 (69.2)	2 (15.4)	3 (23.1)
Others (n=243)	186 (76.5)	63 (25.9)	71 (29.2)
Employment type			
Full time (n=26)	18 (69.2)	5 (19.2)	4 (15.4)
Part time (n=230)	177 (77.0)	60 (26.1)	70 (30.4)

Abbreviation: HTPs, heated tobacco products.

[a] HTP smokers are those who currently smoke HTPs only.

[b] Dual smokers are those who currently smoke both combustible cigarettes and HTPs.

STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

		Item No	Recommendation
	Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract
P1-3			(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found
	Introduction		
P5-7	Background/rationale	2	Explain the scientific background and rationale for the investigation being reported
P7	Objectives	3	State specific objectives, including any prespecified hypotheses
	Methods		
P8	Study design	4	Present key elements of study design early in the paper
P8	Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection
P8-9	Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants
P9-12	Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable
P9-12	Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group
P13	Bias	9	Describe any efforts to address potential sources of bias
P8	Study size	10	Explain how the study size was arrived at
P9-12	Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why
P12-13	Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding
			(*b*) Describe any methods used to examine subgroups and interactions
			(*c*) Explain how missing data were addressed
			(*d*) If applicable, describe analytical methods taking account of sampling strategy
			(*e*) Describe any sensitivity analyses
	Results		
P14	Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed
			(b) Give reasons for non-participation at each stage
			(c) Consider use of a flow diagram
P14-15	Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders
			(b) Indicate number of participants with missing data for each variable of interest
P14-15	Outcome data	15*	Report numbers of outcome events or summary measures
P14-15	Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included
			(*b*) Report category boundaries when continuous variables were categorized
			(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
P15-16	Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses

	Discussion		
P17	Key results	18	Summarise key results with reference to study objectives
P18-19	Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias
P17-18	Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
P20	Generalisability	21	Discuss the generalisability (external validity) of the study results
	Other information		
P2	Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

Positive occupational difference in use of heated tobacco products: A cross-sectional analysis of retail workers in Japan

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2021-049395.R1
Article Type:	Original research
Date Submitted by the Author:	11-May-2021
Complete List of Authors:	Myagmar-Ochir, Enkhtuguldur; Dokkyo Medical University, Department of Public Health Kaneko, Makiko; Department Store Health Insurance Association, Division of Health Support Tomiyama, Kiyomi; Department Store Health Insurance Association, Division of Health Support Zaitsu, Masayoshi ; Dokkyo Medical University, Department of Public Health Watanabe, Shuichi; Department Store Health Insurance Associatio, Division of Health Support Nishino, Yoshitaka; Dokkyo Medical University, Department of Public Health Takahashi, Kyo; Dokkyo Medical University, Department of Public Health Haruyama, Yasuo; Dokkyo Medical University Kobashi, Gen; Dokkyo Medical University, Department of Public Health
Primary Subject Heading:	Smoking and tobacco
Secondary Subject Heading:	Public health, Addiction, Epidemiology, Health policy, Occupational and environmental medicine
Keywords:	PUBLIC HEALTH, PREVENTIVE MEDICINE, Health policy < HEALTH SERVICES ADMINISTRATION & MANAGEMENT, EPIDEMIOLOGY

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Positive occupational difference in use of heated tobacco products: A cross-sectional analysis of retail workers in Japan

Enkhtuguldur Myagmar-Ochir,[1] Makiko Kaneko,[2] Kiyomi Tomiyama,[2] Masayoshi Zaitsu,[1] Shuichi Watanabe,[2] Yoshitaka Nishino,[1] Kyo Takahashi,[1] Yasuo Haruyama,[3] Gen Kobashi[1]

[1] Department of Public Health, School of Medicine, Dokkyo Medical University, Mibu, Tochigi, Japan

[2] Division of Health Support, Department Store Health Insurance Association, Tokyo, Japan

[3] Integrated Research Faculty for Advanced Medical Sciences, School of Medicine, Dokkyo Medical University, Mibu, Tochigi, Japan

Corresponding to: Masayoshi Zaitsu, MD, PhD

Department of Public Health, School of Medicine, Dokkyo Medical University

880 Kitakobayashi, Mibu, Shimotsuga-gun, Tochigi, 321-00293 Japan

Tel: +81-282-87-2133; Fax: +81-282-86-2935

Email: m-zaitsu@dokkyomed.ac.jp: ORCID: orcid.org/0000-0001-7616-355X

Word count: 2,791

Abstract

Objective: Although heated tobacco products (HTPs) have become popular worldwide, research on occupational differences in smoking HTPs remains scarce.

Setting, design, and participants: In 2018, we conducted a cross-sectional study comprised of 7,714 retail business workers in the service industry in Japan.

Primary and secondary outcome measures: For the definition of smoking HTPs, we identified current HTP smokers who only smoked HTPs, using five mutual categories of current smoking status (never, former, HTPs only, combustible cigarettes only, and dual smokers who smoked both combustible cigarettes and HTPs). Occupational classes were classified into higher occupational class workers (e.g., upper non-manual workers) and other workers. Odds ratios (ORs) and 95% confidence interval (CIs) of higher occupational class workers were estimated for HTP usage, adjusted for age, sex, employment type, and cigarette smoking-related health knowledge.

Results: The overall prevalence of smoking HTPs was 3.0% (male 5.0%, female 2.2%). The prevalence of HTP smokers differed across occupational classes (5.6% in higher occupational class workers vs. 2.5% in others; $P < 0.05$). Compared with other workers, the adjusted odds of higher occupational class workers for smoking HTPs remained elevated (OR 1.97, 95% CI 1.40 to 2.77). Sensitivity analyses with workers of all smoking status showed the same pattern. When stratified by sex, the occupational difference only remained significant in male

workers.

Conclusions: We found a positive occupational difference in smoking HTPs, particularly among male workers in the retail sector in Japan. National tobacco control should explicitly address this occupational gap and further encourage individuals to quit smoking.

Key words: heated tobacco products, occupation, smoking, socioeconomic status

Strengths and limitations of this study

- Little is known about heated tobacco products (HTPs) usage among working population.
- This study examined occupational differences in HTPs smoking prevalence, which remains unclear under the widespread use of HTPs worldwide.
- Higher occupational class workers have higher prevalence of HTPs usage.
- This occupational difference remained significant in male workers when stratified by sex.
- The cross-sectional design does not allow firm conclusions regarding the causal mechanisms underlying the relationship between occupation and HTP usage.

Introduction

Heated tobacco products (HTPs) are smoking devices that heat tobacco sticks to produce aerosols containing nicotine and other chemicals for inhalation [1, 2]. The widespread use of HTPs represents an emerging public health concern. After the initial marketing of IQOS (a brand of HTPs) in Japan and Italy in 2014, HTP usage rapidly spread to more than 30 countries [2]. In Japan, HTP brands IQOS and Ploom Tech (launched in March 2016) and Glo (launched in December 2016) are currently available [2], and the market share was accounted for 21% in total tobacco sales in 2018 [3]. The prevalence of HTP usage was found to have reached approximately 8% in men and 2% in women in 2018 [4]. Although limited studies on HTPs usage are available, the prevalence has begun to increase worldwide (approximately 1.4% in Italy in 2017 and 2.9% in Guatemala adolescents in 2020) [5,6]. In some Asian countries, the market for HTPs remains relatively small, and HTPs are not officially retailed in China and Hong Kong [7]. Although the impression of HTPs as a healthy alternative is promoted by direct- and indirect-to-consumer advertising of HTPs compared with conventional combustible cigarettes (e.g., reduced harmfulness and a smoke-free image) [8], there is accumulating evidence for HTP-related adverse effects on health, including acute respiratory diseases and cardiovascular events [9, 10]. In addition, the long-term safety of HTPs has not been proven.

In Japan, the use of HTPs may be related to social patterning. For instance, the

distribution of HTP usage has been found to differ across sex and age: men and younger people in their 20s and 30s were found to be more likely to smoke HTPs compared with their female and older counterparts [11-13], which has been proposed to be partly attributable to a popular television program [2]. Furthermore, several studies have suggested that a socioeconomic difference for the use of HTPs should be investigated [4, 11, 13, 14]. A recent online cross-sectional survey suggested a potential "positive" socioeconomic difference in HTP usage [11]. In that study, individuals with higher socioeconomic status (SES), in terms of educational attainment and household income, were more likely to smoke HTPs compared with their lower SES counterparts. However, the occupational difference, one of three fundamental SES indicators (education, income, and occupation), remains unclear in relation to the use of HTPs.

The present study aimed to examine the overall and sex-specific prevalence of smoking HTPs among a sizable working population in the retail sector, a common service industry sector in Japan. We sought to examine whether higher occupational class is associated with higher prevalence of smoking HTPs.

Methods

Data setting

Among a working population of the Department Store Health Insurance Association in the

retail sector, we conducted a cross-sectional survey about smoking and related health knowledge in August 2018. As a baseline survey, this study was intended to capture a broad overview of occupational factors associated with smoking HTPs. The survey instrument was a self-report questionnaire about smoking behaviors (smoking status and duration of smoking) and HTPs. The survey also asked respondents about their knowledge of smoking-related adverse effects such as cancer and cardiovascular risks. We distributed 8,638 questionnaires to all workers in the working population of department stores; 7,837 self-reported questionnaires were collected (response rate, 90.7%). For each participant, the Department Store Health Insurance Association mutually linked collected data to individual basic demographics (age and sex) and current job information, including occupational class (e.g., managerial and clerical workers) and employment type (full-time or part-time workers). We obtained a de-identified dataset from the Department Store Health Insurance Association. Written informed consent was obtained and participants received a prepaid card with a value of 300 Japanese yen (approximately US $3) after the survey for their cooperation. The ethical committee of Dokkyo Medical University approved this study (Protocol Number, 30007).

From 7,837 study participants, we excluded data from participants with missing information (n = 123, 1.6%), which gave a total of 7,714 study participants (2,215 men and 5,499 women; mean age, 46.6 [SD 12.8] years) for analysis.

Main outcome of HTP usage

The primary outcome was to assess the prevalence of smoking HTPs currently in the retail sector in Japan.

In the questionnaire, HTPs were described as "tobacco", in accord with the Tobacco Business Act in Japan. We cited the IQOS, Glo, and Ploom Tech as HTPs with pictures because these products were commercially available in Japan in 2018. The study participants chose one status for smoking (never, former, sometimes, or every day) from the question, "Do you currently smoke?" If they answered "sometimes" or "every day," we defined them as current smokers. For current smokers, we distinguished between smoking combustible cigarettes, HTPs, or both, using the following question: "Which type(s) of tobacco do you smoke? Please choose all options that apply from the following: combustible cigarettes, IQOS, Glo, or Ploom Tech." Based on this protocol, we classified participants into three current smoking status categories (never, former, and current). We also divided current smokers using HTPs, ultimately identifying five mutually exclusive groups, as follows.

1. Never smokers
2. Former smokers
3. HTP smokers, who currently smoke HTPs only

4. Combustible cigarette smokers, who currently smoke combustible cigarettes only

5. Dual smokers, who currently smoke both combustible cigarettes and HTPs

To clarify and simplify the context of using HTPs, we defined smoking HTPs by identifying HTPs smokers only (but excluding dual smokers). Following the rapid rise in prevalence of HTPs after 2016 in Japan [2], most HTP smokers were found to have switched from combustible cigarettes, after a long history of smoking (≥15 years of smoking history, 140 of 229 participants, 61.1%).

Occupational information, smoking-related health knowledge, and other variables

According to the Erikson–Goldthorpe–Portocarero scheme, an internationally valid occupational class measurement for SES [15] and previous studies that adapted the Erikson–Goldthorpe–Portocarero scheme for Japanese occupational classes [11, 16, 17], we defined two groups of occupational classes: a higher occupational class group (managerial and professional workers, 5.2% [n=399] and clerical workers, 9.4% [n=723]) and other workers (service workers, 78.4% [n=6,047] and manual workers, 7.1% [n=545]). In the Erikson–Goldthorpe–Portocarero scheme, clerical workers (classified as lower non-manual workers) are considered as a lower job class group compared with managerial and professional workers (classified as upper non-manual workers). However, because clerical workers tended

to have more favorable health outcomes compared with managerial and professional workers in Japan [16], we classified clerical workers into the higher occupational class group.

For a broad indicator of health knowledge that might affect risky behavior of smoking HTPs (because the long-term safety of HTPs has not been proven), study participants were asked whether they knew about the link between cigarette smoking and each of five common diseases: asthma (yes/no), lung cancer (yes/no), stroke (yes/no), angina/myocardial infarction (yes/no), and periodontal disease (yes/no). By calculating how many links they knew about, we obtained a total sum score of smoking-related health knowledge, a continuous variable ranging from 0 (did not know about any links to diseases) to 5 (knew about all links to diseases). Because the study participants may have learned about all of the links to diseases through public education provided by the government [18], we handled all diseases equally without using different weights.

In our analytical model for explaining the association between occupational class and smoking HTPs, potential confounding variables included basic demographics (age and sex) and employment type (full-time or part-time workers) [11]. As a potential mediating variable that could explain the association (but not be a confounding factor), we included the total sum score of smoking-related health knowledge as an explanatory variable in our regression model. Although HTP-related risks for common chronic diseases have not been established and health-related knowledge regarding cigarette smoking might not provide a

complete substitute for the potential motivations for smoking HTPs, we empirically employed this indicator as a potential behavioral mediator.

Statistical analysis

Descriptive analyses were used to report the background characteristics of the study participants and the prevalence of HTP usage.

Next, compared with the other workers, we estimated odds ratios (ORs) and 95% confidence intervals (CIs) of higher occupational class workers for HTP usage using logistic regression. In multivariable regression analyses, we adjusted for age, sex, and employment type (full-time/part-time) (model 1). In model 2, we additionally adjusted for smoking-related health knowledge as a continuous variable. Analyses were also stratified by sex.

Furthermore, we used all 7,714 study participants, which also included former smokers, combustible cigarette smokers, and dual smokers. To examine the association for each smoking status against occupational classes, we estimated multinomial odds ratios using multinomial logistic regression [11]. Again, we adjusted for age, sex, and employment type in model 1 and additionally adjusted for smoking-related health knowledge in model 2. Analyses were also stratified by sex. For a supplementary analysis within HTP smokers, we explored potential reasons for smoking HTPs and health attitudes regarding HTPs.

All P-values were both sided and the alpha level was set at 0.05. Data were analyzed

using SPSS version 26.0 (SPSS Inc., Chicago, IL., USA).

Patient and Public Involvement

No patients or the public involved.

Results

Of the total 7,714 study participants, the prevalence of HTPs was 3.0% (male 5.0%, female 2.2%; Table 1). The prevalence of HTPs smokers was greater in a younger population aged in their 30s and 40s than an older population aged in their 60s and above. The prevalence of HTPs smokers differed across occupational classes and employment types, respectively (all $P < 0.05$, Figure 1). Occupational differences only remained significant in male workers when stratified by sex (Figure 1).

The percentage of current smokers among higher occupational class workers was higher than that among other workers ($P < 0.001$) (Table 2). Among male workers in those higher occupational classes, the prevalence of individuals who had ever smoked or were HTP smokers was again greater, and the prevalence of current smokers tended to be greater (Table 2). Meanwhile, none of the smoking status groups differed across occupational classes among female workers.

Overall, most of the specific disease knowledge was insufficient, except for lung cancer, and most of the study participants did not know about the link between smoking and

cardiovascular diseases (Table 2).

In regression analyses, although the background characteristics differed across occupation and smoking status (Table 2 and Table S1), a positive occupational difference for HTP usage was observed in multivariable logistic regression (model 1, Table 3). Even after controlling for smoking-related health knowledge (model 2), the elevated odds remained significant (OR 1.97, 95% CI 1.40 to 2.77, Table 3). In addition, the odds of full-time employment and smoking-related health knowledge were significantly elevated (model 2, Table 3). However, for the sex-specific association, the occupational difference only remained significant in male workers (Table 3).

In addition, in a sensitivity analysis including all types of smokers, higher occupational class workers were more likely to smoke HTPs (Table 4), and the observed patterns were almost identical. Among HTP smokers, the dominant reason for smoking HTPs was reduced odor and smoke, rather than taking care of others (i.e., not to bother others) or considering health-related aspects (Table S2).

Discussion

Using a large working population in the retail sector in Japan, we first found that the prevalence of HTP usage was at least 5% in male workers and 2% in female workers, with a positive occupational difference for smoking HTPs. Male workers in the higher occupational

class in this population were more likely to be ever smokers, with a higher prevalence of smoking HTPs. In addition, no significant occupational difference was observed in current smoking status among female workers. Public awareness was generally insufficient regarding tobacco-induced health disadvantages, despite contemporary public education.

Cigarette smokers, particularly those in high occupational classes, should fundamentally be encouraged to quit smoking, and not to use HTPs [19]. The majority of HTP smokers in the current study (> 60%) were former combustible cigarette smokers, and higher occupational class workers were more likely to have ever been smokers than their occupational counterparts, consistent with a well-known contemporary pattern in Japan [20, 21]. Additionally, among HTP smokers, the dominant reason for smoking HTPs was reduced odor or reduced smoke.

Behavioral and environmental aspects associated with the workplace in Japan may also play a role in the pattern of results we observed. In contrast to the contemporary pattern seen in Western countries, higher occupational class workers are likely to experience greater job stress, potentially stemming from overtime work, hierarchical corporate culture in Japanese companies, and a strongly emphasized concept of hospitality to meet customers' expectations [22]. Previous studies suggest that male full-time workers experience higher levels of job stress [23], and occupational stress has long been assumed to lead to the development of stress coping responses, such as smoking [24]. In the current study, it might

be expected that male workers in higher occupational positions, particularly those in the service sector [22,25,26], are more likely to smoke, irrespective of tobacco products.

In addition to HTP product advertisements promoting a clean image of reduced harmfulness [8], other behavioral drives for HTPs smoking may exist in Japan. For instance, an increase of tobacco ads has been observed in Japan [27] and tobacco industry widely promotes HTPs (e.g., online stores and convenience stores) [28]. Economic dimensions of HTPs may also support the positive occupational difference we observed. For instance, the price of an HTP device was reported to be 6–18 times more expensive than a pack of cigarettes in 2018 [29], and the prevalence of HTP smokers was higher among full-time workers (i.e., affluent workers) in the present study. In addition, the higher price might be related to subjective impressions of high-quality products, which could act as another potential driver for using HTPs.

Several limitations of the current study should be noted. First, our cross-sectional design does not allow firm conclusions regarding the causal mechanisms underlying the relationship between occupation and HTP usage. Additionally, we were not able to assess other relevant SES indicators (i.e., educational attainment and income) in this working population. However, reverse causality appears to be unlikely because occupational classes are a fundamental SES indicator, and studies suggest a potential SES gap in smoking HTPs [11]. Second, although our data were extracted from a sizable working population in the retail

sector, the numbers of male and female workers were not balanced. In addition, the study participants only included workers in department stores, thereby limiting the generalizability of our findings. Despite these limitations, the current study is one of the most extensive investigations of the use of HTPs in Japan. Third, our self-reported questionnaires may have been subject to under-reporting of HTP usage. Smoking duration, amount (number of heat sticks/cartridge per day), and intensity were not separately available for combustible cigarettes and HTPs. Thus, these limitations might have introduced potential misclassifications in smoking categories. However, previous studies have supported the validity of self-reported smoking status and tobacco use [30]. Fourth, we intended to capture a broad overview of the relationship between occupation and HTPs. Thus, data for potential acute and chronic clinical outcomes were not available. In addition, due to the limitations of our data set, we were unable to completely assess how health knowledge related to HTPs is associated with smoking HTPs. Additionally, it remains unclear whether the observed positive occupational difference for HTP usage is associated with overall mortality and cardiovascular risk, combined with inflammatory and oxidative stress (e.g., C-reactive protein and urinary 8-hydroxydeoxyguanosine) [31, 32]. Despite these limitations, the strengths of the current study included a large sample size for overall and female participants, providing the first report of an occupational difference in smoking HTPs with a robust occupational indicator [11, 16, 17].

Finally, our results suggest that HTP smoking is getting prevalent, particularly among higher-SES males in Japan. Previous studies reported a potential occupational difference in smoking HTPs among men but not among women [4,11], which are in line with our result. In this higher-SES group, unfavorable health outcomes have been highlighted, and higher occupational class workers in Japan do not always enjoy favorable health benefits. For instance, higher occupational workers are reported to have higher overall mortality and cardiovascular risk [16, 22]. In addition, the long-term safety of HTPs has not been proven, and there is accumulating evidence for HTP-related adverse effects on health [9, 10]. Therefore, further public education on tobacco control, including population approaches and high-risk approaches, should remain a high priority for combustible cigarette and HTPs smoking.

In conclusion, the current findings indicated that higher occupational class is associated with a higher prevalence of smoking HTPs, particularly among male retail workers in the service industry in Japan. Public awareness of tobacco-related health impacts is currently insufficient. Hence, national tobacco control should explicitly address this occupational gap and further encourage individuals to quit smoking.

Acknowledgments: We thank Benjamin Knight, MSc., from Edanz Group (https://en-author-

services.edanzgroup.com/ac) for editing a draft of this manuscript.

Author contribution: EM, MZ, and YH designed the study. MK, KT and SW created the dataset. EM, YN, and MZ analyzed the data. EM wrote the first draft of the manuscript. MK, KT, MZ, SW, YN, KT, YH and GK commented on the manuscript. All authors read and approved the final manuscript.

Funding: This work was supported in part by Health, Labour and Welfare Sciences Research Grants (20FA1005) and Japan Society for the Promotion of Science (JSPS KAKENHI JP18K17351).

Conflict of interest: The authors declare no potential conflicts of interest.

Data availability statement: No additional data available.

Ethics approval: The study was approved by the Ethics Committee of Dokkyo Medical University (Protocol Number 30007).

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Figure legends

Figure 1. Prevalence of heated tobacco smokers across various background characteristics in the cohort. Each bar shows the prevalence of heated tobacco smokers within specific background characteristics. Abbreviation: HTP, heated tobacco products.

Table1. Background characteristics of a large working cohort of department stores in Japan

Characteristics	N (%) or mean (SD)[a]		
	Total (n=7,714)	Male (n=2,215)	Female (n=5,499)
Age, mean (SD)	46.6 (12.8)	40.2 (13.7)	49.2 (11.4)
Higher occupational class	1,122 (14.5)	797 (36.0)	325 (5.9)
Full time employment	1,800 (23.3)	1,349 (60.9)	451 (8.2)
Current smoking status			
Never smokers	4,580 (59.4)	1,011 (45.6)	3,569 (64.9)
Former smokers	1,428 (18.5)	466 (21.0)	962 (17.5)
Current smoker	1,706 (22.1)	738 (33.3)	968 (17.6)
Combustible cigarette smokers	1,217 (15.8)	505 (22.8)	712 (12.9)
HTPs smokers	229 (3.0)	110 (5.0)	119 (2.2)
Dual smokers[b]	260 (3.4)	123 (5.6)	137 (2.5)

Abbreviation: HTPs, heated tobacco products.

[a] Percentage may not total 100 due to rounding.

[b] Dual smokers are those who currently smoke both combustible cigarettes and HTPs.

Table 2. Occupational differences in smoking status and cigarette smoking-related heath knowledge stratified by sex

Characteristics	N (%) or mean (SD)		*P*[a]
	Higher occupational class workers	Others	
Total	*n=1,122*	*n=6,592*	
Age, mean (SD)	45.5 (11.8)	46.8 (12.9)	0.001
Female	325 (29.0)	5,174 (78.5)	<0.001
Full time employment	466 (41.5)	1,334 (20.2)	<0.001
Current smoking status			
Never smokers	518 (46.2)	4,062 (61.6)	<0.001
Former smokers	273 (24.3)	1,155 (17.5)	<0.001
Current smoker	331 (29.5)	1,375 (20.9)	<0.001
Combustible cigarette smokers	222 (19.8)	995 (15.1)	<0.001
Dual smokers	46 (4.1)	214 (3.2)	0.143
HTPs smokers	63 (5.6)	166 (2.5)	<0.001
Total score, mean (SD)[b]	2.9 (1.4)	2.7 (1.3)	<0.001
Asthma	794 (70.8)	4,581 (69.5)	0.391
Lung cancer	1,042 (92.9)	6,150 (93.3)	0.600
Stroke	509 (45.4)	2,671 (40.5)	0.002
Angina/myocardial infarction	540 (48.1)	2,707 (41.1)	<0.001
Periodontal disease	342 (30.5)	1,789 (27.1)	0.021
Male	*n=797*	*n=1,418*	
Age, mean (SD)	45.4 (11.8)	37.4 (13.9)	<0.001
Full time employment	426 (53.5)	923 (65.1)	<0.001
Current smoking status			
Never smokers	304 (38.1)	707 (49.9)	<0.001
Former smokers	219 (27.5)	247 (17.4)	<0.001
Current smoker	274 (34.4)	464 (32.7)	0.427
Combustible cigarette smokers	178 (22.3)	327 (23.1)	0.696
Dual smokers	41 (5.1)	82 (5.8)	0.529
HTPs smokers	55 (6.9)	55 (3.9)	0.002
Total score, mean (SD)	3.0 (1.4)	2.6 (1.4)	<0.001
Asthma	574 (72.0)	908 (64.0)	<0.001
Lung cancer	752 (94.4)	1,286 (90.7)	0.002
Stroke	385 (48.3)	589 (41.5)	0.002

Angina/myocardial infarction	411 (51.6)	507 (35.8)	<0.001
Periodontal disease	261 (32.7)	453 (31.9)	0.699
Female	*n=325*	*n=5,174*	
Age, mean (SD)	45.7 (11.8)	49.4 (11.4)	<0.001
Full time employment	40 (12.3)	411 (7.9)	0.005
Current smoking status			
Never smokers	214 (65.8)	3,355 (64.8)	0.713
Former smokers	54 (16.6)	908 (17.5)	0.667
Current smoker	57 (17.5)	911 (17.6)	0.975
Combustible cigarette smokers	44 (13.5)	668 (12.9)	0.744
Dual smokers	5 (1.5)	132 (2.6)	0.256
HTPs smokers	8 (2.5)	111 (2.1)	0.704
Total score, mean (SD)	2.6 (1.4)	2.7 (1.3)	0.069
Asthma	220 (67.7)	3,673 (71.0)	0.205
Lung cancer	290 (89.2)	4,864 (94.0)	0.001
Stroke	124 (38.2)	2,082 (40.2)	0.457
Angina/myocardial infarction	129 (39.7)	2,200 (42.5)	0.317
Periodontal disease	81 (24.9)	1,336 (25.8)	0.719

Abbreviation: HTPs, heated tobacco products.

[a] P-values for t-test or chi-squared test.

[b] Total scores were created by summing up each link known.

Table 3. Odds ratios for heated tobacco smokers against occupational class and other factors

Characteristics	N (%) or mean (SD)		Odds ratio (95% confidence interval)		
	Never	HTPs	Crude	Model 1[a]	Model 2[b]
Total	*n=4,580*	*n=229*			
Higher occupational class	518 (11.3%)	63 (27.5%)	2.98 (2.20 to 4.03)	1.99 (1.42 to 2.78)	1.97 (1.40 to 2.77)
Full time employment	988 (21.6%)	99 (43.2%)	2.77 (2.11 to 3.63)	1.75 (1.21 to 2.53)	1.73 (1.20 to 2.50)
Age	45.8 (13.5)	42.4 (11.1)	0.98 (0.97 to 0.99)	1.00 (0.99 to 1.02)	1.00 (0.99 to 1.01)
Female	3,569 (77.9%)	119 (52.0%)	0.31 (0.23 to 0.40)	0.50 (0.34 to 0.72)	0.50 (0.35 to 0.73)
Total knowledge	2.5 (1.3)	3.0 (1.4)	1.33 (1.20 to 1.47)		1.34 (1.21 to 1.48)
Male	*n=1,011*	*n=110*			
Higher occupational class	304 (30.1%)	55 (50.0%)	2.33 (1.56 to 3.46)	2.15 (1.37 to 3.36)	2.09 (1.33 to 3.28)
Full time employment	658 (65.1%)	90 (81.8%)	2.41 (1.46 to 3.99)	3.52 (2.05 to 6.04)	3.48 (2.02 to 5.99)
Age	34.9(11.9)	38.3 (9.9)	1.02 (1.01 to 1.04)	1.03 (1.01 to 1.05)	1.03 (1.004 to 1.05)
Total knowledge	2.4 (1.4)	3.0 (1.4)	1.35 (1.17 to 1.55)		1.31 (1.13 to 1.53)
Female	*n=3,569*	*n=119*			
Higher occupational class	214 (6.0%)	8 (6.7%)	1.13 (0.54 to 2.35)	1.04 (0.50 to 2.17)	1.11 (0.53 to 2.32)
Full time employment	330 (9.2%)	9 (7.6%)	0.80 (0.40 to 1.60)	0.51 (0.24 to 1.08)	0.51 (0.24 to 1.09)
Age	48.9 (12.2)	46.1 (10.7)	0.98 (0.97 to 0.997)	0.98 (0.96 to 0.99)	0.98 (0.96 to 0.99)
Total knowledge	2.6 (1.3)	3.1 (1.4)	1.34 (1.17 to 1.54)		1.35 (1.18 to 1.55)

Abbreviation: HTPs, heated tobacco products.

[a]Odds ratios for heated tobacco smokers against occupational class were estimated with unconditional logistic regression, adjusted for age, sex, and employment type.

[b]Additional adjustment for smoking-related health knowledge.

Table 4. Multinomial odds ratios for each smoking status in high occupational class workers

Characteristics	Multinominal odds ratio (95% confidence interval)	
	Model 1[a]	Model 2[b]
HTPs smokers		
Higher occupational class	1.99 (1.42 to 2.79)	1.94 (1.38 to 2.72)
Full time employment	1.62 (1.12 to 2.33)	1.58 (1.09 to 2.29)
Age, continuous	0.997 (0.99 to 1.01)	0.99 (0.98 to 1.01)
Female	0.51 (0.36 to 0.73)	0.51 (0.35 to 0.73)
Total knowledge		1.34 (1.22 to 1.48)
Combustible cigarette smokers		
Higher occupational class	1.02 (0.84 to 1.23)	0.99 (0.81 to 1.20)
Full time employment	0.89 (0.73 to 1.09)	0.88 (0.72 to 1.07)
Age, continuous	1.03 (1.02 to 1.03)	1.03 (1.02 to 1.03)
Female	0.29 (0.24 to 0.35)	0.29 (0.24 to 0.34)
Total knowledge		1.31 (1.24 to 1.37)
Dual smokers		
Higher occupational class	1.01 (0.71 to 1.45)	0.97 (0.67 to 1.40)
Full time employment	1.83 (1.27 to 2.62)	1.79 (1.24 to 2.57)
Age, continuous	1.01 (0.99 to 1.02)	1.00 (0.99 to 1.01)
Female	0.43 (0.31 to 0.60)	0.42 (0.30 to 0.60)
Total knowledge		1.44 (1.31 to 1.59)
Former smokers		
Higher occupational class	1.38 (1.15 to 1.65)	1.34 (1.12 to 1.61)
Full time employment	0.82 (0.67 to 1.00)	0.81 (0.66 to 0.99)
Age, continuous	1.03 (1.03 to 1.04)	1.03 (1.02 to 1.03)
Female	0.44 (0.37 to 0.53)	0.44 (0.37 to 0.53)
Total knowledge		1.30 (1.24 to 1.36)

Abbreviation: HTP, heated tobacco product.

[a] Adjusted for age, sex, and employment type.

[b] Additional adjustment for smoking-related health knowledge.15

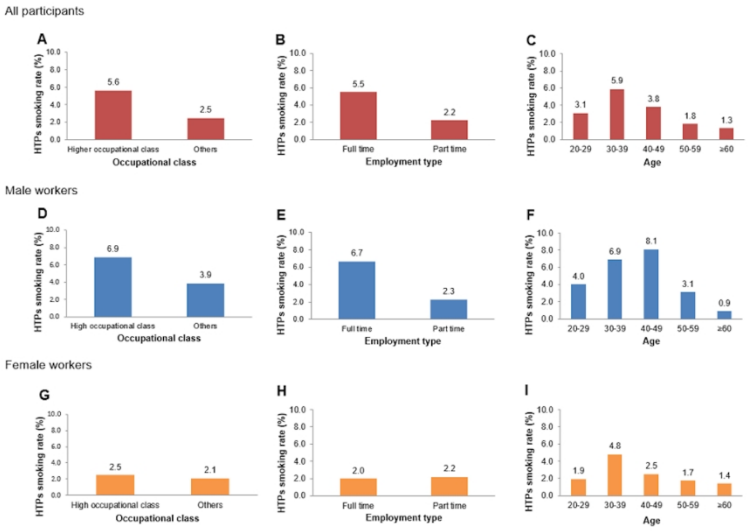

Figure 1. Prevalence of heated tobacco smokers across various background characteristics in the cohort. Each bar shows the prevalence of heated tobacco smokers within specific background characteristics. Abbreviation: HTP, heated tobacco products.

160x90mm (300 x 300 DPI)

Table S1. Background characteristics across each current smoking status group

Characteristics	N (%) or mean (SD)[a]				
	Never	Former	Combustible cigarette	Dual	HTPs
Total (n=7,714)	n=4,580	n=1,428	n=1,217	n=260	n=229
Age, mean (SD)	**45.8 (13.5)**	**49.4 (10.8)**	**48.0 (11.9)**	**42.7 (12.4)**	**42.4 (11.1)**
Female	**3,569 (77.9)**	**962 (67.4)**	**712 (58.5)**	**137 (52.7)**	**119 (52.0)**
Higher occupational class	**518 (11.3)**	**273 (19.1)**	**222 (18.2)**	**46 (17.7)**	**63 (27.5)**
Full time employment	**988 (21.6)**	**285 (20.0)**	**314 (25.8)**	**114 (43.8)**	**99 (43.2)**
Smoking-related health knowledge					
Total score, mean (SD)	**2.5 (1.3)**	**3.0 (1.3)**	**3.0 (1.4)**	**3.2 (1.3)**	**3.0 (1.4)**
Asthma	**3,121 (68.1)**	**1,088 (76.2)**	**824 (67.7)**	**184 (70.8)**	**158 (69.0)**
Lung cancer	4,260 (93.0)	1,352 (94.7)	1,125 (92.4)	244 (93.8)	211 (92.1)
Stroke	**1,540 (33.6)**	**672 (47.1)**	**688 (56.5)**	**160 (61.5)**	**120 (52.4)**
Angina/myocardial infarction	**1,607 (35.1)**	**747 (52.3)**	**630 (51.8)**	**147 (56.5)**	**116 (50.7)**
Periodontal disease	**1,056 (23.1)**	**476 (33.3)**	**421 (34.6)**	**87 (33.5)**	**91 (39.7)**
Men (n=2,215)	n=1,011	n=466	n=505	n=123	n=110
Age, mean (SD)	**34.9 (11.9)**	**48.5 (13.0)**	**44.4 (13.7)**	**38.0 (12.6)**	**38.3 (9.9)**
Higher occupational class	**304 (30.1)**	**219 (47.0)**	**178 (35.2)**	**41 (33.3)**	**55 (50.0)**
Full time employment	**658 (65.1)**	**231 (49.6)**	**273 (54.1)**	**97 (78.9)**	**90 (81.8)**
Smoking-related health knowledge					
Total score, mean (SD)	**2.4 (1.4)**	**3.1 (1.3)**	**3.0 (1.4)**	**3.1 (1.3)**	**3.0 (1.4)**
Asthma	**648 (64.1)**	**346 (74.2)**	**329 (65.1)**	**86 (69.9)**	**73 (66.4)**
Lung cancer	**913 (90.3)**	**435 (93.3)**	**467 (92.5)**	**120 (97.6)**	**103 (93.6)**
Stroke	**317 (31.4)**	**243 (52.1)**	**278 (55.0)**	**75 (61.0)**	**61 (55.5)**
Angina/myocardial infarction	**295 (29.2)**	**258 (55.4)**	**248 (49.1)**	**62 (50.4)**	**55 (50.0)**
Periodontal disease	297 (29.4)	159 (34.1)	179 (35.4)	40 (32.5)	39 (35.5)
Women (n=5,499)	n=3,569	n=962	n=712	n=137	n=119
Age, mean (SD)	**48.9 (12.2)**	**49.9 (9.6)**	**50.6 (9.6)**	**47.0 (10.7)**	**46.1 (10.7)**
Higher occupational class	214 (6.0)	54 (5.6)	44 (6.2)	5 (3.6)	8 (6.7)
Full time employment	**330 (9.2)**	**54 (5.6)**	**41 (5.8)**	**17 (12.4)**	**9 (7.6)**
Smoking-related health knowledge					
Total score, mean (SD)	**2.6 (1.3)**	**3.0 (1.3)**	**3.1 (1.4)**	**3.2 (1.3)**	**3.1 (1.4)**
Asthma	**2,473 (69.3)**	**742 (77.1)**	**495 (69.5)**	**98 (71.5)**	**85 (71.4)**
Lung cancer	**3,347 (93.8)**	**917 (95.3)**	**658 (92.4)**	**124 (90.5)**	**108 (90.8)**
Stroke	**1,223 (34.3)**	**429 (44.6)**	**410 (57.6)**	**85 (62.0)**	**59 (49.6)**
Angina/myocardial infarction	**1.312 (36.8)**	**489 (50.8)**	**382 (53.7)**	**85 (62.0)**	**61 (51.3)**
Periodontal disease	**759 (21.3)**	**317 (33.0)**	**242 (34.0)**	**47 (34.3)**	**52 (43.7)**

Abbreviation: HTPs, heated tobacco products. Bold numbers indicate $P < 0.05$ (ANOVA or chi-squared test).

Table S2. Reasons for smoking heated tobacco products

Characteristics	**Reason 1** "Smoking HTPs reduce the odor and smoke."	**Reason 2** "Smoking HTPs do not bother others."	**Reason 3** "Smoking HTPs was healthier."
	n (%)	n (%)	n (%)
HTPs smokers[a]			
Total, n=229			
Occupational class			
Higher occupational class workers (n=63)	57 (90.5)	15 (23.8)	25 (39.7)
Others (n=166)	137 (82.5)	54 (32.5)	59 (35.5)
Employment type			
Full time (n=99)	82 (82.8)	34 (34.3)	36 (36.4)
Part time (n=130)	112 (86.2)	35 (26.9)	48 (36.9)
Sex			
Male (n=110)	94 (85.5)	34 (30.9)	43 (39.1)
Female (n=119)	100 (84.0)	35 (29.4)	41 (34.5)
Male, n=110			
Occupational class			
Higher occupational class workers (n=55)	49 (89.1)	13 (23.6)	22 (40.0)
Others (n=55)	45 (81.8)	21 (38.2)	21 (38.2)
Employment type			
Full time (n=90)	77 (85.6)	31 (34.4)	34 (37.8)
Part time (n=20)	17 (85.0)	3 (15.0)	9 (45.0)
Female, n=119			
Occupational class			
Higher occupational class workers (n=8)	8 (100)	2 (25.0)	3 (37.5)
Others (n=111)	92 (82.9)	33 (29.1)	38 (34.2)
Employment group			
Full time (n=9)	5 (55.6)	3 (33.3)	2 (22.2)
Part time (n=110)	95 (86.4)	32 (29.1)	39 (35.5)
HTPs smokers plus dual smokers[b]			
Total, n=489			
Occupational class			
Higher occupational class workers (n=109)	89 (81.7)	23 (21.1)	31 (28.4)
Others (n=380)	291 (76.6)	105 (27.6)	107 (28.2)
Employment type			
Full time (n=213)	170(79.8)	60 (28.2)	52 (24.4)
Part time (n=276)	210 (76.1)	68 (24.6)	86 (31.2)
Sex			
Male (n=233)	185 (79.4)	63 (27.0)	64 (27.5)
Female (n=256)	195 (76.2)	65 (25.4)	74 (28.9)
Male, n=233			
Occupational class			
Higher occupational class workers (n=96)	80 (83.3)	21 (21.9)	28 (29.2)
Others (n=137)	105 (76.6)	42 (30.7)	36 (26.3)
Employment type			
Full time (n=187)	152 (81.3)	55 (29.4)	48 (25.7)
Part time (n=46)	33 (71.7)	8 (17.4)	16 (34.8)
Female, n=256			
Occupational class			
Higher occupational class workers (n=13)	9 (69.2)	2 (15.4)	3 (23.1)
Others (n=243)	186 (76.5)	63 (25.9)	71 (29.2)
Employment type			
Full time (n=26)	18 (69.2)	5 (19.2)	4 (15.4)
Part time (n=230)	177 (77.0)	60 (26.1)	70 (30.4)

Abbreviation: HTPs, heated tobacco products.

[a] HTP smokers are those who currently smoke HTPs only.

[b] Dual smokers are those who currently smoke both combustible cigarettes and HTPs.

STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

		Item No	Recommendation
	Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract
P1-3			(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found
	Introduction		
P5-7	Background/rationale	2	Explain the scientific background and rationale for the investigation being reported
P7	Objectives	3	State specific objectives, including any prespecified hypotheses
	Methods		
P8	Study design	4	Present key elements of study design early in the paper
P8	Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection
P8-9	Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants
P9-12	Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable
P9-12	Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group
P13	Bias	9	Describe any efforts to address potential sources of bias
P8	Study size	10	Explain how the study size was arrived at
P9-12	Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why
P12-13	Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding
			(*b*) Describe any methods used to examine subgroups and interactions
			(*c*) Explain how missing data were addressed
			(*d*) If applicable, describe analytical methods taking account of sampling strategy
			(*e*) Describe any sensitivity analyses
	Results		
P14	Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed
			(b) Give reasons for non-participation at each stage
			(c) Consider use of a flow diagram
P14-15	Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders
			(b) Indicate number of participants with missing data for each variable of interest
P14-15	Outcome data	15*	Report numbers of outcome events or summary measures
P14-15	Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included
			(*b*) Report category boundaries when continuous variables were categorized
			(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
P15-16	Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses

	Discussion		
P17	Key results	18	Summarise key results with reference to study objectives
P18-19	Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias
P17-18	Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
P20	Generalisability	21	Discuss the generalisability (external validity) of the study results
	Other information		
P2	Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

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Journal:	*BMJ Open*
Manuscript ID	bmjopen-2021-049395.R2
Article Type:	Original research
Date Submitted by the Author:	29-Jun-2021
Complete List of Authors:	Myagmar-Ochir, Enkhtuguldur; Dokkyo Medical University, Department of Public Health Kaneko, Makiko; Department Store Health Insurance Association, Division of Health Support Tomiyama, Kiyomi; Department Store Health Insurance Association, Division of Health Support Zaitsu, Masayoshi ; Dokkyo Medical University, Department of Public Health Watanabe, Shuichi; Department Store Health Insurance Associatio, Division of Health Support Nishino, Yoshitaka; Dokkyo Medical University, Department of Public Health Takahashi, Kyo; Dokkyo Medical University, Department of Public Health Haruyama, Yasuo; Dokkyo Medical University Kobashi, Gen; Dokkyo Medical University, Department of Public Health
Primary Subject Heading:	Smoking and tobacco
Secondary Subject Heading:	Public health, Addiction, Epidemiology, Health policy, Occupational and environmental medicine
Keywords:	PUBLIC HEALTH, PREVENTIVE MEDICINE, Health policy < HEALTH SERVICES ADMINISTRATION & MANAGEMENT, EPIDEMIOLOGY

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Occupational difference in use of heated tobacco products: A cross-sectional analysis of retail workers in Japan

Enkhtuguldur Myagmar-Ochir,[1] Makiko Kaneko,[2] Kiyomi Tomiyama,[2] Masayoshi Zaitsu,[1] Shuichi Watanabe,[2] Yoshitaka Nishino,[1] Kyo Takahashi,[1] Yasuo Haruyama,[3] Gen Kobashi[1]

[1] Department of Public Health, School of Medicine, Dokkyo Medical University, Mibu, Tochigi, Japan

[2] Division of Health Support, Department Store Health Insurance Association, Tokyo, Japan

[3] Integrated Research Faculty for Advanced Medical Sciences, School of Medicine, Dokkyo Medical University, Mibu, Tochigi, Japan

Corresponding to: Masayoshi Zaitsu, MD, PhD

Department of Public Health, School of Medicine, Dokkyo Medical University

880 Kitakobayashi, Mibu, Shimotsuga-gun, Tochigi, 321-00293 Japan

Tel: +81-282-87-2133; Fax: +81-282-86-2935

Email: m-zaitsu@dokkyomed.ac.jp: ORCID: orcid.org/0000-0001-7616-355X

Word count: 2830

Abstract

Objective: Although heated tobacco products (HTPs) have become popular worldwide, research on occupational differences in smoking HTPs remains scarce. We aimed to examine the prevalence of smoking HTPs among a working population in Japan.

Setting, design, and participants: In 2018, we conducted a cross-sectional study comprised of 7,714 retail business workers in the service industry in Japan.

Primary and secondary outcome measures: For the definition of smoking HTPs, we identified current HTP smokers who only smoked HTPs, using five mutual categories of current smoking status (never, former, HTPs only, combustible cigarettes only, and dual smokers who smoked both combustible cigarettes and HTPs). Occupational classes were classified into office workers (e.g., upper non-manual workers) and other workers. Odds ratios (ORs) and 95% confidence interval (CIs) of office workers were estimated for HTP usage, adjusted for age, sex, employment type, and cigarette smoking-related health knowledge.

Results: The overall prevalence of smoking HTPs was 3.0% (male 5.0%, female 2.2%). The prevalence of HTP smokers differed across occupational classes (5.6% in office workers vs. 2.5% in others; $P < 0.05$). Compared with other workers, the adjusted odds of office workers for smoking HTPs remained elevated (OR 1.97, 95% CI 1.40 to 2.77). Sensitivity analyses with workers of all smoking status showed the same pattern. When stratified by sex, the

occupational difference only remained significant in male workers.

Conclusions: We found a positive occupational difference in smoking HTPs, particularly among male workers in the retail sector in Japan. National tobacco control should explicitly address this occupational gap and further encourage individuals to quit smoking.

Key words: heated tobacco products, occupation, smoking, socioeconomic status

Strengths and limitations of this study

- This is the first study to examine occupational differences in the prevalence of smoking heated tobacco products (HTPs) among a sizable working population in Japan.
- This study analyzed a sample of over 7700 retail business workers reporting their HTP usage and occupational class in 2018.
- This study adjusted for variables that might affect occupational differences in smoking HTPs.
- This study documented sex-specific occupational differences in smoking HTPs stratified by sex.
- Limitations include a cross-sectional design, which does not allow firm conclusions regarding causal mechanisms.

Introduction

Heated tobacco products (HTPs) are smoking devices that heat tobacco sticks to produce aerosols containing nicotine and other chemicals for inhalation [1, 2]. The widespread use of HTPs represents an emerging public health concern. After the initial marketing of IQOS (a brand of HTPs) in Japan and Italy in 2014, HTP usage rapidly spread to more than 30 countries [2]. In Japan, HTP brands IQOS and Ploom Tech (launched in March 2016) and Glo (launched in December 2016) are currently available [2], and the market share was accounted for 21% in total tobacco sales in 2018 [3]. The prevalence of HTP usage was found to have reached approximately 8% in men and 2% in women in 2018 [4]. Although limited studies on HTPs usage are available, the prevalence has begun to increase worldwide (approximately 1.4% in Italy in 2017 and 2.9% in Guatemala adolescents in 2020) [5,6]. In some Asian countries, the market for HTPs remains relatively small, and HTPs are not officially retailed in China and Hong Kong [7]. Although the impression of HTPs as a healthy alternative is promoted by direct- and indirect-to-consumer advertising of HTPs compared with conventional combustible cigarettes (e.g., reduced harmfulness and a smoke-free image) [8], there is accumulating evidence for HTP-related adverse effects on health, including acute respiratory diseases and cardiovascular events [9, 10]. In addition, the long-term safety of HTPs has not been proven.

In Japan, the use of HTPs may be related to social patterning. For instance, the

distribution of HTP usage has been found to differ across sex and age: men and younger people in their 20s and 30s were found to be more likely to smoke HTPs compared with their female and older counterparts [11-13], which has been proposed to be partly attributable to a popular television program [2]. Furthermore, several studies have suggested that a socioeconomic difference for the use of HTPs should be investigated [4, 11, 13, 14]. A recent online cross-sectional survey suggested a potential "positive" socioeconomic difference in HTP usage [11]. In that study, individuals with higher socioeconomic status (SES), in terms of educational attainment and household income, were more likely to smoke HTPs compared with their lower SES counterparts. However, the occupational difference, one of three fundamental SES indicators (education, income, and occupation), remains unclear in relation to the use of HTPs.

The present study aimed to examine the overall and sex-specific prevalence of smoking HTPs among a sizable working population in the retail sector, a common service industry sector in Japan. We sought to examine whether higher occupational class is associated with higher prevalence of smoking HTPs.

Methods

Data setting

Among a working population of the Department Store Health Insurance Association in the

retail sector, we conducted a cross-sectional survey about smoking and related health knowledge in August 2018. As a baseline survey, this study was intended to capture a broad overview of occupational factors associated with smoking HTPs. The survey instrument was a self-report questionnaire about smoking behaviors (smoking status and duration of smoking) and HTPs. The survey also asked respondents about their knowledge of smoking-related adverse effects such as cancer and cardiovascular risks. We distributed 8,638 questionnaires to all workers in the working population of department stores; 7,837 self-reported questionnaires were collected (response rate, 90.7%). For each participant, the Department Store Health Insurance Association mutually linked collected data to individual basic demographics (age and sex) and current job information, including occupational class (e.g., managerial and clerical workers) and employment type (full-time or part-time workers). We obtained a de-identified dataset from the Department Store Health Insurance Association. Written informed consent was obtained and participants received a prepaid card with a value of 300 Japanese yen (approximately US $3) after the survey for their cooperation. The ethical committee of Dokkyo Medical University approved this study (Protocol Number, 30007).

From 7,837 study participants, we excluded data from participants with missing information (n = 123, 1.6%), which gave a total of 7,714 study participants (2,215 men and 5,499 women; mean age, 46.6 [SD 12.8] years) for analysis.

Main outcome of HTP usage

The primary outcome was to assess the prevalence of smoking HTPs currently in the retail sector in Japan.

In the questionnaire, HTPs were described as "tobacco", in accord with the Tobacco Business Act in Japan. We cited the IQOS, Glo, and Ploom Tech as HTPs with pictures because these products were commercially available in Japan in 2018. The study participants chose one status for smoking (never, former, sometimes, or every day) from the question, "Do you currently smoke?" If they answered "sometimes" or "every day," we defined them as current smokers. For current smokers, we distinguished between smoking combustible cigarettes, HTPs, or both, using the following question: "Which type(s) of tobacco do you smoke? Please choose all options that apply from the following: combustible cigarettes, IQOS, Glo, or Ploom Tech." Based on this protocol, we classified participants into three current smoking status categories (never, former, and current). We also divided current smokers using HTPs, ultimately identifying five mutually exclusive groups, as follows.

1. Never smokers
2. Former smokers
3. HTP smokers, who currently smoke HTPs only

4. Combustible cigarette smokers, who currently smoke combustible cigarettes only

5. Dual smokers, who currently smoke both combustible cigarettes and HTPs

To clarify and simplify the context of using HTPs, we defined smoking HTPs by identifying HTPs smokers only (but excluding dual smokers). Following the rapid rise in prevalence of HTPs after 2016 in Japan [2], most HTP smokers were found to have switched from combustible cigarettes, after a long history of smoking (≥15 years of smoking history, 140 of 229 participants, 61.1%).

Occupational information, smoking-related health knowledge, and other variables

According to the Erikson–Goldthorpe–Portocarero scheme, an internationally valid occupational class measurement for SES [15] and previous studies that adapted the Erikson–Goldthorpe–Portocarero scheme for Japanese occupational classes [11, 16, 17], we defined two groups of occupational classes: office workers (managerial and professional workers, 5.2% [n=399] and clerical workers, 9.4% [n=723]) and other workers (service workers, 78.4% [n=6,047] and manual workers, 7.1% [n=545]). In the Erikson–Goldthorpe–Portocarero scheme, clerical workers (classified as lower non-manual workers) are considered as a lower job class group compared with managerial and professional workers (classified as upper non-manual workers). In a prior analysis of this study sample, we

preliminarily observed occupational differences in smoking HTPs using different reference groups, as follows: (a) compared with service and manual workers, the adjusted odds ratio (OR) of upper non-manual workers for smoking HTPs was 3.54 (95% confidence interval [CI] 2.16 to 5.80); and (b) compared with clerical, service, and manual workers combined, the OR of upper non-manual workers for smoking HTPs was 3.04 (95% CI 1.88 to 4.89). However, because clerical workers have been reported to have more favorable health outcomes in terms of mortality and cancer survival compared with managerial and professional workers in Japan [16,18], we classified clerical workers into the office worker group.

For a broad indicator of health knowledge that might affect risky behavior of smoking HTPs (because the long-term safety of HTPs has not been proven), study participants were asked whether they knew about the link between cigarette smoking and each of five common diseases: asthma (yes/no), lung cancer (yes/no), stroke (yes/no), angina/myocardial infarction (yes/no), and periodontal disease (yes/no). By calculating how many links they knew about, we obtained a total sum score of smoking-related health knowledge, a continuous variable ranging from 0 (did not know about any links to diseases) to 5 (knew about all links to diseases). Because the study participants may have learned about all of the links to diseases through public education provided by the government [19], we handled all diseases equally without using different weights.

In our analytical model for explaining the association between occupational class and smoking HTPs, potential confounding variables included basic demographics (age and sex) and employment type (full-time or part-time workers) [11]. As a potential mediating variable that could explain the association (but not be a confounding factor), we included the total sum score of smoking-related health knowledge as an explanatory variable in our regression model. Although HTP-related risks for common chronic diseases have not been established and health-related knowledge regarding cigarette smoking might not provide a complete substitute for the potential motivations for smoking HTPs, we empirically employed this indicator as a potential behavioral mediator.

Statistical analysis

Descriptive analyses were used to report the background characteristics of the study participants and the prevalence of HTP usage.

Next, compared with the other workers, we estimated ORs and 95% CIs of office workers for HTP usage using logistic regression. In multivariable regression analyses, we adjusted for age, sex, and employment type (full-time/part-time) (model 1). In model 2, we additionally adjusted for smoking-related health knowledge as a continuous variable. Analyses were also stratified by sex.

Furthermore, we used all 7,714 study participants, which also included former

smokers, combustible cigarette smokers, and dual smokers. To examine the association for each smoking status against occupational classes, we estimated multinomial odds ratios using multinomial logistic regression [11]. Again, we adjusted for age, sex, and employment type in model 1 and additionally adjusted for smoking-related health knowledge in model 2. Analyses were also stratified by sex. For a supplementary analysis within HTP smokers, we explored potential reasons for smoking HTPs and health attitudes regarding HTPs.

All P-values were both sided and the alpha level was set at 0.05. Data were analyzed using SPSS version 26.0 (SPSS Inc., Chicago, IL., USA).

Patient and Public Involvement

No patients or the public involved.

Results

Of the total 7,714 study participants, the prevalence of HTPs was 3.0% (male 5.0%, female 2.2%; Table 1). The prevalence of HTPs smokers was greater in a younger population aged in their 30s and 40s than an older population aged in their 60s and above. The prevalence of HTPs smokers differed across occupational classes and employment types, respectively (all $P < 0.05$, Figure 1). Occupational differences only remained significant in male workers when stratified by sex (Figure 1).

The percentage of current smokers among office workers was higher than that

among other workers (P < 0.001) (Table 2). Among male office workers, the prevalence of individuals who had ever smoked or were HTP smokers was again greater, and the prevalence of current smokers tended to be greater (Table 2). Meanwhile, none of the smoking status groups differed across occupational classes among female workers.

Overall, most of the specific disease knowledge was insufficient, except for lung cancer, and most of the study participants did not know about the link between smoking and cardiovascular diseases (Table 2).

In regression analyses, although the background characteristics differed across occupation and smoking status (Table 2 and Table S1), a positive occupational difference for HTP usage was observed in multivariable logistic regression (model 1, Table 3). Even after controlling for smoking-related health knowledge (model 2), the elevated odds remained significant (OR 1.97, 95% CI 1.40 to 2.77, Table 3). In addition, the odds of full-time employment and smoking-related health knowledge were significantly elevated (model 2, Table 3). However, for the sex-specific association, the occupational difference only remained significant in male workers (Table 3).

In addition, in a sensitivity analysis including all types of smokers, office workers were more likely to smoke HTPs (Table 4), and the observed patterns were almost identical. Among HTP smokers, the dominant reason for smoking HTPs was reduced odor and smoke, rather than taking care of others (i.e., not to bother others) or considering health-related

aspects (Table S2).

Discussion

Using a large working population in the retail sector in Japan, we first found that the prevalence of HTP usage was at least 5% in male workers and 2% in female workers, with a positive occupational difference for smoking HTPs. Male workers in the higher occupational class in this population were more likely to be ever smokers, with a higher prevalence of smoking HTPs. In addition, no significant occupational difference was observed in current smoking status among female workers. Public awareness was generally insufficient regarding tobacco-induced health disadvantages, despite contemporary public education.

Cigarette smokers, particularly those in high occupational classes, should fundamentally be encouraged to quit smoking, and not to use HTPs [20]. The majority of HTP smokers in the current study (> 60%) were former combustible cigarette smokers, and office workers were more likely to have ever been smokers than their occupational counterparts, consistent with a well-known contemporary pattern in Japan [21, 22]. Additionally, among HTP smokers, the dominant reason for smoking HTPs was reduced odor or reduced smoke.

Behavioral and environmental aspects associated with the workplace in Japan may also play a role in the pattern of results we observed. In contrast to the contemporary pattern

seen in Western countries, higher occupational class workers are likely to experience greater job stress, potentially stemming from overtime work, hierarchical corporate culture in Japanese companies, and a strongly emphasized concept of hospitality to meet customers' expectations [23]. Previous studies suggest that male full-time workers experience higher levels of job stress [24], and occupational stress has long been assumed to lead to the development of stress coping responses, such as smoking [25]. In the current study, it might be expected that male workers in higher occupational positions, particularly those in the service sector [23,26,27], are more likely to smoke, irrespective of tobacco products.

In addition to HTP product advertisements promoting a clean image of reduced harmfulness [8], other behavioral drives for HTPs smoking may exist in Japan. For instance, an increase of tobacco ads has been observed in Japan [28] and tobacco industry widely promotes HTPs (e.g., online stores and convenience stores) [29]. Economic dimensions of HTPs may also support the positive occupational difference we observed. For instance, the price of an HTP device was reported to be 6–18 times more expensive than a pack of cigarettes in 2018 [30], and the prevalence of HTP smokers was higher among full-time workers (i.e., affluent workers) in the present study. In addition, the higher price might be related to subjective impressions of high-quality products, which could act as another potential driver for using HTPs.

Several limitations of the current study should be noted. First, our cross-sectional

design does not allow firm conclusions regarding the causal mechanisms underlying the relationship between occupation and HTP usage. Additionally, we were not able to assess other relevant SES indicators (i.e., educational attainment and income) in this working population. However, reverse causality appears to be unlikely because occupational classes are a fundamental SES indicator, and studies suggest a potential SES gap in smoking HTPs [11]. Second, although our data were extracted from a sizable working population in the retail sector, the numbers of male and female workers were not balanced. In addition, the study participants only included workers in department stores, thereby limiting the generalizability of our findings. Despite these limitations, the current study is one of the most extensive investigations of the use of HTPs in Japan. Third, our self-reported questionnaires may have been subject to under-reporting of HTP usage. Smoking duration, amount (number of heat sticks/cartridge per day), and intensity were not separately available for combustible cigarettes and HTPs. Thus, these limitations might have introduced potential misclassifications in smoking categories. However, previous studies have supported the validity of self-reported smoking status and tobacco use [31]. Fourth, we intended to capture a broad overview of the relationship between occupation and HTPs. Thus, data for potential acute and chronic clinical outcomes were not available. In addition, due to the limitations of our data set, we were unable to completely assess how health knowledge related to HTPs is associated with smoking HTPs. Additionally, it remains unclear whether the observed

positive occupational difference for HTP usage is associated with overall mortality and cardiovascular risk, combined with inflammatory and oxidative stress (e.g., C-reactive protein and urinary 8-hydroxydeoxyguanosine) [32, 33]. Despite these limitations, the strengths of the current study included a large sample size for overall and female participants, providing the first report of an occupational difference in smoking HTPs with a robust occupational indicator [11, 16, 17].

Finally, our results suggest that HTP smoking is getting prevalent, particularly among higher-SES males in Japan. Previous studies reported a potential occupational difference in smoking HTPs among men but not among women [4,11], which are in line with our result. Higher occupational workers are reported to have higher overall mortality and cardiovascular risk [16, 23]. In addition, the long-term safety of HTPs has not been proven, and there is accumulating evidence for HTP-related adverse effects on health [9, 10]. Therefore, further public education on tobacco control, including population approaches and high-risk approaches, should remain a high priority for combustible cigarette and HTPs smoking.

In conclusion, the current findings indicated that higher occupational class is associated with a higher prevalence of smoking HTPs, particularly among male retail workers in the service industry in Japan. Public awareness of tobacco-related health impacts is currently insufficient. Hence, national tobacco control should explicitly address this

occupational gap and further encourage individuals to quit smoking.

Acknowledgments: We thank Benjamin Knight, MSc., from Edanz Group (https://en-author-services.edanzgroup.com/ac) for editing a draft of this manuscript.

Author contribution: EM, MZ, and YH designed the study. MK, KT and SW created the dataset. EM, YN, and MZ analyzed the data. EM wrote the first draft of the manuscript. MK, KT, MZ, SW, YN, KT, YH and GK commented on the manuscript. All authors read and approved the final manuscript.

Funding: This work was supported in part by Health, Labour and Welfare Sciences Research Grants (20FA1005) and Japan Society for the Promotion of Science (JSPS KAKENHI JP18K17351).

Conflict of interest: The authors declare no potential conflicts of interest.

Data availability statement: No additional data available.

Ethics approval: The study was approved by the Ethics Committee of Dokkyo Medical University (Protocol Number 30007).

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Figure legends

Figure 1. Prevalence of heated tobacco smokers across various background characteristics in the cohort. Each bar shows the prevalence of heated tobacco smokers within specific background characteristics. Abbreviation: HTP, heated tobacco products.

Table1. Background characteristics of a large working cohort of department stores in Japan

Characteristics	N (%) or mean (SD)[a]		
	Total (n=7,714)	Male (n=2,215)	Female (n=5,499)
Age, mean (SD)	46.6 (12.8)	40.2 (13.7)	49.2 (11.4)
Office workers	1,122 (14.5)	797 (36.0)	325 (5.9)
Full time employment	1,800 (23.3)	1,349 (60.9)	451 (8.2)
Current smoking status			
Never smokers	4,580 (59.4)	1,011 (45.6)	3,569 (64.9)
Former smokers	1,428 (18.5)	466 (21.0)	962 (17.5)
Current smoker	1,706 (22.1)	738 (33.3)	968 (17.6)
Combustible cigarette smokers	1,217 (15.8)	505 (22.8)	712 (12.9)
HTPs smokers	229 (3.0)	110 (5.0)	119 (2.2)
Dual smokers[b]	260 (3.4)	123 (5.6)	137 (2.5)

Abbreviation: HTPs, heated tobacco products.

[a] Percentage may not total 100 due to rounding.

[b] Dual smokers are those who currently smoke both combustible cigarettes and HTPs.

Table 2. Occupational differences in smoking status and cigarette smoking-related heath knowledge stratified by sex

Characteristics	N (%) or mean (SD)		*P*[a]
	Office workers	Others	
Total	*n=1,122*	*n=6,592*	
Age, mean (SD)	45.5 (11.8)	46.8 (12.9)	0.001
Female	325 (29.0)	5,174 (78.5)	<0.001
Full time employment	466 (41.5)	1,334 (20.2)	<0.001
Current smoking status			
Never smokers	518 (46.2)	4,062 (61.6)	<0.001
Former smokers	273 (24.3)	1,155 (17.5)	<0.001
Current smoker	331 (29.5)	1,375 (20.9)	<0.001
Combustible cigarette smokers	222 (19.8)	995 (15.1)	<0.001
Dual smokers	46 (4.1)	214 (3.2)	0.143
HTPs smokers	63 (5.6)	166 (2.5)	<0.001
Total score, mean (SD)[b]	2.9 (1.4)	2.7 (1.3)	<0.001
Asthma	794 (70.8)	4,581 (69.5)	0.391
Lung cancer	1,042 (92.9)	6,150 (93.3)	0.600
Stroke	509 (45.4)	2,671 (40.5)	0.002
Angina/myocardial infarction	540 (48.1)	2,707 (41.1)	<0.001
Periodontal disease	342 (30.5)	1,789 (27.1)	0.021
Male	*n=797*	*n=1,418*	
Age, mean (SD)	45.4 (11.8)	37.4 (13.9)	<0.001
Full time employment	426 (53.5)	923 (65.1)	<0.001
Current smoking status			
Never smokers	304 (38.1)	707 (49.9)	<0.001
Former smokers	219 (27.5)	247 (17.4)	<0.001
Current smoker	274 (34.4)	464 (32.7)	0.427
Combustible cigarette smokers	178 (22.3)	327 (23.1)	0.696
Dual smokers	41 (5.1)	82 (5.8)	0.529
HTPs smokers	55 (6.9)	55 (3.9)	0.002
Total score, mean (SD)	3.0 (1.4)	2.6 (1.4)	<0.001
Asthma	574 (72.0)	908 (64.0)	<0.001
Lung cancer	752 (94.4)	1,286 (90.7)	0.002
Stroke	385 (48.3)	589 (41.5)	0.002

Angina/myocardial infarction	411 (51.6)	507 (35.8)	<0.001
Periodontal disease	261 (32.7)	453 (31.9)	0.699
Female	*n=325*	*n=5,174*	
Age, mean (SD)	45.7 (11.8)	49.4 (11.4)	<0.001
Full time employment	40 (12.3)	411 (7.9)	0.005
Current smoking status			
Never smokers	214 (65.8)	3,355 (64.8)	0.713
Former smokers	54 (16.6)	908 (17.5)	0.667
Current smoker	57 (17.5)	911 (17.6)	0.975
Combustible cigarette smokers	44 (13.5)	668 (12.9)	0.744
Dual smokers	5 (1.5)	132 (2.6)	0.256
HTPs smokers	8 (2.5)	111 (2.1)	0.704
Total score, mean (SD)	2.6 (1.4)	2.7 (1.3)	0.069
Asthma	220 (67.7)	3,673 (71.0)	0.205
Lung cancer	290 (89.2)	4,864 (94.0)	0.001
Stroke	124 (38.2)	2,082 (40.2)	0.457
Angina/myocardial infarction	129 (39.7)	2,200 (42.5)	0.317
Periodontal disease	81 (24.9)	1,336 (25.8)	0.719

Abbreviation: HTPs, heated tobacco products.

[a] P-values for t-test or chi-squared test.

[b] Total scores were created by summing up each link known.

Table 3. Odds ratios for heated tobacco smokers against occupational class and other factors

Characteristics	N (%) or mean (SD)		Odds ratio (95% confidence interval)		
	Never	HTPs	Crude	Model 1[a]	Model 2[b]
Total	*n=4,580*	*n=229*			
Office workers	518 (11.3%)	63 (27.5%)	2.98 (2.20 to 4.03)	1.99 (1.42 to 2.78)	1.97 (1.40 to 2.77)
Full time employment	988 (21.6%)	99 (43.2%)	2.77 (2.11 to 3.63)	1.75 (1.21 to 2.53)	1.73 (1.20 to 2.50)
Age	45.8 (13.5)	42.4 (11.1)	0.98 (0.97 to 0.99)	1.00 (0.99 to 1.02)	1.00 (0.99 to 1.01)
Female	3,569 (77.9%)	119 (52.0%)	0.31 (0.23 to 0.40)	0.50 (0.34 to 0.72)	0.50 (0.35 to 0.73)
Total knowledge	2.5 (1.3)	3.0 (1.4)	1.33 (1.20 to 1.47)		1.34 (1.21 to 1.48)
Male	*n=1,011*	*n=110*			
Office workers	304 (30.1%)	55 (50.0%)	2.33 (1.56 to 3.46)	2.15 (1.37 to 3.36)	2.09 (1.33 to 3.28)
Full time employment	658 (65.1%)	90 (81.8%)	2.41 (1.46 to 3.99)	3.52 (2.05 to 6.04)	3.48 (2.02 to 5.99)
Age	34.9(11.9)	38.3 (9.9)	1.02 (1.01 to 1.04)	1.03 (1.01 to 1.05)	1.03 (1.004 to 1.05)
Total knowledge	2.4 (1.4)	3.0 (1.4)	1.35 (1.17 to 1.55)		1.31 (1.13 to 1.53)
Female	*n=3,569*	*n=119*			
Office workers	214 (6.0%)	8 (6.7%)	1.13 (0.54 to 2.35)	1.04 (0.50 to 2.17)	1.11 (0.53 to 2.32)
Full time employment	330 (9.2%)	9 (7.6%)	0.80 (0.40 to 1.60)	0.51 (0.24 to 1.08)	0.51 (0.24 to 1.09)
Age	48.9 (12.2)	46.1 (10.7)	0.98 (0.97 to 0.997)	0.98 (0.96 to 0.99)	0.98 (0.96 to 0.99)
Total knowledge	2.6 (1.3)	3.1 (1.4)	1.34 (1.17 to 1.54)		1.35 (1.18 to 1.55)

Abbreviation: HTPs, heated tobacco products.

[a]Odds ratios for heated tobacco smokers against occupational class were estimated with unconditional logistic regression, adjusted for age, sex, and employment type.

[b]Additional adjustment for smoking-related health knowledge.

Table 4. Multinomial odds ratios for each smoking status in high occupational class workers

Characteristics	Multinominal odds ratio (95% confidence interval)	
	Model 1[a]	Model 2[b]
HTPs smokers		
Office workers	1.99 (1.42 to 2.79)	1.94 (1.38 to 2.72)
Full time employment	1.62 (1.12 to 2.33)	1.58 (1.09 to 2.29)
Age, continuous	0.997 (0.99 to 1.01)	0.99 (0.98 to 1.01)
Female	0.51 (0.36 to 0.73)	0.51 (0.35 to 0.73)
Total knowledge		1.34 (1.22 to 1.48)
Combustible cigarette smokers		
Office workers	1.02 (0.84 to 1.23)	0.99 (0.81 to 1.20)
Full time employment	0.89 (0.73 to 1.09)	0.88 (0.72 to 1.07)
Age, continuous	1.03 (1.02 to 1.03)	1.03 (1.02 to 1.03)
Female	0.29 (0.24 to 0.35)	0.29 (0.24 to 0.34)
Total knowledge		1.31 (1.24 to 1.37)
Dual smokers		
Office workers	1.01 (0.71 to 1.45)	0.97 (0.67 to 1.40)
Full time employment	1.83 (1.27 to 2.62)	1.79 (1.24 to 2.57)
Age, continuous	1.01 (0.99 to 1.02)	1.00 (0.99 to 1.01)
Female	0.43 (0.31 to 0.60)	0.42 (0.30 to 0.60)
Total knowledge		1.44 (1.31 to 1.59)
Former smokers		
Office workers	1.38 (1.15 to 1.65)	1.34 (1.12 to 1.61)
Full time employment	0.82 (0.67 to 1.00)	0.81 (0.66 to 0.99)
Age, continuous	1.03 (1.03 to 1.04)	1.03 (1.02 to 1.03)
Female	0.44 (0.37 to 0.53)	0.44 (0.37 to 0.53)
Total knowledge		1.30 (1.24 to 1.36)

Abbreviation: HTP, heated tobacco product.

[a] Adjusted for age, sex, and employment type.

[b] Additional adjustment for smoking-related health knowledge.15

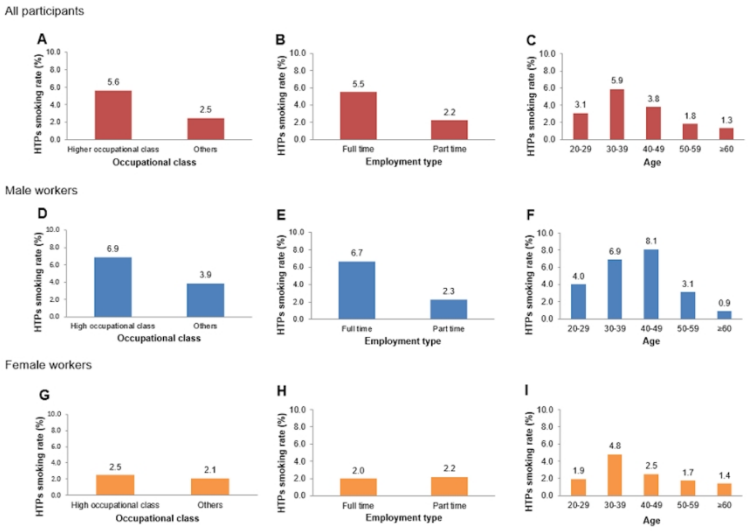

Figure 1. Prevalence of heated tobacco smokers across various background characteristics in the cohort. Each bar shows the prevalence of heated tobacco smokers within specific background characteristics. Abbreviation: HTP, heated tobacco products.

160x90mm (300 x 300 DPI)

Table S1. Background characteristics across each current smoking status group

Characteristics	N (%) or mean (SD)[a]				
	Never	Former	Combustible cigarette	Dual	HTPs
Total (n=7,714)	n=4,580	n=1,428	n=1,217	n=260	n=229
Age, mean (SD)	**45.8 (13.5)**	**49.4 (10.8)**	**48.0 (11.9)**	**42.7 (12.4)**	**42.4 (11.1)**
Female	**3,569 (77.9)**	**962 (67.4)**	**712 (58.5)**	**137 (52.7)**	**119 (52.0)**
Office worker	**518 (11.3)**	**273 (19.1)**	**222 (18.2)**	**46 (17.7)**	**63 (27.5)**
Full time employment	**988 (21.6)**	**285 (20.0)**	**314 (25.8)**	**114 (43.8)**	**99 (43.2)**
Smoking-related health knowledge					
Total score, mean (SD)	**2.5 (1.3)**	**3.0 (1.3)**	**3.0 (1.4)**	**3.2 (1.3)**	**3.0 (1.4)**
Asthma	**3,121 (68.1)**	**1,088 (76.2)**	**824 (67.7)**	**184 (70.8)**	**158 (69.0)**
Lung cancer	4,260 (93.0)	1,352 (94.7)	1,125 (92.4)	244 (93.8)	211 (92.1)
Stroke	**1,540 (33.6)**	**672 (47.1)**	**688 (56.5)**	**160 (61.5)**	**120 (52.4)**
Angina/myocardial infarction	**1,607 (35.1)**	**747 (52.3)**	**630 (51.8)**	**147 (56.5)**	**116 (50.7)**
Periodontal disease	**1,056 (23.1)**	**476 (33.3)**	**421 (34.6)**	**87 (33.5)**	**91 (39.7)**
Men (n=2,215)	n=1,011	n=466	n=505	n=123	n=110
Age, mean (SD)	**34.9 (11.9)**	**48.5 (13.0)**	**44.4 (13.7)**	**38.0 (12.6)**	**38.3 (9.9)**
Office worker	**304 (30.1)**	**219 (47.0)**	**178 (35.2)**	**41 (33.3)**	**55 (50.0)**
Full time employment	**658 (65.1)**	**231 (49.6)**	**273 (54.1)**	**97 (78.9)**	**90 (81.8)**
Smoking-related health knowledge					
Total score, mean (SD)	**2.4 (1.4)**	**3.1 (1.3)**	**3.0 (1.4)**	**3.1 (1.3)**	**3.0 (1.4)**
Asthma	**648 (64.1)**	**346 (74.2)**	**329 (65.1)**	**86 (69.9)**	**73 (66.4)**
Lung cancer	**913 (90.3)**	**435 (93.3)**	**467 (92.5)**	**120 (97.6)**	**103 (93.6)**
Stroke	**317 (31.4)**	**243 (52.1)**	**278 (55.0)**	**75 (61.0)**	**61 (55.5)**
Angina/myocardial infarction	**295 (29.2)**	**258 (55.4)**	**248 (49.1)**	**62 (50.4)**	**55 (50.0)**
Periodontal disease	297 (29.4)	159 (34.1)	179 (35.4)	40 (32.5)	39 (35.5)
Women (n=5,499)	n=3,569	n=962	n=712	n=137	n=119
Age, mean (SD)	**48.9 (12.2)**	**49.9 (9.6)**	**50.6 (9.6)**	**47.0 (10.7)**	**46.1 (10.7)**
Office worker	214 (6.0)	54 (5.6)	44 (6.2)	5 (3.6)	8 (6.7)
Full time employment	**330 (9.2)**	**54 (5.6)**	**41 (5.8)**	**17 (12.4)**	**9 (7.6)**
Smoking-related health knowledge					
Total score, mean (SD)	**2.6 (1.3)**	**3.0 (1.3)**	**3.1 (1.4)**	**3.2 (1.3)**	**3.1 (1.4)**
Asthma	**2,473 (69.3)**	**742 (77.1)**	**495 (69.5)**	**98 (71.5)**	**85 (71.4)**
Lung cancer	**3,347 (93.8)**	**917 (95.3)**	**658 (92.4)**	**124 (90.5)**	**108 (90.8)**
Stroke	**1,223 (34.3)**	**429 (44.6)**	**410 (57.6)**	**85 (62.0)**	**59 (49.6)**
Angina/myocardial infarction	**1.312 (36.8)**	**489 (50.8)**	**382 (53.7)**	**85 (62.0)**	**61 (51.3)**
Periodontal disease	**759 (21.3)**	**317 (33.0)**	**242 (34.0)**	**47 (34.3)**	**52 (43.7)**

Abbreviation: HTPs, heated tobacco products. Bold numbers indicate $P < 0.05$ (ANOVA or chi-squared test).

Table S2. Reasons for smoking heated tobacco products

Characteristics	**Reason 1** "Smoking HTPs reduce the odor and smoke."	**Reason 2** "Smoking HTPs do not bother others."	**Reason 3** "Smoking HTPs was healthier."
	n (%)	n (%)	n (%)
HTPs smokers[a]			
Total, n=229			
Occupational class			
Office workers (n=63)	57 (90.5)	15 (23.8)	25 (39.7)
Others (n=166)	137 (82.5)	54 (32.5)	59 (35.5)
Employment type			
Full time (n=99)	82 (82.8)	34 (34.3)	36 (36.4)
Part time (n=130)	112 (86.2)	35 (26.9)	48 (36.9)
Sex			
Male (n=110)	94 (85.5)	34 (30.9)	43 (39.1)
Female (n=119)	100 (84.0)	35 (29.4)	41 (34.5)
Male, n=110			
Occupational class			
Office workers (n=55)	49 (89.1)	13 (23.6)	22 (40.0)
Others (n=55)	45 (81.8)	21 (38.2)	21 (38.2)
Employment type			
Full time (n=90)	77 (85.6)	31 (34.4)	34 (37.8)
Part time (n=20)	17 (85.0)	3 (15.0)	9 (45.0)
Female, n=119			
Occupational class			
Office workers (n=8)	8 (100)	2 (25.0)	3 (37.5)
Others (n=111)	92 (82.9)	33 (29.1)	38 (34.2)
Employment group			
Full time (n=9)	5 (55.6)	3 (33.3)	2 (22.2)
Part time (n=110)	95 (86.4)	32 (29.1)	39 (35.5)
HTPs smokers plus dual smokers[b]			
Total, n=489			
Occupational class			
Office workers (n=109)	89 (81.7)	23 (21.1)	31 (28.4)
Others (n=380)	291 (76.6)	105 (27.6)	107 (28.2)
Employment type			
Full time (n=213)	170(79.8)	60 (28.2)	52 (24.4)
Part time (n=276)	210 (76.1)	68 (24.6)	86 (31.2)
Sex			
Male (n=233)	185 (79.4)	63 (27.0)	64 (27.5)
Female (n=256)	195 (76.2)	65 (25.4)	74 (28.9)
Male, n=233			
Occupational class			
Office workers (n=96)	80 (83.3)	21 (21.9)	28 (29.2)
Others (n=137)	105 (76.6)	42 (30.7)	36 (26.3)
Employment type			
Full time (n=187)	152 (81.3)	55 (29.4)	48 (25.7)
Part time (n=46)	33 (71.7)	8 (17.4)	16 (34.8)
Female, n=256			
Occupational class			
Office workers (n=13)	9 (69.2)	2 (15.4)	3 (23.1)
Others (n=243)	186 (76.5)	63 (25.9)	71 (29.2)
Employment type			
Full time (n=26)	18 (69.2)	5 (19.2)	4 (15.4)
Part time (n=230)	177 (77.0)	60 (26.1)	70 (30.4)

Abbreviation: HTPs, heated tobacco products.

[a] HTP smokers are those who currently smoke HTPs only.

[b] Dual smokers are those who currently smoke both combustible cigarettes and HTPs.

STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

		Item No	Recommendation
	Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract
P1-3			(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found
	Introduction		
P5-7	Background/rationale	2	Explain the scientific background and rationale for the investigation being reported
P7	Objectives	3	State specific objectives, including any prespecified hypotheses
	Methods		
P8	Study design	4	Present key elements of study design early in the paper
P8	Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection
P8-9	Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants
P9-12	Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable
P9-12	Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group
P13	Bias	9	Describe any efforts to address potential sources of bias
P8	Study size	10	Explain how the study size was arrived at
P9-12	Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why
P12-13	Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding
			(*b*) Describe any methods used to examine subgroups and interactions
			(*c*) Explain how missing data were addressed
			(*d*) If applicable, describe analytical methods taking account of sampling strategy
			(*e*) Describe any sensitivity analyses
	Results		
P14	Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed
			(b) Give reasons for non-participation at each stage
			(c) Consider use of a flow diagram
P14-15	Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders
			(b) Indicate number of participants with missing data for each variable of interest
P14-15	Outcome data	15*	Report numbers of outcome events or summary measures
P14-15	Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included
			(*b*) Report category boundaries when continuous variables were categorized
			(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
P15-16	Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses

	Discussion		
P17	Key results	18	Summarise key results with reference to study objectives
P18-19	Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias
P17-18	Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
P20	Generalisability	21	Discuss the generalisability (external validity) of the study results
	Other information		
P2	Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

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Journal:	*BMJ Open*
Manuscript ID	bmjopen-2021-049395.R3
Article Type:	Original research
Date Submitted by the Author:	30-Jul-2021
Complete List of Authors:	Myagmar-Ochir, Enkhtuguldur; Dokkyo Medical University, Department of Public Health Kaneko, Makiko; Department Store Health Insurance Association, Division of Health Support Tomiyama, Kiyomi; Department Store Health Insurance Association, Division of Health Support Zaitsu, Masayoshi ; Dokkyo Medical University, Department of Public Health Watanabe, Shuichi; Department Store Health Insurance Associatio, Division of Health Support Nishino, Yoshitaka; Dokkyo Medical University, Department of Public Health Takahashi, Kyo; Dokkyo Medical University, Department of Public Health Haruyama, Yasuo; Dokkyo Medical University Kobashi, Gen; Dokkyo Medical University, Department of Public Health
Primary Subject Heading:	Smoking and tobacco
Secondary Subject Heading:	Public health, Addiction, Epidemiology, Health policy, Occupational and environmental medicine
Keywords:	PUBLIC HEALTH, PREVENTIVE MEDICINE, Health policy < HEALTH SERVICES ADMINISTRATION & MANAGEMENT, EPIDEMIOLOGY

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Occupational difference in use of heated tobacco products: A cross-sectional analysis of retail workers in Japan

Enkhtuguldur Myagmar-Ochir,[1] Makiko Kaneko,[2] Kiyomi Tomiyama,[2] Masayoshi Zaitsu,[1] Shuichi Watanabe,[2] Yoshitaka Nishino,[1] Kyo Takahashi,[1] Yasuo Haruyama,[3] Gen Kobashi[1]

[1] Department of Public Health, School of Medicine, Dokkyo Medical University, Mibu, Tochigi, Japan

[2] Division of Health Support, Department Store Health Insurance Association, Tokyo, Japan

[3] Integrated Research Faculty for Advanced Medical Sciences, School of Medicine, Dokkyo Medical University, Mibu, Tochigi, Japan

Corresponding to: Masayoshi Zaitsu, MD, PhD

Department of Public Health, School of Medicine, Dokkyo Medical University

880 Kitakobayashi, Mibu, Shimotsuga-gun, Tochigi, 321-00293 Japan

Tel: +81-282-87-2133; Fax: +81-282-86-2935

Email: m-zaitsu@dokkyomed.ac.jp: ORCID: orcid.org/0000-0001-7616-355X

Word count: 2870

Abstract

Objective: Although heated tobacco products (HTPs) have become popular worldwide, research on occupational differences in smoking HTPs remains scarce. We aimed to examine the prevalence of smoking HTPs among a working population in Japan.

Setting, design, and participants: In 2018, we conducted a cross-sectional study comprised of 7,714 retail business workers in the service industry in Japan.

Primary and secondary outcome measures: For the definition of smoking HTPs, we identified current HTP smokers who only smoked HTPs, using five mutual categories of current smoking status (never, former, HTPs only, combustible cigarettes only, and dual smokers who smoked both combustible cigarettes and HTPs). Occupational classes were classified into office workers (e.g., upper non-manual workers) and other workers. Odds ratios (ORs) and 95% confidence interval (CIs) of office workers were estimated for HTP usage, adjusted for age, sex, employment type, and cigarette smoking-related health knowledge.

Results: The overall prevalence of smoking HTPs was 3.0% (male 5.0%, female 2.2%). The prevalence of HTP smokers differed across occupational classes (5.6% in office workers vs. 2.5% in others; $P < 0.05$). Compared with other workers, the adjusted odds of office workers for smoking HTPs remained elevated (OR 1.97, 95% CI 1.40 to 2.77). Sensitivity analyses with workers of all smoking status showed the same pattern. When stratified by sex, the

occupational difference only remained significant in male workers.

Conclusions: We found a positive occupational difference in smoking HTPs, particularly among male workers in the retail sector in Japan. National tobacco control should explicitly address this occupational gap and further encourage individuals to quit smoking.

Key words: heated tobacco products, occupation, smoking, socioeconomic status

Strengths and limitations of this study

- This is the first study to examine occupational differences in the prevalence of smoking heated tobacco products (HTPs) among a sizable working population in Japan.
- This study analyzed a sample of over 7700 retail business workers reporting their HTP usage and occupational class in 2018.
- This study adjusted for variables that might affect occupational differences in smoking HTPs.
- Limitations include a cross-sectional design, which does not allow firm conclusions regarding causal mechanisms.

Introduction

Heated tobacco products (HTPs) are smoking devices that heat tobacco sticks to produce aerosols containing nicotine and other chemicals for inhalation [1, 2]. The widespread use of HTPs represents an emerging public health concern. After the initial marketing of IQOS (a brand of HTPs) in Japan and Italy in 2014, HTP usage rapidly spread to more than 30 countries [2]. In Japan, HTP brands IQOS and Ploom Tech (launched in March 2016) and Glo (launched in December 2016) are currently available [2], and the market share was accounted for 21% in total tobacco sales in 2018 [3]. The prevalence of HTP usage was found to have reached approximately 8% in men and 2% in women in 2018 [4]. Although limited studies on HTPs usage are available, the prevalence has begun to increase worldwide (approximately 1.4% in Italy in 2017 and 2.9% in Guatemala adolescents in 2020) [5,6]. In some Asian countries, the market for HTPs remains relatively small, and HTPs are not officially retailed in China and Hong Kong [7]. Although the impression of HTPs as a healthy alternative is promoted by direct- and indirect-to-consumer advertising of HTPs compared with conventional combustible cigarettes (e.g., reduced harmfulness and a smoke-free image) [8], there is accumulating evidence for HTP-related adverse effects on health, including acute respiratory diseases and cardiovascular events [9, 10]. In addition, the long-term safety of HTPs has not been proven.

In Japan, the use of HTPs may be related to social patterning. For instance, the

distribution of HTP usage has been found to differ across sex and age: men and younger people in their 20s and 30s were found to be more likely to smoke HTPs compared with their female and older counterparts [11-13], which has been proposed to be partly attributable to a popular television program [2]. Furthermore, several studies have suggested that a socioeconomic difference for the use of HTPs should be investigated [4, 11, 13, 14]. A recent online cross-sectional survey suggested a potential "positive" socioeconomic difference in HTP usage [11]. In that study, individuals with higher socioeconomic status (SES), in terms of educational attainment and household income, were more likely to smoke HTPs compared with their lower SES counterparts. However, the occupational difference, one of three fundamental SES indicators (education, income, and occupation), remains unclear in relation to the use of HTPs.

The present study aimed to examine the overall and sex-specific prevalence of smoking HTPs among a sizable working population in the retail sector, a common service industry sector in Japan. We sought to examine whether higher occupational class is associated with higher prevalence of smoking HTPs.

Methods

Data setting

Among a working population of the Department Store Health Insurance Association in the

retail sector, we conducted a cross-sectional survey about smoking and related health knowledge in August 2018. As a baseline survey, this study was intended to capture a broad overview of occupational factors associated with smoking HTPs. The survey instrument was a self-report questionnaire about smoking behaviors (smoking status and duration of smoking) and HTPs. The survey also asked respondents about their knowledge of smoking-related adverse effects such as cancer and cardiovascular risks. We distributed 8,638 questionnaires to all workers in the working population of department stores; 7,837 self-reported questionnaires were collected (response rate, 90.7%). For each participant, the Department Store Health Insurance Association mutually linked collected data to individual basic demographics (age and sex) and current job information, including occupational class (e.g., managerial and clerical workers) and employment type (full-time or part-time workers). We obtained a de-identified dataset from the Department Store Health Insurance Association. Written informed consent was obtained and participants received a prepaid card with a value of 300 Japanese yen (approximately US $3) after the survey for their cooperation. The ethical committee of Dokkyo Medical University approved this study (Protocol Number, 30007).

From 7,837 study participants, we excluded data from participants with missing information (n = 123, 1.6%), which gave a total of 7,714 study participants (2,215 men and 5,499 women; mean age, 46.6 [SD 12.8] years) for analysis.

Main outcome of HTP usage

The primary outcome was to assess the prevalence of smoking HTPs currently in the retail sector in Japan.

In the questionnaire, HTPs were described as "tobacco", in accord with the Tobacco Business Act in Japan. We cited the IQOS, Glo, and Ploom Tech as HTPs with pictures because these products were commercially available in Japan in 2018. The study participants chose one status for smoking (never, former, sometimes, or every day) from the question, "Do you currently smoke?" If they answered "sometimes" or "every day," we defined them as current smokers. For current smokers, we distinguished between smoking combustible cigarettes, HTPs, or both, using the following question: "Which type(s) of tobacco do you smoke? Please choose all options that apply from the following: combustible cigarettes, IQOS, Glo, or Ploom Tech." Based on this protocol, we classified participants into three current smoking status categories (never, former, and current). We also divided current smokers using HTPs, ultimately identifying five mutually exclusive groups, as follows.

1. Never smokers
2. Former smokers
3. HTP smokers, who currently smoke HTPs only

4. Combustible cigarette smokers, who currently smoke combustible cigarettes only

5. Dual smokers, who currently smoke both combustible cigarettes and HTPs

To clarify and simplify the context of using HTPs, we defined smoking HTPs by identifying HTPs smokers only (but excluding dual smokers). Following the rapid rise in prevalence of HTPs after 2016 in Japan [2], most HTP smokers were found to have switched from combustible cigarettes, after a long history of smoking (≥15 years of smoking history, 140 of 229 participants, 61.1%).

Occupational information, smoking-related health knowledge, and other variables

According to the Erikson–Goldthorpe–Portocarero scheme, an internationally valid occupational class measurement for SES [15] and previous studies that adapted the Erikson–Goldthorpe–Portocarero scheme for Japanese occupational classes [11, 16, 17], we defined two groups of occupational classes: office workers (managerial and professional workers, 5.2% [n=399] and clerical workers, 9.4% [n=723]) and other workers (service workers, 78.4% [n=6,047] and manual workers, 7.1% [n=545]). In the Erikson–Goldthorpe–Portocarero scheme, clerical workers (classified as lower non-manual workers) are considered as a lower job class group compared with managerial and professional workers (classified as upper non-manual workers). However, because clerical workers have been

reported to have more favorable health outcomes in terms of mortality and cancer survival compared with managerial and professional workers in Japan [16,18], we classified clerical workers into the office worker group.

For a broad indicator of health knowledge that might affect risky behavior of smoking HTPs (because the long-term safety of HTPs has not been proven), study participants were asked whether they knew about the link between cigarette smoking and each of five common diseases: asthma (yes/no), lung cancer (yes/no), stroke (yes/no), angina/myocardial infarction (yes/no), and periodontal disease (yes/no). By calculating how many links they knew about, we obtained a total sum score of smoking-related health knowledge, a continuous variable ranging from 0 (did not know about any links to diseases) to 5 (knew about all links to diseases). Because the study participants may have learned about all of the links to diseases through public education provided by the government [19], we handled all diseases equally without using different weights.

In our analytical model for explaining the association between occupational class and smoking HTPs, potential confounding variables included basic demographics (age and sex) and employment type (full-time or part-time workers) [11]. As a potential mediating variable that could explain the association (but not be a confounding factor), we included the total sum score of smoking-related health knowledge as an explanatory variable in our regression model. Although HTP-related risks for common chronic diseases have not been

established and health-related knowledge regarding cigarette smoking might not provide a complete substitute for the potential motivations for smoking HTPs, we empirically employed this indicator as a potential behavioral mediator.

Statistical analysis

Descriptive analyses were used to report the background characteristics of the study participants and the prevalence of HTP usage.

Next, compared with the other workers, we estimated odds ratios (ORs) and 95% confidence intervals (CIs) of office workers for HTP usage using logistic regression. In multivariable regression analyses, we adjusted for age, sex, and employment type (full-time/part-time) (model 1). In model 2, we additionally adjusted for smoking-related health knowledge as a continuous variable. Analyses were also stratified by sex.

Furthermore, we used all 7,714 study participants, which also included former smokers, combustible cigarette smokers, and dual smokers. To examine the association for each smoking status against occupational classes, we estimated multinomial odds ratios using multinomial logistic regression [11]. Again, we adjusted for age, sex, and employment type in model 1 and additionally adjusted for smoking-related health knowledge in model 2. Analyses were also stratified by sex. For a supplementary analysis within HTP smokers, we explored potential reasons for smoking HTPs and health attitudes regarding HTPs.

In addition, to further elucidate occupational differences in use of HTPs, we performed sensitivity analyses using two different occupational categories: (a) upper non-manual workers (i.e., managerial and professional workers) versus service and manual workers and (b) upper non-manual workers versus clerical, service, and manual workers combined.

All P-values were both sided and the alpha level was set at 0.05. Data were analyzed using SPSS version 26.0 (SPSS Inc., Chicago, IL., USA).

Patient and Public Involvement

No patients or the public involved.

Results

Of the total 7,714 study participants, the prevalence of HTPs was 3.0% (male 5.0%, female 2.2%; Table 1). The prevalence of HTPs smokers was greater in a younger population aged in their 30s and 40s than an older population aged in their 60s and above. The prevalence of HTPs smokers differed across occupational classes and employment types, respectively (all $P < 0.05$, Figure 1). Occupational differences only remained significant in male workers when stratified by sex (Figure 1).

The percentage of current smokers among office workers was higher than that among other workers ($P < 0.001$) (Table 2). Among male office workers, the prevalence of

individuals who had ever smoked or were HTP smokers was again greater, and the prevalence of current smokers tended to be greater (Table 2). Meanwhile, none of the smoking status groups differed across occupational classes among female workers.

Overall, most of the specific disease knowledge was insufficient, except for lung cancer, and most of the study participants did not know about the link between smoking and cardiovascular diseases (Table 2).

In regression analyses, although the background characteristics differed across occupation and smoking status (Table 2 and Table S1), a positive occupational difference for HTP usage was observed in multivariable logistic regression (model 1, Table 3). Even after controlling for smoking-related health knowledge (model 2), the elevated odds remained significant (OR 1.97, 95% CI 1.40 to 2.77, Table 3). In addition, the odds of full-time employment and smoking-related health knowledge were significantly elevated (model 2, Table 3). However, for the sex-specific association, the occupational difference only remained significant in male workers (Table 3).

In addition, in a sensitivity analysis including all types of smokers, office workers were more likely to smoke HTPs (Table 4), and the observed patterns were almost identical. In sensitivity analyses using different occupational categories, the observed patterns were almost identical: (a) compared with service and manual workers, the OR of upper non-manual workers for smoking HTPs was 3.54 (95% CI 2.16 to 5.80, model 2) and (b)

compared with clerical, service, and manual workers combined, the OR of upper non-manual workers for smoking HTPs was 3.04 (95% CI 1.88 to 4.89, model 2). Among HTP smokers, the dominant reason for smoking HTPs was reduced odor and smoke, rather than taking care of others (i.e., not to bother others) or considering health-related aspects (Table S2).

Discussion

Using a large working population in the retail sector in Japan, we first found that the prevalence of HTP usage was at least 5% in male workers and 2% in female workers, with a positive occupational difference for smoking HTPs. Male workers in the higher occupational class in this population were more likely to be ever smokers, with a higher prevalence of smoking HTPs. In addition, no significant occupational difference was observed in current smoking status among female workers. Public awareness was generally insufficient regarding tobacco-induced health disadvantages, despite contemporary public education.

Cigarette smokers, particularly those in high occupational classes, should fundamentally be encouraged to quit smoking, and not to use HTPs [20]. The majority of HTP smokers in the current study (> 60%) were former combustible cigarette smokers, and office workers were more likely to have ever been smokers than their occupational counterparts, consistent with a well-known contemporary pattern in Japan [21, 22]. Additionally, among HTP smokers, the dominant reason for smoking HTPs was reduced odor

or reduced smoke.

Behavioral and environmental aspects associated with the workplace in Japan may also play a role in the pattern of results we observed. In contrast to the contemporary pattern seen in Western countries, higher occupational class workers are likely to experience greater job stress, potentially stemming from overtime work, hierarchical corporate culture in Japanese companies, and a strongly emphasized concept of hospitality to meet customers' expectations [23]. Previous studies suggest that male full-time workers experience higher levels of job stress [24], and occupational stress has long been assumed to lead to the development of stress coping responses, such as smoking [25]. In the current study, it might be expected that male workers in higher occupational positions, particularly those in the service sector [23,26,27], are more likely to smoke, irrespective of tobacco products.

In addition to HTP product advertisements promoting a clean image of reduced harmfulness [8], other behavioral drives for HTPs smoking may exist in Japan. For instance, an increase of tobacco ads has been observed in Japan [28] and tobacco industry widely promotes HTPs (e.g., online stores and convenience stores) [29]. Economic dimensions of HTPs may also support the positive occupational difference we observed. For instance, the price of an HTP device was reported to be 6–18 times more expensive than a pack of cigarettes in 2018 [30], and the prevalence of HTP smokers was higher among full-time workers (i.e., affluent workers) in the present study. In addition, the higher price might be

related to subjective impressions of high-quality products, which could act as another potential driver for using HTPs.

Several limitations of the current study should be noted. First, our cross-sectional design does not allow firm conclusions regarding the causal mechanisms underlying the relationship between occupation and HTP usage. Additionally, we were not able to assess other relevant SES indicators (i.e., educational attainment and income) in this working population. However, reverse causality appears to be unlikely because occupational classes are a fundamental SES indicator, and studies suggest a potential SES gap in smoking HTPs [11]. Second, although our data were extracted from a sizable working population in the retail sector, the numbers of male and female workers were not balanced. In addition, the study participants only included workers in department stores, thereby limiting the generalizability of our findings. Despite these limitations, the current study is one of the most extensive investigations of the use of HTPs in Japan. Third, our self-reported questionnaires may have been subject to under-reporting of HTP usage. Smoking duration, amount (number of heat sticks/cartridge per day), and intensity were not separately available for combustible cigarettes and HTPs. Thus, these limitations might have introduced potential misclassifications in smoking categories. However, previous studies have supported the validity of self-reported smoking status and tobacco use [31]. Fourth, we intended to capture a broad overview of the relationship between occupation and HTPs. Thus, data for potential

acute and chronic clinical outcomes were not available. In addition, due to the limitations of our data set, we were unable to completely assess how health knowledge related to HTPs is associated with smoking HTPs. Additionally, it remains unclear whether the observed positive occupational difference for HTP usage is associated with overall mortality and cardiovascular risk, combined with inflammatory and oxidative stress (e.g., C-reactive protein and urinary 8-hydroxydeoxyguanosine) [32, 33]. Despite these limitations, the strengths of the current study included a large sample size for overall and female participants, providing the first report of an occupational difference in smoking HTPs with a robust occupational indicator [11, 16, 17].

Finally, our results suggest that HTP smoking is getting prevalent, particularly among higher-SES males in Japan. Previous studies reported a potential occupational difference in smoking HTPs among men but not among women [4,11], which are in line with our result. Higher occupational workers are reported to have higher overall mortality and cardiovascular risk [16, 23]. In addition, the long-term safety of HTPs has not been proven, and there is accumulating evidence for HTP-related adverse effects on health [9, 10]. Therefore, further public education on tobacco control, including population approaches and high-risk approaches, should remain a high priority for combustible cigarette and HTPs smoking.

In conclusion, the current findings indicated that higher occupational class is

associated with a higher prevalence of smoking HTPs, particularly among male retail workers in the service industry in Japan. Public awareness of tobacco-related health impacts is currently insufficient. Hence, national tobacco control should explicitly address this occupational gap and further encourage individuals to quit smoking.

Acknowledgments: We thank Benjamin Knight, MSc., from Edanz Group (https://en-author-services.edanzgroup.com/ac) for editing a draft of this manuscript.

Author contribution: EM, MZ, and YH designed the study. MK, KT and SW created the dataset. EM, YN, and MZ analyzed the data. EM wrote the first draft of the manuscript. MK, KT, MZ, SW, YN, KT, YH and GK commented on the manuscript. All authors read and approved the final manuscript.

Funding: This work was supported in part by Health, Labour and Welfare Sciences Research Grants (20FA1005) and Japan Society for the Promotion of Science (JSPS KAKENHI JP18K17351).

Conflict of interest: The authors declare no potential conflicts of interest.

Data availability statement: No additional data available.

Ethics approval: The study was approved by the Ethics Committee of Dokkyo Medical University (Protocol Number 30007).

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Figure legends

Figure 1. Prevalence of heated tobacco smokers across various background characteristics in the cohort. Each bar shows the prevalence of heated tobacco smokers within specific background characteristics. Abbreviation: HTP, heated tobacco products.

Table1. Background characteristics of a large working cohort of department stores in Japan

Characteristics	N (%) or mean (SD)[a]		
	Total (n=7,714)	Male (n=2,215)	Female (n=5,499)
Age, mean (SD)	46.6 (12.8)	40.2 (13.7)	49.2 (11.4)
Office workers	1,122 (14.5)	797 (36.0)	325 (5.9)
Full time employment	1,800 (23.3)	1,349 (60.9)	451 (8.2)
Current smoking status			
Never smokers	4,580 (59.4)	1,011 (45.6)	3,569 (64.9)
Former smokers	1,428 (18.5)	466 (21.0)	962 (17.5)
Current smoker	1,706 (22.1)	738 (33.3)	968 (17.6)
Combustible cigarette smokers	1,217 (15.8)	505 (22.8)	712 (12.9)
HTPs smokers	229 (3.0)	110 (5.0)	119 (2.2)
Dual smokers[b]	260 (3.4)	123 (5.6)	137 (2.5)

Abbreviation: HTPs, heated tobacco products.

[a] Percentage may not total 100 due to rounding.

[b] Dual smokers are those who currently smoke both combustible cigarettes and HTPs.

Table 2. Occupational differences in smoking status and cigarette smoking-related heath knowledge stratified by sex

Characteristics	N (%) or mean (SD)		*P*[a]
	Office workers	Others	
Total	*n=1,122*	*n=6,592*	
Age, mean (SD)	45.5 (11.8)	46.8 (12.9)	0.001
Female	325 (29.0)	5,174 (78.5)	<0.001
Full time employment	466 (41.5)	1,334 (20.2)	<0.001
Current smoking status			
Never smokers	518 (46.2)	4,062 (61.6)	<0.001
Former smokers	273 (24.3)	1,155 (17.5)	<0.001
Current smoker	331 (29.5)	1,375 (20.9)	<0.001
Combustible cigarette smokers	222 (19.8)	995 (15.1)	<0.001
Dual smokers	46 (4.1)	214 (3.2)	0.143
HTPs smokers	63 (5.6)	166 (2.5)	<0.001
Total score, mean (SD)[b]	2.9 (1.4)	2.7 (1.3)	<0.001
Asthma	794 (70.8)	4,581 (69.5)	0.391
Lung cancer	1,042 (92.9)	6,150 (93.3)	0.600
Stroke	509 (45.4)	2,671 (40.5)	0.002
Angina/myocardial infarction	540 (48.1)	2,707 (41.1)	<0.001
Periodontal disease	342 (30.5)	1,789 (27.1)	0.021
Male	*n=797*	*n=1,418*	
Age, mean (SD)	45.4 (11.8)	37.4 (13.9)	<0.001
Full time employment	426 (53.5)	923 (65.1)	<0.001
Current smoking status			
Never smokers	304 (38.1)	707 (49.9)	<0.001
Former smokers	219 (27.5)	247 (17.4)	<0.001
Current smoker	274 (34.4)	464 (32.7)	0.427
Combustible cigarette smokers	178 (22.3)	327 (23.1)	0.696
Dual smokers	41 (5.1)	82 (5.8)	0.529
HTPs smokers	55 (6.9)	55 (3.9)	0.002
Total score, mean (SD)	3.0 (1.4)	2.6 (1.4)	<0.001
Asthma	574 (72.0)	908 (64.0)	<0.001
Lung cancer	752 (94.4)	1,286 (90.7)	0.002
Stroke	385 (48.3)	589 (41.5)	0.002

Angina/myocardial infarction	411 (51.6)	507 (35.8)	<0.001
Periodontal disease	261 (32.7)	453 (31.9)	0.699
Female	*n=325*	*n=5,174*	
Age, mean (SD)	45.7 (11.8)	49.4 (11.4)	<0.001
Full time employment	40 (12.3)	411 (7.9)	0.005
Current smoking status			
Never smokers	214 (65.8)	3,355 (64.8)	0.713
Former smokers	54 (16.6)	908 (17.5)	0.667
Current smoker	57 (17.5)	911 (17.6)	0.975
Combustible cigarette smokers	44 (13.5)	668 (12.9)	0.744
Dual smokers	5 (1.5)	132 (2.6)	0.256
HTPs smokers	8 (2.5)	111 (2.1)	0.704
Total score, mean (SD)	2.6 (1.4)	2.7 (1.3)	0.069
Asthma	220 (67.7)	3,673 (71.0)	0.205
Lung cancer	290 (89.2)	4,864 (94.0)	0.001
Stroke	124 (38.2)	2,082 (40.2)	0.457
Angina/myocardial infarction	129 (39.7)	2,200 (42.5)	0.317
Periodontal disease	81 (24.9)	1,336 (25.8)	0.719

Abbreviation: HTPs, heated tobacco products.

[a] P-values for t-test or chi-squared test.

[b] Total scores were created by summing up each link known.

Table 3. Odds ratios for heated tobacco smokers against occupational class and other factors

Characteristics	N (%) or mean (SD)		Odds ratio (95% confidence interval)		
	Never	HTPs	Crude	Model 1[a]	Model 2[b]
Total	*n=4,580*	*n=229*			
Office workers	518 (11.3%)	63 (27.5%)	2.98 (2.20 to 4.03)	1.99 (1.42 to 2.78)	1.97 (1.40 to 2.77)
Full time employment	988 (21.6%)	99 (43.2%)	2.77 (2.11 to 3.63)	1.75 (1.21 to 2.53)	1.73 (1.20 to 2.50)
Age	45.8 (13.5)	42.4 (11.1)	0.98 (0.97 to 0.99)	1.00 (0.99 to 1.02)	1.00 (0.99 to 1.01)
Female	3,569 (77.9%)	119 (52.0%)	0.31 (0.23 to 0.40)	0.50 (0.34 to 0.72)	0.50 (0.35 to 0.73)
Total knowledge	2.5 (1.3)	3.0 (1.4)	1.33 (1.20 to 1.47)		1.34 (1.21 to 1.48)
Male	*n=1,011*	*n=110*			
Office workers	304 (30.1%)	55 (50.0%)	2.33 (1.56 to 3.46)	2.15 (1.37 to 3.36)	2.09 (1.33 to 3.28)
Full time employment	658 (65.1%)	90 (81.8%)	2.41 (1.46 to 3.99)	3.52 (2.05 to 6.04)	3.48 (2.02 to 5.99)
Age	34.9(11.9)	38.3 (9.9)	1.02 (1.01 to 1.04)	1.03 (1.01 to 1.05)	1.03 (1.004 to 1.05)
Total knowledge	2.4 (1.4)	3.0 (1.4)	1.35 (1.17 to 1.55)		1.31 (1.13 to 1.53)
Female	*n=3,569*	*n=119*			
Office workers	214 (6.0%)	8 (6.7%)	1.13 (0.54 to 2.35)	1.04 (0.50 to 2.17)	1.11 (0.53 to 2.32)
Full time employment	330 (9.2%)	9 (7.6%)	0.80 (0.40 to 1.60)	0.51 (0.24 to 1.08)	0.51 (0.24 to 1.09)
Age	48.9 (12.2)	46.1 (10.7)	0.98 (0.97 to 0.997)	0.98 (0.96 to 0.99)	0.98 (0.96 to 0.99)
Total knowledge	2.6 (1.3)	3.1 (1.4)	1.34 (1.17 to 1.54)		1.35 (1.18 to 1.55)

Abbreviation: HTPs, heated tobacco products.

[a]Odds ratios for heated tobacco smokers against occupational class were estimated with unconditional logistic regression, adjusted for age, sex, and employment type.

[b]Additional adjustment for smoking-related health knowledge.

Table 4. Multinomial odds ratios for each smoking status in high occupational class workers

Characteristics	Multinominal odds ratio (95% confidence interval)	
	Model 1[a]	Model 2[b]
HTPs smokers		
Office workers	1.99 (1.42 to 2.79)	1.94 (1.38 to 2.72)
Full time employment	1.62 (1.12 to 2.33)	1.58 (1.09 to 2.29)
Age, continuous	0.997 (0.99 to 1.01)	0.99 (0.98 to 1.01)
Female	0.51 (0.36 to 0.73)	0.51 (0.35 to 0.73)
Total knowledge		1.34 (1.22 to 1.48)
Combustible cigarette smokers		
Office workers	1.02 (0.84 to 1.23)	0.99 (0.81 to 1.20)
Full time employment	0.89 (0.73 to 1.09)	0.88 (0.72 to 1.07)
Age, continuous	1.03 (1.02 to 1.03)	1.03 (1.02 to 1.03)
Female	0.29 (0.24 to 0.35)	0.29 (0.24 to 0.34)
Total knowledge		1.31 (1.24 to 1.37)
Dual smokers		
Office workers	1.01 (0.71 to 1.45)	0.97 (0.67 to 1.40)
Full time employment	1.83 (1.27 to 2.62)	1.79 (1.24 to 2.57)
Age, continuous	1.01 (0.99 to 1.02)	1.00 (0.99 to 1.01)
Female	0.43 (0.31 to 0.60)	0.42 (0.30 to 0.60)
Total knowledge		1.44 (1.31 to 1.59)
Former smokers		
Office workers	1.38 (1.15 to 1.65)	1.34 (1.12 to 1.61)
Full time employment	0.82 (0.67 to 1.00)	0.81 (0.66 to 0.99)
Age, continuous	1.03 (1.03 to 1.04)	1.03 (1.02 to 1.03)
Female	0.44 (0.37 to 0.53)	0.44 (0.37 to 0.53)
Total knowledge		1.30 (1.24 to 1.36)

Abbreviation: HTP, heated tobacco product.

[a] Adjusted for age, sex, and employment type.

[b] Additional adjustment for smoking-related health knowledge.15

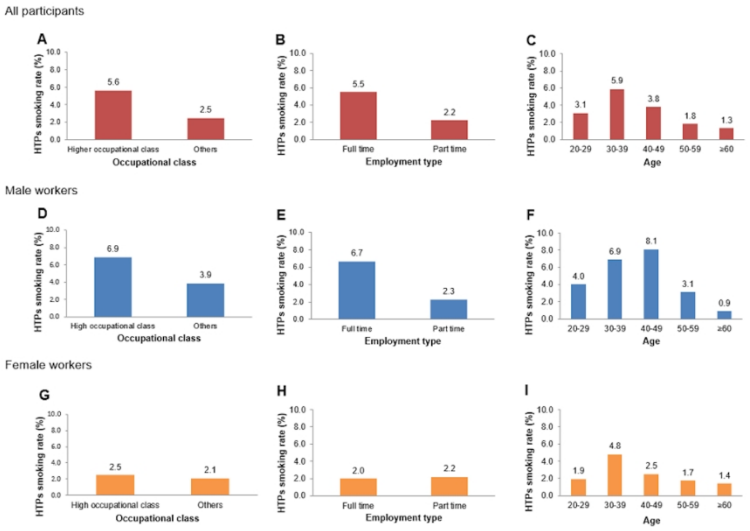

Figure 1. Prevalence of heated tobacco smokers across various background characteristics in the cohort. Each bar shows the prevalence of heated tobacco smokers within specific background characteristics. Abbreviation: HTP, heated tobacco products.

160x90mm (300 x 300 DPI)

Table S1. Background characteristics across each current smoking status group

Characteristics	N (%) or mean (SD)[a]				
	Never	Former	Combustible cigarette	Dual	HTPs
Total (n=7,714)	n=4,580	n=1,428	n=1,217	n=260	n=229
Age, mean (SD)	**45.8 (13.5)**	**49.4 (10.8)**	**48.0 (11.9)**	**42.7 (12.4)**	**42.4 (11.1)**
Female	**3,569 (77.9)**	**962 (67.4)**	**712 (58.5)**	**137 (52.7)**	**119 (52.0)**
Office worker	**518 (11.3)**	**273 (19.1)**	**222 (18.2)**	**46 (17.7)**	**63 (27.5)**
Full time employment	**988 (21.6)**	**285 (20.0)**	**314 (25.8)**	**114 (43.8)**	**99 (43.2)**
Smoking-related health knowledge					
Total score, mean (SD)	**2.5 (1.3)**	**3.0 (1.3)**	**3.0 (1.4)**	**3.2 (1.3)**	**3.0 (1.4)**
Asthma	**3,121 (68.1)**	**1,088 (76.2)**	**824 (67.7)**	**184 (70.8)**	**158 (69.0)**
Lung cancer	4,260 (93.0)	1,352 (94.7)	1,125 (92.4)	244 (93.8)	211 (92.1)
Stroke	**1,540 (33.6)**	**672 (47.1)**	**688 (56.5)**	**160 (61.5)**	**120 (52.4)**
Angina/myocardial infarction	**1,607 (35.1)**	**747 (52.3)**	**630 (51.8)**	**147 (56.5)**	**116 (50.7)**
Periodontal disease	**1,056 (23.1)**	**476 (33.3)**	**421 (34.6)**	**87 (33.5)**	**91 (39.7)**
Men (n=2,215)	n=1,011	n=466	n=505	n=123	n=110
Age, mean (SD)	**34.9 (11.9)**	**48.5 (13.0)**	**44.4 (13.7)**	**38.0 (12.6)**	**38.3 (9.9)**
Office worker	**304 (30.1)**	**219 (47.0)**	**178 (35.2)**	**41 (33.3)**	**55 (50.0)**
Full time employment	**658 (65.1)**	**231 (49.6)**	**273 (54.1)**	**97 (78.9)**	**90 (81.8)**
Smoking-related health knowledge					
Total score, mean (SD)	**2.4 (1.4)**	**3.1 (1.3)**	**3.0 (1.4)**	**3.1 (1.3)**	**3.0 (1.4)**
Asthma	**648 (64.1)**	**346 (74.2)**	**329 (65.1)**	**86 (69.9)**	**73 (66.4)**
Lung cancer	**913 (90.3)**	**435 (93.3)**	**467 (92.5)**	**120 (97.6)**	**103 (93.6)**
Stroke	**317 (31.4)**	**243 (52.1)**	**278 (55.0)**	**75 (61.0)**	**61 (55.5)**
Angina/myocardial infarction	**295 (29.2)**	**258 (55.4)**	**248 (49.1)**	**62 (50.4)**	**55 (50.0)**
Periodontal disease	297 (29.4)	159 (34.1)	179 (35.4)	40 (32.5)	39 (35.5)
Women (n=5,499)	n=3,569	n=962	n=712	n=137	n=119
Age, mean (SD)	**48.9 (12.2)**	**49.9 (9.6)**	**50.6 (9.6)**	**47.0 (10.7)**	**46.1 (10.7)**
Office worker	214 (6.0)	54 (5.6)	44 (6.2)	5 (3.6)	8 (6.7)
Full time employment	**330 (9.2)**	**54 (5.6)**	**41 (5.8)**	**17 (12.4)**	**9 (7.6)**
Smoking-related health knowledge					
Total score, mean (SD)	**2.6 (1.3)**	**3.0 (1.3)**	**3.1 (1.4)**	**3.2 (1.3)**	**3.1 (1.4)**
Asthma	**2,473 (69.3)**	**742 (77.1)**	**495 (69.5)**	**98 (71.5)**	**85 (71.4)**
Lung cancer	**3,347 (93.8)**	**917 (95.3)**	**658 (92.4)**	**124 (90.5)**	**108 (90.8)**
Stroke	**1,223 (34.3)**	**429 (44.6)**	**410 (57.6)**	**85 (62.0)**	**59 (49.6)**
Angina/myocardial infarction	**1.312 (36.8)**	**489 (50.8)**	**382 (53.7)**	**85 (62.0)**	**61 (51.3)**
Periodontal disease	**759 (21.3)**	**317 (33.0)**	**242 (34.0)**	**47 (34.3)**	**52 (43.7)**

Abbreviation: HTPs, heated tobacco products. Bold numbers indicate $P < 0.05$ (ANOVA or chi-squared test).

Table S2. Reasons for smoking heated tobacco products

Characteristics	**Reason 1** "Smoking HTPs reduce the odor and smoke."	**Reason 2** "Smoking HTPs do not bother others."	**Reason 3** "Smoking HTPs was healthier."
	n (%)	n (%)	n (%)
HTPs smokers[a]			
Total, n=229			
Occupational class			
Office workers (n=63)	57 (90.5)	15 (23.8)	25 (39.7)
Others (n=166)	137 (82.5)	54 (32.5)	59 (35.5)
Employment type			
Full time (n=99)	82 (82.8)	34 (34.3)	36 (36.4)
Part time (n=130)	112 (86.2)	35 (26.9)	48 (36.9)
Sex			
Male (n=110)	94 (85.5)	34 (30.9)	43 (39.1)
Female (n=119)	100 (84.0)	35 (29.4)	41 (34.5)
Male, n=110			
Occupational class			
Office workers (n=55)	49 (89.1)	13 (23.6)	22 (40.0)
Others (n=55)	45 (81.8)	21 (38.2)	21 (38.2)
Employment type			
Full time (n=90)	77 (85.6)	31 (34.4)	34 (37.8)
Part time (n=20)	17 (85.0)	3 (15.0)	9 (45.0)
Female, n=119			
Occupational class			
Office workers (n=8)	8 (100)	2 (25.0)	3 (37.5)
Others (n=111)	92 (82.9)	33 (29.1)	38 (34.2)
Employment group			
Full time (n=9)	5 (55.6)	3 (33.3)	2 (22.2)
Part time (n=110)	95 (86.4)	32 (29.1)	39 (35.5)
HTPs smokers plus dual smokers[b]			
Total, n=489			
Occupational class			
Office workers (n=109)	89 (81.7)	23 (21.1)	31 (28.4)
Others (n=380)	291 (76.6)	105 (27.6)	107 (28.2)
Employment type			
Full time (n=213)	170(79.8)	60 (28.2)	52 (24.4)
Part time (n=276)	210 (76.1)	68 (24.6)	86 (31.2)
Sex			
Male (n=233)	185 (79.4)	63 (27.0)	64 (27.5)
Female (n=256)	195 (76.2)	65 (25.4)	74 (28.9)
Male, n=233			
Occupational class			
Office workers (n=96)	80 (83.3)	21 (21.9)	28 (29.2)
Others (n=137)	105 (76.6)	42 (30.7)	36 (26.3)
Employment type			
Full time (n=187)	152 (81.3)	55 (29.4)	48 (25.7)
Part time (n=46)	33 (71.7)	8 (17.4)	16 (34.8)
Female, n=256			
Occupational class			
Office workers (n=13)	9 (69.2)	2 (15.4)	3 (23.1)
Others (n=243)	186 (76.5)	63 (25.9)	71 (29.2)
Employment type			
Full time (n=26)	18 (69.2)	5 (19.2)	4 (15.4)
Part time (n=230)	177 (77.0)	60 (26.1)	70 (30.4)

Abbreviation: HTPs, heated tobacco products.

[a] HTP smokers are those who currently smoke HTPs only.

[b] Dual smokers are those who currently smoke both combustible cigarettes and HTPs.

STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

		Item No	Recommendation
	Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract
P1-3			(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found
	Introduction		
P5-7	Background/rationale	2	Explain the scientific background and rationale for the investigation being reported
P7	Objectives	3	State specific objectives, including any prespecified hypotheses
	Methods		
P8	Study design	4	Present key elements of study design early in the paper
P8	Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection
P8-9	Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants
P9-12	Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable
P9-12	Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group
P13	Bias	9	Describe any efforts to address potential sources of bias
P8	Study size	10	Explain how the study size was arrived at
P9-12	Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why
P12-13	Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding
			(*b*) Describe any methods used to examine subgroups and interactions
			(*c*) Explain how missing data were addressed
			(*d*) If applicable, describe analytical methods taking account of sampling strategy
			(*e*) Describe any sensitivity analyses
	Results		
P14	Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed
			(b) Give reasons for non-participation at each stage
			(c) Consider use of a flow diagram
P14-15	Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders
			(b) Indicate number of participants with missing data for each variable of interest
P14-15	Outcome data	15*	Report numbers of outcome events or summary measures
P14-15	Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included
			(*b*) Report category boundaries when continuous variables were categorized
			(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
P15-16	Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses

	Discussion		
P17	Key results	18	Summarise key results with reference to study objectives
P18-19	Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias
P17-18	Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
P20	Generalisability	21	Discuss the generalisability (external validity) of the study results
	Other information		
P2	Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.