



Factors Associated With Smoking Relapse Among Women in Japan From Pregnancy to Early Parenthood

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SMOKING RELAPSE AMONG WOMEN IN JAPAN FROM PREGNANCY TO EARLY PARENTHOOD

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Precis	Smoking relapse was associated with symptoms of depression when participants quit before pregnancy and with multiparity when they quit after pregnancy.

2

3 **Abstract**

4 *Objective:* To identify factors, including mental health, associated with smoking relapse among
 5 women in Japan from pregnancy to early parenthood.

6 *Design:* Secondary analysis of data from an ongoing cross-sectional study conducted between

SMOKING RELAPSE AMONG WOMEN IN JAPAN FROM PREGNANCY TO EARLY PARENTHOOD 3

7 2013 and 2016.

8 *Setting:* We mailed questionnaires to all women who received a maternal and child health
9 handbook from a municipality in Fukushima Prefecture or who underwent a maternal health
10 checkup and gave birth in Fukushima Prefecture.

11 *Participants:* Of the 28,562 women who responded to the questionnaire, 6,747 who previously
12 smoked and quit around the time they registered their pregnancies were included in the
13 analysis.

14 *Methods:* Participants were divided into groups according to smoking relapse status: non-
15 relapse group, including those who maintained smoking cessation, and relapse group, including
16 those who quit smoking but later relapsed. We further classified the latter group into those who
17 quit smoking before or after pregnancy registration. We used a logistic regression model with
18 forced entry was used to calculate adjusted odds ratios.

19 *Results:* Of the 6,747 participants who previously smoked, 881 (13.1%) relapsed. Regardless of
20 the timing of smoking cessation, younger age and living in a specific region of Fukushima
21 Prefecture were associated with smoking relapse. Relapse was associated with symptoms of
22 depression in women who quit smoking before registration and with multiparity in women who
23 quit smoking after registration of their pregnancies.

24 *Conclusions:* Support for women at risk of smoking relapse following pregnancy requires
25 consideration of regional characteristics and incorporation of family and mental health support
26 with a focus on young mothers.

27 *Keywords:* smoking, relapse, mothers, child health, depression

28 **Callouts**

SMOKING RELAPSE AMONG WOMEN IN JAPAN FROM PREGNANCY TO EARLY PARENTHOOD

- 29 1. With the progress of measures to prevent smoking in public places in Japan,
30 further efforts are needed to prevent smoking during and relapse after pregnancy.
- 31 2. Smoking cessation relapse was associated with younger age, region of residence,
32 multiparity, and symptoms of depression.
- 33 3. It is necessary to build a maternal and child health care system that addresses
34 regional characteristics and integrates smoking cessation and mental health
35 support.

36

37 Smoking among pregnant women harms the health of the woman, her fetus, and her
38 children via passive exposure. Negative effects include the risk of perinatal mortality, sudden
39 infant death syndrome (Pineles et al., 2016), middle ear disease, asthma, wheezing (Avşar et al.,
40 2021), and childhood obesity (Rayfield & Plugge, 2017). In addition to the effects of passive
41 smoking, infants are also at risk of exposure to nicotine through breastmilk (Primo et al., 2013).
42 Yamagata (2015) reported that the proportion of women in Japan who smoked during
43 pregnancy in 2013 was 3.8%, whereas 8.5% of women smoked when their children were 18
44 months old. In a longitudinal study of smoking status among women in Japan from pregnancy
45 to the postpartum period, Ueda et al. (2020) found that approximately 60% of women who
46 smoked before pregnancy and quit during pregnancy relapsed after giving birth. This finding
47 highlights the importance of support for women during pregnancy and the postpartum period to
48 continue smoking cessation.

49 As a part of the Japanese government's national health plan, the aim of the Healthy
50 Parents and Children 21 campaign is to reduce the smoking rate among pregnant women to 0%
51 by 2024. To meet this goal, support for women who smoke during pregnancy was developed. In

52 addition, the awarding of the 2020 Olympic and Paralympic Games to Tokyo further increased
53 the need to prevent passive smoking, which led to a revision of the Health Promotion Act in
54 2018 aimed at prohibiting indoor smoking (Ministry of Health, Labour and Welfare, 2018). The
55 revision of passive smoking prevention laws recently led to the passage of ordinances to
56 prevent passive smoking in different areas throughout Japan. The government of Fukushima
57 Prefecture, which is located in the Tohoku region of Japan and is the country's third largest
58 prefecture by area, is also taking steps to develop an ordinance to protect pregnant women and
59 children from smoking.

60 On March 11, 2011, Fukushima Prefecture was struck by the Great East Japan
61 Earthquake and was also affected by the accident at the Fukushima Daiichi Nuclear Power
62 Plant. After the accident, the Fukushima Health Management Survey (FHMS) was launched in
63 Fukushima Prefecture to assess the long-term effects of low-dose radiation exposure from the
64 accident (Yasumura et al., 2012). Since then, four focused surveys were conducted. The aims of
65 the Pregnancy and Childbirth Survey were to understand the physical and mental health of
66 pregnant women who will give birth and raise children in Fukushima, to alleviate their
67 concerns, and to provide them with necessary care. In the 2013 survey, the smoking rate was
68 3.8% during pregnancy and 6.7% in early parenthood. In the 2016 survey, the respective rates
69 were 3.0% and 5.5% (Fukushima Medical University Radiation Medical Science Center for the
70 Fukushima Health Management Survey, n.d.), which reflected the downward nationwide trend.
71 However, the national goal of a 0% smoking rate during pregnancy has not been reached, and
72 relapse also occurs in the postpartum period.

73 Smoking associated with psychological factors is more common in women than in men
74 (Scherman et al., 2018). Although pregnancy motivates many women to quit smoking, some

75 relapse occurs after pregnancy because of the burden of raising children (Fujioka & Kobayashi,
76 2015). Moreover, women who became pregnant and gave birth in Fukushima Prefecture may
77 also have been psychologically affected by the disaster of 2011. While Japan has made progress
78 in measures to prevent smoking in public places, further efforts that could potentially be
79 facilitated by health care providers at the family and individual levels are needed to prevent
80 smoking during the perinatal period. Therefore, the aim of our study was to identify factors,
81 including mental health, associated with smoking relapse among women in Japan from
82 pregnancy to early parenthood.

83 **Methods**

84 **Design**

85 We conducted a secondary analysis of cross-sectional data collected in ongoing
86 questionnaire-based surveys. This study was approved by the Fukushima Medical University
87 Institutional Review Board (No. 1317). The objective of the survey was clearly explained on
88 the survey form, the return of which constituted consent to participate in the study. All
89 Pregnancy and Childbirth Survey data were managed by the Radiation Medical Science Center
90 for the FHMS at Fukushima Medical University. We used anonymized data in the analysis.

91 **Survey Methods**

92 The protocol of the Pregnancy and Childbirth Survey was described previously
93 (Yasumura et al., 2012). The Pregnancy and Childbirth Survey of FHMS has been conducted
94 every year since 2011 (Fujimori et al., 2014). The questionnaires for each survey year were sent
95 to women who were issued maternal and child health handbooks in Fukushima Prefecture or
96 who were issued handbooks in other prefectures but gave birth in Fukushima Prefecture
97 between August 1 of the previous year and July 31 of the survey year. In Japan, all pregnant

98 women are required to register their pregnancies, and all pregnant women receive maternal and
99 child health handbooks. This registration system enables the provision of maternal and child
100 health services such as antenatal checkups. The maternal and child health handbook can be used
101 to record the health status of women and their children from pregnancy to infancy and allows
102 medical care providers and women to manage their health.

103 We identified the target participants using pregnancy registration information obtained
104 from municipalities in the prefecture. We sent a single questionnaire to each of the targeted
105 women from one month after their expected date of birth. We also added an explanatory note
106 asking participants to complete the questionnaire at least one month after they gave birth. The
107 survey included questions about the one-month child health checkup, after which participants
108 completed and returned the questionnaires. Data collection proceeded for approximately one
109 year in each survey year. With the aim of providing continuous support to women who need
110 assistance, we offered support by phone to those who answered “Yes” to both questions about
111 symptoms of depression and to those whose free responses indicated a need for support. We
112 categorized the content of those consultations and categorized the data collected.

113 **Participants**

114 Of the 14,516, 15,218, 15,125, 14,572, and 14,154 women identified for the annual
115 surveys conducted from 2012 to 2016, respectively, 7,181 (49.5%) returned their questionnaires
116 in 2012, 7,260 (47.7%) in 2013, 7,132 (47.2%) in 2014, 7,031 (48.3%) in 2015, and 7,326
117 (51.8%) in 2016 (Fig. 1). Of these women, we excluded 319 women whose pregnancies
118 resulted in miscarriage, abortion, or stillbirth; 414 women who were issued their maternal and
119 child health handbooks outside of Fukushima Prefecture; 2,667 women who provided multiple
120 responses; 261 whose answers were provided by someone other than themselves; and 114

121 women with missing values regarding smoking when they registered their pregnancies, during
122 pregnancy, or at the time of the survey (total 3,775 women). We then excluded 16,447 women
123 who responded that they never smoked before registering their pregnancies and 1,593 women
124 who responded that they continued smoking after they registered their pregnancies. We received
125 multiple responses from women who gave birth more than once from 2013 to 2016 and
126 responded to the survey for multiple pregnancies. In these cases, we used responses from the
127 first pregnancy only because second or later pregnancies were potentially affected by repeated
128 responses. In addition, because the risk group for smoking relapse during pregnancy and the
129 postpartum period consisted of only women who smoked previously and then quit, we excluded
130 those who never smoked before pregnancy and those who continued to smoke up to the time of
131 the survey. Finally, we included 6,747 women in our analyses.

132 **Measures**

133 *Smoking Status*

134 In the survey, the participants were retrospectively asked about their smoking status at
135 three different points: at registration of the pregnancy, during pregnancy, and at the time of the
136 survey. The first question was “Were you smoking around the time you registered your
137 pregnancy?” Responses consisted of “I have never smoked,” “I stopped before I realized I was
138 pregnant,” “I stopped when I realized I was pregnant,” and “Yes.” The second question was
139 “Did you smoke during your pregnancy?” Responses consisted of “No” and “Yes.” The third
140 question was “Do you currently smoke?” Responses consisted of “No” and “Yes.”

141 Participants who stopped smoking around the time (just before or just after) they
142 registered their pregnancies and maintained smoking cessation were classified as the non-
143 relapse group, whereas women who temporarily stopped smoking around the time they

144 registered their pregnancies but later resumed smoking were classified as the relapse group
145 (Fig. 2). For analysis, participants were also divided into two groups based on the timing of
146 smoking cessation: those who quit smoking before they realized they were pregnant were
147 classified as before pregnancy registration, whereas those who quit smoking once they realized
148 they were pregnant were classified as after pregnancy registration.

149 ***Basic Characteristics***

150 Basic characteristics consisted of the region in Fukushima Prefecture where the maternal
151 and child health handbook was issued, the mother's age, and family structure. The regions
152 included Hamadori (Pacific coast), Aizu (mountains near Niigata Prefecture), and Nakadori
153 (between the Hamadori and Aizu regions). Age was divided into four groups: 24 years or less,
154 25 to 29 years, 30 to 34 years, and 35 years or more. Family structure was divided into nuclear
155 family and extended family.

156 ***Pregnancy-Related Items***

157 Pregnancy-related items consisted of reproductive history and satisfaction with
158 pregnancy/childbirth care. Reproductive history was divided into primiparity and multiparity.
159 For satisfaction with pregnancy/childbirth care, participants responded to the question, "How
160 satisfied were you with the care you received throughout your pregnancy and during
161 childbirth?" on a 5-point scale from "Very satisfied" to "Not at all". We included participants
162 who responded "Very satisfied" or "Satisfied" in the "satisfied group," whereas we included
163 participants with other responses in the "unsatisfied group." Although the survey contained
164 other pregnancy and birth questions, such as complications and route of birth, these were not
165 deemed relevant to the current analysis on smoking relapse.

166 ***Health Status-Related Items***

167 Health status-related items consisted of symptoms of depression and self-rated health.
168 We asked about symptoms of depression with the questions, “During the past month, have you
169 often felt down, depressed, or hopeless?” “During the past month, have you often found little
170 interest or pleasure in doing things?” Participants who responded “Yes” to either question were
171 classified as having symptoms of depression. For self-rated health, participants responded to the
172 question, “Do you usually consider yourself to be healthy?” on a 4-point scale from “Very
173 healthy” to “Unhealthy”; participants who responded “Very healthy” or “Somewhat healthy”
174 were classified as having good self-rated health, whereas all others were classified as having
175 poor self-rated health.

176 ***Other Items***

177 Other items consisted of survey year and information from free-responses. The
178 information in the free text section of the questionnaire was categorized and coded by multiple
179 people, and this coding was double-checked. The coding consisted of eight categories: radiation
180 anxieties, radiation-related examination and surveys, opinions or complaints about this survey,
181 positive comments about this survey, request for health care/childcare service, financial
182 anxiety/needs, complaints about their own poor physical condition, and personal relationships.
183 The free-response text information was divided into “Yes” or “No,” depending on whether or
184 not a response was entered for that category.

185 ***Phone Consultation***

186 Phone consultation content was divided into eight categories: mothers themselves,
187 children’s illnesses, parenting, family, evacuation, radiation, nothing in particular, and unclear.
188 For each consultation, each content category was coded as either “Yes” or “No,” depending on
189 whether that category was mentioned.

190 **Analysis**

191 We divided participants into a non-relapse group and a relapse group (Figure 2) and
192 compared them in terms of the timing of smoking cessation, survey year, basic characteristics,
193 and pregnancy/health-related items using the chi-squared test or Fisher's exact test. We
194 performed univariate and multivariate logistic regression analyses with smoking status as the
195 dependent variable and the following as moderator variables: survey year, region where
196 handbook was issued, age, and family structure as basic characteristics; symptoms of
197 depression and self-rated health as indicators of health status; and reproductive history and
198 satisfaction with pregnancy/birth care as perinatal factors. Using forced entry, we calculated the
199 odds ratio (OR) and 95% confidence interval (95% CI) for every item. We stratified participants
200 based on smoking cessation timing into "before pregnancy registration" and "after pregnancy
201 registration" for the same analysis described above. In addition, to clarify the behavioral
202 tendencies of women in the two groups, we compared free-response text information and phone
203 consultation content using the Chi-square test or Fisher's exact test. We performed all statistical
204 analyses using SPSS Statistics 25 (IBM, Armonk, NY) with the level of significance set at p
205 $< .05$.

206 **Results**

207 Of the 6,747 participants, 5,866 (86.9%) maintained smoking cessation and 881 (13.1%)
208 relapsed (see Table 1). In the non-relapse group, 2,021 (34.5%) were in the 30 to 34 year age
209 group and 2,243 (45.6%) were primiparous. In the relapse group, 275 (31.2%) were in 25 to 29
210 year age group and 272 (36.9%) were primiparous (see Table 1). Of the 3,235 participants who
211 ceased smoking before registering their pregnancy, 76 (2.3%) relapsed. Of the 3,512
212 participants who ceased smoking after registering their pregnancy, 805 (22.9%) relapsed.

213 **Associations of Smoking Status with Variables According to Time of Smoking Cessation**

214 After confirming that the timing of smoking cessation was strongly associated with
215 smoking relapse, we conducted analyses stratified by the timing of smoking cessation. In
216 univariate analysis of participants who ceased smoking before registering their pregnancies, the
217 following factors were significantly associated with smoking relapse compared with the non-
218 relapse group: being issued a maternal and child health handbook in the Aizu region (*OR* 2.3,
219 95% CI [1.3–3.9]), age 24 years or less (*OR* 5.1, 95% CI [2.4–10.6]), age 25 to 29 years (*OR*
220 2.1, 95% CI [1.1–3.9]), extended family (*OR* 1.8, 95% CI [1.1–2.8]), and symptoms of
221 depression (*OR* 1.8, 95% CI [1.1–2.9]). In multivariate analysis, age 24 years or less (*OR* 6.1,
222 95% CI [2.7–13.6]), age 25 to 29 years (*OR* 2.5, 95% CI [1.2–4.9]), symptoms of depression
223 (*OR* 1.7, 95% CI [1.03–2.95]), and being issued a maternal and child health handbook in the
224 Aizu region (*OR* 2.0, 95% CI [1.1–3.7]) were significantly associated with smoking relapse (see
225 Table 2).

226 In univariate analysis of participants who ceased smoking after registering their
227 pregnancies, the following factors were significantly associated with smoking relapse compared
228 with the non-relapse group: taking the survey in 2015 and 2016 (*OR* 0.7, 95% CI [0.5–0.8], and
229 *OR* 0.8, 95% CI [0.6–0.9], respectively), age 24 years or less (*OR* 2.0, 95% CI [1.6–2.5]),
230 symptoms of depression (*OR* 1.3, 95% CI [1.0–1.4]), poor self-rated health (*OR* 1.4, 95% CI
231 [1.02–1.99]), and multiparity (*OR* 1.8, 95% CI [1.5–2.2]). In multivariate analysis, age 24 years
232 or less (*OR* 2.1, 95% CI [1.5–2.7]), multiparity (*OR* 2.0, 95% CI [1.6–2.4]), and being issued a
233 maternal and child health handbook in the Hamadori region (*OR* 1.2, 95% CI [1.01–1.52]) were
234 significantly associated with smoking relapse (see Table 2).

235 **Associations Between Smoking Status and Free-Response Variables According to Time of**

236 **Smoking Cessation**

237 When participants ceased smoking before registering their pregnancies, free-response
238 text information associated with personal relationships was significantly more common in the
239 relapse group than in the non-relapse group ($p = .007$). Among participants who ceased
240 smoking after registering their pregnancies, we found no significant associations (see Table 3).

241 **Associations Between Smoking Status and Phone Consultation Content According to Time**
242 **of Smoking Cessation**

243 Among participants who ceased smoking before registering their pregnancies, we found
244 no significant associations with any categories of phone consultation content. Among
245 participants who ceased smoking after registering their pregnancies, the relapse group
246 demonstrated significant trends in consultations related to children's illnesses ($p = .067$) and
247 parenting ($p = .058$) compared with the non-relapse group (see Table 4).

248 **Discussion**

249 We used data from all of Fukushima Prefecture to compare women who did not relapse
250 to smoking with those who relapsed to smoking. We found that 13.1% of the 6,747 participants
251 relapsed to smoking within one month to one year after giving birth. Regardless of the timing of
252 smoking cessation, younger age and region of residence within the Prefecture were associated
253 with smoking relapse. In the group that quit smoking before pregnancy registration, relapse was
254 also associated with symptoms of depression. In the group that quit smoking after pregnancy
255 registration, relapse was also associated with multiparity.

256 When we examined factors that were associated with smoking relapse, we found that
257 women who relapsed were younger and concentrated in certain regions of the Prefecture
258 regardless of whether they ceased smoking before or after registering their pregnancy. In our

259 examination of the association between residential regions and smoking relapse, perinatal
260 factors (reproductive history and satisfaction with care) were negative confounders. Failing to
261 adjust for such confounders may result in underestimation of an important factor associated
262 with smoking relapse (Choi et al., 2008). We identified that region of residence was associated
263 with smoking relapse independent of perinatal and other factors, which suggests community-
264 based efforts to prevent smoking relapse are needed.

265 Miyazaki et al. (2015) reported that there were differences in the number of women who
266 relapsed to smoking depending on their region of residence. Regional differences may be
267 affected by the age distribution of the population, lifestyle habits, and cultural traditions of the
268 residents in a given region. Smoking cessation is affected by an individual's lifestyle
269 background (Barnett et al., 2019), whereas lifestyle habits at the level of individual behaviors
270 are affected by regional cultural traditions. Passage and implementation of a passive smoking
271 prevention ordinance would be effective strategies at the community and regional levels (Faber
272 et al., 2017). Further, two regions in our study in which participants had higher relapse rates
273 also have a lower number of obstetric care facilities. Therefore, the opportunities for public
274 health nurses and midwives working at health centers in these regions to intervene to influence
275 women's smoking behaviors are critical.

276 Other researchers have reported that young adulthood (age less than 24 years) is a factor
277 in early smoking relapse in the postpartum period (Miyazaki et al., 2015; Orton et al., 2018). In
278 their 2014 Japanese nationwide survey on children's health and the environment, Miyazaki et
279 al. (2015) reported high postpartum smoking relapse rates among women in their twenties.
280 These findings suggest the need for smoking relapse prevention measures aimed at young
281 pregnant women. Smoking behaviors in young people are easily influenced by the smoking

282 behaviors of their friends and family (Fujioka & Kobayashi, 2015). Several researchers have
283 reported an association between smoking relapse prevention interventions for pregnant women
284 and smoking cessation by their partners (Miyazaki et al., 2015; Scheffers-van Schayck et al.,
285 2019). In a study using the Reasons for Smoking Assessment Scale, Fujioka and Kobayashi
286 (2015) found that smoking habits such as “I find myself smoking” and “I feel comfortable
287 smoking” were associated with postpartum smoking relapse. Thus, women may be motivated
288 by pregnancy to cease smoking, but cessation may be only temporary.

289 In addition to the factors that were common to women who ceased smoking before and
290 after registering their pregnancies, we found that participants who ceased smoking before
291 registering their pregnancy were 1.7 times more likely to relapse if they had symptoms of
292 depression. Many participants wrote about “personal relationships” in their free-text responses.
293 Fujita et al. (2021) reported an association between smoking and depression. Ooka et al. (2019)
294 reported a lack of counselors and peers, and a lack of participation in maternal and child health
295 services were significantly associated with maternal smoking during pregnancy. These studies
296 suggest that the parenting environment in which pregnant women find themselves may cause
297 smoking relapse. In Japan, owing to increasing cases of child abuse (Ministry of Health, Labour
298 and Welfare, 2016) and high rates of maternal suicide (Takeda, 2016) due to postpartum
299 depression, support for postpartum depression has recently been strengthened. Therefore, it is
300 necessary to construct a system to promote smoking cessation within the context of postpartum-
301 depression support.

302 In addition to the factors common to participants who ceased smoking before and after
303 registering their pregnancies, those who ceased smoking after registering their pregnancies
304 were 2.0 times more likely to relapse if they were multiparous. In studies conducted in the

305 United States and the Netherlands, researchers also found that multiparous women have a high
306 risk of postpartum smoking relapse (Mumford et al., 2014; Scheffers-van Schayek et al., 2019).
307 For multiparous women, there is a high probability that smoking relapse exposes their older
308 children to second-hand smoke. For infants, second-hand smoke exposure is associated with
309 conditions such as asthma, sudden infant death syndrome, and otitis media (Avşar et al., 2021).
310 Primary prevention of children's exposure to second-hand smoke in the home is an important
311 area for intervention to promote their short and long-term health. Participants in the smoking
312 relapse group had a relatively high frequency of phone consultation content about children's
313 illness and parenting, which suggests that these consultations could be an opportunity to
314 support smoking cessation through the maternal and child health services that are widely
315 available in Japan.

316 **Implications**

317 The results of our analyses stratified by the timing of smoking cessation can help to
318 clarify which smoking cessation measures should be used at different points (e.g., before
319 pregnancy registration and after pregnancy registration). In the United States, behavioral
320 interventions are recommended as a way to effectively decrease smoking rates among pregnant
321 women. These non-pharmacological interventions include ongoing counseling and motivational
322 interviewing (Siu et al., 2015). In Japan, maternal and child health services are mandated under
323 the Maternal and Child Health Act and are provided by hospitals, maternity homes, and health
324 centers. In hospitals, health checkups for women are conducted regularly during pregnancy, and
325 health checkups are also conducted at one month postpartum followed by child health
326 checkups. Obstetricians-gynecologists and midwives are in unique and important positions to
327 provide continual healthcare support for women and their families in the prepregnancy,

328 pregnancy, and postpartum periods.

329 At these medical service encounters, it is advisable to check not only the smoking
330 history and status of the woman but also whether there are any smokers in her home. If so,
331 support for smoking cessation should also be provided to the family. In Japan, support for
332 postpartum depression has been strengthened in recent years, and it may be effective to
333 combine such efforts with anti-smoking measures. Furthermore, women who are breastfeeding
334 may be more responsive to smoking relapse interventions (Gilbert et al., 2015; Logan et al.,
335 2017). Therefore, it may be effective to use breastfeeding as a motivation for women to quit
336 smoking. We believe it is necessary to incorporate anti-smoking measures in childrearing
337 support as a whole.

338 **Limitations**

339 The participants in our study were limited to Fukushima Prefecture and the survey
340 response rate was only about 50%, meaning that the data did not represent the smoking
341 histories of all women who gave birth during the survey years. In addition, because the survey
342 used a self-reporting format, women may have underreported their smoking status owing to
343 social norms. Furthermore, educational background, income, and partner's smoking habits were
344 not collected in the questionnaire, all of which may be related to smoking relapse and should be
345 collected in future research as potential confounders (Orton et al., 2018). However, by using
346 data from surveys targeting all pregnant women in Fukushima Prefecture conducted over
347 multiple years and by considering maternal mental health, we obtained practical and useful
348 suggestions for support targets and methods to prevent smoking relapse among women during
349 pregnancy and the postpartum period.

350 **Conclusions**

351 The associations of younger age and region of residence in the Prefecture with smoking
352 relapse indicate the need to provide support for young pregnant women as well as the need to
353 build a regional system that can maintain support not only during pregnancy but also after
354 childbirth. Since symptoms of depression were associated with an increased likelihood of
355 smoking relapse among women who ceased smoking before registering their pregnancies, it is
356 important to promote smoking cessation as part of the support for mitigating the development
357 of postpartum depression. Further, the association of multiparity with an increased likelihood of
358 smoking relapse among women who ceased smoking after registering their pregnancies
359 highlights the need to provide support not only for pregnant women but also for the members of
360 their families to create personal environments without smokers. Midwives and nurses can play
361 the following roles in smoking cessation efforts: 1) intervening with women during pregnancy
362 and the postpartum period in a comprehensive manner to provide smoking cessation and
363 parenting support, 2) promoting smoking cessation as part of perinatal mental health care, and
364 3) providing support not only to women during pregnancy and the postpartum period but also to
365 their families.

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Table 1*Demographic Characteristics (N = 6,747)*

Characteristics	Non-relapse group (n = 5,866)		Relapse group (n = 881)		p value
	n	%	n	%	
Smoking cessation timing					
Before	3,159	53.9	76	8.6	<0.001
After	2,707	46.1	805	91.4	
Survey year					
2013	1,771	30.2	289	32.8	0.066
2014	1,561	26.6	246	27.9	
2015	1,277	21.8	159	18.1	
2016	1,257	21.4	187	21.2	
Residential regions ^a					
Nakadori	3,627	61.8	508	57.7	0.060
Hamadori	1,471	25.1	244	27.7	
Aizu	768	13.1	129	14.6	
Age (years)					
24 or younger	569	9.7	207	23.5	<0.001

SMOKING RELAPSE AMONG WOMEN IN JAPAN FROM PREGNANCY TO EARLY PARENTHOOD

25

25–29	1,701	29.0	275	31.2	
30–34	2,021	34.5	231	26.2	
35 or older	1,575	26.8	168	19.1	
Family structure					
Nuclear	4,041	68.9	561	63.7	0.002
Extended	1,825	31.1	320	36.3	
Symptoms of depression					
No	4,399	75.2	603	68.8	<0.001
Yes	1,453	24.8	273	31.2	
Self-rated health					
Good	5,587	95.4	824	93.6	0.027
Poor	272	4.6	56	6.4	
Reproductive history					
Primiparous	2,243	45.6	272	36.9	<0.001
Multiparous	2,674	54.4	465	63.1	
Satisfaction with pregnancy/obstetrical care					
Satisfied	5,074	86.7	731	83.1	0.004
Unsatisfied	781	13.3	149	16.9	

^a Region where maternal and child health handbook was issued.

Table 2*Factors Associated With Smoking Relapse Stratified by Smoking Cessation Timing*

Variable	Univariate (stratified)				Multivariate (stratified)					
	Univariate		Before pregnancy registration (n = 3,235)	After pregnancy registration (n = 3,512)	Before pregnancy registration (n = 2,738)	After pregnancy registration (n = 2,889)				
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI		
Smoking cessation timing										
Before	1.0									
After	12.4	[9.72, 15.7]*								
Survey year										
2013	1.0		1.0		1.0		1.0		1.0	
2014	1.0	[0.80, 1.16]	1.0	[0.57, 1.69]	0.9	[0.75, 1.13]	0.9	[0.47, 1.70]	1.0	[0.76, 1.32]
2015	0.8	[0.62, 0.94]*	0.6	[0.31, 1.24]	0.7	[0.52, 0.82]*	0.6	[0.27, 1.33]	0.8	[0.58, 1.04]
2016	0.9	[0.75, 1.11]	0.7	[0.36, 1.40]	0.8	[0.61, 0.94]*	0.6	[0.26, 1.35]	0.9	[0.65, 1.16]
Residential regions ^a										
Nakadori	1.0		1.0		1.0		1.0		1.0	

Hamadori	1.2	[1.01, 1.40]*	0.9	[0.46, 1.57]	1.2	[0.97, 1.39]	1.0	[0.54, 1.90]	1.2	[1.01, 1.52]*
Aizu	1.2	[0.97, 1.48]	2.3	[1.32, 3.91]*	1.1	[0.86, 1.39]	2.0	[1.11, 3.75]*	1.1	[0.86, 1.46]
Age (years)										
24 or younger	3.2	[2.58, 3.92]*	5.1	[2.49, 10.6]*	2.0	[1.60, 2.53]*	6.1	[2.74, 13.66]*	2.1	[1.59, 2.71]*
25–29	1.4	[1.17, 1.70]*	2.1	[1.11, 3.91]*	1.1	[0.90, 1.35]	2.5	[1.29, 4.94]*	1.2	[0.96, 1.51]
30–34	1.0		1.0		1.0		1.0		1.0	
35 or older	0.9	[0.76, 1.15]	1.4	[0.75, 2.72]	1.0	[0.82, 1.32]	1.4	[0.71, 2.83]	1.0	[0.77, 1.28]
Family structure										
Nuclear	1.0		1.0		1.0		1.0		1.0	
Extended	1.3	[1.09, 1.47]*	1.8	[1.14, 2.87]*	1.1	[0.92, 1.28]	1.5	[0.90, 2.49]	1.0	[0.85, 1.24]
Symptoms of depression										
No	1.0		1.0		1.0		1.0		1.0	
Yes	1.4	[1.17, 1.60]*	1.8	[1.14, 2.99]*	1.3	[1.05, 1.49]*	1.7	[1.03, 2.95]*	1.2	[0.94, 1.41]
Self-rated health										
Good	1.0		1.0		1.0		1.0		1.0	
Poor	1.4	[1.04, 1.88]*	1.4	[0.57, 3.57]	1.4	[1.02, 1.99]*	1.1	[0.41, 2.92]	1.3	[0.91, 1.99]
Reproductive history										

Primiparous	1.0		1.0		1.0		1.0		1.0	
Multiparous	1.4	[1.22, 1.68]*	1.5	[0.88, 2.50]	1.8	[1.54, 2.20]*	1.6	[0.84, 2.99]	2.0	[1.63, 2.43]*
Satisfaction with pregnancy/ obstetrical care										
Satisfied	1.0		1.0		1.0		1.0		1.0	
Unsatisfied	1.6	[1.30, 1.87]*	1.4	[0.78, 2.63]	1.2	[0.99, 1.52]	1.4	[0.73, 2.80]	1.2	[0.90, 1.48]

Note. * $p < 0.05$. CI = confidence interval, OR = odds ratio.

^a Region where maternal and child health handbook was issued.

Table 3*Associations of Smoking Status With Free-response Text Information According to Smoking Cessation Timing*

Variable	Before pregnancy registration (n = 3,235)					After pregnancy registration (n = 3,512)				
	Non-relapse group		Relapse group		p value	Non-relapse group		Relapse group		p value
	n	%	n	%		n	%	n	%	
	Radiation anxieties									
Yes	73	2.3	1	1.3	>.999	47	1.7	12	1.5	0.634
No	3,086	97.7	75	98.7		2,660	98.3	793	98.5	
Radiation-related examination and surveys										
Yes	38	1.2	1	1.3	0.607	26	1.0	8	1.0	0.932
No	3,121	98.8	75	98.7		2,681	99.0	797	99.0	
Opinions or complaints about this survey										
Yes	44	1.4	1	1.3	>.999	22	0.8	6	0.7	0.850
No	3,115	98.6	75	98.7		2,685	99.2	799	99.3	
Positive comments about this survey										
Yes	14	0.4	0	0.0		10	0.4	0	0.0	
No	3,145	99.6	76	100.0	>.999	2,697	99.6	805	100.0	0.130

Request for health care/childcare services										
Yes	188	6.0	6	7.9		153	5.7	42	5.2	
No	2,971	94.0	70	92.1	0.459	2,554	94.3	763	94.8	0.636
Financial anxiety/requests										
Yes	26	0.8	1	1.3		26	1.0	9	1.1	
No	3,133	99.2	75	98.7	0.475	2,681	99.0	796	98.9	0.693
Complaints about their own poor physical health										
Yes	80	2.5	4	5.3		45	1.7	12	1.5	
No	3,079	97.5	72	94.7	0.133	2,662	98.3	793	98.5	0.735
Personal relationships										
Yes	14	0.4	3	3.9		14	0.5	6	0.7	
No	3,145	99.6	73	96.1	0.007	2,693	99.5	799	99.3	0.430

Table 4

Associations Between Smoking Status and Phone Consultation Content According to Smoking Cessation Timing

Variable	Before pregnancy registration (n = 483)					After pregnancy registration (n = 515)				
	Non-relapse group		Relapse group		p value	Non-relapse group		Relapse group		p value
	n	%	n	%		n	%	n	%	
Mothers themselves										
Yes	232	49.9	9	50.0	0.993	182	48.7	72	51.1	0.627
No	233	50.1	9	50.0		192	51.3	69	48.9	
Children's illnesses										
Yes	87	18.7	3	16.7	>.999	50	13.4	28	19.9	0.067
No	378	81.3	15	83.3		324	86.6	113	80.1	
Parenting										
Yes	185	39.8	6	33.3	0.583	128	34.2	61	43.3	0.058
No	280	60.2	12	66.7		246	65.8	80	56.7	
Family										
Yes	95	20.4	2	11.1	0.548	78	20.9	39	27.7	0.100
No	370	79.6	16	88.9		296	79.1	102	72.3	
Evacuation										
Yes	6	1.3	0	0.0	>.999	0	0.0	1	0.7	0.274
No	459	98.7	18	100.0		374	100.0	140	99.3	
Radiation										
Yes	44	9.5	2	11.1	0.686	31	8.3	9	6.4	0.471
No	421	90.5	16	88.9		343	91.7	132	93.6	
Nothing in particular										
Yes	25	5.4	0	0.0	0.615	25	6.7	7	5.0	0.471

SMOKING RELAPSE AMONG WOMEN IN JAPAN FROM PREGNANCY TO EARLY

PARENTHOOD

32

No	440	94.6	18	100.0		349	93.3	134	95.0	
Unclear										
Yes	119	25.6	5	27.8	0.788	92	24.6	29	20.6	0.336
No	346	74.4	13	72.2		282	75.4	112	79.4	

Figure 1 *Flowchart of Participant Enrolment*

* Refers to women who delivered more than once from 2013 to 2016 and responded to the survey each time; only responses from the first survey were used.

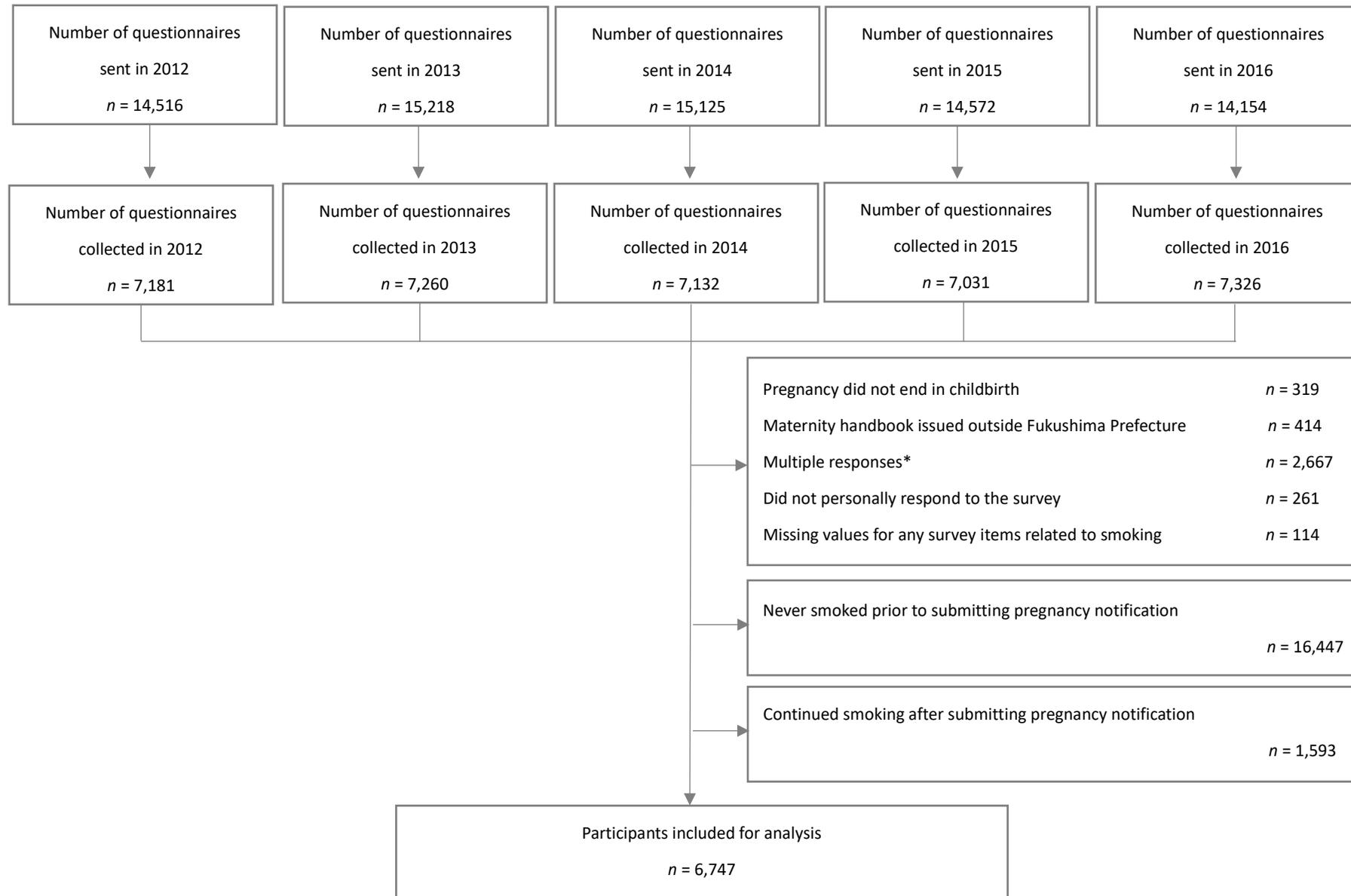


Figure 2

Conceptual Diagram of Analysis

