

BMJ Open Impact of workplace smoke-free policy on secondhand smoke exposure from cigarettes and exposure to secondhand heated tobacco product aerosol during COVID-19 pandemic in Japan: the JACSIS 2020 study

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To cite: Takenobu K, Yoshida S, Katanoda K, *et al*. Impact of workplace smoke-free policy on secondhand smoke exposure from cigarettes and exposure to secondhand heated tobacco product aerosol during COVID-19 pandemic in Japan: the JACSIS 2020 study. *BMJ Open* 2022;**12**:e056891. doi:10.1136/bmjopen-2021-056891

► Prepublication history and additional supplemental material for this paper are available online. To view these files, please visit the journal online (<http://dx.doi.org/10.1136/bmjopen-2021-056891>).

Received 29 August 2021
Accepted 24 February 2022



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ABSTRACT

Objectives Promoting smoke-free policies is a key intervention for reducing secondhand smoke (SHS) exposure. During the COVID-19 pandemic in Japan, many indoor smoking spaces in workplaces were closed. This study aimed to reveal the association between a workplace smoke-free policy and SHS exposure among non-smoking employees, distinguishing between SHS exposure from cigarettes and exposure to secondhand heated tobacco product (HTP) aerosol, which have recently become popular in Japan.

Design and setting We used data from the Japan COVID-19 and Society Internet Survey conducted in August–September 2020.

Participants Among the 25 482 eligible respondents, 8196 non-smoking employees were analysed.

Primary outcome measure Multivariable logistic regression models were used to examine the impact of smoke-free policies in the workplace.

Results Compared with complete smoking bans, the ORs and 95% CIs for workplace SHS exposure at least once a week from cigarettes were 2.06 (95% CI: 1.60 to 2.65) for partial bans with no longer available smoking spaces, 1.92 (95% CI: 1.63 to 2.25) for partial smoking bans with still available smoking spaces and 5.33 (95% CI: 4.10 to 6.93) for no smoking bans. The corresponding ORs and 95% CIs for exposure to secondhand HTP aerosol were 4.15 (95% CI: 3.22 to 5.34), 2.24 (95% CI: 1.86 to 2.71) and 3.88 (95% CI: 2.86 to 5.26), respectively.

Conclusions The effect of partial bans was limited, and temporary closure of smoking spaces might contribute to increased exposure to secondhand HTP aerosol. Complete smoking bans in the workplace were reaffirmed to be the best way to reduce SHS exposure from cigarettes and exposure to secondhand HTP aerosol.

INTRODUCTION

Secondhand smoke (SHS) exposure is one of the most prevalent but preventable risk factors that cause many adverse health outcomes.¹

Strengths and limitations of this study

- This study used data from the Japan COVID-19 and Society Internet Survey (JACSIS) conducted in August–September 2020 and multivariable logistic regression models were used to examine the impact of smoke-free policies in the workplace.
- The JACSIS study had been designed to investigate the social and health situation during COVID-19 pandemic in Japan, and the large sample size of the JACSIS data is a strength of our study.
- The validity of the questionnaire items was not completely confirmed, and our results may contain some self-reporting bias.
- The respondents had voluntarily registered themselves as internet survey participants and our population may not be completely representative of all non-smoking employees in Japan.

WHO reported that SHS caused >1.2 million premature deaths per year and serious cardiovascular and respiratory diseases.² Such exposures occur in various places, including the workplace.³ In Japan, the number of non-smoking employees who reported SHS exposure in the workplace has been decreasing; however, 26.1% of non-smoking employees still reported SHS exposure in the workplace in 2019.⁴

Adopting a smoke-free policy is a key intervention in tobacco control.⁵ Many studies show that the introduction of national-level legislative smoking bans has been effective in reducing the prevalence of smoking and burden of SHS-related cardiac, cerebrovascular and respiratory diseases.^{5–7} Furthermore, WHO Framework Convention on Tobacco Control has recommended

complete workplace smoking bans as a means of reducing workplace SHS exposure.⁸

In Japan, the Health Promotion Law was revised to include the regulation to prohibit indoor smoking as a matter of principle in 2018 with fines, and this amendment came into force in April 2020.⁹ However, many exemptions were added, where partial smoking bans were allowed (ie, indoor smoking spaces have remained unprohibited).^{9–12} A partial ban could include designated ventilated smoking spaces, such as smoking rooms and smoking areas separated by a wall.¹³ The construction of these smoking spaces has been recommended by the tobacco industry instead of complete smoking bans in the workplaces,^{14–16} and as a result, partial bans remain widespread.¹⁷ However, a previous study that analysed 11 090 Japanese employees aged 20–64 years in 2011 by using a nationally representative, population-based cross-sectional study suggested that partial bans may not be as effective as no ban.¹³

COVID-19 has had a significant influence on a number of social activities worldwide. On 12 March 2020, there was a call by Japan Society for Tobacco Control that all smoking rooms and areas should be closed to prevent the spread of infection.¹⁸ In Japan, many companies changed their smoke-free policies, for example, many indoor smoking spaces were closed. Meanwhile, heated tobacco products (HTPs) have recently become popular in Japan,¹⁹ and HTPs have been introduced to the market as ‘less hazardous’ versions of cigarettes and as a means to evade smoke-free regulations.²⁰ According to a previous study conducted during February–March 2020 with individuals aged 15–74 years (n=9044), the prevalence of current HTP use was 10.9% in 2020 in Japan.²¹ Some workplaces have adopted different smoke-free regulations for different tobacco products. Therefore, this study aimed to examine the effect of workplace smoke-free policies on workplace SHS exposure among non-smoking employees during the COVID-19 pandemic in Japan, distinguishing between SHS exposure from cigarettes and exposure to secondhand HTP aerosol.

MATERIALS AND METHODS

Data

We used data from the Japan COVID-19 and Society Internet Survey (JACSIS), which had been designed to investigate the social and health situation during the COVID-19 pandemic. Our questionnaires were distributed from 25 August 2020 to 30 September 2020, when the target numbers by sex, age and prefecture category was achieved. A total of 28 000 respondents’ data were collected from among 2.2 million participants registered with a Japanese internet survey agency (Rakuten Insight, Tokyo, Japan).²² The survey invitations were sent by the research agency to 224 389 candidates of the 2.2 million participants. Using a computer algorithm, a random sampling method was used to recruit participants for this study. We set a target sample size of 28 000 people, based

on a statistical presumption (ie, each age and sex stratum required sufficient numbers to estimate the proportion of events) and available survey budget. The sample represented the official demographic composition in Japan as of 1 October 2019, based on the categories of age, sex and prefecture.

Participants

Among the 28 000 participants in the JACSIS, 25 482 participants remained after excluding 2518 participants whose data showed discrepancies and/or artificial/unnatural responses. Three question items namely ‘choosing the second from the bottom’, ‘choosing the positive options in a set of questions on drug use’ and ‘choosing the positive options in a set of questions on current chronic diseases’ were used to detect any discrepancies.^{23 24} After further excluding current cigarette smokers (n=3403), current HTP users (n=2082), non-workers (work-at-home people, students, retired people, housewives/husbands and people out of jobs) (n=10 116), those who did not go to their workplaces (n=6997) and those whose workplace smoke-free policies were unknown (n=1628), 8196 respondents remained for the analysis. Thus, participants who met any of the exclusion criteria were excluded from this study.

Measures

Workplace smoke-free policies

In one question of the JACSIS questionnaire, the respondents selected their workplace smoke-free policies. The options were: (1) ‘smoking is not allowed both indoors and outdoors’, (2) ‘smoking is not allowed indoors’, (3) ‘smoking is allowed in the smoking room but not available now’, (4) ‘smoking is allowed in the smoking corner but not available now’, (5) ‘smoking is allowed in the smoking room’, (6) ‘smoking is allowed in the smoking corner’, (7) ‘no smoking bans’, (8) ‘none of the above (non-workers)’ and (9) ‘I don’t know’. As previously mentioned, those who selected (8) or (9) were excluded from the analysis. We combined (1) and (2) into ‘complete smoking bans’, (3) and (4) into ‘partial smoking bans with no longer available smoking spaces (closure of smoking spaces)’ and (5) and (6) into ‘partial smoking bans with still available smoking spaces’.

SHS exposure at workplace

In the JACSIS questionnaire, there were two sets of variables regarding SHS exposure in the workplace: SHS exposure from cigarettes and exposure to secondhand HTP aerosol. In one question, the respondents were asked, ‘Did you have any opportunity in the workplace to be exposed to SHS from cigarettes (not HTPs) that others used in the last month?’ The options were: (1) ‘almost every day’, (2) ‘several times a week’, (3) ‘once a week’, (4) ‘once a month’, (5) ‘none’ and (6) ‘did not go to the workplace’. Those who did not go to their workplaces (ie, those who answered (6)) were excluded from the analysis. Next, the respondents were asked, ‘Did you have

any opportunity at workplace to be exposed to second-hand HTP aerosol that others used in the last month?" The options were: (1) 'almost every day', (2) 'several times a week', (3) 'once a week', (4) 'once a month' and (5) 'none'. SHS exposure at least once a week included (1) 'almost every day', (2) 'several times a week' and (3) 'once a week', while SHS exposure at least several times a week included (1) 'almost every day' and (2) 'several times a week'.

Covariates

The regional infection status was divided into tertile categories (low: <0.5, middle: 0.5–0.8 and high: >0.8), using the cumulative number of people infected with COVID-19 per 10 000 people per prefecture from 1 January 2020 to 16 April 2020. Equivalent household annual income was calculated by dividing household annual income by the square root of the number of household members, and classified into tertile categories (<2.75 million Japanese yen (JPY), 2.75–4.5 million JPY and >4.5 million JPY). Sex (male, female); age (≤ 29 years, 30–49 years, 50–64 years and ≥ 65 years); educational level (high school or below, college and 4-year university or above); marital status (married, never married and widowed/divorced); recognition of the adverse health effects of SHS exposure (no, neither yes nor no or yes to a question 'Is secondhand smoke bad for health?'); self-rated health status (good, normal and bad); employment pattern (permanent employee, company executive, temporary employee, part-time employee and self-employed) and labour type (manual and non-manual labour) were also classified. No variables had missing values.

Statistical analyses

The baseline characteristics were summarised according to SHS exposure from cigarettes and exposure to secondhand HTP aerosol. Multivariable logistic regression models were fitted to estimate the OR and 95% CI for the association of workplace smoke-free policy to SHS exposure from cigarettes and exposure to secondhand HTP aerosol, with adjustments for covariates listed above. In supplementary analysis, workplace smoke-free policy 'partial smoking bans with still available smoking spaces' was chosen as reference to assess the effect of temporary closure of smoking spaces on SHS exposure from cigarettes and exposure to secondhand HTP aerosol. All statistical analyses were performed using the Stata software (V.16.1; StataCorp, Lakeway, Texas, USA).

Ethical issues

All procedures related to this study were conducted in accordance with the ethical standards of the Helsinki Declaration of 1975, as revised in 2013.²⁵ All participants provided a web-based informed consent form before participating in the online questionnaire.

Patient and public involvement

Patients or the public were not involved in the design, or conduct, or reporting, or dissemination plans of our study.

RESULTS

Table 1 shows the baseline characteristics of the participants and their SHS exposure status. Among those whose workplace smoke-free policy was 'complete smoking bans', 11.9% and 6.8% were exposed to SHS from cigarettes and exposure to secondhand HTP aerosol at least once a week, and 8.0% and 4.5% were exposed to the former and latter at least several times a week, respectively. Among those whose workplace smoke-free policy was 'partial smoking bans with no longer available smoking spaces', 23.9% and 26.4% were exposed to SHS from cigarettes and secondhand HTP aerosol at least once a week and 12.4% and 15.2% were exposed to the former and latter at least several times a week, respectively. Among those whose workplace smoke-free policy was 'partial smoking bans with still available smoking spaces', 22.7% and 15.8% were exposed to SHS from cigarettes and secondhand HTP aerosol at least once a week and 15.6% and 10.0% were exposed to the former and latter at least several times a week, respectively. Among those whose workplace had no rules or restrictions on smoking, 43.2% and 24.2% were exposed to SHS from cigarettes and secondhand HTP aerosol at least once a week 34.0% and 19.4% were exposed to the former and latter at least several times a week, respectively. Other characteristics of the participants exposed to SHS from cigarettes and secondhand HTP aerosol at workplace were: male, younger age, lower level of education, lower equivalent household income, lower regional infection status of COVID-19, no recognition of the adverse health effects of SHS exposure, worse self-rated health status, permanent employment and manual labour. Online supplemental table 1 also shows the baseline characteristics of the participants and their SHS exposure status. SHS exposure was divided into five categories ('almost every day', 'several times a week', 'once a week', 'once a month' and 'none').

Table 2 shows the estimated ORs and 95% CIs for workplace SHS exposure. The presence of a non-complete workplace smoke-free policy was significantly associated with workplace SHS exposure. The ORs and 95% CIs for workplace SHS exposure from cigarettes at least once a week were 2.06 (95% CI: 1.60 to 2.65) for partial smoking bans with no longer available smoking spaces, 1.92 (95% CI: 1.63 to 2.25) for partial smoking bans with still available smoking spaces and 5.33 (95% CI: 4.10 to 6.93) for no smoking bans, compared with complete smoking bans. The ORs and 95% CIs for workplace exposure to secondhand HTP aerosol at least once a week were 4.15 (95% CI: 3.22 to 5.34) for partial smoking bans with no longer available smoking spaces, 2.24 (95% CI: 1.86 to 2.71) for partial smoking bans with still available smoking

**Table 1** The baseline characteristics of the participants who do not smoke and their SHS exposure status at workplace (n=8196)

	Total, n	SHS exposure			
		Cigarettes		HTPs	
		At least once a week	At least several times a week	At least once a week	At least several times a week
		%	%	%	%
Workplace smoke-free policy					
Complete smoking bans	6273	11.9	8.0	6.8	4.5
Partial smoking bans with no longer available smoking spaces	402	23.9	12.4	26.4	15.2
Partial smoking bans with still available smoking spaces	1227	22.7	15.6	15.8	10.0
No smoking bans	294	43.2	34.0	24.2	19.4
Sex					
Male	4485	17.9	11.9	12.2	7.9
Female	3711	11.9	8.4	6.8	4.6
Age (years)					
15–29	1244	20.6	13.8	14.4	8.1
30–49	3742	16.2	10.9	10.5	7.2
50–64	2317	12.8	8.7	7.9	5.4
65–79	893	10.0	7.2	4.9	3.6
Marital status					
Married	4923	13.6	8.9	8.7	5.8
Never married	2617	17.9	12.5	11.5	7.5
Widowed/Divorced	656	16.9	11.9	10.1	7.3
Educational level					
High school or below	1806	22.8	17.1	13.3	10.0
College	1826	14.2	9.9	8.8	6.3
University or above	4564	12.6	7.8	8.6	5.1
Equivalent household income					
<2.75 million JPY	2119	17.9	13.3	11.3	7.9
2.75–4.5 million JPY	2513	16.0	10.6	10.1	6.7
>4.5 million JPY	2441	12.4	7.1	8.5	4.8
Did not know/Did not want to answer	1123	14.4	11.0	8.5	6.5
Regional infection status of COVID-19					
Low	2848	16.5	11.8	10.1	7.1
Middle	2449	15.3	9.9	10.0	6.4
High	2899	13.8	9.2	9.1	5.7
Recognition of the adverse health effects of SHS exposure					
No	920	20.7	14.7	16.7	10.8
Neither yes nor no	1560	17.2	11.5	11.9	7.5
Yes	5716	13.8	9.3	8.0	5.4
Self-rated health status					
Good	4575	13.9	9.5	8.9	5.7
Normal	2627	16.0	10.7	9.7	6.7
Bad	994	19.1	12.9	13.3	8.9
Employment pattern					

Continued

Table 1 Continued

	Total, n	SHS exposure			
		Cigarettes		HTPs	
		At least once a week	At least several times a week	At least once a week	At least several times a week
		%	%	%	%
Permanent employee	4702	17.1	11.6	11.2	7.5
Company executive	402	18.2	12.7	13.7	8.5
Temporary employee	734	12.0	7.8	7.2	4.4
Part-time employee	1641	12.2	8.3	6.6	4.3
Self-employed	717	11.2	8.0	7.3	5.0
Labour type					
Manual labour	2086	20.5	14.4	12.0	7.9
Non-manual labour	6110	13.4	8.9	8.9	5.9

Percentages were calculated for each row.

HTPs, heated tobacco products; JPY, Japanese yen; SHS, secondhand smoke.

spaces and 3.88 (95% CI: 2.86 to 5.26) for no smoking bans, compared with complete smoking bans. The ORs and 95% CIs for workplace SHS exposure at least several times a week and at least once a week were similar.

Online supplemental table 2 shows the estimated ORs and 95% CIs for workplace SHS exposure with ‘partial smoking bans with still available smoking spaces’ being chosen as reference. Temporary closure of smoking spaces was not significantly associated with SHS exposure from cigarettes, but this was significantly associated with exposure to secondhand HTP aerosol. The ORs and 95% CIs for workplace exposure to secondhand HTP aerosol at least once a week and at least several times a week were 1.85 (95% CI: 1.40 to 2.44) and 1.59 (95% CI: 1.13 to 2.24) for partial smoking bans with no longer available smoking spaces, respectively, compared with partial smoking bans with still available smoking spaces.

As for covariates, the male sex, younger age, lower level of education, low equivalent household income, lack of recognition of the adverse health effects of SHS exposure, poor self-rated health status, permanent employment and manual labour were significantly associated with high SHS exposure from cigarettes and exposure to secondhand HTP aerosol. The ORs and 95% CIs for workplace SHS exposure from cigarettes at least once a week were 1.65 (95% CI: 1.42 to 1.91) for male; 2.20 (95% CI: 1.62 to 2.99) for 15–29 years, 1.74 (95% CI: 1.33 to 2.26) for 30–49 years and 1.31 (95% CI: 1.00 to 1.72) for 50–64 years, compared with 65–79 years; 2.02 (95% CI: 1.72 to 2.36) for high school or below and 1.33 (95% CI: 1.12 to 1.59) for college, compared with 4-year university or above; 1.35 (95% CI: 1.12 to 1.63) for low income; 1.31 (95% CI: 1.09 to 1.58) for no recognition of the adverse effects of SHS exposure; 1.41 (95% CI: 1.17 to 1.7) for bad self-rated health status; 1.86 (95% CI: 1.41 to 2.44) for permanent employment and 2.06 (95% CI: 1.42 to 2.99) for company executive, compared

with self-employment; and 1.46 (95% CI: 1.27 to 1.69) for manual labour. The ORs and 95% CIs for workplace exposure to secondhand HTP aerosol at least once a week were 1.77 (95% CI: 1.47 to 2.13) for male; 2.80 (95% CI: 1.89 to 4.15) for 15–29 years, 2.11 (95% CI: 1.49 to 2.99) for 30–49 years and 1.62 (95% CI: 1.13 to 2.32) for 50–64 years, compared with 65–79 years; 1.74 (95% CI: 1.43 to 2.11) for high school or below and 1.30 (95% CI: 1.05 to 1.61) for college, compared with 4-year university or above; 1.32 (95% CI: 1.06 to 1.65) for low income; 1.77 (95% CI: 1.43 to 2.18) for no recognition of the adverse effects of SHS exposure; 1.52 (95% CI: 1.22 to 1.9) for bad self-rated health status; 1.51 (95% CI: 1.09 to 2.1) for permanent employment and 1.95 (95% CI: 1.27 to 3) for company executive, compared with self-employment; and 1.28 (95% CI: 1.07 to 1.52) for manual labour.

DISCUSSION

We confirmed that non-complete workplace smoke-free policies were significantly associated with SHS exposure among non-smoking employees during COVID-19 pandemic, consistent with previous studies.¹³ The lack of rules or restrictions on smoking was associated with an approximately fivefold increased risk of SHS exposure from cigarettes and a fourfold increased risk of exposure to secondhand HTP aerosol. Compared with complete smoking bans, partial smoking bans were associated with a 1.4-fold to 2.1-fold increased risk of SHS exposure from cigarettes and a 2.0-fold to 4.2-fold increased risk of exposure to secondhand HTP aerosol. On the other hand, the effect of temporary closure of smoking spaces was different on SHS exposure from cigarettes and exposure to secondhand HTP aerosol. Temporary closure of smoking spaces was not significantly associated with SHS exposure from cigarettes but was significantly associated

Table 2 Multivariable logistic regression model for the association between subjects' characteristics and SHS exposure at workplace among non-smoking employees (n=8196)

	SHS exposure			
	At least once a week		At least several times a week	
	Cigarettes	HTPs	Cigarettes	HTPs
	Adjusted OR (95% CI)	Adjusted OR (95% CI)	Adjusted OR (95% CI)	Adjusted OR (95% CI)
Workplace smoke-free policy				
Complete smoking bans	1 (reference)	1 (reference)	1 (reference)	1 (reference)
Partial smoking bans with no longer available smoking spaces	2.06 (1.60 to 2.65)	4.15 (3.22 to 5.34)	1.43 (1.04 to 1.97)	3.23 (2.37 to 4.39)
Partial smoking bans with still available smoking spaces	1.92 (1.63 to 2.25)	2.24 (1.86 to 2.71)	1.85 (1.54 to 2.23)	2.03 (1.62 to 2.54)
No smoking bans	5.33 (4.10 to 6.93)	3.88 (2.86 to 5.26)	5.15 (3.90 to 6.8)	4.22 (3.03 to 5.89)
Sex				
Male	1.65 (1.42 to 1.91)	1.77 (1.47 to 2.13)	1.50 (1.26 to 1.79)	1.72 (1.38 to 2.14)
Female	1 (reference)	1 (reference)	1 (reference)	1 (reference)
Age (years)				
15–29	2.20 (1.62 to 2.99)	2.80 (1.89 to 4.15)	1.86 (1.30 to 2.65)	1.98 (1.24 to 3.16)
30–49	1.74 (1.33 to 2.26)	2.11 (1.49 to 2.99)	1.56 (1.15 to 2.12)	1.91 (1.27 to 2.87)
50–64	1.31 (1.00 to 1.72)	1.62 (1.13 to 2.32)	1.22 (0.89 to 1.67)	1.44 (0.95 to 2.2)
65–79	1 (reference)	1 (reference)	1 (reference)	1 (reference)
Marital status				
Married	1 (reference)	1 (reference)	1 (reference)	1 (reference)
Never married	1.07 (0.92 to 1.25)	1.03 (0.85 to 1.23)	1.12 (0.93 to 1.34)	1.04 (0.84 to 1.3)
Widowed/Divorced	1.30 (1.03 to 1.65)	1.25 (0.93 to 1.68)	1.26 (0.96 to 1.66)	1.29 (0.92 to 1.81)
Educational level				
High school or below	2.02 (1.72 to 2.36)	1.74 (1.43 to 2.11)	2.30 (1.92 to 2.76)	2.14 (1.71 to 2.69)
College	1.33 (1.12 to 1.59)	1.30 (1.05 to 1.61)	1.43 (1.16 to 1.76)	1.55 (1.20 to 1.99)
4-year university or above	1 (reference)	1 (reference)	1 (reference)	1 (reference)
Equivalent household income				
<2.75 million JPY	1.35 (1.12 to 1.63)	1.32 (1.06 to 1.65)	1.73 (1.38 to 2.15)	1.62 (1.23 to 2.12)
2.75–4.5 million JPY	1.18 (0.99 to 1.39)	1.10 (0.90 to 1.35)	1.33 (1.08 to 1.64)	1.26 (0.98 to 1.62)
>4.5 million JPY	1 (reference)	1 (reference)	1 (reference)	1 (reference)
Did not know/Did not want to answer	1.18 (0.95 to 1.48)	1.10 (0.84 to 1.45)	1.57 (1.21 to 2.03)	1.47 (1.07 to 2.03)
Regional infection status of COVID-19				
Low	1 (reference)	1 (reference)	1 (reference)	1 (reference)
Middle	0.96 (0.82 to 1.12)	1.01 (0.83 to 1.21)	0.88 (0.73 to 1.06)	0.94 (0.75 to 1.18)
High	0.90 (0.77 to 1.05)	0.94 (0.78 to 1.14)	0.89 (0.75 to 1.07)	0.89 (0.71 to 1.11)
Recognition of the adverse health effects of SHS exposure				
No	1.31 (1.09 to 1.58)	1.77 (1.43 to 2.18)	1.43 (1.15 to 1.77)	1.67 (1.30 to 2.14)
Neither yes nor no	1.12 (0.95 to 1.31)	1.31 (1.08 to 1.59)	1.13 (0.93 to 1.36)	1.20 (0.95 to 1.5)
Yes	1 (reference)	1 (reference)	1 (reference)	1 (reference)
Self-rated health status				
Good	1 (reference)	1 (reference)	1 (reference)	1 (reference)
Normal	1.13 (0.98 to 1.3)	1.06 (0.90 to 1.26)	1.07 (0.91 to 1.26)	1.13 (0.92 to 1.38)
Bad	1.41 (1.17 to 1.7)	1.52 (1.22 to 1.9)	1.33 (1.07 to 1.66)	1.50 (1.16 to 1.96)
Employment pattern				

Continued

Table 2 Continued

	SHS exposure			
	At least once a week		At least several times a week	
	Cigarettes	HTPs	Cigarettes	HTPs
	Adjusted OR (95% CI)	Adjusted OR (95% CI)	Adjusted OR (95% CI)	Adjusted OR (95% CI)
Permanent employee	1.86 (1.41 to 2.44)	1.51 (1.09 to 2.1)	1.91 (1.39 to 2.63)	1.72 (1.17 to 2.53)
Company executive	2.06 (1.42 to 2.99)	1.95 (1.27 to 3)	2.23 (1.45 to 3.44)	1.99 (1.19 to 3.33)
Temporary employee	1.23 (0.87 to 1.73)	0.98 (0.64 to 1.49)	1.13 (0.75 to 1.70)	0.92 (0.55 to 1.53)
Part-time employee	1.35 (0.99 to 1.83)	1.09 (0.75 to 1.58)	1.22 (0.85 to 1.74)	1.05 (0.67 to 1.64)
Self-employed	1 (reference)	1 (reference)	1 (reference)	1 (reference)
Labour type				
Manual labour	1.46 (1.27 to 1.69)	1.28 (1.07 to 1.52)	1.40 (1.19 to 1.65)	1.13 (0.92 to 1.4)
Non-manual labour	1 (reference)	1 (reference)	1 (reference)	1 (reference)

HTPs, heated tobacco products; JPY, Japanese yen; SHS, secondhand smoke.

with a 1.6-fold to 1.9-fold increased risk of exposure to secondhand HTP aerosol.

Our study showed that temporary closure of smoking spaces did not have a significant effect on SHS exposure from cigarettes but rather contributed to increased exposure to secondhand HTP aerosol. According to the 2019 Japan Society and New Tobacco Internet Survey study whose respondents included those that registered with the same internet survey agency as those in our study, 11.9% of HTP users had used HTPs in smoke-free locations.²⁶ Moreover, approximately one-fourth of the HTP users thought that HTP use was not prohibited in places where smoking was not allowed, and these respondents were likely to use HTPs in such locations.²⁶ Considering these findings, HTPs might have been used outside the temporarily closed smoking spaces. In Japan, recently, the number of HTP users has been increasing. However, there had been no legislation banning HTP use in the workplace, and some workplaces have voluntarily adopted their own smoke-free policies regarding HTP use.²⁷ To improve such situations, the Health Promotion Law was revised to include smoke-free regulations with fines in 2018; moreover, tobacco use, including cigarettes and HTPs, has been forbidden indoors in facilities for children and patients such as schools, hospitals and government offices since July 2019. In other places, such as general offices, factories and restaurants (except for restaurants with 100 m² or smaller), tobacco use has been allowed in two types of designated tobacco rooms since April 2020: (1) tobacco rooms for tobacco products (including cigarettes and HTPs): only smoking is allowed in this room and (2) tobacco rooms for only HTPs: HTP use is allowed in the room as well as eating/drinking and other activities.⁹ In other words, HTPs are regulated differently from cigarettes, despite WHO recommending that HTP use should be regulated in accordance with the policy and regulatory measures applied to all other tobacco products.^{28,29} Such Japanese smoking regulations, which distinguish HTPs

from cigarettes,⁹ as well as the assumption that HTPs are less hazardous than cigarettes may lead to confusion about the use of HTPs and promote HTP use in places where smoking is not allowed. Comprehensive regulation, as recommended by WHO, should be enforced.

In our study, compared with complete smoking bans, partial smoking bans and no smoking bans were significantly associated with high SHS exposure from cigarettes and exposure to secondhand HTP aerosol. A previous study conducted in China reported that working in a company with strict smoke-free policies was significantly associated with low SHS exposure, and they suggested that all countries should enact stringent smoke-free policies in workplaces.³⁰ Another study conducted in Japan reported that partial smoking bans were less effective than complete smoking bans³¹; in that study, partial smoking bans were associated with an approximately twofold increased risk of SHS exposure among non-smoking employees.³¹ Partial smoking bans were not enough to reduce SHS exposure and complete smoking bans might be the best way to reduce SHS exposure. As mentioned in the previous paragraph, we examined the effect of temporary closure of smoking spaces on SHS exposure. According to previous studies,^{30,31} SHS exposure was expected to decrease in workplaces that had adopted partial bans but had substantially shifted towards complete bans by permanently closing smoking spaces. However, the closure of smoking spaces examined in our study was a temporary one during COVID-19 pandemic, and this temporary closure had no significant effect on SHS exposure from cigarettes and contributed to increased exposure to secondhand HTP aerosol. Temporary closure of smoking spaces is insufficient, and permanent transition to complete bans might be necessary to especially reduce exposure to secondhand HTP aerosol.

In our study, SHS exposure was high among the participants who were male, young aged, less educated, permanent employee, manual labourer, had low income, had no



understanding of the adverse health effects of SHS exposure and had poor self-rated health status. These results were similar to those of a previous study that examined social inequalities in SHS exposure among Japanese non-smokers.³² There are social inequalities in SHS exposure both at workplace and home, and these inequalities may lead to unequal prevalence of smoking-related diseases among different social groups.^{32 33} Our study showed a difference in SHS exposure from cigarettes and exposure to secondhand HTP aerosol between various employee age groups. Although younger employees were more likely to report SHS exposure from cigarettes and exposure to secondhand HTP aerosol, they were also more likely than older employees to report exposure to secondhand HTP aerosol than SHS exposure from cigarettes. Since HTPs were recently introduced to the Japanese market¹⁹ and cigarettes have been popular for a long time, HTPs have become more popular among the younger generation.²⁷ No recognition of adverse health effects of SHS exposure contributed to increased SHS exposure from cigarettes and exposure to secondhand HTP aerosol. People who did not understand the adverse effects might be careless and less likely to avoid SHS exposure. Moreover, approximately 30% of respondents were not sure about the adverse effects of SHS exposure. Although less educated people tend to ignore such effects of SHS exposure, this high rate might be attributed to incomplete smoke-free policies, which allow partial bans as an option. The comprehensive smoke-free regulation is essential to give such people a chance to know the adverse effects of SHS exposure. It could be possible that associations between sociodemographic patterns and SHS exposure within complete smoking bans differ from those within partial smoking bans, but there was no significant difference within complete and partial/no bans (data not shown).

To the best of our knowledge, this is the first study to examine the effect of a workplace smoke-free policy on SHS exposure from cigarettes and exposure to secondhand HTP aerosol among non-smoking employees. Furthermore, the large sample size (n=28 000) of the JACSIS data is a strength of our study. Since the survey continued as a longitudinal study, we will be able to collect their data and monitor their workplace SHS exposure status.

Limitations

Our study has several limitations. First, the validity of the questionnaire items was not completely confirmed. Although we excluded respondents whose data showed discrepancies and/or artificial/unnatural responses, our results may contain some reporting bias because of the self-report nature of the survey. Second, as HTPs look like e-cigarettes and the definition of these tobacco products is complicated, it might be difficult for non-smokers to distinguish between them. Although it is possible that some reports of exposure to secondhand HTP aerosol may be related to exposure to secondhand e-cigarettes aerosol, the prevalence of e-cigarettes use is considerably

lower than that of HTPs in Japan.²⁰ Third, the respondents had voluntarily registered themselves as internet survey participants. The percentage of smoking in our study were similar with that of national representative survey in Japan, although the percentage of smoking in women was slightly higher than that of national survey.⁴ Therefore, our study population may, to some extent, be representative of all non-smoking employees in Japan. However, our hypothesis was limited to non-smoking employees, and the 8196 sample size of our study was determined post hoc and may not have been an adequate sample size for our study. Fourth, this was a cross-sectional study. We observed an association between non-complete workplace smoke-free policies and SHS exposure from cigarettes and exposure to secondhand HTP aerosol. However, we could not examine whether smoke-free policies affect the habits of smoking cigarettes and using HTPs. Similarly, we are unable to examine the effect of 'work from home' policies, although people who worked more frequently from home than before COVID-19 pandemic might be less exposed to SHS from cigarettes and secondhand HTP aerosol. Finally, this study used data from Japan. Since workplace smoke-free policies may differ from country to country, studies based on the regulations in different countries are needed to examine the widespread effect of smoke-free policies globally.

CONCLUSION

Although new regulations against smoking cigarettes and using HTPs established in April 2020 in Japan recommended indoor smoking bans, many workplaces have introduced only partial smoking bans due to the wide exemption of the regulation. Temporary closure of smoking rooms or areas did not help reduce SHS exposure from cigarettes; even worse, this might have contributed to increased exposure to secondhand HTP aerosol because HTPs are categorised as an exemption of the regulation. Hence, complete smoking bans should be recommended, and continued monitoring of SHS exposure from cigarettes and exposure to secondhand HTP aerosol is required to examine the precise effect of workplace smoke-free policies.

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Funding This study was funded by the Japan Society for the Promotion of Science (JSPS) KAKENHI Grants (grant numbers 17H03589, 19K10671, 19K10446, 18H03107, 18H03062, 21H04856, 21K06666), the JSPS Grant-in-Aid for Young

Scientists (grant number 19K19439), Research Support Programme to Apply the Wisdom of the University to tackle COVID-19-Related Emergency Problems, University of Tsukuba, and Health Labour Sciences Research Grant (grant numbers 19FA1005, 19FG2001).

Competing interests KKat received a JMWH Bayer Grant (1 million JPY) from 1 September 2017 to 31 August 2019 via the Japan Society for Menopause and Women's Health. KKaw has received research funds from Eisai; Kyowa Kirin; Sumitomo Dainippon Pharma; Pfizer; Stella Pharma Corporation; CMIC; Suntory Beverage & Food; Mitsubishi and Real World Data; consulting fees from LEBER; JMDC; Shin Nippon Biomedical Laboratories; Kaken Pharmaceutica and Advanced Medical Care; executive compensation from Cancer Intelligence Care Systems; honorarium from Mitsubishi Chemical Holdings, Mitsubishi and Pharma Business Academy; and holds stock in Real World Data.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Consent obtained directly from patient(s).

Ethics approval Our study protocol was reviewed and approved on 19 June 2020 by the Research Ethics Committee of the Osaka International Cancer Institute (approval number: 20084) and National Cancer Centre Institutional Review Board (approval number: 2020-447).

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data sharing not applicable as no datasets generated and/or analysed for this study.

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Supplemental Table 1 The baseline characteristics of the participants who don't smoke and their secondhand smoke exposure status at workplace (N=8,196)

	Total, n	SHS exposure									
		Cigarettes					HTPs				
		Almost everyday	Several times a week	Once a week	Once a month	None	Almost everyday	Several times a week	Once a week	Once a month	None
		%	%	%	%	%	%	%	%	%	%
Workplace smoke-free policy											
Complete smoking bans	6,273	3.4	4.6	3.9	5.5	82.6	2.0	2.5	2.2	4.1	89.1
Partial smoking bans with no longer available smoking spaces	402	4.5	8.0	11.4	10.0	66.2	5.2	10.0	11.2	4.5	69.2
Partial smoking bans with still available smoking spaces	1,227	7.9	7.7	7.1	9.3	68.1	4.4	5.6	5.8	5.4	78.8
No smoking bans	294	21.8	12.2	9.2	6.5	50.3	11.2	8.2	4.8	6.8	69.1
Sex											
Male	4,485	5.5	6.4	6.0	7.5	74.6	3.3	4.6	4.2	5.2	82.6
Female	3,711	3.9	4.4	3.6	5.0	83.1	2.4	2.2	2.2	3.4	89.9
Age											
15-29 years	1,244	5.9	7.9	6.8	8.3	71.1	4.0	4.1	6.3	7.3	78.3
30-49 years	3,742	5.1	5.8	5.3	6.5	77.3	2.9	4.3	3.3	4.6	85.0
50-64 years	2,317	4.5	4.3	4.1	5.7	81.5	2.8	2.6	2.5	3.1	89.1
65-79 years	893	2.9	4.3	2.8	4.5	85.6	1.2	2.4	1.3	2.9	92.2
Marital status											
Married	4,923	4.2	4.8	4.6	6.3	80.2	2.6	3.2	3.0	3.9	87.4
Never married	2,617	5.7	6.7	5.4	6.6	75.5	3.2	4.3	4.1	5.7	82.8
Widowed/divorced	656	5.6	6.3	5.0	6.0	77.1	3.7	3.7	2.7	3.2	86.7
Educational level											
High school or below	1,806	8.2	8.9	5.7	6.7	70.5	4.8	5.2	3.4	4.2	82.5
College	1,826	4.9	4.9	4.4	5.8	80.0	3.1	3.2	2.5	3.8	87.4

4 year-University or above	4,564	3.4	4.4	4.8	6.4	81.0	2.0	3.0	3.6	4.7	86.7
Equivalent household income											
< 2.75 million JPY	2,119	6.5	6.8	4.7	6.8	75.2	3.9	4.0	3.4	4.5	84.2
2.75-4.5 million JPY	2,513	4.8	5.8	5.4	6.4	77.6	2.8	3.9	3.4	4.6	85.3
> 4.5 million JPY	2,441	3.0	4.2	5.2	6.6	81.0	1.9	2.9	3.7	4.5	87.0
Did not know/did not want to answer	1,123	5.5	5.4	3.5	4.6	80.9	3.1	3.4	2.0	3.5	88.1
Regional infection status of COVID-19											
Low	2,848	5.9	5.8	4.7	6.4	77.1	3.4	3.7	3.0	4.7	85.3
Middle	2,449	4.5	5.4	5.4	6.5	78.2	2.8	3.6	3.6	4.9	85.1
High	2,899	4.0	5.2	4.6	6.2	79.9	2.4	3.4	3.4	3.7	87.2
Recognition of the adverse health effects of SHS exposure											
No	920	7.4	7.3	6.0	6.1	73.3	5.4	5.3	6.0	4.1	79.1
Neither Yes nor No	1,560	5.5	6.1	5.6	6.8	76.0	3.7	3.9	4.4	5.5	82.7
Yes	5,716	4.2	5.1	4.5	6.3	80.0	2.2	3.2	2.6	4.2	87.9
Self-rated health status											
Good	4,575	4.2	5.3	4.4	6.2	79.9	2.6	3.1	3.2	4.5	86.6
Normal	2,627	5.3	5.4	5.3	6.4	77.6	2.8	3.9	3.0	4.1	86.2
Bad	994	6.2	6.6	6.2	6.6	74.3	4.0	4.8	4.4	4.7	82.0
Employment pattern											
Permanent employee	4,702	5.3	6.2	5.6	6.9	76.0	3.4	4.1	3.7	5.2	83.6
Company executive	402	6.2	6.5	5.5	8.2	73.6	3.7	4.7	5.2	5.7	80.6
Temporary employee	734	4.5	3.3	4.2	5.3	82.7	2.0	2.3	2.9	3.8	89.0
Part-time employee	1,641	3.2	5.1	3.9	5.2	82.6	1.7	2.7	2.3	2.6	90.9
Self-employed	717	4.5	3.5	3.2	5.6	83.3	2.7	2.4	2.2	3.4	89.4
Labour type											
Manual labour	2,086	6.6	7.9	6.1	6.3	73.2	3.4	4.5	4.1	4.1	83.9
Non-manual labour	6,110	4.2	4.7	4.5	6.4	80.3	2.7	3.2	3.0	4.5	86.6

Percentages were calculated for each row.

Abbreviations: SHS, secondhand smoke; HTPs, Heated Tobacco Products; JPY, Japanese yen

Supplemental Table 2 Multivariable logistic regression model for the association between subjects characteristics and secondhand smoke exposure at workplace among non-smoking employees (N=8,196)

	SHS exposure			
	At least once a week		At least several times a week	
	Cigarettes	HTPs	Cigarettes	HTPs
	Adjusted OR (95%CI)	Adjusted OR (95%CI)	Adjusted OR (95%CI)	Adjusted OR (95%CI)
Workplace smoke-free policy				
Complete smoking bans	0.52 (0.44-0.61)	0.45 (0.37-0.54)	0.54 (0.45-0.65)	0.49 (0.39-0.62)
Partial smoking bans with no longer available smoking spaces	1.08 (0.82-1.42)	1.85 (1.40-2.44)	0.77 (0.55-1.09)	1.59 (1.13-2.24)
Partial smoking bans with still available smoking spaces	1 (reference)	1 (reference)	1 (reference)	1 (reference)
No smoking bans	2.78 (2.09-3.71)	1.73 (1.24-2.4)	2.78 (2.04-3.79)	2.08 (1.44-3.01)
Sex				
Male	1.65 (1.42-1.91)	1.77 (1.47-2.13)	1.50 (1.26-1.79)	1.72 (1.38-2.14)
Female	1 (reference)	1 (reference)	1 (reference)	1 (reference)
Age				
15-29 years	2.20 (1.62-2.99)	2.80 (1.89-4.15)	1.86 (1.30-2.65)	1.98 (1.24-3.16)
30-49 years	1.74 (1.33-2.26)	2.11 (1.49-2.99)	1.56 (1.15-2.12)	1.91 (1.27-2.87)
50-64 years	1.31 (1.00-1.72)	1.62 (1.13-2.32)	1.22 (0.89-1.67)	1.44 (0.95-2.2)
65-79 years	1 (reference)	1 (reference)	1 (reference)	1 (reference)
Marital status				
Married	1 (reference)	1 (reference)	1 (reference)	1 (reference)
Never married	1.07 (0.92-1.25)	1.03 (0.85-1.23)	1.12 (0.93-1.34)	1.04 (0.84-1.3)
Widowed/divorced	1.30 (1.03-1.65)	1.25 (0.93-1.68)	1.26 (0.96-1.66)	1.29 (0.92-1.81)
Educational level				
High school or below	2.02 (1.72-2.36)	1.74 (1.43-2.11)	2.30 (1.92-2.76)	2.14 (1.71-2.69)
College	1.33 (1.12-1.59)	1.30 (1.05-1.61)	1.43 (1.16-1.76)	1.55 (1.20-1.99)

4 year-University or above	1 (reference)	1 (reference)	1 (reference)	1 (reference)
Equivalent household income				
< 2.75 million JPY	1.35 (1.12-1.63)	1.32 (1.06-1.65)	1.73 (1.38-2.15)	1.62 (1.23-2.12)
2.75-4.5 million JPY	1.18 (0.99-1.39)	1.10 (0.90-1.35)	1.33 (1.08-1.64)	1.26 (0.98-1.62)
> 4.5 million JPY	1 (reference)	1 (reference)	1 (reference)	1 (reference)
Did not know/did not want to answer	1.18 (0.95-1.48)	1.10 (0.84-1.45)	1.57 (1.21-2.03)	1.47 (1.07-2.03)
Regional infection status of COVID-19				
Low	1 (reference)	1 (reference)	1 (reference)	1 (reference)
Middle	0.96 (0.82-1.12)	1.01 (0.83-1.21)	0.88 (0.73-1.06)	0.94 (0.75-1.18)
High	0.90 (0.77-1.05)	0.94 (0.78-1.14)	0.89 (0.75-1.07)	0.89 (0.71-1.11)
Recognition of the adverse health effects of SHS exposure				
No	1.31 (1.09-1.58)	1.77 (1.43-2.18)	1.43 (1.15-1.77)	1.67 (1.30-2.14)
Neither Yes nor No	1.12 (0.95-1.31)	1.31 (1.08-1.59)	1.13 (0.93-1.36)	1.20 (0.95-1.5)
Yes	1 (reference)	1 (reference)	1 (reference)	1 (reference)
Self-rated health status				
Good	1 (reference)	1 (reference)	1 (reference)	1 (reference)
Normal	1.13 (0.98-1.3)	1.06 (0.90-1.26)	1.07 (0.91-1.26)	1.13 (0.92-1.38)
Bad	1.41 (1.17-1.7)	1.52 (1.22-1.9)	1.33 (1.07-1.66)	1.50 (1.16-1.96)
Employment pattern				
Permanent employee	1.86 (1.41-2.44)	1.51 (1.09-2.1)	1.91 (1.39-2.63)	1.72 (1.17-2.53)
Company executive	2.06 (1.42-2.99)	1.95 (1.27-3)	2.23 (1.45-3.44)	1.99 (1.19-3.33)
Temporary employee	1.23 (0.87-1.73)	0.98 (0.64-1.49)	1.13 (0.75-1.70)	0.92 (0.55-1.53)
Part-time employee	1.35 (0.99-1.83)	1.09 (0.75-1.58)	1.22 (0.85-1.74)	1.05 (0.67-1.64)
Self-employed	1 (reference)	1 (reference)	1 (reference)	1 (reference)
Labour type				
Manual labour	1.46 (1.27-1.69)	1.28 (1.07-1.52)	1.40 (1.19-1.65)	1.13 (0.92-1.4)
Non-manual labour	1 (reference)	1 (reference)	1 (reference)	1 (reference)

SHS, secondhand smoke; HTPs, Heated Tobacco Products; OR, odds ratios; CI, confidence interval; JPY, Japanese yen