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The mental health status of children who have been evacuated or migrated from rural areas in Fukushima prefecture after the Fukushima daiichi nuclear power station accident : results from the Fukushima health management survey

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Abstract

Introduction : We evaluated the mental health status of children residing in Kawauchi village (Kawauchi), Fukushima Prefecture, after the 2011 accident at the Fukushima Daiichi Nuclear Power Station, based on the children's experience of the nuclear disaster.

Methods : We conducted this cross-sectional study within the framework of the Fukushima Health Management Survey (FHMS) ; FHMS data on age, sex, exercise habits, sleeping times, experience of the nuclear disaster, and the "Strengths and Difficulties Questionnaire (SDQ)" scores for 156 children from Kawauchi in 2012 were collected. Groups with and without experience of the nuclear disaster — "nuclear disaster (+)" and "nuclear disaster (-)" — were also compared.

Results : Our effective response was 93 (59.6%) ; the mean SDQ score was 11.4 ± 6.8 among elementary school-aged participants and 12.4 ± 6.8 among junior high school-aged ones. We statistically compared the Total Difficulties Scores (TDS) and sub-item scores of the SDQ between "elementary school" and "junior high school" or "nuclear disaster" (+) and (-). There was no significant difference between these items.

Conclusions : We found indications of poor mental health among elementary and junior high school-aged children in the disaster area immediately following the accident, but no differences based on their experience of the nuclear disaster. These results indicate the possibility of triggering stress, separate to that from experiences related to the nuclear disaster, in children who lived in affected rural areas and were evacuated just after the nuclear disaster.

Key words : children, mental health status, Strengths and Difficulties Questionnaire, Fukushima Nuclear Accident, Great East Japan Earthquake

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Introduction

On 11 March 2011, the Great East Japan Earthquake struck the east coast of Japan. This natural disaster caused immense devastation in Japan and severely damaged the Fukushima Daiichi Nuclear Power Station (FDNPS)^{1,2}, resulting in the release of large amounts of radionuclides into the environment³⁻⁷. After the accident, the Japanese and Fukushima prefectural governments issued instructions for the immediate evacuation of areas within a 20 km radius of the FDNPS. Consequently, many residents of Fukushima Prefecture were evacuated to areas farther away from FDNPS or outside of Fukushima Prefecture due to the fear of radiation exposure². The external and internal exposure doses just after the accident itself were estimated to be very low, but concerns were raised about the effect on residents' health following evacuation after the accident.

A report into the health impact of the Chernobyl nuclear accident, prepared 20 years after the accident by the World Health Organization (WHO), showed that mental health issues were the most serious public health problem resulting from that nuclear accident^{8,9}. In particular, Bromet *et al.* pointed out issues regarding the mental health status of children¹⁰. Other studies have also reported on the mental health status and the neurobehavioral and cognitive performances of mothers with young children^{11,12}. Ongoing investigations continue to focus on the problem of health effects, including mental health effects, in children after the Chernobyl nuclear accident¹³.

The lessons learned from past nuclear disasters led to the implementation of the Fukushima Health Management Survey (FHMS) by the Fukushima prefectural government and Fukushima Medical University, to assess the health impact on residents in Fukushima Prefecture, including on their mental health^{14,15}. The FHMS report included data on the radiation dose at the time, lifestyle-related disease, and the mental health of residents. A survey of the mental health status of Fukushima residents also indicated the same problem observed after the Chernobyl nuclear accident, so these investigations should continue in the future^{15,16}. We reported the mental health status of children, as measured by the Strengths and Difficulties Questionnaire (SDQ), in the FHMS about one year after the nuclear accident. The proportions of those who scored above the cut-off (≥ 16) of the SDQ, reflecting a mental health status in the clinical range, were 22.0% (aged 7-12

years) and 16.3% (aged 13-15 years), which is higher than those in the usual state (9.5%)¹⁷.

Previous studies have pointed out the problem of children's poor mental health status, but the effects of disasters on their mental health are not always consistent¹⁸⁻²¹, and differences in mental health status relative to environmental radiation levels have not been recognized¹⁷. Also, despite improvements in overall mental health²², long-term PTSD after a nuclear disaster and mental health problems associated with evacuation and migration have been pointed out²³. Furthermore, it should be noted that previous studies have reported that the mental health status of children living in rural areas is worse than that of children in urban areas^{24,25}.

Other surveys conducted to date have not considered the mental health status of children living in rural areas and the relationship between an experience of a nuclear accident and the mental health of children who were evacuated following a nuclear accident. In addition, the mental health of children in Kawauchi Village (Kawauchi), which is a rural area, was not as good as that of children in other areas who had been evacuated¹⁷. Kawauchi was selected as a survey target as this data can be used for considering future support. Therefore, the aim of the present study was to evaluate the mental health status of children who lived in Kawauchi, which was a town of fewer than 3,000 people at the time of the accident.

Materials and methods

Study population and data collection

Kawauchi Village, Fukushima Prefecture, is located within a 30 km radius from FDNPS. Although there was damage from the earthquake there was none from the tsunami; however, due to the accident at the nuclear power plant, almost all residents of the village, fewer than 3,000 people, were evacuated. The radiation dose rate remained relatively low compared to other evacuation areas. On January 31, 2012, the mayor of the village declared that residents who lived at least 20 km away from FDNPS could return to their homes, because the Japanese Prime Minister had declared that the reactors had achieved a state of cold shutdown in December 2011. Kawauchi village was the first local authority whose residents returned to their hometown after the evacuation due to the accident, and the number of residents returning to the village has

gradually increased²⁶⁾.

This cross-sectional study used data from the 2012 FHMS, which was collected between January and October 2012. The aim of the FHMS was to monitor the long-term health and daily lives of Fukushima residents and to provide them with proper care; it was conducted via postal mail on about 200,000 residents who had been living in the evacuation area at the time of the disaster. The entire protocol of this survey is published elsewhere¹⁵⁾. The surveys included a self-administered mental health questionnaire focusing on school year, gender, exercise habits (four categories; almost every day, 2-4 times a week, once a week, and almost never), sleep times (bedtime to wake-up time), "What did your child experience during the disaster?" (earthquake, tsunami, nuclear power plant accident, none of these), and the "Strengths and Difficulties questionnaire (SDQ)"²⁷⁾. We used survey data obtained from children of elementary and junior high school age (7-12 years old and 13-15 years old, respectively) and their parents in Kawauchi, who were included in the FHMS. In principle, the children's parents answered the questionnaire by recalling the child's circumstances at the time of the earthquake and beyond.

The mental health status of the children was assessed using the Japanese version of the SDQ scales. This Japanese version has been validated in previous reports^{28,29)}, and consists of 25 questions to the parents concerning both positive and negative behaviors of their child. One subscale evaluates prosocial behavior (social strength), and four subscales evaluate difficult behaviors (emotional symptoms, conduct problems, hyperactivity/inattention, and peer relationship problems). Each question was scored on a 3-point Likert scale from zero (none of the time) to two (all of the time). For SDQ-prosocial behavior, higher scores indicated a more positive behavior (range: 0-10), and for SDQ-difficult behavior, higher scores indicated more problematic behavior (range: 0-40). The total score of the four subscales for SDQ-difficult behavior is shown as a Total Difficulties Score (TDS), and we used the scoring classification of the previous study to classify the need for support into three types: normal range (low), borderline range (middle), and clinical range (high)²⁸⁾, as follows. Normal range (scores): TDS = 0-12, emotional symptoms, behavioral and peer relationship problems = 0-3, hyperactivity/inattention = 0-5, prosocial behavior = 6-10. Borderline range (scores): TDS = 13-15, emotional symptoms, behavioral and peer relationship problems = 4,

hyperactivity/inattention = 6, prosocial behavior = 5. Clinical range (scores): TDS = 16-40, emotional symptoms, behavioral and peer relationship problems = 5-10, hyperactivity/inattention = 7-10, prosocial behavior = 0-4.

Statistical analysis

We compared two groups of children, elementary and junior high school-aged (7-12 years and 13-15 years, respectively) based on each questionnaire item. We also compared the children's mental health status by classifying the group that had experienced the nuclear accident as "nuclear disaster (+)", and the group that had not "nuclear disaster (-)". The exercise habits "almost every day," "2-4 times a week," and "once a week" were classified as "Yes," whereas "almost never" was classified as "No." We used the chi-square test, the Mann-Whitney U test and covariance analysis to compare the data for the two areas. In this study, the dependent variable was "nuclear disaster (+/-)," the exposure variables were "TDS," "Emotional symptoms," "Conduct problems," "Hyperactivity/inattention," "Peer relationship problems," and "Social strength." *P* values of less than 0.05 were considered statistically significant. Statistical analysis was performed using SPSS Statistics 23.0 (IBM Japan, Tokyo, Japan).

Ethics statement

This study was approved by the ethics committee of Fukushima Medical University (No. 2046) before commencement. Prior to the study, we distributed the instructions for the FHMS and other surveys to residents. We considered that residents who responded to the questionnaires had agreed to participate in the study.

Results

We sent questionnaires to 156 families in Kawauchi. Of these families, 99 (63.5%) sent responses, and 93 (59.6%) answered all the questions and were included in the study analysis. The demographics of children whose families returned the surveys are presented in Table 1. The study included 65 elementary school students and 28 junior high school students. There were no differences in the gender ratios between elementary school and junior high school students (*P*=0.66). There were also no differences in the exercise habits or experience of the nuclear disaster between elementary and junior high school-aged children (*P*=1.00, re-

Table 1. Comparison of gender, lifestyle, experience of nuclear disaster, and the SDQ score between elementary and junior high school students.

		Elementary school <i>n</i> = 65	Junior high school <i>n</i> = 28	All <i>n</i> = 93	<i>p</i> [†]
		<i>n</i> (%)	<i>n</i> (%)	<i>n</i>	
Gender	Boy	36 (55.4%)	17 (60.7%)	53	0.66
	Girl	29 (44.6%)	11 (39.3%)	40	
Exercise habits	Yes	22 (33.8%)	10 (35.7%)	32	1.00
	No	43 (66.2%)	18 (64.3%)	61	
Sleeping time (Hour)	mean±SD	8.4±0.9	7.3±1.4	8.1±1.2	<0.001
Experience of nuclear disaster	Yes	24 (36.9%)	10 (35.7%)	34	1.00
	No	41 (63.1%)	18 (64.3%)	59	
SDQ score		mean±SD	mean±SD	mean±SD	
Total difficulties score		11.4±6.8	12.4±6.8	11.7±6.7	0.47
Emotional symptoms		3.0±2.7	2.9±2.3	3.0±2.6	0.98
Conduct problems		2.6±1.9	3.3±2.1	2.8±2.0	0.15
Hyperactivity/inattention		3.6±2.6	3.7±2.7	3.6±2.6	0.98
Peer relationship problems		2.2±2.2	2.6±1.7	2.3±2.1	0.20
Prosocial behavior		5.5±2.0	5.4±1.7	5.5±1.9	0.71

SDQ ; Strengths and difficulties questionnaire

[†] ; Chi-square test and the Mann-Whitney U test

Table 2. Classification of the need for support in elementary and junior high school students.

		Elementary school <i>n</i> = 65			Junior high school <i>n</i> = 28			<i>p</i> [†]
		low	middle	high	low	middle	high	
Total difficulties score	<i>n</i>	41	10	14	15	3	10	0.35
	%	63.1	15.4	21.5	53.6	10.7	35.7	
Emotional symptoms	<i>n</i>	40	9	16	19	3	6	0.84
	%	61.5	13.9	24.6	67.9	10.7	21.4	
Conduct problems	<i>n</i>	47	7	11	16	5	7	0.35
	%	72.3	10.8	16.9	57.1	17.9	25.0	
Hyperactivity/inattention	<i>n</i>	49	4	12	19	4	5	0.44
	%	75.4	6.1	18.5	67.8	14.3	17.9	
Peer relationship problems	<i>n</i>	48	8	9	20	3	5	0.88
	%	73.8	12.3	13.8	71.4	10.7	17.9	
Social strength	<i>n</i>	31	20	14	11	14	3	0.17
	%	47.7	30.8	21.5	39.3	50.0	10.7	

[†] ; Chi-square test

spectively). Furthermore, there was no significant difference in the sub-items and SDQ scores between the elementary and junior high school-aged children.

Table 2 shows the need for support in elementary school and junior high school students, as calculated from the SDQ. Their TDS showed no significant differences in their need for assistance, based on differences among all elementary and junior high school-aged children ($P=0.35$). Similarly, for other items, there was no significant difference in the need

for assistance based on differences among the elementary and junior high school-aged children.

Table 3 shows a comparison of lifestyle and SDQ score results for children based on differences in their experience of the nuclear disaster. There was no significant difference in the presence or absence of exercise or the average sleep time due to the difference in experience ($P=0.07$ and $P=0.90$, respectively). The SDQ results also showed no significant difference in each item.

Table 3. Comparison of gender, age, lifestyle and SDQ score due to differences in experience of nuclear disasters.

		Nuclear disaster (+)		Nuclear disaster (-)		p^\dagger
		$n = 34$	$n = 59$	$n = 34$	$n = 59$	
		n (%)		n (%)		
Gender	Boy	36 (55.4%)	17 (60.7%)			0.52
	Girl	29 (44.6%)	11 (39.3%)			
Age	mean \pm SD	11.0 \pm 2.3	10.6 \pm 2.4			0.34
Exercise habits	Yes	16 (47.1%)	16 (27.1%)			0.07
	No	18 (52.9%)	43 (72.9%)			
Sleeping time (Hour)	mean \pm SD	8.1 \pm 1.1	8.1 \pm 1.3			0.90
SDQ score						
Total difficulties score	mean \pm SD	10.9 \pm 6.7	12.2 \pm 6.8			0.31
Emotional symptoms	mean \pm SD	2.8 \pm 2.8	3.1 \pm 2.5			0.42
Conduct problems	mean \pm SD	2.4 \pm 1.7	3.0 \pm 2.2			0.37
Hyperactivity/inattention	mean \pm SD	3.1 \pm 2.6	3.9 \pm 2.6			0.19
Peer relationship problems	mean \pm SD	2.5 \pm 1.9	2.2 \pm 2.1			0.32
Prosocial behavior	mean \pm SD	5.7 \pm 1.8	5.3 \pm 2.0			0.34

SDQ ; Strengths and difficulties questionnaire

 † ; Chi-square test and the Mann-Whitney U test

Table 4. Classification of the need for support due to differences in experience of nuclear disasters.

		Nuclear disaster (+)			Nuclear disaster (-)			p^\dagger
		$n = 34$			$n = 59$			
		low	middle	high	low	middle	high	
Total difficulties score	n	22	4	8	34	9	16	0.79
	%	64.7	11.8	23.5	57.6	15.3	27.1	
Emotional symptoms	n	22	6	6	37	6	16	0.41
	%	64.7	17.6	17.6	62.7	10.2	27.1	
Conduct problems	n	24	5	5	39	7	13	0.67
	%	70.6	14.7	14.7	66.1	11.9	22.0	
Hyperactivity/inattention	n	28	0	6	40	8	11	0.07
	%	82.4	0	17.6	67.8	13.6	18.6	
Peer relationship problems	n	23	6	5	45	5	9	0.42
	%	67.6	17.6	14.7	76.3	8.5	15.2	
Social strength	n	17	11	6	25	23	11	0.76
	%	50.0	32.4	17.6	42.4	39.0	18.6	

 † ; Chi-square test

Table 4 shows the need to support children due to their different experience of the nuclear disaster, as calculated with the SDQ. Their TDS showed no significant differences due to a difference in experience ($P=0.79$). Similarly, for other items, there were no significant differences in the need for assistance based on the different experience of the nuclear disaster.

Discussion

This mental health survey, conducted in Kawau-

chi within the framework of the FHMS ten months after the nuclear disaster, had the objective of providing adequate mental health care and lifestyle support for evacuees^{14,15}. In addition, this study was analyzed to assist with problems related to the evacuation and migration of children living in the countryside at the time of the accident.

SDQ was employed in this survey to estimate the mental health states of the children. The results of the SDQ study, conducted within the FHMS framework during the same period as this study^{15,17}, indicated ratios of children in elementary and junior

high school who scored above the cut-off points of 22.0% and 16.2%, respectively. These ratios are substantially higher than reported previously (9.5%) for the usual condition²⁸. Kawauchi is located relatively far from the surveyed towns and villages. It was damaged by the earthquake, but not by the tsunami, because of its inland location. Due to the accident at the nuclear power plant, almost all residents who lived in the village, fewer than 3,000 people, were evacuated. The radiation dose rate remained relatively low compared to other evacuation areas. By contrast, the proportions of those who scored above the cutoff (≥ 16) of the SDQ were 23.5% (aged 7–12 years) and 33.3% (aged 13–15 years), were relatively higher than that of other areas in FHMS¹⁷.

Overall, more than half the children of Kawauchi had no regular exercise habits, and the average sleep time was about 8 hours. Itagaki *et al.* suggested that a lack of regular exercise and the shortening of sleep time among Fukushima's children may lead to the further deterioration of their mental health^{31,32}. Also, a short sleep duration was reported in children who experienced the earthquake disaster, and a relationship was noted between short sleep duration and increased traumatic symptoms^{18,33}. In this way, the lack of exercise and shortening of sleep time need attention, not only in terms of their physical effects on children, but also the mental effects. Furthermore, Chen *et al.* suggested that children living in rural areas and rural-to-urban migrant children had poorer mental health than children in urban areas²⁴. Several other studies have reported that indicators of social disadvantage (single-parent families, parents who are unemployed or have low incomes) are associated with poor mental health in children^{34–36}. This finding appears to have arisen due to the experience of a major disaster and evacuation during adolescence, however it should be carefully evaluated in terms of socioeconomic factors, including region (rural or urban, etc.) and for migrant children, factors including time course and parental income.

There are several reports related to the mental health states of children after the Great East Japan Earthquake. A comparative survey of SDQ in children in other areas who experienced the same disaster indicated that the experiences of loss in children who had been displaced due to the tsunami was related to their higher SDQ scores¹⁹. Fujiwara *et al.* found that more than 90% of the children who experienced the Great East Japan Earthquake are undergoing trauma, and according to the clinical zone for

the Child Behavior Checklist (CBCL), 27.7% are showing introverted problem behaviors, 21.2% are showing diplomatic problem behaviors, and 25.9% are showing overall behavioral problems²⁰. In another post-disaster report, McLaughlin *et al.* investigated emotional disturbance in children from 4 to 16 years old after hurricane damage; they reported that the proportion of children with emotional disorders decreased with the passage of time, but remained at a higher rate than normal³⁷. These results suggest the need to identify the problems present in the children from the disaster area, to increase sensitivity to children's mental health status, and to provide them with appropriate support. Although the children of Kawauchi village are expected to improve overall as time goes on, our opinion is that continued support is necessary, including support tailored to dealing with the effects of long-term trauma following a disaster.

In this study, we found no differences in mental health status related to experience of the nuclear accident. Since the SDQ actually captured the views of the children from their parents' perspective, it may have affected the SDQ outcomes, as it is not a direct reflection of the children's self-reported mental health. The children's mental health may also be affected by their parents' mental health status^{23,29}, so the results of other surveys conducted during the same period as this study may have also been influenced by their parents' mental health status³⁰. On the other hand, a longitudinal study by Oe *et al.* suggested a link between the experience of nuclear disasters and the emotional symptoms noted in the SDQ. Therefore, when assessing a child's mental health, it is also necessary to consider whether the child experienced the nuclear disaster³⁸.

Although there were no differences in the mental health status of children due to the experience of the nuclear disaster, there is no doubt that the effects of radiation exposure and related anxiety should be taken into consideration when thinking about the situation of the affected areas in Fukushima Prefecture. The FHMS estimates of the external radiation doses to residents living in Fukushima Prefecture during the accident were based on their behaviors during the four subsequent months¹⁴. The doses were evaluated as less than 5 mSv in 99.8% of all respondents; for residents of Kawauchi, it was less than 1 mSv in 72%, and less than 2 mSv in 99%³⁹. Nonetheless, radiation exposure to children causes anxiety among their parents⁴⁰. Since the accident, risk communication is ongoing in Fukushima and will continue to be needed for every

generation in order to avoid misunderstandings about radiation exposure and its health effects⁴¹⁾.

The present study has several limitations. First, the study was only conducted in Kawauchi, in the disaster area, and it is a cross-sectional study completed one year after the earthquake. For these reasons, the number of subjects is small and the generalizability of the results is limited. Second, because the FHMS SDQ results show recovery to the control level over time²²⁾, interpretation is limited when assessing acute psychological responses. Furthermore, since the definition of the experience of the nuclear accident is ambiguous, and the range of experiences is wide, the answers will vary depending on the perceptions of the research subjects. The SDQ and experience of disasters are also an evaluation of the children based on their parents' perceptions, so it does not directly reflect the mental health of the children themselves. We must also keep in mind that some differences emerge based on the assessors themselves²⁹⁾. Nevertheless, the SDQ is considered highly reliable because it is an evaluation by guardians who live in close contact with the children, and is a meaningful way of assessing such factors and their impact on mental health. Thirdly, the lack of survey items regarding socio-economic factors and living conditions in rural areas, and the fact that they are not compared with urban areas, is another limitation of this survey. Another factor to bear in mind is the suitability of the SDQ cut-off, which has been reported for Japanese subjects, but is not a world standard. With these possible limitations, further study is needed to understand the situation of the affected area, the regional lifestyle circumstances, and how quickly children can return to their original lives.

Conclusions

In this study, we investigated the mental health states of children who were evacuated from rural areas following the Fukushima nuclear accident. We found indications of poor mental health among elementary and junior high school-aged children in the disaster area immediately following the accident, but no differences based on their experience of the nuclear disaster. These results suggest harmful effects on the development of the affected children. Our findings indicate a need to provide those children who experienced evacuation, especially migrant children and children returning to rural areas, with continuous mental health support to facilitate the recovery of Fukushima.

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Disclosure

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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