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Protocol and Research Perspectives of the ToMMo Child Health Study after the 2011 Great East Japan Earthquake

Masahiro Kikuya,[1,2] Masako Miyashita,[1] Chizuru Yamanaka,[1] Mami Ishikuro,[1,2] Yuki Sato,[1,2] Taku Obara,[1,2] Hirohito Metoki,[1,2] Naoki Nakaya,[1,2] Fuji Nagami,[1,2] Hiroaki Tomita,[1,2,3] Hideyasu Kiyomoto,[1,2] Junichi Sugawara,[1,2] Atsushi Hozawa,[1,2] Nobuo Fuse,[1,2] Yoichi Suzuki,[1,2] Ichiro Tsuji,[1,2] Shigeo Kure,[1,2] Nobuo Yaegashi,[1,2] Masayuki Yamamoto [1,2] and Shinichi Kuriyama[1,2,3]

[1]Tohoku Medical Megabank Organization, Tohoku University, Sendai, Miyagi, Japan
[2]Tohoku University Graduate School of Medicine, Sendai, Miyagi, Japan
[3]Tohoku University International Research Institute of Disaster Science, Sendai, Miyagi, Japan

Residents of areas affected by the Great East Japan Earthquake may suffer from diseases or health problems. We are conducting a cross-sectional study from 2012 to 2015 to investigate and address the health needs of schoolchildren affected by this disaster. In this paper, we describe the protocol and research perspectives of our long-term child health study, and present the results obtained immediately after the disaster. The parent-administered questionnaire includes the International Study of Asthma and Allergies in Childhood questionnaire for asthma and eczema symptoms, the Strengths and Difficulties Questionnaire (SDQ), and a questionnaire on influenza infection and vaccination status. In 2012, we distributed the questionnaire to 3,505 (2nd, 4th, 6th, and 8th graders) in three municipalities located in southern coastal area among the 28 municipalities, and 1,277 (36.4%) returned the completed questionnaire. Mean age was 11.1 ± 2.2 years old. The number of children with symptoms of wheeze and eczema in the past 12 months was 146 (11.4%) and 199 (15.6%), respectively. The SDQ total difficulties score revealed 174 (13.6%) children with some form of difficulty in their daily lives. From May 2011 to April 2012, 195 (15.3%) and 649 (50.8%) children received the influenza vaccination once and twice, respectively, and 532 (41.7%) had suffered from influenza. The prevalence of eczema symptoms or some form of difficulty was higher than the Japanese average. However, careful interpretation was required because of potential self-selection bias from the low response rate. We will continue this study of schoolchildren to provide aggregate findings.

Keywords: atopic dermatitis; bronchial asthma; disaster; earthquake; SDQ
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Introduction

The Great East Japan Earthquake caused catastrophic damage, especially along the Pacific coast in northeast Japan (Fig. 1). Tohoku University, based in this area, strives to contribute to reconstruction efforts in the area in a creative manner. In this context, Tohoku University proposed the Tohoku Medical Megabank Organization (ToMMo) to develop future-oriented medical services while advancing the reconstruction process, and is working towards accomplishing these goals. The ToMMo will continuously study the health of residents in disaster-stricken areas and contribute to the early diagnosis and early treatment of illnesses.

Residents of areas affected by the Great East Japan Earthquake may suffer not only from damage sustained at the time of the disaster, but also from post-traumatic stress response and infectious diseases. The ToMMo is performing three health studies of the residents of areas affected by the Great East Japan Earthquake: a three-generation cohort study, a community resident cohort of participants aged 20 or older, and a child health study.

Previous studies have reported health issues among survivors of the Great East Japan Earthquake with careful attention to vulnerable persons such as the elderly, disabled, and patients with respiratory illness (Kobayashi et al. 2013; Ohkouchi et al. 2013). However, there has been little research documenting children's health after this disaster. In this paper, we describe the rationale for and design of the ToMMo child health study and present the results obtained

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Correspondence: Masahiro Kikuya, M.D., Ph.D., Tohoku Medical Megabank Organization, Tohoku University, 2-1 Seiryo-machi, Aoba-ku, Sendai, Miyagi 980-8573, Japan.
e-mail: kikuyam@med.tohoku.ac.jp

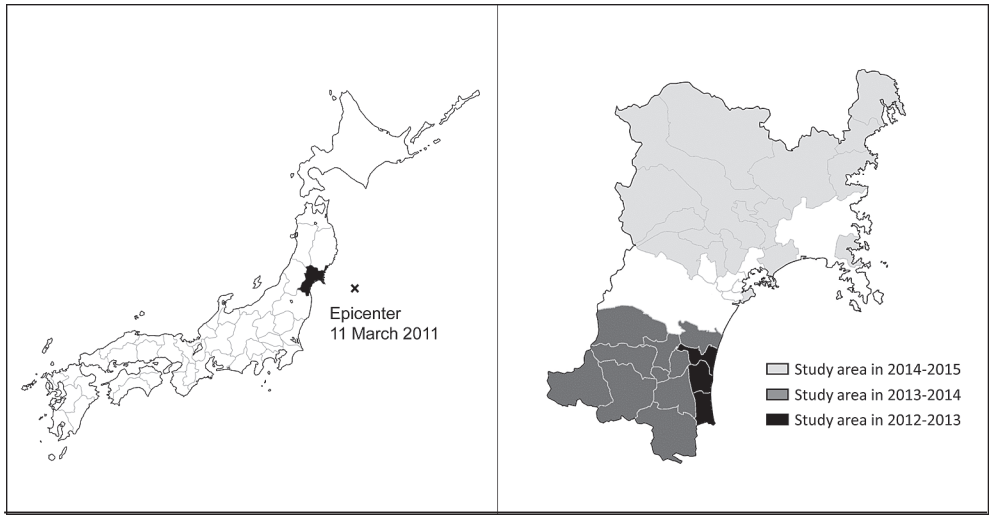

Fig. 1. Map of study area and epicenter of the Great East Japan Earthquake.
Miyagi Prefecture is shown in black in Japan map (left panel). Study area is located in Miyagi Prefecture (right panel).

immediately after the disaster.

The purpose of this study was to address the health needs of children who are at risk of increased illnesses or a worsening of symptoms following the Great East Japan Earthquake. The study had three main objectives: 1) to assess the health status of children and develop measures to meet their needs, 2) to provide appropriate support to children with health concerns, and 3) to identify children whose symptoms and prognosis will improve as quickly as possible with cutting-edge medical support services.

Methods

Design

Miyagi Prefecture was closest to the epicenter of the Great East Japan Earthquake (Fig. 1) and had the largest recorded death count among all 47 prefectures in Japan. The ToMMo child health study is an ongoing cross-sectional study conducted in Miyagi Prefecture. It consists of a parent-administered questionnaire study distributed in public elementary, junior high and special-needs schools, and will be carried out over a total of 4 years from 2012 to 2015. Parents or guardians complete the questionnaire and send it to our laboratory by mail. In 2012, we started the questionnaire survey in the three municipalities of Iwanuma, Watari, and Yamamoto, coastal areas located in southern Miyagi Prefecture, and obtained the results immediately after the disaster (Fig. 1). The reasons why this area was selected for the initial survey were as follows. Firstly, these municipalities are located in the coastal region that was most severely devastated by both the earthquake and subsequent tsunami in Miyagi Prefecture. Secondly, among the coastal regions of Miyagi Prefecture, these three municipalities drew less media attention, and as a result, external support from disaster relief activities was thought to be relatively small compared to northern coastal regions of Miyagi Prefecture. We expanded the study area to other areas in southern Miyagi Prefecture in 2013 and to northern areas of Miyagi Prefecture in 2014. According to the study plan, which was approved by the Miyagi Office of Education, we asked all 35 municipal school boards throughout Miyagi Prefecture to participate in the study; of these, 28 agreed to participate. Therefore, 28 municipalities were defined as the study area (Fig. 1): the three abovementioned municipalities that participated in the 2012 study, the 10 municipalities in southern Miyagi Prefecture that participated in the 2013 study (Shiroishi, Natori, Kakuda, Zao, Shichikashuku, Ogawara, Murata, Shibata, Kawasaki, and Marumori), and the 15 municipalities that participated in the 2014 study (Kesennuma, Tome, Kurihara, Higashimatsushima, Osaki, Shichigahama, Taiwa, Osato, Ohira, Shikama, Kami, Wakuya, Misato, Onagawa, and Minamisanriku). Ethical approval was obtained from the Institutional Review Board of Tohoku University Graduate School of Medicine on September 24, 2012 (No. 2012-1-278). Informed consent to participate in our investigation was assumed by returning the questionnaire.

Study population

Eligible children were public elementary and junior school students located in 28 municipalities in Miyagi Prefecture with the exception of 9th grade students. The main reason for this was because in Japan, the 9th grade is the final year of compulsory education and these students are usually concentrating on high school entrance exams; therefore, these students and their parents or guardian would not have much time to spend in a health study and we did not want to place any additional burden on them. Therefore, eligible children consisted of students in eight academic years ranging from 1st to 8th grade who were attending public schools located in Miyagi Prefecture.

Since elementary and junior high school education is compulsory in Japan, almost all children in the target region were affiliated with a school. According to the Miyagi Office of Education, in 2012, 74,545 children were attending an elementary, junior high, or special-needs school in the 28 municipalities included in this study and 74,344 (about 99.7%) of them were attending public school. After excluding 9th grade students, the total number of eligible subjects totaled 65,881.

In each municipality, the questionnaire survey was divided into two consecutive years due to insufficient human resources and annual research budget limitations. In the first year, we examined children in the 2nd, 4th, 6th, and 8th grades, then, in the second year, we examined

students in the other grades, i.e. the 1st, 3rd, 5th, and 7th grades. Since students progressed to the next grade the following year, the 2nd, 4th, 6th, and 8th grade students were examined at that time.

Target diseases and questionnaire items

We defined target diseases according to following criteria: diseases that increased in prevalence since the disaster, diseases expected to increase in prevalence in the future according to community medicine professionals in the region, and diseases with social demand. Based on these criteria, the target diseases for the study were defined as allergic diseases, infection, and pediatric neuropsychiatric disorders, including posttraumatic stress disorder, autism spectrum disorders, and attention deficit hyperactivity disorder.

For allergic diseases, symptoms of asthma and eczema were investigated using the Japanese version (Nishima and Odajima 2002) of the International Study of Asthma and Allergies in Childhood (ISAAC) questionnaire on allergic symptoms (Asher et al. 1995; Ellwood et al. 2005) (items 1-8 of Table 1 for asthma; items 1-7 of Table 2 for eczema). For all children regardless of age, we adopted a parent-administered questionnaire (i.e. the *Core Questionnaire 6-7 years*), and not a self-administered questionnaire (i.e. the *Core Questionnaire 13-14 years*) (Asher et al. 1995; Ellwood et al. 2005). The former and the latter are the same word for word with the exception of the following two points: 1) the nominative used in each question, such as "Has *your child* ever had wheezing…" for the *Core Questionnaire 6-7 years* vs. "Have *you* ever had wheezing…" for the *Core Questionnaire 13-14 years*, and 2) the item "At what age did this itchy rash first occur?" is only included in the *Core Questionnaire 6-7 years*. In this study, we defined current wheeze as a positive response to the item, wheeze in the past 12 months (item 2, Table 1) (Lai et al. 2009). Symptoms of severe wheeze were defined as current wheeze with ≥ 4 attacks of wheeze (item 3, Table 1), or ≥ 1 night per week sleep disturbance from wheeze (item 4, Table 1), or wheeze affecting speech (item 5, Table 1) (Lai et al. 2009). Current eczema was defined as positive responses to the two items on eczema in Table 2: "Has your child had this itchy rash at any time during the past 12 months?" (item 2) and "Has this itchy rash at any time affected any of the following places: the folds of the elbows, behind the knees, in front of the ankles, under the buttocks, or around the neck, ears or eyes?" (item 3) (Odhiambo et al. 2009). Severe eczema was defined as current eczema with sleep disturbance ≥ 1 night per week (item 6, Table 2) (Odhiambo et al. 2009). We also asked about doctor diagnosis, treatment, and treatment interruption at the time of the disaster (items 9-12, Table 1; items 8-10, Table 2).

For pediatric neuropsychiatric disorders, we used the Japanese version of the parent-rated Strengths and Difficulties Questionnaire (SDQ) (Matsuishi et al. 2008) obtained from the official SDQ website (http://www.sdqinfo.com), where authorized translated versions of SDQ are available in over 40 languages. The SDQ is a short screening instrument inquiring into developmental disabilities, psychological and psychiatric conditions or disorders in children, and consists of 25 items grouped into five subscales including emotional symptoms (5 items), conduct problems (5 items), hyperactivity/

Table 1. Summary of questionnaire items regarding asthma symptoms (N = 1,277).

Questionnaire item		N (%)
1. Has your child ever had wheezing or whistling in the chest at any time in the past?		367 (28.7)
2. Has your child had wheezing or whistling in the chest in the past 12 months?		146 (11.4)
3. How many attacks of wheezing has your child had in the past 12 months?	1 to 3	134 (10.5)
	4 to 12	28 (2.2)
	More than 12	7 (0.6)
4. In the past 12 months, how often, on average, has your child's sleep been disturbed due to wheezing?		
	Never woken with wheezing	163 (12.8)
	Less than 1 night per week	29 (2.3)
	1 or more nights per week	15 (1.2)
5. In the past 12 months, has wheezing ever been severe enough to limit your child's speech to only one or two words at a time between breaths?		12 (0.9)
6. Has your child ever had asthma?		264 (20.7)
7. In the past 12 months, has your child's chest sounded wheezy during or after exercise?		86 (6.7)
8. In the past 12 months, has your child had a dry cough at night, apart from a cough associated with a cold or chest infection?		101 (7.9)
If your child has ever had asthma, please also answer items 9-12.		
9. Is your child currently receiving treatment for bronchial asthma?		78 (6.1)
10. Does your child receive treatment for bronchial asthma even when he/she is not experiencing asthma attacks or only when he/she has an asthma attack?		
	Even when there is no asthma attack	64 (5.0)
	Only when he/she has an asthma attack	128 (10.0)
11. Currently, what is your child's bronchial asthma treatment?	Internal agent	134 (10.5)
	Inhaler	91 (7.1)
	Adhesive skin patch	79 (6.2)
12. At the time of the disaster, was your child's treatment for bronchial asthma interrupted for more than 1 month?		46 (3.6)

inattention (5 items), peer relationship problems (5 items), and prosocial behavior (5 items) (Goodman 1997). For each item, there are three answer choices: "not true", "somewhat true", and "certainly true" scores for each of the five subscales subtotaled between 0 and 10. Total difficulties score was defined as the sum of the subscale scores except for prosocial behavior (Goodman 1997). Thus, total difficulties score ranged from 0 to 40. We classified children as within normal, borderline, or clinical range according to previously established cut-offs (Matsuishi et al. 2008). The cut-off values for normal, borderline, and clinical range were 0-12, 13-15, and 16-40 for total difficulties score, 0-3, 4, and 5-10 for emotional symptoms score, 0-3, 4, and 5-10 for conduct problems score, 0-5, 6, and 7-10 for hyperactivity/inattention score, 0-3, 4, and 5-10 for peer problems score, and 6-10, 5, and 0-4 for prosocial behavior score, respectively (Matsuishi et al. 2008).

For infection, we investigated influenza since Japan is a developed country and the major infectious disease among schoolchildren is influenza (National Institute of Infectious Diseases 2012). Furthermore, because the Great East Japan Earthquake occurred in the March that was epidemic season of seasonal influenza, we were afraid of enhancement of epidemic of influenza in the affected areas. Questionnaire items about influenza inquired into vaccination status, the reason for declining vaccination, as well as onset, treatment, and complications of influenza (Table 3).

This project also aimed to identify children whose symptoms and prognosis are expected to improve with cutting-edge medical support services. With this in mind, we focused on citrin deficiency (Kobayashi et al. 1999) and pyridoxine-dependent autism (Kuriyama et al. 2002), a subgroup of autism expected to benefit from pyridoxine treatment, which shows similar clinical features to pyridoxine-dependent epilepsy but without seizures. The findings of specific symptoms of these diseases will be reported in separate publications.

The questionnaire also collected basic characteristics including birth year, birth month, and the relationship between the child and the person who completed the questionnaire. Regarding disaster experience, we asked, "At the time of this disaster, please choose all that your child experienced" with the answer choices provided as earthquake, tsunami, both or none.

The 2012 study

From November 1 to November 28, 2012, we conducted an initial questionnaire survey and obtained the results immediately after the disaster in the three municipalities of Iwanuma, Watari, and Yamamoto. The questionnaire was distributed to 3,505 public school children at 15 elementary schools, 10 junior high schools and one special-needs school in the target grades (2^{nd}, 4^{th}, 6^{th}, and 8^{th} grades). The children brought the questionnaire home for their parents or guardian to complete, and 1,369 (39.1%) were returned. We excluded 92 questionnaires because of missing of age data (N = 2), responses for children outside the target grades (N = 21), and missing responses for asthma symptoms (N = 4), eczema symptoms (N = 1), SDQ (N = 45), vaccination status (N = 10) or influenza infection (N = 9). Thus, the total number of children included in the present analyses was 1,277.

Continuous variables are reported as mean and standard deviation (SD), whereas categorical variables are reported as percentage. All analyses were conducted using SAS statistical software (version 9.3; SAS Institute Inc., Cary, NC, USA). We compared means and proportions using the unpaired t-test, the chi-square test and the large sample *z*-test.

Results

The 1,277 children comprised 672 girls (52.6%) and 605 boys (47.4%), with a mean age of 11.2 ± 2.2 and 11.0 ± 2.2 years, respectively ($P = 0.18$). The number of 2^{nd}, 4^{th}, 6^{th}, and 8^{th} grade children were 300, 339, 359, and 279, respectively. The person who completed the questionnaire

Table 2. Summary of questionnaire items regarding eczema symptoms (N = 1,277).

Questionnaire item		N (%)
1. Has your child ever had an itchy rash that came and went for at least 6 months?		254 (19.9)
2. Has your child had this itchy rash at any time during the past 12 months?		257 (20.1)
3. Has this itchy rash at any time affected any of the following places: the folds of the elbows, behind the knees, in front of the ankles, under the buttocks, or around the neck, ears or eyes?		208 (16.3)
4. At what age did this itchy rash first occur?	Under 2 years	79 (6.2)
	Age 2-4 years	66 (5.2)
	Age 5 or older	129 (10.1)
5. Has this rash cleared up completely at any time during the past 12 months?		186 (14.6)
6. In the past 12 months, how often, on average, has your child been kept awake at night by this itchy rash?		
	Never in the past 12 months	203 (15.9)
	Less than 1 night per week	53 (4.2)
	1 or more nights per week	26 (2.0)
7. Has your child ever had eczema?		808 (63.3)
8. Has your child been diagnosed by a doctor as having atopic dermatitis?		238 (18.6)
If your child has been diagnosed with atopic dermatitis by a doctor, please also answer items 9-10.		
9. Currently, is your child receiving treatment for atopic dermatitis?		96 (7.5)
10. At the time of the disaster, was your child's treatment for atopic dermatitis interrupted for more than 1 month?		59 (4.6)

was mostly the mother (N = 1,177, 92.2%), followed by the father (N = 84, 6.6%), a grandparent (N = 14, 1.1%), and other (N = 3, 0.2%). The number of children who had experienced the earthquake and tsunami were 1,270 (99.5%) and 291 (22.8%), respectively.

Table 1 shows a summary of the responses regarding asthma symptoms. Among the 1,277 children, 146 (11.4%) children had wheezing or whistling in the past 12 months. The number of children who had ≥ 4 attacks of wheeze, ≥ 1 night per week sleep disturbance from wheeze, and wheeze affecting speech were 35 (2.7%), 15 (1.1%), and 12 (0.9%), respectively. Of the 264 (20.7%) children who had ever had asthma, 78 (6.1%) were receiving treatment at the time of the survey, and 64 (5.0%) were receiving regular treatment for bronchial asthma. At the time of the disaster, treatment for bronchial asthma was interrupted for more than 1 month in 46 (3.6%) children.

Table 2 shows a summary of the responses regarding eczema symptoms. Among the 1,277 children, 257 (20.1%) children had suffered from itchy rash in the past 12 months, 208 (16.3%) had suffered itchy rash in specific areas of the body, and 26 (2.0%) had been kept awake at night by this itchy rash ≥ 1 nights per week. Moreover, 238 (18.6%) had received diagnosis of atopic dermatitis from a doctor and 96 (7.5%) were receiving treatment for atopic dermatitis at the time of the survey. At the time of the disaster, treatment for atopic dermatitis was interrupted for more than 1 month in 59 (4.6%) children.

In relation to SDQ, a widely used instrument for screening mental problems in children and adolescents, the total difficulties score (mean ± SD) was 9.46 ± 5.48, and the scores of the SDQ subscales are presented in Table 3. According to the total difficulties score, 953 (74.6%), 150 (11.8%), and 174 (13.6%) children were classified as within the normal, borderline, and clinical range, respectively. The results of classification by each of the SDQ subscales are also shown in Table 3.

Table 4 shows a summary of the responses regarding vaccination status and influenza infection. From May 1, 2011 to April 30, 2012, 433 (33.9%) children were not vaccinated for influenza, and 195 (15.3%) and 649 (50.8%) children were vaccinated once and twice, respectively. The major reason why the children were not vaccinated or received a single vaccination was the parent or guardian "did not want the vaccination" (N = 248), followed by "other reasons" (N = 209), "child suffered from the flu before vaccination" (N = 67), and "poor physical condition or allergy" (N = 55). During the same period, 532 (41.7%) children suffered from the flu. The treatments for the flu were mainly inhalation (N = 358) and internal agents (N =184). Six children developed severe flu complications, mainly pneumonia (N = 3).

Table 5 shows the number and prevalence of children within SDQ clinical range, and symptoms of asthma and eczema, vaccination status and influenza infection by sex and age group. The prevalence of SDQ clinical range according to total difficulties for girls tended to be lower than that for boys (11.9% vs. 15.5%, $P = 0.06$). Among the five SDQ subscales, the prevalence of SDQ clinical range for hyperactivity/inattention and prosocial behavior in boys was significantly higher than that in girls ($P < 0.01$). An increase in grades was associated with reduced prevalence of total difficulties, emotional symptoms, and hyperactivity/inattention ($P < 0.05$). In relation to allergic diseases, current wheeze was more frequent in boys ($P < 0.01$), while current eczema tended to be more frequent in girls. Both current wheeze and current eczema were less frequent in the upper grades than the lower grades ($P < 0.01$). Vaccination and influenza infection did not show any sex differences; however, clear differences were found with respect to school grade. Vaccinations were mostly performed twice in the 2nd, 4th, and 6th grades (more than 55.7%), and only once in the 8th grade (47.3%). Influenza infection was significantly lower in the upper grades than the lower grades ($P < 0.01$).

Among the 1,369 parents or guardian who returned the questionnaire, 309 indicated that they had received mental and physical health counseling from public health nurses and psychologists through our telephone consultation line. Face-to-face meetings and referring cases to the psychiatric service were also held as requested.

Table 3. Strengths and Difficulties Questionnaire scores and the number of children within the normal, borderline, and clinical range according to score (N = 1,277).

	Mean score	SD	N (%) within normal range	N (%) within borderline range	N (%) within clinical range
Total difficulties score	9.46	5.48	953 (74.6)	150 (11.8)	174 (13.6)
Emotional symptoms score	2.11	2.15	983 (77.0)	118 (9.2)	176 (13.8)
Conduct problems score	2.20	1.68	1,022 (80.0)	132 (10.3)	123 (9.6)
Hyperactivity/inattention score	3.28	2.29	1,046 (81.9)	97 (7.6)	134 (10.5)
Peer problems score	1.87	1.65	1,082 (84.7)	92 (7.2)	103 (8.1)
Prosocial behavior score	5.98	2.08	726 (56.9)	286 (22.4)	265 (20.8)

Cut-offs for normal, borderline, and clinical range were 0-12, 13-15, and 16-40 for total difficulties score, 0-3, 4, and 5-10 for emotional symptoms score, 0-3, 4, and 5-10 for conduct problems score, 0-5, 6, and 7-10 for hyperactivity/inattention score, 0-3, 4, and 5-10 for peer problems score, and 6-10, 5, and 0-4 for prosocial behavior score, respectively.

Table 4. Summary of questionnaire items regarding influenza infection and vaccination status (N = 1,277).

Questionnaire item		N (%)
From May 1, 2011 to April 30, 2012, was your child vaccinated for influenza?		
No		433 (33.9)
Vaccinated ONCE during this period		195 (15.3)
Vaccinated TWICE during this period		649 (50.8)
If your child was not vaccinated or was vaccinated only once, please select the reason.		
Poor physical condition or allergy		55 (4.3)
There are no medical institutions providing vaccination services		8 (0.6)
Your child suffered from the flu before vaccination		67 (5.3)
Did not want the vaccination for your child		248 (19.4)
Other reasons		209 (16.4)
From May 1, 2011 to April 30, 2012, did your child suffer from flu?		532 (41.7)
What was the treatment for the flu?		
Internal agent (oseltamivir, amantadine)		184 (14.4)
Inhalation agent (zanamivir, laninamivir)		358 (28.0)
Injection or drip-infusion (peramivir)		5 (0.4)
Other		11 (0.9)
Uncertain		6 (0.5)
Did your child develop severe disease such as pneumonia or encephalopathy when they suffered from flu?		6 (0.5)
What kind of severe disease did your child suffer from?	Pneumonia	3 (0.2)
	Encephalopathy	0 (0.0)
	Other	3 (0.2)

Table 5. Number (%) of children within SDQ clinical range, asthma and eczema symptoms, vaccination status and influenza infection by sex and age group.

	Total (N = 1,277)	Girls (N = 672)	Boys (N = 605)	2nd grade (N = 300)	4th grade (N = 339)	6th grade (N = 359)	8th grade (N = 279)
SDQ clinical range							
Total difficulties	174 (13.6)	80 (11.9)	94 (15.5)*	56 (18.7)	44 (13.0)	43 (12.0)	31 (11.1)‡
Emotional symptoms	176 (13.8)	97 (14.4)	79 (13.1)	54 (18.0)	51 (15.0)	37 (10.3)	34 (12.2)‡
Conduct problems	123 (9.6)	61 (9.1)	62 (10.3)	29 (9.7)	34 (10.0)	34 (9.5)	26 (9.3)
Hyperactivity/inattention	134 (10.5)	47 (7.0)	87 (14.4)†	44 (14.7)	43 (12.7)	30 (8.4)	17 (6.1)§
Peer problems	103 (8.1)	56 (8.3)	47 (7.8)	29 (9.7)	18 (5.3)	36 (10.0)	20 (7.2)
Prosocial behavior	265 (20.8)	111 (16.5)	154 (25.5)†	61 (20.3)	63 (18.6)	69 (19.2)	72 (25.8)
Asthma symptoms							
Current wheeze	146 (11.4)	62 (9.2)	84 (13.9)†	35 (11.7)	50 (14.8)	43 (12.0)	18 (6.5)‡
Severe wheeze	45 (3.5)	21 (3.1)	24 (4.0)	10 (3.3)	9 (2.7)	19 (5.3)	7 (2.5)
Eczema symptoms							
Current eczema	199 (15.6)	115 (17.1)	84 (13.9)	56 (18.7)	61 (18.0)	52 (14.5)	30 (10.8)‡
Severe eczema	19 (1.5)	11 (1.6)	8 (1.3)	5 (1.7)	6 (1.8)	6 (1.7)	2 (0.7)
Influenza							
Vaccinated once	195 (15.3)	99 (14.7)	96 (15.9)	15 (5.0)	22 (6.5)	26 (7.2)	132 (47.3)§
Vaccinated twice	649 (50.8)	334 (49.7)	315 (52.1)	203 (67.7)	216 (63.7)	200 (55.7)	30 (10.8)§
Infected	532 (41.7)	282 (42.0)	250 (41.3)	152 (50.7)	157 (46.3)	141 (39.3)	82 (29.4)§

*$P = 0.06$ and †$P < 0.01$ were results of the chi-square test between girls and boys. ‡$P = 0.05$ and §$P < 0.01$ were results of the chi-square test among 2nd, 4th, 6th, and 8th grade children.

Discussion

The ToMMo child health study will examine the impacts of the Great East Japan Earthquake on the health of schoolchildren, offer appropriate mental and physical counseling to each and every child, and encourage them to seek medical attention when necessary. We began a parent-administered questionnaire survey of schoolchildren in 28 municipalities in Miyagi Prefecture in 2012 to inquire into symptoms of asthma and eczema, difficulties in daily life, and influenza infection and vaccination status. Several studies reported mental and physical symptoms of children at the time of other disasters (Thienkrua et al. 2006; Thomas et al. 2008; Mitchell et al. 2012); however, studies on complex disasters such as earthquakes and tsunamis in developed countries are limited. One study focused on post-traumatic stress disorder and depression among children after the 2004 Sumatra earthquake, which was a complex earthquake and tsunami disaster that struck the coast of countries such as Indonesia, Thailand, India, and Sri Lanka (Thienkrua et al. 2006). However, since that event occurred in a developing country in a tropical zone, the mental and physical symptoms of children could differ from those of children who experienced the Great East Japan Earthquake that occurred in a developed country in a temperate zone. Our study is expected to obtain new findings in terms of mental and physical symptoms of schoolchildren living in such a disaster area.

Although the response rate of 36.4% in the 2012 study was low, this was expected given the circumstances after the disaster. Since the completed questionnaires were mailed to our laboratory by parents or guardian, not schoolteachers, we expected the response rate to be around 30%. In this initial survey, we asked schoolteachers to distribute the questionnaire in public schools, but the completed questionnaires were not collected by the teachers because of the potential for the children to lose the completed questionnaires on their way to school. With this low response rate, careful interpretation was required when comparing allergy prevalence results with the national or world average because of the possibility of self-selection bias among the children's parents or guardians. However, in contrast to several other studies (The International Study of Asthma and Allergies in Childhood (ISAAC) Steering Committee 1998; Nishima and Odajima 2002; Matsuishi et al. 2008; Odhiambo et al. 2009; National Institute of Infectious Diseases 2012), we covered most of schools in our study area.

Using this strong point, we plan to investigate the following research objectives using the data that will be obtained: 1) compare symptoms of asthma and eczema among the participating children by region, or by disaster experience such as the tsunami, or relocation to temporary housing, though questionnaire about housing was implemented in 2013 or later. 2) investigate the relationship between pediatric neuropsychiatric disorders and residential area and tsunami experience, 3) investigate interruption of asthma and eczema treatment and worsening symptoms in the disaster area, 4) investigate the relationship between pediatric neuropsychiatric disorders and asthma and eczema symptoms in the disaster area, 5) determine the influenza infection and vaccination status in the disaster area, and 6) clarify the needs of children living in the disaster area from findings from individual interview assistance and telephone consultations.

In the 2012 study, diseases were surveyed in the three municipalities of Iwanuma, Watari, and Yamamoto. In line with previous findings (Matsuishi et al. 2008), the prevalence of SDQ clinical range was higher in boys than girls for total difficulties score, hyperactivity/inattention and prosocial behavior. In the upper grades, the prevalence of SDQ clinical range for total difficulties, emotional symptoms, and hyperactivity/inattention was lower than that of lower grades (Matsuishi et al. 2008). The prevalence of SDQ clinical range for total difficulties was 13.6%, which was higher than that of previous study in 2,899 Japanese children aged 4-12 years (9.5%, $P < 0.0001$) (Matsuishi et al. 2008). However, careful interpretation was required because of potential self-selection bias from the low response rate. The results of the sex and age distribution of allergic diseases were also consistent with previous findings (The International Study of Asthma and Allergies in Childhood (ISAAC) Steering Committee 1998; Nishima and Odajima 2002; Odhiambo et al. 2009). Current wheeze was more frequent in boys, while current eczema tended to be more frequent in girls (Nishima and Odajima 2002; Odhiambo et al. 2009). Both symptoms were more frequent in lower grades (Nishima and Odajima 2002). The results of influenza infection in upper grades were also in line with Japanese national statistics (National Institute of Infectious Diseases 2012). The consistencies between our results and previous research suggest validity of our data. In Table 2, item 2 of itchy rash during the past 12 months was 20.1%, which was also higher than that of Japanese average i.e. 16.6% for 6-7 years old and 10.7% for 13-14 years old (Akazawa et al. 2010). However, again, careful interpretation was required. It is important to note that the response rate was only 36.4%. For symptoms of asthma, prevalence of wheeze was similar to Japanese average (Akazawa et al. 2010).

Vaccination frequencies of mainly twice in the 2nd, 4th, and 6th grades and mainly once in the 8th grade were consistent with the provisions of the Japanese medical administration. The Ministry of Health, Labour and Welfare of Japan has stated that receiving the influenza vaccine twice under the age of 13 is the standard immunization protocol for children and adolescents. The prevalence of Vaccination was similar to Japanese average of seasonal influenza in 2011/2012 (National Institute of Infectious Diseases 2013).

As one of the aims of our study, we are providing support to children with health concerns, including having mental and physical health counseling with parents or

guardian. In fact, of the 3,505 parents or guardian in the study area, 309 used our telephone consultation line in 2012. Since the percentage of parents or guardian and children receiving support was high, we consider the objective of providing appropriate support to have been fully achieved. We will continue to provide these supports throughout the entire study period.

In this paper, we describe the rationale for and design of the ToMMo child health study and present the results obtained immediately after the disaster. We have conducted a parent-administered questionnaire survey of schoolchildren in 28 municipalities in Miyagi Prefecture to inquire into asthma and eczema symptoms, difficulties in daily life, and influenza vaccination and infection status. For the purpose of improving the health of children in the Great East Japan Earthquake area, we will continue the study to provide aggregate findings and valuable epidemiological evidence which will shed light on the impact of this disaster on schoolchildren.

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Conflict of Interest

The authors declare no conflict of interest.

References

Akazawa, K., Yoshida, K. & Adachi, Y. (2010) Prevalence of asthma symptoms in Japanese children. In *Nationwide Survey of Prevalence, Dissemination of Guideline, and QOL of asthma symptom in Japanese children* (in Japanese). https://mhlw-grants.niph.go.jp/niph/search/NIDD00.do?resrchNum=200934001B [*Accessed*: May 7, 2015].

Asher, M.I., Keil, U., Anderson, H.R., Beasley, R., Crane, J., Martinez, F., Mitchell, E.A., Pearce, N., Sibbald, B., Stewart, A.W., Strachan, D., Weiland, S.K. & Williams, H.C. (1995) International Study of Asthma and Allergies in Childhood (ISAAC): rationale and methods. *Eur. Respir. J.*, **8**, 483-491.

Ellwood, P., Asher, M.I., Beasley, R., Clayton, T.O. & Stewart, A.W. (2005) The international study of asthma and allergies in childhood (ISAAC): phase three rationale and methods. *Int. J. Tuberc. Lung Dis.*, **9**, 10-16.

Goodman, R. (1997) The Strengths and Difficulties Questionnaire: a research note. *J. Child Psychol. Psychiat.*, **38**, 581-586.

Kobayashi, K., Sinasac, D.S., Iijima, M., Boright, A.P., Begum, L., Lee, J.R., Yasuda, T., Ikeda, S., Hirano, R., Terazono, H., Crackower, M.A., Kondo, I., Tsui, L.C., Scherer, S.W. & Saheki, T. (1999) The gene mutated in adult-onset type II citrullinaemia encodes a putative mitochondrial carrier protein. *Nat. Genet.*, **22**, 159-163.

Kobayashi, S., Hanagama, M., Yamanda, S., Satoh, H., Tokuda, S., Kobayashi, M., Ueda, S., Suzuki, S. & Yanai, M. (2013) Impact of a large-scale natural disaster on patients with chronic obstructive pulmonary disease: the aftermath of the 2011 Great East Japan Earthquake. *Respir. Investig.*, **51**, 17-23.

Kuriyama, S., Kamiyama, M., Watanabe, M., Tamahashi, S., Muraguchi, I., Watanabe, T., Hozawa, A., Ohkubo, T., Nishino, Y., Tsubono, Y., Tsuji, I. & Hisamichi, S. (2002) Pyridoxine treatment in a subgroup of children with pervasive developmental disorders. *Dev. Med. Child Neurol.*, **44**, 284-286.

Lai, C.K., Beasley, R., Crane, J., Foliaki, S., Shah, J. & Weiland, S. (2009) Global variation in the prevalence and severity of asthma symptoms: phase three of the International Study of Asthma and Allergies in Childhood (ISAAC). *Thorax*, **64**, 476-483.

Matsuishi, T., Nagano, M., Araki, Y., Tanaka, Y., Iwasaki, M., Yamashita, Y., Nagamitsu, S., Iizuka, C., Ohya, T., Shibuya, K., Hara, M., Matsuda, K., Tsuda, A. & Kakuma, T. (2008) Scale properties of the Japanese version of the Strengths and Difficulties Questionnaire (SDQ): a study of infant and school children in community samples. *Brain Dev.*, **30**, 410-415.

Mitchell, H., Cohn, R.D., Wildfire, J., Thornton, E., Kennedy, S., El-Dahr, J.M., Chulada, P.C., Mvula, M.M., Grimsley, L.F., Lichtveld, M.Y., White, L.E., Sterling, Y.M., Stephens, K.U. & Martin, W.J. (2012) Implementation of evidence-based asthma interventions in post-Katrina New Orleans: the Head-off Environmental Asthma in Louisiana (HEAL) study. *Environ. Health Perspect.*, **120**, 1607-1612.

National Institute of Infectious Diseases (2012) SENTINEL-REPORTING DISEASES (WEEKLY & MONTHLY) Number of cases and cases per sentinel by age group, sex, and prefecture. http://www.nih.go.jp/niid/ja/survei/2270-idwr/nenpou/4307-syulist2012.html [*Accessed*: May 7, 2015].

National Institute of Infectious Diseases (2013) Infectious Agents Surveillance Report. *IASR*, **34**, 334-336 (in Japanese). http://www.nih.go.jp/niid/ja/iasr-sp/2257-related-articles/related-articles-405/4090-dj4052.html [*Accessed*: May 7, 2015].

Nishima, S. & Odajima, H. (2002) Prevalence of childhood allergic diseases in Japan using international study of asthma and allegies in childhood (ISAAC) phase I protocol. *Jpn. J. Pediatr. Allergy Clin. Immunol.*, **16**, 207-220.

Odhiambo, J.A., Williams, H.C., Clayton, T.O., Robertson, C.F. & Asher, M.I. (2009) Global variations in prevalence of eczema symptoms in children from ISAAC Phase Three. *J. Allergy Clin. Immunol.*, **124**, 1251-1258.

Ohkouchi, S., Shibuya, R., Yanai, M., Kikuchi, Y., Ichinose, M. & Nukiwa, T. (2013) Deterioration in regional health status after the acute phase of a great disaster: respiratory physicians' experiences of the Great East Japan Earthquake. *Respir. Investig.*, **51**, 50-55.

The International Study of Asthma and Allergies in Childhood (ISAAC) Steering Committee (1998) Worldwide variations in the prevalence of asthma symptoms: the International Study of Asthma and Allergies in Childhood (ISAAC). *Eur. Respir. J.*, **12**, 315-335.

Thienkrua, W., Cardozo, B.L., Chakkraband, M.L., Guadamuz, T.E., Pengjuntr, W., Tantipiwatanaskul, P., Sakornsatian, S., Ekassawin, S., Panyayong, B., Varangrat, A., Tappero, J.W., Schreiber, M. & van Griensven, F. (2006) Symptoms of posttraumatic stress disorder and depression among children in tsunami-affected areas in southern Thailand. *JAMA*, **296**, 549-559.

Thomas, P.A., Brackbill, R., Thalji, L., DiGrande, L., Campolucci, S., Thorpe, L. & Henning, K. (2008) Respiratory and other health effects reported in children exposed to the World Trade Center disaster of 11 September 2001. *Environ. Health Perspect.*, **116**, 1383-1390.