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# Increasing Incidence of Tuberculosis Infection in the Coastal Region of Northern Miyagi after the Great East Japan Earthquake

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On March 11, 2011, the Great East Japan Earthquake struck off the northeast coast of Japan. Within an hour of the earthquake, devastating tsunamis swept over the coastal region of the Miyagi Prefecture, facing Pacific Ocean. Accordingly, more than 400,000 residents were forced to stay at evacuation shelters. We investigated the changes in tuberculosis prevalence after the disaster. Annual data for all tuberculosis patients between April 1, 2009 and March 31, 2013 were extracted from the database of the Miyagi Prefectural Government. In the coastal region of Northern Miyagi, the number of tuberculosis patients increased in the post-disaster period ($p < 0.001$, 9.6 vs.19.1 per 100,000 people), compared to the pre-disaster period. In contrast, its prevalence did not change in the inland region of Northern Miyagi and the coastal and inland regions of Southern Miyagi. Importantly, in the inland and coastal regions of Northern Miyagi, the number of patients with latent tuberculosis infection (LTBI) increased in the post-disaster period ($p < 0.001$). Furthermore, in the coastal shelters, 11 evacuees with the history of contacting tuberculosis patients were diagnosed with LTBI, whereas no cases of LTBI patients were observed in the inland shelters. Thus, staying in the coastal shelters was a risk factor for contracting tuberculosis (OR: 19.31, 95% CI: 1.11-334.80); indeed, twice as many evacuees visited each coastal shelter on April 1, 2011, compared to the inland region. We should prepare the shelters to avoid overcrowding, and long-term observation is required to detect the prevalence of tuberculosis infection.

**Keywords:** Miyagi coastal region; shelter; the Great East Japan Earthquake; tsunami; tuberculosis
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## Introduction

On March 11, 2011, a magnitude-9.0 earthquake struck off the northeast coast of Japan. Within an hour of the earthquake, devastating tsunamis swept over the eastern coast of the Tohoku region, resulting in approximately 20,000 deaths and catastrophic damage to the local infrastructure and environment (Nagamatsu et al. 2011; National Police Agency of Japan 2012; Ishigaki et al. 2013). Due to the extensive destruction of homes, more than 400,000 displaced persons were moved to emergency evacuation shelters, which were not supplied with electricity, gas, water, or food, despite the sub-zero winter temperatures (McCurry 2011; Cabinet Office, Government of Japan 2012).

Miyagi Prefecture is located approximately 350 km north of the Japanese capital (Tokyo), with its eastern border facing Pacific Ocean (Fig. 1). Miyagi Prefecture is divided into a southern region, which includes the prefectural capital (Sendai), and a northern region, which is again divided into an inland region and a coastal region (Fig. 2). In 2010, the population of Northern Miyagi was 956,225, 25.6% of the population was > 65 years old. In contrast, the population of Southern Miyagi was 1,366,999 in 2010 and 19.1% of the population was > 65 years old, and this difference is significant (Miyagi Prefectural Government 2011b).

After the disaster, 8,658 of the 495,148 Northern costal residents and 3,129 of the 569,348 Southern coastal residents became victims (Ministry of Internal Affairs and Communications Fire and Disaster Management Agency anti disaster headquarters 2015). Furthermore, since March 11, 2011, many people living in the coastal areas of the Tohoku region feel profound sadness due to the loss of family, friends, jobs, houses and/or communities (Ishigaki et al. 2013). In addition, many of those people are elderly (aged 65 years or over) and have a large financial burden as well as psychological stress. In fact, after the Great East Japan Earthquake, there have been reports showing the increased

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Fig. 1. The location of Miyagi Prefecture.
Miyagi Prefecture is located approximately 350 km north of the Japanese capital (Tokyo), facing east towards the Pacific Ocean.
Epicenter: North latitude 38 degrees 06.2 minutes, east longitude 142 degrees 51.6 minutes, depth 24 km.

prevalence or worsening of various diseases, including influenza infection, chronic obstructive pulmonary disease, and pneumonia (for review, Ishigaki et al. 2013).

There is evidence that tuberculosis (TB) rates increase during military conflicts. Several studies after World War I and World War II have reported an increase in incidence and mortality due to TB (Campbell et al. 1968; Keehn et al. 1980; Barr and Menzies 1994). However, data regarding the association between natural disasters and TB incidence are limited. Various factors are presumed to cause an increase in the prevalence of TB after a large-scale disaster; damage to public health infrastructure, shortage of trained medical personnel, and the discontinuation of regular hospital visits. However, several studies (Connolly et al. 2004; Ghobarah et al. 2004; Watson et al. 2007) have reported that the incidence of TB is low after a catastrophic natural disaster (Kimbrough et al. 2012), although they have only followed patients for a short period of time, without extended follow-up (Kimbrough et al. 2012).

Although there are little data regarding a potential increase in TB infection after a natural disaster, precautions against TB infection are included in the national response to a large-scale disaster (World Health Organization 2008a). In Japan, elderly persons frequently develop TB, as a previous infection becomes reactivation, whereas the rate of TB infection is low among young people (Japan Anti-Tuberculosis Association 2014a). Moreover, approximately 80% of infected patients show symptoms of TB within two years.

On April 1, 2011, 57,693 of 495,158 (11.7%) Northern coastal residents took refuge in 379 shelters (152 evacuees per shelter), while 12,332 of 488,330 (2.5%) Southern coastal residents took refuge in 106 shelters (116 evacuees per shelter) (Table 1). There were a significantly higher number of evacuees per population in the Northern coastal region ($p < 0.001$), and there were also significantly more evacuees per shelter than the Southern coastal region ($p = 0.015$). In fact, the shelters in the Southern Miyagi coastal region could be closed by August 2011, whereas in the Northern Miyagi coastal region, the shelters could not be closed until December 2011(Miyagi Prefectural Government 2012). Furthermore, in the Northern coastal region 217 public health nurses have worked to cover 57,693 evacuees, whereas 117 public health nurses have worked to cover 12,332 evacuees in the Southern coastal region (Miyagi Public Health Nurse Council 2011). There were significantly more evacuees per public health nurse comparing the Northern and Southern coastal shelters ($p < 0.001$) (Table

Table 1. April 1, 2011. Number of evacuees in Northern and Southern coastal region.

| | North | South | |
|---|---|---|---|
| Population, n | 495,158 | 488,330 | |
| Evacuees, n | 57,693 | 12,332 | $p < 0.001$ |
| Shelters, n | 379 | 106 | $p = 0.015$ |
| Per shelter | 152 | 116 | |
| Public Health Nurse, n | 217 | 117 | $p < 0.001$ |
| Per Public Health Nurse | 266 | 105 | |

Table 2. TB patients in Northern and Southern Miyagi.

| | Pre-disaster | Post-disaster | Pre vs. Post |
|---|---|---|---|
| | 2009+2010 | 2011+2012 | |
| Northern Miyagi | | | |
| Population, n | 1,909,249 | 1,869,853 | |
| Tuberculosis, n | 221 | 306 | $p < 0.001$ |
| Per 100,000 people | 11.6 | 16.4 | |
| Coastal region | | | |
| Population, n | 993,209 | 959,435 | |
| Tuberculosis, n | 95 | 184 | $p < 0.001$ |
| Per 100,000 people | 9.6 | 19.1 | |
| Inland region | | | |
| Population, n | 916,040 | 910,418 | |
| Tuberculosis, n | 126 | 122 | ns |
| Per 100,000 people | 13.8 | 13.4 | |
| Southern Miyagi | | | |
| Population, n | 2,760,450 | 2,780,492 | |
| Tuberculosis, n | 425 | 428 | ns |
| Per 100,000 people | 15.4 | 15.4 | |
| Coastal region | | | |
| Population, n | 971,636 | 971,264 | |
| Tuberculosis, n | 132 | 160 | ns |
| Per 100,000 people | 13.6 | 16.5 | |
| Inland region | | | |
| Population, n | 1,788,814 | 1,809,228 | |
| Tuberculosis, n | 293 | 268 | ns |
| Per 100,000 people | 16.4 | 14.8 | |

1). Thus, evacuees in the Northern coastal region had suffered from overcrowded shelters and insufficient healthcare services, which in turn may have affected the incidence of TB. Although the prevalence of TB has increased in Northern Miyagi after the disaster, there were no changes in TB prevalence in Southern Miyagi comparing between pre-disaster and post-disaster periods despite the many victims in this area (Miyagi Prefectural Government 2014) (Table 2). Therefore, we investigated the cause of the increase in TB prevalence in Northern Miyagi two years before and after the Great East Japan Earthquake.

## Methods

*Data acquisition*

In Japan, all patients with TB are registered with each public health centre in the region, and placed under state control. Patients were divided into two groups, those who resided in the northern inland region and those who resided in the coastal region (Fig. 2). The northern inland region reports to the Kurihara, Osaki, Tome, and Kurokawa public health centres, the coastal region reports to the Kesennuma, Ishinomaki, and Shiogama public health centres. In this study, annual data (April 1 to March 31) for all patients with TB between April 1, 2009 and March 31, 2013 were extracted from the


Fig. 2. The coastal and inland regions of Miyagi Prefecture.
The eastern part of Miyagi Prefecture faces the Pacific Ocean, the northern part borders Akita and Iwate, the western part borders Yamagata, and the southern part borders Fukushima Prefecture. In 2010, the population of the coastal region was 494,372 and the population of the inland region was 461,835.

database of the public health centres of the Miyagi Prefectural Government. Data for the 2 years before (April 1, 2009 to March 31, 2011) and the 2 years after (April 1, 2011 to March 31, 2013) the Great East Japan Earthquake (March 11, 2011) were compared.

A diagnosis of TB was reached using the septum smear test, interferon-gamma release assays (IGRA), tubercle bacillus laboratory cultures, PCR, chest radiography, and computed tomography. Tubercle bacillus infections were classified as pulmonary TB, extra pulmonary TB, or latent tuberculosis infection (LTBI). The number of registered tuberculosis cases was classified according to sex, and according to 10-year age groups for all patients (0-99 years old). In addition, the number of TB patients (sputum smear-test or culture positive) that required contact person screening was investigated. TB screening was performed for persons using Tuberculin skin test (TST) or IGRA and chest radiography. Furthermore, the number of evacuees, who had contact with TB patients in the shelters and were subsequently diagnosed with LTBI, was also investigated.

*Statistical analysis*

Chi-square tests or two-tailed Fisher's exact tests were used to compare categorical data. All tests were two-sided, and a p-value < 0.05 was considered statistically significant. To calculate the odds ratio (OR) of infection from a specific cause, we constructed two-by-two tables, and the 95% confidence intervals (95% CI) were also estimated.

## Results

In the coastal region, the annual population numbers per year were 498,061 (2009) and 495,148 (2010) before the disaster, and 492,537 (2011) and 466,898 (2012) after the disaster. In the inland region, the annual population numbers per year were 459,060 (2009) and 456,980 (2010) before the disaster, and 455,495 (2011) and 454,923 (2012) after the disaster. Over the study period (April 1, 2009 to March 31, 2012), 527 TB patients were registered in Northern Miyagi.

In the coastal region, the annual cases per year were 43 (2009) and 52 (2010) before the disaster, which increased to 95 (2011) and 89 (2012) after the disaster. In contrast, the number of cases in the inland region remained fairly consistent at 60, 66, 61, and 61 per year, respectively. The number of TB patients in Northern Miyagi significantly increased after the disaster ($p < 0.001$: 11.6 vs. 16.3 per 100,000 people) (Table2).

Before the disaster, 95 patients were registered in the coastal region and 126 patients were registered in the inland region. After the disaster, 184 patients were registered in the coastal region and 122 patients were registered in the inland region. The number of patients with TB significantly increased in the coastal region after the disaster ($p < 0.001$: 9.6 vs. 19.1 per 100,000 people) and the number of patients with TB in the inland region did not change after the disaster (Table 2).

Before the disaster, 80 patients required contact screening (sputum smear-test or culture positive) in

Table 3. TB patients and contact persons in Northern Miyagi.

| | Pre-disaster | Post-disaster | Pre vs. Post |
|---|---|---|---|
| | 2009+2010 | 2011+2012 | |
| Tuberculosis patients who required screening | | | |
| Total number, n | 80 | 78 | |
| Coastal region, n (%) | 34 (42.5) | 46 (59.0) | ns |
| Inland region, n (%) | 46 (57.5) | 32 (41.0) | ns |
| Contact persons | | | |
| Total number, n | 3,348 | 3,159 | |
| Coastal region, n (%) | 1,468 (43.8) | 1,479 (46.8) | ns |
| Inland region, n (%) | 1,880 (56.2) | 1,680 (53.2) | ns |

Table 4. TB patients in the coastal region of Northern Miyagi.

| | | Pre-disaster | Post-disaster | Pre vs. Post |
|---|---|---|---|---|
| Population, n | | 993,209 | 959,435 | |
| TB patients, n | | 95 | 184 | $p < 0.001$ |
| Female, n (%) | | 56 (58.9) | 90 (48.9) | ns |
| Pulmonary TB, n | | 67 | 77 | ns |
| Per 100,000 people | | 6.7 | 8.0 | |
| Age, n (%) | 0-19 years | 0 (0.0) | 0 (0.0) | ns |
| | 20-49 years | 12 (17.9) | 8 (10.4) | ns |
| | 50-69 years | 17 (25.4) | 19 (24.5) | ns |
| | ≥ 70 years | 38 (56.7) | 50 (64.9) | ns |
| Extra-pulmonary TB, n | | 10 | 28 | $p = 0.003$ |
| Per 100,000 people | | 1.0 | 2.9 | |
| Age, n (%) | 0-19 years | 0 (0.0) | 1 (3.6) | ns |
| | 20-49 years | 1 (10.0) | 3 (10.7) | ns |
| | 50-69 years | 3 (30.0) | 3 (10.7) | ns |
| | ≥ 70 years | 6 (60.0) | 21 (75.0) | ns |
| LTBI, n | | 18 | 79 | $p < 0.001$ |
| Per 100,000 people | | 1.8 | 8.2 | |
| Age, n (%) | 0-19 years | 3 (16.7) | 2 (2.6) | ns |
| | 20-49 years | 9 (50.0) | 30 (37.2) | ns |
| | 50-69 years | 6 (33.4) | 28 (35.9) | ns |
| | ≥ 70 years | 0 (0.0) | 19 (24.4) | ns |

TB, tuberculosis; LTBI, latent tuberculosis infection.

Northern Miyagi, including 34 patients in the coastal region and 46 patients in the inland region. After the disaster, 78 patients required contact screening, including 46 patients in the coastal region and 32 patients in the inland region. The total number of TB patients who required contact screening did not change between the pre- and post-disaster periods (Table 3).

Before the disaster, the number of persons who had contact with TB patients was 3,348 in Northern Miyagi, comprising 1,468 in the coastal region and 1,880 in the inland region. After the disaster, the number of persons who had contact with TB patients was 3,159 in Northern Miyagi, comprising 1,479 in the coastal region and 1,680 in the inland region. The total number of contact persons did not significantly change between the pre- and post-disaster periods (Table 3).

In the coastal region, the distribution of TB patients did not differ according to sex or age grouping. Before the disaster, the number of patients with pulmonary TB, extra-pulmonary TB, and LTBI were 67, 10, and 18, respectively. After the disaster, the number of patients with pulmonary TB, extra-pulmonary TB, and LTBI were 77, 28, and 79, respectively. The numbers of patients with pulmonary TB did not change in the coastal region after the disaster (6.7

Table 5. TB patients in the inland region of Northern Miyagi.

| | | Pre-disaster | Post-disaster | Pre vs. Post |
|---|---|---|---|---|
| Population, n | | 916,040 | 910,418 | |
| TB patients, n | | 126 | 122 | ns |
| Female, n (%) | | 66 (52.4) | 60 (49.6) | ns |
| Pulmonary TB, n | | 83 | 56 | p = 0.024 |
| Per 100,000 people | | 9.1 | 6.2 | |
| Age, n (%) | 0-19 years | 0 (0.0) | 1 (1.8) | ns |
| | 20-49 years | 10 (12.0) | 7 (12.5) | ns |
| | 50-69 years | 23 (27.7) | 12 (21.4) | ns |
| | ≥ 70 years | 50 (60.2) | 36 (64.3) | ns |
| Extra-pulmonary TB, n | | 21 | 9 | p = 0.03 |
| Per 100,000 people | | 2.3 | 1.0 | |
| Age, n (%) | 0-19 years | 0 (0.0) | 0 (0.0) | ns |
| | 20-49 years | 1 (4.8) | 1 (11.1) | ns |
| | 50-69 years | 8 (38.1) | 3 (33.3) | ns |
| | ≥ 70 years | 12 (57.1) | 5 (55.6) | ns |
| LTBI, n | | 22 | 57 | p < 0.001 |
| Per 100,000 people | | 2.4 | 6.3 | |
| Age, n (%) | 0-19 years | 2 (9.1) | 9 (15.8) | ns |
| | 20-49 years | 15 (68.2) | 24 (42.1) | ns |
| | 50-69 years | 3 (13.6) | 19 (33.3) | ns |
| | ≥ 70 years | 2 (9.1) | 5 (8.8) | ns |

TB, tuberculosis; LTBI, latent tuberculosis infection.

vs. 8.0 per 100,000) (Table 4). The number of extra-pulmonary TB patients significantly increased ($p = 0.003$: 1.0 vs. 2.9 per 100,000), and the number of LTBI patients significantly increased ($p < 0.001$: 1.8 vs. 8.1 per 100,000) (Table 4). The percentage of patients with pulmonary, extra-pulmonary TB and LTBI were similar for all age groups (Table 4).

In the inland region, the number of male and female patients with TB was similar (Table 5). Before the disaster, the number of patients with pulmonary TB, extra-pulmonary TB, and LTBI was 83, 21, and 22, respectively. After the disaster, the number of patients with pulmonary TB, extra-pulmonary TB, and LTBI was 56, 9, and 57, respectively. The number of patients with pulmonary TB decreased comparing before and after the disaster ($p = 0.024$: 9.1 vs. 6.2 per 100,000), and the number of patients with extra-pulmonary TB also decreased after the disaster ($p = 0.03$: 2.3 vs. 1.0 per 100,000), while the number of patients with LTBI increased after the disaster ($p < 0.001$: 2.4 vs. 6.3 per 100,000) (Table 5). The number of patients with pulmonary TB, extra-pulmonary TB, and LTBI was similar for all age groups (Table 5).

In the coastal region, 9.8% of TB patients (18 of 184) had stayed in an emergency shelter. Of these 18 patients, 3 were diagnosed with pulmonary TB in the shelters, and 4 were diagnosed with pulmonary TB after returning home (it was not known if they were in contact with TB patients in the shelter). Furthermore, we have identified 11 evacuees who had been in contact with TB patients in the shelters, and were subsequently diagnosed with LTBI. Ten of the 11 evacuees were reported by Kanamori et al. (2013a, b) and one evacuee was identified by our investigation. In contrast, no TB cases were observed in the shelters in the inland region after the disaster. These results suggest that staying in emergency shelters in the coastal region was a significant risk factor for contracting TB (OR: 19.31, 95% CI: 1.11-334.80).

## Discussion

In the coastal and inland regions of Northern Miyagi, the total population, number of elderly persons, and the distribution of employment by industry were all similar (Miyagi Prefectural Government 2011a, b, c). Therefore, Northern Miyagi is suitable for 2 or more years of monitoring for TB infections. In Japan, the incidence of TB was 17.7 per 100,000 people in 2011, and Japan remains one of the countries most affected by TB (Japan Anti-Tuberculosis Association 2014b).

After the Great East Japan Earthquake, a disaster volunteer was diagnosed with the first case of pulmonary TB at the beginning of January 2012 (Kanamori et al. 2013b). In this case, several physicians who saw the index patient did not consider a diagnosis of TB, or could not perform the Acid-Fast Bacilli smear and/or culture, which may have lengthened the time to TB diagnosis and treatment. Therefore, public health officials should conduct appropriate investigations after a confirmed diagnosis of TB to help identify persons who might have come into contact with the indexed case.

In Japan, the number of new LTBI cases increased in 2011(Japan Anti-Tuberculosis Association 2014b). The factors responsible for the increase in LTBI cases was the number of QuantiFERON (QFT) tests (which increased after the age limit abolition) and the fact that a third generation of QFT test, with high sensitivity to TB, was introduced in 2010 (Japan Anti-Tuberculosis Association 2014b). Based on these factors, the increase in positive results was confirmed for the third generation QFT test, when compared to the second generation QFT test (Ministry of Health, Labor and Welfare, Japan 2014). However, the numbers of new TB cases (including LTBI) have decreased, despite the increase in LTBI cases in Japan (Japan Anti-Tuberculosis Association 2014b). Our results indicate that, in the inland region, the total number of new TB cases did not increase after the disaster, although the number of new LTBI cases increased in 2011. These results suggest that the route of infection in new TB cases in the inland region may be similar to the route of infection in new TB cases in the general Japanese population.

Although data regarding the incidence of TB after natural disasters are limited, there is evidence that TB rates increase during military conflicts. Several studies after World War I and World War II reported an increase in incidence and mortality from TB (Keehn et al. 1980; Campbell et al. 1968; Barr and Menzies 1994). In addition, Drobniewski and Verlander (2000) reviewed data regarding TB infection during 36 conflicts that took place between 1975 and 1995. More recently, a threefold increase in smear-positive TB cases was reported during the 1999 conflict in the Democratic Republic of Timor-Leste (Heldal et al. 2007).

Previous reviews (Ghobarah et al. 2004; Kimbrough et al. 2012) have reported that natural disasters do not usually lead to disease outbreaks, and there are no reports of TB epidemics (Floret et al. 2006). In addition, several factors make the measurement and comparison of disease burdens difficult in the post-disaster period. For example, natural disasters vary in terms of severity, duration, and the extent to which they affect the existing healthcare infrastructure (Khan et al. 2010). The immediate influx of humanitarian aid might also result in high notification rates in the short-term. Although a resilient healthcare system can effectively control TB in disasters, several crisis-associated risk factors could lead to an increased burden from TB infection, including malnutrition, overcrowding, and disruption of health services. Mild malnutrition alone can increase the risk of TB progression and case-fatality (Cegielski and McMurray 2004), and lower intake of macronutrients and micronutrients is nearly ubiquitous during crises. Therefore, reduced nutritional intake might account for a large portion of the excess risk. Furthermore, poor accommodation is a risk factor for TB disease (Matsumoto et al. 2011; Kanamori et al. 2012).

Kanamori et al. (2013a) reported on a shelter in coastal region, stating that the shelter after the earthquake was small (60 $m^2$), and ≈ 50 evacuees stayed there, with poor ventilation, because the weather was cold and the windows were not opened. In this shelter, 8 contact persons were diagnosed with LTBI (Kanamori et al. 2013a). The 8 LTBI cases were higher in the shelters (16%) compared to the general Japanese population (7.1%) (Kanamori et al. 2013a). Thus, overcrowding is also an important risk factor in the transmission of pulmonary TB during crises (Beggs et al. 2003).

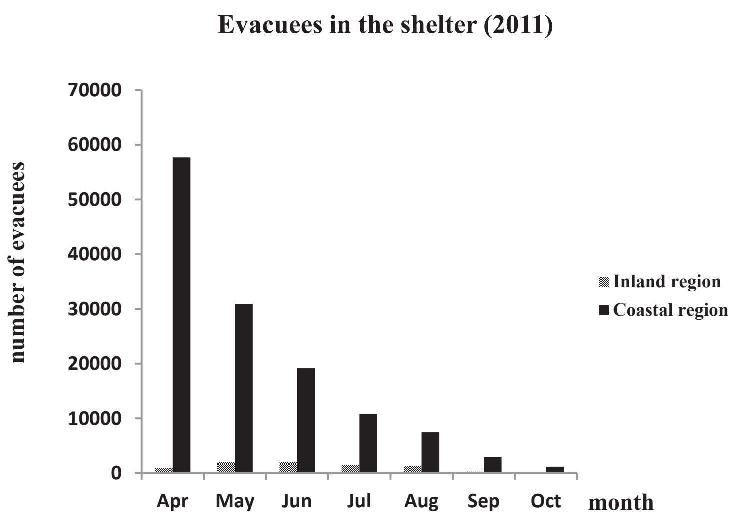


Fig. 3. The number of evacuees stayed in shelters located in the coastal and inland regions.
The changes in the number of evacuees who stayed in shelters from April 2 to October 1, 2011 are shown. On April 1, 2011, 11.7% of the coastal population stayed in shelters, compared to 0.2% of the inland population. This graph was created using data from the Miyagi Prefectural Government.

On April 1, 2011, 57,693 of 495158 (11.7%) Northern coastal residents took refuge in 379 shelters (152 evacuees per shelter), while 946 of 456,326 (0.2%) Northern inland residents took refuge in 17 shelters (56 evacuees per shelter). There were significantly more evacuees per population ($p < 0.001$) (Fig. 3), and there were significantly more evacuees per shelter in the coastal region than the inland region ($p < 0.001$). Furthermore, Ishinomaki Red Cross Hospital, located in Northern Miyagi coastal region, reported that evacuee's per capita exclusive area of the shelter was about 2 $m^2$. This is less than the United Nations High Commissioner for Refugees (UNHCR) stipulated as refugee camp installation criteria (3.5 $m^2$) (47news 2011). These results suggest that overcrowding was applicable only in the coastal region of Northern Miyagi (Miyagi Prefectural Government 2012). Although the number of evacuees in both regions decreased, the number of evacuees in the coastal region was greater than that from six months in the inland region (Fig. 3) (Miyagi Prefectural Government 2012. These results suggest that the Coastal region shelters may have had overcrowding, which, in turn, may have affected the incidence of TB.

In addition, the disruption of existing healthcare services may have interrupted treatment for TB infection. In the intensive early phase of therapy, this could cause a relapse of the active, contagious disease, promote drug resistance, and promote the development of multidrug resistance (World Health Organization 2008b). Another factor might have been the construction of a highway into the inland region, which did not link the coastal regions of Northern and Southern Miyagi (Miyagi Prefectural Government 2010). After the disaster, no gasoline was delivered to these regions for 1 month. Furthermore, a long-term blockage of traffic occurred in the coastal region, due to the tsunami's damage (Ministry of Land, Infrastructure, Transport and Tourism Japan 2012), and coastal residents were forced to stay in emergency shelters for 2 months (Miyagi Prefectural Government 2010; Ministry of Land, Infrastructure, Transport and Tourism Japan 2012). These factors might have combined to increase the risk of LTBI progression to the active disease, and transmission would increase due to the higher prevalence of the active disease and overcrowding. In our study, 3 persons were diagnosed with pulmonary TB in the shelters. Furthermore, 11 evacuees in our study had contact with TB patients in the shelters, and were subsequently diagnosed with LTBI.

One limitation of this study is that we have not investigated the complications of the TB patients. It is well known that it is easy to develop TB in patients with Diabetes mellitus, HIV, and Renal dysfunction, etc. The other limitation of this study is that we have not investigated patients who evacuated to other prefectures and developed TB. In Japan, all TB patients are registered with each public health centre. Furthermore, there are no relevant data regarding TB patients after Hansin-Awaji Great Earthquake.

In conclusion, this study suggests that the shelters in the Northern coastal region may have had inappropriate conditions for evacuees, which contributed to the increase in TB cases after the Great East Japan Earthquake. Disasters such as the Great East Japan Earthquake have broad and serious effects on the population, we should prepare the shelters to avoid overcrowding and isolation, and prolonged observation is required to adequately detect the prevalence of TB infection.

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## Conflict of Interest

The authors declare no conflict of interest.

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