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【Title】

The Influence of the Great East Japan Earthquake and the Fukushima Daiichi Nuclear Disaster on the Birth Weight of Newborns in Fukushima Prefecture : Fukushima Health Management Survey

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Short running title:
SGA and the Great East Japan Earthquake

Key words: **SGA, disaster, the Great East Japan Earthquake, disaster, the Fukushima Daiichi Nuclear Disaster, tsunami**

[Abstracts]

Objective: The Great East Japan Earthquake and the Fukushima Daiichi nuclear disaster occurred on 11th of March, 2011.The objective of this research is to investigate the incidence of SGA in Fukushima Prefecture, and to identify the risk factors on small for gestational age(SGA) (birth weight<-1.5S.D.)

Subjects and Methods: The subjects of this study were women who were pregnant at the disaster. Questionnaires were sent to women who lived in the Hamadori area(near seaside and the nuclear power plant) at the time of the incident, as well as to a control group of women who lived outside the Hamadori area. The incidence of SGA was examined. Logistic regression was performed to identify the risk factors on SGA.

Results: There were 5,790 corresponding to the criteria. 325(5.6%) were SGA. No difference was found in the two areas. No differences were identified in the comparison on the effect of trimester at disaster on SGA. Comparing between non-SGA and SGA, Pregnancy induced hypertension(PIH) incidence was high in SGA group(99(1.8%)vs.16(4.9%) p-value 0.001).Using logistic regression model, only PIH was found to be the risk factor on SGA incidence.

Conclusion: We found no evidence that the disasters increased SGA incidence in Fukushima prefecture.

Introduction:

The Great East Japan Earthquake occurred on 11th of March, 2011. Following the Tsunami, the lives of individuals on the Pacific Coast (of Japan) was forever changed. In Fukushima prefecture, the tsunami directly hit the Fukushima Daiichi Nuclear Power Plant, and the anxiety of the residents toward radiation hazard increased. Even among those who were living away from the evacuation target areas whose directives are given out by the Japanese government. Especially those living in the Hamadori area where the damage from Tsunami was large and people living there were forced to evacuate since the distance from Fukushima Daiichi Nuclear Power Plant was close evacuated to non-Hamadori areas in Fukushima Prefecture or to other prefectures. For pregnant women ,physical stress would be high because not only were they forced to evacuate but to change the medical institutes for their health check-up. Further more, it is thought that the level of their mental stress concerning the effect of the Fukushima Daiichi nuclear disaster on the fetal health would be much higher than pregnant women living in other areas.

Fukushima prefecture government established the Fukushima Health Management Survey in July 2011 to watch over the health of the residents that may be affected by the nuclear disaster in addition to the direct impact of the earthquake disaster and started investigation.

The pregnancy and birth survey is one of the 4 categories within the Fukushima Health Management Survey. It is questionnaire-based survey created by Fukushima prefecture and Fukushima Medical University for the purpose of understanding the health conditions and supporting the health management of pregnant women in Fukushima since the disaster at the nuclear power plant forced the pregnant women to take shelter, a life completely different from what it was before the disaster, forced to change the medical institute and/or irregular health check-up, which in return might result in incapability of managing the health of themselves and/or their fetuses.

There have been many studies investigating the maternal stress during pregnancy and abnormal outcomes occurred to newborns. Their results show various outcomes; however, enough evidence on the possibility of some causal effect of the maternal stress at prebirth on the abnormal birth outcomes and other life-time adverse events.

Out of the evidence, it is pointed out that maternal stress prevents fetal development[1)2)]. For instance, it has been reported that pregnant women under intense stress show the rate of low birth-weight baby becomes double or higher[3)]. Another report showed the risk for low birth weight(LBW), and small for gestational age(SGA) could be greater following stress exposure during the 5th and/or 6th month of pregnancy[4).]

Stress due to the Great East Japan Earthquake caused to the residents in the Hamadori area, located in Pacific coast of Fukushima Prefecture, was tremendous due to the damage of earthquake and tsunami and/or possible radioactive exposure by continuing to live in the area after the accident at Fukushima Daiichi Nuclear Power Plant.

In this research, variance in the incidence of SGA newborns due to stress caused to pregnant women who experienced these two disasters. Also, the relation of the trimester at the time pregnant women experienced the earthquake with SGA incidence was examined.

Methods

This survey was approved by the ethics committee of Fukushima Medical University (approval #13047). The outline of the survey was previously published, and some results have been demonstrated [5)].

Questionnaires, which can be seen on our website[6)], have been mailed out since January 18, 2012 to women who were pregnant at the time of the disaster. A total of 16,001 questionnaires were ultimately distributed.

9,298 responses were obtained, categorized into 4 areas based on the area mothers received their handbook (3 areas in Fukushima prefecture and non-Fukushima), and analyzed.

Fukushima prefecture can be geographically divided to 3 areas: Hamadori, Nakadori, and Aizu area. The Hamadori area is located seaside and the damage from tsunami was severe and many were forced to evacuate since the distance from Fukushima Daiichi Nuclear Power Plant was close. In order to investigate the factor which influences SGA, enrolled women were divided into two groups; those who lived in Hamadori area and non-Hamadori area(Figure 1).

We defined SGA as <-1.5S.D. from the weight equivalent of their gestational age. From the responses obtained, the cases with birth weight and expected delivery date were used for analysis, and “Japanese neonatal anthropometric

charts for gestational age at birth"[7] established by a research group granted by Ministry of Health, Labour and Welfare in March, 2010 was referred to find the equivalent weight and height based on gestational age. Therefore, the gestational weeks of the newborn targeted for this research were from 22 weeks and less than 42 weeks.

Inclusive criteria of this research were single pregnancy, no birth defects, replies with the newborn's birth weight answered to the questionnaire.

The pregnant woman who got the maternal and child health handbooks outside the prefecture was excluded from this research.

The questionnaire required the participants to fill in the expected delivery date, which ensured the pregnancy of all target cases at the Great East Japan Earthquake on 11th of March, 2011. Also, the information was used to examine the effect of the period of pregnancy at the time of disaster on SGA incidence.

Incidence and proportion of SGA newborns caused to pregnant women who experienced the Great East Japan Earthquake in Fukushima were calculated in sum, across Fukushima prefecture, and by area (Hamadori area, non-Hamadori area), and analyzed the variance by area in conjunction with the maternal characteristics.

Finally factors influencing SGA was analysed.

Subjects

The subjects of this study were women who were pregnant at the disaster. To investigate these women, we recruited participation to our study by sending a questionnaire to women who received maternal and child health handbook from municipal governments in Fukushima Prefecture between 1st of August,2011 and 31st of July, 2012 and women who received maternal and child health handbook from municipal governments in non-Fukushima prefectures, but delivered their children in Fukushima Prefecture because it is their hometown.

The questionnaire was sent to 16,001 women. The number of responses as of March 31, 2013 was 9,316(58.2%) .

Statistical analysis

All statistical analysis was done using SPSS software (SPSS Statistics v.22, IBM corp., Tokyo, Japan).

Comparison between groups was performed by Pearson's chi-square test,

Fisher's exact test, and one-way analysis of variance.

Logistic-regression analysis was conducted on the factors influencing SGA.

Statistically significant difference was attained when p-value <0.05.

Results

There were 5,790 examples corresponding to the criteria of this research.

Characteristics of mothers and newborns recruited to this study were compared between non-Hamadori area and Hamadori area. The percentage of pregnant women in Hamadori area who were forced to evacuate were significantly high (521(12.3%) vs. 698(44.4%), p-value 0.000), resulted in the fact that more pregnant women in Hamadori area were not able to receive health check-up as they planned (677(16.1％) vs. 572(37.1%), p-value 0.000). Mother's age was higher among those who lived in non-Hamadori area (30.29±4.90 vs. 29.87±5.10, p-value 0.005), and gestational age(days) at disaster were longer for non-Hamadori area (135.9±77.1 vs.142.5±74.8, p-value 0.004). There was no difference in the timing of birth between two areas or no difference in pregnancy complicated psychotic disorder or in the development of both physical and mental disorders after the earthquake was found between the two areas. Furthermore, there was no difference in the onset of pregnancy induced hypertension between the two groups (Table 1).

325 newborns had birth weight of <-1.5SD（5.61%）(113 newborns had birth weight of <-2SD(1.95%)(table 2.). No statistical significance was found in these results between non-Hamadori area and Hamadori area. No significant differences were identified in the comparison on the effect of trimester at disaster on SGA incidence between two areas（table 2）.

Even when removing the area factor, gestational age at disaster did not have effect on SGA incidence.

Comparing between non-SGA and SGA cases, pregnancy induced hypertension (PIH)(defined by) was significantly high in SGA groups in all regions(Table 3.). The same tendency was seen in the comparison of SGA and non-SGA groups in Hamadori area, and also in Non-Hamadori area.

Factors influencing SGA incidence were analyzed using logistic regression model. Only PIH was found to be the independent risk factor which influences SGA (Table 4.).

Discussion

Psychosocial stress due to disaster could affects perinatal outcomes. There have been many reports discussing the disaster and perinatal outcomes; they suggest that pregnant women, postpartum women, and their newborns are vulnerable to the effect of disaster-related economical change and collapse of medical care[8)]. In addition, females are more susceptible to mental illness than males at disaster[9)]. Especially, pregnant women and parous women are known to have high risk of developing sickness[10)].

Harville E. reported the results of 49 meta-analysis concerning a disaster and pregnancy outcome, mental health, and child growth[2)]. In some reports related to earthquakes, some mentions preterm birth and mental health of pregnant women, birth abnormality, and low birth weight; however, there are a few studies with large sample size. The report using the largest sample size was a hospital-based study on the Wenchuan earthquake (70,000 fatalities) including (pre- and post-earthquake group 6638 vs.6365) showed that ratio of low birth weight (%) was 3.72% and 5.01% (pre- vs. post-earthquake group, p-Value<0.01). High consistency was found in the negative effect of disasters including terrorist attacks, bombing, environmental disasters, and natural disasters on the development of fetus and birth weight. At the same time, results opposing to this also exist in the above meta-analysis.

There have been studies on the effect of the pregnancy period at the time of stress exposure on the abnormal pregnancy outcomes. Quetzal A. Class et al. conducted a research on the impact of timing of prenatal stress exposure on offspring risk for shortened gestational age , preterm birth, low birth weight, and small for gestational age using a population-based sample born in Sweden between 1973 and 2004, defining stress as "death of the father of the child or first-degree relative of the mother”. The results showed that prenatal maternal stress occurring between 5th and 6th months of pregnancy, they became especially high risk of gestational age at delivery, preterm birth, low birth weight, and SGA. They argued the potential mechanism behind the findings was the changes in the hypothalamus - pituitary gland - adrenal gland (HPA) system and controlling factors of stress-responsive molecules.

It is possible that small sample size of this study affects the results, but there was no significant difference in the SGA incidence by trimester. A potential cause for this difference may be variability in susceptibility or sensibility to the stress, difference in quality of stress or ethnic background.

The incidence of PIH in Fukushima prefecture obtained from this study was lower than the PIH incidence of the actual Japanese population. This might be due to the fact that this is a questionnaire-based study, and thus, there is a limit to obtain details such as complications during pregnancy in comparison to studies conducted based on medical records.

Some responses lacked necessary information such as parturition time and the birth weight, which reduced the cases available for this study on SGA down to 5,890 cases.

Nonetheless, the information obtained is very important for the residents of Fukushima prefecture since their concern on the health hazard caused by low dose radiation and stress. In future, further research is necessary to observe any changes in the SGA incidence from long-term standpoint.

Conclusion

SGA incidence among pregnant women experienced the disasters showed no difference in two areas or in gestational age at the disasters. No area difference was found in psychiatric disorders during pregnancy. These factors did not have effect on SGA.

Although many of the pregnant women in Hamadori area were forced to move to other areas, this fact did not influence SGA incidence either. PIH incidence had no difference between the areas but was found to be the independent risk fact of SGA incidence.

We found no evidence that the disasters increased the incidence of SGA.

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Fig.1 Hamadori area and non-Hamadori area

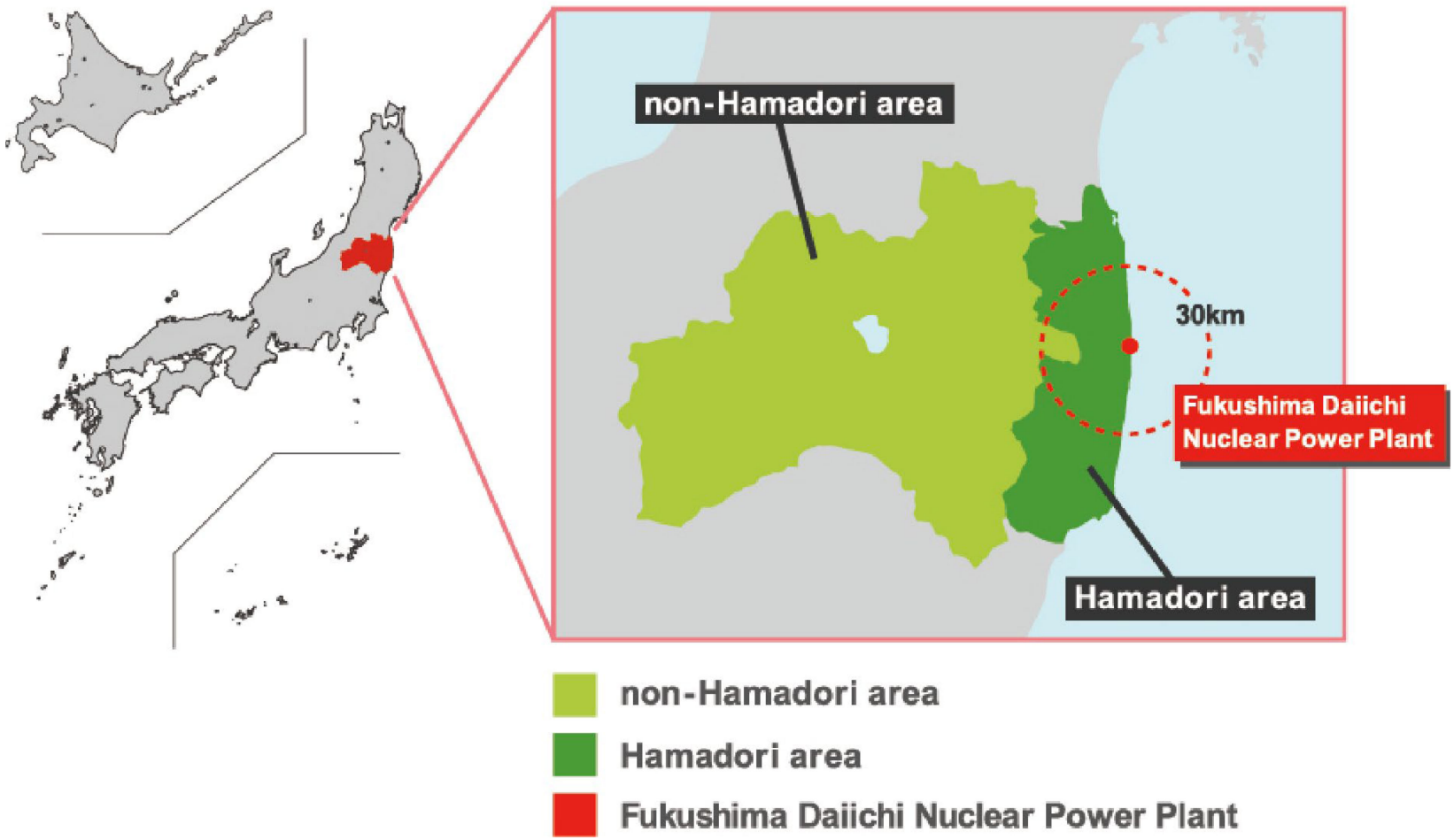

Table1. Characteristics of mothers and newborns enrolled in the study

	All regions	Non-Hamadori	Hamadori			
	Mean±SD (range)	Mean±SD (range)	Mean±SD (range)	p-value	OR(95%CI)	Statistical Analysis
Be forced to move to other cities because of the dissaster(n=5790)	1219 （21.1%）	521(12.3%)	698(44.8%)	0.000	5.789(5.055-6.630)	a)
Couldn't consult her doctor as planned(n=5748)	1249(21.7%)	677(16.1%)	572(37.1%)	0.000	3.070(2.690-3.503)	a)
Psychiatric disorder complicated pregnancy(n=5790)	95(1.6%)	72(1.7%)	23(1.5%)	0.552	0.866(0.540-1.391)	a)
Psychiatric disorder after pregnancy before dissaster(n=5790)	63(1.1%)	45(1.1%)	18(1.2%)	0.775	1.088(0.628-1.886)	a)
Psychiatric disorder after dissaster before delivery(n=5790)	239(4.1%)	168(4.0%)	71(4.6%)	0.316	1.156(0.871-1.535)	a)
Pregnancy induced hypertension(n=5790)	115(2.0%)	79(1.9%)	36(2.3%)	0.281	1.245(0.836-1.854)	a)
female infant(n=5790)	2822(48.7%)	2074(49.0%)	748(48.0%)	0.519	0.962(0.857-1.081)	a)
Natural pregnancy (n=5777)	5532(95.8%)	4039(95.6%)	1493(96.1%)	0.508	1.115(0.830-1.498)	a)
Maternal Age(n=5790)	30.18±4.96 (15-51)	30.29±4.90 (16-51)	29.87±5.10 (15-45)	0.005		b)
Maternal age＜20 years old	62(1.1%)	32(0.8%)	30(1.9%)	0.000	2.579(1.562-4.258)	a)
Maternal age≧35 years old	1164(20.1%)	877(20.7%)	287(18.4%)	0.055	0.865(0.746-1.003)	a)
Gravida(n=5733)	1.51±1.42 (0-16)	1.49±1.40 (0-16)	1.55±1.46 (0-11)	0.176		b)
Para(n=5790)	1.14±0.99 (0-9)	1.13±0.98 (0-9)	1.16±1.01 (0-6)	0.257		b)
Gestational Age(days) at delivery	275.8±10.1 (154-293) n=5790	275.8±1.0 (154-293) n=4233	275.7±10.5 (173-293) n=1557	0.851		b)
Gestational Age(day)at the disaster	137.7±76.5 (0-289) n=5790	135.9±77.1 (0-289) n=4233	142.5±74.8 (0-289) n=1557	0.004		b)
Mean SD of birth weight	-0.06±1.02 n=5790	-0.07±1.03 n=4233	0.00±1.00 n=1557	0.933		b)

a)χ^2-test b)ANOVA

Table 2. Comparison of pregnant women living Non-Hamadori and Hamadori on trimester at the disaster and SGA(BW<-2.0SD and BW＜-1.5SD)

	All regions	Non-Hamadori	Hamadori	p-value	OR(95%CI)
Total(n)	5790	4233	1557		
BW<-1.5SD	325(5.6%)	237(5.6%)	88(5.7%)	0.949	1.010(0.785-1.299)
BW<-2.0SD	113(2.0%)	84(2.0%)	29(1.9%)	0.831	0.938(0.613-1.437)
1st trimester	2169	1634	535		
BW<-1.5SD	122(5.6%)	95(5.8%)	27(5.0%)	0.589	0.861(0.555-1.336)
BW<-2.0SD	45(2.1%)	36(2.2%)	9(1.7%)	0.600	0.760(0.363-1.587)
2nd trimester	2198	1576	621		
BW<-1.5SD	119(5.4%)	80(5.1%)	39(6.3%)	0.295	1.251(0.843-1.856)
BW<-2.0SD	47(2.1%)	32(2.0%)	15(2.4%)	0.623	1.194(0.642-2.221)
3rd trimester	1423	1023	400		
BW<-1.5SD	84(5.9%)	62(6.1%)	22(5.5%)	0.802	0.902(0.547-1.488)
BW<-2.0SD	21(1.5%)	16(1.6%)	5(1.3%)	0.809	0.797(0.613-1.437)

χ^2-test

Table3. Compasion between Non-SGA and SGA(SGA:BW<1.5SD) (All regions)

	Birth weight≧1.5SD	Birth weight<1.5SD	p-value	OR（95%CI）	Statistical analysis
Be forced to move to other cities because of the dissasters(n=5790)	1147(21.0%)	72(22.2%)	0.617	1.071(0.818-1.403)	a)
Couldn't consult her doctor as planned(n=5790)	1181(21.8%)	68(21.0%)	0.739	0.954(0.725-1.256)	a)
Psychiatric disorder complicated pregnancy(n=5790)	89(1.6%)	6(1.8%)	0.655	1.136(0.493-2.617)	a)
Psychiatric disorder after pregnancy before dissaster(n=5790)	61(1.1%)	2(0.6%)	0.583	0.549(0.134-2.253)	a)
Psychiatric disorder after dissaster before delivery(n=5790)	229(4.2%)	10(3.1%)	0.390	0.726(0.381-1.381)	a)
Pregnancy induced hypertension(n=5790)	99(1.8%)	16(4.9%)	0.001	2.807(1.635-4.818)	a)
female infant(n=5790)	2660(48.7%)	162(49.8%)	0.681	1.048(0.838-1.311)	b)
Underwent the disaster at 1st trimester(n=5790)	2047(37.5%)	122(37.5%)	1.000	1.004(0.796-1.264)	b)
Underwent the disaster at 2nd trimester(n=5790)	2079(38.0%)	119(36.6%)	0.607	0.941(0.746-1.187)	b)
Underwent the disaster at 3rd trimester(n=5790)	1339(24.5%)	84(25.8%)	0.584	1.074(0.832-1.387)	b)
Natural pregnancy(n=5777)	5223(95.8%)	309(95.4%)	0.721	0.907(0.531-1.549)	b)
Hamadori(n=5790)	1469(26.9%)	88(27.1%)	0.938	1.010(0.785-1.299)	b)
Maternal age(n=5790)	30.22±4.95(15-51)	29.56±5.16(18-45)	0.021		c)
Maternal age＜20 years old	59(1.1%)	3(0.9%)	1.000	0.854(0.266-2.737)	a)
Maternal age≧35 years old	1111(20.3%)	53(16.3%)	0.087	0.763(0.565-1.032)	a)
gravida(n=5733)	1.51±1.42（0-16）	1.48±1.412(0-9)	0.665		c)
Para (n=5790)	1.14±0.99(0-9)	1.10±0.916(0-6)	0.474		c)
GA at delivery(day) (n=5790)	275.74±10.04(154-293)	276.35±11.26(209-293)	0.292		c)
GA at disaster(day)(n=5790)	137.62±76.36(0-289)	139.05±79.33(0-285)	0.743		c)

a)Fisher's exact test b)Chi square-test c)Welch's test

Table 4. Logistic regression on factors influencing SGA(BW<-1.5SD)

	B	P-value	OR(95%C.I.)
Maternal age	-0.030	0.012	0.971(0.949～0.993)
Female	0.034	0.766	1.035(0.826～1.296)
Be forced to move to other cities because of the disaster	0.083	0.574	1.087(0.812～1.455)
Natural pregnancy	-0.181	0.513	0.834(0.484～1.437)
GA at disaster(day)(n=4223)	0.000	0.695	1.000(0.999～1.002)
Hamadori	-0.052	0.707	0.949(0.723～1.246)
Pregnancy induced hypertension	1.057	0.000	2.879(1.673～4.954)