博士論文

An association and mechanisms between parental socioeconomic status and second hand smoke exposure among young children
-the mediating effect of parental socio-psychological factors-

（親の社会経済的要因と乳幼児の受動喫煙との関連と
そのメカニズム
―親の心理社会的要因の媒介効果の検討―）

齋　藤　順　子

Table of contents

List of Tables

Page

Tables

List of Figures

Page

Figures

List of Appendices

Appendices

Abbreviations

95%CI	95% Confidence Interval
CFI	Bentler’s Comparative Fir Index
FCTC	Framework Convention on Tobacco Control
OR	Odds Ratio
RII	Relative Index of Inequality
RMSEA	Root Mean Square Error of Approximation
SD	Standard Deviations
SEM	Structured Equation Model
SES	Socioeconomic Status
SHS	Secondhand Smoke
SII	Slope Index of Inequality
TLI	Tucker-Lewis Index
WHO	World Health Organization
WLSMV	Weighted Least Squares Means and Variance adjusted

Abstract

Introduction

This thesis covered three objectives: 1) to examine the magnitude of socioeconomic inequalities in infants' secondhand smoke (SHS) exposure, 2) to examine changes in the magnitude of inequalities in infants' SHS exposure, and 3) to test the hypothetical pathways between socioeconomic status (SES) and indoor smoking among parents who smoke.

Methods

The magnitude of inequalities in SHS exposure was estimated among 41,833 infants born in 2001 and 32,120 infants born in 2010 in Japan from nationally representative surveys. The hypothetical pathways between SES and indoor smoking were tested using structured equation modeling approach in a sample of 810 smoking fathers and 772 smoking mothers separately.

Results

The slope index of inequality [SII] was 20.04 and the relative index of inequality [RII] was 1.47 based on income in 2010. The RII increased from 2001 to 2010 (0.87 to 1.47 for income and 1.22 to 2.09 for education). Low-SES smoking fathers had higher social norms of smoking and low-SES smoking parents had less knowledge about children's SHS exposure, and these variables were associated with their indoor smoking behaviors. Furthermore, social norms of smoking were positively associated with household indoor smoking and negatively associated with worksite smoking bans.

Conclusions

Inequalities in infants' secondhand smoke exposure based on income and education existed and increased from 2001 to 2010. The pathway between SES and indoor smoking behavior was mediated by social norms of smoking among fathers who smoke, and knowledge about children's SHS exposure among parents who smoke.

Key words: Socioeconomic factors; tobacco smoke pollution, smoking; children; parents

Chapter 1:

Introduction

1.1 General introduction

1.1.1 Global tobacco use and tobacco control

Tobacco use is the single most preventable cause of death. Tobacco use killed 6 million people worldwide in 2011[1], and this is expected to increase to over 8 million a year by 2030 if urgent action is not taken[2]. Currently, over 1.6 billion people are smoking in the world[1]. As a result of global epidemic of smoking, exposure to secondhand smoke (SHS) occurs at any place where smoking is permitted. SHS is a mixture of side-stream smoke released by the smoldering cigarette and the mainstream smoke that is exhaled by a smoker[3]. SHS is a known human carcinogen (cancer-causing agent) and the concentration is higher than the mainstream smoke[3]. Similar to active smoking, SHS exposure is associated with increased risk for cardiovascular system, coronary heart disease, and lung cancer[3]. Globally, about one third of adults are regularly exposed to SHS. In 2004, 600,000 non-smokers died of SHS exposure related diseases, and about 30% of them were children younger than 15 years old[4].

World Health Organization adopted a treaty “Framework Convention on Tobacco Control (FCTC)” in 2003 to protect people from any consequences of tobacco use[5]. Since then, implementation of tobacco control measures have progressed steadily, especially protection from exposure to SHS progressed the most[6]. Currently, many

countries or states have enacted laws banning smoking in public places (e.g., Ireland, New Zealand, Uruguay, UK, and some states in US) and even private vehicles when carrying children (e.g., Australia, Canada, and UK)[6].

1.1.2 Tobacco use and tobacco control in Japan

In Japan, one-third of men are still smoking. Although Japan showed steady declines in smoking prevalence in the last decade (from 47% to 32% in men and 11% to 8% in women from 2003 to 2013)[7], the smoking prevalence in men is higher than the average of high-income countries in 2014 (28% in men and 18% in women)[6]. Moreover, 47% of non-smoking adults are exposed to SHS in the restaurants in 2013[7]. One of the reasons for their high prevalence is the significantly limited legislative tobacco control measures in Japan. Despite having signed the FCTC in 2004[8,9], only one measure (monitoring of tobacco use) has met the criteria among six measures to complement FCTC (monitoring, protection from tobacco use, offers to help to quit, warning, enforced bans, and raised taxes)[8]. No national law prohibits smoking in public places in Japan. The tax rate of cigarettes in Japan rose from 61% to 65% of the retail price during 1998 to 2010[10]; however, it has not yet reached the criteria set by WHO (of at least 70%)[11].

1.1.3 SHS exposure among children

SHS exposure is one of the major causes of premature death and disease for children[3]. They are especially vulnerable to the health effects of SHS[12], with increased risk of asthma induction and exacerbation, respirator and middle ear infections, lowered lung function and sudden infant death syndrome[3,13]. The exposure to SHS is also linked with smoking initiation in their adolescents[14]. In addition, children exposed to SHS incur higher healthcare costs[15]. In the US, SHS exposure among children results in 4.6 billion dollars per year for direct medical expenditures and more than 8 billion dollars in annual loss of life costs[16]. Thus, the reduction of children's SHS exposure will largely contribute to improving public health worldwide.

Children are more heavily exposed to SHS than any other age-group worldwide[4]. The proportion of SHS exposure is 40% among children under 15 years old globally in 2004[4], and 38% among infants in Japan in 2001[17]. While the majority of exposures occurs in homes or cars because their parents smoke[4], many children are often unable to complain or protect themselves from SHS exposure[12]. Young children under 2 years old are particularly vulnerable as their respiration rate is

higher and body weight is lower than adults, and they generally spend the entire day at home[18,19]. For infants, low level of SHS exposure over the weeks may be equivalent to active adult smoking for several hours[20]. Although an ideal solution to protect children from exposure to SHS is parents' cessation of smoking, this is not necessarily achievable[21,22]. Therefore, 'home smoking bans' might be a realistic strategy to reduce SHS exposure among children[23]. Complete home smoking bans (i.e., no one is allowed to smoke inside the house) can significantly reduce children's respiratory symptoms and presence of nicotine toxins, an indicator of SHS exposure[24,25], although this is not a perfect solution[26].

SHS exposure among children has been significantly reduced in several western countries. The saliva cotinine among children decreased by 79% from 1998 to 2012 in England[27], and the households with children implementing complete home smoking bans increased from 58% to 84% from 1995 to 2007 in the US[28]. These trends occurred because the prevalence of parental smoking continuously decreased along with increased implementation of restrictions on smoking at public places.

1.1.4 Inequalities in exposure to SHS among children

The level of SHS exposure in children differs by parents' socioeconomic status

(SES), such as education, income and occupation. Children in lower SES group are more likely to have smoking parents, and less likely to have complete home smoking bans compared to those in higher SES groups[28–31]. The exposure to SHS among children with low-educated parents were 3.9 times higher than high-educated parents in Germany[29], and 11 times higher in Denmark[31].

However, changes in SHS exposure inequalities among children has not been examined over time in detail. 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[28], and remained the same in Australia and Denmark[31,32]. In Japan, no studies directly examined changes in SHS exposure inequalities among children so far, due to lack of continuous follow-up for SHS exposure. It is partly because nationwide surveys, such as The National Health and Nutrition Survey in Japan, do not routinely collect data regarding children's SHS exposure.

1.1.5 Mechanisms between SES and indoor smoking behaviors among parents

To reduce inequalities in children's SHS exposure, we need to explore the mechanisms linking SES to SHS exposure among children. For adults smoking,

increased tobacco price via tax is confirmed to the great potential to reduce inequality in smoking[33]. However, regarding SHS exposure among children, the evidence about equality impact of tobacco control policies and interventions is very limited and has not been systematically quantified. To establish effective policies and interventions, it is important to understand which factors mediate the relationships between SES to SHS exposure among children. Parental indoor smoking at home is particularly crucial as a measurement of SHS exposure for young children, because it is a primary source for them[3,18]. So far, few studies have tested the specific pathways between SES and indoor smoking behavior among parents, while several conceptual models were developed about the mechanisms between SES and smoking behavior among general populations[34–37].

Several kinds of evidence provide possible mediators for the hypothesized mechanisms linking SES to indoor smoking among parents. First, the conceptual models linking SES to health provide possible mediators. The model explains that SES directly influences environmental and psychological factors, and through these two factors, indirectly influences health behaviors[38]. Another model also hypothesized that SES influences health behaviors through the effects of environmental factors on psychological factors[39]. Other conceptual models linking SES to smoking also

demonstrated that several environmental and psychological factors are mediators, such as self-efficacy[37], social ties[40], social support [34], perceived stress[34,37,40], SHS exposure at home, and the use of smoking cessation resources[35].

Moreover, multiple barriers that low-SES smoking parents were facing would mediate as well. They impose temporary and ad hoc restrictions due to habits, stressors, and limited knowledge about the harm of SHS[41–43]. Their desire to protect children from SHS by restricting indoor smoking could compete with their caring responsibilities (e.g. leaving young children alone), personal discomfort when smoking outside (e.g. bad weather), and physical environment of their homes (e.g. lack of outdoor space, living in a high-rise flat)[43]. As the process of implementing home smoking bans involves negotiation with a smoking partner, partner's support could be also a barrier or motivator[42,44].

1.1.6 Research gaps

A body of evidence is available on social inequalities in adults smoking. However, such evidence in the context of SHS exposure among children, particularly young children, is quite limited[19]. Children under 2 years old including infants are more susceptible to the risks associated with SHS exposure[45]. While the social

inequalities in adults smoking exist and even widening in some European countries[46], few studies examined changes of socioeconomic inequalities in SHS exposure among young children over time. Particularly in Japan, no evidence exists regarding the temporal changes of inequalities in children's SHS exposure.

Evidence is also lacking on the mechanisms between parental SES and SHS exposure among children. Several barriers and motivators have been revealed among low-SES parents to protect children from SHS exposure in the literatures[41–43]. In addition, several environmental and psychological factors were suggested to mediate the pathways from SES to smoking cessation among adults[34–37]. However, no study tested the hypothesized model about the mechanisms between SES and indoor smoking behavior among parents living with young children.

1.1.7 Objectives of the thesis

This doctoral thesis had three objectives which consist of two studies.

1. To examine the magnitude of socioeconomic inequalities in SHS exposure among infants in Japan. (Chapter 2)
2. To examine changes in the magnitude of socioeconomic inequalities in SHS exposure among infants from 2001 to 2010 in Japan. (Chapter 2)

3. To test the hypothetical model of the pathways between socioeconomic status and indoor smoking behaviors among parents living with young children in Japan. (Chapter 3)

1.2 Thesis organization

This thesis consists of four chapters. Chapter 1 describes general introduction, research gaps, and study objectives. The next two chapters are composed of research conducted to address the three objectives. Chapter 2, ”Changes in socioeconomic inequalities in infants’ exposure to secondhand smoke over time in Japan”, examined the magnitude and changes of inequalities in infants’ SHS exposure over time using repeated cross-sectional data from national representative surveys in Japan. Chapter 3, “The pathways between socioeconomic status and indoor smoking behavior among smoking parents living with young children”, describes the evaluation of hypothesized pathways between SES and indoor smoking behavior among parents living with their young children using cross-sectional data. Chapter 4 shows summary of findings from the separate studies and describes general conclusions and implications of findings.

Chapter 2:

Changes in socioeconomic inequalities in infants' exposure to secondhand smoke over time in Japan: a repeated cross-sectional survey

2.1 Introduction

Socioeconomic inequalities 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[17]. Children in the lowest income households are more likely to suffer from asthma compared with those in the highest income households[47], and parental indoor smoking increases and exacerbates children's asthma[48]. Given these findings, I could suppose that SHS exposure is higher among children in low-SES households in Japan.

Moreover, the magnitude of absolute inequalities might differ by parental indoor smoking behaviors (only father, only mother, or both parents smoke indoors). Understanding the parental smoking situation most responsible for inequalities would help prioritize tobacco control interventions that aim to reduce children's SHS exposure. In Wales, 'both parents' showed the larger socioeconomic inequalities in absolute terms, compared with 'only father' or 'only mother'[49]. In Japan, however, there is a large difference in smoking prevalence between men and women[7]. Furthermore, during the pre- and post-natal periods, smoking fathers with a non-smoking partner receive limited support from health professionals to change their smoking behavior compared with smoking mothers and their partners[50]. Thus, low-

SES fathers who are the only smoker might be more likely to continue smoking indoors and contribute the most to the total absolute inequality in SHS exposure.

Regarding the changes in socioeconomic inequalities in children's SHS exposure, we have not known well if they are widening or narrowing. Although social inequalities in the prevalence of adult smoking are widening in some European countries[46], there are limited studies focusing on the temporal change in SHS exposure inequalities in children. In particular, despite their increased susceptibility to the risks associated with SHS exposure, children younger than 2 years old have rarely been studied independent of older children[19]. Furthermore, the available studies in countries other than Japan, which used different indices of inequality, have shown mixed results. In the USA, while the overall prevalence of SHS exposure in children decreased, odds ratio (OR) of smoke-free homes for lowest income versus highest income households increased significantly from 1.32 in 1995 to 2.02 in 2006-2007[28]. In contrast, in Denmark, OR of parental indoor smoking with children by parental education level did not differ significantly over time (OR was 10.4 in 2007 and 11.5 in 2010)[31]. In England, absolute inequality in the level of SHS exposure (median cotinine) among children decreased significantly from 1996 to 2006[51].

Thus, this study 1 had two objectives: 1) to examine the magnitude of

socioeconomic inequalities in SHS exposure in infants and 2) to examine the changes in the magnitude of socioeconomic inequalities in SHS exposure in infants from 2001 to 2010.

I further hypothesized that socioeconomic inequalities in children's SHS exposure exist in Japan (Hypothesis 1), and that socioeconomic inequalities increased from 2001 to 2010 in Japan (Hypothesis 2). Furthermore, I hypothesized that 'only father smoking indoors' contribute the most to absolute inequalities in SHS exposure among infants (Hypothesis 3).

2.2 Methods

2.2.1 Study participants

I 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). I used baseline data of both cohorts 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), with permission from the Ministry of Health, Labour, and Welfare, Japan. The participants who returned the questionnaire to the Ministry were considered to have agreed to participate in the study.

The response rate for the first self-administered questionnaire, which was mailed to all households when the infants were six 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. I 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, I

excluded 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). In the final analyses, I included 41,833 (78.1% of the initial cohort) and 32,120 (73.4% of the initial cohort) participants for the first and second cohorts, respectively.

2.2.2 Secondhand smoke exposure in infants

I used parental indoor smoking behavior as a measurement of SHS exposure in infants[31]. Although this is a proxy measurement, parental indoor smoking is significantly associated with biochemically measured SHS exposure among children[52]. 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, I combined the responses for the smoking behavior 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.

2.2.3 Socioeconomic indicators

I used income and education as SES indicators. For income, I calculated

equivalent household income by adjusting for the square root of the number of persons living in the household and categorized into four groups: 2,000,000 yen or less, 2,000,001 – 3,000,000 yen, 3,000,001 – 4,000 000 yen, or over 4,000,000 yen. Because the education question was only included in the second survey (2002 for the first cohort and 2011 for the second cohort), I used those data 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, I 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.

2.2.4 Statistical analyses

I calculated the prevalence of SHS exposure in infants based on SES by survey year. I adjusted the prevalence in 2010 by the average parental age in 5-year age groups using a direct method and the parental age distribution in 2001 as the base.

To test the first hypothesis, I examined both absolute and relative inequality indices, which is strongly recommended in health equality research to avoid biased judgments by readers[53]. For absolute measures, I estimated the rate difference and

slope index of inequality (SII) with 95% confidence intervals (CIs). The rate difference measures the absolute difference in indoor smoking prevalence between the lowest and highest SES groups. For relative measures, I measured the odds ratio (OR) and relative index of inequality (RII) with 95% CIs. 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[54]), I 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). I 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 are regression-based measurements that took into account the distributions of the sample in each SES group and the entire distribution of the SES groups over time[55]. 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[55,56].

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

To test the third hypothesis, I calculated the prevalence and the magnitude of inequalities (SII and RII) based on income level by parental indoor smoking behavior (only father, only mother, or both parents smoke indoors). Then, I calculated the proportion to the total SII represented by each parental indoor smoking behavior to examine the contribution for the total income inequality[57]. I did not calculate an educational SII by parental indoor smoking behavior because the categorization of education level between father/mother indoor smoking and parental indoor smoking was not the same.

As a sub-analysis, I examined the changes in inequalities in parental smoking

over time to examine whether they were comparable to the changes in inequalities in infants' SHS exposure. I also examined the changes in inequalities in parental smoking over time for each parental smoking behavior (i.e., only father, only mother, or both parents smoke) and compared the changes with those in infants' SHS exposure. I conducted most of the analyses using STATA 13 (StataCorp LP; College Station, TX, US). For the SII and RII calculations, I used HD*calc (version 1.2.4; National Cancer Institute, US)[58].

2.2.5 Ethical considerations

This study was approved by the Research Ethics Committee of the Graduate School of Medicine at The University of Tokyo, Japan (approval number: 10618).

2.3 Results

Table 1 shows the characteristics of the study participants 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 1. Characteristics of the study participants by survey year

	2001		2010	
	n = 41,833	%	n = 32,120	%
Equivalent household income				
Highest (> 4,000,000 yen)	7,175	17.2	6,600	20.5
High (3,000,001 - 4,000,000 yen)	7,573	18.1	6,000	18.7
Low (2,000,001 - 3,000,000 yen)	13,352	31.9	9,909	30.8
Lowest (0 - 2,000,000 yen)	11,179	26.7	7,565	23.6
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 secondhand 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 secondhand smoke was measured by self-reported parental indoor smoking behavior.

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 47.8% and 23.3% in 2001 and 22.3% and 6.6% in 2010, respectively. Income and educational inequalities in SHS exposure in infants existed. Thus, my first hypothesis (socioeconomic inequalities in children's SHS exposure exist in Japan) was supported. For example, in 2010, the rate difference and the SII in the prevalence of infants' SHS exposure based on income were 15.7 and 20.04, demonstrating greater prevalence in the lowest income group compared with the highest group; the OR indicated a 1.97 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.

Table 2. Prevalence and magnitude of inequalities in SHS exposure in infants according to the income and educational level by survey year

	Prevalence of SHS exposure in infants (%)			
	2001	2010[b]	% change ([2010-2001]/2001)	Coefficient (95% CI)[c] (Income × year)
Equivalent household income				
Highest (ref)	23.3	6.6	-71.7	-1.31 (-1.43 to -1.20)
High	29.8	10.1	-66.1	-1.20 (-1.30 to -1.10)
Low	38.1	13.9	-63.5	-1.26 (-1.33 to -1.19)
Lowest	47.8	22.3	-53.4	-1.12 (-1.19 to -1.05)
Rate difference (lowest - highest) (% point)	24.5	15.7		
SII (95% CI)	31.75(30.09 to 33.41)	20.04(18.67 to 21.41)		
Odds ratio[a] (95% CI)	1.78(1.66 to 1.92)	1.97(1.74 to 2.22)		
RII (95% CI)	0.87(0.82 to 0.91)	1.47(1.37 to 1.56)		
Parental education level				
Both are university graduates or higher (highest) (ref)	14.8	4.0	-73.0	-1.46 (-1.61 to -1.31)
Only one is a university graduate	26.2	8.9	-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	-60.0	-1.27 (-1.34 to -1.20)
Both are high school graduates or less (lowest)	51.5	28.1	-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)		

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

Regarding changes over time, the prevalence of SHS exposure decreased in all SES groups from 2001 to 2010 (Table 2). The relative measures of inequality (OR and RII) indicated that the magnitude of income and educational inequalities in SHS exposure among infants increased from 2001 to 2010. Thus, my second hypothesis (socioeconomic inequalities increased from 2001 to 2010 in Japan) was supported. For instance, from 2001 to 2010, the RII for income increased from 0.87 to 1.47. In the comparison of the SES groups, the lowest SES group showed the smallest relative decrease in prevalence of SHS exposure (-53.4 percentage change), supporting the results that income and educational inequalities increased in relative 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 (Table 3) than in infants' 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. Moreover, Table 4 shows that income and educational inequalities in SHS exposure in infants exited even

among households with smoking parent(s). Furthermore, the magnitude of its relative inequalities increased in both income and education from 2001 to 2010.

Table 3. Prevalence of parental smoking and magnitude of inequalities in parental smoking according to the income and educational level by survey year

	Prevalence of parental smoking (%)		% change ([2010-2001]/2001)
	2001	2010[a]	
Equivalent household income			
Highest (ref)	49.5	29.1	-41.2
High	56.9	36.3	-36.3
Low	64.6	42.0	-35.0
Lowest	73.7	52.7	-28.5
SII (95% CI)	30.92 (29.24 to 32.60)	29.91 (27.97 to 31.85)	
RII (95% CI)	0.49 (0.46 to 0.52)	0.74 (0.69 to 0.78)	
Parental education level			
Both are university graduates or higher (highest) (ref)	37.7	22.5	-40.4
Only one is a university graduate	51.9	33.1	-36.2
One is a college graduate and the other is a college graduate or less	68.1	47.4	-30.4
Both are high school graduates or less (lowest)	78.2	61.7	-21.1
SII (95% CI)	48.21 (46.62 to 49.79)	48.46 (46.65 to 50.27)	
RII (95% CI)	0.76 (0.74 to 0.79)	1.19 (1.14 to 1.24)	

[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

Table 4. Prevalence and magnitude of inequalities in SHS exposure in infants who live with smoking parent(s) according to the income and educational level by survey year

	Prevalence of SHS exposure in infants (%)		% change ([2010-2001]/2001)
	2001 (n = 24,729)	2010[a] (n = 11,912)	
Equivalent household income			
Highest (ref)	47.0	22.6	-51.9
High	52.4	27.9	-46.8
Low	58.9	33.1	-43.8
Lowest	64.9	42.2	-34.9
SII (95% CI)	22.41 (20.20 to 24.62)	25.23 (22.23 to 28.23)	
RII (95% CI)	0.39 (0.35 to 0.42)	0.75 (0.67 to 0.84)	
	Prevalence of SHS exposure in infants (%)		% change ([2010-2001]/2001)
	2001 (n = 26,174)	2010[a] (n = 12,717)	
Parental education level			
Both are university graduates or higher (highest) (ref)	39.1	17.9	-54.4
Only one is a university graduate	50.4	26.9	-46.7
One is a college graduate and the other is a college graduate or less	58.7	33.8	-42.4
Both are high school graduates or less (lowest)	65.8	45.5	-30.9
SII (95% CI)	27.33 (25.19 to 29.48)	31.43 (28.57 to 34.29)	
RII (95% CI)	0.47 (0.43 to 0.51)	0.92 (0.84 to 1.01)	

[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

Regarding SHS exposure from the three parental indoor smoking behaviors, 'only father smoking indoors' was a major source of SHS exposure in infants (69.8% in 2001 and 78.7% in 2010) (Table 5). Table 6 shows the prevalence of SHS exposure in infants by parental smoking behavior 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 14.69 in 2001 to 13.45 in 2010) because of the much smaller decrease in the lowest income group (-44.8 percentage change). Figure 1 shows the contributions of absolute income inequality (SII) in SHS exposure in infants to the total income SII by parental indoor smoking behavior. The proportion represented by 'only father smoking indoors' increased (from 46.3% [14.69/31.75] in 2001 to 66.7% [13.45/20.15] in 2010) and became a major contributor in 2010, while the proportion represented by 'both parents smoking indoors' decreased over time (from 50.8% [16.13/31.75] in 2001 to 29.6% [5.96/20.15] in 2010). Thus, my third hypothesis ('only father smoking indoors' contribute the most to absolute inequalities in SHS exposure among infants) was supported.

Table 5. Proportion of each parental indoor smoking behavior 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

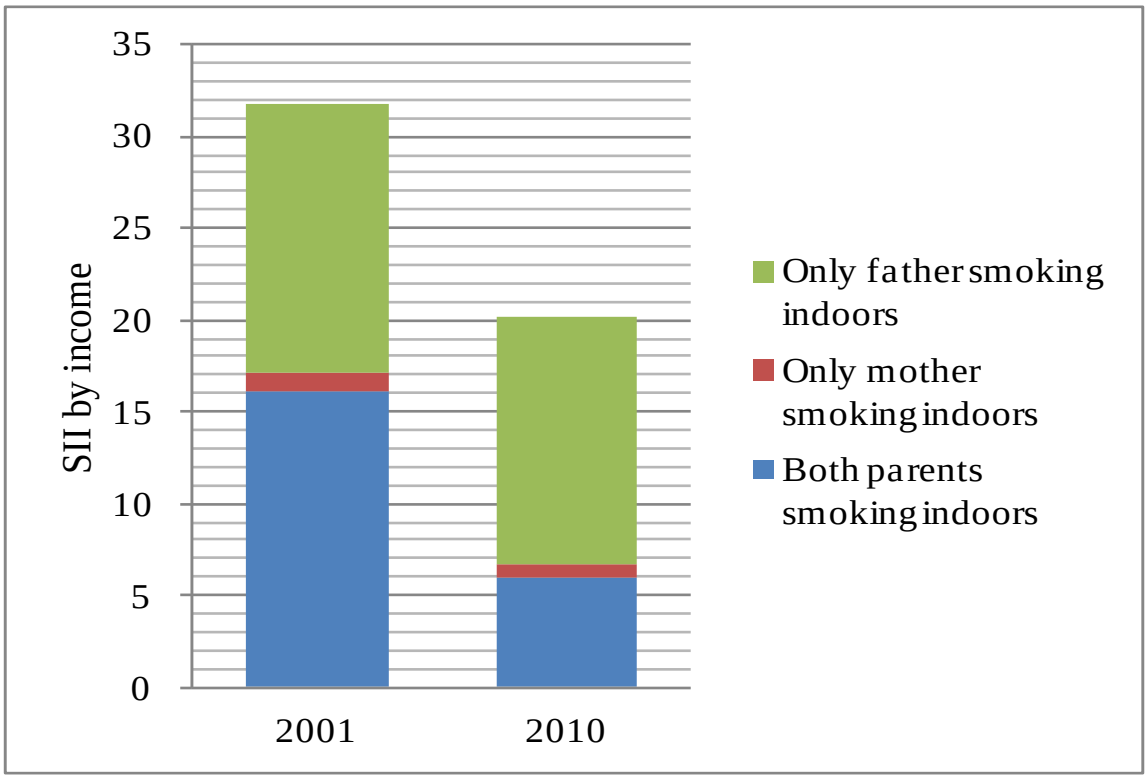
[a] The number and proportion in 2010 was weighted for the average parental age in 5-year age groups using a direct method and the age distribution in 2001 as the base.

Table 6. Prevalence and magnitude of inequalities in SHS exposure in infants according to the income level by parental indoor smoking behaviors by survey year

Equivalent household income	2001	2010[a]	% change ([2010-2001]/2001)
	Prevalence of SHS exposure in infants by both parents smoking indoors (%)		
Overall	9.9	2.6	-73.4
Highest (ref)	4.0	0.5	-86.4
High	6.5	1.3	-79.4
Low	9.6	2.6	-72.8
Lowest	16.4	5.1	-69.0
SII (95% CI)	16.13(15.07 to 17.28)	5.96 (5.34 to 6.59)	
RII (95% CI)	1.63 (1.53 to 1.72)	2.38 (2.18 to 2.58)	
	Prevalence of SHS exposure in infants by only father smoking indoors (%)		
Overall	25.6	11.0	-57.0
Highest (ref)	18.6	5.9	-68.3
High	22.5	8.5	-62.3
Low	27.5	10.9	-60.2
Lowest	30.0	16.5	-44.8
SII (95% CI)	14.69 (13.26 to 16.13)	13.45 (12.02 to 14.88)	
RII (95% CI)	0.57 (0.52 to 0.63)	1.25 (1.12 to 1.39)	
	Prevalence of SHS exposure in infants by only mother smoking indoors (%)		
Overall	1.0	0.4	-62.9
Highest (ref)	0.7	0.1	-79.0
High	0.8	0.3	-64.6
Low	1.0	0.4	-63.4
Lowest	1.4	0.7	-54.4
SII (95% CI)	0.93 (0.57 to 1.29)	0.74 (0.49 to 0.99)	
RII (95% CI)	0.91 (0.57 to 1.26)	1.91 (1.33 to 2.48)	

[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

Figure 1. Contributions of parental indoor smoking behaviors 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 behavior.

By comparing the relative reduction between smoking and indoor smoking by parental smoking behaviors in the sub-analysis (Table 6, Table 7, Figure 2), I found a much larger difference for ‘only father smoking’ (percentage change, -25.0% for only father smoking vs. -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) (Table 7, Table 8).

Table 7. Prevalence of parental smoking and magnitude of inequalities in parental smoking according to the income level by parental smoking behavior

Equivalent household income	2001	2010[a]	% change ([2010-2001]/2001)
	Prevalence of both parents smoking (%)		
Overall	14.2	5.0	-64.9
Highest (ref)	6.7	1.5	-77.9
High	9.7	2.8	-71.0
Low	14.0	4.6	-66.8
Lowest	22.5	9.4	-58.1
SII (95% CI)	20.69 (19.48 to 21.90)	10.10 (9.23 to 10.96)	
RII (95% CI)	1.45 (1.37 to 1.53)	2.12 (1.96 to 2.27)	
	Prevalence of father only smoking (%)		
Overall	47.6	35.6	-25.0
Highest (ref)	41.8	27.3	-34.5
High	46.3	33.0	-28.8
Low	49.6	36.6	-26.1
Lowest	49.7	42.1	-15.2
SII (95% CI)	9.52 (7.75 to 11.28)	18.64 (16.75 to 20.52)	
RII (95% CI)	0.20 (0.16 to 0.24)	0.53 (0.48 to 0.58)	
	Prevalence of mother only smoking (%)		
Overall	1.2	0.7	-41.7
Highest (ref)	1.0	0.3	-74.4
High	0.9	0.5	-50.3
Low	1.1	0.7	-35.0
Lowest	1.5	1.1	-25.1
SII (95% CI)	0.73 (0.37 to 1.11)	1.02 (0.69 to 1.35)	
RII (95% CI)	0.64 (0.32 to 0.95)	1.52 (1.09 to 1.94)	

[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

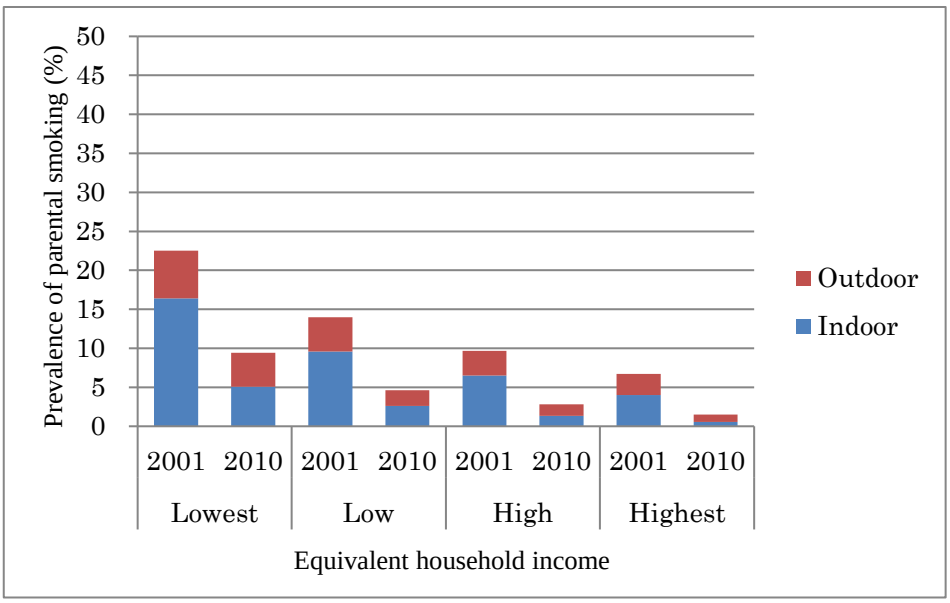
Table 8. Prevalence of parental smoking and magnitude of inequalities in parental smoking according to the income level by fathers and mothers

Equivalent household income	2001	2010[a]	% change ([2010-2001]/2001)
	Prevalence of father smoking (%)		
Overall	61.8	40.6	-34.3
Highest (ref)	48.9	28.8	-41.1
High	56.0	35.8	-36.1
Low	63.5	41.3	-35.0
Lowest	72.2	51.6	-28.6
	Prevalence of mother smoking (%)		
Overall	15.4	5.7	-63.3
Highest (ref)	7.7	1.7	-77.4
High	10.6	3.3	-69.2
Low	15.0	5.3	-64.5
Lowest	24.0	10.5	-56.1

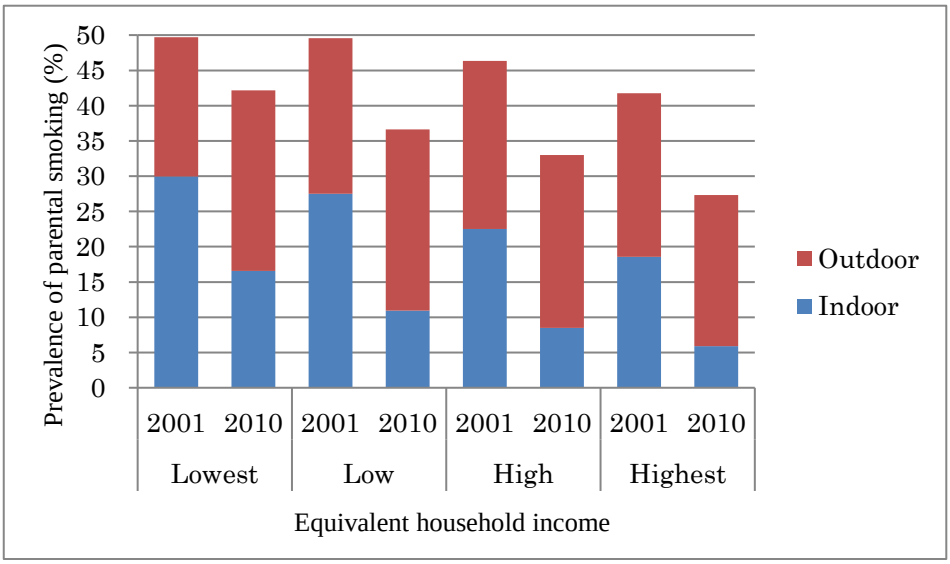
[a] The prevalence in 2010 was weighted for the average parental age in 5-year age groups using a direct method and the age distribution in 2001 as the base.

Figure 2. Prevalence of parental smoking and indoor smoking behaviors according to the income level by both parents smoking and only father smoking

Both parents smoking



Only father smoking



The prevalence is presented in Tables 6 and 7.

The total bar represents the parental smoking in each survey year, and each colored bar, dark gray and light gray, represents the parental indoor smoking (SHS exposure in infants) and outdoor smoking, respectively.

2.4 Discussion

In this repeated nationwide population-based survey, I found marked social inequalities in infants' exposure to SHS in both survey years, with the most exposure occurring for infants in the lowest SES group. From 2001 to 2010, the relative inequalities in infants' SHS exposure increased. Furthermore, 'only father smoking indoors' was a major source of SHS exposure in infants and a major contributor to absolute income inequality in SHS exposure in infants in 2010.

The changes in inequalities in infants' SHS exposure over time in this study are consistent with reports from the USA and England: the SHS exposure inequality increased or stabilized in relative terms over time among children[28,51]. The increase in relative inequalities could result from more barriers to stopping (indoor) smoking in low-SES parents than in high-SES parents. Those barriers would include a greater tendency for nicotine dependence, which is a strong predictor for failure to quit smoking[59,60], conflict between coping and caring, and influence of relationships with families and friends[41]. In addition, the baseline prevalence of exposure among the lowest SES infants in 2001 were much higher than the highest SES infants in 2001, making it challenging for the lowest SES infants to attain the same or greater proportional reduction as the highest SES infants[61].

Furthermore, ‘only father smoking indoors’ contributed the most to the total absolute inequality in infants’ SHS exposure based on income and represented the highest contributor in 2010 (Figure 1). The smallest relative reductions for both ‘only father smoking’ (percentage change: -15.2%) and ‘only father smoking indoors’ (percentage change: -44.8%) were in the lowest income group (Table 6, Table 7, Figure 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 a self-efficacy to avoid SHS exposure than high SES women[62]. Although a mother’s self-efficacy in asking others to smoke outdoors is strongly associated with actual preventive behavior for their children, non-smoking mothers have a lower self-efficacy than smoking mothers[63].

In contrast, ‘both parents smoking indoors’ considerably decreased the contribution to the total absolute income inequality, mainly due to the large reduction in the mother’s smoking across all SES levels. From 2001 to 2010, the prevalence of smoking in mothers decreased (percentage change -63.3%) more than in fathers (percentage change -34.3%) (Table 8) and in women in the general population (percentage change -15.5%)[7,64]. This might be because the proportion of women who quit smoking when they become pregnant considerably increased from 2001 to 2010,

though the postpartum relapse rates remain high (approximately 43% at 18 months after childbirth in Japan in 2009)[65].

Compared with income, educational inequalities in infants' SHS exposure appeared to be greater in a similar manner using quartile distribution in both years in study 1. 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[66,67]. Thus, compared with income, education level might predict parental nicotine dependence more accurately, and this dependence is one of the main barriers for parents to quit smoking and/or stop indoor smoking[41,60,68].

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. This is the first study to report temporal changes in inequalities in infants' SHS exposure in Japan. Moreover, I applied the regression based indices of inequalities (SII and RII), which are advantageous when comparing groups with different population sizes[56].

Nevertheless, the study has certain limitations. First, the exposure to SHS might have been underestimated as parental indoor smoking behavior was measured as a

proxy measurement of SHS exposure in infants, and 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[3], 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[69]. 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[70]. Social movements, such as a proposal to decrease children's passive smoking by the Japan Pediatric Society in 2002[71], might also have influenced under-reporting. However, potential underreporting is not likely to have significantly influenced the changes in inequality as underreporting is not different across SES groups[72].

In conclusion, although the prevalence of SHS exposure in infants decreased considerably from 2001 to 2010 in Japan, the relative inequalities in SHS exposure in infants increased. In addition, 'only father smoking indoors' was a major source of SHS exposure in infants and a major contributor to absolute income inequality in SHS

exposure in infants in 2010. 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.

Chapter 3:

The pathways between socioeconomic status and indoor smoking behavior among smoking parents living with young children

3.1 Introduction

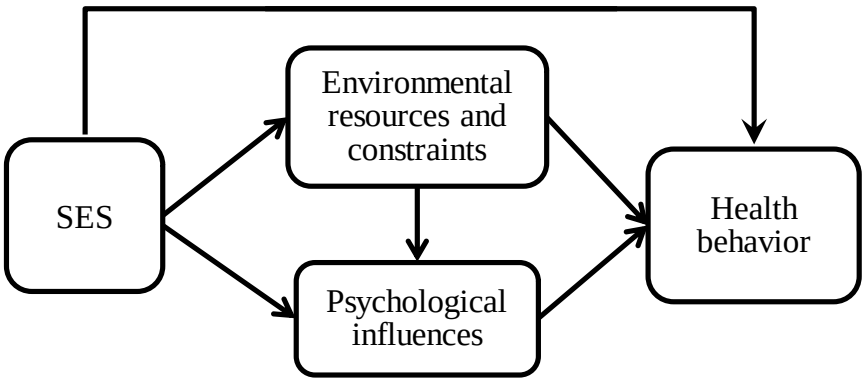
Evidence is lacking on the mechanisms between parental socioeconomic status (SES) and secondhand smoke (SHS) exposure among children. As parental smoking is the main source of SHS exposure for young children[3,12,18], smoke-free homes (voluntary rules to completely restrict indoor smoking at home) is the second best option for smoking parents, next to smoking cessation, to protect their children from SHS exposure. However, a previous study showed that smoking households with children in the lowest SES were 0.43 times less likely to live in smoke-free homes compared to smoking households in the highest SES[32]. The findings of Study 1 (Chapter 2) also suggested that social inequalities in indoor smoking behavior among infants who live smoking parent(s) existed and even increased in both absolute and relative terms from 2001 to 2010 (Table 4). To protect children from SHS exposure and concurrently narrow the inequalities among children with smoking parents, it is crucial to understand what factors mediate the pathways between SES and indoor smoking behavior among smoking parents. Understanding these mechanisms will strongly contribute to developing effective policies and interventions for children who are most likely to be exposed to SHS, that is, children with low-SES smoking parents. Thus, I

tested a hypothesized model of the pathways between SES and indoor smoking behavior among smoking parents.

3.1.1 Hypothesized model of the pathways between SES and SHS exposure among children

Several conceptual models have showed the possible pathways between SES and modifiable risk factors. Among them, Adler explained that SES directly influences environmental and psychological factors, and that environmental factors also influence psychological factors[38]. Thus, SES indirectly influences health behaviors through these two factors (Figure 3). I developed my model based on this concept and both theoretical and empirical research findings regarding SES and parental smoking behavior.

Figure 3. Conceptual framework of this study 2



Extracted from "the model of the pathways by which SES influences health"[38]

Descriptive and subjective social norms of smoking

According to social cognitive theory, social norms are created by perceptions of the environment, and influence people's health behavior[73]. Descriptive norms are norms of "is" and characterize perceptions of what most people do. On the other hand, subjective norms are norms of "ought" and characterize perceived approval about performing a given behavior by significant others, such as family and friends[74]. As low-SES smokers were more likely to belong to a pro-smoking social context compared to high-SES smokers[75,76], they tend to overestimate the smoking prevalence[77], thus increasing perceived social acceptability of smoking. Social norms about the acceptability of smoking predict smoking behavior[78], and are an important mechanism for spreading smoking behavior across close and distant social ties[79].

Furthermore, parental social norms with regard to smoking are supposed to be one of the mechanisms between smoke-free legislation and increased implementations of smoke-free homes with children[80]. Therefore, I hypothesized that both descriptive and subjective norms of smoking mediate the relationship (descriptive norms and subjective norms, in that order) between SES and indoor smoking behavior among smoking parents.

Then, I hypothesized that environmental variables (household indoor smoking, smoking-related social support, and worksite smoking bans) influence social norms of smoking, as well as mediating the association between SES and indoor smoking behavior among smoking parents.

Household indoor smoking

Low-SES smokers are more likely to marry a smoker[81,82]. Having a smoking partner is a strong predictor of an absence of smoking cessation and relapse[83–85], and is also associated with an absence of quitting smoking for pregnancy among mothers of newborns[86]. Moreover, low-SES, vs. high-SES, households with children are less likely to restrict indoor smoking inside the house[32]. Households with sole smokers are 4.0 times more likely to implement a complete smoke-free homes than are households

with multiple smokers[87]. Further, mothers of newborns with an indoor smoking partner are 7.7 times more likely to smoke indoors than mothers without an indoor smoking partner are[88].Thus, I hypothesized that indoor smoking behaviors by household members would influence social norms of smoking, and act as a mediator in the relationship between SES and indoor smoking behavior among smoking parents.

Smoking-related social support

Smoking-related social support by a partner has both positive and negative impacts on smoking cessation[82]. Having a partner who supports smoking cessation predicts cessation success[89,90], whereas one's family's negative behaviors, such as nagging and complaining, are associated with failure to cease smoking[91]. The positive or negative attitudes of family members toward smoking are also associated with implementation of smoke-free homes[92]. Smokers in low-SES households have fewer people who support their quitting due to the higher proportion of smokers in their social networks[82], and this might also be true for indoor smoking behavior. Moreover, smoking-related social support provided by a partner might decrease the perceived approval of smoking by families, friends, and colleagues (subjective norms of smoking). Therefore, I hypothesized that smoking-related support provided by a partner

would influence social norms of smoking, and act as a mediator in the relationship between SES and parental indoor smoking.

Worksite smoking bans

Low-SES workers are more likely to work at a tobacco-friendly worksite compared with high-SES workers. Related to this, smokers employed at worksites without strict smoking bans are less likely to quit compared with those at worksites with strict bans[93]. A meta-analysis reported that smoke-free work policies were associated with a median 6.4% increase in tobacco use cessation, and a median 3.4% decrease in tobacco use prevalence[94]. Social norms on acceptability of smoking in a work unit is considered as a mechanism of an impact of worksite smoking bans on smoking cessation[95]. Therefore, I hypothesized that worksite smoking bans would influence social norms of smoking, and act as a mediator in the relationship between SES and indoor smoking behavior.

I hypothesized that knowledge about children's SHS exposure mediates the association between SES and indoor smoking behavior among smoking parents.

Knowledge about the risks of SHS exposure in children and precautions to avoid

SHS exposure in children

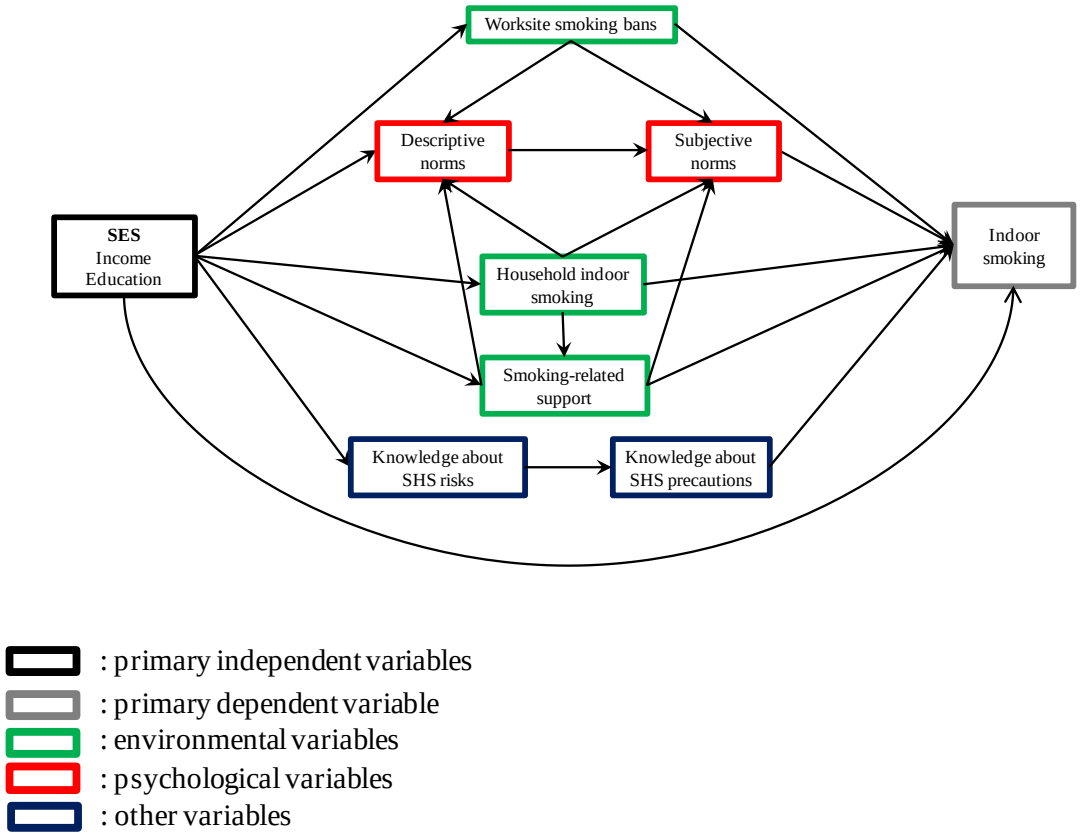
Low-SES parents are less knowledgeable about the harmful health effects of SHS on children, and less likely to restrict smoking at home to avoid these, compared to high-SES parents[96]. Some disadvantaged smoking parents believe that simply avoiding smoking in front of their children is enough, whereas other parents know that completely restricting indoor smoking inside the house is necessary to reduce exposure[41]. Parents' knowledge level about the health risks of SHS is associated with SHS exposure among their children[97]. Although most parents want to protect their children from health risks, differences in knowledge levels across social classes may generate an unequal distribution in indoor smoking behavior. Thus, I hypothesized that low-SES parents would be less likely to have correct knowledge about children's SHS exposure risks, and it leads less knowledge about precautions to take to avoid these compared to high-SES parents, thus leading to higher rates of indoor smoking among the former group.

The hypothesized model in Figure 4 summarizes these expected relationships. In summary, low-SES smoking parents are assumed to have higher perceived acceptability of smoking (*subjective social norms of smoking*), via the higher prevalence of smoking within their social networks, including family, friends, and colleagues (*descriptive*

social norms of smoking). Such social norms will positively affect indoor smoking, along with likelihood of having indoor smoking household members (*household indoor smoking*). *Household indoor smoking* will positively affect social norms of smoking (*descriptive and subjective norms of smoking*), and will negatively affect support to quit smoking by a partner (*smoking-related social support*). In addition, low-SES smoking parents tend to work at tobacco-friendly worksites (*worksite smoking bans*), thus leading to higher social norms of smoking (*descriptive norms of smoking, subjective norms of smoking*) and indoor smoking behavior.

Moreover, low-SES smoking parents might also have lesser support from their partner with regard to quitting smoking (*smoking-related social support*), and *smoking-related social support* would also affect the assumption of smoking and perception of approval by others (*descriptive and subjective norms of smoking*). Finally, they are assumed to have less knowledge about the risks of SHS in children (*knowledge about the risks of SHS exposure in children*), and it would lead less knowledge about precautions that can be taken to avoid SHS exposure among children (*knowledge about precautions to avoid SHS in children*), and positively affect indoor smoking behavior.

Figure 4 Hypothesized model from SES to indoor smoking behavior



The objective of this study 2 therefore was to test the hypothetical model of the pathways between socioeconomic status and indoor smoking behavior among smoking parents living with young children in Japan.

I further hypothesized that social norms of smoking mediate the association between SES and indoor smoking behavior among smoking parents (Hypothesis 4), and that environmental variables (household indoor smoking, smoking-related social support, and worksite smoking bans) influence social norms of smoking, as well as

mediating the association between SES and indoor smoking behavior among smoking parents (Hypothesis 5). Furthermore, I hypothesized that knowledge about children's SHS exposure mediates the association between SES and indoor smoking behavior among smoking parents (Hypothesis 6).

3.2 Methods

3.2.1 Study design

This cross-sectional study was conducted using a self-administered online questionnaire through MACROMILL (MACROMILL, Inc. Tokyo, Japan) in Japan. The online survey is a common research tool for behavioral surveys, and has been used to collect reliable and valid data regarding smoking behaviors from smokers[98].

The biggest advantage of using the online survey method in this study lies in its accessibility for smokers living with young children, especially mothers. In Japan, it is not easy to access mothers who smoke and who have young children using conventional sampling procedure, such as a mail survey or at a baby check-up venue, due to the low prevalence of smoking in this group (8.2% among women in 2013 and 10.4% among mothers in 2010)[7,99]. The online survey method provides access to populations that cannot be easily reached in other ways[100].

On the other hand, online populations have demographic biases (e.g., generally much younger and better educated) compared to general populations due to using convenience sampling[101]. The distribution of household income and residential area among MACROMILL members shows a little difference from that of participants in national representative surveys[102]. However, educational level of study participants

(14.5 years for fathers and 12.8 years for mothers) was higher than the average among smoking parents from the national representative survey (13.2 years for fathers and 12.1 years for mothers)[99].

3.2.2 Study participants

Among the approximately 2,000,000 members of the online survey company, I recruited individuals who fulfilled the following inclusion criteria: (1) aged 20 to 59 for fathers and 20 to 49 for mothers, (2) current smokers, and (3) living together with his or her own children under 6 years old. I recruited fathers and mothers who smoke separately, rather than from the same household, as I conducted all the analyses by gender separately; thus, they do not comprise both members of a couple. I excluded participants aged under 20 years old from this study, as smoking is illegal for minors under this age in Japan, and collecting illegal information was not allowed by the survey company. I also excluded participants who did not live with a partner in the analysis (14 fathers and 52 mothers). As smoking-related social support was related to one's partner's behavior, the absence of a partner in the household would bias the effect of these variables.

3.2.3 Sample size estimation

I calculated the sample size using G*power version3.1.9. The prevalence of indoor smoking behavior among smoking parents with the lowest and the highest income levels was estimated as 42% and 28% among fathers, and 54% and 42% among mothers by the Longitudinal Survey of Newborns in the 21st Century in 2010[99]. Thus, standardized effect size was 0.36 for fathers and 0.24 for mothers. With a 95% confidence interval (CI) and 80% power, the minimal required sample size was 246 among fathers and 548 among mothers. Furthermore, regarding social norms of smoking (the main hypothesized mediator), the mean score for subjective norms of smoking was 2.70 (SD 1.01) among smoking men and 2.97 (SD 1.02) among smoking women in a previous study[103]. Thus, the standardized effect size was 0.26 for men and 0.29 for women. With a 95% confidence interval (CI) and 80% power, the minimal required sample size was 468 among fathers and 376 among mothers. To account for non-eligible participants and responses that would need to be discarded due to missing information, I decided on a sample size of 800 fathers and 800 mothers.

I also calculated minimum sample size for the robustness of structural equation modeling (SEM) using Kim's equation 7, where $\delta_{1-\beta}$ is the critical non-centrality parameter, ε is the population Root Mean Square Error of Approximation (RMSEA),

and *df* is the degrees of freedom[104]:

$$N\,\varepsilon = \frac{\delta_{1-\beta}}{\varepsilon^2\, df} + 1 = \frac{24.547}{0.05^2\,(31)} + 1 = 318$$

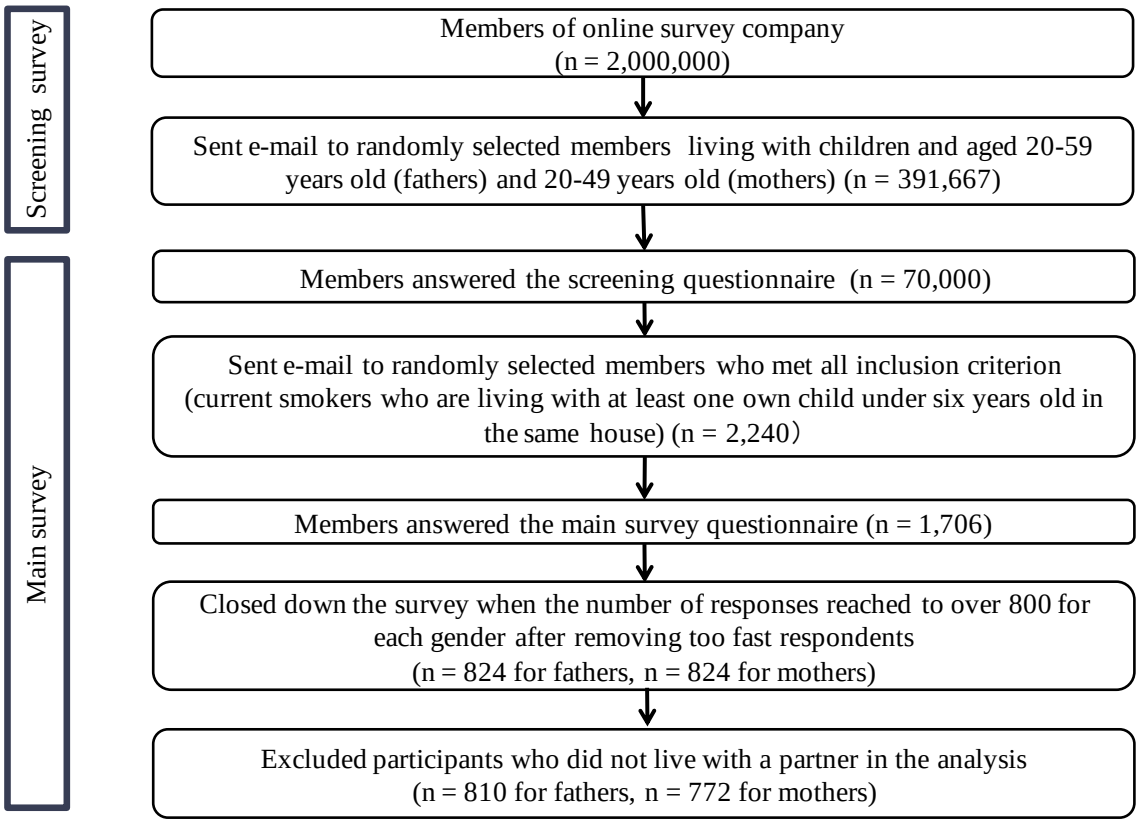
The hypothesized model (Figure 4) considers 12 measured variables (1 primary independent variable, 1 primary dependent variable, 7 mediating variables, and 3 confounding variables) with 31 *df*. According to the list of critical non-centrality parameters supplied by Kim, $\delta_{1-\beta} = 24.547$ for power = 0.80[104]. Thus, the proposed minimum sample size to achieve a power of 0.80 and RMSEA of 0.05 was 318 people, which were smaller than the required minimal sample size for expected effect size.

3.2.4 Data collection

In September 2014, I collected data from registered MACROMILL members. The survey consisted of two phases: the screening survey (four questions to screen for eligibility) and the main survey. The data collection procedure was as follows (Figure 5). First, the company sent emails to randomly selected members who have children and aged 20 to 59 for fathers and 20 to 49 for mothers from about 2,000,000 overall members. Second, the members who are interested in the survey accessed the webpage. On the online information sheet, I requested a participation in the screening survey and the following main survey if they met all inclusion criterion. Third, the members who

agreed the participation pressed the agree button and responded to online screening questionnaire with three questions. Fourth, after closing the screening survey, the company checked the eligibility of participants (i.e., current smokers who are living with at least one child under six years old in the same house) and sent the e-mail to request the participation in the main survey for those who met all inclusion criterion. Fifth, the participants who received the e-mail voluntarily accessed the webpage again, and responded to questionnaire by entering the answers directly on the main survey form on the web. Responding took about 15 to 20 minutes. Finally, the company closed the survey when the number of eligible respondents reached 800 in each gender group, after those who responded to the items too quickly were removed.

Figure 5 Data collection procedure



3.2.5 Measures

3.2.5.1 SES

I used education year and household income as SES measures.

Education year: I calculated education year based on the participants' educational attainment: 9 years for middle-school graduate, 12 years for high-school graduate, 14 years for having completed some college, 16 years for university graduate, and 18 years for postgraduate. I did not count dropping out as graduation and, thus, moved these individual to one education level lower (e.g., individuals who dropped out of university were assigned to the 12 education years).

Household income: I calculated the annual equivalent per capita household income in 2013 by dividing the annual household income by the square root of the number of persons living in the household. Then, I categorized the responses into quartiles in each gender group. The response options for annual household income were as follows: (1) no income, (2) 1,000,000 yen or less, (3) 1,000,000 yen to less than 2,000,000 yen, (4) 2,000,000 yen to less than 3,000,000 yen, (5) 3,000,000 yen to less than 4,000,000 yen, (6) 4,000,000 yen to less than 5,000,000 yen, (7) 5,000,000 yen to less than 6,000,000 yen, (8) 6,000,000 yen to less than 7,000,000 yen, (9) 7,000,000 yen to less than 8,000,000 yen, (10) 8,000,000 yen to less than 9,000,000 yen, (11)

9,000,000 yen to less than 10,000,000 yen, (12) 10,000,000 yen to less than 11,000,000 yen, (13) 11,000,000 yen to less than 12,000,000 yen, (14) 12,000,000 yen to less than 13,000,000 yen, (15) over 13,000,000 yen, and (16) do not want to answer/do not know. I assigned the household income values of all participants based on the mid-point of each income category.

3.2.5.2 Indoor smoking behavior

I measured parental indoor smoking behavior as a proxy of children's SHS exposure because it is significantly associated with biochemically measured SHS exposure in children. Among children whose parent(s) smoke indoors, 91.6% had a medium or high saliva cotinine level (≥ 0.10 ng/ml)[52].

I assessed self-reported smoking behavior inside the house with one question, based on a previous study[105]: "Do you smoke cigarettes inside the house?" The response options were "1 = every day," "2 = more than once per week," "3 = more than once per month," "4 = several times per year," and "5 = never." I then categorized indoor smoking as follows: 1) indoor smoking (participants who smoked inside the house every day or more than once per week), and 2) no indoor smoking (participants who smoked inside the house more than once per month, several times per year, or

never).

3.2.5.3 Possible mediating factors

I measured the following seven possible mediating factors in the relationship between SES and indoor smoking.

Descriptive social norms of smoking: I used six items to measure descriptive norms, based on a previous study about anti-smoking norms[106]. The definition of descriptive norms of smoking in this study is the perception of how many other people smoke (including close social network and the general public)[107]. I asked participants to estimate what percentage of different groups of people would smoke, using the question "How many (of your friends/typical Japanese men or women/typical Japanese men or women in your generation) do you think would smoke?" Responses were made on a 7-point Likert scale ranging from "1 = 0%" to "7 = 100%," in 20-point increments. I also asked the same question regarding how many indoor smokers at home there would be among (your friends/typical Japanese men or women/typical Japanese men or women in your generation). For this question, I added one further response option ("8 = none of my friends smoke") and replaced this with 0% when calculating the average score. I then calculated the average score for all response items, where a higher score

indicates having higher pro-smoking norms. The internal reliabilities (Cronbach's alpha) were 0.87 among fathers and 0.86 among mothers.

Subjective social norms of smoking: I used the following 12 items to measure subjective norms, based on a previous study about anti-smoking norms[106]. The definition of subjective norms of smoking in this study is the perception of what significant others approve of one's own smoking behavior[106]. The questions were "To what extent do/does your (friends/family/colleagues) approve of the following behaviors you engage in: (1) smoking; (2) smoking in your house; (3) smoking in front of others (or public places); and (4) smoking in your workplace?" Responses were made on a 5-point Likert scale ranging from "1 = strongly disapprove" to "5 = strongly approve." If the participants were unemployed, the online questionnaire automatically skipped the three questions about smoking in the workplace and the three questions about approval of smoking behavior by colleagues. I then calculated the average scores for all response items, where a higher score indicates having higher pro-smoking norms. The internal reliabilities (Cronbach's alpha) were 0.92 among fathers and 0.93 among mothers.

Household indoor smoking: I assessed indoor smoking behavior among household members by self-reported responses. First, I asked about the number of

cohabiting household members. Then, I asked if they were current smokers; if they were, I asked if they smoked indoors. On the basis of the responses, I formed the following household indoor smoking categories: (1) at least one household member smokes indoors; and (2) none of the members of the household smokes indoors.

Smoking-related social support: I assessed smoking-related social support using the *Partner Interaction Questionnaire* (PIQ), which is a 76-item scale that was originally developed to measure positive and negative perceived support for smoking cessation from one's spouse or partner[108]. The scale was later abbreviated to 20 items (PIQ-20)[91], and then to 10 items (PIQ-10) five of which are positive and five negative[109]. To minimize the burden on participants and maintain the quality of their responses, I used the PIQ-10 in this study. I translated all of the questions into Japanese and checked the accuracy using the back-translation method.

I asked participants to answer the questions with regard to smoking-related support from their spouse or partner. If they did not have a spouse or partner, I asked them to pick the person, friend, or relative who would follow their smoking behavior most closely[91]. Participants provided the frequency with which their spouse/partner/significant other had performed certain smoking-related support behaviors (e.g., giving compliments for not smoking [positive behavior], talking the

participant out of smoking a cigarette [negative behavior]) in the last month. Responses were made on a 5-point Likert scale ranging from "1 = never" to "5 = very often." The total score is calculated by summing scores for the five positive (range = 5–25) and five negative (range = 5–25) items separately. Then I calculated smoking-related social support score (range = 0.2–5) by multiplying the positive total score by the negative total score. The ratio of positive/negative support is a better predictor of abstinence than either positive or negative score alone[91]. The internal reliabilities (Cronbach's alpha) were 0.91 for the positive scale and 0.91 for the negative scale among fathers and 0.87 for the positive scale and 0.89 for the negative scale among mothers.

Worksite smoking bans: I measured worksite smoking bans using the following question, which was developed in previous research in Japan[110]: "Which of the following statements best describes the rules about smoking bans in your workplace?" The response options were "1 = complete smoking bans in the area," "2 = complete smoking bans inside the building," "3 = separation of smoking areas (smoking room and corner)," "4 = no smoking bans," "5 = no workplace (e.g., working in the home)." The responses were divided into the following three categories: (1) complete bans (1 and 2 ratings); (2) partial bans (3 rating); and (3) no bans (4 and 5 ratings). While most of the fathers were employed (employment rate: 98.0%), over half of the mothers were

unemployed in the participants (employment rate: 44.4%). However, I included unemployed participants in the analysis and categorized as (3) no bans, because my interest was whether or not they were exposed to smoke-free policies every weekday.

Knowledge about the risks of SHS exposure in children: I used five items to measure knowledge about SHS risks by revising questions that were used in previous studies so that these related more specifically to SHS knowledge in regard to children[111,112]. The questions described the effects of SHS on sudden infant death syndrome, asthma induction and exacerbation, bronchitis, middle ear infection, and likelihood of becoming a smoker in the future. The response options were "1 = correct," "2 = incorrect," and "3 = don't know." The total score is calculated by summing scores for the correct items (range = 0–5). The internal reliabilities (Cronbach's alpha) were 0.80 among fathers and 0.71 for mothers.

Knowledge about precautions to avoid SHS exposure in children: I used three items to measure knowledge about precautions to avoid SHS exposure among children, based on previous studies about misconceptions in this regard among parents in Japan[113–115]. The questions were "Do you think the following sentences are correct or incorrect? 'We can avoid SHS among children by permitting smoking only in certain rooms/installing an electronic air cleaner/moving a fan'." The response options were "1

= correct," "2 = incorrect," and "3 = don't know." The total score is calculated by summing scores for the incorrect items (range = 0–3). The internal reliabilities (Cronbach's alpha) were 0.80 among fathers and 0.79 for mothers.

3.2.5.4 Socio-demographic variables

I assessed participants' age, marital status, and age of the youngest children living at home as socio-demographic variables, and adjusted for these in analyzing both father and mother models.

3.2.6 Questionnaire

I used a structured questionnaire in Japanese for data collection. I applied validated and widely used scales for environmental and psychological variables, which were possible mediators of the examined relationship. For the scale that had not been validated in Japanese (smoking-related social support), translation and back-translation was undertaken by bilingual speakers of Japanese and English. For variables that had no validated scale (social norms and knowledge), I developed the questions based on the previous literature, as mentioned in the "Measures" subsection of the Method.

To check the flow of questionnaire and readability and acceptability of the

contents of the questionnaire, several professional researchers reviewed the questionnaire including tobacco control expert, public health researchers, and economics researcher. Two professional community workers with experience in supporting disadvantaged households with young children also reviewed the four items regarding indoor smoking to ensure that they reflected the real living environments among disadvantaged households. On the basis of comments from these reviewers, I revised the questionnaires before conducting a pilot study among 40 members (20 of each gender).

To assess the reliability, I calculated Cronbach's alpha for each possible mediating variable except for categorical variables (household indoor smoking, and worksite smoking bans). I considered 0.70 as an acceptable value of alpha[116].

3.2.7 Statistical analyses

I tested the bivariate associations between SES and the mediating variables using t tests and chi-square tests (χ^2) as appropriate. Then, I tested bivariate regression analysis of the associations between SES/possible mediating variables and indoor smoking behavior, and the associations between SES and possible mediating variables. I also calculated Pearson's correlations between mediating variables. I conducted all bivariate

analyses with Stata version 13.0.

Next, I applied the SEM approach to test the hypothesized model using Mplus 7.0 software package. The biggest advantage of applying the SEM approach in this study is that it can be used to test overall models rather than individual coefficients, incorporating multiple dependents as well as mediating variables. The model was constructed with pathways from SES to indoor smoking behavior, with the 7 mediating factors included. I used weighted least squares with robust standard errors (WLSMV) parameter estimation to estimate free parameters in the analysis, as the dependent variable (indoor smoking behavior) is categorical.

I tested the hypothesized model in each gender group separately, and identified gender differences in the relationships among variables. I used three model fit statistics that are commonly used in SEM: Bentler's comparative fit index (CIF), Tucker-Lewis index (TLI), and RMSEA. The following model fit indices are recommended as indicating good model fit: CFI > 0.95, TLI > 0.95, and RMSEA < 0.06[117].

I used the full information maximum likelihood estimator to account for missing data. This estimator shows less bias and is more efficient than other methods, including the listwise deletion approach[118]. In this study, only the household income variable had missing data (41 missing [5.0%] for fathers, 62 missing [7.8%] for mothers). I

assumed that these were missing at random as non-completion of this variable was not significantly associated with indoor smoking behavior ($p = 0.81$ for fathers, $p = 0.88$ for mothers).

3.2.8 Ethical considerations

On the online information sheet that appeared prior to the screening and main surveys, I informed the participants that (1) participation in the study was completely voluntary and they were free to withdraw at any time without any consequences, (2) all responses would be kept confidential and the study results would be anonymous, and (3) collected data will be used for scientific purposes only (Appendices 3-5). I required participants who agreed with participation to press an "agree" button instead of providing a signature. Those who pressed the "agree" button could then access the online questionnaire.

The online survey company paid reward points to participants who completed the whole questionnaire, which could then be used for online shopping. This study was approved by the Research Ethics Committee of the Graduate School of Medicine at The University of Tokyo, Japan (approval number: 10603).

3.3 Results

3.3.1 Descriptive characteristics of the study participants

Table 9 shows the descriptive characteristics of the study participants by gender. The mean age was 38.9 years old (SD 6.8) for fathers and 31.6 years old (SD 5.9) for mothers. Most of fathers (99.3%) and mothers (99.4%) were married. The mean age of the youngest child was 3.1 years old (SD 2.0) for fathers and 2.4 years old (SD 2.0) for mothers.

The mean education year was 14.5 years (SD 2.1) for fathers and 12.8 years (SD 2.1) for mothers, and the mean annual equivalent household income per capita was 3,300,273 yen for fathers (SD 1,528,064) and 2,550,084 yen for mothers (SD 1,308,352). The lowest quartile of annual equivalent household income per capita was 2,020,000 yen or less, low quartile income was from 2,250,000 yen to 3,170,000 yen, high quartile income was from 3,180,000 yen to 3,890,000 yen, and the highest quartile income was 4,250,000 yen or more for fathers; and the lowest quartile of annual equivalent household income was 1,700,000 yen or less, low quartile income was from 1,750,000 yen to 2,080,000 yen, high quartile income was from 2,250,000 yen to 3,060,000 yen, and the highest quartile income was 3,180,000 yen or more for mothers.

Most fathers (98.3%) were employed, while over half (55.6%) of the mothers were unemployed.

The prevalence of indoor smoking was much higher among mothers (63.7%) than fathers (35.8%). Most fathers (84.3%) did not live with smoking household members, while over half of mothers (58.5%) live with smoking household members.

Table 9 Characteristics of the study participants by gender

	Fathers n = 810			Mothers n = 772			
Socio-economic status							
	Range	Mean	SD	Range	Mean	SD	*p* -value a)
Education year	9-18	14.5	2.1	9-18	12.8	2.1	<0.001*
Equivalent household income (thousand yen)	0-9,550	3,302	1,528	0-8,840	2,550	1,308	<0.001*
		n	%		n	%	
Equivalent household income (quartile)							
Lowest		172	21.2		157	20.3	
Low		192	23.7		161	20.9	
High		193	23.8		189	24.5	
Highest		213	26.3		208	26.9	
Missing		40	4.9		57	7.4	
Employment status							<0.001*
Unemployed		14	1.7		429	55.6	
Employed		796	98.3		343	44.4	
Possible mediating factors							
	Range	Mean	SD	Range	Mean	SD	
Knowledge about the risks of SHS expousre in children	0-5	2.5	1.8	0-5	3.0	1.5	<0.001*
Knowledge about precautions to avoid SHS in children	0-3	1.3	1.2	0-3	1.4	1.2	0.962
Descriptive social norms	1-7	3.4	0.9	1-6.8	3.5	1.1	0.020*
Subjective social norms	1-5	3.2	0.7	1-5	3.3	0.9	0.083
Smoking-related social support	0.2-5	0.8	0.3	0.2-5	1.0	0.4	<0.001*
		n	%		n	%	
Household members smoke indoors							<0.001*
No or not living with a partner		683	84.3		320	41.5	
Yes		127	15.7		452	58.5	
Smoking bans at worksite							<0.001*
No smoking bans or no worksite or unemployed		147	18.1		504	65.3	
Separation of smoking areas		513	63.3		189	24.5	
Complete smoking bans inside the building or area		150	18.5		79	10.2	
Socio-demographic status							
	Range	Mean	SD	Range	Mean	SD	
Age (years)							<0.001*
	20-59	38.9	6.8	20-49	31.6	5.9	
Age of the youngest child (years)							<0.001*
	0-6	3.1	2.0	0-6	2.4	2.0	
		n	%		n	%	
Marital status							0.824
Unmarried		6	0.7		5	0.6	
Married		804	99.3		767	99.4	
Smokes indoors							<0.001*
No		520	64.2		280	36.3	
Yes		290	35.8		492	63.7	

* $p < 0.05$

a) p-value is based on t-test for continuous variables and chi-square test for categorical variables between fathers and mothers.

3.3.2 Bivariate associations between SES/possible mediating variables and indoor smoking behavior

Tables 10 and 11 show the results of bivariate regression analysis of associations between SES and indoor smoking behavior by gender. For both fathers and mothers who smoke, a lower income and education were significantly associated with indoor smoking behavior. Tables 10 and 11 also show the results of bivariate associations between possible mediating variables and indoor smoking behavior by gender. For fathers who smoke, indoor smoking behavior was negatively associated with better knowledge about the risks of SHS exposure and better knowledge about precautions to avoid SHS exposure, and positively associated with higher descriptive norms, higher subjective norms, higher smoking-related social support, worksite smoking bans, and household indoor smoking.

For mothers who smoke, indoor smoking behavior was negatively associated with better knowledge about precautions to avoid SHS exposure in children, and positively associated with higher descriptive norms, higher subjective norms, and household indoor smoking. No statistically significant associations were detected between indoor smoking behavior and knowledge about the risks of SHS exposure, smoking-related social support, or worksite smoking bans.

Table 10 Results of the regression analysis of indoor smoking behavior among fathers

	Fathers	**n = 810**		
	Smokes indoors			
	Yes	No		*P*-value
Socio-economic status				
	Mean		Coefficient	
Education year	14.2	14.7	-0.02	0.003*
Equivalent household income (thousand yen)	3,130	3,395	-0.01	0.021*
	Percent		OR	
Equivalent household income (quartile)				
Lowest	47.1	52.9	1.00	
Low	32.3	67.7	0.54	0.004*
High	34.2	65.8	0.58	0.012*
Highest	31.5	68.5	0.52	0.002*
Missing	35.0	65.0	0.60	0.168
Possible mediating variables				
	Mean		Coefficient	
Knowledge about the risks of SHS expousre in children	2.4	2.6	-0.02	0.039*
Knowledge about precautions to avoid SHS in children	1.2	1.4	-0.03	0.032*
Descriptive social norms	3.6	3.3	0.08	<0.001*
Subjective social norms	3.4	3.1	0.14	<0.001*
Smoking-related social support	0.8	0.9	0.09	<0.001*
	Percent		OR	
Worksite smoking bans				
No smoking bans or no worksite or unemployed	43.5	56.5	1.00	
Separation of smoking areas	33.5	66.5	0.65	0.026*
Complete smoking bans inside the building or the area	36.0	64.0	0.73	0.185
Household members smoke indoors				<0.001*
No or not living with an adult	28.0	72.0	1.00	
Yes	78.0	22.0	9.11	
Socio-demographic status				
	Mean		Coefficient	
Age (years)	39.7	38.5	0.01	0.016*
Age of the youngest child (years)	3.5	2.8	0.04	<0.001*
	Percent		OR	
Marital status				0.044 *
Unmarried	83.3	16.7	1.00	
Married	35.5	64.6	0.11	

OR: odds ratio

* $p < 0.05$

Table 11 Results of the regression analysis of indoor smoking behavior among mothers

	Mothers n = 772			
	Smokes indoors			
	Yes	No		*P*-value
Socio-economic status				
	Mean		Coefficient	
Education year	12.6	13.2	-0.03	<0.001*
Equivalent household income (thousand yen)	2,474	2,684	-0.01	0.039*
	Percent		OR	
Equivalent household income (quartile)				
Lowest	68.8	31.2	1.00	
Low	64.0	36.0	0.81	0.364
High	66.7	33.3	0.91	0.674
Highest	56.7	43.3	0.59	0.019*
Missing	64.9	35.1	0.84	0.592
Possible mediating variables				
	Mean		Coefficient	
Knowledge about the risks of SHS expousre in children	3.0	3.1	-0.02	0.117
Knowledge about precautions to avoid SHS in children	1.3	1.5	-0.04	0.005*
Descriptive social norms	3.7	3.2	0.09	<0.001*
Subjective social norms	3.4	3.0	0.12	<0.001*
Smoking-related social support	1.0	1.0	0.01	0.909
	Percent		OR	
Worksite smoking bans				
No smoking bans or no worksite or unemployed	6.7	93.3	1.00	
Separation of smoking areas	58.7	41.3	0.71	0.052
Complete smoking bans inside the building or the area	57.0	43.0	0.66	0.093
Household members smoke indoors				<0.001*
No or not living with an adult	30.3	69.7	1.00	
Yes	87.4	12.6	15.93	
Socio-demographic status				
	Mean		Coefficient	
Age (years)	31.3	32.1	0.01	0.136
Age of the youngest child (years)	2.5	2.4	0.01	0.654
	Percent		OR	
Marital status				0.862
Unmarried	60.0	40.0	1.00	
Married	63.8	36.2	1.17	

OR: odds ratio

* $p < 0.05$

3.3.3 Bivariate associations between SES and possible mediating variables

Tables 12 and 13 show the results of bivariate regression analysis between SES and possible mediating variables. Among fathers who smoke (Table 12), education year was positively associated with better knowledge about the risks of SHS exposure and worksite smoking bans. In contrast, education year was negatively associated with higher descriptive norms, higher subjective norms, higher social stress, and household indoor smoking. No statistically significant associations were detected between education year and knowledge about precautions to avoid SHS in children, or smoking-related social support. Household income was positively associated with higher general social support and worksite smoking bans. In contrast, household income was negatively associated with higher descriptive norms, higher subjective norms, and higher social stress. No statistically significant associations were detected between household income and knowledge about the risks of SHS exposure, knowledge about precautions to avoid SHS, smoking-related social support, or household indoor smoking.

Among mothers who smoked (Table 13), education year was positively associated with better knowledge about the risks of SHS exposure, and worksite smoking bans. In contrast, education year was negatively associated with higher descriptive norms, higher

subjective norms, and household indoor smoking. No statistically significant associations were detected between education year and knowledge about precautions to avoid SHS, or smoking-related social support. Household income was positively associated with worksite smoking bans. In contrast, household income was negatively associated with higher descriptive norms and household indoor smoking. No statistically significant associations were detected between household income and knowledge about the risks of SHS exposure, knowledge about precautions to avoid SHS, subjective norms, or smoking-related social support.

Tables 14 and 15 show Pearson's correlations of possible mediating variables among fathers and mothers.

Table 12 Results of the regression analysis of possible mediating variables as dependent variables among fathers

	Eductinoal year (n = 810)		Household income (n = 770)	
	Coefficient	*P* -value	Coefficient	*P* -value
Possible mediating factors				
Knowledge about the risks of SHS expousre in children	0.07	0.018*	0.08	0.178
Knowledge about precautions to avoid SHS in children	-0.01	0.808	0.05	0.250
Descriptive social norms	-0.12	<0.001*	-0.15	<0.001*
Subjective social norms	-0.03	0.008*	-0.05	0.028*
Smoking-related social support	0.01	0.401	-0.01	0.669
Smoking bans at worksite	0.09	<0.001*	0.12	<0.001*
Household members smoke indoors	-0.02	<0.001*	-0.02	0.080
Socio-demographic status				
Age	0.33	0.004*	1.16	<0.001*
The youngest age of child	0.03	0.348	0.15	0.023*
Marital status	-0.01	0.566	-0.01	0.097

* $p < 0.05$

Table 13 Results of the regression analysis of possible mediating variables as dependent variables among mothers

	Eductinoal year (n = 772)		Household income (n = 715)	
	Coefficient	*P* -value	Coefficient	*P* -value
Possible mediating factors				
Knowledge about the risks of SHS expousre in children	0.07	0.008*	0.01	0.798
Knowledge about precautions to avoid SHS in children	0.03	0.167	0.05	0.198
Descriptive social norms	-0.16	<0.001*	-0.20	<0.001*
Subjective social norms	-0.09	<0.001*	-0.04	0.156
Smoking-related social support	-0.01	0.565	-0.01	0.722
Smoking bans at worksite	0.06	<0.001*	0.11	<0.001*
Household members smoke indoors	-0.04	<0.001*	-0.04	0.018*
Socio-demographic status				
Age	0.72	<0.001*	1.33	<0.001*
The youngest age of child	0.11	0.001*	0.38	<0.001*
Marital status	0.01	0.270	0.00	0.501

* $p < 0.05$

Table 14 Pearson's correlations of possible mediating variables among fathers

		1	2	3	4	5	6	7
Possible mediating factors								
1	Knowledge about the risks of SHS expousre in children	—						
2	Knowledge abour precautions to avoid SHS in children	0.18***	—					
3	Descriptive social norms	-0.06	0.01	—				
4	Subjective social norms	-0.06	-0.02	0.22***	—			
5	Smoking-related social support	0.01	-0.09*	0.04	0.07*	—		
6	Smoking bans at worksite	0.06	0.07*	-0.13***	-0.09*	0.04	—	
7	Household members smoke indoors	-0.01	0.01	0.18***	0.18***	0.12***	-0.06	—

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 15 Pearson's correlations of possible mediating variables among mothers

		1	2	3	4	5	6	7
Possible mediating factors								
1	Knowledge about the risks of SHS expousre in children	—						
2	Knowledge abour precautions to avoid SHS in children	0.17***	—					
3	Descriptive social norms	-0.11***	-0.04	—				
4	Subjective social norms	-0.12***	-0.03	0.38***	—			
5	Smoking-related social support	-0.01	0.01	0.10**	0.18***	—		
6	Smoking bans at worksite	0.03	0.04	-0.13***	-0.14***	0.02	—	
7	Household members smoke indoors	-0.04	-0.09*	0.21***	0.25***	0.11**	-0.02	—

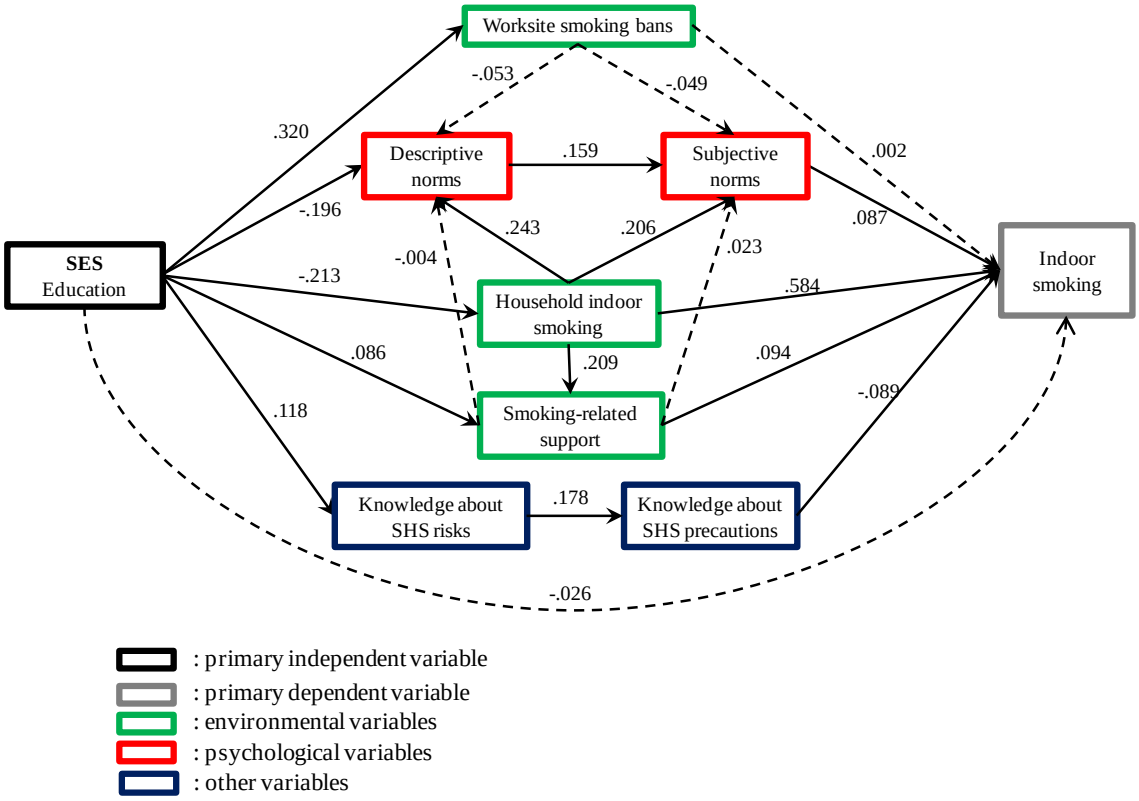
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

3.3.4 Path analysis for the hypothesized models

3.3.4.1 Education model

First, I conducted a path analysis of hypothesized model (Figure 4) using the SEM approach with education year as the primary independent variable. Figure 6 shows the standardized estimates of the path coefficients in the final model among fathers who smoke. The WLSMV estimation showed acceptable model fit values: RMSEA = 0.001, CFI = 1.000, and TLI = 1.003. Education year was negatively associated with higher descriptive norms and descriptive norms were positively associated with indoor smoking behavior via the mediator of higher subjective norms. Furthermore, household indoor smoking was positively associated with both descriptive and subjective social norms of smoking, but smoking-related support and worksite smoking bans were not associated with either descriptive or subjective social norms of smoking. In addition, education year was negatively associated with better knowledge about the risks, and it was positively associated with indoor smoking behavior via the mediator of knowledge about precautions. The variables in the model accounted for 46.4% of the variance in indoor smoking behavior ($R^2 = 0.464$).

Figure 6. Model of the pathways between education year and indoor smoking behavior among smoking fathers.



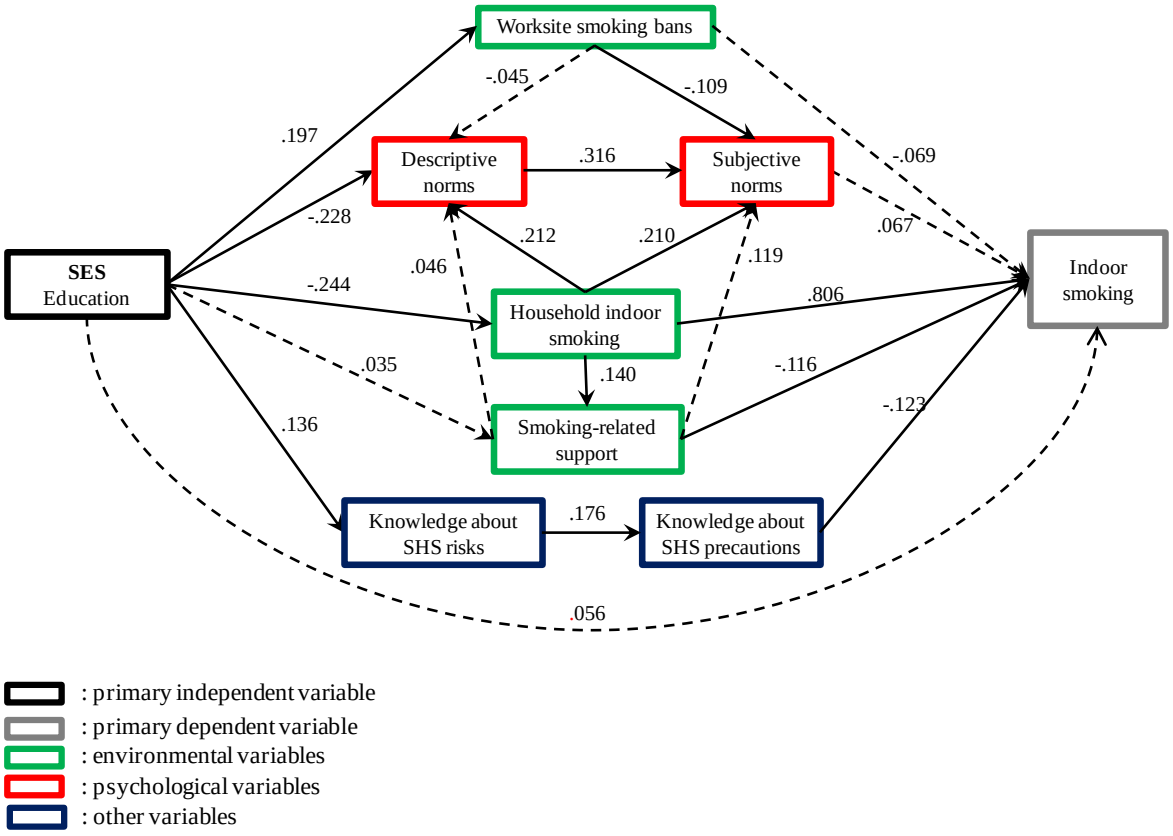
The analysis was adjusted by age, marital status, and age of the youngest child. Path coefficient scores are provided on paths with standardized coefficients. Dotted lines denote non-significant paths ($p > 0.05$). (n = 810; $R^2 = 0.464$)

Figure 7 shows the standardized estimates of path coefficients in the hypothesized model among mothers who smoke. The WLSMV estimation showed acceptable model fit values: RMSEA = 0.031, CFI = 0.978, and TLI = 0.955. Education year was negatively associated with higher descriptive norms and descriptive norms were positively associated with subjective norms, but they were not significantly associated with indoor smoking behavior. Furthermore, household indoor smoking and worksite smoking bans were positively associated with one or both social norms of

smoking, but smoking-related support was not associated with either descriptive or subjective norms of smoking. In addition, education year was positively associated with better knowledge about the risks of SHS, and it was negatively associated with indoor smoking behavior via knowledge about precautions to avoid SHS exposure. The variables in the model accounted for 68.4% of the variance in indoor smoking behavior ($R^2 = 0.684$). The direct effect of education year on indoor smoking was not statistically significant for either fathers or mothers.

Therefore, for educational model, my fourth hypothesis (social norms of smoking mediate the association between SES and indoor smoking behavior among smoking parents) was supported only among fathers. My fifth hypothesis (environmental variables (household indoor smoking, smoking-related social support, and worksite smoking bans) influence social norms of smoking, and also mediate the association between SES and indoor smoking behavior among smoking parents) was supported, except for smoking-related social support. Finally, my sixth hypothesis (knowledge about children's SHS exposure mediates the association between SES and indoor smoking behavior among smoking parents) was supported.

Figure 7. Model of the pathways between education year and indoor smoking behavior among smoking mothers.

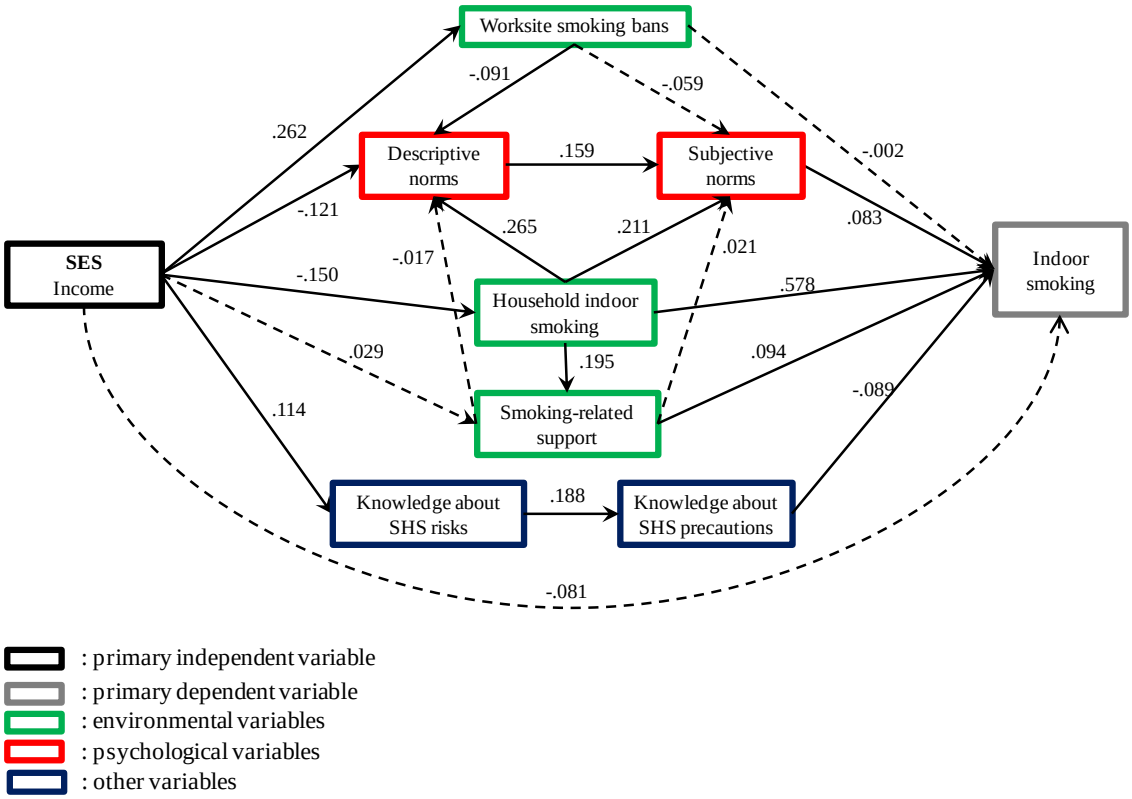


The analysis was adjusted by age, marital status, and age of the youngest child.
Path coefficient scores are provided on paths with standardized coefficients.
Dotted lines denote non-significant paths ($p > 0.05$). (n =772; $R^2 = 0.684$)

3.3.4.2 Household income model

Figure 8 shows the standardized estimates of path coefficients in the hypothesized model among mothers who smoke. The WLSMV estimation showed acceptable model fit values: RMSEA = 0.013, CFI = 0.992, and TLI = 0.983. Household income was negatively associated with higher descriptive norms and descriptive norms were positively associated with indoor smoking behavior via the mediator of higher subjective norms. Furthermore, household indoor smoking and worksite smoking bans were positively associated with one or both social norms of smoking, but smoking-related support was not associated with either descriptive or subjective norms of smoking. In addition, education year was positively associated with better knowledge about the risks of SHS, and it was negatively associated with indoor smoking behavior via the mediator of knowledge about precautions. The variables in the model accounted for 46.9% of the variance in indoor smoking behavior ($R^2 = 0.469$).

Figure 8. Model of the pathways between household income and indoor smoking behavior among smoking fathers



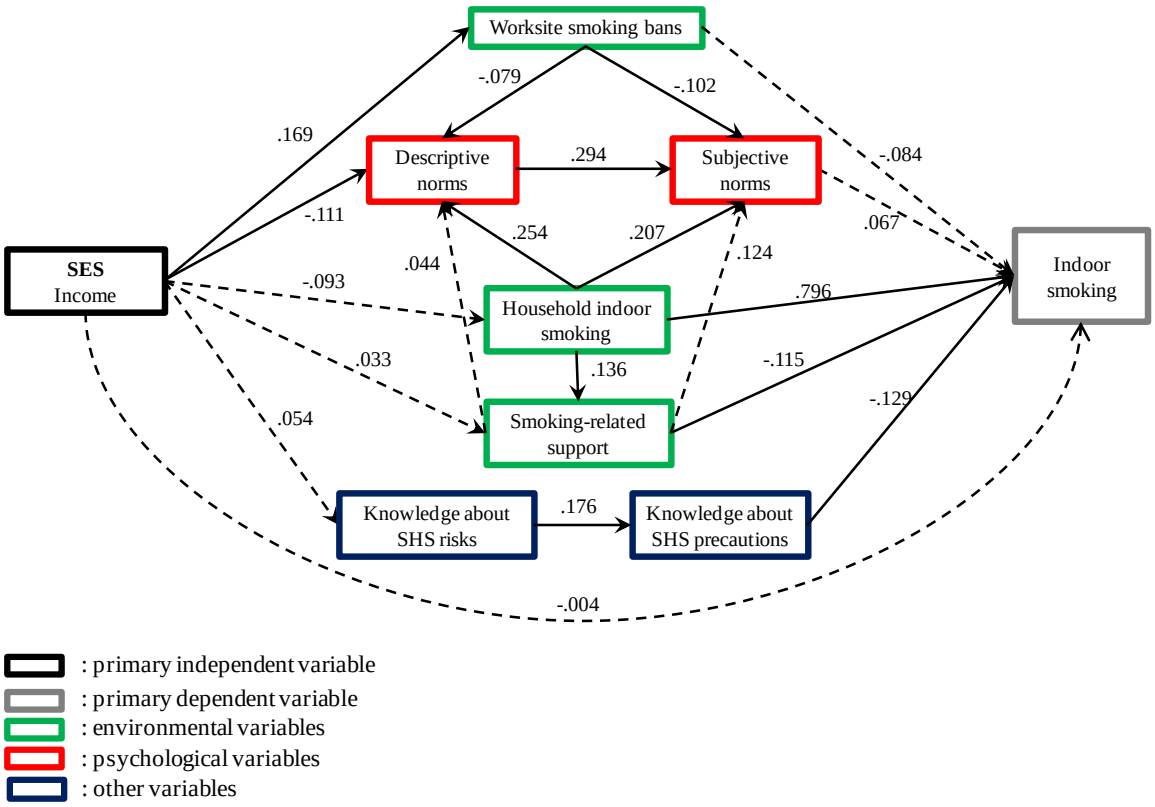
The analysis was adjusted by age, marital status, and age of the youngest child.
Path coefficient scores are provided on paths with standardized coefficients.
Dotted lines denote non-significant paths ($p > 0.05$). (n = 810; $R^2 = 0.469$)

Figure 9 shows the standardized estimates of path coefficients in the hypothesized model among mothers who smoke. The WLSMV estimation showed acceptable model fit values: RMSEA = 0.038, CFI = 0.965, and TLI = 0.929. Household income was negatively associated with higher descriptive norms and descriptive norms were positively associated with subjective norms, but they were not significantly associated with indoor smoking behavior. Furthermore, household indoor smoking and

worksite smoking bans were positively associated with both social norms of smoking, but smoking-related support was not associated with either descriptive or subjective norms of smoking. In addition, education year was not positively associated with better knowledge about the risks of SHS, although it was negatively associated with indoor smoking behavior via the mediator of knowledge about precautions to avoid SHS exposure. The variables in the model accounted for 68.7% of the variance in indoor smoking behavior ($R^2 = 0.687$). The direct effect of household income on indoor smoking was not statistically significant for either fathers or mothers.

Therefore, for household income model, my fourth hypothesis (social norms of smoking mediate the association between SES and indoor smoking behavior among smoking parents) was supported only among fathers. My fifth hypothesis (environmental factors (household indoor smoking, smoking-related social support, and worksite smoking bans) influence social norms of smoking, and also mediate the association between SES and indoor smoking behavior among smoking parents) was supported, except for smoking-related social support. Finally, my sixth hypothesis (knowledge about children's SHS exposure mediates the association between SES and indoor smoking behavior among smoking parents) was supported only among fathers.

Figure 9. Model of the pathways between household income and indoor smoking behavior among smoking mothers.



The analysis was adjusted by age, marital status, and age of the youngest child. Path coefficient scores are provided on paths with standardized coefficients. Dotted lines denote non-significant paths ($p > 0.05$). (n = 772; $R^2 = 0.687$)

In all models for education and household income, age was adjusted as a confounding variable in the relationship between SES and indoor smoking, and a predictor variable of all possible mediating variables. The age of the youngest child and marital status were adjusted as predictor variables of indoor smoking behavior.

3.4 Discussion

The proposed final models indicates that social norms of smoking mediated the pathways between SES and indoor smoking behavior among fathers who smoke, and knowledge about children's SHS exposure mediated the pathways among parents who smoke. In the same pathway models, social norms of smoking were positively associated with household indoor smoking and negatively associated with worksite smoking bans.

To the best of my knowledge, this is the first study to test the pathways between SES and indoor smoking behavior among smoking parents living with their own children. Previous studies identified that social norms[37] and health concerns[37] mediate the pathways between SES and smoking behavior (e.g., smoking cessation), and the findings in this study extended the evidence to indoor smoking behavior among parents who smoke.

3.4.1 Social norms of smoking

Descriptive and subjective norms of smoking mediated the pathways between SES and indoor smoking behavior among fathers, but not mothers. Compared with fathers who smoke in the high-SES group, low-SES smoking fathers were more likely

to estimate a higher prevalence of smoking among others (descriptive norms) and tended to receive higher approval of smoking behavior from significant others (subjective norms), making them more likely to smoke indoors. Previous studies also support this finding, with SES indicators are predictors of descriptive norms of smoking[77], and social norms regarding what ought to be done (subjective norms) predict smoking cessation more strongly than the actions that most people engage in (descriptive norms)[107]. But this study extended the evidence for social norms as a mediator between SES and indoor smoking behavior among smoking parents. For smoking fathers, the desire to be seen by family and friends to act in acceptable way in their social context would promote or inhibit to smoke inside the house[119].

Contrary to my hypothesis, social norms of smoking did not mediate the pathways among mothers who smoke. Although low-SES mothers were more likely to have pro-smoking norms, this was not associated with their indoor smoking behaviors. One possible explanation for this finding is that participants in this study (current smoking mothers) might already be resistant to social pressure to quit smoking because they are a minority group, even in the lowest SES group in Japan. Thus, they might not care whether or not their family or friends accept their smoking behavior when they smoke indoors. Rather, low-SES mothers might perceive that smoking at home is a necessary

daily habit that brings them emotional relief[120].

3.4.2 Environmental variables and social norms of smoking

Descriptive and subjective norms of smoking were associated with environmental variables (household indoor smoking and worksite smoking bans). Worksite smoking bans are effective to facilitate smoking cessation among parents who smoke[121], and changing social norms of pro-smoking attitudes may be a mechanism for this association[93]. This study suggests that the effects of worksite smoking bans may not only contribute to smoking cessation, but also help smoking fathers to stop indoor smoking, even if they cannot entirely quit smoking. Similarly, watching smoking behaviors of household members provides consensus information about what is acceptable, and may motivate fathers to engage in the same behavior[103,122]. Thus, to discourage pro-smoking norms among low-SES fathers, it would be effective to address smoking behavior among household members and work colleagues[123].

Furthermore, household indoor smoking also directly mediated the pathways between SES and indoor smoking behavior. It is well known that smokers are more likely to have a smoking partner than are non-smokers[81]. This study showed that the association of indoor smoking behavior between couples or families was stronger

among low-SES parents, which suggests the need to consider the mutual effects of smoking behavior between parents in this group[124]. According to a study which examined the person-to-person spread of smoking behavior, smokers in interconnected groups (such as a partner, siblings, and friends) share social norms of smoking and change their smoking behavior in concert[79]. In the same way, high-SES smoking parents might be more likely to stop their indoor smoking than low-SES parents, as they share less pro-smoking norms with their families.

In the father model, the association between smoking-related support and indoor smoking behavior showed unexpected direction. Smoking-related support (i.e., the positive support score multiplied by the negative support score) was positively associated with indoor smoking behavior. This finding is inconsistent with previous studies about smoking cessation, which showed that positive support predicted successful quitting[90,109], whereas negative support predicted relapse[84,125]. It is puzzling that partner's positive support was positively associated with indoor smoking behavior. Smoking behavior change would vary depend on the couples' dynamics including disengaged, conflictual, or accommodating relationship regarding tobacco use[124]. Further study is needed to determine the mechanisms of this unexpected relationship among fathers who smoke.

3.4.3 Knowledge about SHS exposure among children

Knowledge about SHS exposure among children also mediated the relationship between SES and indoor smoking behavior. While over 60% of fathers and nearly 80% of mothers knew that SHS exposure increases the risk of bronchitis and asthma among children, the percentage who knew this was approximately 40% among fathers who had a middle school education year or less. Along with expanding tobacco control measures, knowledge about SHS risks has greatly improved among the general population[126]. However, this finding suggested that the level of knowledge differs by SES among smoking parents[96], and knowledge about precautions to avoid SHS was positively associated with indoor smoking behavior. The knowledge does not necessarily predict behavior change for their own health, but it might do so in the case of their children's health. In Japan, the concept of smoke-free homes has not been disseminated well, and smoking under the kitchen extractor fan is common in households with children[127]. Thus, many low-SES parents might mistakenly believe that such a partial smoking ban is effective. While most parents implement their own way to protect their children from health risks, different levels of accurate knowledge across social classes may generate an unequal distribution in indoor smoking behavior. Thus, to narrow the inequalities in

parental indoor smoking behavior, it would be effective to improve knowledge about effective precautions as well as risks for SHS among low-SES parents who smoke.

To confirm the proposed final models, I plan to test the final models using prospective designs to determine the relationships between SES, mediating factors, and indoor smoking behavior over time in future. It is also important to identify other key pathways (both mediators and modifiers) between SES and indoor smoking behaviors among smoking parents. In particular, social norms of smoking did not mediate the pathways in the mother model, and an association between one's partner's smoking-related support and indoor smoking behaviors showed an unexpected direction in the father model. Gender difference on the mechanisms between SES and smoking behavior is suggested, although evidence is limited[35,128]. By clarifying other factors that might affect gender difference (e.g., the quality of partner-relationships[91], partners' smoking histories[83], and father's caring circumstances[21]), more effective interventions can be developed to reduce SHS exposure in low-SES children.

This study has several limitations need to be considered. First, as this study had a cross-sectional design, the associations did not prove causality. Regarding the association between SES and the mediating variables, the causality is likely to be justified as SES indicators, especially educational attainment, would not change over

the time period of interest. However, such an assumption is not valid for the causality from the mediating variables to indoor smoking behavior. The relationship between indoor smoking behavior and indoor smoking by household members, in particular, might have mutual effects. Future studies should collect longitudinal data to obtain a more accurate pathway model.

Second, selection bias might exist due to the self selection of participants in the online survey, and exclusion of single and teenage parent(s). Participants in this study had higher levels of education than nationally representative random samples. Thus, an association between educational level and mediating variables might have been underestimated. In addition, a difference in responses about attitudes, perception, and motivation are reported among online and telephone survey respondents in a previous study, which may be because telephone respondents tended to choose positive options more often[129]. However, such differences are not reported for psychological variables such as depression and social stress[130,131]. Furthermore, exclusion of single and teenage parent(s) would limit the generalizability, although the proportions of those parent(s) are small in Japan (3% of fathers and 6% of mothers were single parents in this study; and 0.2% of fathers and 1.8% of mothers were teenage parents among

smoking parents[99]). Future studies could determine whether the identified models are also applicable to random samples and those excluded groups as well.

Third, the coefficient of determination (R^2) was relatively low for fathers. Although the tested models adequately fit the data, the model explained about the 46% of the variance in indoor smoking in the father models. For mothers, the R^2 was relatively higher (around 68%), but none of the variables mediated the pathways in the mother income model. Thus, other important and omitted variables might exist that mediate the pathways between SES and indoor smoking behavior for both fathers and mothers. For instance, social norms of smoking at the community level[132] was not measured in this study.

Finally, the intensity of indoor smoking behavior was not considered in this study. Although partial restrictions of indoor smoking have a more negative effect on children's health compared to complete bans, the level of exposure to SHS among children is lower in this instance than no smoking restrictions[105]. Measuring the intensity of indoor smoking behavior (e.g., the number of cigarettes parents smoke in front of their children) would provide more accurate results.

Despite these limitations, this study is the first to examine the multiple pathways between SES and indoor smoking behavior among smoking parents with young

children. The SEM approach allows for simultaneous testing of two or more relationships among variables in the same model[133], and has, thus, contributed more to understand the mechanisms in this relationship than general multiple regression analysis would have. Furthermore, stratified analysis of fathers and mothers using a relatively large sample allowed for more accurate inferences about the gender specificity of the pathways.

In conclusion, this study provided the evidence that low-SES smoking fathers had higher descriptive and subjective norms of smoking and low-SES smoking parents had less knowledge about the risks of and precautions to avoid children's SHS exposure, and these variables were significantly associated with their indoor smoking behaviors. Furthermore, social norms of smoking were positively associated with household indoor smoking and negatively associated with worksite smoking bans.

Discouraging pro-smoking norms and improving knowledge about children's SHS exposure would provide clear opportunities for low-SES smoking parents to reduce their indoor smoking behaviors, and would, thus, lead to reducing inequalities in children's SHS exposure.

Chapter 4:

General conclusions and recommendations

In conclusion, Study1 (Chapter 2) provided new evidence about the remaining inequalities in infants' SHS exposure from 2001 to 2010 in Japan, with increased relative magnitude[134]. Furthermore, only father smoking indoors was a major source of SHS exposure in infants and a major contributor to absolute income inequality in SHS exposure in infants in 2010. Study2 (Chapter 3) showed that the pathway between SES and indoor smoking behavior was mediated by social norms of smoking among fathers who smoke, and knowledge about children's SHS exposure among parents who smoke. In the same pathway models, social norms of smoking were positively associated with household indoor smoking and negatively associated with worksite smoking bans.

The findings of Studies1 and 2 highlight two important insights. First, they suggest the potential role of non-smoking mothers with smoking husband in low-SES groups. In Japan, the majority of smoking fathers live with a non-smoking partner (87.8% in Study 2), and the factor of 'only father indoor smoking' was a major contributor to absolute inequality in children's SHS exposure based on income (Study 1). Compared with fathers, mothers tend to be motivated to protect children from SHS exposure and to have more contact with health professionals[21]. However, as interventions for parental smoking cessation mainly focus on smoking parents, non-

smoking mothers might receive less knowledge and support for protecting children from SHS exposure during the pre and post-natal periods compared to smoking mothers, even if their partners smoke. Furthermore, low-SES mothers have limited control over their partners' smoking behavior[135]. Thus, encouraging non-smoking mothers in low-SES groups to support their partners to change their smoking behaviors could narrow the inequalities in parental indoor smoking behaviors.

The home visiting program for all households with infants in Japan is one example of an intervention to encourage non-smoking low-SES mothers to support their partner in quitting smoking. Local municipalities have implemented this program across the country since 2009. A midwife, nurse, or trained community resident visits homes with infants aged under 4 months to provide advice regarding child-rearing as well as counseling, and offers follow-up services if necessary[136,137]. Incorporating tobacco-related issues into this program could help to provide accurate knowledge and 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 husbands. The program could also be used to 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.

Second, the combined findings suggest a dilemma between motivations and barriers among low-SES smoking mothers toward indoor smoking behavior. The smoking prevalence of mothers decreased substantially compared to fathers across all SES levels, but their prevalence of indoor smoking remained much higher than that in smoking fathers (Study 1). Compared to fathers, mothers are more likely to quit smoking after their children are born[138]. According to self-determination theory, individuals engage in behavior change through two different processes: making decisions with one's core sense of self (autonomous regulation) or making decisions that are controlled but not accepted as one's own (controlled regulation)[139]. In this regard, smoking mothers may have more autonomous motivation toward protecting their children from SHS than fathers do, and, thus, be more successful in achieving smoking cessation. At the same time, however, smoking mothers had higher social barriers toward stopping indoor smoking than smoking fathers did, including indoor smoking by household members (Study 2). They also received less support for quitting smoking from their partners than smoking fathers did (Study 2). Thus, smoking mothers might have higher intention to quit smoking compared to smoking fathers, but failure to do so may mean that stopping indoor smoking is much more difficult for them than it is for fathers. Thus, interventions need to be tailored to low-SES parents in the context of

gender and family influence. For instance, couple-focused approach might be effective, as it considers gender power issues and partner conflicts that may be associated with indoor smoking behaviors[124].

Acknowledgements

I would like to convey my sincere gratitude to the members of the Department of Community and Global Health, School of International Health, Graduate School of Medicine, The University of Tokyo, especially, Prof. Masamine Jimba, who kindly accepted me as his student from 2009 to 2016. I deeply appreciate his constant guidance, tireless support, precious advice, and patience. I would also like to thank Dr. Junko Yasuoka for her kindness as well as warm and tireless support. I would also like to thank Mr.Akira Shibanuma, for his kindness and tireless support especially regarding statistics. My warmest regards also goes to Dr. Keiko Nanishi, Dr. Kimiyo Kikuchi, and Dr. Sumiyo Okawa, for their warm support and valuable comments. I am also grateful administrative support from Ms. Junko Kimura, Ms. Junko Nakajima, Ms. Kaoru Tanaka, and Ms. Naoko Hashizume.

Special thanks are offered to all the study participants: fathers and mothers in the 21st new born surveys, and fathers and mothers among online survey members. Dr. Takahiro Tabuchi and Dr. Masakazu Nakamura kindly supported my research as a co-researcher of Study 1 of my thesis. I sincerely appreciate their enormous support, and invaluable comments for the study. My warmest thanks are proffered to Dr. Sumihiro Suzuki who provided precious advice for statistical analysis of my thesis. I also

sincerely appreciate The International Nursing Foundation of Japan to financially support my PhD program.

Most importantly, I greatly appreciate my husband Mr. Ryo Saito for his understanding of my study as well as endless and enormous support during the whole study periods including the struggles of thesis research. I would also like to thank my little son Hisashi for his emotional support with happy time during my study periods. I would like to sincerely thank my parents and parents-in-law for their endless and warm support all the time. Last but not least, I would like to thank all my friends and colleagues for their endless encouragement and support.

This thesis was funded by grants from: The Ministry of Health, Labour and Welfare (Grant; Comprehensive Research on Life-Style Related Diseases including Cardiovascular Diseases and Diabetes Mellitus (H25-010)), The Japan Health Foundation (Study 2), and the Department of Community and Global Health, Graduate School of Medicine, The University of Tokyo (Study 1 and 2).

References

1. Eriksen M, Mackay J, Ross H. The Tobacco Atlas 4th Edition. Gerogia, USA: the American Cancer Society, 2012.

2. WHO. WHO Report on th Global Tobacco Epidemic 2008. The MPOWER package. Geneva, Switzland: World Health Organiation, 2008.

3. U.S. Department of Health and Human Services. The health consequences of exposure to tobacco smoke: a report of the Surgeon General. Gerogia, USA: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, Coordinating Center for Health Promotion, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health, 2006.

4. 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;377:139–46.

5. WHO. The WHO Framework Convention on Tobacco Control. MPOWER Broch. Geneva, Switzland: World Health Organiation, 2013.

6. WHO. 2014 Global progress report on implementation of the WHO Framework Convention of Tobacco Control. 2014;1–118.

7. Ministry of Health Labour and Welfare. The National Health and Nutrition Survey. 2001.

8. MacKay J, Ritthiphakdee B, Reddy KS. Tobacco control in Asia. Lancet. 2013;381:1581–7.

9. WHO. FCTC fourth implementation report (Japan). World Health Organiation, 2014.

10. Japan Tobacco. Trends in cigarette tax.

11. WHO. Tobacco Free Initiative (TFI), Taxation.

12. Ashley MJ, Ferrence R. Reducing children's exposure to environmental tobacco smoke in homes: issues and strategies. Tob Control. 1998;13:61–5.

13. DiFranza JR, Aligne CA, Weitzman M. Prenatal and postnatal environmental tobacco smoke exposure and children's health. Pediatrics. 2004;113:1007-15.

14. Farkas AJ , Gilpin EA, White, Pierce JP. Association between household and workplace smoking restrictions and adolescent smoking. JAMA. 2000;284:717–22.

15. Batscheider A, Zakrzewska S, Heinrich J, Teuner CM, Menn P, Bauer CP, et al. Exposure to second-hand smoke and direct healthcare costs in children - results from two German birth cohorts, GINIplus and LISAplus. BMC Health Serv Res. 2012;12:344.

16. Aligne CA, Stoddard JJ. Tobacco and Children. An Economic Evaluation of the Medical Effects of Parental Smoking. Arch Pediatr Adolesc Med. 1997;151:648-53.

17. 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 survey. Prev Med. 2006;42:210–7.

18. Matt GE, Hovell MF, Zakarian JM, Bernert JT, Pirkle JL, Hammond SK. Measuring secondhand smoke exposure in babies: The reliability and validity of mother reports in a sample of low-income families. Heal Psychol. 2000;19:232–41.

19. 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.

20. Matt GE, Bernert JT, Hovell MF. Measuring secondhand smoke exposure in children: An ecological measurement approach. J Pediatr Psychol. 2008;33:156–75.

21. Blackburn C, Bonas S, Spencer N, Dolan A, Coe C, Moy R. Smoking behaviour change among fathers of new infants. Soc Sci Med. 2005;61:517–26.

22. Rosen LJ, Noach MB, Winickoff JP, Hovell MF. Parental smoking cessation to protect young children : a systematic review and meta-analysis. Pediatrics. 2012;129:141–52.

23. 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;5:901–10.

24. Johansson A, Halling A, Hermansson G. Indoor and outdoor smoking: impact on children's health. Eur J Public Health. 2003;13:61–6.

25. Blackburn C, Spencer N, Bonas S, Coe C, Dolan A, Moy R. Effect of strategies to reduce exposure of infants to environmental tobacco smoke in the home: cross sectional survey. BMJ. 2003;327:257.

26. 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.

27. 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;110:1484–92.

28. 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;21:330–6.

29. 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;19:52–8.

30. Moore GF, Currie D, Gilmore G, Holliday JC, Moore L. Socioeconomic inequalities in childhood exposure to secondhand smoke before and after smoke-free legislation in three UK countries. J Public Health. 2012;34:599–608.

31. Pisinger C, Hammer-Helmich L, Andreasen AH, Jørgensen T, Glümer C. Social disparities in children's exposure to second hand smoke at home: a repeated cross-sectional survey. Environ Heal. 2012;11:65.

32. Gartner CE, Hall WD. Is the socioeconomic gap in childhood exposure to secondhand smoke widening or narrowing? Tob Control. 2013;22:344–8.

33. Thomas S, Fayter D, Misso K, Ogilvie D, Petticrew M, Sowden A, et al. Population tobacco control interventions and their effects on social inequalities in smoking: systematic review. Tob Control. 2008;17:230–7.

34. Businelle MS, Kendzor DE, Reitzel LR, Costello TJ, Cofta-Woerpel L, Li Y, et al. Mechanisms linking socioeconomic status to smoking cessation: a structural equation modeling approach. Health Psychol. 2010;29:262–73.

35. Honjo K, Tsutsumi A, Kawachi I, Kawakami N. What accounts for the relationship between social class and smoking cessation? Results of a path analysis. Soc Sci Med. 2006;62:317–28.

36. Hiscock R, Judge K, Bauld L. Social inequalities in quitting smoking: What factors mediate the relationship between socioeconomic position and smoking cessation? J Public Health. 2011;33:39–47.

37. Manfredi C, Cho YI, Crittenden KS, Dolecek TA. A path model of smoking cessation in women smokers of low socio-economic status. Health Educ Res. 2007;22:747–56.

38. Adler NE, Ostrove JM. Socioeconomic Status and Health: What We Know and What We Don't. Ann N Y Acad Sci. 1999;896:3–15.

39. Gallo LC, Matthews K a. Understanding the association between socioeconomic status and physical health: Do negative emotions play a role? Psychol Bull. 2003;129:10–51.

40. Harwood GA, Salsberry P, Ferketich AK, Wewers ME. Cigarette smoking, socioeconomic status, and psychosocial factors: Examining a conceptual framework. Public Health Nurs. 2007;24:361–71.

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;13:479–86.

42. Robinson J, Ritchie D, Amos A, Greaves L, Cunningham-Burley S. Volunteered, negotiated, enforced: family politics and the regulation of home smoking. Sociol Health Illn. 2011;33:66–80.

43. Robinson J, Kirkcaldy AJ. “You think that I”m smoking and they’re not': why mothers still smoke in the home. Soc Sci Med. 2007;65:641–52.

44. Wilson IS, Ritchie D, Amos A, Shaw A, O’Donnell R, Mills LM, et al. “I”m not doing this for me’: mothers' accounts of creating smoke-free homes. Health Educ Res. 2013;28:165–78.

45. Carlsen K-H, Carlsen KCL. Respiratory effects of tobacco smoking on infants and young children. Paediatr Respir Rev. 2008;9:11–20.

46. 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.

47. Abe A. Health disparity in children: is there a difference in the effect of past illness? Iryo To Shakai. 2013;22:255–69.

48. 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;147:103–8.

49. Moore GF, Holliday JC, Moore LAR. Socioeconomic Patterning in Changes in Child Exposure to Secondhand Smoke After Implementation of Smoke-Free Legislation in Wales. Nicotine Tob Res. 2011;13:903–10.

50. Toyoshima Y, Washio M, Imamura M, Aramaki K, Koga Y, Kaneko H, et al. Ninpu no kitsuen no kanren youin: hahaoya gakkyuu sannkasha no anke-to chousa yori. Japanese J Cardiovasc Dis Prev. 2012;47:37–42.

51. 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;105:543–53.

52. 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.

53. 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.

54. Schisterman EF, Cole SR, Platt RW. Overadjustment bias and unnecessary adjustment in epidemiologic studies. Epidemiology. 2009;20:488–95.

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

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

57. Blakely T, Tobias M, Atkinson J. Inequalities in mortality during and after restructuring of the New Zealand economy: repeated cohort studies. BMJ. 2008;336:371–5.

58. National Cancer Institute. Health Disparities Calculator, Version 1.2.4 - October 29, 2013.

59. Siahpush M, McNeill A, Borland R, Fong GT. Socioeconomic variations in nicotine dependence, self-efficacy, and intention to quit across four countries: findings from the International Tobacco Control (ITC) Four Country Survey. Tob Control. 2006;15:iii71–5.

60. Hagimoto A, Nakamura M, Morita T, Masui S, Oshima A. Smoking cessation patterns and predictors of quitting smoking among the Japanese general population: a 1-year follow-up study. Addiction. 2010;105:164–73.

61. Easterly W. How the Millennium Development Goals are unfair to Africa. World Dev. 2009;37:26–35.

62. 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;16:869–78.

63. 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;32:209–17.

64. Ministry of Health Labor and Welfare. The National Health and Nutrition Surbey. 2001.

65. 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;39:1505–12.

66. 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;15:445–52.

67. 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;29:327–33.

68. 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.

69. 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;16:256–64.

70. 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.

71. Japan Pediatric Society. Poposal to decrease the child's passive smoking. Acta Paediatr Jpn. 2002;106:436–7.

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

73. Bandura A. Social foundations of thought and action: A social cognitive theory. NJ, USA: Prentice-Hall, Inc; 1985.

74. Ajzen I. The theory of planned behavior. Orgnizational Behav Hum Decis Process. 1991;50:179–211.

75. Paul CL, Ross S, Bryant J, Hill W, Bonevski B, Keevy N. The social context of smoking: A qualitative study comparing smokers of high versus low socioeconomic position. BMC Public Health. 2010;10:211.

76. Sorensen G, Emmons K, Stoddard AM, Linnan L, Avrunin J. Do Social Influences Contribute to Occupational Differences in Quitting Smoking and Attitudes Toward Quitting? Am J Heal Promot. American Journal of Health Promotion; 2002;16:135–41.

77. Bryant J, Bonevski B, Paul C, O'Brien J, Oakes W. Developing cessation interventions for the social and community service setting: A qualitative study of barriers to quitting among disadvantaged Australian smokers. BMC Public Health. 2011;11:493.

78. Etcheverry PE, Agnew CR. Romantic partner and friend influences on young adult cigarette smoking: Comparing close others' smoking and injunctive norms over time. Psychol Addict Behav. 2008. p. 313–25.

79. Christakis NA, Fowler JH. Quitting in Droves: Collective Dynamics of Smoking Behavior in a Large Social Network. N Engl J Med. 2010;358:2249–58.

80. Akhtar PC, Haw SJ, Currie DB, Zachary R, Currie CE. Smoking restrictions in the home and secondhand smoke exposure among primary schoolchildren before and after introduction of the Scottish smoke-free legislation. Tob Control. 2009;18:409–15.

81. Venters MH. Spouse concordance of smoking patterns: the Minnesota Heart Survey. Am J Epidemiol. Oxford University Press; 1984;120:608.

82. Hiscock R, Bauld L, Amos A, Fidler J a., Munafò M. Socioeconomic status and smoking: A review. Ann N Y Acad Sci. 2012;1248:107–23.

83. Monden CWS, De Graaf ND, Kraaykamp G. How important are parents and partners for smoking cessation in adulthood? An event history analysis. Prev Med. 2003;36:197–203.

84. Homish GG, Leonard KE. Spousal influence on smoking behaviors in a US community sample of newly married couples. Soc Sci Med. 2005;61:2557–67.

85. Tabuchi T, Fujiwara T. Are secondhand smoke-related diseases of children associated with parental smoking cessation? Determinants of parental smoking cessation in a population-based cohort study. Prev Med. 2015;73:81–7.

86. Severson HH, Andrews JA, Lichtenstein E, Wall M, Zoref L. Predictors of smoking during and after pregnancy: a survey of mothers of newborns. Prev Med. 1995:23–8.

87. Gilpin EA, White MM, Farkas AJ, Pierce JP. Home smoking restrictions: which smokers have them and how they are associated with smoking behavior. Nicotine Tob Res. 1999;1:153–62.

88. Schonberger H, Maas T, Dompeling E, Pisters J, Sijbrandij J, van der Heide S, et al. Environmental exposure reduction in high-risk newborns: where do we start? Ann Allergy Asthma Immunol. 2003;91:531–8.

89. Gulliver SB, Hughes JR, Solomon LJ, Dey a. N. An investigation of self-efficacy, partner support and daily stresses as predictors of relapse to smoking in self-quitters. Addiction. 1995;90:767–72.

90. Coppotelli HC, Orleans CT. Partner support and other determinants of smoking cessation maintenance among women. J Consult Clin Psychol. 1985;53:455–60.

91. Cohen S, Lichtenstein E. Partner behaviors that support quitting smoking. J Consult Clin Psychol. 1990;58:304–9.

92. Pizacani BA, Martin DP, Stark MJ, Koepsell TD, Thompson B, Diehr P. Longitudinal study of household smoking ban adoption among households with at least one smoker: associated factors, barriers, and smoker support. Nicotine Tob Res. 2008;10:533–40.

93. Brownson RC, Hopkins DP, Wakefield M a. Effects of smoking restrictions in the workplace. Annu Rev Public Health. 2002;23:333–48.

94. Hopkins DP, Razi S, Leeks KD, Priya Kalra G, Chattopadhyay SK, Soler RE. Smokefree policies to reduce tobacco use. A systematic review. Am J Prev Med. 2010;38:S275–89.

95. Nishiura C, Narai R, Ohguri T, Funahashi a, Yarita K, Hashimoto H. The effect of smoking prevalence at worksites on individual cessation behavior. J Occup Health. 2009;51:48–56.

96. Abdullah AS, Hitchman SC, Driezen P, Nargis N, Quah ACK, Fong GT. Socioeconomic Differences in Exposure to Tobacco Smoke Pollution (TSP) in Bangladeshi Households with Children: Findings from the International Tobacco Control (ITC) Bangladesh Survey. Int J Environ Res Public Health. 2011;8:842–60.

97. Lund KE, Helgason AR. Environmental tobacco smoke in Norwegian homes, 1995 and 2001: changes in children's exposure and parents attitudes and health risk awareness. Eur J Public Health. 2005;15:123–7.

98. Ramo DE, Hall SM, Prochaska JJ. Reliability and validity of self-reported smoking in an anonymous online survey with young adults. Heal Psychol. 2011;30:693–701.

99. Ministry of Health Labour and Welfare. The Longitudinal Survey of Newborns in the 21st Century. 2001.

100. Kevin BW. Researching Internet-Based Populations: Advantages and Disadvantages of Online Survey Research, Online Questionnaire Authoring Software Packages, and Web Survey Services. J Comput Commun. 2005; tb00259.x.

101. Taylor H. Does internet research work? comparing electronic survey results with telephone survey. Int J Mark Res. 1999;42:51–63.

102. Macromill Inc. Life style survey among Macromill monitors. 2015.

103. Dohnke B, Weiss-Gerlach E, Spies CD. Social influences on the motivation to quit smoking: Main and moderating effects of social norms. Addict Behav. 2011;36:286–93.

104. Kim KH. The Relation Among Fit Indexes , Power , and Sample Size in Structural Equation Modeling. Struct Equ Model. 2009;12:368–90.

105. Johansson A, Halling A, Hermansson G, Ludvigsson J. Assessment of smoking behaviors in the home and their influence on children's passive smoking: development of a questionnaire. Ann Epidemiol. 2005;15:453–9.

106.Lee H, Paek H-J. Impact of norm perceptions and guilt on audience response to anti-smoking norm PSAs: A case of Korean male smokers. Health Educ J. 2012;0:1–9.

107.Van Den Putte B, Yzer MC, Brunsting S. Social influences on smoking cessation: A comparison of the effect of six social influence variables. Prev Med. 2005;41:186–93.

108.Mermelstein R, Lichtenstein E, McIntyre K. Partner support and relapse in smoking-cessation programs. J Consult Clin Psychol. 1983;51:465–6.

109.Roski J, Schmid LA, Lando HA. Long-term associations of helpful and harmful spousal behaviors with smoking cessation. Addict Behav. 1996;21:173–85.

110.Yamato H, Ohta M, Nakamura M, Kawai K, Kunugita N. Survey on local smoking-ban policy in Japan. Japan. The Ministry of Health Labour and Welfare, 2014.

111.McMillen RC, Winickoff JP, Klein JD, Weitzman M. US adult attitudes and practices regarding smoking restrictions and child exposure to environmental tobacco smoke: changes in the social climate from 2000-2001. Pediatrics. 2003;112:e55–60.

112.Bleakley A, Hennessy M, Mallya G, Romer D. Home smoking policies in urban households with children and smokers. Prev Med. 2014;62:30–4.

113.Jochelson T, Hua M, Rissel C. Knowledge, attitudes and behaviours of caregivers regarding children's exposure to environmental tobacco smoke among Arabic and Vietnamese-speaking communities in Sydney, Australia. Ethn Health. 2003;8:339–51.

114.Kouketsu T, Ishihara T, Tmaki M. Katei niokeru judoukituen bakurojoukyou ni kansuru chousa: judoukituen wozero nisuru taisaku wo kangaeru (in Japanesae). Hokenshi Jounral. 2012;68:518–23.

115.Johansson A, Hermansson G, Ludvigsson J. How should parents protect their children from environmental tobacco-smoke exposure in the home? Pediatrics. 2004;113:e291–5.

116. Tavakol M, Dennick R. Making sense of Cronbach's alpha. Int J Med Educ. 2011;2:53–5.

117. Hu L, Bentler PM. Fit indices in covariance structure modeling: Sensitivity to underparameterized model misspecification. Psychol Methods. 1998;3:424–53.

118. Enders CK, Bandalos DL. The Relative Performance of Full Information Maximum Likelihood Estimation for Missing Data in Structural Equation Models. Struct Equ Model A Multidiscip J. 2001;8:430–57.

119. Schmitt N. Uses and abuses of coefficient alpha. Psychol Assess. 1996;8:350–3.

120. Businelle MS, Kendzor DE, Reitzel LR, Vidrine JI, Castro Y, Dolan Mullen P, et al. Pathways Linking Socioeconomic Status and Postpartum Smoking Relapse. Ann Behav Med. 2013;45.

121. Flemming K, Graham H, McCaughan D, Angus K, Bauld L. The barriers and facilitators to smoking cessation experienced by women's partners during pregnancy and the post-partum period: a systematic review of qualitative research. BMC Public Health. 2015;15:849.

122. Cialdini RB, Kallgren C a, Reno RR. A Focus Theory of Normative Conduct: A Theoretical Refinement and Reevaluation of the Role of Norms in Human Behavior. Adv Exp Soc Psychol. 1991;24:201–34.

123. Ratner P a, Johnson JL, Bottorff JL. Mothers' efforts to protect their infants from environmental tobacco smoke. Can J public Heal Rev Can sante publique. 2001;92:46–7.

124. Bottorff JL, Kalaw C, Johnson JL, Stewart M, Greaves L, Carey J. Couple dynamics during women's tobacco reduction in pregnancy and postpartum. Nicotine Tob Res. 2006;8:499–509.

125. Ferguson J, Bauld L, Chesterman J, Judge K. The English smoking treatment services: One-year outcomes. Addiction. 2005;100:59–69.

126. Lonergan BJ, Meaney S, Perry IJ, Comber H, Power B, Bradley C, et al. Smokers Still Underestimate the Risks Posed by Secondhand Smoke: A Repeated Cross-Sectional Study. Nicotine Tob Res. 2014;16:1121–8.

127.Makita I, Hosobe C, Ito K, Inami M, Kurosawa S, Kodaira K, et al. The first survey of living environment around the children: tobacco. J Japan Pediatr Assoc. 2010;39:113–9.

128.Takagi D, Kondo N, Takada M, Hashimoto H. Differences in spousal influence on smoking cessation by gender and education among Japanese couples. BMC Public Health. 2014;14:1184.

129.Honda N. Interent chousa/monitor chousa no tokushitu. Nihon Roudou Kenkyu Zasshi. 2006;551:32–41.

130.Herrero J, Meneses J. Short Web-based versions of the perceived stress (PSS) and Center for Epidemiological Studies-Depression (CESD) Scales: A comparison to pencil and paper responses among Internet users. Comput Human Behav. 2006;22:830–46.

131.Riva G, Teruzzi T, Anolli L. The Use of the Internet in Psychological Research: Comparison of Online and Offline Questionnaires. 2003;6:73–81.

132.Hamilton WL, Biener L, Brennan RT. Do local tobacco regulations influence perceived smoking norms? Evidence from adult and youth surveys in Massachusetts. Health Educ Res. 2008;23:709–22.

133.Shook CL, Ketchen DJ, Hult GTM, Kacmar MK. Research Notes and Commentaries an Assessment of the Use of Structural Equation Modeling in Strategic Management Research. Strateg Manag J. 2004;25:397–404.

134.Saito J, Tabuchi T, Shibanuma A, Yasuoka J, Nakamura M, Jimba M. "Only Fathers Smoking" Contributes the Most to Socioeconomic Inequalities: Changes in Socioeconomic Inequalities in Infants' Exposure to Second Hand Smoke over Time in Japan. PLoS One. 2015;10:e0139512.

135.Mao A, Bottorff JL, Oliffe JL, Sarbit G, Kelly MT. A qualitative study of Chinese Canadian fathers' smoking behaviors: intersecting cultures and masculinities. BMC Public Health. 2015;15:286.

136.Ministry of Health Labour and Welfare. The report of implementation status of advice service for household with children in municipalities, 2011.

137.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. 2011;59:169–75.

138.Brenner H, Mielck A. The Role of Childbirth in Smoking Cessation. Prev Med. 1993;22:225–36.

139.Deci EL, Eghrari H, Patrick BC, Leone DR. Facilitating internalization: the self-determination theory perspective. J Pers. 1994;62:119–41.