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Effects of external radiation exposure  
on perinatal outcomes in pregnant women  
after the Fukushima Daiichi Nuclear Power Plant accident:  
The Fukushima Health Management Survey

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FUKUSHIMA  
MEDICAL  
UNIVERSITY



# COI Disclosure

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# Introduction

The Great East Japan &  
Earthquake

(March 11, 2011)

The Fukushima Daiichi Nuclear  
Disaster (FDND)

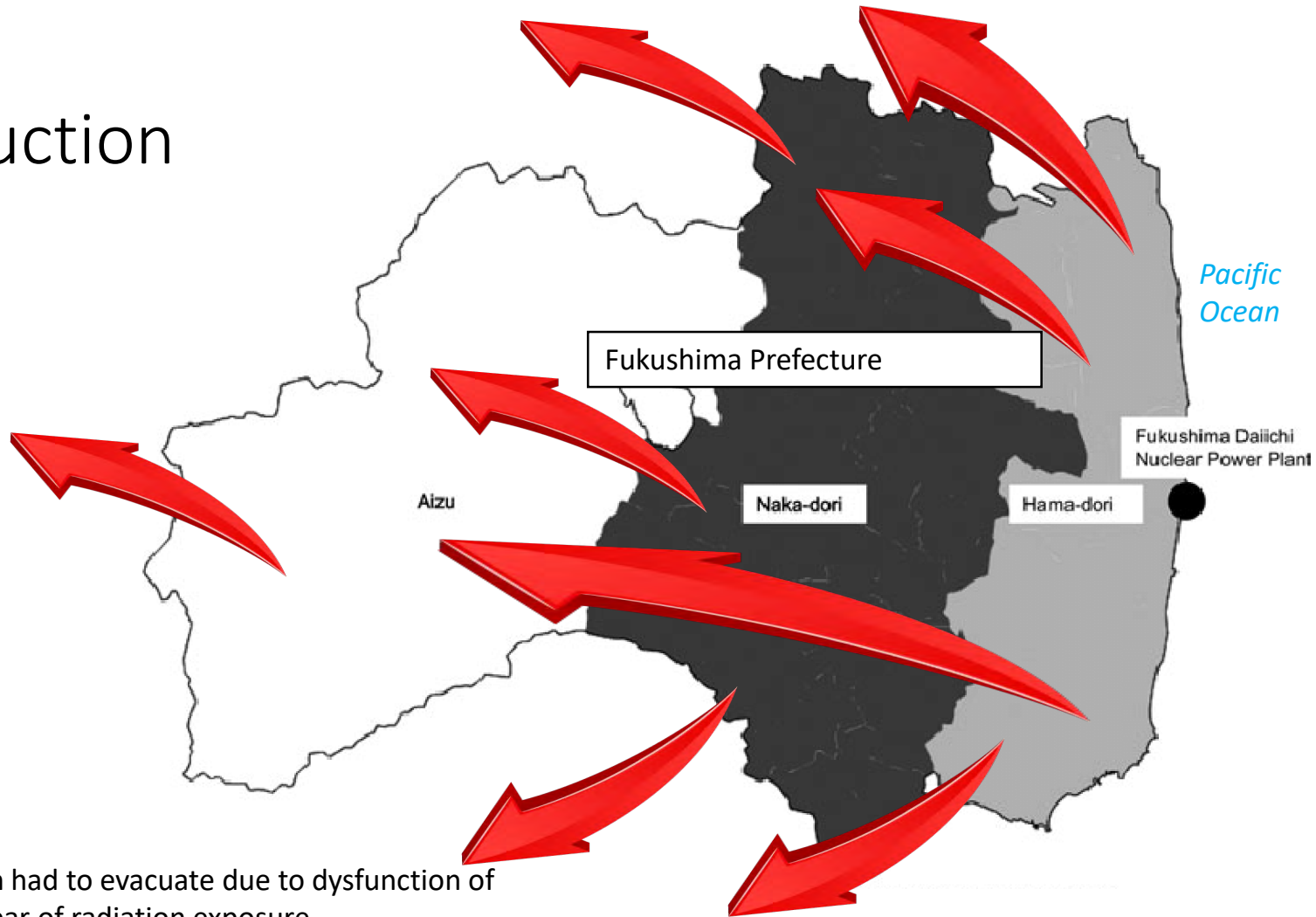


<https://www.youtube.com/watch?v=pDGv0YD3evQ>  
'FNN 3.11'



<https://www.yomiuri.co.jp/pluralphoto/20210225-OYT1150016/>

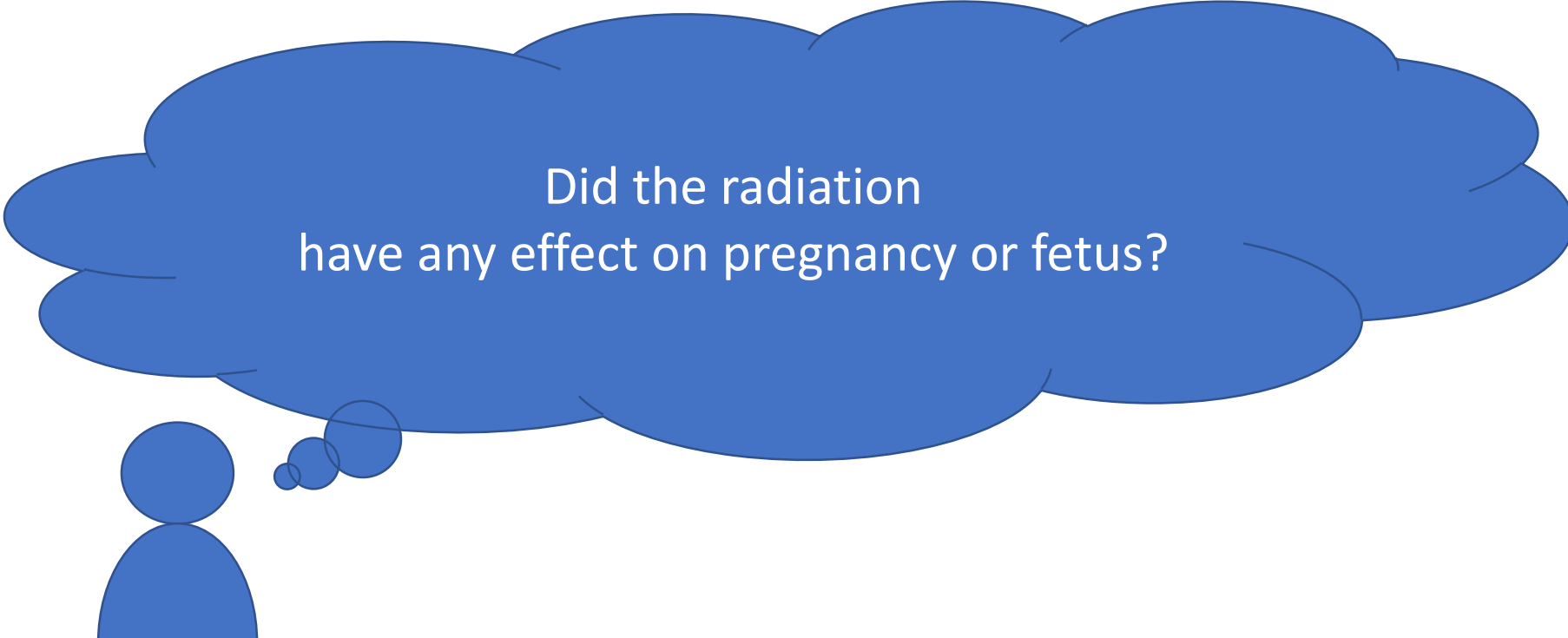
# Introduction



Many pregnant women had to evacuate due to dysfunction of medical facilities and fear of radiation exposure.

# Introduction

One of the concerns for the Japanese about the FDND has always been...



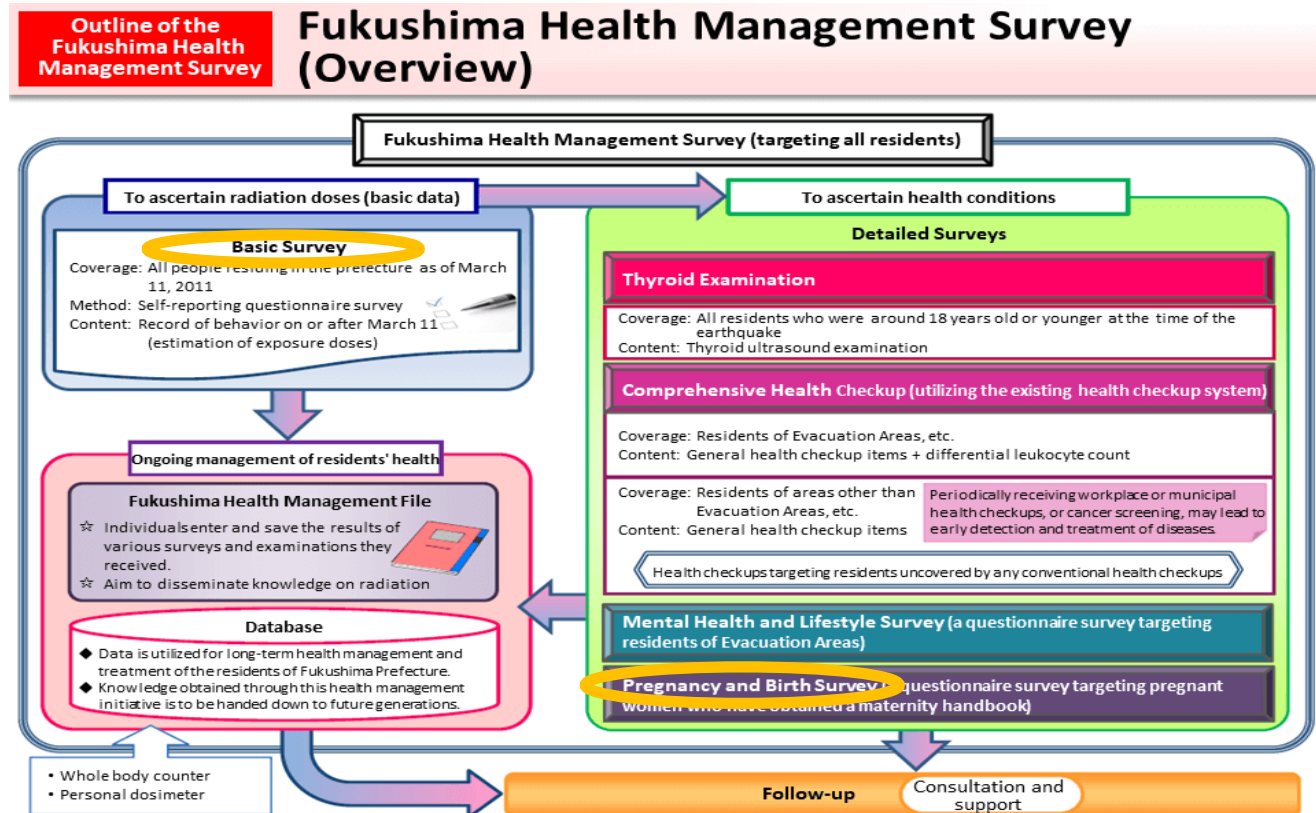
Did the radiation  
have any effect on pregnancy or fetus?

# Introduction

FDND (March 11, 2011)



Fukushima Health Management Survey (FHMS)  
launched in June 2011



Prepared based on the outline of the "Fukushima Health Management Survey," Fukushima Prefecture

<https://www.env.go.jp/en/chemi/rhm/basic-info/1st/10-01-03.html>

# Introduction

## Basic Survey: Inquiry Sheets

In November 2013, a simplified inquiry sheet was introduced.

### ● Detailed version (conventional version)

The detailed version is a grid-based form with columns for dates (M/11 to M/25) and rows for time slots (e.g., 08:00-09:00, 09:00-10:00). It includes a header for 'Location' and 'Name' and various checkboxes for different activities.

All respondents were asked to record the activities they conducted on an hourly basis for the period from March 11 to March 25, but the simplified inquiry sheet allows some respondents to summarize their behavior and only enter basic behavioral patterns for a certain period of time.

### ● Simplified version

The simplified version consists of several numbered questions:
 

1. 避難の経緯は、2ページに記載した住所と同じですか? (Was the evacuation route the same as the address recorded on page 2?)
2. 避難先での生活は、平常時の生活と異なる点がありますか? (Were there any differences in daily life at the evacuation site compared to normal life?)
3. 避難先での生活は、1日あたりどのくらいでしたか? (How many days per day was life at the evacuation site?)

### [Requirements for using the simplified inquiry sheet]

People who have experienced none or only one significant behavioral pattern change (such as a change of residence, school or workplace due to evacuation or moving) in the four months following the earthquake

### Examples

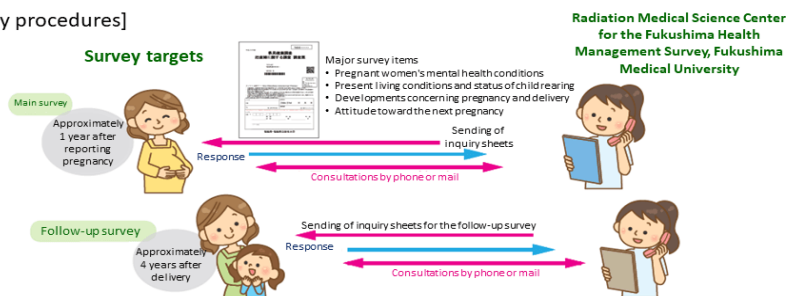
1. A person who was residing in Fukushima City at the time of the earthquake, evacuated to Kanagawa on March 15 and continued staying in Kanagawa until July 11
2. A person who was residing in Fukushima City at the time of the earthquake, evacuated to Aizuwakamatsu on March 18 but returned to Fukushima City on June 10

Prepared based on the website of the Radiation Medical Science Center for the Fukushima Health Management Survey, Fukushima Medical University, "Information on the Fukushima Health Management Survey"

## Pregnancy and Birth Survey

## Pregnancy and Birth Survey: Outline (2/2)

[Survey procedures]



Radiation Medical Science Center for the Fukushima Health Management Survey, Fukushima Medical University

- Coverage of the FY2017 main survey
  - (i) Pregnant women who obtained a maternity handbook in any municipality in Fukushima Prefecture from August 1, 2016, to July 31, 2017
  - (ii) Pregnant women who obtained a maternity handbook outside Fukushima Prefecture during the period mentioned above but gave birth in Fukushima Prefecture
- Coverage of the FY2017 follow-up survey
 

Respondents of the FY2013 survey who gave birth from August 1, 2012, to April 8, 2014  
 → Since the FY2016 survey, responses can also be submitted online.  
 On the website of the Radiation Medical Science Center for the Fukushima Health Management Survey, responses can be made using personal computers or smartphones.

Prepared based on the leaflet on the Pregnancy and Birth Survey, and the website of the Radiation Medical Science Center for the Fukushima Health Management Survey, Fukushima Medical University

- Conducted for the purpose of estimating residents' external doses for the **4 months** after the FDND based on their behavioral records.
- Questionnaire survey

- Conducted on an annual basis since FY2011.
- Collected information on **the status of antenatal checks, evacuation, pregnancy complications, complicated pregnancies, delivery results,** and postpartum depression.
- Questionnaire survey



# Introduction

Internal exposure from FDND: extremely low ( $\ll 1\text{mSv/yr}$ )

Yasumura S, Hosoya M, Yamashita S, et al. J Epidemiol.22;375

External radiation dose ? ?

# Objective of the study

To investigate the relationship between maternal 'external' radiation dose and major pregnancy outcomes—preterm birth, low birth weight (LBW), small for gestational age (SGA), and congenital anomalies—based on individuals' external radiation doses obtained through the Basic Survey.

# Methods:

Pregnancy and Birth Survey

## Pregnancy and Birth Survey: Outline (2/2)

[Survey procedures]

Radiation Medical Science Center  
for the Fukushima Health  
Management Survey, Fukushima  
Medical University

FY2011  
&  
FY2012-2018

Preterm Birth  
LBW  
SGA  
Congenital Anomalies

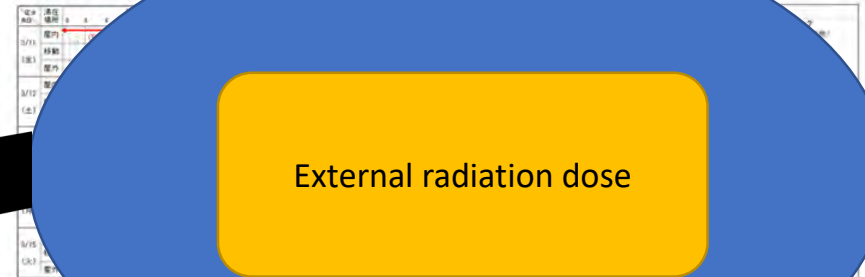
- Coverage of the survey period from August 2011 to the end of the survey period
  - Respondents of the survey are pregnant women who have given birth to a child in the survey period
  - On the website of the Radiation Medical Science Center for the Fukushima Health Management Survey, responses can be made using personal computers
- Prepared based on the leaflet on the Pregnancy and Birth Survey, and the website of the Radiation Medical Science Center for the Fukushima Health Management Survey, Fukushima Medical University

Basic Survey

## Basic Survey: Inquiry Sheets

In November 2011, the following inquiry sheets were produced.

• Detailed version



[Required inquiry sheets]

People who had one significant benefit (such as a change of residence or workplace due to evacuation or moving to the four months following the earthquake)

Detailed version

Prepared based on the website of the Radiation Medical Science Center for the Fukushima Health Management Survey, Fukushima Medical University, "Information on the Fukushima Health Management Survey"

# Methods:

Data from  
the 'Pregnancy and Birth Survey'

Data from  
the 'Basic Survey'

Case	Maternal Age	Delivery	Birth Weight	Child's sex	Congenital anomaly	Had to change health check facility	Trimester of pregnancy at earthquake	Evacuation	HDP	...	External radiation dose
1	21	39w4d	3024g	male	no	yes	first	yes	no	...	0.1 $\mu$ Sv
2	25	40w1d	2546g	male	no	no	second	yes	yes	...	0.2 $\mu$ Sv
3	32	39w5d	3256g	female	no	no	third	no	no	...	0.3 $\mu$ Sv
4	43	37w5d	3124g	male	cleft lip		second	no	no	...	0.1 $\mu$ Sv
5	26	38w9d	2470g	female	no	yes	third	yes	no	...	0.4 $\mu$ Sv
6	42	36w5d	3290g	male	no	no	first	no	no	...	0.8 $\mu$ Sv
7	37	39w0d	3890g	female	no	yes	second	yes	yes	...	0.1 $\mu$ Sv
...	...	...	...	...	...	...	...	...	...	...	...

Missing data  
for external  
radiation dose!

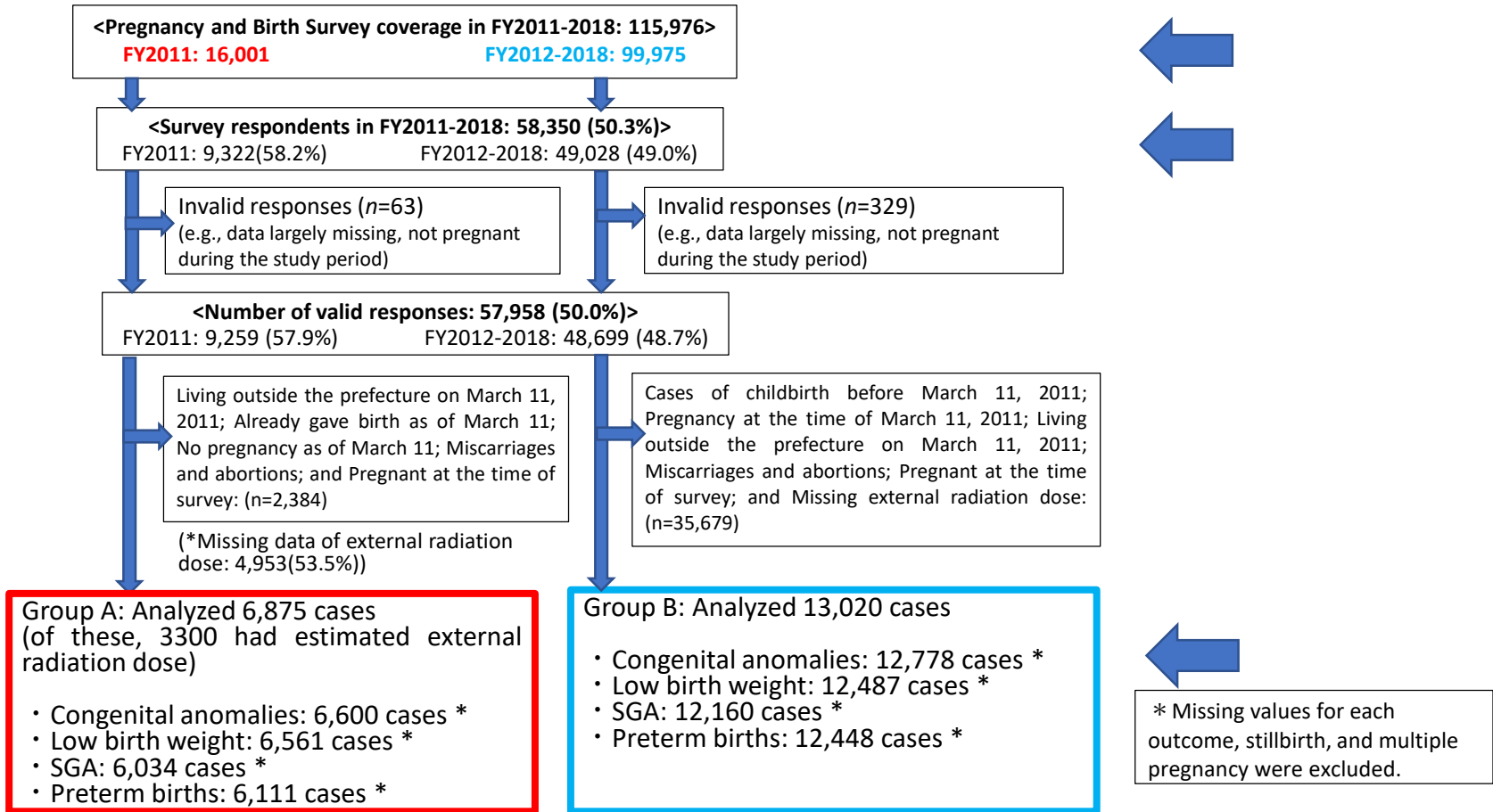


Supplemented  
by Multiple  
Imputation

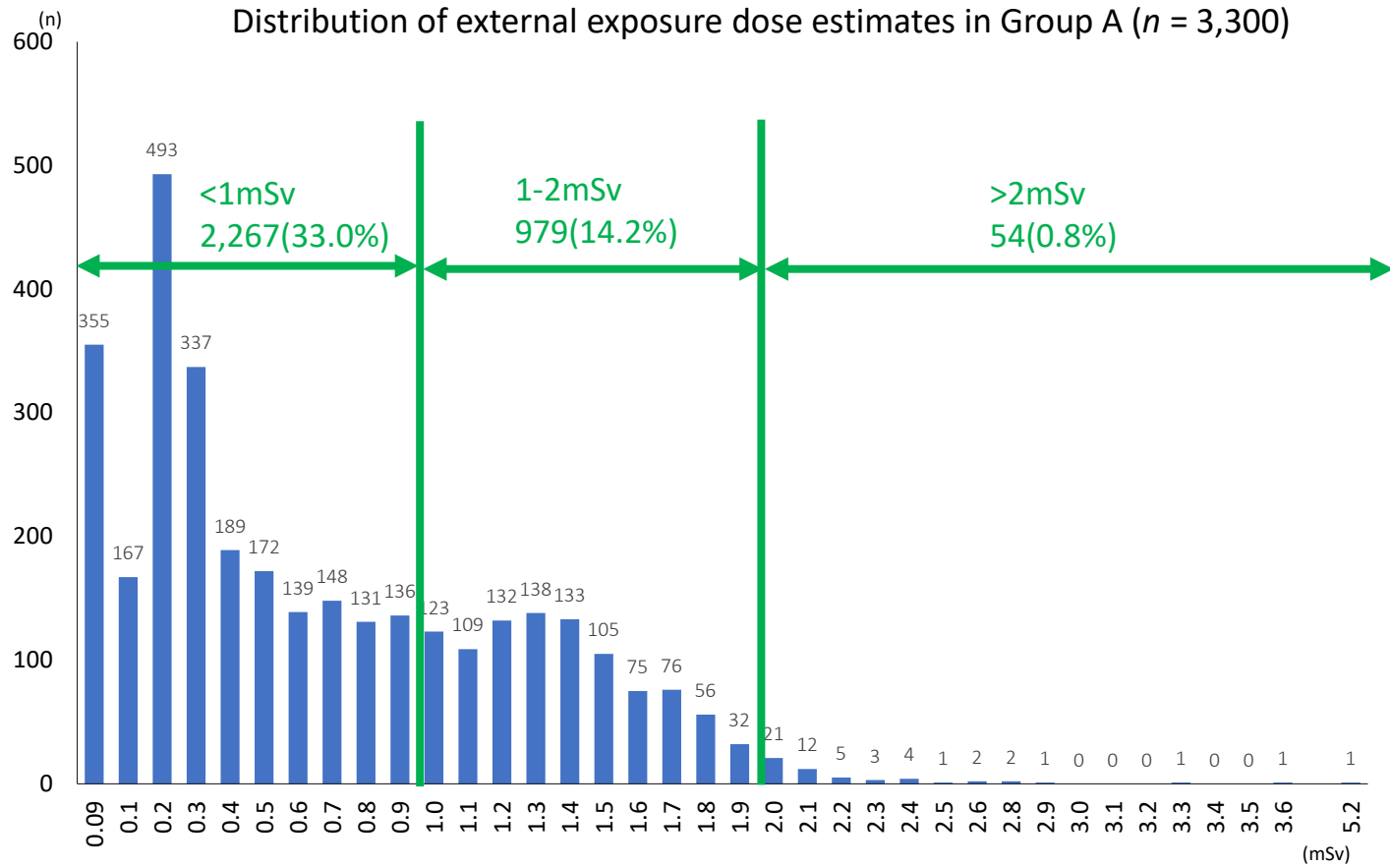
Relation between external radiation dose and each perinatal outcome was analyzed using binominal logistic regression analysis.

# Methods:

## Participants in the Pregnancy and Birth Survey and inclusion criteria of the study



# Results:



# Results:

Characteristics of Group A (n=6,875) according to external radiation dose

	n	Maternal external radiation dose (mSv)					p-value *
		Total 6,875 (100.0)	(missing) 3,575 (52.0)	<1mSv 2,267 (33.0)	1-2mSv 979 (14.2)	≥2mSv 54 (0.8)	
Maternal age, years	6,875	30.9(5.0)	30.3(5.2)	31.5(4.6)	31.6(4.7)	30.5(5.4)	0.238
Sex of the child (Male), %.	6,814	51.3	51.8	50.6	51.8	46.3	0.650
Child's length/height, cm	6,783	49.1(2.2)	49.1(2.3)	49.1(2.2)	49.2(2.2)	49.1(2.1)	0.397
Child's weight, g	6,815	3,029.3(403.1)	3,025.6(411.8)	3,036.1(394.9)	3,028.0(391.1)	3,006.2(382.4)	0.763
Gestational days at delivery, days	6,348	276(11.0)	275.2(11.4)	275.7(10.6)	276.1(10.0)	275.3(10.7)	0.569
LBW (less than 2500g), %	6,815	7.6	7.8	7.3	7.3	9.3	0.861
SGA(<-10%), %	6,270	8.9	8.5	8.8	10.7	4.4	0.144
Congenital anomalies, %	6,600	2.9	3.1	2.9	2.0	0.0	0.163
Stillbirth,%	6,875	0.2	0.3	0.2	0.1	0.0	0.847
Preterm birth (less than 37 weeks), %	6,348	4.1	4.5	3.6	3.5	4.3	0.942
Multiple pregnancy, %	6,872	0.9	1.1	0.6	0.8	0.0	0.678
Nulliparous,%	6,840	25.4	24.8	25.3	27.4	37.0	0.084
Infertility treatment, %	6,875	4.9	4.2	5.6	6.0	3.7	0.728
Placenta previa, %	6,875	1.4	1.3	1.3	2.0	1.9	0.307
Had to change health check facility due to disaster, %	6,809	35.4	32.4	45.6	23.7	20.4	<0.001
Time of pregnancy at 3.11.2011	6,259						0.109
1st trimester (2-14 wks),%		32.7	35.0	30.2	30.5	23.4	
2nd trimester (14-28 wks),%		40.0	40.3	40.5	37.1	53.2	
3rd trimester (≥28 weeks),%		27.3	24.7	29.3	32.4	23.4	
Hypertensive disorders of pregnancy,%	6,875	3.3	3.3	3.4	2.8	5.6	0.418
Mental disorders before birth, %	6,875	6.0	5.8	6.1	6.7	3.7	0.592
Evacuation,%	6,875	10.8	9.0	15.5	6.5	5.6	<0.001

\*One-way analysis of variance was used for continuous variables, and  $\chi$ -square tests were used for categorical variables.

## Results: Factors associated with preterm birth

	<b>Preterm birth (n = 6,111)</b>		
	≥37 weeks	<37 weeks	
	N (%) or mean (SD)		p-value*
<b>External radiation dose</b>	5,899 (96.5)	212 (3.5)	<b>0.335</b>
<b>Missing</b>	3,029 (51.4)	122 (57.6)	
<1 mSv, %	1,954 (33.1)	60 (28.3)	
1-2 mSv, %	871 (14.8)	28 (13.2)	
≥2 mSv, %	45 (0.8)	2 (0.9)	
Maternal age, years	30.8 (5.0)	31.6 (5.4)	0.04
Child's sex (male), %	2,983 (50.7)	120 (56.9)	0.08
Child's length/height, cm	49.3 (1.9)	45.2 (3.7)	<0.001
Child's weight, g	3,065 (359.9)	2,329(561.8)	<0.001
Gestational days at delivery, days	276.9 (7.9)	244.5 (18.3)	<0.001
Primiparous, %	1,522 (25.9)	57 (26.9)	0.753
Low birth weight (<2500 g), %	294 (5.0)	130 (61.6)	<0.001
SGA, %	495 (8.5)	23 (10.9)	0.222
Stillbirth, %	-	-	
Preterm birth (<37 weeks), %	-	-	
<b>Had to change health check facility, %</b>	2,059 (35.2)	71 (34.5)	<b>0.822</b>
<b>Trimester of pregnancy at earthquake</b>			<b>0.179</b>
<b>1st (2-14 weeks), %</b>	1,888 (32.5)	69 (33.7)	
<b>2nd (14-28 weeks), %</b>	2,313 (39.8)	91 (44.4)	
<b>3rd (≥28 weeks), %</b>	1,605 (27.6)	45 (22.0)	
Infertility treatment, %	277 (4.7)	13 (6.1)	0.334
Placenta previa, %	76 (1.3)	13 (6.1)	<0.001**
Hypertensive disorders of pregnancy, %	173(2.9)	26 (12.3)	<0.001
<b>Mental disorders before birth, %</b>	360 (6.1)	12 (5.7)	<b>0.791</b>
<b>Evacuation, %</b>	624 (10.6)	18 (8.5)	<b>0.33</b>

\* t-test was used for continuous variables and chi-square tests was used for other categorical variables.

\*\* Fisher's exact test was used for other categorical variables.

SGA, small for gestational age.



## Results: Associations between obstetric outcomes and external radiation dose (imputation of missing doses)

		Ref.	OR	Crude (95% CI)	P*	OR	Multivariate adjusted (95% CI)	p-value**
<b>Preterm birth</b>								
<b>External radiation dose</b>								
	<b>1-2 mSv</b>	<1 mSv	0.92	(0.65-1.30)	0.638	0.91	(0.65-1.29)	<b>0.602</b>
	<b>≥2 mSv</b>	<1 mSv	1.08	(0.24-4.84)	0.919	1.05	(0.22-4.87)	<b>0.955</b>
Maternal age		1SD	1.17	(1.02-1.34)	0.025	1.13	(0.98-1.29)	0.084
Child's sex		Female	1.28	(0.97-1.69)	0.081			
Gestational days at delivery		1SD	-	-				
Primiparous		Multiparous	1.05	(0.77-1.43)	0.753			
LBW		≥2500 g	30.5	(22.6-41.2)	<0.001			
SGA		≥-10%	1.32	(0.85-2.05)	0.222			
Preterm birth		≥37 weeks						
Placenta previa		No	5.01	(2.73-9.17)	<0.001	4.81	(2.60-8.89)	<0.001
<b>Had to change health check facility</b>		No	0.97	(0.72-1.30)	0.823			
<b>Trimester of pregnancy at earthquake</b>								
	<b>2nd (14-28 weeks)</b>	First	1.08	(0.78-1.48)	0.650			
	<b>3rd (≥28 weeks)</b>	First	0.77	(0.52-1.12)	0.173			
Infertility treatment		No	1.33	(0.75-2.36)	0.334			
Hypertensive disorders of pregnancy		No	4.63	(2.99-7.17)	<0.001	4.5	(2.89-7.00)	<0.001
Mental disorders before birth		No	0.92	(0.51-1.67)	0.791			
<b>Evacuation</b>		No	0.79	(0.48-1.28)	0.332			

\* Univariate logistic regression analysis by forced entry method.

\*\* Factors significant in univariate analysis were entered into multivariate analysis using binominal logistic regression.

CI, confidence interval; LBW, low birth weight; OR, odds ratio; SGA, small for gestational age.

## Results: Factors associated with low birth weight(LBW<2500g),

### LBW(n = 6,561)

	≥2500 g	<2500 g	p-value*
	N (%) or mean (SD)		
<b>External radiation dose</b>	6,116 (93.2)	445 (6.8)	<b>0.811</b>
<b>Missing</b>	3150 (51.5)	235 (52.8)	
<b>&lt;1 mSv, %</b>	2,032 (33.2)	141 (31.7)	
<b>1-2 mSv, %</b>	885 (14.5)	64 (14.4)	
<b>≥2 mSv, %</b>	49 (0.8)	5 (1.1)	
Maternal age, years	30.9 (5.0)	31.0 (5.2)	0.458
Child's sex (male), %	3,168 (51.9)	183 (41.1)	<0.001
Child's length/height, cm	49.5 (1.8)	45.5 (2.8)	<0.001
Child's weight, g	3,097 (327.5)	2,251 (318.2)	<0.001
Gestational days at delivery, days	277.0 (8.3)	260.6 (18.9)	<0.001
Primiparous, %	1,537 (25.3)	129 (29.1)	0.077
Low birth weight (<2500 g), %	-	-	
SGA, %	290 (5.2)	228 (54.0)	<0.001
Stillbirth, %	-	-	
Preterm birth (<37 weeks), %	81 (1.4)	130 (30.7)	<0.001
<b>Had to change health check facility, %</b>	2,117 (35.0)	156 (35.3)	0.831
<b>Trimester of pregnancy at earthquake</b>			0.656
<b>1st (2-14 weeks), %</b>	1,830 (32.7)	128 (30.8)	
<b>2nd (14-28 weeks), %</b>	2,229 (39.8)	174 (41.9)	
<b>3rd (≥28 weeks), %</b>	1,537 (27.5)	113 (27.2)	
Infertility treatment, %	275 (4.5)	30 (6.7)	0.030
Placenta previa, %	85 (1.4)	11 (2.5)	0.066
Hypertensive disorders of pregnancy, %	164 (2.7)	46 (10.3)	<0.001
<b>Mental disorders before birth, %</b>	368 (6.0)	24 (5.4)	<b>0.592</b>
<b>Evacuation, %</b>	657 (10.7)	44 (9.8)	<b>0.573</b>

\* t-test was used for continuous variables and chi-square tests was used for other categorical variables.

\*\* Fisher's exact test was used for other categorical variables.

## Results: Associations between obstetric outcomes and external radiation dose (imputation of missing doses)

		Ref.	OR	Crude (95% CI)	P*	OR	Multivariate adjusted (95% CI)	p-value**
<b>External radiation dose</b>								
	<b>1-2 mSv</b>	<1 mSv	0.91	(0.71-1.17)	0.448	0.91	(0.71-1.18)	0.472
	<b>≥2 mSv</b>	<1 mSv	1.26	(0.56-2.83)	0.581	1.21	(0.53-2.79)	0.649
Maternal age		1SD	1.04	(0.94-1.14)	0.458			
Child's sex		Female	0.65	(0.53-0.79)	<0.001	0.65	(0.53-0.79)	<0.001
Gestational days at delivery		1SD	0.26	(0.23-0.29)	<0.001			
Primiparous		Multiparous	1.21	(0.98-1.50)	0.078			
LBW		≥2500 g	-	-				
SGA		≥-10%	21.6	(17.2-27.0)	<0.001			
Preterm birth		≥37 weeks	30.5	(22.6-41.2)	<0.001			
Placenta previa		No	1.80	(0.95-3.40)	0.070			
<b>Had to change health check facility</b>		No	1.02	(0.84-1.25)	0.830			
<b>Trimester of pregnancy at earthquake</b>								
	<b>2nd (14-28 weeks)</b>	First	1.12	(0.88-1.41)	0.363			
	<b>3rd (≥28 weeks)</b>	First	1.05	(0.81-1.37)	0.709			
Infertility treatment		No	1.54	(1.04-2.27)	0.031	1.49	(1.01-2.21)	0.046
Hypertensive disorders of pregnancy		No	4.18	(2.97-5.89)	<0.001	4.14	(2.93-5.84)	<0.001
Mental disorders before birth		No	0.89	(0.58-1.36)	0.592			
<b>Evacuation</b>		No	0.91	(0.66-1.26)	0.573			

\* Univariate logistic regression analysis by forced entry method.

\*\* Factors significant in univariate analysis were entered into multivariate analysis using binominal logistic regression.

CI, confidence interval; LBW, low birth weight; OR, odds ratio; SGA, small for gestational age.

## Results: Factors associated with small for gestational age(SGA<10%ile)

### SGA (n = 6,034)

	≥-10%ile	<-10%ile	p-value*
	N (%) or mean (SD)		
<b>External radiation dose</b>	5,516 (91.4)	518 (8.6)	<b>0.103</b>
<b>Missing</b>	2854 (51.7)	252 (48.7)	
<b>&lt;1 mSv, %</b>	1,818 (33.0)	170 (32.8)	
<b>1-2 mSv, %</b>	800 (14.5)	94 (18.2)	
<b>≥2 mSv, %</b>	44 (0.8)	2 (0.4)	
Maternal age, years	30.9 (5.0)	30.5 (5.2)	0.105
Child's sex (male), %	2,831 (51.3)	248 (47.9)	0.134
Child's length/height, cm	49.4 (2.0)	47.1 (2.3)	<0.001
Child's weight, g	3,091 (359.1)	2,481 (281.6)	<0.001
Gestational days at delivery, days	275.7 (10.1)	276.4 (11.3)	0.189
Primiparous, %	1,465 (26.6)	107 (20.7)	0.003
LBW (<2500 g), %	194 (3.5)	228 (44.0)	<0.001
SGA, %			
Stillbirth, %			
Preterm birth (<37 weeks), %	188 (3.4)	23 (4.4)	0.222
Had to change health check facility, %	1,927 (35.3)	174 (33.8)	<b>0.496</b>
<b>Trimester of pregnancy at earthquake</b>			<b>0.360</b>
<b>1st (2-14 weeks), %</b>	1,765 (32.5)	166 (32.7)	
<b>2nd (14-28 weeks), %</b>	2,181 (40.2)	190 (37.4)	
<b>3rd (≥28 weeks), %</b>	1,483 (27.3)	152 (29.9)	
Infertility treatment, %	259 (4.7)	27 (5.2)	0.597
Placenta previa, %	85 (1.5)	4 (0.8)	0.165
Hypertensive disorders of pregnancy, %	156 (2.8)	40 (7.7)	<0.001
<b>Mental disorders before birth, %</b>	344 (6.2)	24 (4.6)	<b>0.145</b>
<b>Evacuation, %</b>	582 (10.6)	49 (9.5)	<b>0.438</b>

\* t-test was used for continuous variables and chi-square tests was used for other categorical variables.

\*\* Fisher's exact test was used for other categorical variables. SGA, small for gestational age.

## Results: Associations between obstetric outcomes and external radiation dose (imputation of missing doses)

	Ref.	OR	Crude (95% CI)	P*	SGA		
					OR	Multivariate adjusted (95% CI)	p-value**
<b>External radiation dose</b>							
1-2 mSv	<1 mSv	1.12	(0.91-1.40)	0.286	1.14	(0.92-1.42)	0.229
≥2 mSv	<1 mSv	0.84	(0.30-2.39)	0.744	0.84	(0.30-2.37)	0.735
Maternal age	1SD	0.93	(0.85-1.02)	0.105			
Child's sex	Female	0.87	(0.73-1.04)	0.134			
Gestational days at delivery	1SD	1.07	(0.98-1.18)	0.150			
Primiparous	Multiparous	0.72	(0.58-0.90)	0.004	0.69	(0.56-0.87)	0.001
LBW	≥2500 g	21.6	(17.2-27.0)	<0.001			
SGA	≥-10%	-	-				
Preterm birth	≥37 weeks	1.32	(0.85-2.05)	0.222			
Placenta previa	No	0.50	(0.18-1.36)	0.174			
Had to change health check facility	No	0.94	(0.77-1.13)	0.496			
<b>Trimester of pregnancy at earthquake</b>							
2nd (14-28 weeks)	First	0.93	(0.75-1.15)	0.490			
3rd (≥28 weeks)	First	1.09	(0.87-1.37)	0.465			
Infertility treatment	No	1.12	(0.74-1.68)	0.597			
Hypertensive disorders of pregnancy	No	2.88	(2.01-4.12)	<0.001	3.01	(2.10-4.32)	<0.001
Mental disorders before birth	No	0.73	(0.48-1.12)	0.147			
Evacuation	No	0.89	(0.65-1.20)	0.438			

\* Univariate logistic regression analysis by forced entry method.

\*\* Factors significant in univariate analysis were entered into multivariate analysis using binominal logistic regression.

CI, confidence interval; LBW, low birth weight; OR, odds ratio; SGA, small for gestational age.

## Results: Factors associated with congenital anomalies

### Congenital anomaly (n = 6,600)

	No	Yes	p-value*
	N (%) or mean (SD)		
<b>External radiation dose</b>	6,411 (97.1)	189 (2.9)	<b>0.188</b>
<b>Missing</b>	3,308 (51.6)	106 (56.1)	
<b>&lt;1 mSv, %</b>	2,124 (33.1)	64 (33.9)	
<b>1-2 mSv, %</b>	925 (14.4)	19 (10.1)	
<b>≥2 mSv, %</b>	54 (0.8)	0 (0.0)	
Maternal age, years	30.9 (5.0)	30.6 (5.2)	0.456
Child's sex (male), %	3,284 (51.3)	105 (55.9)	0.221
Child's length/height, cm	49.2 (2.1)	48.5 (3.4)	0.007
Child's weight, g	3,036 (392.5)	2,904 (556.8)	0.002
Gestational days at delivery, days	275.7 (10.3)	272.2 (18.4)	0.013
Primiparous, %	1,628 (25.5)	44 (23.4)	0.511
LBW (<2500 g), %	459 (7.2)	33 (17.7)	<0.001
SGA, %	520 (8.8)	24 (13.9)	0.022
Stillbirth, %	5 (0.1)	3 (1.6)	0.001**
Preterm birth (<37 weeks), %	217 (3.6)	22 (12.6)	<0.001
<b>Had to change health check facility, %</b>	2,234 (35.2)	80 (42.6)	<b>0.038</b>
<b>Trimester of pregnancy at earthquake</b>			<b>0.550</b>
<b>1st (2-14 weeks), %</b>	1,900 (32.3)	61 (36.3)	
<b>2nd (14-28 weeks), %</b>	2,355 (40.1)	63 (37.5)	
<b>3rd (≥28 weeks), %</b>	1,625 (27.6)	44 (26.2)	
Infertility treatment, %	316 (4.9)	12 (6.4)	0.376
Placenta previa, %	94 (1.5)	1 (0.5)	0.286
Hypertensive disorders of pregnancy, %	202 (3.2)	5 (2.7)	0.694
<b>Mental disorders before birth, %</b>	382 (6.0)	18 (9.5)	<b>0.043</b>
<b>Evacuation, %</b>	686 (10.7)	20 (10.6)	<b>0.959</b>

\* t-test was used for continuous variables and chi-square tests was used for other categorical variables.

\*\* Fisher's exact test was used for other categorical variables.

# Results: Associations between obstetric outcomes and external radiation dose (imputation of missing doses)

## Congenital anomalies

	Ref.	OR	Crude (95% CI)	P*	Multivariate adjusted (95% CI)	p-value**
<b>External radiation dose</b>						
<b>1-2 mSv</b>	<1 mSv	0.81	(0.56-1.17)	0.253		
<b>≥2 mSv</b>	<1 mSv	-	-			
Maternal age	1SD	0.95	(0.82-1.10)	0.456		
Child's sex	Female	1.2	(0.90-1.61)	0.221		
<b>Gestational days at delivery</b>	1SD	0.79	(0.71-0.88)	<0.001		
Primiparous	Multiparous	0.89	(0.63-1.26)	0.511		
<b>LBW</b>	≥2500 g	2.78	(1.88-4.09)	<0.001		
<b>SGA</b>	≥-10%	1.67	(1.07-2.59)	0.023		
<b>Preterm birth</b>	≥37 weeks	3.83	(2.40-6.11)	<0.001		
Placenta previa	No	-	-			
<b>Had to change health check facility</b>	No	1.36	(1.02-1.83)	0.038		
<b>Trimester of pregnancy at earthquake</b>						
<b>2nd (14-28 weeks)</b>	First	0.78	(0.46-1.30)	0.335		
<b>3rd (≥28 weeks)</b>	First	0.57	(0.31-1.05)	0.069		
Infertility treatment	No	1.31	(0.72-2.37)	0.376		
Hypertensive disorders of pregnancy	No	0.84	(0.34-2.05)	0.695		
<b>Mental disorders before birth</b>	No	1.66	(1.01-2.73)	0.045		
<b>Evacuation</b>	No	0.99	(0.62-1.58)	0.959		

\* Univariate logistic regression analysis by forced entry method.

\*\* Factors significant in univariate analysis were entered into multivariate analysis using binominal logistic regression.

CI, confidence interval; LBW, low birth weight; OR, odds ratio; SGA, small for gestational age.

## Results: Congenital anomalies ( $n = 6,600$ ) in Group A

	Total n = 6,600	<1 mSv n = 2,188	1-2 mSv n = 944	≥2 mSv n = 54	(missing) n = 3,414
Total*	189 (2.86)	64	19	0	106
Cataract	1 (0.02)	0	1	0	0
Neural tube defects	3 (0.05)	1	2	0	0
Microcephaly	0 (0.00)	0	0	0	0
Cardiac malformation	57 (0.86)	20	4	0	33
Kidney/urinary tract malformation	19 (0.29)	5	3	0	11
Hydrocephaly	1 (0.02)	1	0	0	0
Cleft lip/palate	12 (0.18)	1	3	0	8
Digestive tract atresia	5 (0.08)	3	0	0	2
Imperforate anus	4 (0.06)	1	0	0	3
Poly/syndactyly	18 (0.27)	7	1	0	10
Others	83 (1.26)	28	6	0	49

\* Multiple answers were allowed



# Results: Associations between obstetric outcomes and external radiation dose in Group B

	Ref.	Low birth weight Multivariate adjusted			SGA Multivariate adjusted			Preterm birth Multivariate adjusted			Congenital anomalies Multivariate adjusted		
		OR	(95% CI)	p**	OR	(95% CI)	p**	OR	(95% CI)	p**	OR	(95% CI)	p**
<b>External radiation dose</b>													
	<b>1-2 mSv</b>	<1 mSv	0.91	(0.71-1.18)	<b>0.472</b>	1.14	(0.92-1.42)	<b>0.229</b>	0.91	(0.65-1.29)	<b>0.602</b>		
	<b>≥2 mSv</b>	<1 mSv	1.21	(0.53-2.79)	<b>0.649</b>	0.84	(0.30-2.37)	<b>0.735</b>	1.05	(0.22-4.87)	<b>0.955</b>		
Maternal age		1SD							1.13	(0.98-1.29)	0.084		
Child's sex		Female	0.65	(0.53-0.79)	<0.001								
Gestational days at delivery		1SD											
Primiparous		Multiparous				0.69	(0.56-0.87)	0.001					
LBW		≥2500g											
SGA		≥-10%											
Preterm birth		≥37 weeks											
Placenta previa		No							4.81	(2.60-8.89)	<0.001		
<b>Had to change health check facility</b>		No											
<b>Trimester of pregnancy at earthquake</b>													
		<b>2nd (14-28 weeks)</b>	First										
		<b>3rd (≥28 weeks)</b>	First										
Infertility treatment		No	1.49	(1.01-2.21)	0.046								
Hypertensive disorders of pregnancy		No	4.14	(2.93-5.84)	<0.001	3.01	(2.10-4.32)	<0.001	4.5	(2.89-7.00)	<0.001		
<b>Mental disorders before birth</b>		No											
<b>Evacuation</b>		No											

\* Univariate logistic regression analysis by forced entry method.

\*\* Factors significant in univariate analysis were entered into multivariate analysis using binominal logistic regression.

CI, confidence interval; LBW, low birth weight; OR, odds ratio; SGA, small for gestational age.

# Discussion

## Previous results of the Pregnancy and Birth Survey :

Preterm Birth  
Low birth weight (LBW)  
Small for Gestational Age(SGA)  
Congenital anomalies  
Stillbirth

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- Adverse outcomes were not increased by evacuation or earthquake
- Adverse outcome did not deviate from the Japanese standard frequency

Fujimori K, Kyojuka H, Yasuda S, et al. Fukushima J Med Sci. 2014;60:106.  
Yasuda S, Kyojuka H, Nomura Y, et al. J Matern Fetal Neonatal Med. 2017;30:2900.  
Kyojuka H, Murata T, Yasuda S, et al. J Matern Fetal Neonatal Med. 2020;33:4043-4048.  
Kyojuka H, Murata T, Hosoya M, et al. J Exp Med. 2018;246:27

No report has shown an association between radiation dose and perinatal outcome.

# Conclusion

Maternal external radiation exposure following FDND was not associated with preterm birth, LBW, SGA, or congenital anomalies.

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