Study Profile

Design of the health examination survey on early childhood physical growth in the Great East Japan Earthquake affected areas

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A B S T R A C T

Background: To investigate the impact of the Great East Japan Earthquake on preschool children’s physical growth in the disaster-affected areas, the three medical universities in Iwate, Miyagi, and Fukushima Prefectures conducted a health examination survey on early childhood physical growth.

Methods: The survey was conducted over a 3-year period to acquire data on children who were born in different years. Our targets were as follows: 1) children who were born between March 1, 2007 and August 31, 2007 and experienced the disaster at 43–48 months of age, 2) children who were born between March 1, 2009 and August 31, 2009 and experienced the disaster at 19–24 months of age, and 3) children who were born between June 1, 2010 and April 30, 2011 and were under 10 months of age or not born yet when the disaster occurred. We collected their health examination data from local governments in Iwate, Miyagi, and Fukushima Prefectures. We also collected data from Aomori, Akita, and Yamagata Prefectures to use as a control group. The survey items included birth information, anthropometric measurements, and methods of nutrition during infancy.

Results: Eighty municipalities from Iwate, Miyagi, and Fukushima Prefectures and 21 from the control prefectures participated in the survey. As a result, we established three retrospective cohorts consisting of 13,886, 15,474, and 32,202 preschool children.

Conclusions: The large datasets acquired for the present survey will provide valuable epidemiological evidence that should shed light on preschool children’s physical growth in relation to the disaster.

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1. Introduction

The Pacific coastal areas of Iwate, Miyagi, and Fukushima Prefectures were substantially damaged as a result of the Great East Japan Earthquake on March 11, 2011. The damage to human life and property from the massive 9.0 magnitude earthquake and subsequent giant tsunami were unprecedented in modern Japanese history.1–4 While there is great concern regarding the possible
health impact among people who experienced the disaster, there is limited knowledge about how the occurrence of an enormous natural disaster in a developed country affects people’s health.\textsuperscript{5,6} In particular, we are concerned about the health of preschool children who experienced the catastrophe during the most vulnerable period of their physical and mental development.\textsuperscript{7-9} Several factors, such as environmental changes to child care and post-disaster traumatic stress, might affect their health.\textsuperscript{10,11}

One year after the disaster, the Department of Pediatrics at the three medical universities in Iwate, Miyagi, and Fukushima Prefectures collaboratively initiated two surveys: the nationwide nursery school survey on child health throughout the Great East Japan Earthquake-affected areas\textsuperscript{12} and the present health examination survey on early childhood physical growth in the Great East Japan Earthquake-affected areas. Using data from these surveys, we aim to provide comprehensive epidemiological evidence of the impact of the disaster on preschool children’s health.

In our nationwide survey, we targeted nursery school children who experienced the disaster during their preschool days and compared them to children who did not experience the disaster using data collected from all 47 prefectures in Japan. In addition to longitudinal data on physical measurements, we obtained data on the presence of diseases, history of moving in and moving out, and personal experience with the disaster.

In the present survey, we intend to validate the results of the former survey. Furthermore, the present survey will allow us to examine how physical growth differs depending on the age at the time of experiencing the disaster among preschool children in the most affected areas. The present survey also includes information that was not examined in the former survey, including gestational age of newborns, methods of nutrition during infancy, and head circumference. Here, we describe the design of the present survey and the results of data collection.

2. Methods

2.1. Survey design and population

We accessed 3-year-old health examination records, which allowed us to retrospectively acquire children’s anthropometric measurements during early childhood. In accordance with the Maternal and Child Health Act in Japan,\textsuperscript{13} regular health examinations during early childhood are provided at least two times at the municipal level: 1) over the age of 18 months and below the age of 2 years (referred to as the 1-and-a-half-year-old health examination) and 2) over the age of 3 years and below the age of 4 years (referred to as the 3-year-old health examination). The timing of regular health examinations, including additional health examinations during infancy, varies by municipality.

We invited all 127 municipal governments in Iwate, Miyagi, and Fukushima Prefectures, which were most affected by the disaster, to participate in the survey. Iwate Medical University, Tohoku University, and Fukushima Medical University sent invitation letters to all 100 municipal governments in Aomori, Akita, and Yamagata Prefectures. If they agreed to participate in the survey, persons in charge of maternal and child health in the municipalities returned completed survey sheets.

The survey was conducted over the 3-year period from July 2012 to October 2014. We decided the timeframe for birth of our targeted children backward from when they experienced the disaster after undergoing certain health examinations. During the first year, we collected data on children who were born between March 1, 2007 and August 31, 2007 (Cohort 1). These children experienced the disaster within 6 months after undergoing their 3-year-old health examinations. During the second year, we collected data on children who were born between March 1, 2008 and August 31, 2009 (Cohort 2). These children experienced the disaster within 6 months after undergoing their 1-and-a-half-year-old examinations. Finally, during the third year, we collected data on children who were born between June 1, 2010 and April 30, 2011 (Cohort 3). These children experienced the disaster within 6 months after undergoing their 3-month-old health examinations or after birth, or who were not born yet when the disaster occurred (Fig. 1).

The survey in Sendai City was conducted from April 2014 to December 2014. We collected data on children who underwent their 3-year-old health examinations during the survey period. These children were born between September 2010 and May 2011.

2.2. Survey items and measurements

The survey items included sex, birth information (date of birth, gestational age in the newborn, and supine length and weight at birth) and anthropometric measurements (length/height and weight) taken at the following four time points: 1) during the early infancy period, when children were 3–4 months of age; 2) during the late infantile period, when children were between 6 and 10 months of age; 3) at the 1-and-a-half-year-old examination; and 4) at the 3-year-old health examination. Additionally, we obtained information on their methods of nutrition (breast milk, artificial milk, or mixed milk) and head circumference during infancy (Table 1).

2.3. Ethical consideration

The survey protocol was approved by the institutional review boards of Iwate Medical University, Tohoku University, and Fukushima Medical University. The present survey was conducted in accordance with the national Ethical Guidelines for Epidemiological Research.\textsuperscript{19} We did not obtain informed consent from participants. We have publicly disclosed the information of the survey, including the significance, objectives, and methods on the Tohoku University School of Medicine website (http://www.med.tohoku.ac.jp/public/ekigaku2013.html).

3. Results

In total, 80 out of 127 municipalities from Iwate, Miyagi, and Fukushima Prefectures participated in the survey as follows: 30 out of 33 municipalities in Iwate Prefecture (90.9%); 19 out of 35 municipalities in Miyagi Prefecture (54.3%); and 31 out of 59 municipalities in Fukushima Prefecture (52.5%). Regarding the control group, 21 out of 100 municipalities participated in the survey as...
follows: 7 out of 40 municipalities in Aomori Prefecture (17.5%); 8 out of 25 municipalities in Akita Prefecture (32.0%); and 6 out of 35 municipalities in Yamagata Prefecture (17.1%) (Fig. 2). Among 79 municipalities in the affected prefectures, with the exception of Sendai City, 27 municipalities returned completed survey sheets, and two municipalities submitted de-identified electronic datasets. We visited 50 municipalities to transcribe data (Table 2 and eTable 1).

With continued cooperation from local governments, we obtained data on 15,406 preschool children for Cohort 1, 15,541 children for Cohort 2, and 27,422 children for Cohort 3. Among 79 municipalities in the affected prefectures, with the exception of Sendai City, 27 municipalities returned completed survey sheets, and two municipalities submitted de-identified electronic datasets. We visited 50 municipalities to transcribe data (Table 2 and eTable 1).

We excluded children whose sex, birth month, or anthropometric measurements were missing (68 children from Cohort 1, 66 from Cohort 2, and 451 from Cohort 3) and who were born in months outside of our target period (1,452, 1, and 57 children, respectively).

Ultimately, we established three retrospective cohorts of preschool children. Cohort 1 comprised 13,886 children who were born between March 2007 and August 31, 2007. Cohort 2 comprised 15,474 children who were born between March 2009 and August 31, 2009. Cohort 3 comprised 32,202 children: 25,909 children who were born between June 1, 2010 and April 30, 2011 and 6,293 children who were born between September 1, 2010 and May 31, 2011 in Sendai City.

The background characteristics of children by cohort are presented in Table 3.
Additionally, we obtained data from Satsumasendai City in Kagoshima Prefecture, a municipality outside of the Tohoku region (Fig. 2 and eTable 2).

### Table 2

Number of municipalities that participated in the survey and choice of data collection method.

| Affected prefectures | Number of municipalities | As of July 2012 | Participation | Choice of data collection methoda |
|----------------------|--------------------------|----------------|---------------|----------------------------------|
|                      |                          |                |               | 1 | 2 | 3 | 4 |
| Iwate                | 33                       | 30             | 90.9%         | 11 | 17 | 2 | 0 |
| Miyagi               | 35                       | 19             | 54.3%         | 9  | 9  | 0 | 1 |
| Fukushima            | 59                       | 31             | 52.5%         | 7  | 24 | 0 | 0 |
| Total                | 127                      | 80             | 63.0%         | 27 | 50 | 2 | 1 |
| Control prefectures  |                          |                |               | 1 | 2 | 3 | 4 |
| Aomori               | 40                       | 7              | 17.5%         | 7  | 0  | 0 | 0 |
| Akita                | 25                       | 8              | 32.0%         | 8  | 0  | 0 | 0 |
| Yamagata             | 35                       | 6              | 17.1%         | 4  | 2  | 0 | 0 |
| Total                | 100                      | 21             | 21.0%         | 19 | 2  | 0 | 0 |

a Method 1: completion of survey sheets by a person of the municipality.
Method 2: a visit to the municipal government office to transcribe data.
Method 3: submission of de-identified electronic datasets.
Method 4: completion of questionnaires by parents (Sendai City only).

Additionally, we obtained data from Satsumasendai City in Kagoshima Prefecture, a municipality outside of the Tohoku region (Fig. 2 and eTable 2).

### 4. Discussion

Children are one of the most vulnerable populations to the effects of natural disasters, yet little is known about how tragic and devastating disasters affect their health. We conducted the present survey to address specific concerns regarding the impact of the Great East Japan Earthquake on the physical growth of preschool children in the most severely affected areas.

The strength of the present survey is the establishment of three retrospective cohorts of preschool children who were born in different years, which enable us to evaluate differences in physical growth among preschool children of varying ages at the time of the disaster. For example, comparison analyses using growth data from Cohort 1 and Cohort 2 can serve to clarify differences in physical growth between children who experienced the disaster before and after 3 years of age. A part of the growth data from Cohort 3 might provide information about children who experienced the disaster during their prenatal period.

A total of 80 municipalities in the most affected prefectures of Iwate, Miyagi, and Fukushima participated in the survey. With the exception of Sendai City (for Cohort 3), the number of children who participated in Cohort 1, 2, and 3 was equivalent to 50%, 60%, and 63%, respectively, of the total number of births in the three

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**Fig. 2.** Geographical location of the municipalities participated in the survey. In total, 80 out of 127 municipalities in Iwate, Miyagi, and Fukushima Prefectures that were severely affected by the disaster and 21 out of 100 municipalities in Aomori, Akita, and Yamagata Prefectures participated in the survey. Additionally, the data of Satsumasendai City in Kagoshima Prefecture, a municipality other than the Tohoku region was available.
Table 3a
Background characteristics of Cohort 1. Children who were born between March 1, 2007 and August 31, 2007 (n = 13,886).

| Sex         | Affected prefectures | Control prefectures | All Japan (in 2007) |
|-------------|----------------------|---------------------|---------------------|
|             | n        | %       | n        | %       | n        | %       |
| Boy         | 6137     | 51.3%   | 985      | 51.1%   | 559,847  | 51.4%   |
| Girl        | 5823     | 48.7%   | 941      | 48.9%   | 529,971  | 48.6%   |
| Total       | 11,960   | 100.0%  | 1926     | 100.0%  | 1,089,818| 100.0%  |

| Birthweight, g | <1000 | 1000–1499 | 1500–1999 | 2000–2499 | 2500–2999 | 3000–3499 | 3500–3999 | ≥4000 |
|----------------|-------|------------|------------|------------|------------|------------|------------|-------|
| <1000          | 18    | 0.2%       | 0.2%       | 0.2%       | 0.2%       | 0.2%       | 0.2%       | 0.2%   |
| ≥1000          | 44    | 0.4%       | 0.4%       | 0.4%       | 0.4%       | 0.4%       | 0.4%       | 0.4%   |
| Missing        | 1177  | 8.7%       | 8.7%       | 8.7%       | 8.7%       | 8.7%       | 8.7%       | 8.7%   |

| Total          | 11,960| 100.0%  | 1926     | 100.0%  | 1,089,818| 100.0%  |

Table 3b
Background characteristics of Cohort 2. Children who were born between March 1, 2009 and August 31, 2009 (n = 15,474).

| Sex         | Affected prefectures | Control prefectures | All Japan (in 2009) |
|-------------|----------------------|---------------------|---------------------|
|             | n        | %       | n        | %       | n        | %       |
| Boy         | 6891     | 51.3%   | 962      | 50.1%   | 548,993  | 51.3%   |
| Girl        | 6663     | 48.7%   | 958      | 49.9%   | 521,042  | 48.7%   |
| Total       | 13,554   | 100.0%  | 1920     | 100.0%  | 1,070,035| 100.0%  |

| Birthweight, g | <1000 | 1000–1499 | 1500–1999 | 2000–2499 | 2500–2999 | 3000–3499 | 3500–3999 | ≥4000 |
|----------------|-------|------------|------------|------------|------------|------------|------------|-------|
| <1000          | 21    | 0.2%       | 0.2%       | 0.2%       | 0.2%       | 0.2%       | 0.2%       | 0.2%   |
| ≥1000          | 8     | 0.1%       | 0.1%       | 0.1%       | 0.1%       | 0.1%       | 0.1%       | 0.1%   |
| Missing        | 171   | 1.3%       | 1.3%       | 1.3%       | 1.3%       | 1.3%       | 1.3%       | 1.3%   |

| Total          | 13,554| 100.0%  | 1920     | 100.0%  | 1,070,035| 100.0%  |

Table 3c
Background characteristics of Cohort 3-1. Children who were born between June 1, 2010 and February 28, 2011 (n = 25,909).

| Sex         | Affected prefectures | Control prefectures | All Japan (in 2010) |
|-------------|----------------------|---------------------|---------------------|
|             | n        | %       | n        | %       | n        | %       |
| Boy         | 11,851   | 51.3%   | 1926     | 51.8%   | 550,742  | 51.4%   |
| Girl        | 11,229   | 48.7%   | 1926     | 48.2%   | 520,562  | 48.6%   |
| Total       | 23,080   | 100.0%  | 2829     | 100.0%  | 1,071,304| 100.0%  |

| Birthweight, g | <1000 | 1000–1499 | 1500–1999 | 2000–2499 | 2500–2999 | 3000–3499 | 3500–3999 | ≥4000 |
|----------------|-------|------------|------------|------------|------------|------------|------------|-------|
| <1000          | 44    | 0.2%       | 0.2%       | 0.2%       | 0.2%       | 0.2%       | 0.2%       | 0.2%   |
| ≥1000          | 1000   | 0.4%       | 1.3%       | 1.3%       | 1.3%       | 1.3%       | 1.3%       | 1.3%   |
| Missing        | 165    | 0.7%       | 0.7%       | 0.7%       | 0.7%       | 0.7%       | 0.7%       | 0.7%   |

| Total          | 23,080| 100.0%  | 2829     | 100.0%  | 1,071,304| 100.0%  |

Table 3d
Background characteristics of Cohort 3-2. Children who were born between March 1, 2011 and May 31, 2011 (n = 6,293).

| Sex         | Affected prefectures | Control prefectures | All Japan (in 2011) |
|-------------|----------------------|---------------------|---------------------|
|             | n        | %       | n        | %       | n        | %       |
| Boy         | 2850     | 49.6%   | 267      | 48.5%   | 538,271  | 51.4%   |
| Girl        | 2892     | 50.4%   | 284      | 51.5%   | 512,535  | 48.6%   |
| Total       | 5742     | 100.0%  | 551      | 100.0%  | 1,050,806| 100.0%  |

| Birthweight, g | <1000 | 1000–1499 | 1500–1999 | 2000–2499 | 2500–2999 | 3000–3499 | 3500–3999 | ≥4000 |
|----------------|-------|------------|------------|------------|------------|------------|------------|-------|
| <1000          | 8     | 0.1%       | 0.1%       | 0.1%       | 0.1%       | 0.1%       | 0.1%       | 0.1%   |
| ≥1000          | 2000   | 242        | 422        | 242        | 422        | 242        | 422        | 422    |
| Missing        | 239    | 4.2%       | 79         | 14.3%     | 230       | 0.0%      | 230       | 0.0%   |

| Total          | 5742   | 100.0%    | 551       | 100.0%    | 1,050,806 | 100.0%    |

* Affected prefectures include Iwate, Miyagi, and Fukushima Prefectures.
* Control prefectures include Aomori, Akita, and Yamagata Prefectures.
* Source: Vital Statistics in Japan Annual Report 2009, Statistics and Information Department, Ministry of Health, Labour and Welfare (MHLW).
prefectures during the same period (11,960 out of a population of 23,818 for Cohort 1, 13,554 out of a population of 22,634 for Cohort 2, and 23,611 out of a population of 37,554 for Cohort 3). Although we were unable to obtain data from Sendai City for the first 2 years, the number of children who participated in Cohort 3 comprised 75.7% of the births in the city during the corresponding period. Thus, we acquired one of the largest datasets of Japanese preschool children to date, which should guarantee sufficient regional representativeness.

Body measurements at regular health examinations have been performed by trained public health nurses in each municipality who are required to follow appropriate procedures recommended by the Ministry of Health, Labour and Welfare. For the survey in Sendai City, we asked parents to complete the questionnaires based on their maternal and child health handbooks, which are generally mentioned previously, parents completed the questionnaires based on their maternal and child health handbooks, which are generally recorded by health professionals. Also, experienced and expert persons performed data transcription and entry. Fourth, we could not obtain important birth information, such as fetal number, birth order, age of mother, way of delivery, and abnormalities present at birth. We accessed 3-year-old health examination records and acquired children’s anthropometric measurements during early childhood. Because the forms used for maintaining individuals’ health information were not standardized and included items varied by municipality, such information was not available for all municipalities. However, we did obtain some birth information that may influence children’s physical growth and can be used to assess potential confounding. Finally, we were unable to obtain the measurements of 3-year-old health examination from all participants.

Table 4
Differences in basic characteristics between participating and non-participating municipalities in control prefectures.

| Participating municipalities (n = 21) | Non-participating municipalities (n = 79) |
|-------------------------------------|----------------------------------------|
| Municipality | Population | Number of households | Number of births | Birth rate | Municipality | Population | Number of households | Number of births | Birth rate |
| Aomori Prefecture | | | | | Aomori Prefecture | | | | |
| Yonomogawa | 2896 | 957 | 22 | 5.6 | | 287,622 | 118,279 | 2006 | 6.8 |
| Sotogahama | 6197 | 2573 | 20 | 7.7 | | 177,549 | 71,171 | 1252 | 5.2 |
| Fukaura | 8423 | 3304 | 33 | 5.4 | | 231,379 | 93,726 | 1798 | 2.1 |
| Nakadomari | 11,205 | 4111 | 47 | 5.2 | | 34,293 | 11,771 | 270 | 7.0 |
| Shiindono | 15,719 | 5585 | 76 | 3.7 | | 35,171 | 21,136 | 348 | 3.1 |
| Tohoku | 17,969 | 5980 | 135 | 7.0 | | 63,454 | 25,509 | 453 | 7.0 |
| Shingo | 2510 | 831 | 11 | 2.6 | | 40,223 | 16,377 | 410 | 7.8 |

Although we invited all 100 municipalities in Aomori, Akita, and Yamagata Prefectures, only 21 municipalities (21%) agreed to participate in the survey. This low participation of the control prefectures may have resulted in selection bias due to a non-exposed group. However, we obtained data from a variety of municipalities in terms of geographical location, population size, and birth rate (Fig. 2 and Table 4). We assume that any realized bias would be relatively small. Third, for the convenience of participating municipalities, we used four methods to collect data. Data collected using varying procedures may have resulted in different quality or accuracy of information between municipalities. However, our obtained data may be less likely to have flaws and errors than other types of data collected using varying procedures because certified public health nurses in each municipality submitted preexisting datasets or completed survey sheets. As mentioned previously, parents completed the questionnaires based on their maternal and child health handbooks, which are generally recorded by health professionals. Also, experienced and expert persons performed data transcription and entry. Fourth, we could not obtain important birth information, such as fetal number, birth order, age of mother, way of delivery, and abnormalities present at birth. We accessed 3-year-old health examination records and acquired children’s anthropometric measurements during early childhood. Because the forms used for maintaining individuals’ health information were not standardized and included items varied by municipality, such information was not available for all municipalities. However, we did obtain some birth information that may influence children’s physical growth and can be used to assess potential confounding. Finally, we were unable to obtain the measurements of 3-year-old health examination from all participants.
Because the timing of 3-year-old health examinations varies by municipality, 3052 children in 68 municipalities were not scheduled to undergo the examinations at the time of survey. This should be kept in mind when analyzing the data and interpreting the results from the 3-year-old health examinations.

We conducted two surveys that collected different kinds of information. The present survey acquired birth information, methods of nutrition, and head circumference, whereas the nationwide nursery school survey\(^1\) collected information on the presence of diseases, change of residence, and personal experience with the disaster. The results from these two surveys are expected to provide strong evidence both in combination as well as through independent analyses of each survey.

In conclusion, the present survey is one of the largest surveys ever conducted on physical growth among preschool children in relation to the Great East Japan Earthquake. By providing scientific data and interpretation of the findings, our survey results contribute invaluable information regarding the health impacts on children of the Great East Japan Earthquake for health care practitioners, parents, and public policy makers.

**Conflicts of interest**

None declared.

**Acknowledgements**

The present survey was conducted as a part of the “surveillance study on child health in the Great East Japan Earthquake disaster

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### Table 4 (continued)

| Participating municipalities (n = 21) | Non-participating municipalities (n = 79) |
|--------------------------------------|------------------------------------------|
| Municipality                        | Population\(^a\) | Number of households\(^a\) | Number of births\(^b\) | Birth rate\(^b\) | Municipality                        | Population\(^a\) | Number of households\(^a\) | Number of births\(^b\) | Birth rate\(^b\) |
| Akita Prefecture                    |                         |                            |                            |                  | Akita Prefecture                    |                         |                            |                            |                  |
| Noshiro                             | 54,805                   | 22,750                     | 270                         | 4.8              | Noshiro                             | 316,808                | 135,709                     | 2221                        | 6.9              |
| Odate                               | 74,049                   | 28,781                     | 429                         | 5.6              | Odate                               | 91,663                 | 31,873                      | 538                         | 5.7              |
| Yuzawa                              | 46,909                   | 16,250                     | 241                         | 5.0              | Yuzawa                              | 29,123                 | 11,596                      | 126                         | 4.1              |
| Kazuno                              | 31,762                   | 11,659                     | 190                         | 5.8              | Kazuno                              | 33,171                 | 12,392                      | 208                         | 6.2              |
| Yurihonjo                           | 79,573                   | 28,854                     | 513                         | 6.3              | Yurihonjo                           | 82,705                 | 28,630                      | 524                         | 6.2              |
| Mitane                              | 17,050                   | 6266                        | 84                          | 4.7              | Mitane                              | 33,099                 | 12,452                      | 176                         | 5.1              |
| Ogata                               | 3087                     | 801                         | 19                          | 6.1              | Ogata                               | 25,426                 | 9035                        | 129                         | 4.9              |
| Misato                              | 20,060                   | 6190                        | 96                          | 4.6              | Misato                              | 27,226                 | 9741                        | 124                         | 4.4              |

Yamagata Prefecture

| Kaminoyama                          | 31,584                   | 10,724                      | 194                         | 6.0              | Yamagata Prefecture                | 263,453                | 100,669                     | 2043                        | 8.0              |
| Higashine                           | 47,365                   | 15,487                      | 436                         | 9.2              | Higashine                           | 252,453                | 100,669                     | 2043                        | 8.0              |
| Asahi                               | 7122                     | 2243                        | 35                          | 4.7              | Asahi                               | 86,010                 | 32,991                      | 608                         | 7.0              |
| Oguni                               | 7869                     | 2841                        | 49                          | 5.9              | Oguni                               | 129,630                | 45,332                      | 897                         | 6.8              |
| Mikawa                              | 7728                     | 2219                        | 60                          | 7.8              | Mikawa                              | 106,267                | 39,308                      | 734                         | 6.8              |
| Shonai                              | 21,669                   | 6638                        | 142                         | 6.4              | Shonai                              | 36,904                 | 12,976                      | 297                         | 7.9              |

Yamagata Prefecture

| Yamanobe                            | 14,372                   | 4438                        | 86                          | 5.8              | Yamanobe                            | 41,266                 | 13,073                      | 315                         | 7.6              |
| Murayama                            | 24,896                   | 7712                        | 147                         | 5.7              | Murayama                            | 7,716                  | 2144                        | 515                         | 8.3              |
| Nagai                               | 27,716                   | 9114                        | 203                         | 7.1              | Nagai                               | 62,236                 | 21,448                      | 515                         | 8.3              |
| Tendo                               | 62,236                   | 21,448                      | 515                         | 8.3              | Tendo                               | 16,962                 | 5109                        | 107                         | 6.0              |
| Obanazawa                           | 32,284                   | 10,697                      | 236                         | 6.8              | Obanazawa                           | 43,372                 | 14,438                      | 338                         | 7.7              |
| Nanyo                               | 26,740                   | 15,078                      | 102                         | 6.0              | Nanyo                               | 11,366                 | 3466                        | 53                          | 4.5              |
| Yamanobe                            | 19,046                   | 5868                        | 129                         | 6.7              | Yamanobe                            | 5640                   | 1779                        | 23                          | 3.9              |
| Saka                                | 8478                     | 2631                        | 57                          | 6.5              | Saka                                | 5640                   | 1779                        | 23                          | 3.9              |
| Oe                                  | 7359                     | 2143                        | 44                          | 5.8              | Oe                                  | 8478                   | 2631                        | 57                          | 6.5              |
| Ishida                              | 5829                     | 1643                        | 48                          | 7.9              | Ishida                              | 7359                   | 2143                        | 44                          | 5.8              |
| Kaneyama                            | 8908                     | 2674                        | 61                          | 6.5              | Kaneyama                            | 5829                   | 1643                        | 48                          | 7.9              |
| Mogami                              | 8908                     | 2674                        | 61                          | 6.5              | Mogami                              | 5631                   | 1620                        | 35                          | 6.0              |
| Funagata                            | 8136                     | 2520                        | 66                          | 7.7              | Funagata                            | 3413                   | 1017                        | 20                          | 5.6              |
| Mamurogawa                          | 4315                     | 1246                        | 29                          | 6.4              | Mamurogawa                          | 4315                   | 1246                        | 29                          | 6.4              |
| Tozawa                              | 4773                     | 1389                        | 23                          | 4.6              | Tozawa                              | 4773                   | 1389                        | 23                          | 4.6              |
| Takahata                            | 23,887                   | 7215                        | 164                         | 6.8              | Takahata                            | 23,887                 | 7215                        | 164                         | 6.8              |
| Kawanishi                           | 15,756                   | 4550                        | 96                          | 5.8              | Kawanishi                           | 15,756                 | 4550                        | 96                          | 5.8              |
| Shirakami                           | 14,271                   | 4433                        | 84                          | 5.7              | Shirakami                           | 14,271                 | 4433                        | 84                          | 5.7              |
| Idé                                 | 7304                     | 2197                        | 56                          | 7.4              | Idé                                 | 7304                   | 2197                        | 56                          | 7.4              |
| Yusa                                | 14,212                   | 4510                        | 77                          | 5.2              | Yusa                                | 14,212                 | 4510                        | 77                          | 5.2              |

\(^a\) Population and number of households are based on 2015 National population census and cited from Aomori Prefectural Government, Akita Prefectural Government, and Yamagata Prefectural Government’s Web pages.

\(^b\) Number of births and birth rate are cited from 2013 health statistics of Aomori Prefecture, 2013 health statistics of Akita Prefecture, and 2013 statistical yearbook of Yamagata Prefecture.
Appendix A. Supplementary data

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.jje.2016.03.001.

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