

the second birth hazard of working wives. In fact, this positive effect is not found in housewife sample. Therefore, it is possible that wife's double burden of work and household chores is, in large part, mitigated by the help from the couple's parents rather than by the hands of husbands.

It is noteworthy that husband's employment status does not affect the likelihood of the second births in the full-time worker sample, while it does strongly affect likelihood of the second birth in the housewife sample. Wife's economic independence may reduce the importance of husband's breadwinning role in deciding whether to have a second child. Oppenheimer (1997) pointed out that dual-earner couples are more durable to the risk of a spouse's job loss than single-earner couples. The result confirms her statement on dual-earner household in relation to its effects on the second birth.

Effects of other covariates on the second birth hazards also exhibit interesting difference between full-time working wives and housewives. For example, psychological factors are more important for the birth decisions of housewives than those of working wives. Previous study found that negative childrearing experiences of the first child reduce the likelihood of additional childbirths (Yamaguchi 2005). Our result confirms that fertility outcomes of housewives are also more sensitive to her psychological assessment of childcare burdens than working wives.

Another interesting contrast is the effects of the sex of the first child. The sex of the first child matters for the full-time working wives while it does not for housewives. It is reported that daughter preference is more common than son preference among Japanese couples since the mid-1980s (National Institute of Population and Social Security Research 2011). Although it has to be confirmed in further study, it is possible that among couples who are under the strong constraint of having two children, they tend to stop bearing a second child when the first baby meets their preference on the sex of the child.

Finally, our result shows that regional differences in the second birth hazards are observed only in housewife couples. Among full-time working wives, regional differences are remarkably negligible except for the high second birth hazard in Kyushu and Okinawa region. It is assumed that in Kyushu and Okinawa region, there are some unobserved factors which facilitate second births of working wives. To

identify such factors through either qualitative or quantitative studies focusing on this topic is potentially important to understand how constraints of working wives can be reduced and to examine if those identified factors would be extendable to other regions by some forms of policy measure.

7. Conclusion

How gender equality relates to fertility in the highly developed countries and what are the causal linkage between the two become a growing concern for not only population scholars but also policy makers. In this paper, we examined the relationship between couples' domestic work participations and the transitions to the second birth in the beginning of the 21st century Japan by using a newly available nationally representative panel data of LSN21. The data we have used is the highest quality panel data in Japan as LSN21 data is collected by the statistics department of the Ministry of Health, Labour and Welfare as a government statistics and known for its large sample size and the minimum rates of attrition. Our analysis was benefitted from the use of LSN21 data and provided a new insight of the relationship between couples' gender relations and fertility in Japan.

Our analysis revealed that the transition rates from first to second birth are higher in Japan among gender traditional families which are single earner households with husbands' stable employments and wives' great commitments to housework, than gender equal families of dual-earner households. However, husband's greater participation in childcare can contribute to higher chance of the second birth, irrespective to the wife's employment status. Men's greater concern to childrearing is positively relating to fertility outcomes in Japan. In terms of the social role expectation, men's participation in childrearing may be highly demanded by wives and meeting with such expectation affects transitions to the second birth.

We also find a strong negative effect of wife's higher commitment to housework on the second birth hazard when the wife works full-time. We interpret this as a negative fertility response to the "second shift". However, our analyses consistently reveal that husbands' supports in housework do not

remedy the negative consequence on fertility. Instead, our analysis suggests that a large part of the physical and psychological burdens of the full-time employed wives is, in fact, mitigated by coresident parents. The only exception for this relationship seems to be a situation where a wife is self-employed. Husband's greater participation in housework has a positive effect on the transitions to the second birth only when the wife is self-employed. As more than a half of the self-employed wives' husbands are also self-employed, this relationship is considered to be a specific to self-employed couples. However, it is not clear from our analysis on which aspects of the self-employment make husband's housework participation a driving force of the second births. Thus, further study is necessary to search for key factors to extend the observed relationship to a majority of couples whose husbands are employed by a company. In this paper, we only speculate that such work conditions of self-employment as flexible work arrangement, proximity of home and workplace or small gender gap in the workplace may explain the positive link.

Finally, the policy implications of our study will be the followings; First, our analyses consistently reveal that wives' employments relate negatively to the second birth intensities. Therefore, strong policy measures for reducing women's worker-mother conflicts are necessary to establish the positive linkage between gender equality in labor market and fertility as observed in some western countries. However, one remark is that our analysis is based on the first five years of the 21st century Japan where formal introductions of the childcare support policies such as childcare leave system, sick/injured child care leave and reduced work hours for childcare were only its onset. Therefore, using data which covers more recent period may already see some improvement in the negative relationship as indicated in Figure 2. Therefore, the continuous monitoring of the relationship between women's employment and fertility outcomes will be particularly important to evaluate the policy effects as well as future levels of fertility.

Second, our analysis indicates that gender equality at home has some mixed effects on fertility outcomes. Men's participation in childcare seems to be a universally required social role in contemporary Japanese couples and the degree to meeting with such expectation, in fact, affects fertility outcomes. In

this respect, the gender equality in childcare can lead to higher fertility in Japan as similar to some of other European countries (Puur et al. 2008 Miettinen, Basten and Rotkirch 2011). On the other hand, work hours are, in general, very inflexible in Japan. Previous studies suggest this inflexibility, in large part, explains very low levels of husband's participation in housework in Japan (Nishioka 1998, Matsuda 2002, Suruga 2010). Our results, however, shows that husband's greater participation relates positively to the second birth hazard in the self-employed couples who are likely to share both home and work place. Therefore, it is possible that more flexible work arrangement as well as proximity of home and workplace contribute to establish a positive link between the gender equality within the family life and fertility.

APPENDIX :

Table A-1. Fixed Effect Models on Husband's Participations in Housework and Childcare

Fixed effect regression on husband's frequencies in housework and childcare

	All couples		By wife's employment status at wave 1			
	Housework	Childcare	Full-time employee		Staying at home	
	b	b	b	b	b	b
Couple's participation in housework and childcare						
Husband's childcare frequency (Factor score)	0.207 ***	-	0.258 ***	-	0.191 ***	-
Husband's housework frequency (Factor score)	-	0.298 ***	-	0.384 ***	-	0.265 ***
Wife's childcare frequency (Factor score)	-0.015 ***	0.030 ***	-0.004	0.035 ***	-0.014 ***	0.025 ***
Wife's housework frequency (Factor score)	-0.027 ***	0.015 **	-0.032 **	0.024	-0.014 **	0.019 ***
Couple's income						
Husband's income	0.000	-0.030 *	-0.036	-0.006	-0.019	-0.031
Wife's income	-0.017 ***	-0.008	0.000	-0.014	-0.006	-0.005
(Wife's income / Couple's income)*10	0.052 ***	0.016	0.027 *	0.025	0.021	0.013
Wife's employment status (Reference: Not employed or students)						
Self-employed or family businesses	-0.025	-0.066	0.000	0.063	-0.028	-0.110 *
Full-time employees	0.126 ***	0.007	0.199 ***	-0.041	0.380 ***	0.087
Part-time employees	0.061 **	0.000	0.007	-0.124	0.192 ***	0.014
Husband's employment status (Reference: Full-time employee/Self-employed or family businesses)						
Not employed/students/Part-time employees	0.148 ***	0.144 ***	0.037	0.114	0.190 ***	0.164 ***
Pregnancy	0.197 ***	0.076 ***	0.146 ***	0.040	0.227 ***	0.091 ***
Childbirth	-0.071 ***	0.059 ***	-0.167 ***	0.043	-0.057 ***	0.064 ***
Coresidence with parents (Reference: Not living together)	-0.380 ***	0.013	-0.477 ***	0.092	-0.360 ***	0.001
Use of Childcare	0.226 ***	0.126 ***	0.165 ***	0.193 ***	0.096 ***	0.075 ***
Survey wave (Reference: 1st wave)						
2nd wave	-0.127 ***	0.210 ***	0.025	0.230 ***	-0.171 ***	0.199 ***
3rd wave	-0.185 ***	0.265 ***	-0.024	0.233 ***	-0.212 ***	0.266 ***
Constant	0.073	-0.018	0.005	-0.211	0.248 **	0.005
Number of person-period	33597	33597	5871	5871	25845	25845
Number of samples	11199	11199	1957	1957	8615	8615
Within R2	0.112	0.136	0.204	0.233	0.096	0.117
Between R2	0.293	0.288	0.356	0.34	0.227	0.254
Overall R2	0.247	0.233	0.316	0.302	0.187	0.201
Degree of freedom	11214	11214	1972	1972	8630	8630

*, p<.10, **, p<.05, ***, p<.01

Table A-2. Fixed Effect Models on Wife's Participations in Housework and Childcare

	All couples		By wife's employment status at wave 1			
	Housework b	Childcare b	Full-time employee		Staying at home	
			Housework b	Childcare b	Housework b	Childcare b
Couple's participation in housework and childcare						
Husband's childcare frequency (Factor score)	0.015 **	0.057 ***	0.024	0.062 ***	0.021 ***	0.054 ***
Husband's housework frequency (Factor score)	-0.040 ***	-0.042 ***	-0.046 **	-0.009	-0.022 **	-0.042 ***
Wife's childcare frequency (Factor score)	0.110 ***	-	0.146 ***	-	0.081 ***	-
Wife's housework frequency (Factor score)	-	0.206 ***	-	0.263 ***	-	0.156 ***
Couple's income						
Husband's income	-0.033 **	-0.077 ***	0.019	-0.130 ***	-0.013	-0.077 ***
Wife's income	0.030 ***	0.015	0.019	0.024	0.019 **	0.021
(Wife's income / Couple's income)*10	-0.087 ***	-0.068 ***	-0.062 ***	-0.056 **	-0.060 ***	-0.084 ***
Wife's employment status (Reference: Not employed or students)						
Self-employed or family businesses	-0.032	0.005	-0.249	0.495 **	-0.093	-0.094
Full-time employees	-0.156 ***	-0.102 **	-0.157 ***	-0.098	-0.603 ***	-0.461 ***
Part-time employees	-0.034	-0.051	-0.042	-0.027	-0.072 *	-0.027
Husband's employment status (Reference: Full-time employee/Self-employed and family businesses)						
Not employed/students/Part-time employees	-0.093 **	-0.086 *	0.117	-0.189	-0.146 ***	-0.098
Pregnancy	-0.113 ***	-0.001	-0.131 ***	-0.061	-0.118 ***	0.015
Childbirth	0.071 ***	-0.035	0.191 ***	0.058	0.032	-0.068 **
Coresidence with parents (Reference: Not living together)	-0.761 ***	0.052	-0.736 ***	-0.130	-0.882 ***	0.122 ***
Use of Childcare	-0.172 ***	-0.120 ***	-0.121 ***	0.033	-0.082 ***	-0.219 ***
Survey wave (Reference: 1st wave)						
2nd wave	0.126 ***	-0.050 ***	-0.004	-0.154 ***	0.191 ***	-0.018
3rd wave	0.215 ***	-0.298 ***	0.088 ***	-0.319 ***	0.267 ***	-0.310 ***
Constant	0.331 ***	0.651 ***	0.324	1.110 ***	0.123	0.596 ***
Number of person-period	33597	33597	5871	5871	25845	25845
Number of samples	11199	11199	1957	1957	8615	8615
Within R2	0.084	0.065	0.117	0.086	0.085	0.06
Between R2	0.264	0.13	0.349	0.196	0.17	0.04
Overall R2	0.21	0.095	0.283	0.144	0.142	0.052
Degree of freedom	11214	11214	1972	1972	8630	8630

*: p<.10, **: p<.05, ***: p<.01

Table A-3. Definition of Covariates

Names of variables	Definitions
Participation by each spouse in housework and child rearing	
Individual fixed effect on participation in housework (both for husband and wife)	An estimated fixed effect of factor scores based on either husband's or wife's participation in housework measured at wave 1 through wave 3. The factor score is calculated from the following 6 items: (1) Cooking, (2) Doing dishes, (3) Cleaning a house, (4) Washing laundry, (5) Taking out garbage, and (6) Doing daily shopping using a pooled data of wave 1 through wave 3. 0 points are given if the husband "never" does such activity, 1 point if the husband "rarely" does such activity, 2 points if the husband "sometimes" does such activity, and 3 points if the husband "always" does such activity.
Individual fixed effect on participation in child rearing (both for husband and wife)	An estimated fixed effect of factor score based on both husband's and wife's participations in childcare measured at wave 1 through wave 3. The factor score is calculated from the following 3 items: (1) Feeding, (2) Changing diapers, and (3) Bathing using a pooled data of wave 1 through wave 3. 0 points are given if the husband "never" does such activity, 1 point if the husband "rarely" does such activity, 2 points if the husband "sometimes" does such activity, and 3 points if the husband "always" does such activity.
Couple's employment status	
Wife's employment status	Based on the question about the wife's employment status, as asked in each survey, the following 4 categories are created: "1: Not employed or students," "2: Self-employed or family business workers," "3: Regular employment," and "4: Employment other than 2 and 3." **"Self-employed or family business workers" includes the cases where the employment status belongs to "Others." *By using the employment status at t-1, the influence over the birth of a second child occurred during the period from t-1 to t is estimated.
Husband's employment status	Based on the question about the wife's employment status, as asked in each survey, the following 4 categories are created: "1: Not employed or students," "2: Self-employed or family business workers," "3: Regular employment," and "4: Employment other than 2 and 3." **"Self-employed or family business workers" includes the cases where the employment status belongs to "Others." *By using the employment status at t-1, the influence over the birth of a second child occurred during the period from t-1 to t is estimated.
Social variables	
Wife's education level	Based on the question about the wife's education level with respect to the "school that the wife last graduated (or is attending)," as asked in the 2nd wave survey, the following 4 categories are created: "1: Junior high school, special training school, or vocational school (after graduation from junior high school)," "2: High school," "3: Special training school, vocational school (after graduation from high school), junior college, or technical college," or "4: University or graduate school." *The analysis excludes the case where the wife's education level belongs to "Others."
Coresidence with parents	Based on the question about the household member of the first child, the dummy variables are created on whether or not the parents of either the wife or the husband are living together.
Wife's anxiety and feelings of burden over child rearing	
Anxiety and distress over child rearing	For the question "Do you feel anxiety or distress over child rearing? Please check one number that applies," the following response alternatives are provided: "1: Feel a lot," "2: Feel a bit," and "3: Feel very little." These responses are used as category variables. The values at the 1st wave survey are used.
Score on feeling of burden over child rearing	For the question "What makes you feel burdened after you had a child?," the following choices are provided (multiple choices allowed): (1) Physical burden is heavy, (2) Expenses for child rearing is high, (3) Unable to have own free time, (4) Unable to have time for enjoyment for a couple, (5) Unable to have enough time for work, (6) People around do not understand how difficult it is to raise a child, (7) My child is sickly, and (8) Others. We have used the number of selected choices. The values at the 1st wave survey are used.
First child characteristics	
Sex of the first child	0: Male, 1: Female
Premature and underweight baby	Whether first baby was a premature and underweight baby or not. 0: Not premature baby 1: Premature baby (a baby whose weight at the time of birth was less than 2500 g AND who was born in less than 37 weeks of pregnancy).
Premarital pregnancy	Whether first birth is consequence of a premarital pregnancy or not. 0: Not premarital pregnancy 1: Premarital pregnancy (The first birth took place less than 9 months after the father and mother started to live together).
Month of birth	Whether the first child was born in either January or July. 0: January 1: July
Demographic characteristics	
Birth interval	The duration measured in months since the birth of the first child is used as the spline function.
Wife's age at first birth	The dummy variables for the wife's age at the time of giving birth to the first child.
Area of residence	Based on the domicile information obtained in each survey, the following 9 local block categories are created: "1: Hokkaido" "2: Tohoku (Aomori, Iwate, Miyagi, Akita, Yamagata, and Fukushima)" "3: Kanto (Ibaraki, Tochigi, Gunma, Saitama, Chiba, Tokyo, and Kanagawa)" "4: Hokuriku (Niigata, Toyama, Ishikawa, and Fukui)" "5: Chubu (Yamanashi, Nagano, Gifu, Shizuoka, Aichi, and Mie)" "6: Kinki (Shiga, Kyoto, Osaka, Hyogo, Nara, and Wakayama)" "7: Chugoku (Tottori, Shimane, Okayama, Hiroshima, and Yamaguchi)" "8: Shikoku (Tokushima, Kanagawa, Ehime, and Kochi)" "9: Kyusyu and Okinawa (Fukuoka, Saga, Nagasaki, Kumamoto, Oita, Miyazaki, Kagoshima, and Okinawa)"
Size of municipality where the respondent resides	Based on the domicile information obtained in each survey, the following 3 categories are created with respect to the size of the municipality: "1: Large cities," "2: Other cities," and "3: Rural districts" **"Large cities" means the Tokyo Metropolitan Area and the government-ordinance-designated cities as of the time of each survey.

Table A-4. Hazard ratios of the transition to second birth: All covariates

	Model 1	Model 2	Model 3	Model 4	Model 5
Covariates	exp(b)	exp(b)	exp(b)	exp(b)	exp(b)
Couple's participation in housework and child-rearing					
Husband's childcare frequency (Ind. fixed effect)	1.08 ***	1.08 ***	1.08 ***	1.08 ***	1.08 ***
Husband's housework frequency (Ind. fixed effect)	0.99	0.99	0.98	0.99	0.99
Wife's childcare frequency (Ind. fixed effect)	1.01	1.01	1.01	1.01	1.01
Wife's housework frequency (Ind. fixed effect)	1.06 ***	1.06 ***	1.06 ***	1.05 ***	1.11 ***
Wife's employment status (Reference: Not employed or students)					
Not employed or students	1	1	1	1	1
Self-employed or family businesses	0.86 **	0.86 **	0.87 **	0.86 **	0.86 **
Full-time employees	0.86 ***	0.87 ***	0.87 ***	0.86 ***	0.86 ***
Part-time employees	0.67 ***	0.67 ***	0.67 ***	0.67 ***	0.67 ***
Husband's employment status (Reference: Not employed or students)					
Not employed or students	1	1	1	1	1
Self-employed or family businesses	1.50 ***	1.50 ***	1.51 ***	1.50 ***	1.49 ***
Full-time employees	1.45 ***	1.46 ***	1.46 ***	1.46 ***	1.45 ***
Part-time employees	1.18	1.18	1.18	1.18	1.17
Interaction effects:					
Wife's employment status * Husband's child-rearing / housework frequencies (Fixed Effect)		Husband's child-rearing	Husband's housework		
Not employed or students		1	1		
Self-employed or family businesses		1.08	1.25 ***		
Full-time employees		0.98	0.99		
Part-time employees		0.98	1.03		
Wife's employment status * Wife's child-rearing / housework frequencies (Fixed Effect)				Wife's child-rearing	Wife's housework
Not employed or students				1	1
Self-employed and family businesses				1.04	1.09
Full-time employees				1.01	0.89 ***
Part-time employees				0.92	0.95
Wife's education level (Reference: High school)					
Junior high school	1.00	1.00	0.99	0.99	1.00
High school	1	1	1	1	1
Vocational school/Junior college/Technical college	1.13 ***	1.13 ***	1.13 ***	1.13 ***	1.13 ***
University/Graduate school	1.17 ***	1.17 ***	1.17 ***	1.17 ***	1.17 ***
Coresidence with parents (Reference: Not living together)					
Living together	1.09 ***	1.09 ***	1.09 ***	1.09 ***	1.07 **
Wife's anxiety and feelings of burden over child-rearing					
Anxiety or distress over child-rearing					
Feel a lot	0.79 ***	0.79 ***	0.79 ***	0.79 ***	0.79 ***
Feel a bit	1	1	1	1	1
Feel almost none	1.11 ***	1.11 ***	1.11 ***	1.11 ***	1.11 ***
Score on feelings of burden over child-rearing (Reference: 0 point)					
0 point	1	1	1	1	1
1-2 points	1.01	1.01	1.01	1.01	1.01
3-4 points	0.99	1.00	0.99	0.99	1.00
5-8 points	0.80 ***	0.80 ***	0.80 ***	0.80 ***	0.80 ***
First child characteristics					
Sex of the first child (Reference: Male)					
Female	0.98	0.98	0.98	0.98	0.98
Premature, underweight baby (Reference: No)					
Yes	0.66 ***	0.65 ***	0.66 ***	0.65 ***	0.66 ***
Premarital pregnancy (Reference: No)					
Yes	1.14 ***	1.14 ***	1.14 ***	1.14 ***	1.14 ***
Month of birth (Reference: Born in January)					
Born in July	1.04 *	1.04 *	1.04 *	1.04 *	1.04 *
Demographic Characteristics					
Birth interval spline (Base point: 0 year)					
0-3 year	2.17 ***	2.17 ***	2.17 ***	2.17 ***	2.17 ***
3-4 year	0.62 ***	0.62 ***	0.62 ***	0.62 ***	0.62 ***
4-6 year	0.65 ***	0.65 ***	0.65 ***	0.65 ***	0.65 ***
Wife's age at first birth (Reference: Age 25-29)					
Age <24	1.17 ***	1.17 ***	1.17 ***	1.17 ***	1.17 ***
Age 25-29	1	1	1	1	1
Age 30-34	0.72 ***	0.72 ***	0.72 ***	0.72 ***	0.72 ***
Age 35-	0.32 ***	0.32 ***	0.31 ***	0.32 ***	0.31 ***
Area of residence (Reference: Kanto)					
Hokkaido	0.99	0.99	0.98	0.99	0.99
Tohoku	1.09 *	1.09 *	1.09 *	1.09 *	1.08
Kanto	1	1	1	1	1
Hokuriku	1.08	1.08	1.08	1.08	1.08
Chubu	1.14 ***	1.14 ***	1.14 ***	1.14 ***	1.14 ***
Kinki	1.13 ***	1.13 ***	1.13 ***	1.13 ***	1.13 ***
Chugoku	1.14 ***	1.14 ***	1.14 ***	1.14 ***	1.14 ***
Shikoku	1.16 **	1.16 **	1.16 **	1.16 **	1.16 **
Kyusyu and Okinawa	1.27 ***	1.27 ***	1.27 ***	1.27 ***	1.27 ***
Size of the municipality where the respondent resides (Reference: Other cities)					
14 Largest cities	0.91 ***	0.91 ***	0.91 ***	0.91 ***	0.91 ***
Other cities	1	1	1	1	1
Rural districts	1.14 ***	1.14 ***	1.14 ***	1.14 ***	1.14 ***
Constant					
Constant	0.015 ***	0.015 ***	0.015 ***	0.015 ***	0.015 ***
Number of person-period	68503	68503	68503	68503	68503
Number of samples	10808	10808	10808	10808	10808
Number of events	7580	7580	7580	7580	7580
Chi-square values	3371.174	3371.498	3379.055	3375.922	3378.800
Degree of freedom	39	42	42	42	42

*: p<.10, **: p<.05, ***: p<.01

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縦断調査を用いた出生力の規定要因分析

父母の喫煙習慣効果を検証するモデル比較

岩澤美帆¹ 鎌田健司²

目的 本研究では 2001 年に子どもをもった夫妻を追跡した縦断調査データを用い、出生力の規定要因を様々なモデルによって検証した。先行研究で指摘されている父母の喫煙習慣の出生に対するネガティブな効果に着目し、当該出生児出産半年後の父母の喫煙習慣が出生力に与える影響を検証した。

方法 厚生労働省統計情報部が実施した「21 世紀出生児縦断調査 (平成 13 年出生児)」を用い、第 6 回時調査の出生児数を従属変数としたポアソン回帰モデル、第 6 回時調査までの追加出生の有無をモデル化したロジスティック回帰モデル、第 6 回までの脱落データを含まない場合と含んだ場合の次子出生タイミングについてのコックス回帰モデルを推定し、父母の喫煙習慣による効果を検証した。

結果 第 2 子出生への母の喫煙習慣の影響については、ポアソン回帰、ロジスティック回帰、コックス回帰のいずれでも大きなマイナスの効果があり、第 2 子出生ハザード比で言えば 25%減であった。第 3 子についてはロジスティック回帰、コックス回帰でのみ 5%の水準でマイナスの効果を確認された。父の喫煙効果は母に比べて小さくモデルによっては有意にならないが、脱落を含んだコックス回帰では第 2 子で 1%、第 3 子で 5%の水準でハザードを 1 割程度引き下げる効果が示された。

結論 要因によってはモデルや脱落ケースを含むかどうかで結果が異なるので、複数のモデルを試し結果の安定性を確認することが重要である。父母の喫煙習慣のマイナスの効果は働き方など他の社会経済的条件と比べても小さくなく、妊娠中の喫煙を抑制する取り組みは母子の健康増進のみならず出生数の増加そのものにも効果があることが期待できる結果が得られた。なお喫煙者は非喫煙者に比べ属性に偏りがあるといったことが結果に影響していないか、また今回統制できなかった時間変化変数の影響を検証することについては今後の課題としたい。

I はじめに

同一の個人を長年にわたって追跡する縦断調査は、時間的に前に経験されたことのその後の影響について、両方の情報を正確に把握できる利点を持っている。出生力の規定要因をさぐる上で、妊娠前の情報とその後の出生過程が把握できる縦断調査は極めて貴重であると言える。本研究では、「21 世紀出生児縦断調査 (平成 13 年出生児)」における対象児の父母 (夫妻) の情報を用い、父母の妊娠前の行動とその後の出生過程との関係を検証する。今回は、父母の妊娠前の喫煙習慣に着目する。妊娠前や妊娠中の女性の

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喫煙やパートナーの喫煙による受動喫煙は、疫学的な研究により、妊孕力低下や胎児死亡（流死産）のリスク要因になることが知られている(Augood et al. 1998, Dechanet et al. 2011)。今日の再生産年齢にある父母の喫煙行動が実際に日本の出生力にマイナスの影響を与えているかどうかを検証するにあたっては、出生力の指標を何にするかによっていくつかのモデルが考えられる。本研究では様々な出生力指標とそれに適したモデルを整理し、結果の比較およびそれぞれのモデルのメリットやデメリットについて論じることで、縦断調査を用いた出生力の規定要因分析に適した手法に関する知見を提供したい。

II 先行研究における出生力指標

これまでの疫学的な研究により、喫煙は、妊孕力の低下、有害な生殖結果といった様々なリスクを高めることが確認されている(Dechanet et al. 2011)。こうしたリスクには流産、前置胎盤、早期破水、早産、低体重児などが含まれる。

喫煙がネガティブな影響をあたえる生殖に関する指標には、以下のようなものが含まれる。

(1) 受胎待ち時間・不妊

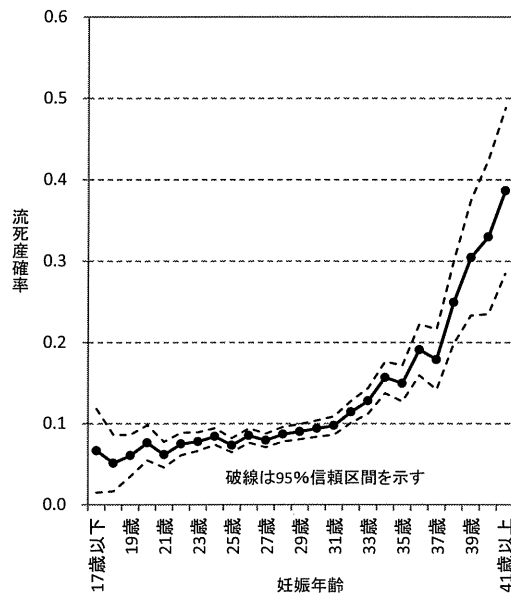
女性の能動喫煙や男性の喫煙による受動喫煙は、受胎待ち時間を長期化させることが分かっている。1日21本以上(Hull et al. 2000)、1日16本以上(Hassan and Killick 2004)のタバコ喫煙が受胎待ち時間を有意に長くするといった結果が得られている。また、喫煙と受胎待ち時間との関係に着目したメタアナリシス（過去に報告された多数の研究結果を、統合して再分析する方法）によれば、12の研究に基づき、受胎待ち時間が一定以上になる不妊に関するオッズを喫煙者と非喫煙者で比べたオッズ比は、コホート調査で1.42、ケース・コントロール研究で2.27、全体で1.60であった(Augood et al. 1998)。

(2) 流死産確率

受胎待ち時間の長期化・不妊の他に母親の喫煙は子宮外妊娠、流産、胎盤剥離、周産期死亡、死産、先天性形成異常のリスクを高めることが知られている(Cnattingius 2004)。Kline et al.(1995)は、1日14本以上の喫煙で、染色体異常のない胎児の死亡リスクを上げることを示している。夫の喫煙による受動喫煙も、妊娠初期の胎児死亡に影響(Venners et al. 2004)。

出生動向基本調査によると、近年の日本における1妊娠あたりの流死産確率は30歳で0.094であった(岩澤 2012)(図1)。Chatenoudら(1998)は、イタリアの医療施設ベースのケース・コントロール研究をもとに、喫煙していた妊婦の流死産のオッズ比が非喫煙者に対し1.3倍であることを示している。仮に出生動向基本調査の0.094を非喫煙者の流死産確率と見なすと、オッズ比が1.3倍となる喫煙者の流死産確率は0.119となる。すなわち、非喫煙者の出生数を100%とすると、喫煙者の出生数は97.3%に抑制される計算となる。これは非喫煙者の出生数が2.0であった場合、喫煙者の出生数は1.95しか実現しないことを意味する。

図1 妊娠年齢別にみた妊娠1回あたりの流死産確率



データ：「出生動向基本調査」(岩澤 2012)

Ⅲ データ

日本において、妊娠前の親の喫煙状況とその後の生殖過程をとらえた大規模調査はほとんどない。2011年に始まった環境省および(独)国立環境研究所による「子どもの健康と環境に関する全国調査(エコチル調査)」においては、母の喫煙習慣や母尿中のニコチンを測定し、妊娠異常や胎児の発達との関係を分析する予定であるが、妊娠後の母親が対象となることから、妊孕性については分析の対象外となっている。喫煙と出生力との関係がわかる唯一の大規模調査が厚生労働省統計情報部による「21世紀出生児縦断調査(平成13年出生児)」であり、本研究ではこの調査の第1回～第6回分を用いる。ただし、出生児を対象とした調査であるため、2001年に出生経験のある、子どもを1人以上生んでいる夫妻が対象であると言い換えることができる。また2001年時点で父母が同居しているケースに限定した。第8回以降も調査は継続されているが、子どもの出生月の項目が削除され出生年情報しか得られないため分析には使用しなかった。

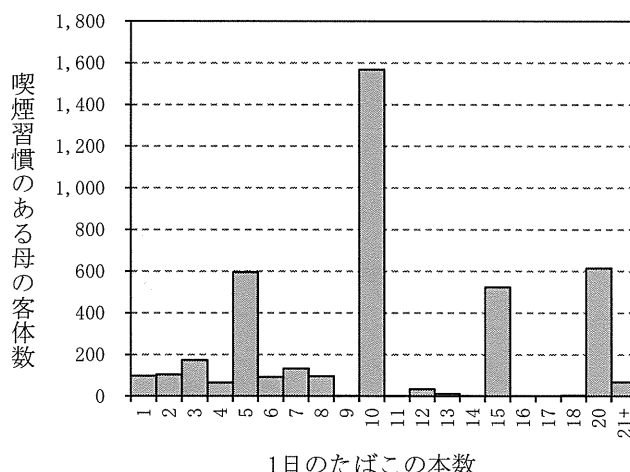
喫煙習慣が出生力に影響を与える経路としては、上記の先行研究により(1)受胎待ち時間の長期化・不妊、(2)子宮外妊娠、(3)流産、(4)胎盤剥離、(5)周産期死亡、(6)死産、(7)先天性形成異常、といったものがあることを示したが、出生児縦断調査には、残念ながら流産経験や妊娠中の問題に関する情報はない。出生児縦断調査で把握できるのは、次子の出生の有無とその出生年月である。本研究ではこれらの情報からとらえられる出生力指標を喫煙習慣で説明するモデルをいくつか提示し、結果を比較する。

また、喫煙と出生力との関係は、喫煙が妊孕力や流死産を通じて出生力を引き下げるほか、喫煙している人は出生意欲が低い傾向にあり、避妊をするなど意図的に出生を回避している場合、その効果も含んでいることになる。したがって本研究における喫煙の

効果は、こうした喫煙者の出生意欲の特徴も含んだ結果であることに留意する必要がある。

分析対象となった夫婦数（母の数）は、32,632 であり、第 1 回調査時において母が喫煙しているケースが 4,197(12.9%)、喫煙していないケースは 28,435(87.1%)であった。また喫煙習慣のある母の 1 日のたばこの本数の分布を図 2 に示したが、1 日 10 本が最も多いケース数となっている。この情報を用い、喫煙習慣の有無のみならず、喫煙本数と子ども数との間に量一反応関係があるかを検証することで、喫煙の直接的影響を確認する。

図 2 21 世紀縦断調査における 1 日のたばこ本数別にみた母の標本数（第 1 回調査）



データ：「21 世紀出生児縦断調査」

注：喫煙習慣のある母 4,197 件について。この他、「たばこを吸っていない」母の標本数は 28,435 件となる。

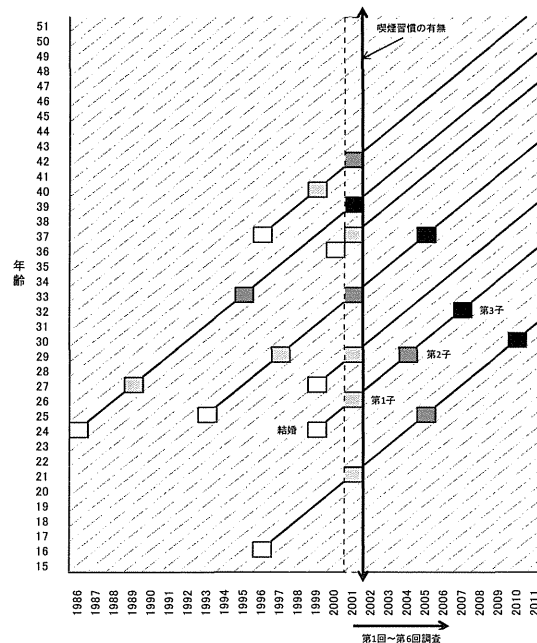
なお、出生児縦断調査における最初の喫煙の情報は、対象児が生まれてから半年後の時点のものとなる。従って、妊娠中の喫煙の有無ではない。また、出生児を対象にしている調査であるため、第 1 回調査の父母の喫煙の情報は、第 1 子の出産後である場合もあれば、第 3 子の出産後である場合もある。本研究では、妊娠中の喫煙の当該に妊娠に与える影響というよりも、再生産期間全般にわたる喫煙習慣が生涯の出生力に与える影響をとらえていることになる。ただし、喫煙の情報が得られた際にすでに生んでいる子ども数を統制することはできる。具体的には、主効果の他に、喫煙と対象児第 2 子、喫煙と対象児第 3 子以上、の交互作用項を投入し、調査時点の影響を統制する。参考までに対象児の親の結婚と出生イベントに関する生命線を図 3 に示した。

以上の目的から、処置変数である父母の喫煙状況は、(1) 父母の喫煙習慣の有無、(2) 母の 1 日の喫煙本数（喫煙なし、1～5 本、6～10 本、11 本以上）、そして既往出生児を扱う場合は (3) 母の喫煙習慣の有無と対象児の出生順位との交互作用効果、の 3 項目について分析を行った。

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21世紀出生児縦断調査の個票データは、統計法（平成19年法律第53号）第32条の規程に基づき、上記研究の遂行を目的として、国立社会保障・人口問題研究所において同調査等に係る調査票情報の提供の申出を行い（平成24年9月25日付、社人研発092502号および平成24年12月18日付、社人研発第121801号）、厚生労働省大臣官房統計情報部から利用の承認を得たものである（平成24年10月25日付、統発1025第1号および平成24年12月25日付、統発1225第1号）。

図3 21世紀出生児縦断調査における母の結婚生命線と出生イベントの例および父母の喫煙習慣調査



注：本研究では対象児出生半年後（第1回調査）の父母の喫煙習慣と第6回時既往出生児数との関係を検証する。

IV 従属変数とモデル、統制変数

分析モデルは従属変数である出生力指標によって異なるものを選択する必要がある。

(1) 第6回時点での夫妻の累積出生児数

この変数はカウント変数である。累積出生児数の分布は図4の通り右に裾をひく形状で有り、この従属変数は0~8をとる。ここでは、ポワソン回帰モデルを推定する。なお、第1回、第2回、第6回の回答者に限定する。

ポワソン分布回帰モデルは、少数のカウントデータがポワソン分布に従って生起すると仮定できる場合に適用できる。子ども数は平均値が2~3となる非負の分布を示すため、通常回帰モデルよりも、ポワソン分布回帰モデルが適合的であると考えられる。ある時点においてあるイベントが発生する確率または期待値を μ 、 y を発生したイベント数を示すランダム変数であるとする。ある時には平均よりも発生回数が少なく、また

別の時には多いようなイベントの場合、観察された y の発生確率は期待値 μ のポワソン分布に従う (Long and Freese 2006)。

$$\Pr(y | \mu) = \frac{e^{-\mu} \mu^y}{y!} \quad \text{ここで } y = 0, 1, 2, \dots$$

ポワソン分布の基本的な性質は以下の通りである。(1) μ は分布の平均を示し、 μ が大きくなるほど分布のピークは右にシフトする。(2) μ は同時に分散でもある。 $\text{Var}(y) = \mu$ という関係となっているため、平均と分散が比例的に変化 (equidispersion) することを仮定している。(3) μ が増加するにつれて、0 カウントの確率が減少する。(4) μ が増加するにつれて、ポワソン分布は正規分布に近似する。

ポワソン回帰モデルは、それぞれの観測値が異なる μ の値を持つことを許容することによってポワソン分布に拡張された回帰モデルである。すなわち、観察されたイベント y_i はポワソン分布における期待値 μ_i であり、 μ_i は観察された特質から推定される。これは観察された異質性 (observed heterogeneity) として知られ、構造方程式が導かれる。

$$\mu_i = E(y_i | x_i) = \exp(x_i' \beta)$$

この式を対数変換すると、

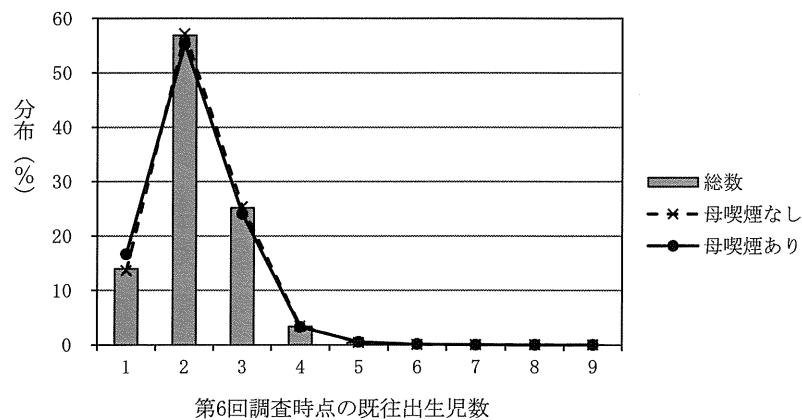
$$\log(\mu_i) = x_i' \beta$$

となり、 \log をリンク関数とした一般化線形モデルの一つと位置づけられる。

ポアソン回帰は平均値と分散が比例的に変化するという強い仮定を前提としている。この仮定が実際のデータに当てはまらない場合は、平均よりも分散が大きくなることを認める負の二項分布モデルや、分散と平均の関係の自由度をより高めた一般化ポワソン回帰モデルのほうが望ましい。こうしたモデルが有効かどうかを検証する。

なお、ポアソン分布は 0 以上をとる分布であるが、本分析に用いるデータは、出生児を対象とした縦断調査であり、父母の既往出生児は必ず 1 以上となる。事象が発生していないという情報が必要となるため、既往出生児数から 1 をマイナスした値を従属変数とした。

図4 21世紀出生児縦断調査における第6回調査時点の既往出生児数



(2) 第6回時点までの追加出生の有無

従属変数は追加出生有りの場合1、ない場合0をとるダミー変数である。ここでは出生順位別ロジスティック回帰モデルを推定する。なお、第1回、第2回、第6回の回答者に限定する。

ロジスティック回帰モデルは、ある現象が発生する確率 p を、説明変数で説明するモデルである。この場合、 p は次子を持つ確率となる。 p は、共変量の影響を線型な合成変数で表すことで、以下のようにモデル化される。

$$p(x_i) = \Pr(Y_i = 1 | x_i) = \frac{1}{1 + \exp(-x_i'\beta)}$$

この式を変形すると

$$\log \frac{p(x_i)}{1 - p(x_i)} = x_i'\beta$$

となり、ロジスティック関数をリンク関数とした一般化線形モデルの一つと位置づけられる。

(3) 出生後9ヶ月以降の追加出生までの待ち時間

縦断調査において第6回時点での状況を従属変数にしたモデルでは、第6回までに脱落した対象を分析から落とすことになる。そうした情報の損失を防ぐ手法に、観察途中で追跡できなくなった打ち切りデータも含めることができるハザードモデルがある。今回のケースでは出生後9ヶ月以降の追加出生までの待ち時間に着目し、要因の効果が比例的に次子出生のハザード関数に影響することを仮定する出生順位別コックス回帰モデル（比例ハザードモデル）が有効である。

なお、脱落の影響を見るために、第1回、第2回、第6回の回答者に限定した場合