ORIGINAL RESEARCH

Impact of the Great East Japan Earthquake on Acute Myocardial Infarction in Fukushima Prefecture

Takayoshi Yamaki, MD; Kazuhiko Nakazato, MD; Mikihiro Kijima, MD; Yukio Maruyama, MD; Yasuchika Takeishi, MD

ABSTRACT

Objective: The incidence of cardiovascular disease (CVD) reportedly increases following a huge disaster. On March 11, 2011, the Great East Japan Earthquake hit a large area of eastern Japan. In Fukushima prefecture, many people suffered from the consequences of the earthquake, the subsequent tsunami, and especially the Fukushima Daiichi Nuclear Power Plant accident. We assessed whether the incidence of acute myocardial infarction (AMI) increased after the earthquake.

Methods: We enrolled AMI patients admitted to 36 hospitals in Fukushima prefecture between March 11, 2009, and March 10, 2013 (n = 3068). We compared the incidence of AMI after the earthquake for more than 3 months and 1 year with that in the control years.

Results: The incidence of Fukushima's annual AMI patients (per 100 000 persons) in 2011 was similar to that of previous years (n = 38.9 [2011] vs 37.2 [2009] and 38.5 [2010], $P = .581$). However, a significantly higher incidence of AMI was found in the Iwaki district after the disaster that corresponded to the 1-year period of observation (n = 38.7 [2011] vs 27.3 [2009] and 32.8 [2010], $P = .045$).

Conclusion: The Great East Japan Earthquake affected the incidence of AMI only in limited areas of Fukushima prefecture. (*Disaster Med Public Health Preparedness*. 2014;8:212-219)

Key Words: acute myocardial infarction, the Great East Japan Earthquake, Fukushima prefecture

On March 11, 2011, at 2:46 PM, the Great East Japan Earthquake hit a large area of eastern Japan, causing enormous damage. The catastrophic earthquake and its accompanying tsunami devastated the Pacific coast of northeastern Japan. The magnitude of this earthquake was 9.0. The number of dead and missing was reported to be 21 176, and the number of injured was 6217. The economic impact of this earthquake was estimated at 16.9 trillion Japanese yen. In Fukushima prefecture, many people suffered from the consequences of the earthquake, the subsequent tsunami, and especially the Fukushima Daiichi Nuclear Power Plant accident.

Fukushima prefecture is divided into 6 districts, and the Fukushima Daiichi Nuclear Power Plant is in the Soso district (Figure 1). The extent of damage differed from region to region. Table 1 shows the maximum seismic intensity by the Japanese Meteorological Agency seismic intensity scale (which differs from the modified Mercalli intensity scale); the number of dead, missing, and injured people; the number of completely destroyed houses; and the tsunami-devastated areas resulting from the earthquake in each of the 6 districts. The Soso and Iwaki districts are located along the Pacific coast (Figure 1), and most of the deaths and destroyed houses were due to the subsequent tsunami rather than the earthquake itself.

In the wake of a huge disaster such as an earthquake, the incidence of cardiovascular disease (CVD) has been reported to increase.[1-5] We therefore sought to determine whether the incidence of acute myocardial infarction (AMI) increased after this earthquake, using the registry study of AMI in Fukushima prefecture that we have conducted since 2009.

METHODS

The study area comprised all 6 districts of Fukushima prefecture (Figure 1). Table 2 shows the residents' population, gender, and average age in 2011, and the population change from 2011 to 2012 in the 6 districts of Fukushima prefecture, as reported by the Fukushima prefecture municipality. Because the Soso and Iwaki districts border on the Pacific coast, they have a temperate climate year round and received light snowfall. In contrast, the Aizu district has heavy snowfall and cold winters. The Kenpoku, Kenchu, and Kennan districts have an intermediate climate.

FIGURE 1

Map of the Study Area in Fukushima Prefecture.

The map on the left shows an outline of Japan. The blue area is Fukushima prefecture, the red line indicates the penetration of the tsunami, and the X marks the epicenter of the earthquake. The map on the right shows the 6 districts of Fukushima prefecture.

TABLE 1

Seismic Intensity and Damage Caused by the Great East Japan Earthquake in Fukushima Prefecture

Fukushima Districts	Maximum Seismic Intensity[a]	No. of Dead	No. of Missing	No. of Injured	No. of Completely Destroyed Houses	Tsunami-Devastated Area, km^2
Kenpoku	6.3	7	0	46	772	0
Kenchu	6.0	14	1	21	4002	0
Kennan	6.2	15	0	19	916	0
Aizu	5.5	1	0	10	22	0
Soso	6.3	1456	4	81	8068	97
Iwaki	5.7	330	0	4	7917	15
All of Fukushima	6.3	1823	5	181	21 697	112

[a] Maximum seismic intensity measured by the Japanese Meteorological Agency seismic intensity scale.

Most deaths from this earthquake resulted from the tsunami in the coastal area of Fukushima prefecture (Table 1).

Figure 2 shows the number of aftershocks with magnitudes higher than 5.0 occurring every 4 weeks after the Great East Japan Earthquake. Aftershocks occurred predominantly in the first 4 weeks, and decreased after 12 weeks. In our preliminary data, the number of AMI patients for 4 weeks and 8 weeks in 2011 did not increase compared with that of the previous 2 years. Based on this finding, we analyzed the incidence of AMI for 1 year and 3 months before and after the earthquake from the Fukushima prefecture AMI registration survey. We defined a year as the anniversary of the earthquake to understand its impact. Therefore, 2011 corresponds to March 11, 2011, to March 10, 2012.

The Fukushima Prefecture AMI Registration Survey

The registry study was established to elucidate the status of AMI and to improve treatment outcomes in Fukushima prefecture in 2009. A total of 36 hospitals that accepted AMI patients participated.[6] All AMI patients of Fukushima prefecture were taken or transferred to the 36 participating hospitals and registered in this study. Patients were georeferenced based on the place of their hospitalization.

Diagnosis of AMI was based on the World Health Organization (WHO) multinational monitoring of trends and determinants of cardiovascular disease (MONICA) criteria. Patients needed to be registered within 72 hours after the onset of symptoms if their level of creatinine phosphokinase (CK) or its MB isoform (CK-MB) increased to more than twice the normal range.

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TABLE 2

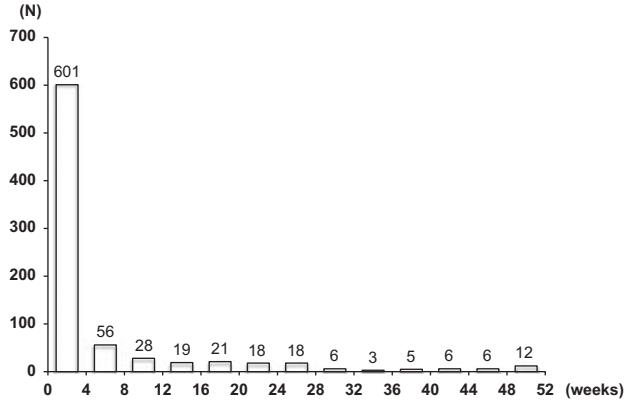
Gender, Average Age, and Change of Resident Populations

Fukushima Districts	Population in 2011	No. of Men (%)	No. of Women (%)	Age, y	Change in Population[a]
Kenpoku	496 586	239 589 (48.2)	256 997 (51.8)	45.7	-9348
Kenchu	551 672	270 339 (49.0)	281 333 (51.0)	44.0	-10 697
Kennan	149 885	73 997 (49.4)	75 888 (50.6)	45.0	-1 732
Aizu	291 374	138 731 (47.6)	152 643 (52.4)	48.4	-2 875
Soso	195 717	95 982 (49.0)	99 735 (51.0)	46.3	-10 927
Iwaki	341 904	165 189 (48.3)	176 715 (51.7)	45.6	-8 568
All of Fukushima	2 027 138	983 827 (48.5)	1 043 311 (51.5)	45.6	-44 147

[a] From 2011 to 2012.

FIGURE 2

Number of Aftershocks with Magnitudes Higher Than 5.0 Every 4 Weeks after the Great East Japan Earthquake.



This study was conducted in a prospective manner. Each physician filled in the survey form in detail and sent it to the registry office. The survey included coronary risk factors; symptoms; change in electrocardiogram (ECG); CK and CK-MB values; infarction site; reperfusion therapies; duration of hospitalization; and outcomes 30 days after hospitalization. These data were entered into the database and analyzed at the headquarters of the registry study (Fukushima Medical University). This study was continued in spite of the enormity of the disaster. The study protocol was approved by the ethics committee of Fukushima Medical University.

Statistical Analysis

Data are expressed as the number of patients, and the incidence of AMI is shown as the number of patients per 100 000 persons per year. We assessed the differences between the incidence of AMI after the earthquake and during the corresponding period of the previous 2 years in the same area. The incidence of AMI after the earthquake was compared to average incidences of AMI in the previous 2 years, and confirmed using the χ^2 test and Fisher exact test.[7] These analyses were carried out with SAS software version 9.1 (SAS Institute, Inc). A P value less than .05 was considered statistically significant.

RESULTS

In the present study, we registered a total of 3068 AMI patients who were taken to 36 hospitals between March 11, 2009, and March 10, 2013. The number of AMI patients throughout Fukushima prefecture was 772 in 2011. The number was almost identical to that in 2009, 2010, and 2012 (n = 759, n = 780, and n = 757, respectively; Figure 3A). The average age of the patients in 2011 was identical to those in 2009, 2010, and 2012 (68.4 vs 69.6 [2009], 69.2 [2010], and 68.4 [2012]). The gender of AMI patients in 2011 did not change compared with that of the control years (72% [2011] vs 70% [2009], 73% [2010], and 73% [2012]). Figure 3B shows the incidence of AMI corrected per 100 000 persons. No significant difference was found between 2011 and the previous 2 years, as compared to the incidence of AMI after the earthquake in Fukushima prefecture (n = 38.9 vs 37.9; $\chi^2 = 0.30$; $P = .58$).

Next, those numbers were counted on a regional basis, because Fukushima is the prefecture with the third largest landmass in Japan, and the extent of the disaster damage differed from region to region (Figure 1 and Table 1). In the Iwaki district, the incidence of AMI patients in 2011 increased remarkably compared with those of the previous 2 years (n = 38.7 vs 30.1; $\chi^2 = 4.01$; $P = .045$), as shown in Figure 3B. On the other hand, the incidence of AMI was not increased in the Soso district, although it was most affected by the tsunami and nuclear power plant disaster. No significant changes were observed in the other districts.

To focus on the effect of this disaster on AMI patients, we analyzed data from 3 months before to 3 months after the earthquake (Figure 4). The incidence of AMI patients from March 11 to June 2, 2011, did not increase, as compared with the previous year in the entire prefecture (n = 9.4 vs 10.1; $\chi^2 = 0.54$; $P = .462$). No significant difference was noted in the incidence of AMI from March 11 to June 2, 2011, as

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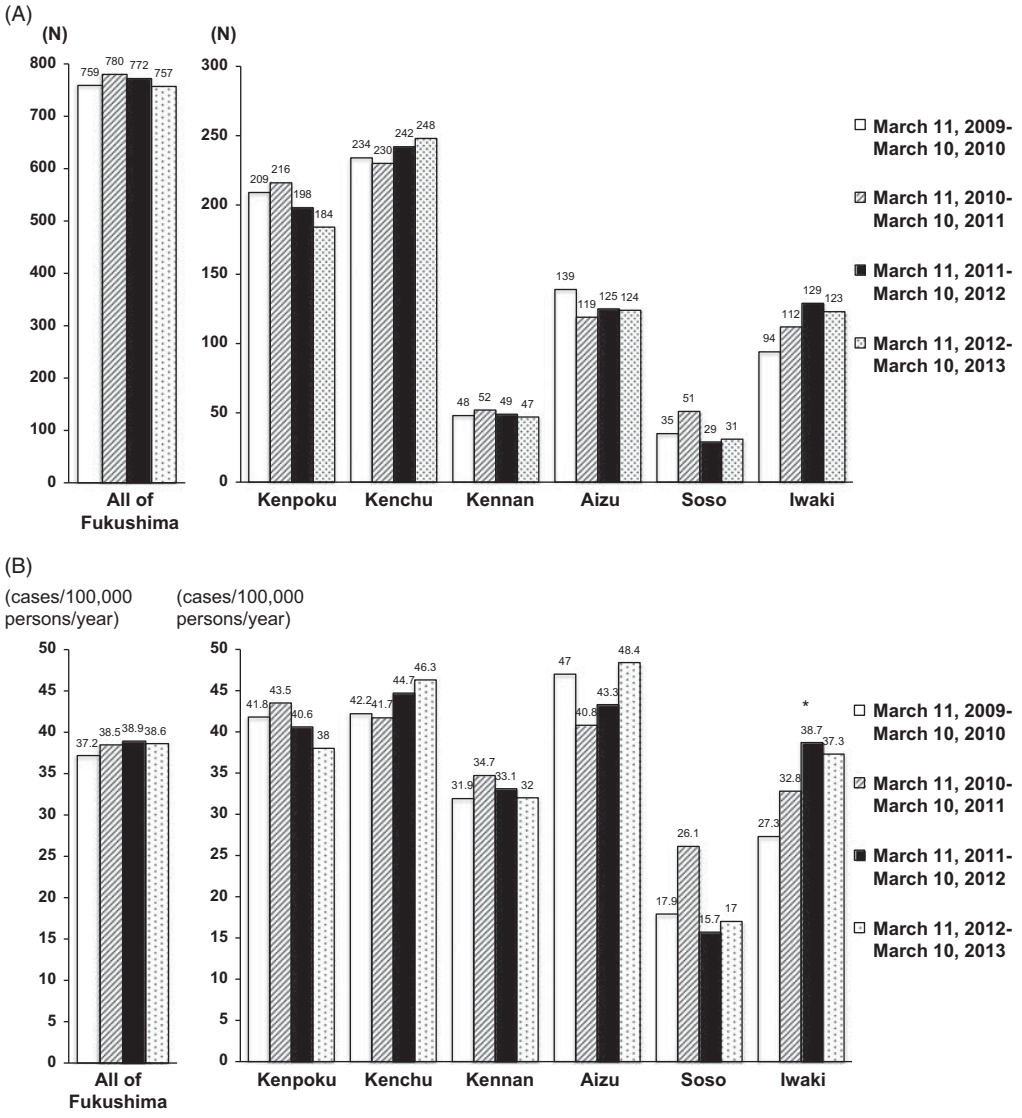
FIGURE 3

Trend of Acute Myocardial Infarction (AMI) in Fukushima Prefecture From 2009 to 2012.



A, The graph on the left shows the number of AMIs in the entire prefecture. The graph on the right shows the number of AMIs in each district of Fukushima prefecture. B, The trend in the annual incidence of AMI (per 100 000 persons). *P < .05 compared to the previous 2 years.

compared with the previous year (n = 11.0 vs 12.9; $\chi^2 = 0.03$; $P = .8634$) in the Iwaki district. There was also no significant difference in any other district. Considering the incidence of AMI during 1 year and 3 months after the earthquake in the Iwaki district, the incidence increased from 4 to 12 months after the disaster.

DISCUSSION

The major findings of the present study were that the incidence of AMI did not increase during the first 3 months after the earthquake in Fukushima prefecture compared with the control years, but it did increase in the Iwaki district from 4 to 12 months after the earthquake.

The incidence of intrinsic CVD, which includes acute coronary syndrome (ACS), increases after major disasters.[2,8,9,10] The mechanisms of inducing ACS entails increased vasomotor reflex response, sympathetic nerve stimulation, worsening of living conditions, and a thrombotic tendency. The physical and psychological stress due to the disaster was assumed to cause AMI. Casualties of the Great East Japan Earthquake

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were mainly from tsunami damage, which may have affected the incidence of AMI less than an epicentral earthquake.[2,3]

One study reported no significant increase in the incidence of AMI with an earthquake at less vulnerable circadian periods.[11] That report compared the incidence of AMI in the 1989 Loma Prieta earthquake at 5:04 PM with that of the 1994 Northridge earthquake at 4:31 AM. Both were similarly intense earthquakes, but the incidence of AMI increased only in the Northridge earthquake. We thought that the Great East Japan Earthquake, which occurred at 2:46 PM, might not have posed as great a risk of AMI as the Northridge earthquake.

Although infection due to worsening environmental conditions might have affected the incidence of AMI, there were no outbreaks of cold or flu in Fukushima prefecture (including Iwaki district) after the earthquake. Also no cold temperature spells were reported after the earthquake in Fukushima prefecture.

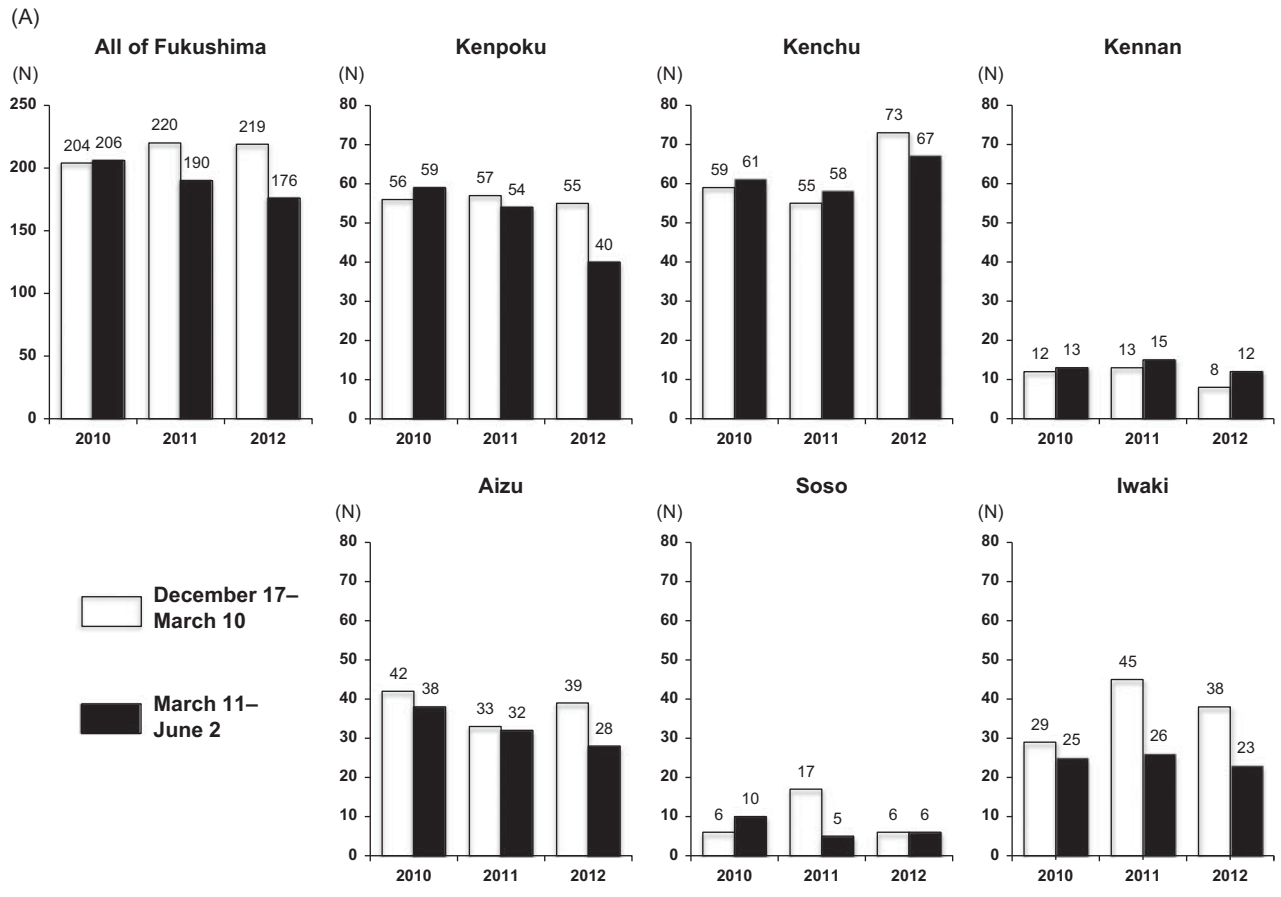
A significant increase in the incidence of AMI was observed in the Iwaki district after the earthquake, as compared to the previous 2 years. However, the precise reason for this increase remains unclear. Because victims were severely stressed mentally as well as physically, we speculated that their sympathetic nervous activation and high blood pressure combined with the unavailability of medications, poor nutrition, and lack of hygiene might have triggered major coronary plaque rupture.[12] Additional studies would be necessary to elucidate the detailed mechanisms of AMI to prevent it in this district in the future.

Limitations

This study has several limitations. First, the tally of the number of AMI patients in Fukushima prefecture may not have been precise, because the study was based on hospital registers. It was not a population-based cohort study, such as the Framingham Heart Study in the United States.

FIGURE 4

Acute Myocardial Infarction (AMI) Cases From 3 Months Before to 3 Months After the Great East Japan Earthquake in 2011 and Control Years in Fukushima Prefecture.



A, Number of AMI patients in Fukushima prefecture.

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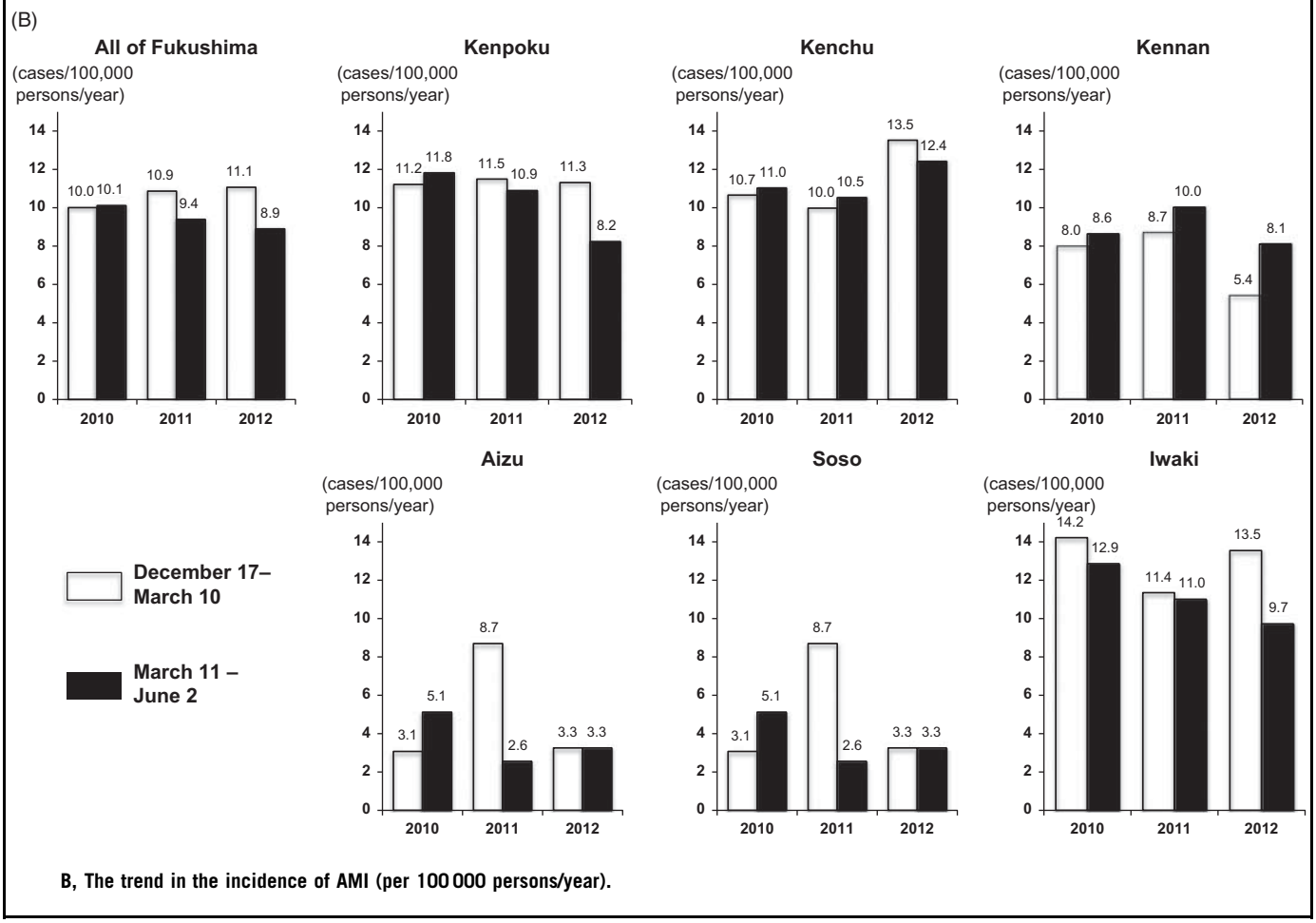
FIGURE 4 (Continued)



B, The trend in the incidence of AMI (per 100 000 persons/year).

Second, we used the place of hospitalization rather than the place of residence to georeference the AMI patients. In future studies, we should use the place of residence. Third, it has been reported that the number of patients with out-of-hospital cardiac arrest increases under stressful situations.[13] Because this study comprised hospitalized patients, a certain number of AMI cases may have been missed before their admission to the hospital. Fourth, stress cardiomyopathy may have been involved in AMI. However, because a high rate (more than 90%) of the coronary angiograms was performed in the acute stage in our study, most cases of stress cardiomyopathy were distinguished from AMI. Fifth, no changes were found in the average age and gender of the AMI patients in the study period, but the age of the patients was not referenced according to gender. Some studies have reported that younger women may have increased susceptibility to earthquake-induced stress. Further studies would be necessary to clarify this issue. Last, because we analyzed the data for 12 weeks and 1 year in this study, the choice of time-windows may have affected our findings.

CONCLUSIONS

The findings of our study demonstrated that the incidence of AMI increased only in limited areas of Fukushima prefecture after the Great East Japan Earthquake.

About the Authors

Departments of Cardiology and Hematology, Fukushima Medical University (Drs Yamaki, Nakazato, and Takeishi), Fukushima; and Hoshi General Hospital (Drs Kijima and Maruyama), Koriyama, Japan.

Address correspondence and reprint requests to Takayoshi Yamaki, MD, PhD, Department of Cardiology and Hematology, Fukushima Medical University, 1 Hikarigaoka, Fukushima 960-1295, Japan (e-mail: ta-yama@fmu.ac.jp).

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APPENDIX. LIST OF PARTICIPATING HOSPITALS AND INVESTIGATORS

Iwaki Kyoritsu Hospital: Masafumi Sugi, MD., Mitsuru Yui, MD., Yoshito Yamamoto, MD., Yutaka Minatoya, MD., Tomohiro Tada, MD., and Yasuhide Asaumi, MD.

Ohta Nishinouchi Hospital: Hiroto Takeda, MD., Nobuo Komatsu, MD., Takeo Niitsuma, MD., Goro Ishida, MD., Akiko Kanazawa, MD., Hiroyuki Yamauchi, MD., Yuichi Nakamura, MD., and Atsuro Masuda, MD.

Takeda General Hospital: Hiroshi Seita, MD., Satoshi Ito, MD., and Mami Sato, MD.

Southern Tohoku Hospital: Masahiro Ono, MD., Mitsuru Muto, MD., Taku Ohsugi, MD., Keiichi Kawamura, MD., and Wakako Naganuma, MD.

Fukushima Red Cross Hospital: Takayuki Owada, MD. and Kenichi Watanabe, MD.

Aizu Chuo Hospital: Michito Kanke, MD.

Hoshi General Hospital: Yoshitane Seino, MD., Eisuke Miura, MD., Keiji Sakamoto, MD., Hironori Kaneko, MD., Yohei Goto, MD., Yasuhiro Shimizu, MD., and Takeshi Shimizu, MD.

Shirakawa Kosei General Hospital: Tomiyoshi Saito, MD., Tsunayoshi Saito, MD., Jiro Izumida, MD., and Takashi Owada, MD.

Fukushima Accident Hospital: Shigebumi Suzuki, MD., Kazuyuki Yoshinari, MD., Yasuyuki Watanabe, MD., Masahito Sando, MD., Hideaki Dairaku, MD., and Kei Haruyama, MD.

Jusendo General Hospital: Masato Iwaya, MD., Toshinori Tanikawa, MD., and Tomohito Suzuki, MD.

Public Soma General Hospital: Masahiko Sato, MD. and Katsuya Ando, MD.

Ohara Medical Center: Yukihiko Abe, MD., Osamu Yamaguchi, MD., Hironori Uekita, MD., and Shunsuke Miura, MD.

Saiseikai Fukushima General Hospital: Hideki Otake, MD., Minoru Mitsugi, MD., and Hirobumi Machii, MD.

Sukagawa Hospital: Akihiro Tsuda, MD. and Jyun Goto, MD.

Fukushima Daiichi Hospital: Katsumi Chiba, MD., Tomohiro Ogawa, MD., and Masatomo Nakao, MD.

Watari Hospital: Tomoyuki Watanabe, MD. and Masaki Sugiyama, MD.

Soma Central Hospital: Yasutoshi Saito, MD.

Shirakawa Hospital: Tsuneo Honda, MD. and Wataru Kuwabara, MD.

Fukushima Prefectural Aizu General Hospital: Kazuaki Tamagawa, MD.

Wakamatsu Intervention Clinic: Wataru Abe, MD.

Fukushima Prefectural Minamiaizu Hospital: Satoshi Abe, MD.

Bange Kosei General Hospital: Junichiro Matsui, MD. and Nobuo Ito, MD.

Northern Fukushima Medical Center: Hiroshi Yoshida, MD. and Yusaku Fukumoto, MD.

Azuma Neurosurgical Hospital: Ryushu Hen, MD. and Yasumori Sodenaga, MD.

Southern Tohoku Fukushima Hospital: Toshio Kobayashi, MD. and Masaki Ando, MD.

Masu Memorial Hospital: Shinichi Hisa, MD.

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Ohmachi Hospital: Hiroshi Takahira, MD. and Toshimitsu Sato, MD.

Watanabe Hospital: Ryuzaburo Shineha, MD.

Minamisoma City General Hospital: Fumio Suzuki, MD.

Fukushima Prefectural Ono Hospital: Sakae Suzuki, MD.

Kuwano Kyoritsu Hospital: Masao Tsuboi, MD.

Aizu Nishi Hospital: Naoto Ohara, MD.

Fukushima Prefectural Kitakata Hospital: Tokuo Yui, MD.

Hanawa Kosei Hospital: Keiichi Sagawa, MD.

Jyoban Hospital: Tadami Maeyama, MD.

Department of Health and Welfare, Fukushima Prefecture: Shuichi Nagasawa, MD.

Fukushima Medical Association: Yuzou Takaya, MD.

Fukushima Hospital Association: Kazuhira Maehara, MD.

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