

Global Health Working Group for the  
2016 G7 Summit (GHWG)

**Roundtable Discussion**

December 17, 2015, Tokyo, Japan

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after Great East Japan Earthquake

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### Abstract

**Background:** The Great East Japan Earthquake and subsequent tsunami and nuclear disaster on March 11, 2011, had a short-term influence on the increase in emergency department visits and hospital admissions due to various diseases. However, it remains unclear whether the earthquake and tsunami disaster affected the long-term health conditions of people in the affected areas.

**Methods:** Using a national inpatient database in Japan, we investigated people's ambulatory care sensitive conditions (ACSCs), which are defined as conditions for which effective management and treatment should prevent admission to a hospital. We compared the number of admissions for ACSCs during before-quake (July 2010 to February 2011) and after-quake (July 2012 to February 2013) periods in the disaster area.

**Results:** Overall ACSCs increased from 70.5 to 76.3 admissions per 100,000 people and acute ACSCs (where early intervention can prevent more serious progression) increased from 22.4 to 26.5 admissions per 100,000 people.

**Conclusions.** Avoidable admissions due to acute ACSCs remained high in the long term after the earthquake and tsunami disaster.

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**Key words:** Ambulatory care sensitive conditions, avoidable admissions, earthquake

## **Introduction**

The Great East Japan Earthquake was followed by a tsunami that hit East Japan on March 11, 2011. A total of 19,225 people died and 2,614 people were still missing as of March 31, 2015.<sup>1</sup> The earthquake and tsunami severely destroyed the Pacific coastline of the Tohoku region, and the subsequent accident at the Fukushima Daiichi nuclear power plant forced nearly 180,000 people to evacuate.<sup>2-4</sup>

The earthquake and the following tsunami completely destroyed 10 out of 380 hospitals and partially destroyed 290 of the 380 hospitals in the Tohoku region, and many hospitals lost their capacity to function. As a result, 19 out of 33 hospitals located in the disaster zone had restricted in-patient care capacity three months after the earthquake.<sup>5</sup> Such a situation may have impaired access to primary and secondary care for people in the most affected areas.

Studies have shown the short-term influence of the earthquake and tsunami disaster on increases in emergency department visits and hospital admissions due to cardiovascular disease<sup>6,7</sup>, cerebrovascular disease<sup>6,8</sup>, respiratory disease<sup>6,9-11</sup>, infectious disease<sup>12</sup>, gastrointestinal bleeding<sup>13</sup>, and others<sup>6,14</sup>. However, it remains unknown whether the earthquake and tsunami disaster affected long-term health conditions of people in the affected areas.

The present study investigates the influence of the Great East Japan Earthquake and subsequent tsunami and nuclear disasters on people's long-term health conditions in terms of their ambulatory care sensitive conditions (ACSCs), using a national inpatient database in Japan. Based on the results, we aim to discuss the resilience of the Japanese universal health coverage system against devastating natural disasters.

## **Materials and Methods**

The Institutional Review Board of the University of Tokyo approved this study. Informed consent was waived due to the anonymous nature of the data.

### *Data source and population*

Patient data for this study were extracted from the Japanese Diagnosis Procedure Combination inpatient database.<sup>15,16</sup> The database includes data from approximately 7 million inpatients at more than 1,000 hospitals, which represents approximately 50% of all discharges from acute care hospitals in Japan. Hospital data were extracted from the Survey of Medical Institutions data in Japan, which includes each hospital's address and number of acute care beds.

We extracted data on patients aged 20 years and up on all hospital admissions due to ACSCs from July 2010 to March 2013. Data included age, sex, and zip code of the patient's residence; diagnoses coded with International Classification of Diseases, Tenth Revision (ICD-10), and Charlson Comorbidity Index<sup>17</sup> codes; and length of stay. Hospital data included type of hospital (academic or non-academic) and the number of beds in each hospital.

We defined the period between July 2010 and February 2011 as "before the quake" and

the period between July 2012 and February 2013 as “after the quake”.

### *Ambulatory care sensitive conditions*

ACSCs are defined as conditions for which appropriate intervention in primary care could prevent admission to a hospital.<sup>18,19</sup> ACSCs have been used as indicators of the accessibility and quality of primary care. High frequencies in admissions for ACSCs indicate poor coordination between primary and secondary care. An avoidable admission for an ACSC indicates poor overall quality of care, even if the ACSC episode itself is well managed.<sup>19</sup>

The outcomes of the present study compared pre-quake and post-quake hospital admissions for the following three types of ACSCs: (i) preventable ACSCs (where immunization and other interventions can prevent illness, e.g. influenza and pneumonia), (ii) chronic ACSCs (where effective care can prevent flare-ups, e.g. asthma, congestive heart failure, diabetes complications, chronic obstructive pulmonary disease, angina, iron deficiency anemia, hypertension, and nutritional deficiency), and (iii) acute ACSCs (where early intervention can prevent more serious progression, e.g. dehydration and gastroenteritis; pyelonephritis; perforated / bleeding ulcer; cellulitis; pelvic inflammatory diseases; ear, nose, and throat infections; dental conditions; convulsions and epilepsy; and gangrene). Table 1 shows the ICD-10 codes used to identify the 19 ACSCs commonly used in the National Health Service in the UK.<sup>18</sup>

### *Statistical analysis*

To estimate the number of admissions for ACSCs, we developed an analytic dataset by stratifying all patients according to age category, sex, prefecture, hospital bed category (categorized by the number of acute care beds in 6 categories), and admission month. We obtained the population corresponding to each stratified unit from the Population Census reported by the Statistics Bureau of Japan. All analyses were performed using SPSS version 22.0.

## **Results**

During the study period, 36,564 patients were admitted for ACSCs in the disaster-affected areas. Table 2 shows the characteristics of patients who were admitted for ACSCs.

Table 3 shows the numbers of admissions for ACSCs per 100,000 people living in disaster-affected before and after the earthquake. Overall ACSCs increased after the quake both in the disaster area from 70.5 to 76.3 admissions per 100,000 people. Acute ACSCs increased from 22.4 to 26.5 admissions per 100,000 people. Similar findings were observed for admissions due to preventable and chronic ACSCs.

## **Discussion**

In the present retrospective cohort study using a national inpatient database, the Great East Japan earthquake and tsunami disaster was associated with changes in admissions for ACSCs in the disaster areas.

Reportedly, emergency department visits and hospitalization due to a variety of diseases

increased just after the earthquake<sup>6-14</sup>. However, the long-term influence of the earthquake and tsunami disaster on people's health conditions remained unclear. Several studies reported that the increase in ACSCs was temporary and that they started to decrease several weeks after the earthquake and tsunami disaster.<sup>6, 7, 9, 11-13</sup>

Our study deserves comparison with studies on the health impacts of other natural disasters. Limited studies such as those after Hurricane Katrina have investigated the impact of natural disasters on long-term health consequences in North America. Several studies suggest that Hurricane Katrina had negative impacts on the management of chronic conditions,<sup>20, 21</sup> while the incidence of several conditions including cardiovascular disease and cerebrovascular disease increased after the storm.<sup>22-25</sup> The populations devastated most by Hurricane Katrina were the poor and the uninsured<sup>26</sup>. Nearly 50% of evacuees living in shelters were uninsured<sup>27</sup>. The lack of health insurance may have affected the long-term health consequence of people living in the hurricane-hit areas.

Our results show that admissions for ACSCs increased after the earthquake and tsunami disaster. The Great East Japan Earthquake was unique in that most victims were not devastated by earthquake itself, but by tsunami, which was rarely seen in previous disasters.<sup>10</sup> Emergency medical teams gathered in the disaster area could not provide sufficient medical care because many victims had died before the rescue teams arrived. Therefore, all healthcare professionals could do was to prevent exacerbation of chronic comorbidities in the disaster area.<sup>10</sup>

Our results have important implications for reducing avoidable admissions in post-disaster settings; that is, avoidable admissions due to ACSCs may remain in the long term after a disaster. Further research is warranted to investigate effective strategies to improve access to early intervention to prevent disease exacerbation and reduce avoidable hospital admissions.

Our study has several limitations. First, we assessed ACSCs as long-term health conditions; however, we could not directly measure outpatient care due to lack of outpatient data. Also, we could not assess the baseline health and socioeconomic status (e.g. income, type of insurance) of the residents. Second, the validity of ACSCs in Japanese clinical settings remains to be further examined. Third, the difference in admission policy between hospitals might have biased the results. Lastly, for evacuees who had lived in the exclusion zone, out-of-pocket payments for healthcare charges were exempted during the time our study was conducted. Such a policy might have affected their consumption of healthcare services.

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Table 1. 19 Ambulatory care sensitive conditions commonly used in the National Health Service in the UK

Ambulatory care sensitive conditions	International Classification of Diseases, Tenth Revision codes (ICD-10)
<b>Preventable conditions</b>	
Influenza and pneumonia	J10 J11 J13 J14 J153 J154 J157 J159 J168 J181 J188
Other vaccine preventable diseases	A35 A36 A37 A80 B05 B06 B161 B169 B180 B181 B26 G000 M014
<b>Chronic conditions</b>	
Asthma	J45 J46
Congestive heart failure	I110 I50 J81
Diabetes complications	E100 E101 E102 E103 E104 E105 E106 E107 E108 E110 E111 E112 E113 E114 E115 E116 E117 E118 E120 E121 E122 E123 E124 E125 E126 E127 E128 E130 E131 E132 E133 E134 E135 E136 E137 E138 E140 E141 E142 E143 E144 E145 E146 E147 E148
Chronic obstructive pulmonary disease	J20 J41 J42 J43 J47
Angina	I20 I240 I248 I249
Iron deficiency anemia	D501 D508 D509
Hypertension	I10 I119
Nutritional deficiency	E40 E41 E42 E43 E550 E643
<b>Acute conditions</b>	
Dehydration and gastroenteritis	E86 K522 K528 K529
Pyelonephritis	N10 N11 N12 N136
Perforated / bleeding ulcer	K250 K251 K252 K254 K255 K256 K260 K261 K262 K264 K265 K266 K270 K271 K272 K274 K275 K276 K280 K281 K282 K284 K285 K286
Cellulitis	L03 L04 L080 L088 L089 L88 L980
Pelvic inflammatory diseases	N70 N73 N74
Ear, nose and throat infections	H66 H67 J02 J03 J06 J312
Dental conditions	A690 K02 K03 K04 K05 K06 K08 K098 K099 K12 K13
Convulsions and epilepsy	G40 G41 R56 O15
Gangrene	R02



Table 2. Patient backgrounds before and after the earthquake in the disaster-affected and other areas

	Before earthquake N=18270	After earthquake N=18294
Age, year, mean (SD)	69.1 (16.8)	69.6 (17.0)
Sex		
Male	56.9	56.7
Female	43.1	43.3
Academic	16.2	11.5
Length of stay, median (IQR)	10 (4-20)	11 (4-21)
Charlson comorbidity index, median (IQR)	0 (0-2)	1 (0-2)

SD, standard deviation; IQR, interquartile range

Table 3. Changes in hospital admissions for ACSCs due to the disaster

ACSCs	Before quake	After quake
Overall	70.5 (64.5 to 76.5)	76.3 (70.5 to 82.0)
Preventable	5.5 (4.8 to 6.2)	6.7 (5.8 to 7.5)
Chronic	45.4 (40.7 to 50.0)	46.7 (42.6 to 50.9)
Acute	22.4 (20.5 to 24.4)	26.5 (24.2 to 28.7)

The numbers of admissions per 100,000 people and their 95% confidence intervals in parentheses  
ACSCs, Ambulatory care sensitive conditions