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'Only Fathers Smoking' Contributes the Most to Socioeconomic Inequalities: Changes in Socioeconomic Inequalities in Infants' Exposure to Second Hand Smoke over Time in Japan

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Abstract

Background

Exposure to second hand smoke (SHS) is one of the major causes of premature death and disease among children. While socioeconomic inequalities exist for adult smoking, such evidence is limited for SHS exposure in children. Thus, this study examined changes over time in socioeconomic inequalities in infants' SHS exposure in Japan.

Methods

This is a repeated cross-sectional study of 41,833 infants born in 2001 and 32,120 infants born in 2010 in Japan from nationally representative surveys using questionnaires. The prevalence of infants' SHS exposure was determined and related to household income and parental education level. The magnitudes of income and educational inequalities in infants' SHS exposure were estimated in 2001 and 2010 using both absolute and relative inequality indices.

Results

The prevalence of SHS exposure in infants declined from 2001 to 2010. The relative index of inequality increased from 0.85 (95% confidence interval [CI], 0.80 to 0.89) to 1.47 (95% CI, 1.37 to 1.56) based on income and from 1.22 (95% CI, 1.17 to 1.26) to 2.09 (95% CI, 2.00 to 2.17) based on education. In contrast, the slope index of inequality decreased from 30.9 (95% CI, 29.3 to 32.6) to 20.1 (95% CI, 18.7 to 21.5) based on income and from 44.6

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(95% CI, 43.1 to 46.2) to 28.7 (95% CI, 27.3 to 30.0) based on education. Having only a father who smoked indoors was a major contributor to absolute income inequality in infants' SHS exposure in 2010, which increased in importance from 45.1% in 2001 to 67.0% in 2010.

Conclusions

The socioeconomic inequalities in infants' second hand smoke exposure increased in relative terms but decreased in absolute terms from 2001 to 2010. Further efforts are needed to encourage parents to quit smoking and protect infants from second hand smoke exposure, especially in low socioeconomic households that include non-smoking mothers.

Introduction

Exposure to second hand smoke (SHS) is one of the major causes of premature death and disease among children[1]. The majority of SHS exposure in children occurs in homes or cars because their parents smoke, and 40% of children worldwide are regularly exposed to SHS indoors[2]. Although an ideal solution to protect children from exposure to SHS is parents' cessation of smoking, this is often not achievable[3,4]. 'Home smoking bans' might be an alternative and realistic strategy to reduce SHS exposure among children[5], although this is not a perfect solution[6].

The level of SHS exposure in children differs based on the parents' socioeconomic status (SES), with children in lower SES groups more likely to be exposed to SHS in their homes or cars than children in higher SES households[7,8]. Although social inequalities in the prevalence of adult smoking are widening in some European countries[9], there are limited studies focusing on the changes in SHS exposure inequalities in children over time. The available studies have shown mixed results. While the overall prevalence of SHS exposure in children decreased, socioeconomic inequalities in children's SHS exposure increased in the USA[10], and remained the same in Australia and Denmark[11,12]. However, children younger than two years old have rarely been studied independent of their older children despite they are more susceptible to the risks associated with SHS exposure[13]. Moreover, although mothers are more likely to be motivated to protect children from SHS exposure than fathers[3], it is not known how the combination of parental indoor smoking (i.e., only father smokes indoors, only mother smokes indoors, and both parents smoke indoors) contributes to these inequalities over time. Examining which combinations of parental indoor smoking drive inequalities the most would help to prioritize tobacco control policies or interventions to reduce children's SHS exposure.

Japan has significantly lagged behind in legislative tobacco control measures, despite having signed the World Health Organization's (WHO) Framework Convention on Tobacco Control in 2004[14,15]. No national law prohibits smoking in public places in Japan. Although two prefectures adopted an ordinance to restrict smoking in indoor public places in 2009 and 2010 [16,17], it is not mandated that all public places provide smoke-free environments[17]. Additionally, the tax rate of cigarettes in Japan rose from 61% to 65% of the retail price during 1998 to 2010[18]; however, it has not yet reached the criteria set by the WHO (at least 70%)[19].

Many children are still exposed to SHS in Japan. While the prevalence of adult smoking decreased from 45.9% in men and 9.9% in women in 2001 to 32.2% in men and 8.4% in women in 2010[20,21], approximately 40% of infants live with a smoking father and 14% live with a father who smokes indoors[22]. Moreover, socioeconomic inequality in SHS exposure

among children is inferred in Japan, although the evidence is limited. A study using nationally representative data in Japan demonstrated a significant relationship between parental smoking and household income[23]. Children in the lowest income households are more likely to suffer from asthma compared with those in the highest income households[24], and parental indoor smoking increases and exacerbates children's asthma[25]. Given these findings, we hypothesise that SHS exposure is higher among children in low-SES households in Japan. However, the change over time regarding the effect of SES on SHS exposure in children has not been studied in Japan.

Thus, we examined the magnitude of inequalities and changes in the magnitude of inequalities in SHS exposure in infants from 2001 to 2010. We hypothesized that the inequalities in SHS exposure based on parental income and education in Japan have remained the same during a recent 10-year period.

Materials and Methods

Study sample

We used data from the Longitudinal Survey of Newborns in the 21st Century, which was a national survey conducted by the Ministry of Health, Labour, and Welfare, Japan. This large panel study has two cohorts (infants who were born in 2001 or 2010). Data were used with permission from the Ministry of Health, Labour, and Welfare, Japan. Baseline data of both cohorts were used in this study, for all infants born in Japan during January 10–17, 2001 or July 10–17, 2001 for the first cohort (n = 53,575) and May 10–24, 2010 for the second cohort (n = 43,767), based on the birth registry. The respondents who returned the questionnaire to the Ministry were considered to have agreed to participate in the study. A detailed description of the cohort survey is available elsewhere[26].

The response rate for the first self-administered questionnaire, which was mailed to all households when the infants were 6 months old, was 87.8% (n = 47,015/53,575) for the first cohort and 88.1% (n = 38,554/43,767) for the second cohort. The response rate for the second questionnaire, which was mailed to participants of the first survey when their children reached 18 months old, was 82.0% (n = 43,925/53,575) for the first cohort and 76.2% (n = 33,356/43,767) for the second cohort. We restricted study participants to infants whose parents lived together at baseline, which led to exclusion of 923 for the first cohort and 686 for the second cohort. In addition, infants lacking parental age (151 for the first cohort, 103 for the second cohort) and parental smoking status (1,021 for the first cohort, 454 for the second cohort) were excluded. In the final analyses, 41,833 (78.1% of the initial cohort) and 32,120 (73.4% of the initial cohort) respondents for the first and second cohorts, respectively, were included. This study was approved by the Research Ethics Committee of the Graduate School of Medicine at The University of Tokyo, Japan.

Second hand smoke exposure in infants

Parental indoor smoking behaviour was used as a measurement of SHS exposure in infants [11]. Although this is a proxy measurement, parental indoor smoking is significantly associated with biochemically measured SHS exposure among children[27]. The parents in the baseline survey were asked whether the father and/or mother smoked, and, if yes, they were asked whether they smoked indoors. Then, we combined the responses for the smoking behaviour of both parents to create parental smoking (at least one parent smoked vs. neither parent smoked) and parental indoor smoking (at least one parent smoked indoors vs. neither parent smoked indoors) variables.

Socioeconomic indicators

We used income and education as SES indicators. For income, equivalent household income was calculated by adjusting for the square root of the number of persons living in the household and categorized into quartiles for each survey. Because the education question was only included in the second survey (2002 for the first cohort and 2011 for the second cohort), those data were used for education level (highest completed level) and categorized into four groups: less than high school graduate, high school graduate, some college, or university graduate or higher. Then, we combined the parental education level of the mother and father as follows: both are high school graduates or less, one is a college graduate and the other is a college graduate or less, only one is a university graduate, or both are university graduates or higher.

Statistical analyses

We calculated the prevalence of SHS exposure in infants based on SES by survey year. The prevalence in 2010 was adjusted by the average parental age in 5-year age groups using a direct method and the parental age distribution in 2001 as the base. Then, we used two methods to examine the change in inequality from 2001 to 2010. First, we compared the inequality indices between the two periods, using both absolute and relative indices, which is strongly recommended in health equality research to avoid biased judgments by readers[28]. For absolute measures, the rate difference and slope index of inequality (SII) with 95% confidence intervals (CIs) were estimated. The rate difference measures the absolute difference in indoor smoking prevalence between the lowest and highest SES groups. For relative measures, the odds ratio (OR) and relative index of inequality (RII) with 95% CIs were estimated. The OR is the ratio of the odds of indoor smoking in the lowest compared with the highest SES group and was estimated using logistic regression models, controlled for infant's sex, father's and mother's ages, and the SES variables (either income or education). To avoid overadjustment (i.e., control of an intermediate variable on a causal path from exposure to outcome[29]), we did not adjust for variables that would possibly mediate the relationship between SES and SHS exposure in infants (e.g., the number of cigarettes parents smoke per day and the spouse's smoking status). We chose SII and RII as inequality indices because the sample sizes of the four parental education groups were quite different across groups in both years. The SII and RII were estimated as regression-based measures of SHS that took into account the distributions of the sample in each SES group and the entire distribution of the SES groups over time[30]. The SII can be interpreted as the estimated absolute difference in the prevalence of SHS between infants with the highest and lowest SES. The RII is derived by dividing the SII by the mean prevalence of SHS exposure and can be interpreted as the estimated proportionate difference, rather than the absolute difference[30,31].

Second, we determined the change in the prevalence over time for each SES group separately using the pooled data in 2001 and 2010. For each SES group, the rate difference and percentage change were calculated. Further, the coefficient of interaction terms between SES (income or education) and year of survey using logit regression models were estimated, controlled for infant's sex, father's and mother's ages, and SES variables. Then, we compared the coefficient of interaction terms (with 95% CIs) across SES groups to examine whether changes in inequality were different by SES.

Further, we calculated the prevalence and the magnitude of inequalities (SII and RII) based on income level by parental indoor smoking behaviour (only father smokes indoors, only mother smokes indoors, and both parents smoke indoors). Then, we calculated the proportion to the total SII represented by each parental indoor smoking behaviour to examine the contribution for the total income inequality[32]. We did not calculate an educational SII by parental

indoor smoking behaviour because the categorization of education level between father/mother indoor smoking and parental indoor smoking was not the same.

As a sub-analysis, we examined the changes in inequalities in parental smoking over time to examine whether they were comparable to the changes in SHS exposure in infants. We also examined the changes in inequalities in parental smoking over time for each parental smoking behaviour and compared the changes with those in SHS exposure in infants. Most of the analyses were conducted using STATA 13 (StataCorp LP; College Station, TX, US); the SII and RII calculations were conducted using HD*calc (version 1.2.4; National Cancer Institute, US)[33].

Results

Table 1 shows the characteristics of the study population by survey year and distribution of infants living with smoking parents and exposed to SHS in 2001 and 2010. The average parental age was 31.1 years old (standard deviation [SD], 4.55; range, 17.5–54.0) in 2001 and 32.6 years old (SD, 4.69; range, 20.0–59.5) in 2010 (data not shown). The percentage of infants exposed to SHS declined from 36.8% in 2001 to 14.4% in 2010.

Table 2 shows the prevalence of SHS exposure and the magnitude of income and educational inequalities in SHS exposure in infants in 2001 and 2010. The prevalence of SHS exposure in infants in the lowest and highest income groups was 47.9% and 24.7% in 2001 and 22.6% and 7.0% in 2010, respectively. Income and educational inequalities in SHS exposure in infants existed; for example, in 2010, the rate difference and the SII in the prevalence of infants' SHS exposure based on income were 15.6 and 20.1, demonstrating greater prevalence in the lowest income group compared with the highest group; the OR indicated a 1.89 times higher odds of infants' SHS exposure in the lowest income group than in the highest income group; and the RII indicated that a move from the highest to the lowest income group was associated with a 147% increase in the prevalence of SHS exposure.

Regarding changes over time, the prevalence of SHS exposure decreased in all SES groups from 2001 to 2010. The absolute measures of inequality (rate difference and SII) indicated that the magnitude of income and educational inequalities in SHS exposure among infants decreased from 2001 to 2010, while the relative measures of inequality (OR and RII) increased. For instance, from 2001 to 2010, the SII for income decreased from 30.9 to 20.1, while the RII for income increased from 0.85 to 1.47. In the comparison of the SES groups, the lowest SES group showed the largest absolute decrease (-25.3 percentage points) in prevalence of SHS exposure, while the relative decrease was the smallest (-52.8 percentage change), supporting the results that income and educational inequalities increased in relative terms but decreased in absolute terms over time. The interaction analysis resulted in statistically significant coefficient of interaction terms in each SES group and negatively larger terms with increasing SES group (both income and parental education). The sub-analysis of inequality changes showed a much smaller relative decrease (percentage change) in parental smoking (S1 Table) than in infant's SHS exposure (Table 2) in each SES level. This suggests that the reduction of infants' SHS exposure was related to the reduction of parental indoor smoking among smoking parents in addition to the reduction of parental smoking overall.

Regarding SHS exposure from the three parental indoor smoking behaviours, 'only father smoking indoors' was a major source of SHS exposure in infants (69.8% in 2001 and 78.7% in 2010) (Table 3). Table 4 shows the prevalence of SHS exposure in infants by parental smoking behaviours according to the income level. Although the overall prevalence of SHS exposure by 'only father smoking indoors' decreased by 57.0%, the absolute inequality did not decrease (SII changed from 13.95 in 2001 to 13.45 in 2010) because of the much smaller decrease in the lowest income group (-43.5 percentage change). Fig 1 shows the contributions of absolute income

Table 1. Characteristics of the study population from the Longitudinal Survey of Newborns in the 21st Century in Japan, by survey year.

	2001		2010	
	n = 41,833	%	n = 32,120	%
Equivalent household income				
Quartile 1 (highest)	9,827	23.5	7,565	23.6
Quartile 2	10,236	24.5	7,541	23.5
Quartile 3	9,503	22.7	7,837	24.4
Quartile 4	9,713	23.2	7,131	22.2
Missing	2,554	6.1	2,046	6.4
Parental education level				
Both are university graduates or higher	4,572	11.0	6,460	20.1
Only one is a university graduate	11,832	28.3	9,720	30.3
One is a college graduate and the other is a college graduate or less	12,555	30.0	9,570	29.8
Both are high school graduates or less	12,473	29.8	6,111	19.0
Missing	401	1.0	259	0.8
Infant sex				
Boy	21,754	52.0	16,548	51.5
Girl	20,079	48.0	15,572	48.5
Father's age (years)				
≤24	2,715	6.5	1,284	4.0
25–29	11,159	26.7	6,310	19.7
30–34	15,413	36.8	11,204	34.9
35–39	8,675	20.7	9,101	28.3
≥40	3,871	9.3	4,221	13.1
Mother's age (years)				
≤24	4,242	10.1	2,053	6.4
25–29	15,210	36.4	8,304	25.9
30–34	16,170	38.7	12,489	38.9
35–39	5,459	13.1	7,803	24.3
≥40	752	1.8	1,471	4.6
Living with smoking parent(s)[a]				
Yes	26,453	63.2	13,406	41.7
No	15,380	36.8	18,714	58.3
Exposed to second hand smoke[a,b]				
Yes	15,403	36.8	4,619	14.4
No	26,430	63.2	27,501	85.6

[a] The number and prevalence in 2010 were weighted for the average parental age in 5-year age groups using a direct method and the age distribution in 2001 as the base.

[b] Exposure to second hand smoke was measured by self-reported parental indoor smoking behaviour.

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inequality (SII) in SHS exposure in infants to the total income SII by parental indoor smoking behaviour. The proportion represented by 'only father smoking indoors' increased (from 45.1% [13.95/30.94] in 2001 to 67.0% [13.45/20.08] in 2010) and became a major contributor in 2010, while the proportion represented by 'both parents smoking indoors' decreased over time (from 51.7% [15.99/30.94] in 2001 to 30.0% [6.02/20.08] in 2010).

By comparing the relative reduction between smoking and indoor smoking by parental smoking behaviours in the sub-analysis (S2 Table, Table 4, Fig 2), we found a much larger difference for 'only father smoking' (percentage change, -25.0% for only father smoking vs.

Table 2. Prevalence of second hand smoke (SHS) exposure in infants and magnitude of inequalities in SHS exposure in infants according to income and educational level by survey year.

	Prevalence of SHS exposure in infants (%)				
	2001	2010[b]	Rate difference (%point) (2010–2001)	% change ([2010–2001]/2001)	Coefficient (95% CI)[c] (Income × year)
Equivalent household income					
Quartile 1 (highest) (ref)	24.7	7.0	-17.7	-71.7	-1.32 (-1.42 to -1.22)
Quartile 2	33.1	10.7	-22.4	-67.7	-1.30 (-1.39 to -1.21)
Quartile 3	41.0	14.9	-26.1	-63.7	-1.29 (-1.37 to -1.21)
Quartile 4 (lowest)	47.9	22.6	-25.3	-52.8	-1.11 (-1.18 to -1.04)
Rate difference (lowest—highest) (% point)	23.2	15.6			
SII (95% CI)	30.9 (29.3 to 32.6)	20.1 (18.7 to 21.5)			
Odds ratio[a] (95% CI)	1.69 (1.58 to 1.81)	1.89 (1.68 to 2.12)			
RII (95% CI)	0.85 (0.80 to 0.89)	1.47 (1.37 to 1.56)			
Parental education level					
Both are university graduates or higher (highest) (ref)	14.8	4.0	-10.8	-73.0	-1.46 (-1.61 to -1.31)
Only one is a university graduate	26.2	8.9	-17.3	-66.0	-1.36 (-1.44 to -1.27)
One is a college graduate and the other is a college graduate or less	40.0	16.0	-24.0	-60.0	-1.27 (-1.34 to -1.20)
Both are high school graduates or less (lowest)	51.5	28.1	-23.4	-45.4	-1.06 (-1.13 to -0.99)
Rate difference (lowest—highest) (% point)	36.7	24.1			
SII (95% CI)	44.6 (43.1 to 46.2)	28.7 (27.3 to 30.0)			
Odds ratio[a] (95% CI)	4.65 (4.23 to 5.10)	6.58 (5.67 to 7.64)			
RII (95% CI)	1.22 (1.17 to 1.26)	2.09 (2.00 to 2.17)			

CI, confidence interval; SII, slope index of inequality; RII, relative index of inequality

[a] Adjusted by father's age, mother's age, infant sex, and socioeconomic status indicators (either income or education)

[b] The prevalence in 2010 was weighted for the average parental age in 5-year age groups using a direct method and the age distribution in 2001 as the base.

[c] Adjusted by father's age, mother's age, infant sex, and socioeconomic status indicators (both income and education)

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Table 3. Proportion of each parent's indoor smoking behaviour to the total SHS exposure in infants by survey year.

	2001 (n = 15,403)		2010[a] (n = 4,619)	
	Number	Proportion	Number	Proportion
Both parents smoking indoors	4,217	27.4	855	18.5
Only father smoking indoors	10,752	69.8	3,635	78.7
Only mother smoking indoors	434	2.8	129	2.8

[a] The number and proportion in 2010 was weighted for the average parental age in 5-year age groups using a direct method and the age distribution in 2001 as the base.

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Table 4. Prevalence and magnitude of inequalities in SHS exposure in infants according to the income level by parental smoking behaviour by survey year.

	2001	2010[a]		
Equivalent household income	**Prevalence of SHS exposure in infants by both parents smoking indoors (%)**		**Rate difference (%point) (2010–2001)**	**% change ([2010–2001]/ 2001)**
Overall	9.9	2.6	-7.3	-73.4
Quartile 1 (highest) (ref)	4.5	0.6	-3.9	-86.9
Quartile 2	7.6	1.5	-6.1	-79.7
Quartile 3	11.0	2.9	-8.0	-73.3
Quartile 4 (lowest)	16.8	5.2	-11.5	-68.9
SII (95% CI)	15.99 (14.92 to 17.05)	6.02 (5.37 to 6.66)		
RII (95% CI)	1.61 (1.51 to 1.71)	2.37 (2.17 to 2.57)		
	Prevalence of SHS exposure in infants by only father smoking indoors (%)			
Overall	25.6	11.0	-14.6	-57.0
Quartile 1 (highest) (ref)	19.5	6.3	-13.3	-68.0
Quartile 2	24.4	8.9	-15.6	-63.7
Quartile 3	29.1	11.6	-17.5	-60.2
Quartile 4 (lowest)	29.6	16.7	-12.9	-43.5
SII (95% CI)	13.95 (12.43 to 15.47)	13.45 (12.19 to 14.70)		
RII (95% CI)	0.54 (0.49 to 0.60)	1.25 (1.14 to 1.36)		
	Prevalence of SHS exposure in infants by only mother smoking indoors (%)			
Overall	1.0	0.4	-0.6	-62.9
Quartile 1 (highest) (ref)	0.6	0.2	-0.5	-73.7
Quartile 2	1.0	0.3	-0.7	-69.7
Quartile 3	1.0	0.4	-0.6	-62.3
Quartile 4 (lowest)	1.5	0.7	-0.8	-55.3
SII (95% CI)	1.00 (0.64 to 1.36)	0.61 (0.35 to 0.86)		
RII (95% CI)	0.98 (0.64 to 1.32)	1.64 (1.02 to 2.26)		

CI, confidence interval; SII, slope index of inequality; RII, relative index of inequality

[a] The prevalence in 2010 was weighted for the average parental age in 5-year age groups using a direct method and the age distribution in 2001 as the base.

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-57.0% for only father smoking indoors) than for 'both parents smoking' (percentage change, -64.9% for both parents smoking vs. -73.4% for both parents smoking indoors). This suggests that the prevalence of 'only father smoking indoors' decreased because not only did the only father smokers decrease, but the indoor smoking among only father smokers also decreased. In contrast, the prevalence of both parents smoking indoors decreased mainly because both parental smokers decreased. Furthermore, the reduction in 'both parental smoking' originated mainly from the reduction of the mother smoking, as the relative decrease was as large as both parents smoking (percentage change, -64.9% for both parents smoking and -63.3% for mother smoking) (S2 Table, S3 Table).

Discussion

In this repeated nationwide population-based survey, we found marked social inequalities in infants' exposure to SHS in both survey years, with the most exposure occurring for infants in

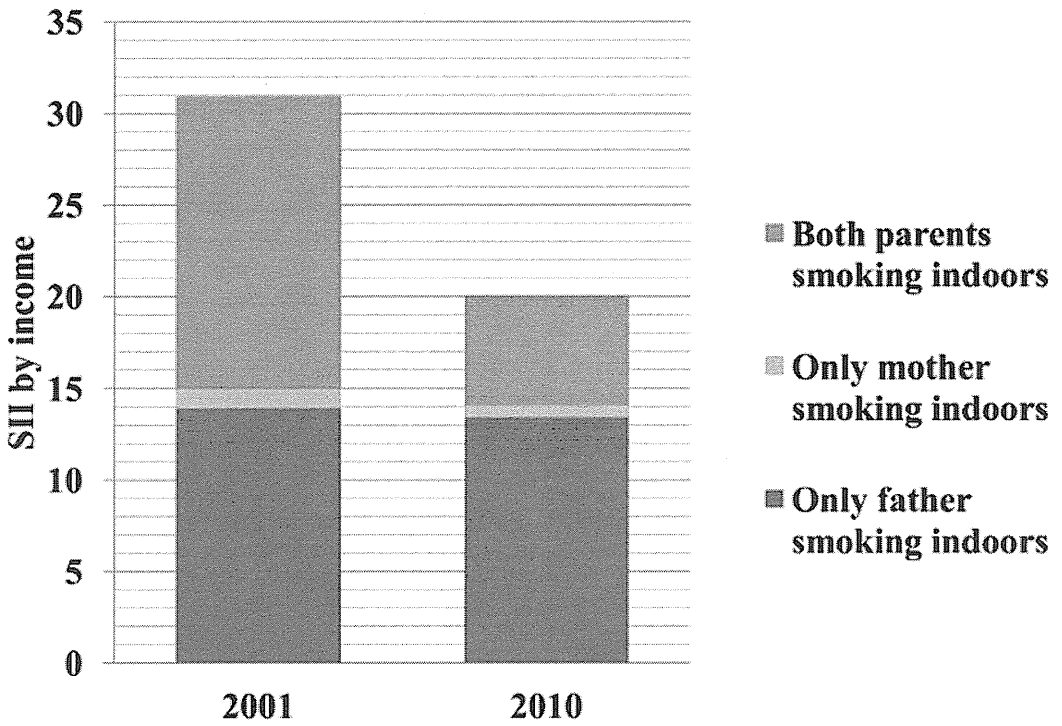

Fig 1. Contributions of parental indoor smoking behaviour to absolute income inequality in SHS exposure in infants. The total bar represents the total absolute income inequality (SII) in each survey year, and each component represents the SII of each parental indoor smoking behaviour.

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the lowest SES group. From 2001 to 2010, relative inequalities in SHS exposure increased but absolute inequalities in SHS exposure decreased in infants. Furthermore, only father smoking indoors caused 78.7% of infants to be exposed to SHS and it was a major contributor to absolute income inequality in SHS exposure in infants in 2010.

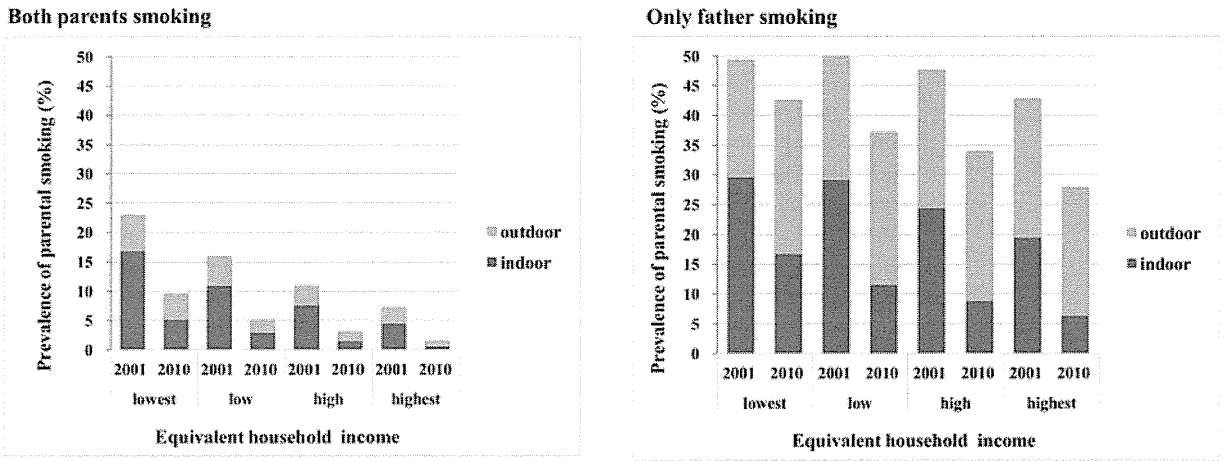

Fig 2. Prevalence of parental smoking and indoor smoking according to the income level by both parents smoking and only father smoking. The prevalence is presented in Table 4. The total bar represents the parental smoking in each survey year, and each coloured bar, dark gray and light gray, represents the parental indoor smoking (SHS exposure in infants) and outdoor smoking, respectively.

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The changes in inequalities in infants' SHS exposure over time we found in this study are consistent with reports from the USA and England: the SHS exposure inequality there also decreased in absolute but not in relative terms[10,34]. In the USA 7.6% of children are exposed at home (in 2007)[8], in England 12.7% (in 2012)[35], while it is still 14.4% in Japan (in 2010).

The unique finding of this study is that 'only father smoking indoors' increased the contribution to the total absolute inequality in infants' SHS exposure based on income, and it represented the highest contributor in 2010 (Fig 1). The absolute income inequality did not decrease from 2001 to 2010 because the relative reductions for both 'only father smoking' and 'only father smoking indoors' were the smallest in the lowest income group (S2 Table, Table 4, Fig 2). This might be explained by the low self-efficacy of non-smoking mothers living with a smoking husband in the lowest income group. Low-SES women are less likely to have self-efficacy to avoid SHS exposure than high SES women[36]. Although a mother's self-efficacy in asking others to smoke outdoors is strongly associated with actual preventive behaviour for their children, non-smoking mothers have a lower self-efficacy than smoking mothers [37].

In contrast, SHS exposure from both parents smoking indoors considerably decrease the absolute income inequality, mainly due to the large reduction in the mother's smoking. The prevalence of smoking in mothers decreased substantially across all SES levels from 2001 to 2010, compared with that in fathers (percentage change, -34.3% for fathers and -63.3% for mothers) (S3 Table), whereas the prevalence of smoking among men in the general population decreased more than among women during the same periods[20,21]. This is because the prevalence of smoking in women substantially decrease when they become pregnant, although the postpartum relapse rates remain high (approximately 43% at 18 months after childbirth in Japan)[38].

Compared with income, educational inequalities in infants' SHS exposure appeared to be greater in a similar manner using quartile distribution in both years. In the case of inequalities in parental indoor smoking, nicotine dependence might be a key factor that makes education a stronger predictor of SHS exposure than income. School performance is an indicator of early smoking initiation, which leads to nicotine dependence in later life[39,40]. Thus, compared with income, education level might predict parental nicotine dependence more accurately, and this dependence is one of the main barriers for smoking parents to stop smoking indoors [41,42].

This study showed increases in relative inequalities in infants' SHS exposure over time, which suggests a need to encourage parents to quit smoking and protect infants from SHS exposure, especially among fathers living with mothers who do not smoke in low-income groups. To reduce father's (indoor) smoking, targeting non-smoking mothers would be effective for intervention. Compared with fathers, mothers tend to be motivated to protect children from SHS exposure and have many contacts with health professionals[3]. In Japan, local municipalities have implemented "the home visiting program for all households with infants" across the country since 2009. A midwife, nurse, or trained community resident visits homes with infants <4 months old to provide advice regarding child-rearing as well as counselling, and they could provide follow-up services if necessary[43,44]. If tobacco-related issues can be incorporated in this program, it could provide sustainable and individually tailored support to increase self-efficacy in reducing infants' SHS exposure for low-SES mothers who do not smoke but live with smoking fathers. The program can also encourage smoking fathers and mothers to receive smoking cessation treatments, including nicotine replacement therapy, which have been covered by health insurance in Japan since 2006.

Our study can contribute to strengthen the evidence regarding the inequalities in SHS exposure in infants, particularly regarding the importance of only father smoking in Japan. Nevertheless, the study has certain limitations. First, the exposure to SHS might have been

underestimated as parental indoor smoking, a proxy measurement of SHS exposure in infants, did not include exposure from household members other than parents or while outside the home. However, home is known as a primary source of SHS exposure among children[1], and more than 80% of infants in this study did not live with adults other than their parents. Second, the intensity of smoking in the household, such as the number of smokers or number of cigarettes smoked, was not considered[45]. For instance, exposure from mother's indoor smoking might be more intense than fathers as mothers spend more time at home with their children. Finally, SHS exposure was based solely on parental self-report without biochemical validation, which might be less reliable for populations under pressure not to smoke[46]. Social movements, such as a proposal to decrease children's passive smoking by the Japan Paediatric Society in 2002[47], might also have influenced under-reporting. However, potential underreporting is not likely to have significantly influenced the changes in inequality as under-reporting is not different across SES groups[48].

In conclusion, although the prevalence of SHS exposure in infants decreased considerably from 2001 to 2010 in Japan, inequalities in SHS exposure in infants remained, with increased relative magnitude and decreased absolute magnitude. Further efforts are necessary to encourage parents to quit smoking and protect infants from SHS exposure, especially in low-SES households that include mothers who do not smoke.

Supporting Information

S1 Table. Prevalence of parental smoking and magnitude of inequalities in parental smoking according to the income and educational level by survey year. [a] The prevalence in 2010 was weighted for the average parental age in 5-year age groups using a direct method and the age distribution in 2001 as the base. CI, confidence interval; SII, slope index of inequality; RII, relative index of inequality.
(DOCX)

S2 Table. Prevalence of parental smoking and magnitude of inequalities in parental smoking according to the income level by combination of parental smoking behavior by survey year. [a] The prevalence in 2010 was weighted for the average parental age in 5-year age groups using a direct method and the age distribution in 2001 as the base. CI, confidence interval; SII, slope index of inequality; RII, relative index of inequality.
(DOCX)

S3 Table. Prevalence of parental smoking and magnitude of inequalities in parental smoking according to the income level by fathers and mothers by survey year. [a] The prevalence in 2010 was weighted for the average parental age in 5-year age groups using a direct method and the age distribution in 2001 as the base.
(DOCX)

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Author Contributions

Conceived and designed the experiments: JS TT. Performed the experiments: JS TT. Analyzed the data: JS TT. Contributed reagents/materials/analysis tools: AS. Wrote the paper: JS.

Provided critical advice for the design: AS JY MN MJ. Critically edited the manuscript: TT AS JY MN MJ.

References

1. US Surgeon General. The Health Consequences of Exposure to Tobacco Smoke: A Report of the Surgeon General. Atlanta. 2006.
2. Oberg M, Jaakkola MS, Woodward A, Peruga A, Prüss-Ustün A. Worldwide burden of disease from exposure to second-hand smoke: a retrospective analysis of data from 192 countries. Lancet 2011; 377:139–146. doi: 10.1016/S0140-6736(10)61388-8 PMID: 21112082
3. Blackburn C, Bonas S, Spencer N, Dolan A, Coe C, Moy R. Smoking behaviour change among fathers of new infants. Soc Sci Med 2005; 61:517–526. PMID: 15899312
4. Rosen LJ, Noach MB, Winickoff JP, Hovell MF. Parental smoking cessation to protect young children: a systematic review and meta-analysis. Pediatrics 2012; 129:141–152. doi: 10.1542/peds.2010-3209 PMID: 22201152
5. Sockrider MM, Hudmon KS, Addy R, Dolan Mullen P. An exploratory study of control of smoking in the home to reduce infant exposure to environmental tobacco smoke. Nicotine Tob Res 2003; 5:901–910. PMID: 14668074
6. Matt GE, Quintana PJ, Hovell MF, Bernert JT, Song S, Novianti N, et al. Households contaminated by environmental tobacco smoke: sources of infant exposures. Tob Control 2004; 13:29–37. PMID: 14985592
7. Bolte G, Fromme H, GME Study Group. Socioeconomic determinants of children's environmental tobacco smoke exposure and family's home smoking policy. Eur J Public Health 2009; 19:52–58. doi: 10.1093/eurpub/ckn114 PMID: 19033356
8. Singh GK, Siahpush M, Kogan MD. Disparities in children's exposure to environmental tobacco smoke in the United States, 2007. Pediatrics 2010; 126:4–13. doi: 10.1542/peds.2009-2744 PMID: 20587673
9. Giskes K, Kunst AE, Benach J, Borrell C, Costa G, Dahl E, et al. Trends in smoking behaviour between 1985 and 2000 in nine European countries by education. J Epidemiol Community Health 2005; 59:395–401. PMID: 15831689
10. Zhang X, Martinez-Donate AP, Kuo D, Jones NR, Palmersheim KA. Trends in home smoking bans in the U.S.A., 1995–2007: prevalence, discrepancies and disparities. Tob Control 2012; 21:330–336. doi: 10.1136/tc.2011.043802 PMID: 21813487
11. Pisinger C, Hammer-Helmich L, Andreasen AH, Jorgensen T, Glumer C. Social disparities in children's exposure to second hand smoke at home: a repeated cross-sectional survey. Environ Heal 2012; 11:65.
12. Gartner CE, Hall WD. Is the socioeconomic gap in childhood exposure to secondhand smoke widening or narrowing? Tob Control 2013; 22:344–348. doi: 10.1136/tobaccocontrol-2011-050297 PMID: 22467710
13. Orton S, Jones LL, Cooper S, Lewis S, Coleman T. Predictors of children's secondhand smoke exposure at home: a systematic review and narrative synthesis of the evidence. PLoS One 2014; 9: e112690. doi: 10.1371/journal.pone.0112690 PMID: 25397875
14. MacKay J, Ritthiphakdee B, Reddy KS. Tobacco control in Asia. Lancet 2013; 381:1581–1587. doi: 10.1016/S0140-6736(13)60854-5 PMID: 23642699
15. World Health Organization. FCTC fourth implementation report (Japan). 2014. Available: http://www.who.int/fctc/reporting/party_reports/japan_2014_report.pdf?ua=1.
16. Hyogo Prefecture Department of Health and Welfare. Ordinance on the prevention of second-hand smoke exposure (Ordinance 18). 2012. Available: http://web.pref.hyogo.jp/kf17/documents/03jourei.pdf.
17. Kashiwabara M, Armada F, Yoshimi I. Kanagawa, Japan ' s tobacco control legislation: a breakthrough? Asian Pacific J Cancer Prev 2011; 12:1909–1916.
18. Japan Tobacco. Trends in cigarette tax. Available: http://www.jti.co.jp/news/tax_system_20110708.html.
19. World Health Organization. Tobacco Free Initiative (TFI), Taxation. Available: http://www.who.int/tobacco/economics/taxation/en/index1.html.
20. Ministry of Health Labour and Welfare, Japan. The National Health and Nutrition Survey. 2001. Available: http://www.mhlw.go.jp/houdou/2002/12/h1211-1b3.html.

21. Ministry of Health Labour and Welfare, Japan. The National Health and Nutrition Survey. 2013. Available: http://www.mhlw.go.jp/file/04-Houdouhappyou-10904750-Kenkoukyoku-Gantaisakukenkouzoushinka/0000068070.pdf.

22. Ministry of Health Labour and Welfare, Japan. The Longitudinal Survey of Newborns in the 21st Century. Available: http://www.mhlw.go.jp/toukei/saikin/hw/shusshoujib/01/dl/gaikyo01.pdf.

23. Kaneita Y, Yokoyama E, Miyake T, Harano S, Asai T, Tsutsui T, et al. Epidemiological study on passive smoking among Japanese infants and smoking behavior of their respective parents: A nationwide cross-sectional. Prev Med 2006; 42:210–217. PMID: 16410021

24. Abe A. Health disparity in children: is there a difference in the effect of past illness? Iryo To Shakai (in Japanese) 2013; 22:255–269.

25. Tabuchi T, Fujiwara T, Nakayama T, Miyashiro I, Tsukuma H, Ozaki K, et al. Maternal and paternal indoor or outdoor smoking and the risk of asthma in their children: A nationwide prospective birth cohort study. Drug Alcohol Depend 2015; 147:103–108. doi: 10.1016/j.drugalcdep.2014.12.001 PMID: 25542825

26. Fujiwara T, Ito J, Kawachi I. Income inequality, parental socioeconomic status, and birth outcomes in Japan. Am J Epidemiol 2013; 177:1042–1052. doi: 10.1093/aje/kws355 PMID: 23576676

27. Holliday JC, Moore GF, Moore LA. Changes in child exposure to secondhand smoke after implementation of smoke-free legislation in Wales: a repeated cross-sectional study. BMC Public Health 2009; 9:430.

28. Harper S, King NB, Young ME. Impact of selective evidence presentation on judgments of health inequality trends: an experimental study. PLoS One 2013; 8:e63362. doi: 10.1371/journal.pone.0063362 PMID: 23696818

29. Schisterman EF, Cole SR, Platt RW. Overadjustment bias and unnecessary adjustment in epidemiologic studies. Epidemiology 2009; 20:488–495. doi: 10.1097/EDE.0b013e3181a819a1 PMID: 19525685

30. Harper S, Lynch J. Methods for Measuring Cancer Disparities: Using Data Relevant to Healthy People 2010 Cancer-Related Objectives. 2005.

31. Pamuk ER. Social class inequality in mortality from 1921 to 1972 in England and Wales. Popul Stud 1985; 39:17–31.

32. Blakely T, Tobias M, Atkinson J. Inequalities in mortality during and after restructuring of the New Zealand economy: repeated cohort studies. BMJ 2008; 336:371–375. doi: 10.1136/bmj.39455.596181.25 PMID: 18218998

33. National Cancer Institute. Health Disparities Calculator, Version 1.2.4—October 29, 2013.

34. Sims M, Tomkins S, Judge K, Taylor G, Jarvis MJ, Gilmore A. Trends in and predictors of second-hand smoke exposure indexed by cotinine in children in England from 1996 to 2006. Addiction 2010; 105:543–553. doi: 10.1111/j.1360-0443.2009.02805.x PMID: 20402999

35. Jarvis MJ, Feyerabend C. Recent trends in children's exposure to second-hand smoke in England: cotinine evidence from the Health Survey for England. Addiction 2015; 110:1484–1492. doi: 10.1111/add.12962 PMID: 26061741

36. Chen CM, Lee PH, Chou YH, Kuo SF, Hsu YH. Avoidance of environmental tobacco smoke among pregnant Taiwanese women: knowledge, self-efficacy, and behavior. J Womens Health 2015; 16:869–878.

37. Crone MR, Reijneveld SA, Burgmeijer RJ, Hirasing RA. Factors that influence passive smoking in infancy: a study among mothers of newborn babies in The Netherlands. Prev Med 2001; 32:209–217. PMID: 11277677

38. Yasuda T, Ojima T, Nakamura M, Nagai A, Tanaka T, Kondo N, et al. Postpartum smoking relapse among women who quit during pregnancy: Cross-sectional study in Japan. J Obstet Gynaecol Res 2013; 39:1505–1512. doi: 10.1111/jog.12098 PMID: 23875711

39. Everett SA, Warren CW, Sharp D, Kann L, Husten CG, Crossett LS. Initiation of cigarette smoking and subsequent smoking behavior among U.S. high school students. Prev Med 1999; 29:327–333. PMID: 10564623

40. Karp I, O'Loughlin J, Paradis G, Hanley J, Difranza J. Smoking trajectories of adolescent novice smokers in a longitudinal study of tobacco use. Ann Epidemiol 2005; 15:445–452. PMID: 15967392

41. Jones LL, Atkinson O, Longman J, Coleman T, McNeill A, Lewis SA. The motivators and barriers to a smoke-free home among disadvantaged caregivers: identifying the positive levers for change. Nicotine Tob Res 2011; 13:479–486. doi: 10.1093/ntr/ntr030 PMID: 21447837

42. Halterman JS, Fagnano M, Conn KM, Lynch KA, DelBalso MA, Chin NP. Barriers to reducing ETS in the homes of inner-city children with asthma. J Asthma 2007; 44:83–8. PMID: 17454320

43. Ministry of Health Labour and Welfare, Japan. The report of implementation status of advice service for household with children in municipalities, 2011. Available: http://www.mhlw.go.jp/file/04-Houdouhappyou-11901000-Koyoukintoujidoukateikyoku-Soumuka/0000035098.pdf.

44. Kondo R, Tsukahara T, Hori A, Wada T, Inaba Y, Kanai M, et al. Current state of "infant home visiting service for all houses" in Nagano prefecture. Shinshu Med J (in Japanese) 2011; 59:169–175.

45. Streja L, Crespi CM, Bastani R, Wong GC, Jones CA, Bernert JT, et al. Can a minimal intervention reduce secondhand smoke exposure among children with asthma from low income minority families? Results of a randomized trial. J Immigr Minor Health 2014; 16:256–264. doi: 10.1007/s10903-012-9713-4 PMID: 22945813

46. Shipton D, Tappin DM, Vadiveloo T, Crossley JA, Aitken DA, Chalmers J. Reliability of self reported smoking status by pregnant women for estimating smoking prevalence: a retrospective, cross sectional study. BMJ 2009; 339:b4347. doi: 10.1136/bmj.b4347 PMID: 19875845

47. Japan Pediatric Society. Poposal to decrease the child's passive smoking. Acta Paediatr Jpn (in Japanese) 2002; 106:436–437.

48. Graham H, Owen L. Are there socioeconomic differentials in under-reporting of smoking in pregnancy? Tob Control 2003; 12:434. PMID: 14660784

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特集：たばこ規制枠組み条約に基づいたたばこ対策の推進

＜総説＞

第8条　たばこの煙にさらされることからの保護

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Framework Convention on Tobacco Control, Article 8. Protection from exposure to tobacco

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抄録

「たばこの規制に関する世界保健機関枠組条約」第8条では，受動喫煙を防止するためには屋内を100％完全禁煙とすることが必要であり，わが国で行われている喫煙室（専用の排気装置の有無にかかわらず）や空気清浄機による対策は不適切であることが述べられている．世界保健機関（WHO）が行ったモニタリング（MPOWER2015）では，2014年時点で49カ国が一般の職場だけでなくレストランやバーなどのサービス産業を含めて屋内を全面禁煙とする法律を施行しており，そのような国では国民の病気が減ったこと，サービス産業に経済的なマイナスは発生しなかったことが報告されている．

2010年以降，わが国でも公共的施設や職場の受動喫煙防止対策を強化する動きが見られているが，全面禁煙以外の措置も選択肢として残されているため，官公庁や医療施設，教育施設の全面禁煙も完全ではなく，レストランや居酒屋などのサービス産業の禁煙化は大幅に遅れている．今後，サービス産業で働く労働者を受動喫煙の曝露から保護する観点からの議論とサービス産業を禁煙化しても経済的なマイナスは発生しないことを啓発し，わが国でも屋内を全面禁煙とする法律の施行を求めていかねばならない．

キーワード：受動喫煙，喫煙関連疾患，全面禁煙，サービス産業，立法措置

Abstract

Article 8 of the Framework Convention on Tobacco Control explains that approaches other than 100% smoke-free environments, including ventilation, air filtration, and the use of designated smoking areas (whether with separate ventilation systems or not), have repeatedly been shown to be ineffective. Article 8 calls for parties, including the hospitality industry, to implement a total ban in order to protect non-smokers from second-hand smoke (SHS). The World Health Organization MPOWER 2015 report showed that 49 countries had already implemented a total ban by 2014 and that smoking related diseases rapidly decreased in those countries with no economic losses to the hospitality industry.

The Japanese government has begun strengthening restrictions on SHS in public spaces and

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workplaces. These restrictions present smoke-free buildings as the best countermeasure, but still allow implementation of designated smoking rooms/sections. Therefore, countermeasures against SHS in the hospitality industry are far behind other countries. It is necessary to discuss the countermeasures required to protect workers in the hospitality industry. In addition, scientists should disseminate information revealing that the national comprehensive smoking ban has not affected the hospitality industry.

keywords: second-hand smoke, tobacco related disease, total ban, entertainment industry, jurisdiction
(accepted for publication, 3rd September 2015)

I. はじめに

「たばこの規制に関する世界保健機関枠組条約(FCTC)」第8条「Protection from exposure to tobacco smoke（たばこの煙にさらされることからの保護)」により，second-hand smoke（受動喫煙）を完全に防止することが求められている [1]．2011年，第8条を含む8つの条項の「実施のためのガイドライン」が発表された．受動喫煙防止について規定された第8条実施のためのガイドラインは和訳され，厚生労働省のホームページに公表されているので参照して欲しい [2]．

II. 「第8条の実施のためのガイドライン」と各国の実施状況

「受動喫煙」を指す言葉として "second-hand smoke (SHS)"，または，"environmental tobacco smoke（ETS：環境タバコ煙)"，"other people's smoke（他者の煙)" の使用を推奨しており，これまで使われてきた "passive smoking" と "involuntary exposure to tobacco smoke (不随意喫煙)" は避けるべきであると説明している．その理由として，たばこ産業が "voluntary（自発的)" に曝露されることは許容すべきである，と用いる事例が発生するから，と述べられている．

1990年代までの科学論文では，受動喫煙を意味する言葉としてはETSが一般的であった．第8条のガイドラインの冒頭でもSHSとETSの2つの言葉の使用が推奨されている．しかし，ETSには「自然発生的な煙」というニュートラルな印象を持たせるためにたばこ産業が好んで使用する言葉であるため，2000年代以降，まず，メディアが「好ましくない中古の煙」という意味を込めてSHSを使い始めた．その後，科学論文でもSHSが一般的に使用されるようになり，第8条のガイドラインでもSHSが使用されている．

第8条のガイドラインでは，「原則1」として，受動喫煙には他の化学物質のように曝露が許容される閾値が存在しないこと，受動喫煙を防止するためには屋内を100%完全禁煙とすることが必要であることが明確に述べられている．それ以外の手段，つまり，喫煙室の設置（一般空調と独立した排気システムの有無にかかわらず）や空気清浄機などの工学的な手段では受動喫煙を防止できないことも明記してある．

完全禁煙とすべき「公共の場」は，「一般市民が立ち入ることが出来るすべての場所」と定義され，その場所の所有権や立ち入り許可の有無には関わらない，としている（筆者注：メンバーシップが必要なクラブやラウンジも含む)．さらに，禁煙とすべき「屋内」と「周りを囲われた場所」は，できる限り広く捉えるべきであること，喫煙を容認する屋内以外の場所のリストは作るべきでないことが述べられている．たとえ屋外であっても一方向，もしくは，二方向以上が屋根で覆われ，壁，面で囲われている場所は「周りを囲われた場所」として認識すべきこと，しかも，それらの素材にかかわらず，また，常設ではなく一時的な設置であったとしても禁煙化するべき場所である，と述べられている（筆者注：一時的に置かれたレストランやイベントのパラソルのついたテラス席を想定していると思われる)．

第8条のガイドライン第1の目的は，SHSを防止するためにすでに達成されているベストプラクティス，つまり，法律によりすべての屋内空間を完全に禁煙とすることをすべての締約国が達成するように支援することである．第2の目的は，そのような屋内禁煙法を達成するための重要な要素を明らかにすることである，と述べられている．

2004年，アイルランドが世界で初めて，国法として一般職場や公共交通機関だけでなく，レストランやバー（居酒屋）まで全面禁煙とした．その後，ニュージーランド（2004年)，ウルグアイ（2006年)，イギリス（2007年)，トルコ（2009年）などで同様の屋内全面禁煙法が施行された [3]．

FCTCは，各国政府に対して条約発効から5年以内，つまり，2010年2月27日までに法律により屋内を全面禁煙とすることを求め，実施状況のモニタリングを定期的に行いMPOWERとして公表している [4]．MPOWER2015の第8条に関するモニタリングでは，2014年時点で8領域（①医療施設，②大学以外の教育施設，③大学，④官公庁，⑤一般の職場，⑥食事を主とするレストラン，⑦飲物を主とするカフェ，パブ，バー（居酒屋)，⑧公共交通機関）のすべてが法律で全面禁煙となっている国を濃い色で示すとともに（図1)，国民所得で3分類して集計している（図2)．2014年までに，高所得国だけでなく中～低所得国を含む49ヵ国，13億人，

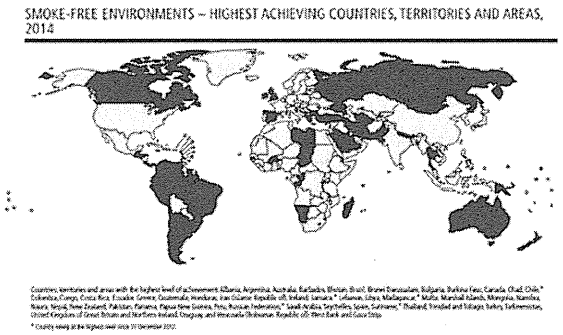

図１　2014年までに屋内全面禁煙法を実施した49ヵ国

包括的な屋内全面禁煙法を実施：アルバニア，アルゼンチン，オーストラリア，バルバドス，ブータン，ブルネイ，ブルガリア，ブルキナファソ，カナダ，チャド，チリ*，コロンビア，コンゴ，コスタリカ，エクアドル，ギリシャ，グアテマラ，ホンジュラス，イラン，アイルランド，ジャマイカ*，レバノン，リビア，マダガスカル*，マルタ，マーシャル諸島，モンゴル，ナミビア，ナウル，ネパール，ニュージーランド，パキスタン，パナマ，パプアニューギニア，ペルー，ロシア*，サウジアラビア，セーシェル，スペイン，スリナム*，タイ，トリニダードトバコ，トルコ，トルクメニスタン，イギリス，ウルグアイ，ベネズエラ，ヨルダン川西岸地区，ガザ地区
*：2012年12月31日以降に実施した国

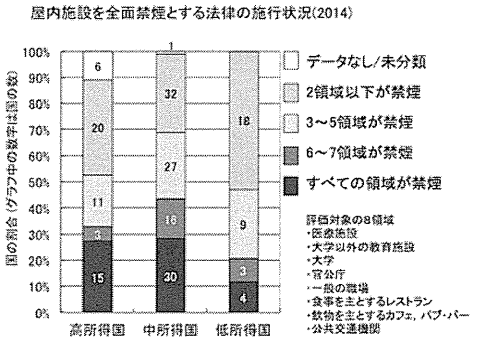

図２　国民所得別の屋内全面禁煙法の実施状況

総人口の18％が屋内完全禁煙法により受動喫煙から保護されている（2015年１月から韓国も禁煙化）．官公庁や医療機関，教育機関でさえ全面禁煙ではない日本は，高所得国の最も遅れたカテゴリーに分類されている．

比較的早期に屋内全面禁煙法を実施した国では，レストラン等の屋外部分（パティオ，テラス席）では喫煙を容認している場合が多い．しかし，2015年１月に同法を実施した韓国では店舗の屋外部分での喫煙も禁止された．図３は2015年６月に撮影したソウルの焼き肉店の屋外席である．店舗が占有する範囲（点線の左側）は，屋根で覆われていないが禁煙であり，喫煙者は食事を中座して歩道に出て喫煙していた（図中⇩）．風が写真の右から左に吹いている日には多少の受動喫煙は発生したとしても，先行国よりも厳しい内容になっている．

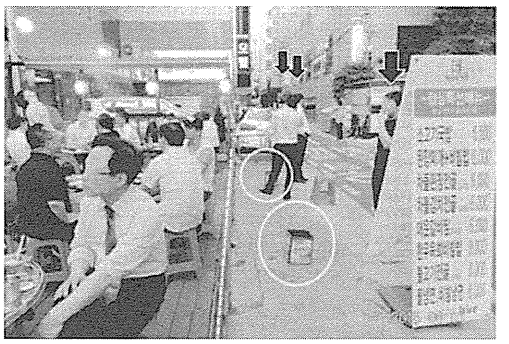

図３　2015年に韓国で実施された屋内禁煙法
テラス席も禁煙となり，喫煙者（⇩）は食事を中座して敷地外の歩道へ

第８条のガイドラインでは，「職場」は「業務として立ち入る場所」と定義され，いわゆる執務空間だけでなく，廊下，エレベーター，階段の吹き抜け，車両等，すべて全面禁煙とすべきことが述べられている．多くの人が全面禁煙化の例外と考えがちな刑務所や精神科の施設，老人ホーム等の居住空間も，そこを職場として働く労働者（看守，医療職，介護職など）を受動喫煙から保護するために全面禁煙化されねばならないことも詳細に述べている．

第８条のガイドラインでは，移動する空間であるタクシーなどの「公共交通機関（営利を目的として一般市民の移動に用いられる）」の乗り物も全面禁煙とされねばならない，とされている．

タクシーを禁煙とすべき乗り物として挙げられているのは，喫煙対策が遅れているわが国でも乗り合いバス，一般鉄道はすでに全面禁煙化されているためと思われる．しかし，わが国では公共交通機関の全面禁煙化を規定する法律がないため，タクシーでさえ100％禁煙化されていない．JRの在来線特急は全面禁煙化されたが，寝台列車（サンライズ瀬戸・出雲，カシオペア）に喫煙車両が残っている．東京以北の新幹線は完全禁煙であるが，2015年８月時点で東海道・山陽新幹線の700系「ひかり」「こだま」，近鉄特急には喫煙車両が運行されており，高濃度の受動喫煙に従業員と乗客が曝露されている．また，東海・山陽新幹線と山陽・九州新幹線の500系とN700系には喫煙室があり，受動喫煙の原因となっている．図４はN700系新幹線の喫煙室内，デッキ，客席でたばこの燃焼により発生する微小粒子状物質（PM2.5）を測定した結果である．喫煙室から漏れるたばこ煙により受動喫煙が発生していることが確認された．また，喫煙室内のPM2.5は1000μg/m^{3}に達しており，喫煙者の毛髪や衣服，気道粘膜に付着したPM2.5から発生するガス状物質によるthird-hand smoke（三次喫煙，残留たばこ成分）の原因にもなっている．

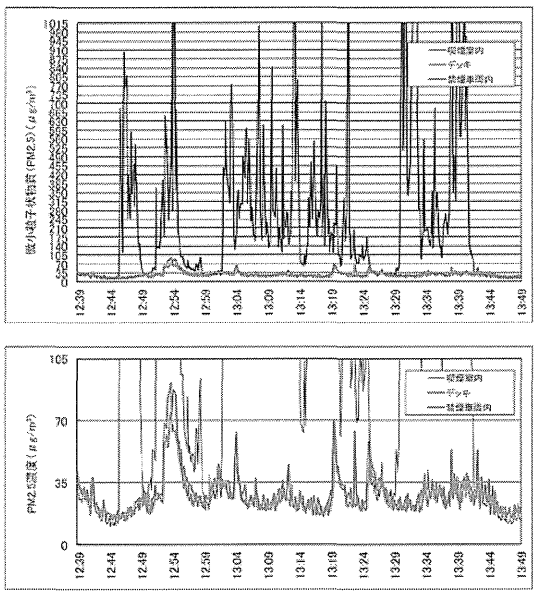

図4　N700系新幹線の喫煙室内，デッキ，客席の微小粒子状物質（PM2.5）濃度

III.　受動喫煙の有害性

1．米国保健省公衆衛生総監報告の結論

第8条で示されたように，屋内と屋内に準ずる空間が全面禁煙化されてきたのは，受動喫煙でも健康障害が発生することが明らかになってきたからである．その過程を米国保健省公衆衛生総監の報告書で振り返る．

1986年の米国公衆衛生総監報告の受動喫煙による健康影響に関する結論として以下の3点が強調された [5].

1）受動喫煙は，健康な非喫煙者に肺がんなどの疾病をもたらす
2）喫煙する両親の子どもは，喫煙しない両親の子どもよりも，呼吸器の感染症を起こす頻度が多く，呼吸器症状を増加させ，呼吸機能の発達が若干阻害される
3）同じ空間を喫煙区域と禁煙区域に分けることは，受動喫煙の曝露濃度を多少減少させることができても，受動喫煙をなくすことはできない

2006年の米国公衆衛生総監報告では，受動喫煙に起因する健康影響に関する結論として以下の6点が示された [6].

1）受動喫煙は非喫煙者（成人と小児）の早世と疾患の原因となる
2）乳幼児突然死症候群，急性呼吸器症状，耳鼻科疾患，重症化する喘息は受動喫煙と明らかな因果関係がある．両親の喫煙は呼吸器症状の原因となり，かつ，小児の肺の発達障害の原因となる．
3）受動喫煙の曝露は成人の心血管系疾患と肺癌について，直ちに悪影響を及ぼす．
4）受動喫煙の曝露に安全なレベル（閾値）は存在しない
5）アメリカでは喫煙対策が進んだにも関わらず，数百万人の非喫煙者（成人，小児）が家庭や職場で受動喫煙に曝露されている
6）受動喫煙を完全に防止するためには屋内を完全禁煙とするしかない．喫煙する空間を分けること，空気清浄や強制換気を用いた空間分煙では受動喫煙を防止することはできない．

主要な結論の一つ，受動喫煙の曝露により肺癌リスクが20～30％増加することについてのメタアナリシスの一覧を表1に示す．同様のメタアナリシスが冠動脈疾患，乳児突然死症候群，乳がん，小児の耳鼻科疾患についても行われているが本稿では割愛する．

さらに，2014年の米国公衆衛生総監報告「喫煙による健康影響：50年間の進歩」の結論として以下の10点が示された [7].

1）1世紀にわたるタバコの流行は，1964年の米国公衆衛生総監報告以降も2000万人の早世の原因となり，本来，予防できたはずの公衆衛生上の悲劇をもたらした
2）タバコ産業がもたらしたタバコ疫病は，現在も続いている．そのために，タバコ産業は，喫煙の被害を計画的に過小評価させることで国民をミスリードする，という積極的な戦略をおこなってきた
3）1964年の報告後，喫煙はほぼすべてのがんの原因であること，健康状態を悪化させること，胎児に悪影響があることが判明した．50年後の現在，これまで喫煙とは無関係と思われていた疾病（糖尿病，関節リウマチ，大腸癌など）も喫煙と関連することが明らかとなりつつある
4）受動喫煙が非喫煙者の発がん，呼吸器疾患，心疾患の原因となること，および，乳幼児や小児の健康に悪影響を及ぼすことが明らかとなった
5）過去50年で女性の喫煙者が急増した結果，喫煙による女性の現在の被害（肺がん，COPD，心疾患）は男性と同程度に増加した
6）喫煙は，多くの疾患の原因になるだけでなく，全身の炎症，免疫機能の障害などの悪影響が発生することが分かった
7）1964年以降，アメリカ国民の喫煙率は減少したが，人種や教育レベル，社会経済的要因（貧困）により，喫煙率の不均衡（喫煙率が高い集団）が残っている
8）1964年以降，包括的な喫煙対策が取られたことでタバコの使用が大幅に減少した．さらに強力な喫煙対策を継続することで，より大きな効果が期待される
9）たばこ，その他のたばこ製品の使用が，早世と疾病として米国社会にもたらした負担は莫大な

表１　受動喫煙による肺癌のメタアナリシス結果の一覧

Table 7.4　Quantitative estimate of lung cancer risk with differing sources of exposure to secondhand smoke

Study	Data source	Exposure vs. referent	Relative risk	95% confidence interval
Previous meta-analyses				
Hackshaw et al. 1997	37 studies	Smoking vs. nonsmoking spouse	1.24	1.13–1.36
Zhong et al. 2000	40 studies (including 37 from Hackshaw et al. 1997)	Smoking vs. nonsmoking husband	1.20	1.12–1.29
Spousal smoking (52 studies)				
Meta-analysis conducted for this 2006 Surgeon General's report	Case-control (44 studies)	Smoking vs. nonsmoking spouse	1.21	1.13–1.30
	Cohort (8 studies)	Smoking vs. nonsmoking spouse	1.29	1.125–1.49
	Men	Smoking vs. nonsmoking wife	1.37	1.05–1.79
	Women	Smoking vs. nonsmoking husband	1.22	1.13–1.31
	United States and Canada	Smoking vs. nonsmoking spouse	1.15	1.04–1.26
	Europe	Smoking vs. nonsmoking spouse	1.16	1.03–1.30
	Asia	Smoking vs. nonsmoking spouse	1.43	1.24–1.66
Workplace exposure (25 studies)				
Meta-analysis conducted for this 2006 Surgeon General's report	Nonsmokers (25 studies)	Workplace secondhand smoke vs. none	1.22	1.13–1.33
	Nonsmoking men (11 studies)	Workplace secondhand smoke vs. none	1.12	0.86–1.50
	Nonsmoking women (25 studies)	Workplace secondhand smoke vs. none	1.22	1.10–1.35
	Nonsmokers in the United States and Canada (8 studies)	Workplace secondhand smoke vs. none	1.24	1.03–1.49
	Nonsmokers in Europe (7 studies)	Workplace secondhand smoke vs. none	1.13	0.96–1.34
	Nonsmokers in Asia (10 studies)	Workplace secondhand smoke vs. none	1.32	1.13–1.55
Childhood exposure (24 studies)				
Meta-analysis conducted for this 2006 Surgeon General's report	Men and women	Maternal smoking	1.15	0.86–1.52
	Men and women	Paternal smoking	1.10	0.89–1.36
	Men and women	Smoking by either parent	1.11	0.94–1.31
	Women	Maternal smoking	1.28	0.93–1.78
	Women	Paternal smoking	1.17	0.91–1.50
	United States and Canada (5 studies)	Smoking by either parent	0.93	0.81–1.07
	Europe (6 studies)	Smoking by either parent	0.81	0.71–0.92
	Asia (10 studies)	Smoking by either parent	1.59	1.18–2.15

ものである．たばことたばこ製品を消滅させることで，社会的な負担は急速に減少する

10）喫煙と健康への悪影響に関する50年間の本報告は，タバコの消費量を減らし，喫煙関連疾患と早世を予防するための公衆衛生活動に重大で科学的な根拠を提供してきた

２．国際がん研究機関の結論

2004年，WHOの研究組織である国際がん研究機関（International Agency for Research Organization: IARC）のモノグラフ第83巻「Tobacco smoke and involuntary smoke」では，アンモニア，カドミウム，ニトロサミン，ヒ素，ベンゾ［a］ピレン，ホルムアルデヒド，ポロニウム-210など64種類の発がん性物質の一覧表が示され，能動喫煙だけでなく受動喫煙も「ヒトに対する発がん性がある物質（Group 1）」として分類されている [8].

IV．わが国における受動喫煙防止対策

１．公共的施設における受動喫煙防止対策

1995年３月，公衆衛生審議会が取りまとめた「たばこ行動計画」では，①防煙，②分煙，③禁煙支援の３つの柱が提言され [9]，1996年３月，「公共の場所における分煙のあり方検討会報告書」を公表している [10]．2000年４月から開始した「21世紀における国民健康づくり運動（健康日本21）」における，たばこ分野の４つの目標の中に「公共の場及び職場での分煙の徹底及び効果の高い分煙に関する知識の普及」が掲げられた [11]．厚生省（当時）から「分煙効果判定基準策定検討会報告書」が提出され，公共的施設における受動喫煙防止対策として喫煙室を作成する場合には，「非喫煙場所から喫煙場所方向に一定の空気の流れ（0.2m/s以上）」を設定することが示された [12].

2003年，健康寿命の延伸を目的とした健康増進法が施行された [13]．第25条には「学校，体育館，病院，劇場，観覧場，集会場，展示場，百貨店，事務所，官公庁施設，飲食店，その他の多数の者が利用する施設を管理する者は，これらを利用する者について，受動喫煙を防止するために必要な措置を講ずるように努めなければならない」とされ，全国の郵便局や銀行の窓口，関東の私鉄が全面禁煙となるなど，一定の効果が得られた．

２．職場における受動喫煙防止対策

受動喫煙に対する社会的な関心の高まりにより，1996

年，労働省（当時）により「職場における喫煙対策のためのガイドライン」として禁煙タイムを設ける「時間分煙」，および，喫煙コーナー・喫煙室の設置による「空間分煙」が紹介された [14]．しかし，禁煙タイムや開放式の喫煙コーナーでは受動喫煙の防止の効果は得られないことから，2003年，「職場における喫煙対策のための新ガイドライン」では，屋内で喫煙する場合は部屋として隔離した上で排気装置により陰圧とし，出入口で0.2m/sの空気の流れを確保した「一定の要件を満たす喫煙室」が厚生労働省として推奨された [15]．

公共的施設と職場に喫煙室を設置する際に設定された条件として示された非喫煙場所から喫煙室に流れる空気の流れの基準として示された0.2m/sは，有機溶剤を使用する際の囲い式フードの制御風速の半分を目安に，喫煙者の出入りがない状態で，かつ，喫煙室内の空調を止めた状態で，「煙が漏れない」風速をスモークテスターで視認して得られた値である．実際に，「一定の要件を満たす喫煙室」を設置したところ，後述するようにドアの開閉，喫煙者の退出，肺に貯留したたばこ煙，空調や空気清浄機の排気が原因となり受動喫煙を防止できないことが判明した．

3．わが国における屋内全面禁煙化の検討

「一定の要件を満たす喫煙室」では受動喫煙を防止できないこと，また，諸外国では全面禁煙化が進められていることから，わが国でも2009年以降，複数の分野で屋内の全面禁煙化を第1選択とする対策が検討されてきた．同時進行で，お互いの内容を引用しながら検討しているため，公表された順番に記載する．

（1）公共的施設：厚生労働省健康局総務課生活習慣病対策室

第8条で求められていた受動喫煙防止法の期限の直前，2010年2月25日に健康局長通知として発出された「受動喫煙防止対策について」（健発0225第2号）では，FCTCを引用して「受動喫煙が死亡，疾病及び障害を引き起こすことは科学的に明らかである」との認識に立った上で「多数の者が利用する公共的な空間については，原則として全面禁煙であるべきである」「少なくとも官公庁と医療施設は全面禁煙とすることが望ましい」と述べられた [16]．また，当時の健康局長は「受動喫煙は『他者危害』である」とも述べている [17]．この通知を契機に道府県庁など多くの地方自治体で喫煙室が廃止されて建物内全面禁煙が導入された [18]．さらに，2012年10月29日，重ねて「受動喫煙防止対策の徹底について」（健発1029第5号）が発せられた [19]．

（2）職域：厚生労働省労働基準局安全衛生部環境改善室

2009年7月より検討が重ねられてきた「職場における受動喫煙防止対策に関する検討会報告書」が2010年5月26日に取りまとめられ公表された [20]．厚生労働省が2007年に実施した労働者健康状況調査をもとに，「喫煙対策に取り組んでいる事業所の割合は増加していること，特に，事業所全体を禁煙にしている割合は18.4%（2007年）に増加した」ことが述べられている．しかし，その一方で，「全面禁煙又は喫煙室を設けそれ以外を禁煙とする，いずれの対策も講じていない事業所は全体で53.6%」であり，多くの労働者が受動喫煙に曝露されている実態から，「今後の職場における受動喫煙防止対策の具体的な措置」として，「一般の事務所，工場等における措置は，全面禁煙又は空間分煙とすることが必要である」と述べた．

「職場における喫煙対策のための新ガイドライン」からの改善は，事務室だけでなく工場も対策の対象となったこと，および，2007年に施行された労働契約法に基づく安全配慮義務の観点から，労働者の健康障害防止に着目した対策として全面禁煙が強調された点である．しかし，「一定の要件を満たす喫煙室」も有効な対策とされていること，および，飲食店等のサービス産業では「顧客が喫煙するため，全面禁煙の措置が困難」と述べ，「サービス産業の労働者の受動喫煙の曝露を完全に防ぐことはできない」とした点が課題であった．

（3）日本産業衛生学会

2010年5月26日の総会において，「許容濃度等の勧告」を改定し，「タバコ煙」を人体に対して明らかな発がん物質である第1群に追加収載した [21]．

（4）閣議決定「新成長戦略」

2010年6月18日，民主党政権で閣議決定された「新成長戦略」では，2020年までの政策目標として「受動喫煙の無い職場の実現」が掲げられた [22]．

（5）労働安全衛生法の改正案（受動喫煙防止対策の義務化）

2010年12月22日，労働政策審議会が「今後の職場における安全衛生対策について（建議）」（労審発1222第597号）を厚生労働大臣に提出し [23]，翌2011年12月2日の閣議決定で，安全配慮義務の観点から労働安全衛生法の一部を改正し，職場の受動喫煙防止対策を義務化する法律案が第179回国会に提出された．しかし，2012年11月16日の衆議院解散により廃案となった．

（6）受動喫煙防止対策助成金制度

2010年12月の建議に基づく形で，2011年10月1日より，「顧客が喫煙できることをサービスに含めて提供している旅館，料理店又は飲食店を営む中小企業に対し，喫煙室の設置等の取組に対し助成することにより受動喫煙防止対策を推進することを目的」とする助成金制度が始まった．2012年度までの助成率は設置費用の4分の1（上限額は200万円）であったが，2013年5月16日からはサービス産業以外の中小企業にも適用が拡大され，かつ，助成率が2分の1に引き上げられた（上限額は200万円）[24]．2014年度以降も同様である．

（7）がん対策推進基本計画の変更：がん対策推進協議会

2012年6月8日に閣議決定された「がん対策推進基本計画」の変更により，政府として初めて成人喫煙率に関する数値目標を「2010年の成人喫煙率19.5%を2022年ま