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Title

The impact of the 2011 Great East Japan Earthquake on hospitalization for respiratory disease in advanced aging society: a retrospective descriptive and cross-sectional study at the disaster base hospital in Ishinomaki

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Article summary

Article focus

The Great East Japan Earthquake attacked one of the most advanced aging societies in the world. Respiratory medicine is the major field in gerontology. Here we address how seriously the disaster affected respiratory diseases in the most heavily stricken area, which has one of the highest ratios of elderly people in Japan.

The study gives lessons against natural disasters and aging society.

Key messages

After the earthquake and tsunami, admission from pneumonia and exacerbation of chronic respiratory disease in elderly increased.

Harsh conditions and poor ADL after the disaster may be associated with increase in hospitalization for respiratory diseases in elderly people.

Strengths and limitations of study

We could obtain detailed data of patient even in catastrophic state.

We analyzed only hospitalized patients. But there were a great number of outpatients as well as heavy loss of lives.

Abstract

Objective

To investigate the impact of the 2011 Great East Japan earthquake on hospitalization for respiratory disease at the disaster base hospital in aging society.

Design

Descriptive and cross sectional study.

Setting

Emergency care in Japanese Red Cross Ishinomaki Hospital, a regional disaster base hospital, Miyagi, Japan.

Participants

322 emergency patients who hospitalized for respiratory disease from March 11 to May 9 in 2011, and 204 emergency patients who hospitalized in the corresponding time period of 2009 and 2010.

Main outcome measures

Description and comparison of patient's characteristics and disease distribution in terms of age, time after the disaster, and activity of daily living (ADL).

Results

Totally 1,769 patients admitted to our hospital, and 322 of them were hospitalized for respiratory disease during the first 60 days after the earthquake. Mean age of patient was 75.7±12.5 years old. Pneumonia was the most frequent disease (n=190, 59.0%), followed by acute exacerbation of chronic obstructive disease (AE-COPD) (n=53, 16.5%), attack of asthma (n=27, 8.4%), and progression of lung cancer (n=22, 6.8%). Compared with the corresponding period of 2009 or 2010, increase in absolute number of hospitalization was the highest for pneumonia, followed by AE-COPD and attack of asthma. Elderly patients were more likely hospitalized after the earthquake, especially for pneumonia and AE-COPD. At hospitalization, 195 patients were "dependent" and 54 patients were "partially dependent". Deterioration of ADL was more frequent in elderly and female patients. The mean age was 73.1±11.2 years old in the patients with deterioration of ADL and 69.9±15.1 in the patients without deterioration of ADL. The male proportion was 60.6% in the patients with deterioration of ADL and 70% in the patients without deterioration of ADL.

Conclusions

After Great East Japan Earthquake, admission for pneumonia and exacerbation of chronic respiratory disease in elderly increased at the disaster base hospital.

Introduction

On March11, 2011, at 2:46 pm Japan time, the Pacific coast of Japan's Tohoku (northeastern)

region was struck by the massive earthquake (The Great East Japan Earthquake), measuring magnitude 9.0 on the Richter scale[1]. The earthquake triggered a devastating tsunami which destroyed many towns and villages near the seashore. The epicenter was estimated to be about 70 kilometers east of Oshika Peninsula of Ishinomaki in Miyagi. Officially, over 19,000 people were killed or missing and the maximum number of refugees reached more than 550,000[2].

Ishinomaki city, located in Pacific coast of Honshu Island, suffered from the largest number of victims in Japan, 3,280 people were killed and 669 people were still missing. A great number of casualties, more than 10,000 patients in the first 30 days, were treated at Japanese Red Cross Ishinomaki Hospital, a regional disaster base hospital in Ishinomaki which uniquely preserved its hospital function in Ishinomaki region.

Japan is one of the most advanced aging society in the world. 23% of Japanese citizens were 65 years old or more in 2010[3]. Especially, Tohoku region is a highly advanced aging society in Japan, 26.6% of people living in Ishinomaki city were 65 years old or more in 2011. Although several reports showed the significant association between age and earthquake and tsunami death[4-8], there were few reports investigating the impact of a tremendous disaster on such an aging society[9 10].

Respiratory diseases are common in elderly people even in ordinary times. So, investigating the impact of the disasters on respiratory health will contribute to elucidating the problem of aging society. Thus, we performed retrospective descriptive and cross-sectional analysis of the medical and epidemiologic data of the patient requiring hospitalization for respiratory disease after the Great East Japan Earthquake and following tsunami.

Methods

This study was a retrospective descriptive and cross-sectional analysis of the data obtained from the medical records at Japanese Red Cross Ishinomaki Hospital. We reviewed medical records of patients admitted to the hospital for respiratory diseases during the first 60 days after the Great East Japan Earthquake, when the hospital solely accepted emergency patients. We also reviewed medical records of patients who required unscheduled hospitalization for respiratory disease in the corresponding period of 2009 and 2010.

Japanese Red Cross Ishinomaki Hospital which had 402 beds for inpatients was located at 4.5 km inland from Pacific Ocean. It has covered about 220,000 people living in its medical zone (Ishinomaki, Onagawa, or Higashi-matsushima) and assigned to a regional disaster base hospital. It has received almost all of the emergency respiratory patients even in ordinary time, because it is the unique hospital having the respiratory department and pulmonary specialists in the region.

Medical records were investigated in terms of date of admission, age, sex, diagnosis. We also investigated activity of daily living (ADL) at hospitalization and ADL before earthquake, and

their residence before admission on the medical record of 2011 study period. For comparison, the total number of unscheduled hospitalization to the hospital during the corresponding periods in 2009 and 2010 was counted.

Pneumonia was defined as the presence of the infiltration on chest radiograph along with one or more of the following symptoms or signs: fever, cough, sputum production, breathlessness, pleuritic chest pain or signs consistent with pneumonia on auscultation.

Chronic obstructive pulmonary disease (COPD) and bronchial asthma were detected by the previous spirometric data, patient's self-report, or physician's diagnosis made by patient's history, physical examination, and radiological finding. An acute exacerbation of COPD(AE-COPD) was defined as an increase in or new onset of more than one symptom of COPD (cough, sputum, wheezing, dyspnea or chest tightness) without pneumonia or pneumothorax. An attack of asthma was defined as the presentation of wheezes or severe cough in asthma patients without pneumonia. Progression of lung cancer was defined as requirement for admission for lung cancer associated condition such as dehydration, respiratory failure, or uncontrolled pain. Obstructive pneumonia due to lung cancer was considered as progression of lung cancer. Chest trauma and traumatopnea were not considered as respiratory disease but chest injury.

ADL was assessed by the information from a patient, patient's family, or patient's caregiver, and classified into three categories; "independent" who could live without particular support, "partially dependent" who could not leave their residence without any support, "dependent" who spent a day on the bed or the chair and lost the ability to move for themselves. Furthermore, we defined as "originally dependent" who were dependent or partially dependent before the disaster, and as "newly dependent" who became dependent or partially dependent after the disaster.

Data analysis

All data were entered into a personal computer and analyzed using Microsoft ™ Excel software and statistical analysis was performed using JMP9 (SAS Institute Inc., Cary, NC, USA). A missing value in medical record was treated as "unknown". Results were given as mean ± SD for numerical variables and as proportions for categorical variables. To analyze sequential change of the effect of the disaster, we divided 60 days of study period into six groups of each ten days. To investigate the risk of hospitalization for respiratory disease after the earthquake and tsunami, we compared the patient's characteristics of 2011 study period with that of 2010 and 2009 corresponding period as ordinary time. We used two-sided Student's *t*-test for numerical variables and chi-square test for the categorical variables. We calculated the effect of age and sex on the odds ratio for hospitalization for respiratory disease after the earthquake by

logistic regression models. The $p < 0.05$ is accepted as statistically significant.

Result

All of the scheduled hospitalization was cancelled and emergency admission was solely accepted during the first 60 day after the earthquake at Japanese Red Cross Ishinomaki Hospital. 1,769 patients admitted to the hospital, and 322 of them were hospitalized for respiratory disease during the study period. Patients hospitalized for respiratory disease accounted for 18.2% of total hospitalization during the study period. This proportion was higher than the corresponding period of past two years, 10.2% of 2010 and 11.6% of 2009. While the number of total hospitalizations of this period in 2011 was about twice of that in 2009 and 2010, hospitalization for respiratory disease in 2011 reached about three times or more than that of 2009 and 2010. The total number of hospitalizations was at peak in the first ten days and then decreased, but the number of hospitalization for respiratory disease kept increasing for 20 days (Figure 1A and B).

We compared the disease distribution between 2011, 2010, and 2009 (Figure 2). Pneumonia was the most frequent disease (n=190, 59.0%), followed by AE-COPD (n=53, 16.5%), attack of asthma (n=27, 8.4%), and progression of lung cancer (n=22, 6.8%). One case of AE-COPD and seven cases of attack of asthma were physician's diagnosis. Others included pneumothorax, restrictive thoracic disease, pleural effusion, influenza, drowning, primary pulmonary hypertension, requirement of mechanical ventilator support for neuromuscular disease, and so on. One patient diagnosed as pneumonia was complicated by attack of asthma and two patients of pneumonia exacerbated their symptom of COPD. They were treated for both conditions and counted as pneumonia. In comparison with the past two years, the increase in absolute number of hospitalizations was the largest for pneumonia, followed by AE-COPD and attack of asthma. The number of hospitalization for progression of lung cancer and that for other diseases were not so deferent from the past two years. 39.4% of patients stayed at emergency shelters before hospitalization..

To investigate the disease specific effect of earthquake, age and sex of each disease were compared between the study period in 2011 and the corresponding period in the past two years (Table 1). The mean age of patients hospitalized for respiratory disease was significantly higher in 2011 than in the past two years (75.7±12.5 years old in 2011, 73.2±13.4 years old in 2010 and 2009. p=0.03). Male proportion tended to be lower in 2011 than in the past two years (59.6% in 2011, 67.2% in 2010 and 2009. p=0.08). Specifically, pneumonia patients and AE-COPD patients were significantly older in 2011 study period than in 2010 and 2009 corresponding

period(p=0.03 and p=0.03, respectively). Male population of AE-COPD was significantly higher, whereas that of attack of asthma significantly lower in 2011 period than 2010 and 2009 periods(p=0.01 and p=0.03, respectively).

Furthermore, the effect of age and sex on the odds ratio for hospitalization with respiratory disease was calculated (Table 2). We found older patients were more likely hospitalized after the earthquake, especially for pneumonia and AE-COPD. Male patients were more likely hospitalized for AE-COPD and less likely hospitalized for attack of asthma.

Actual numbers of hospitalization for the main respiratory diseases in terms of every ten days during the study period is shown in Figure 3. Pneumonia presented its peak in the second period. Following pneumonia, AE-COPD presented its peak in the third period and progression of lung cancer had its peak in the fifth period. Attack of asthma had small peak in the same third period as AECOPD.

Next, we investigated ADL at hospitalization and ADL before the disaster among the patients hospitalized in 2011 study period. Because of confusing situation of medical activities after the disaster, ADL before the disaster, ADL at hospitalization, and both ADL were not recorded in 8, 1, and 2 patients, respectively. Six of them were hospitalized for pneumonia and remaining five patients were hospitalized for AE-COPD. At hospitalization, 195 patients were “dependent” and 54 patients were “partially dependent”. Those patients accounted for 76.9 % of the patients hospitalized after the earthquake. On the other hand, before earthquake, only 86 patients were “dependent” and 51 patients were “partially dependent”. Those patients accounted for 42.5% of hospitalized patients after the earthquake. We analyze sequential change in the number of the patients who were “originally dependent”, “newly dependent”, or “independent” at hospitalization (Figure 4). Throughout the study period, majority of patients were dependent or partially dependent patient. Originally dependent patients were hospitalized especially in early period (first and second periods), and newly dependent patients showed its keen peak of hospitalization in the third period, the day from 21 to 30 after the earthquake, and kept high incidence of admission thereafter. Independent patients were hospitalized mainly during first 20 days.

Table 3 showed the association of ADL category (independent, newly dependent, and originally dependent) with patient’s age, sex, and diagnosis. Regarding diagnosis, ratio of each disease was calculated in each category. Eleven patients whose ADL was not completely recorded were excluded from the data. Young and male patients were more frequent in order of independent, newly dependent and originally dependent. On investigation in patient’s diagnosis, the

proportion of pneumonia and progression of lung cancer increased in the same order, while the proportion of AE-COPD and asthma decreased.

Discussion

Summary

In this retrospective descriptive and cross-sectional study, we found substantial increase in elderly patients hospitalized for respiratory disease after the earthquake and tsunami. Pneumonia, AE-COPD, and attack of asthma were apparently increased after earthquake. Mean age of patients hospitalized for respiratory disease after the earthquake was significantly higher than that of ordinary years. Majority of patients had poor ADL and many of them experienced deterioration of ADL after the earthquake.

Effect on respiratory disease

Previous reports on Hanshin-Awaji earthquake showed initial rush of patients with injury and following increase of patients with respiratory disease, especially pneumonia[11-13]. Similarly, our observation showed marked increase in pneumonia patients, although initial rush of heavy injury patients was absent in this disaster because majority of victims were drawn to death and heavily injured patients were seldom carried to the hospital.

The cause of increase in respiratory disease was different in each situation. After the 2004 Sumatra-Andaman earthquake and following tsunami, the number of lower respiratory infection in Ache was rapidly increased after the disaster and sharply declined in the second week[14]. On the other hand, after the 1995 Hanshin-Awaji earthquake, the number of patients hospitalized for pneumonia was gradually increased and kept high proportion over the two month[9 10]. This difference is ascribable to the mechanism of developing pneumonia. In Sumatra-Andaman earthquake, many of pneumonia were resulted from aspiration of tsunami-water in near-drowning events[15 16]. Those pneumonias were called “tsunami lung”. On the other hand, in the Hanshin-Awaji earthquake, many patients developed pneumonia in shelters under unhealthy environment and most of them were in elderly. Those pneumonias were called ‘‘shelter pneumonia’’ [17]. In this earthquake and tsunami, we experienced few number of pneumonia directly caused by aspiration of tsunami-water even in very acute period. Most patients came from their own or relative’s home, other hospital, nursing home, or shelter, and a few of the patient directory came from the field. The mean age of them was significantly higher than that of 2010 and 2009. Therefore, we thought most of pneumonia we treated was the same kind of ‘‘shelter pneumonia’’.

AE-COPD was also remarkably increased. COPD was one of the most common chronic respiratory diseases, especially in elderly people. It is well known that interruption of treatment

for chronic disease will easily exacerbate patient's condition, and it is also true after a natural disaster[14 18-20]. Many patients lost their drugs by tsunami flooding, therefore, interruption of regular medication may partly account for the increase in hospitalization by AE-COPD. We also speculate that air pollution caused by tsunami dust may raise the hospitalization by AE-COPD. After cold and snowy weather for ten days from the disaster, cold, sunny, and windy days covered over Ishinomaki region, and dense dust containing tsunami sediment floated in the air for the following three weeks.

Although asthma was also one of the most common chronic respiratory diseases and had the same precipitating cause with COPD, attack of asthma was not so much increased as AE-COPD. This difference might be caused by two important differences between asthma and COPD. First, generally, patients of COPD were older than those of asthma. Therefore, baseline health condition of patients of COPD would be poorer than that of asthma[21]. As a result, COPD patients required more frequent hospitalization. In our study, mean age of AE-COPD was higher than that of attack of asthma as well. Second, bacterial respiratory infection affects patients with COPD more than those with asthma[22]. In the aftermath of earthquake, loss of hygiene and overcrowding in the shelter could increase the risk of respiratory bacterial infection and cause AE-COPD.

Lung cancer related hospitalization did not increase much and its ratio to total hospitalization for respiratory diseases rather declined. Mean age of lung cancer patients was similar to that in the past two years. Maeda et al. also reported that no increase in lung cancer related hospitalization was observed after Hanshin-Awaji earthquake[23]. Progression of lung cancer may not be influenced by environment as much as cancer growth itself. So, the disaster will not impact on lung cancer immediately. Although the interruption of chemotherapy and/or radiotherapy would worsen the prognosis, it cannot be confirmed during our study period.

Effect on ADL

Our observation demonstrated that drastic deterioration of ADL after the disaster resulted in increase in hospitalization by respiratory diseases. In acute phase, patients with poor ADL, especially originally dependent ones, were hospitalized for pulmonary diseases, typically pneumonia; although substantial number of good ADL patients was also hospitalized. After 3 or 4 weeks, many people who deteriorated their ADL (newly dependent) were hospitalized for pulmonary diseases. It was reported that physical disability was an independent risk factor for death in Hanshin-Awaji earthquake and the 1999 Taiwan earthquake[9 10]. However, those reports investigated the mortality in acute phase, not hospitalization in subacute or chronic phase. After the earthquake and tsunami, one fourth of people in Ishinomaki region fled into shelters, many of which were also flooded by tsunami. They lacked water and food under harsh condition of cold season without heating in overcrowded room just letting them lie on the floor without beds.

In such bad condition, elderly people restricted their consumption food and water, and kept still in one space; as a result, they deteriorated their ADLs. In addition, scarcity of water worsened oral hygiene. Both poor functional status and oral hygiene were the major risk factor of pneumonia[24-27], especially in elderly people. Subsequently, many elderly people were hospitalized for "shelter pneumonia" after the earthquake. Also, poor oral hygiene induces swallowing dysfunction[28] and swallowing dysfunction could be a risk factor of exacerbation of COPD[29]. It would be one of the reasons why AE-COPD increased especially in elderly people.

Effect on aging society

According to the report of government of Japan, 93% of the fatalities were drowning and more than 60% of them were 60 years old or more in the Great East Japan earthquake. Although it was reported by many previous reports that elderly people had a greater risk of death after the earthquake, the proportion of elderly people was extremely high in comparison to other major earthquake or tsunami in the world[4-8]. Similar finding was reported only in 1995 Hanshin-Awaji earthquake and 2004 Mid Niigata earthquake in Japan[12 17]. Moreover, 90.8% of the patients hospitalized for respiratory disease after the earthquake were 60 years old or more in our study. These result suggested that elderly people were vulnerable not only immediately after the earthquake but also for a while after the earthquake.

In 1999 Taiwan earthquake, 2003 heat waves in the Czech Republic, and 2004 Sumatra-Andaman earthquake, it is demonstrated that these disasters has left decreased mortality in the stricken area, resulted from a large number of direct death by disasters among a vulnerable population such as elderly people or children[5 30 31] , called "harvesting effect". However, our observation suggests that, in the aging society, a huge disaster not only directly kills the vulnerable people but also newly produces vulnerable people. Previous reports demonstrated that prolonged harmful influence on mental health and psychological slow recovery were seen more frequently in the elderly people than young people[32-35]. Therefore, we should pay a long-term attention on those elderly people after a disaster.

Implications for policy and practice

Our observation suggests two important targets for reducing hospitalization for respiratory disease after the major disaster in aging society. One target is interruption of treatment for chronic respiratory disease and the other target is deterioration of ADL. Interruption of treatment for chronic respiratory disease was preventable by storing the drugs for a few days. However, it is necessary for valid storage to grasp regional prescription data of each drug and patient's personal medication data. Telemedicine system or web-based patient data storage system might be useful. Prevention of deterioration of ADL is also important. Elderly people is potentially vulnerable and easily deteriorate their ADL. In our study, remaining at shelters in

stricken area for more than three weeks led increase in deterioration of ADL and hospitalization for respiratory diseases. Therefore, we propose to transfer elderly people to out of the stricken area as soon as possible.

Strengths and weaknesses of study

Our study had two important strengths. First, the Great East Japan Earthquake hit one of the most advanced aging societies in the world[3]. As the proportion of elderly people continues to increase in not only developed countries but also developing countries, there is an urgent need of information and analysis on the aging society to plan countermeasures against it. Our study will give lessons against natural disaster to all the countries. Secondly, we obtained detailed data of patient's demographics, diagnosis, and ADL in a catastrophic situation. It is because that our hospital has kept its medical function, including electronic medical record system or laboratory systems, while devastating earthquake and tsunami hit Ishinomaki city and almost all medical facilities lost their function, and that stuffs in our hospital has trained for the coming earthquake and has had an strong motivation to record disaster medicine for the future.

Our study is single center study. This might be weakness of our study, but our hospital was the only functional hospital after the earthquake in Ishinomaki medical zone which account for more than 30% of victims of this earthquake. Also, it has been the only hospital which has the department of respiratory medicine and pulmonary specialists in the medical zone. Even in the ordinary time, it accepted almost all of the serious patients with pulmonary diseases who needed hospitalization. Therefore, we think our study well represents impact of the earthquake on pulmonary diseasese[2]. It is also weakness of our study that we analyzed only hospitalized patients. There were a great number of outpatients and a heavy loss of lives. These events will be analyzed in the future report. Another weakness of our study is that cross-sectional study cannot elucidate a causal relationship. Finally, we did not clearly define the condition of hospitalization. Because the destruction of ordinary healthcare system and poor hygiene outside the hospital, we hospitalized some patients who could be treated in outpatient setting in ordinary time. However, this was a real situation after devastating disaster.

Conclusion

The Great East Japan earthquake and following tsunami hit the one of the most advanced aging society in the world. After the disaster, pneumonia, exacerbation of COPD, bronchial asthma attack associated with bad ADL in elderly provoked the most part of hospitalization for pulmonary diseases. These observations should be exploited in constructing emergency medical management for disasters in progressive advanced aging society.

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Competing interests: None declared.

Ethical approval: Approval of ethical review committee of Japanese Red Cross Ishinomaki Hospital was obtained.

Contributors: SY was responsible for study design and interpretation of the data, and drafted the manuscript. MH, SK, HS, ST, and MY were responsible for collection and interpretation of the data. KN drafted the statistical analysis part in the manuscript, and provided suggestions on public health and epidemiology. MH, SK and MY were responsible for study design and revised the drafted manuscript. SY, MH, SK, HS, ST and MY treated the patients. All authors approved the final version of the manuscript.

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Tables

Table 1. Demographics and patient characteristics in 2011 and past two years.

	After the earthquake (2011) n=322	Past two years (2010 and 2011) n=204	p value
All cause			
age (year)	75.7±12.5 *	73.2±13.4	0.03
male	192 (59.6)	137 (67.2)	0.08
Pneumonia			
age	77.6±11.8*	74.3±12.8	0.03
male	111 (58.4)	63 (66.3)	0.20
AE-COPD			
age	76.0±8.7*	69.3±15.9	0.03
male	43 (81.1) *	8 (50.0)	0.01
Asthma			
age	68.7±19.7	67.2±19.4	0.83
male	5 (18.5) *	6 (54.6)	0.03
Lung cancer			
age	74.3±12.1	73.2±16.0	0.79
male	16 (72.7)	18 (66.7)	0.65
Others			
age	70.4±11.6	73.8±11.3	0.19
male	17 (56.7)	42 (76.4)	0.06

AE-COPD, acute exacerbation of COPD.

Data are mean±SD for numerical variables and number (%) for categorical variables. *p<0.05.

Table 2. Association of age and sex with hospitalization for respiratory disease after the earthquake.

	Hospitalization for respiratory disease after the earthquake	
	Unadjusted OR (95% CI)	*Adjusted OR (95% CI)
All cause		
age (year)	1.01† (1.00-1.03)	1.02† (1.00-1.03)
male (reference: female)	0.72 (0.50-1.04)	0.71 (0.19-1.03)
Pneumonia		
age	1.02† (1.00-1.04)	1.02† (1.00-1.04)
male	0.71 (0.42-1.19)	0.74 (0.44-1.23)
AE-COPD		
age	1.05† (1.00-1.11)	1.05 (1.00-1.11)
male	4.30† (1.30-14.66)	4.17 † (1.21-14.84)
Asthma		
age	1.00 (0.97-1.04)	1.00 (0.96-1.05)
male	0.19 † (0.04-0.85)	0.19 † (0.04-0.85)
Lung cancer		
age	1.01 (0.97-1.05)	1.00 (0.96-1.05)
male	1.33 (0.39-4.76)	1.30 (0.37-4.83)
Others		
age	0.97 (0.94-1.01)	0.97 (0.93-1.01)
male	0.40 (0.15-1.05)	0.39 (0.15-1.03)

AE-COPD, acute exacerbation of COPD; OR, odds ratio; CI, confidence interval.

*Adjusted for age and sex with each other. †$p<0.05$

Table 3. Association of ADL with patient's characteristics and respiratory disease.

	Independent n=70	Newly dependent n=104	Originally dependent n=137
Age	69.9±15.1	73.1±11.2	80.3±10.5
Male	49 (70.0)	63 (60.6)	69 (50.4)
Diagnosis			
Pneumonia	31 (44.3)	59 (56.7)	94 (68.6)
AE-COPD	17 (24.3)	17 (16.4)	15 (11.0)
Asthma	11 (15.7)	11 (10.6)	5 (3.7)
Lung cancer	3 (4.3)	6 (5.8)	12 (8.8)
Others	8 (11.4)	11 (8.0)	11 (8.0)

AE-COPD, acute exacerbation of COPD.

Data are mean ±SD for numerical variables and number (%) for categorical variables.

Figure legends

Figure 1. Sequential change of the number of unscheduled hospitalization for all causes (A) and for respiratory disease (B) from March 11 to May 9 in 2011, 2010 and 2009.

Figure 2. The number and proportion of patients hospitalized for respiratory disease from March 11 to May 9 in 2011, 2010, and 2009.

Figure 3. Sequential change of disease distribution of patients hospitalized for respiratory disease after the Great East Japan earthquake.

Figure 4. Influence of the earthquake on the patient's ADL.

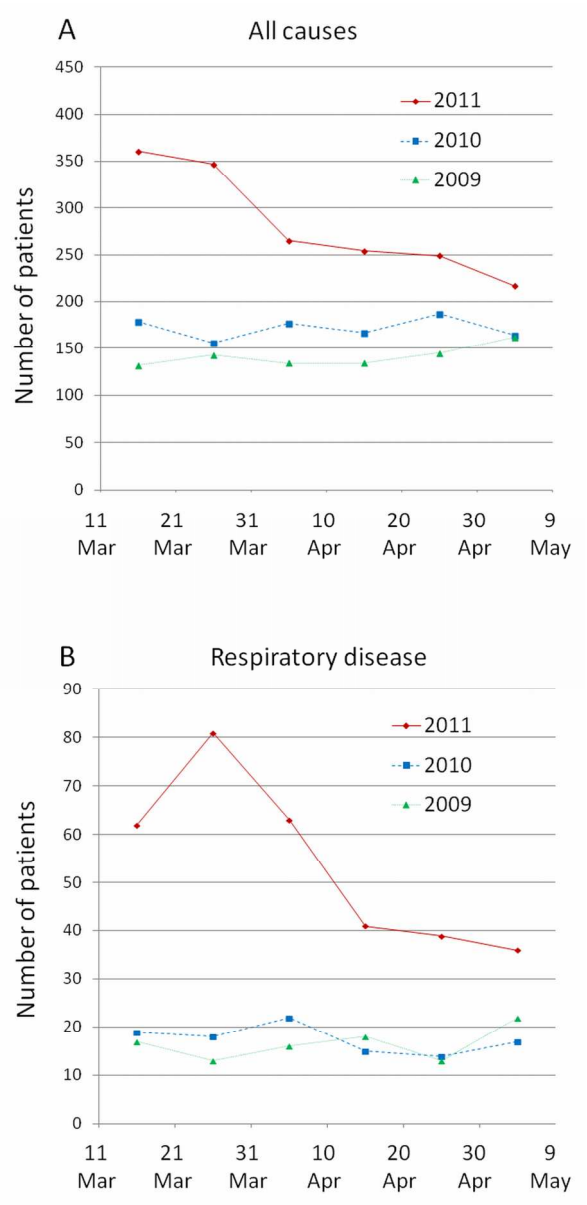
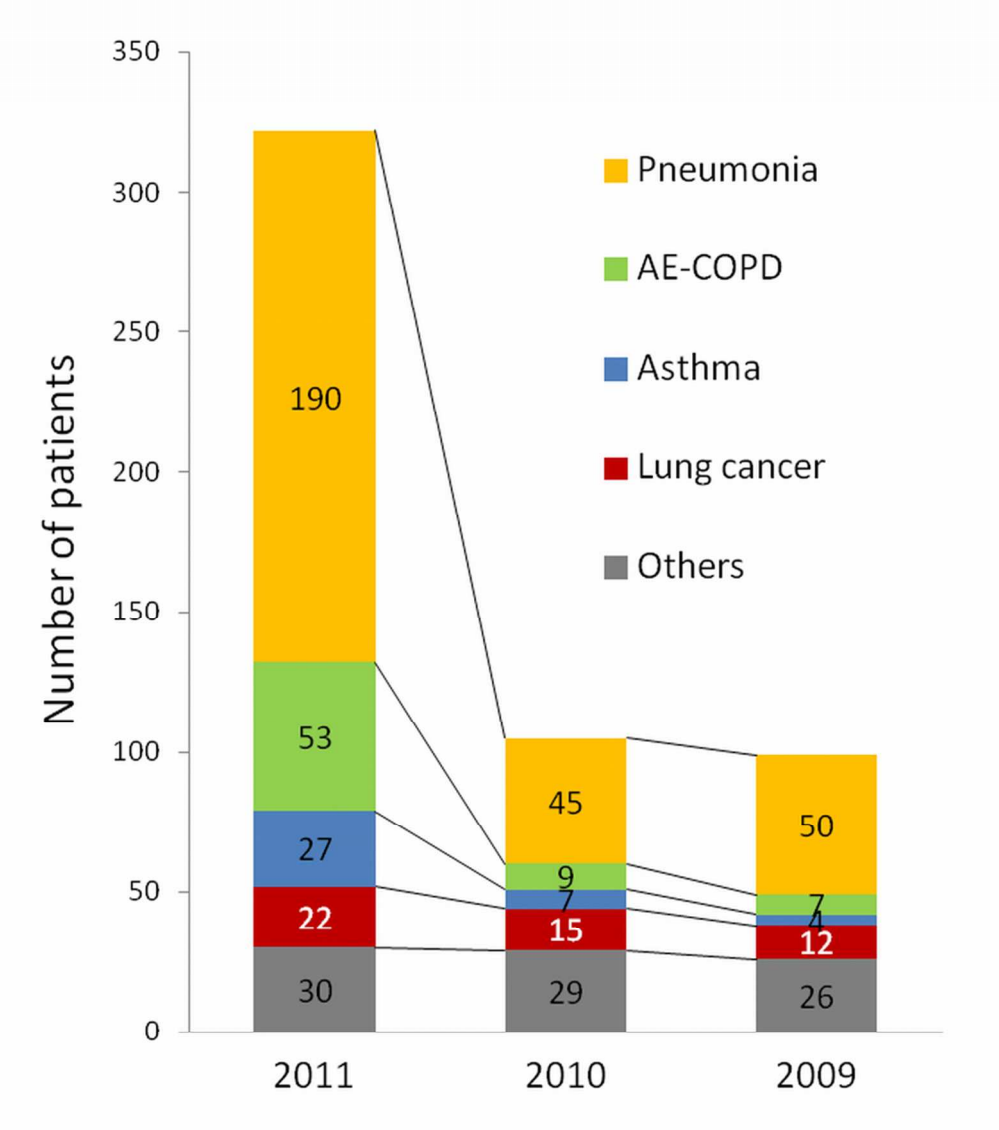


Figure 1. The number of unscheduled hospitalization for all causes (A) and for respiratory disease (B) from March 11 to May 9 in 2009, 2010 and 2011, presented in 10 day bins.
90x185mm (300 x 300 DPI)



90x102mm (300 x 300 DPI)

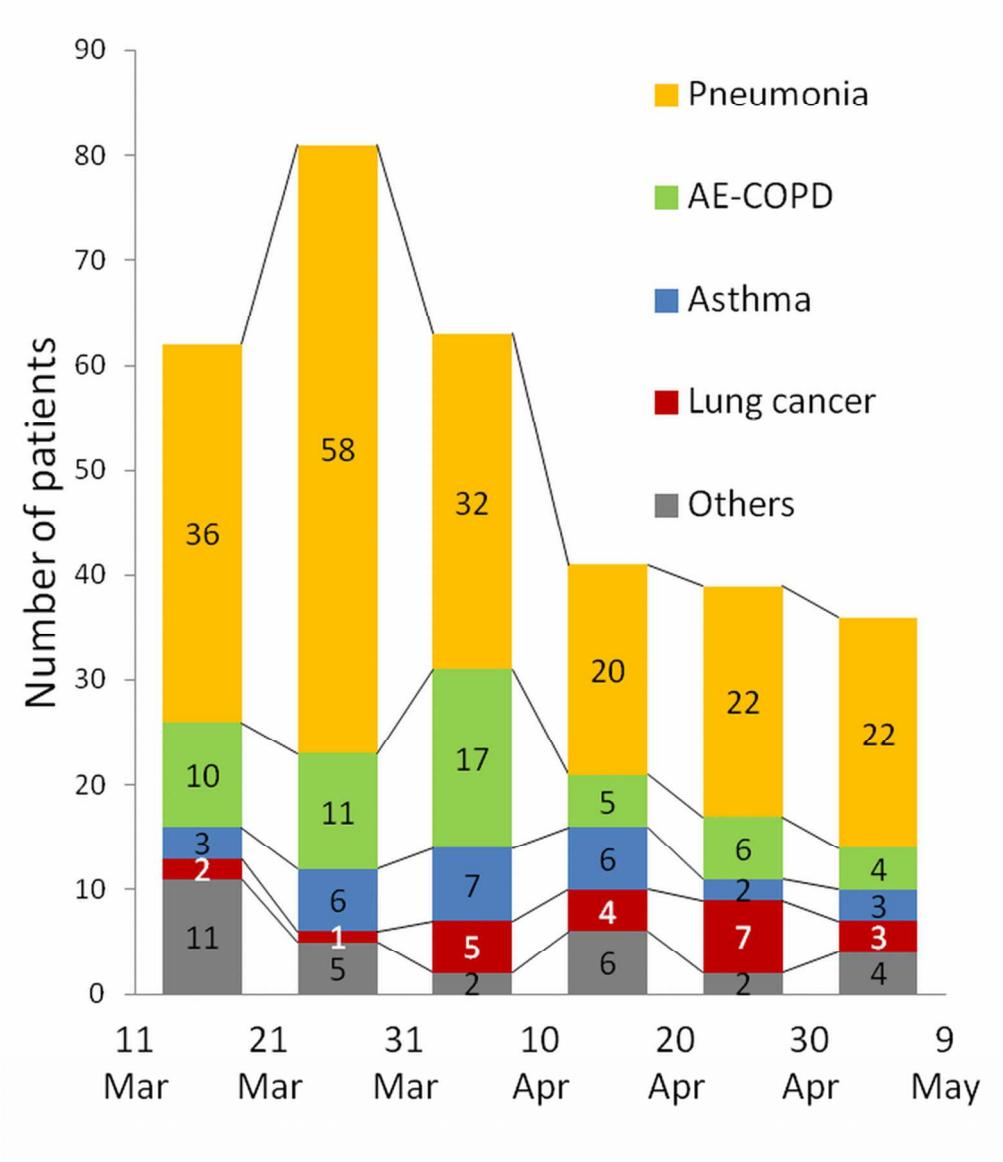
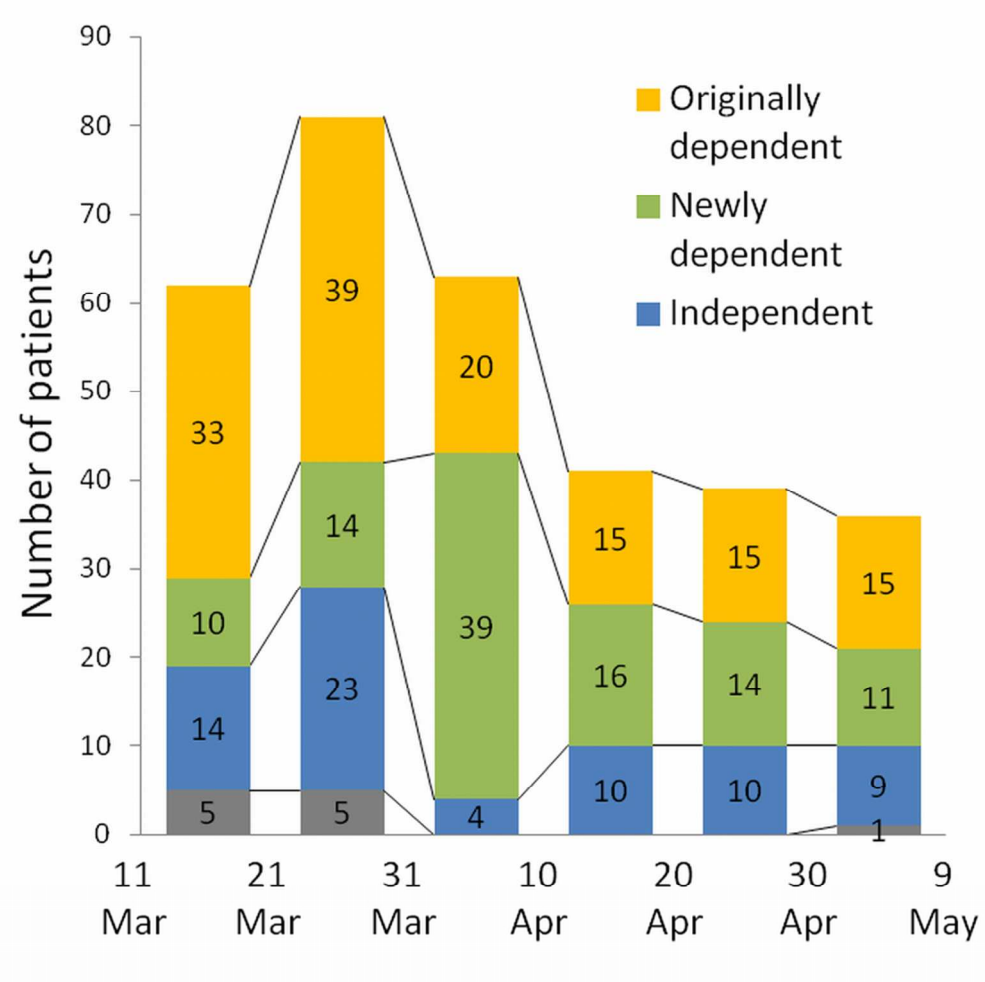


Figure 3. Distribution of patients hospitalized for respiratory disease after the Great East Japan earthquake from March 11 to May 9 in 2011, presented in 10 day bins.
90x104mm (300 x 300 DPI)



90x88mm (300 x 300 DPI)

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2, 3
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3-4
Objectives	3	State specific objectives, including any prespecified hypotheses	3-4
Methods			
Study design	4	Present key elements of study design early in the paper	4-6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	4-6
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	4-6
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	4-6
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	4-6
Bias	9	Describe any efforts to address potential sources of bias	-
Study size	10	Explain how the study size was arrived at	4
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	4, 5
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	5, 6
		(*b*) Describe any methods used to examine subgroups and interactions	-
		(*c*) Explain how missing data were addressed	7
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	-
		(*e*) Describe any sensitivity analyses	-
Results			

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	6
		(b) Give reasons for non-participation at each stage	-
		(c) Consider use of a flow diagram	-
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	6-7 + Table 1
		(b) Indicate number of participants with missing data for each variable of interest	7
Outcome data	15*	Report numbers of outcome events or summary measures	3
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	3 + Table 2
		(*b*) Report category boundaries when continuous variables were categorized	5
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	-
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	-
Discussion			
Key results	18	Summarise key results with reference to study objectives	8
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	11
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	8, 10-11
Generalisability	21	Discuss the generalisability (external validity) of the study results	10-11
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	12

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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The impact of the 2011 Great East Japan Earthquake on hospitalization for respiratory disease in rapidly aging society: a retrospective descriptive and cross-sectional study at the disaster base hospital in Ishinomaki

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Title

The impact of the 2011 Great East Japan Earthquake on hospitalization for respiratory disease in rapidly aging society: a retrospective descriptive and cross-sectional study at the disaster base hospital in Ishinomaki

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Article summary

Article focus

The Great East Japan Earthquake attacked one of the most rapidly aging societies in the world. Respiratory medicine is the major field in gerontology. Here we address how seriously the disaster affected respiratory diseases in the most heavily stricken area, which has one of the highest ratios of elderly people in Japan.

The study gives lessons against natural disasters and aging society.

Key messages

After the earthquake and tsunami, admission from pneumonia and exacerbation of chronic respiratory disease in elderly increased.

Harsh conditions and poor ADL after the disaster may be associated with increase in hospitalization for respiratory diseases in elderly people.

Strengths and limitations of study

We could obtain detailed data of patient even in the catastrophic state.

We analyzed only hospitalized patients. But there were a great number of outpatients as well as heavy loss of lives.

Abstract

Objective

To investigate the impact of the 2011 Great East Japan earthquake on hospitalization for respiratory disease at the disaster base hospital in aging society.

Design

Descriptive and cross sectional study.

Setting

Emergency care in Japanese Red Cross Ishinomaki Hospital, a regional disaster base hospital, Miyagi, Japan.

Participants

322 emergency patients who hospitalized for respiratory disease from March 11 to May 9 in 2011, and 99 and 105 emergency patients who hospitalized in the corresponding period of 2009 and 2010, respectively.

Main outcome measures

Description and comparison of patient's characteristics and disease distribution in terms of age, time after the disaster, and activities of daily living (ADL).

Results

Total number of patients hospitalized in our hospital in the study period was 1769 (850 in 2009, 1030 in 2010), and the number of hospitalized for respiratory disease in them was 322 (99 in 2009, 105 in 2010). Among admission for pulmonary diseases, pneumonia was the most frequent disease (n=190, 59.0%), followed by acute exacerbation of chronic obstructive disease (AE-COPD) (n=53, 16.5%), attack of asthma (n=27, 8.4%), and progression of lung cancer (n=22, 6.8%). Compared with the corresponding period of 2009 or 2010, increase in absolute number of hospitalization was the highest for pneumonia, followed by AE-COPD and attack of asthma. At hospitalization, 195 patients were "dependent" and 54 patients were "partially dependent". Respiratory admission accompanied by deterioration of ADL after the disaster was more frequent in elderly and female patients.

Conclusions

After the Great East Japan Earthquake, admission for pneumonia and exacerbation of chronic respiratory disease in elderly increased at the disaster base hospital.

Introduction

On March11, 2011, at 2:46 pm Japan time, the Pacific coast of Japan's Tohoku (northeastern) region was struck by the massive earthquake (The Great East Japan Earthquake), measuring magnitude 9.0 on the Richter scale[1]. The earthquake triggered a devastating tsunami which destroyed many towns and villages near the seashore. The epicenter was estimated to be about 70 kilometers east of Oshika Peninsula of Ishinomaki in Miyagi. Officially, over 19,000 people were killed or missing and the maximum number of refugees reached more than 550,000[2].

Ishinomaki city, located in Pacific coast of Honshu Island, suffered from the largest number of victims in Japan, 3,280 people were killed and 669 people were still missing. A great number of casualties, more than 10,000 patients in the first 30 days, were treated at Japanese Red Cross Ishinomaki Hospital, a regional disaster base hospital in Ishinomaki which uniquely preserved its hospital function in Ishinomaki region during and after the disaster.

Japan is one of the most rapidly aging society in the world. 23% of Japanese citizens were age 65 or over in 2010[3]. Tohoku region is especially rapidly aging society in Japan, 26.6% of people living in Ishinomaki city were age 65 or over in 2010. Although several reports showed the significant association between age and earthquake and tsunami death[4-8], there were few reports investigating the impact of a tremendous disaster on elderly peoples in such an aging society[9 10]. Respiratory diseases are common in the elderly even in ordinary times. So, investigating the impact of the disasters on respiratory health will contribute to elucidating the problem of aging society. Thus, we performed retrospective descriptive and cross-sectional analysis of the medical and epidemiologic data of the patient required hospitalization for respiratory disease after the Great East Japan Earthquake and following tsunami.

Methods

This study was a retrospective descriptive and cross-sectional analysis of the data obtained from the medical records at Japanese Red Cross Ishinomaki Hospital. We reviewed medical records of patients admitted to the hospital for respiratory diseases during the first 60 days after the Great East Japan Earthquake, when the hospital solely accepted emergency patients. We also reviewed medical records of patients who required unscheduled hospitalization for respiratory disease in the corresponding period of 2009 and 2010.

Japanese Red Cross Ishinomaki Hospital which had 402 beds for inpatients was located at 4.5 km inland from Pacific Ocean. It has covered about 220,000 people living in its medical zone (Ishinomaki City, Onagawa Town, and Higashi-matsushima City) and assigned to a regional disaster base hospital. It has accepted almost all of the emergency respiratory patients even in the ordinary time before the disaster, because it has been the unique hospital having the

respiratory department and pulmonary specialists in the region.

Medical records were investigated in terms of date of admission, age, sex, diagnosis. We also investigated activities of daily living (ADL) at hospitalization and ADL before earthquake, and their residence before admission on the medical record of 2011 study period. For comparison, the total number of unscheduled hospitalization during the corresponding periods in 2009 and 2010 was counted.

Pneumonia was defined as the presence of the infiltration on chest radiograph along with one or more of the following symptoms or signs: fever, cough, sputum production, breathlessness, pleuritic chest pain or signs consistent with pneumonia on auscultation.

Chronic obstructive pulmonary disease (COPD) and bronchial asthma were detected by the previous spirometric data, patient's self-report, or physician's diagnosis made by patient's history, physical examination, and radiological finding. An acute exacerbation of COPD(AE-COPD) was defined as an increase in or new onset of more than one symptom of COPD (cough, sputum, wheezing, dyspnea or chest tightness) without pneumonia or pneumothorax. An attack of asthma was defined as the presentation of wheezes or severe cough in asthma patients without pneumonia. Progression of lung cancer was defined as requirement for admission for lung cancer associated condition such as dehydration, respiratory failure, or uncontrolled pain. Obstructive pneumonia due to lung cancer was considered as progression of lung cancer. Chest trauma and traumatopnea were not considered as respiratory disease but chest injury.

ADL was assessed by the information from a patient, patient's family, or patient's caregiver, and classified into three categories; "independent" who could live without particular support, "partially dependent" who could not leave their residence without any support, "dependent" who spent a day on the bed or the wheelchair and lost the ability to move for themselves. To investigate the impact of the disaster on ADL, we defined as "originally dependent" who were dependent or partially dependent before the disaster, and as "newly dependent" who became dependent or partially dependent after the disaster.

Data analysis

All data were entered into a personal computer and analyzed using Microsoft ™ Excel software and statistical analysis was performed using JMP9 (SAS Institute Inc., Cary, NC, USA). A missing value in medical record was treated as "unknown". Results were given as mean ± SD for numerical variables and as proportions for categorical variables. To analyze sequential change of the effect of the disaster, we divided 60 days of study period into six groups of ten day bins. To investigate the risk of hospitalization for respiratory disease after the earthquake and tsunami, we compared the patient's characteristics of 2011 study period with the combined

data of 2009 and 2010 corresponding period as ordinary time. We used two-sided Student's *t*-test for numerical variables and chi-square test for the categorical variables. The p <0.05 is accepted as statistically significant.

Result

All of the scheduled hospitalization was cancelled and emergency admission was solely accepted during the first 60 day after the earthquake at Japanese Red Cross Ishinomaki Hospital. 1,769 patients admitted to the hospital, and 322 of them were hospitalized for respiratory disease during the study period. In the corresponding period, total number of unscheduled hospitalization was 850 and that for respiratory disease was 99 in 2009 and 1,030 and 105 in 2010. Patients hospitalized for respiratory disease accounted for 18.2% of total hospitalization during the study period. This proportion was significantly higher than that of 2009 and 2010 (11.6% in 2009. P<0.001. 10.2% in 2010. P<0.001). While the number of total hospitalizations of this period in 2011 was about twice of that in 2009 and 2010, hospitalization for respiratory disease in 2011 reached about three times or more than that of 2009 and 2010. The total number of hospitalizations was peaked in the first ten days, but the number of hospitalization for respiratory disease kept increasing for 20 days (Figure 1A and B).

We compared the number and proportion of patients hospitalized for respiratory disease between 2011, 2010, and 2009 study periods (Figure 2). Pneumonia was the most frequent disease (n=190, 59.0%), followed by AE-COPD (n=53, 16.5%), attack of asthma (n=27, 8.4%), and progression of lung cancer (n=22, 6.8%). One case of AE-COPD and seven cases of attack of asthma were physician's diagnosis. Category "Others" included pneumothorax, restrictive thoracic disease, pleural effusion, influenza, drowning, primary pulmonary hypertension, requirement of mechanical ventilator support for neuromuscular disease, and so on. One patient diagnosed as pneumonia was complicated by attack of asthma and two patients of pneumonia exacerbated their symptom of COPD. They were treated for both conditions and counted as pneumonia. In comparison with the past two years, the increase in number of hospitalizations was the largest for pneumonia, followed by AE-COPD and attack of asthma. The number of hospitalization for progression of lung cancer and that for "others" were not so different from the past two years. 39.4% of patients were hospitalized from emergency shelters.

To investigate the disease specific effect of earthquake, age and sex of each disease were compared between the study period in 2011 and the corresponding period in the past two years. The mean age of patients hospitalized for respiratory disease was significantly higher in 2011 than in the past two years (75.7±12.5 v.s. 73.2±13.4 years old. p=0.03). Male proportion tended to be lower in 2011 than in the past two years (59.6% in 2011, 67.2% in 2010 and 2009. p=0.08).

Specifically, pneumonia patients and AE-COPD patients were significantly older in 2011 study period than in 2010 and 2009 corresponding period(77.6±11.8 v.s. 74.3±12.8 years old in pneumonia patients. p=0.03. 76.0±8.7 v.s. 69.5±15.9 years old in AE-COPD patients. p=0.03). Male population of AE-COPD was significantly higher (81.1% v.s. 50.0%. p=0.01), whereas that of asthma attack significantly lower in 2011 period than 2010 and 2009 periods (18.5% v.s. 54.6%. p=0.03).

Actual numbers of hospitalization for the main respiratory diseases in terms of every ten day bins during the study period is shown in Figure 3. Pneumonia peaked in the second 10 day bin. Following pneumonia, AE-COPD and attack of asthma peaked in the third 10 day bin.Progression of lung cancer had its peak in the fifth 10 day bin.

Next, we investigated ADL at hospitalization and ADL before the disaster among the patients hospitalized in 2011 study period. Because of confusing situation of medical activities after the disaster, ADL was not recorded in 11 patients At hospitalization, 195 patients (60.5%) were "dependent" and 54 patients (16.7%) were "partially dependent". On the other hand, before earthquake, only 86 patients (26.7%) were "dependent" and 51 patients (15.8%) were "partially dependent". To investigate the impact of ADL and its deterioration on admission for pulmonary disease in terms of time after the disaster, we counted the number of the patients who were "originally dependent", "newly dependent", or "independent throughout" during 60 days presented in 10 day bins (Figure 4). Throughout the study period, majority of patients were dependent or partially dependent patient. In the first 20 days, the majority of admissions were for originally dependent people. After 30days, there was a sharp increase in newly dependent people, as assessed by ADL. Independent patients were hospitalized mainly during first 20 days.

Table 1 showed the association of ADL category (independent throughout, newly dependent, and originally dependent) with patient's age, sex, and diagnosis. Regarding diagnosis, ratio of each disease was calculated in each category. Eleven patients whose ADL was not completely recorded were excluded from the data. Young and male patients were more frequent in order of independent, newly dependent and originally dependent. On investigation in patient's diagnosis, the proportion of pneumonia and progression of lung cancer increased in the same order, while the proportion of AE-COPD and asthma decreased.

Discussion

Summary

In this retrospective descriptive and cross-sectional study, we found substantial increase in elderly patients hospitalized for respiratory disease after the earthquake and tsunami. Pneumonia,

AE-COPD, and attack of asthma were apparently increased after earthquake. Mean age of patients hospitalized for respiratory disease after the earthquake was significantly higher than that of corresponding periods of the past two years. Majority of patients had poor ADL and many of them experienced deterioration of ADL after the earthquake.

Effect on respiratory disease

Previous reports on Hanshin-Awaji earthquake showed initial rush of patients with injury and following increase of patients with respiratory disease, especially pneumonia[11-13]. Similarly, our observation showed marked increase in pneumonia patients, although initial rush of heavy injury patients was absent in this disaster because majority of victims were drowned to death and heavily injured patients were seldom carried to the hospital.

The cause of increase in respiratory disease was different in each situation. After the 2004 Sumatra-Andaman earthquake and following tsunami, the number of lower respiratory infection in Ache was rapidly increased after the disaster and sharply declined in the second week[14]. On the other hand, after the 1995 Hanshin-Awaji earthquake, the number of patients hospitalized for pneumonia was gradually increased and kept high proportion over the two month[9 10]. This difference is ascribable to the mechanism of developing pneumonia. In Sumatra-Andaman earthquake, many of pneumonia were resulted from aspiration of tsunami-water in near-drowning events[15 16]. Those pneumonias were called "tsunami lung". On the other hand, in the Hanshin-Awaji earthquake, many patients developed pneumonia in shelters under unhealthy environment and most of them were in elderly. Those pneumonias were called ''shelter pneumonia'' [17]. In this earthquake and tsunami, we experienced few number of pneumonia directly caused by aspiration of tsunami-water even in the very acute period. A few of the patient directory came from the field, instead, most patients came from shelters, their own or relative's homes, other hospitals, or nursing homes. The mean age of them was significantly higher than that of 2010 and 2009. Therefore, we regarded most of pneumonia we treated as the same kind of ''shelter pneumonia''.

AE-COPD was also remarkably increased. COPD was one of the most common chronic respiratory diseases, especially in elderly people. It is well known that interruption of treatment for chronic disease will frequently exacerbate patient's condition, and it is also true after a natural disaster[14 18-20]. Many patients lost their drugs by tsunami flooding, therefore, interruption of regular medication may partly account for the increase in hospitalization by AE-COPD. Sunny and windy days lasted from the end of March and dust from the tsunami sludge was an important component of particulate air pollution; it may have contributed to the significant increase in hospitalization by AE-COPD.

Although asthma was also one of the most common chronic respiratory diseases and had the

same precipitating cause with COPD, attack of asthma was not so much increased as AE-COPD. This difference might be caused by two important differences between asthma and COPD. First, generally, patients of COPD were older than those of asthma. Therefore, baseline health condition of patients of COPD would be poorer than that of asthma[21]. As a result, COPD patients required more frequent hospitalization. In our study, mean age of AE-COPD was higher than that of attack of asthma as well. Second, bacterial respiratory infection affects patients with COPD more than those with asthma[22]. In the aftermath of earthquake, loss of hygiene and overcrowding in the shelter could increase the risk of respiratory bacterial infection and cause AE-COPD.

Hospitalization for lung cancer related symptons did not increase much and its ratio to total hospitalization for respiratory diseases rather declined. Mean age of lung cancer patients was similar to that in the past two years. Maeda et al. also reported that no increase in lung cancer related hospitalization was observed after Hanshin-Awaji earthquake[23]. Progression of lung cancer may not be influenced by environment as much as cancer growth itself. So, the disaster will not impact on lung cancer immediately. Although the interruption of chemotherapy and/or radiotherapy would worsen the prognosis, it cannot be confirmed during our study period.

Effect on ADL

In acute phase, patients with poor ADL, especially those originally dependent, were hospitalized for pulmonary diseases, typically pneumonia, although substantial number of good ADL patients was also hospitalized. After 3 weeks, there was a sharp increase in newly dependent people who deteriorated their ADL after the disaster. It was reported that physical disability was an independent risk factor for death in Hanshin-Awaji earthquake and the 1999 Taiwan earthquake[9 10]. However, those reports investigated the mortality in acute phase, not hospitalization in subacute or chronic phase. After the earthquake and tsunami, one fourth of people in Ishinomaki region fled into shelters, many of which were also flooded by tsunami. They lacked water and food under harsh condition of cold season without heating in overcrowded quarter just letting them lie on the floor without beds. In such bad conditions, elderly people were restricted their consumption food and water, and kept still in a small space, resulting in deterioration of ADL. In addition, scarcity of water worsened oral hygiene. Both poor functional status and loss of oral hygiene were the major risk factor of pneumonia[24-27], especially in elderly people. Subsequently, many elderly people were hospitalized for “shelter pneumonia” after the earthquake. Also, poor oral hygiene induces swallowing dysfunction[28] and swallowing dysfunction could be a risk factor of exacerbation of COPD[29]. It would be one of the reasons why AE-COPD increased especially in elderly people.

Effect on aging society

According to the report of government of Japan, 93% of the fatalities were drowning and more than 60% of them were over 60 years old in the Great East Japan earthquake. Although it was reported by many previous reports that elderly people had a greater risk of death after the earthquake, the proportion of the elderly killed by this earthquake and tsunami was extremely high in comparison to other major earthquake or tsunami in the world[4-8]. Similar finding was reported only in 1995 Hanshin-Awaji earthquake and 2004 Mid Niigata earthquake in Japan[12 17]. Moreover, 90.8% of the patients hospitalized for respiratory disease after the earthquake were over 60 years old in our study. These results suggest that elderly people were vulnerable not only immediately after the earthquake but also for a while after the earthquake.

In 1999 Taiwan earthquake, 2003 heat waves in the Czech Republic, and 2004 Sumatra-Andaman earthquake, it is demonstrated that these disasters has left decreased mortality in the stricken area, resulted from a large number of direct death by disasters among a vulnerable population such as elderly people or children[5 30 31] , called "harvesting effect". However, our observation suggests that, in the aging society, a huge disaster not only directly kills the vulnerable people but also produces new vulnerable people. Previous reports demonstrated that prolonged harmful influence on mental health and psychological slow recovery were seen more frequently in the elderly people than young people[32-35]. Therefore, we should pay a long-term attention on those elderly people after a disaster.

Implications for policy and practice

Our observation suggests two important targets for reducing hospitalization for respiratory disease after the major disaster in aging society. One target is interruption of treatment for chronic respiratory disease and the other target is deterioration of ADL. Interruption of treatment for chronic respiratory disease was preventable by storing the drugs for a few days. However, it is necessary to establish the system of valid storage to grasp regional prescription data of each drug and patient's personal medication data. Telemedicine system or web-based patient data storage system might be useful. Prevention of deterioration of ADL is also important. Elderly people are potentially vulnerable and easily deteriorate their ADL. In our study, remaining at shelters in stricken area for more than three weeks led increase in deterioration of ADL and hospitalization for respiratory diseases. Therefore, we propose to evacuate elderly people out of the stricken area as soon as possible.

Strengths and weaknesses of study

Our study had two important strengths. First, the Great East Japan Earthquake hit one of the most rapidly aging societies in the world[3]. As the proportion of elderly people continues to

increase in not only developed but also developing countries, there is an urgent need of information and analysis on the aging society to plan countermeasures against it. Our study will give lessons against natural disaster to all the countries. Secondly, we obtained detailed data of patient's demographics, diagnosis, and ADL in a catastrophic situation. It is because that our hospital has kept its medical function, including electronic medical record system or laboratory systems, while devastating earthquake and tsunami hit Ishinomaki city and almost all medical facilities lost their function, and that stuffs in our hospital has trained for the coming earthquake and has had an strong motivation to record our experiences as memos or on digital recorders for future disaster medicine.

Our study is single center study. This might be weakness of our study, but our hospital was the only functional hospital after the earthquake in Ishinomaki medical zone which account for more than 30% of total fatalities of this earthquake in Japan. Also, it has been the only hospital which has the department of respiratory medicine and pulmonary specialists in the medical zone. Even in the ordinary time before the disaster, it accepted almost all of the serious patients with pulmonary diseases who needed hospitalization. Therefore, we think our study well represents impact of the earthquake on pulmonary diseases and describes what happened in the hospital which faced the earthquake at the front[2]. It is also weakness of our study that we analyzed only hospitalized patients. There were a great number of outpatients and a heavy loss of lives. These events will be analyzed in the future report. Another weakness of our study is that cross-sectional study cannot elucidate a causal relationship. Finally, we did not clearly define the condition of hospitalization. Because the destruction of ordinary healthcare system and poor hygiene outside the hospital, we hospitalized some patients who could be treated in outpatient setting in ordinary time. However, this was a real situation after devastating disaster.

Conclusion

The Great East Japan earthquake and following tsunami hit the one of the most rapidly aging society in the world. After the disaster, pneumonia, exacerbation of COPD, bronchial asthma attack associated with bad ADL in the elderly provoked the most part of increase in hospitalization for pulmonary diseases. These observations should be exploited in constructing emergency medical management for disasters in progressive rapidly aging society.

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Competing interests: None declared.

Ethical approval: Approval of ethical review committee of Japanese Red Cross Ishinomaki Hospital was obtained.

Contributors: SY was responsible for study design and interpretation of the data, and drafted the manuscript. MH, SK, HS, ST, and MY were responsible for collection and interpretation of the data. KN drafted the statistical analysis part in the manuscript, and provided suggestions on public health and epidemiology. MH, SK and MY were responsible for study design and revised the drafted manuscript. SY, MH, SK, HS, ST and MY treated the patients. All authors approved the final version of the manuscript.

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Table

Table 1. Association of ADL with patient's characteristics and respiratory disease.

	Independent n=70	Newly dependent n=104	Originally dependent n=137
Age	69.9±15.1	73.1±11.2	80.3±10.5
Male	49 (70.0)	63 (60.6)	69 (50.4)
Diagnosis			
Pneumonia	31 (44.3)	59 (56.7)	94 (68.6)
AE-COPD	17 (24.3)	17 (16.4)	15 (11.0)
Asthma	11 (15.7)	11 (10.6)	5 (3.7)
Lung cancer	3 (4.3)	6 (5.8)	12 (8.8)
Others	8 (11.4)	11 (8.0)	11 (8.0)

AE-COPD, acute exacerbation of COPD.

Data are mean ±SD for numerical variables and number (%) for categorical variables.

Figure legends

Figure 1. The number of unscheduled hospitalization for all causes (A) and for respiratory disease (B) from March 11 to May 9 in 2009, 2010 and 2011, presented in 10 day bins.

Figure 2. The number and proportion of patients hospitalized for respiratory disease from March 11 to May 9 in 2009, 2010, and 2011, presented in 10 day bins.

Figure 3. Distribution of patients hospitalized for respiratory disease after the Great East Japan earthquake from March 11 to May 9 in 2011, presented in 10 day bins.

Figure 4. Influence of the disaster on ADL status and its deterioration in hospitalized patients for respiratory disease from March 11 to May 9 in 2011, presented in 10 day bins.

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Title

The impact of the 2011 Great East Japan Earthquake on hospitalization for respiratory disease in ~~advanced~~rapidly aging society: a retrospective descriptive and cross-sectional study at the disaster base hospital in Ishinomaki

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Article summary

Article focus

The Great East Japan Earthquake attacked one of the most ~~advanced~~rapidly aging societies in the world. Respiratory medicine is the major field in gerontology. Here we address how seriously the disaster affected respiratory diseases in the most heavily stricken area, which has one of the highest ratios of elderly people in Japan.

The study gives lessons against natural disasters and aging society.

Key messages

After the earthquake and tsunami, admission from pneumonia and exacerbation of chronic respiratory disease in elderly increased.

Harsh conditions and poor ADL after the disaster may be associated with increase in hospitalization for respiratory diseases in elderly people.

Strengths and limitations of study

We could obtain detailed data of patient even in the catastrophic state.

We analyzed only hospitalized patients. But there were a great number of outpatients as well as heavy loss of lives.

Abstract

Objective

To investigate the impact of the 2011 Great East Japan earthquake on hospitalization for respiratory disease at the disaster base hospital in aging society.

Design

Descriptive and cross sectional study.

Setting

Emergency care in Japanese Red Cross Ishinomaki Hospital, a regional disaster base hospital, Miyagi, Japan.

Participants

322 emergency patients who hospitalized for respiratory disease from March 11 to May 9 in 2011, and 99 and 105~~204~~ emergency patients who hospitalized in the corresponding ~~time~~ period of 2009 and 2010, respectively.

Main outcome measures

Description and comparison of patient's characteristics and disease distribution in terms of age, time after the disaster, and activities~~y~~ of daily living (ADL).

Results

Total number of patients hospitalized in our hospital in the study period was 1769 (~~1y 1,769~~850 in 2009, 1030 in 2010), and the ~~patients admitted to our hospital, and~~ number of hospitalized for respiratory disease in them was 322 (99 in 2009, 105 in 2010). ~~322 of them were hospitalized for respiratory disease during the first 60 days after the earthquake. Mean age of patient was 75.7±12.5 years old.~~Among admission for pulmonary diseases, p~~P~~neumonia was the most frequent disease (n=190, 59.0%), followed by acute exacerbation of chronic obstructive disease (AE-COPD) (n=53, 16.5%), attack of asthma (n=27, 8.4%), and progression of lung cancer (n=22, 6.8%). Compared with the corresponding period of 2009 or 2010, increase in absolute number of hospitalization was the highest for pneumonia, followed by AE-COPD and attack of asthma. ~~Elderly patients were more likely hospitalized after the earthquake, especially for pneumonia and AE-COPD.~~ At hospitalization, 195 patients were "dependent" and 54 patients were "partially dependent". Respiratory admission accompanied by deterioration ~~Deterioration~~ of ADL after the disaster was more frequent in elderly and female patients.

~~The mean age was 73.1±11.2 years old in the patients with deterioration of ADL and 69.9±15.1 in the patients without deterioration of ADL. The male proportion was 60.6% in the patients with deterioration of ADL and 70% in the patients without deterioration of ADL.~~

Conclusions

After the Great East Japan Earthquake, admission for pneumonia and exacerbation of chronic respiratory disease in elderly increased at the disaster base hospital.

Introduction

On March11, 2011, at 2:46 pm Japan time, the Pacific coast of Japan's Tohoku (northeastern) region was struck by the massive earthquake (The Great East Japan Earthquake), measuring magnitude 9.0 on the Richter scale[1]. The earthquake triggered a devastating tsunami which destroyed many towns and villages near the seashore. The epicenter was estimated to be about 70 kilometers east of Oshika Peninsula of Ishinomaki in Miyagi. Officially, over 19,000 people were killed or missing and the maximum number of refugees reached more than 550,000[2].

Ishinomaki city, located in Pacific coast of Honshu Island, suffered from the largest number of victims in Japan, 3,280 people were killed and 669 people were still missing. A great number of casualties, more than 10,000 patients in the first 30 days, were treated at Japanese Red Cross Ishinomaki Hospital, a regional disaster base hospital in Ishinomaki which uniquely preserved its hospital function in Ishinomaki region during and after the disaster.

Japan is one of the most rapidly ~~advanced~~ aging society in the world. 23% of Japanese citizens were age 65 or over~~years old or more~~ in 2010[3]. ~~Especially,~~ Tohoku region is especially rapidly ~~a highly advanced~~ aging society in Japan, 26.6% of people living in Ishinomaki city were age 65 or over~~years old or more~~ in 2010~~1~~. Although several reports showed the significant association between age and earthquake and tsunami death[4-8], there were few reports investigating the impact of a tremendous disaster on elderly peoples in~~–~~ such an aging society[9] [10].

Respiratory diseases are common in the elderly ~~people~~ even in ordinary times. So, investigating the impact of the disasters on respiratory health will contribute to elucidating the problem of aging society. Thus, we performed retrospective descriptive and cross-sectional analysis of the medical and epidemiologic data of the patient ~~requiring~~required hospitalization for respiratory disease after the Great East Japan Earthquake and following tsunami.

Methods

This study was a retrospective descriptive and cross-sectional analysis of the data obtained from

the medical records at Japanese Red Cross Ishinomaki Hospital. We reviewed medical records of patients admitted to the hospital for respiratory diseases during the first 60 days after the Great East Japan Earthquake, when the hospital solely accepted emergency patients. We also reviewed medical records of patients who required unscheduled hospitalization for respiratory disease in the corresponding period of 2009 and 2010.

Japanese Red Cross Ishinomaki Hospital which had 402 beds for inpatients was located at 4.5 km inland from Pacific Ocean. It has covered about 220,000 people living in its medical zone (Ishinomaki City, Onagawa Town, ~~or~~and Higashi-matsushima City) and assigned to a regional disaster base hospital. It has ~~received~~accepted almost all of the emergency respiratory patients even in the ordinary time before the disaster, because it ~~is~~has been the unique hospital having the respiratory department and pulmonary specialists in the region.

Medical records were investigated in terms of date of admission, age, sex, diagnosis. We also investigated activities~~activity~~ of daily living (ADL) at hospitalization and ADL before earthquake, and their residence before admission on the medical record of 2011 study period. For comparison, the total number of unscheduled hospitalization ~~to the hospital~~ during the corresponding periods in 2009 and 2010 was counted.

Pneumonia was defined as the presence of the infiltration on chest radiograph along with one or more of the following symptoms or signs: fever, cough, sputum production, breathlessness, pleuritic chest pain or signs consistent with pneumonia on auscultation.

Chronic obstructive pulmonary disease (COPD) and bronchial asthma were detected by the previous spirometric data, patient's self-report, or physician's diagnosis made by patient's history, physical examination, and radiological finding. An acute exacerbation of COPD(AE-COPD) was defined as an increase in or new onset of more than one symptom of COPD (cough, sputum, wheezing, dyspnea or chest tightness) without pneumonia or pneumothorax. An attack of asthma was defined as the presentation of wheezes or severe cough in asthma patients without pneumonia. Progression of lung cancer was defined as requirement for admission for lung cancer associated condition such as dehydration, respiratory failure, or uncontrolled pain. Obstructive pneumonia due to lung cancer was considered as progression of lung cancer. Chest trauma and traumatopnea were not considered as respiratory disease but chest injury.

ADL was assessed by the information from a patient, patient's family, or patient's caregiver, and classified into three categories; "independent" who could live without particular support, "partially dependent" who could not leave their residence without any support, "dependent" who spent a day on the bed or the wheelchair and lost the ability to move for themselves. ~~Furthermore~~To investigate the impact of the disaster on ADL, we defined as "originally dependent" who were dependent or partially dependent before the disaster, and as "newly

dependent" who became dependent or partially dependent after the disaster.

Data analysis

All data were entered into a personal computer and analyzed using Microsoft ™ Excel software and statistical analysis was performed using JMP9 (SAS Institute Inc., Cary, NC, USA). A missing value in medical record was treated as "unknown". Results were given as mean ± SD for numerical variables and as proportions for categorical variables. To analyze sequential change of the effect of the disaster, we divided 60 days of study period into six groups of ~~each~~ ten day~~s~~ bins. To investigate the risk of hospitalization for respiratory disease after the earthquake and tsunami, we compared the patient's characteristics of 2011 study period with the ~~that of~~ combined data of~~2010 and 2009~~ 2009 and 2010 corresponding period as ordinary time. We used two-sided Student's *t*-test for numerical variables and chi-square test for the categorical variables. ~~We calculated the effect of age and sex on the odds ratio for hospitalization for respiratory disease after the earthquake by logistic regression models.~~ The p <0.05 is accepted as statistically significant.

Result

All of the scheduled hospitalization was cancelled and emergency admission was solely accepted during the first 60 day after the earthquake at Japanese Red Cross Ishinomaki Hospital. 1,769 patients admitted to the hospital, and 322 of them were hospitalized for respiratory disease during the study period. ~~Patients hospitalized for respiratory disease accounted for 18.2% of total hospitalization during the study period.~~ In the corresponding period, total number of unscheduled hospitalization was 850 and that for respiratory disease was 99 in 2009 and 1,030 and 105 in 2010. Patients hospitalized for respiratory disease accounted for 18.2% of total hospitalization during the study period. This proportion was significantly higher than that of 2009 and 2010 (11.6% in 2009. P<0.001. 10.2% in 2010. P<0.001).~~the corresponding period of past two years, 10.2% of 2010 and 11.6% of 2009.~~ While the number of total hospitalizations of this period in 2011 was about twice of that in 2009 and 2010, hospitalization for respiratory disease in 2011 reached about three times or more than that of 2009 and 2010. The total number of hospitalizations was ~~at peak~~peaked in the first ten days ~~and then decreased~~, but the number of hospitalization for respiratory disease kept increasing for 20 days (Figure 1A and B).

We compared the number and proportion of patients hospitalized for respiratory disease~~disease distribution~~ between 2011, 2010, and 2009 study periods (Figure 2). Pneumonia was the most

frequent disease (n=190, 59.0%), followed by AE-COPD (n=53, 16.5%), attack of asthma (n=27, 8.4%), and progression of lung cancer (n=22, 6.8%). One case of AE-COPD and seven cases of attack of asthma were physician's diagnosis. Category "Others" included pneumothorax, restrictive thoracic disease, pleural effusion, influenza, drowning, primary pulmonary hypertension, requirement of mechanical ventilator support for neuromuscular disease, and so on. One patient diagnosed as pneumonia was complicated by attack of asthma and two patients of pneumonia exacerbated their symptom of COPD. They were treated for both conditions and counted as pneumonia. In comparison with the past two years, the increase in ~~absolute~~ number of hospitalizations was the largest for pneumonia, followed by AE-COPD and attack of asthma. The number of hospitalization for progression of lung cancer and that for "others" ~~diseases~~ were not so ~~deferent~~different from the past two years. 39.4% of patients were hospitalized from~~stayed at~~ emergency shelters ~~before hospitalization.~~.

To investigate the disease specific effect of earthquake, age and sex of each disease were compared between the study period in 2011 and the corresponding period in the past two years ~~(Table 1)~~. The mean age of patients hospitalized for respiratory disease was significantly higher in 2011 than in the past two years (75.7±12.5 ~~years old~~ v.s. ~~in 2011,~~ 73.2±13.4 years old ~~in 2010 and 2009~~. p=0.03). Male proportion tended to be lower in 2011 than in the past two years (59.6% in 2011, 67.2% in 2010 and 2009. p=0.08). Specifically, pneumonia patients and AE-COPD patients were significantly older in 2011 study period than in 2010 and 2009 corresponding period(77.6±11.8 v.s. 74.3±12.8 years old in pneumonia patients. p=0.03, 76.0±8.7 v.s. 69.5±15.9 years old in AE-COPD patients. ~~and~~ p=0.03~~, respectively~~). Male population of AE-COPD was significantly higher (81.1% v.s. 50.0%. p=0.01), whereas that of ~~attack of~~ asthma attack significantly lower in 2011 period than 2010 and 2009 periods (18.5% v.s. 54.6%. ~~p=0.01 and~~ p=0.03~~, respectively~~).

~~Furthermore, the effect of age and sex on the odds ratio for hospitalization with respiratory disease was calculated (Table 2). We found older patients were more likely hospitalized after the earthquake, especially for pneumonia and AE-COPD. Male patients were more likely hospitalized for AE-COPD and less likely hospitalized for attack of asthma.~~

Actual numbers of hospitalization for the main respiratory diseases in terms of every ten day~~s~~ bins during the study period is shown in Figure 3. Pneumonia ~~presented its peak~~ peaked in the second ~~period~~10 day bin. Following pneumonia, AE-COPD and attack of asthma ~~presented its peak~~peaked in the third 10 day bin~~period. and p~~Progression of lung cancer had its peak in the fifth 10 day bin~~period~~. ~~Attack of asthma had small peak in the same third period as AECOPD.~~

Next, we investigated ADL at hospitalization and ADL before the disaster among the patients hospitalized in 2011 study period. Because of confusing situation of medical activities after the disaster, ADL was not recorded in 11 patients ~~ADL before the disaster, ADL at hospitalization, and both ADL were not recorded in 8, 1, and 2 patients, respectively. Six of them were hospitalized for pneumonia and remaining five patients were hospitalized for AE-COPD.~~ At hospitalization, 195 patients (60.5%) were "dependent" and 54 patients (16.7%) were "partially dependent". ~~Those patients accounted for 76.9 % of the patients hospitalized after the earthquake.~~ On the other hand, before earthquake, only 86 patients (26.7%) were "dependent" and 51 patients (15.8%) were "partially dependent". ~~Those patients accounted for 42.5% of hospitalized patients after the earthquake.~~ To investigate the impact of ADL and its deterioration on admission for pulmonary disease in terms of time after the disaster, ~~We~~ we ~~analyze sequential change in~~counted the number of the patients who were "originally dependent", "newly dependent", or "independent throughout" ~~at hospitalization~~during 60 days presented in 10 day bins (Figure 4). Throughout the study period, majority of patients were dependent or partially dependent patient. In the first 20 days, the majority of admissions were for originally dependent people. After 30days, there was a sharp increase in newly dependent people, as assessed by ADL ~~Originally dependent patients were hospitalized especially in early period (first and second periods), and newly dependent patients showed its keen peak of hospitalization in the third period, the day from 21 to 30 after the earthquake, and kept high incidence of admission thereafter~~. Independent patients were hospitalized mainly during first 20 days.

Table ~~1~~3 showed the association of ADL category (independent throughout, newly dependent, and originally dependent) with patient's age, sex, and diagnosis. Regarding diagnosis, ratio of each disease was calculated in each category. Eleven patients whose ADL was not completely recorded were excluded from the data. Young and male patients were more frequent in order of independent, newly dependent and originally dependent. On investigation in patient's diagnosis, the proportion of pneumonia and progression of lung cancer increased in the same order, while the proportion of AE-COPD and asthma decreased.

Discussion

Summary

In this retrospective descriptive and cross-sectional study, we found substantial increase in elderly patients hospitalized for respiratory disease after the earthquake and tsunami. Pneumonia, AE-COPD, and attack of asthma were apparently increased after earthquake. Mean age of

patients hospitalized for respiratory disease after the earthquake was significantly higher than that of ~~ordinary years~~corresponding periods of the past two years. Majority of patients had poor ADL and many of them experienced deterioration of ADL after the earthquake.

Effect on respiratory disease

Previous reports on Hanshin-Awaji earthquake showed initial rush of patients with injury and following increase of patients with respiratory disease, especially pneumonia[11-13]. Similarly, our observation showed marked increase in pneumonia patients, although initial rush of heavy injury patients was absent in this disaster because majority of victims were ~~drawn~~drowned to death and heavily injured patients were seldom carried to the hospital.

The cause of increase in respiratory disease was different in each situation. After the 2004 Sumatra-Andaman earthquake and following tsunami, the number of lower respiratory infection in Ache was rapidly increased after the disaster and sharply declined in the second week[14]. On the other hand, after the 1995 Hanshin-Awaji earthquake, the number of patients hospitalized for pneumonia was gradually increased and kept high proportion over the two month[9 10]. This difference is ascribable to the mechanism of developing pneumonia. In Sumatra-Andaman earthquake, many of pneumonia were resulted from aspiration of tsunami-water in near-drowning events[15 16]. Those pneumonias were called "tsunami lung". On the other hand, in the Hanshin-Awaji earthquake, many patients developed pneumonia in shelters under unhealthy environment and most of them were in elderly. Those pneumonias were called "shelter pneumonia" [17]. In this earthquake and tsunami, we experienced few number of pneumonia directly caused by aspiration of tsunami-water even in the very acute period. ~~Most patients came from their own or relative's home, other hospital, nursing home, or shelter, and a~~A few of the patient directory came from the field, instead, most patients came from shelters, their own or relative's homes, other hospitals, or nursing homes.~~.~~ The mean age of them was significantly higher than that of 2010 and 2009. Therefore, we ~~thought~~regarded most of pneumonia we treated ~~was~~as the same kind of "shelter pneumonia".

AE-COPD was also remarkably increased. COPD was one of the most common chronic respiratory diseases, especially in elderly people. It is well known that interruption of treatment for chronic disease will ~~easily~~frequently exacerbate patient's condition, and it is also true after a natural disaster[14 18-20]. Many patients lost their drugs by tsunami flooding, therefore, interruption of regular medication may partly account for the increase in hospitalization by AE-COPD. Sunny and windy days lasted from the end of March and dust from the tsunami sludge was an important component of particulate air pollution; it may have contributed to the significant increase in ~~We also speculate that air pollution caused by tsunami dust may raise the~~

hospitalization by AE-COPD. ~~After cold and snowy weather for ten days from the disaster, cold, sunny, and windy days covered over Ishinomaki region, and dense dust containing tsunami sediment floated in the air for the following three weeks.~~

Although asthma was also one of the most common chronic respiratory diseases and had the same precipitating cause with COPD, attack of asthma was not so much increased as AE-COPD. This difference might be caused by two important differences between asthma and COPD. First, generally, patients of COPD were older than those of asthma. Therefore, baseline health condition of patients of COPD would be poorer than that of asthma[21]. As a result, COPD patients required more frequent hospitalization. In our study, mean age of AE-COPD was higher than that of attack of asthma as well. Second, bacterial respiratory infection affects patients with COPD more than those with asthma[22]. In the aftermath of earthquake, loss of hygiene and overcrowding in the shelter could increase the risk of respiratory bacterial infection and cause AE-COPD.

Hospitalization for lung~~Lung~~ cancer related symptons~~hospitalization~~ did not increase much and its ratio to total hospitalization for respiratory diseases rather declined. Mean age of lung cancer patients was similar to that in the past two years. Maeda et al. also reported that no increase in lung cancer related hospitalization was observed after Hanshin-Awaji earthquake[23]. Progression of lung cancer may not be influenced by environment as much as cancer growth itself. So, the disaster will not impact on lung cancer immediately. Although the interruption of chemotherapy and/or radiotherapy would worsen the prognosis, it cannot be confirmed during our study period.

Effect on ADL

~~Our observation demonstrated that drastic deterioration of ADL after the disaster resulted in increase in hospitalization by respiratory diseases.~~ In acute phase, patients with poor ADL, especially those originally dependent~~ ones~~, were hospitalized for pulmonary diseases, typically pneumonia,~~;~~ although substantial number of good ADL patients was also hospitalized. After 3~~ or 4~~ weeks, there was a sharp increase in newly dependent people~~many people~~ who deteriorated their ADL after the disaster~~(newly dependent) were hospitalized for pulmonary diseases~~. It was reported that physical disability was an independent risk factor for death in Hanshin-Awaji earthquake and the 1999 Taiwan earthquake[9 10]. However, those reports investigated the mortality in acute phase, not hospitalization in subacute or chronic phase. After the earthquake and tsunami, one fourth of people in Ishinomaki region fled into shelters, many of which were also flooded by tsunami. They lacked water and food under harsh condition of cold season without heating in overcrowded ~~room~~quarter just letting them lie on the floor without beds. In such bad conditions, elderly people were restricted their consumption food and water, and kept

still in ~~one~~a small space,~~; as a result, they deteriorated their~~resulting in deterioration of ADL~~s~~. In addition, scarcity of water worsened oral hygiene. Both poor functional status and loss of oral hygiene were the major risk factor of pneumonia[24-27], especially in elderly people. Subsequently, many elderly people were hospitalized for "shelter pneumonia" after the earthquake. Also, poor oral hygiene induces swallowing dysfunction[28] and swallowing dysfunction could be a risk factor of exacerbation of COPD[29]. It would be one of the reasons why AE-COPD increased especially in elderly people.

Effect on aging society

According to the report of government of Japan, 93% of the fatalities were drowning and more than 60% of them were over 60 years old ~~or more~~ in the Great East Japan earthquake. Although it was reported by many previous reports that elderly people had a greater risk of death after the earthquake, the proportion of the elderly ~~people~~ killed by this earthquake and tsunami was extremely high in comparison to other major earthquake or tsunami in the world[4-8]. Similar finding was reported only in 1995 Hanshin-Awaji earthquake and 2004 Mid Niigata earthquake in Japan[12 17]. Moreover, 90.8% of the patients hospitalized for respiratory disease after the earthquake were over 60 years old ~~or more~~ in our study. These results suggest~~ed~~ that elderly people were vulnerable not only immediately after the earthquake but also for a while after the earthquake.

In 1999 Taiwan earthquake, 2003 heat waves in the Czech Republic, and 2004 Sumatra-Andaman earthquake, it is demonstrated that these disasters has left decreased mortality in the stricken area, resulted from a large number of direct death by disasters among a vulnerable population such as elderly people or children[5 30 31] , called "harvesting effect". However, our observation suggests that, in the aging society, a huge disaster not only directly kills the vulnerable people but also ~~newly~~ produces new vulnerable people. Previous reports demonstrated that prolonged harmful influence on mental health and psychological slow recovery were seen more frequently in the elderly people than young people[32-35]. Therefore, we should pay a long-term attention on those elderly people after a disaster.

Implications for policy and practice

Our observation suggests two important targets for reducing hospitalization for respiratory disease after the major disaster in aging society. One target is interruption of treatment for chronic respiratory disease and the other target is deterioration of ADL. Interruption of treatment for chronic respiratory disease was preventable by storing the drugs for a few days. However, it is necessary to establish the system of~~or~~ valid storage to grasp regional prescription data of each drug and patient's personal medication data. Telemedicine system or web-based

patient data storage system might be useful. Prevention of deterioration of ADL is also important. Elderly people are~~is~~ potentially vulnerable and easily deteriorate their ADL. In our study, remaining at shelters in stricken area for more than three weeks led increase in deterioration of ADL and hospitalization for respiratory diseases. Therefore, we propose to ~~transfer~~evacuate elderly people ~~to~~ out of the stricken area as soon as possible.

Strengths and weaknesses of study

Our study had two important strengths. First, the Great East Japan Earthquake hit one of the most ~~advanced~~rapidly aging societies in the world[3]. As the proportion of elderly people continues to increase in not only developed ~~countries~~ but also developing countries, there is an urgent need of information and analysis on the aging society to plan countermeasures against it. Our study will give lessons against natural disaster to all the countries. Secondly, we obtained detailed data of patient's demographics, diagnosis, and ADL in a catastrophic situation. It is because that our hospital has kept its medical function, including electronic medical record system or laboratory systems, while devastating earthquake and tsunami hit Ishinomaki city and almost all medical facilities lost their function, and that stuffs in our hospital has trained for the coming earthquake and has had an strong motivation to record our experiences as memos or on digital recorders for future disaster medicine ~~for the future~~.

Our study is single center study. This might be weakness of our study, but our hospital was the only functional hospital after the earthquake in Ishinomaki medical zone which account for more than 30% of total fatalities~~victims~~ of this earthquake in Japan. Also, it has been the only hospital which has the department of respiratory medicine and pulmonary specialists in the medical zone. Even in the ordinary time before the disaster, it accepted almost all of the serious patients with pulmonary diseases who needed hospitalization. Therefore, we think our study well represents impact of the earthquake on pulmonary disease~~s~~ and describes what happened in the hospital which faced the earthquake at the front[2]. It is also weakness of our study that we analyzed only hospitalized patients. There were a great number of outpatients and a heavy loss of lives. These events will be analyzed in the future report. Another weakness of our study is that cross-sectional study cannot elucidate a causal relationship. Finally, we did not clearly define the condition of hospitalization. Because the destruction of ordinary healthcare system and poor hygiene outside the hospital, we hospitalized some patients who could be treated in outpatient setting in ordinary time. However, this was a real situation after devastating disaster.

Conclusion

The Great East Japan earthquake and following tsunami hit the one of the most ~~advanced~~rapidly aging society in the world. After the disaster, pneumonia, exacerbation of COPD, bronchial

asthma attack associated with bad ADL in the elderly provoked the most part of increase in hospitalization for pulmonary diseases. These observations should be exploited in constructing emergency medical management for disasters in progressive ~~advanced~~rapidly aging society.

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Competing interests: None declared.

Ethical approval: Approval of ethical review committee of Japanese Red Cross Ishinomaki Hospital was obtained.

Contributors: SY was responsible for study design and interpretation of the data, and drafted the manuscript. MH, SK, HS, ST, and MY were responsible for collection and interpretation of the data. KN drafted the statistical analysis part in the manuscript, and provided suggestions on public health and epidemiology. MH, SK and MY were responsible for study design and revised the drafted manuscript. SY, MH, SK, HS, ST and MY treated the patients. All authors approved the final version of the manuscript.

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institutionalized elderly. *Am J Respir Crit Care Med* 2003;**167**:1650-1654.
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Tables

Table 1. Demographics and patient characteristics in 2011 and past two years.

	After the earthquake (2011) n=322	Past two years (2010 and 2011) n=204	p value
All cause			
age (year)	75.7±12.5 *	73.2±13.4	0.03
male	192 (59.6)	137 (67.2)	0.08
Pneumonia			
age	77.6±11.8*	74.3±12.8	0.03
male	111 (58.4)	63 (66.3)	0.20
AE-COPD			
age	76.0±8.7*	69.3±15.9	0.03
male	43 (81.1) *	8 (50.0)	0.01
Asthma			
age	68.7±19.7	67.2±19.4	0.83

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male	5 (18.5) *	6 (54.6)	0.03
Lung cancer			
age	74.3±12.1	73.2±16.0	0.79
male	16 (72.7)	18 (66.7)	0.65
Others			
age	70.4±11.6	73.8±11.3	0.19
male	17 (56.7)	42 (76.4)	0.06

AE-COPD, acute exacerbation of COPD.

Data are mean±SD for numerical variables and number (%) for categorical variables. *p<0.05.

Table 2. Association of age and sex with hospitalization for respiratory disease after the earthquake.

	Hospitalization for respiratory disease after the earthquake	
	Unadjusted OR (95% CI)	*Adjusted OR (95% CI)
All cause		
age (year)	1.01† (1.00-1.03)	1.02† (1.00-1.03)
male (reference: female)	0.72 (0.50-1.04)	0.71 (0.19-1.03)
Pneumonia		
age	1.02† (1.00-1.04)	1.02† (1.00-1.04)
male	0.71 (0.42-1.19)	0.74 (0.44-1.23)
AE-COPD		
age	1.05† (1.00-1.11)	1.05 (1.00-1.11)
male	4.30† (1.30-14.66)	4.17 † (1.21-14.84)
Asthma		
age	1.00 (0.97-1.04)	1.00 (0.96-1.05)
male	0.19 † (0.04-0.85)	0.19 † (0.04-0.85)

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~~Lung cancer~~		
~~— age~~	~~1.01 (0.97-1.05)~~	~~1.00 (0.96-1.05)~~
~~— male~~	~~1.33 (0.39-4.76)~~	~~1.30 (0.37-4.83)~~
~~Others~~		
~~— age~~	~~0.97 (0.94-1.01)~~	~~0.97 (0.93-1.01)~~
~~— male~~	~~0.40 (0.15-1.05)~~	~~0.39 (0.15-1.03)~~

~~AE-COPD, acute exacerbation of COPD; OR, odds ratio; CI, confidence interval.~~

~~*Adjusted for age and sex with each other. †p<0.05~~

Table 1~~3~~. Association of ADL with patient's characteristics and respiratory disease.

	Independent n=70	Newly dependent n=104	Originally dependent n=137
Age	69.9±15.1	73.1±11.2	80.3±10.5
Male	49 (70.0)	63 (60.6)	69 (50.4)
Diagnosis			
Pneumonia	31 (44.3)	59 (56.7)	94 (68.6)
AE-COPD	17 (24.3)	17 (16.4)	15 (11.0)
Asthma	11 (15.7)	11 (10.6)	5 (3.7)
Lung cancer	3 (4.3)	6 (5.8)	12 (8.8)
Others	8 (11.4)	11 (8.0)	11 (8.0)

AE-COPD, acute exacerbation of COPD.

Data are mean ±SD for numerical variables and number (%) for categorical variables.

Figure legends

Figure 1. The number of unscheduled hospitalization~~Sequential change of the number of unscheduled hospitalization~~ for all causes (A) and for respiratory disease (B) from March 11 to May 9 in 2009~~11~~, 2010 and 2011, presented in 10 day bins~~09~~.

Figure 2. The number and proportion of patients hospitalized for respiratory disease from March 11 to May 9 in 2009~~11~~, 2010, and 2011~~09~~, presented in 10 day bins.

Figure ~~–~~3. Distribution~~Sequential change~~ of ~~disease distribution of~~ patients hospitalized for respiratory disease after the Great East Japan earthquake from March 11 to May 9 in 2011, presented in 10 day bins.

Figure 4. ~~Influence of the earthquake on the patient's ADL.~~ Influence of the disaster on ADL status and its deterioration in hospitalized patients for respiratory disease from March 11 to May 9 in 2011, presented in 10 day bins.

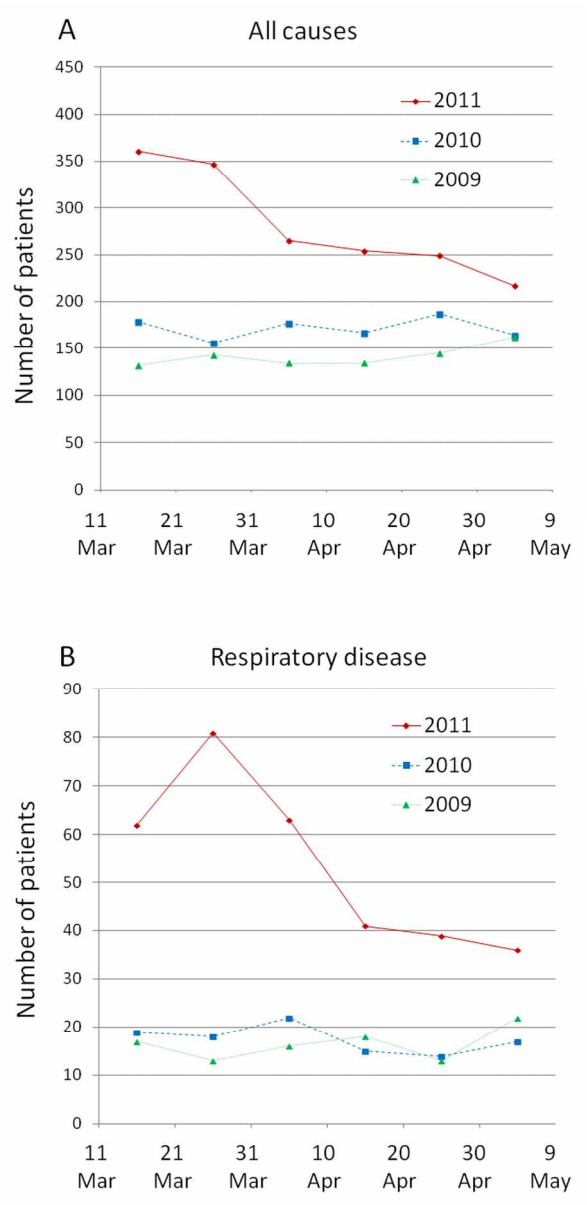

Figure 1. The number of unscheduled hospitalization for all causes (A) and for respiratory disease (B) from March 11 to May 9 in 2009, 2010 and 2011, presented in 10 day bins.
90x185mm (300 x 300 DPI)

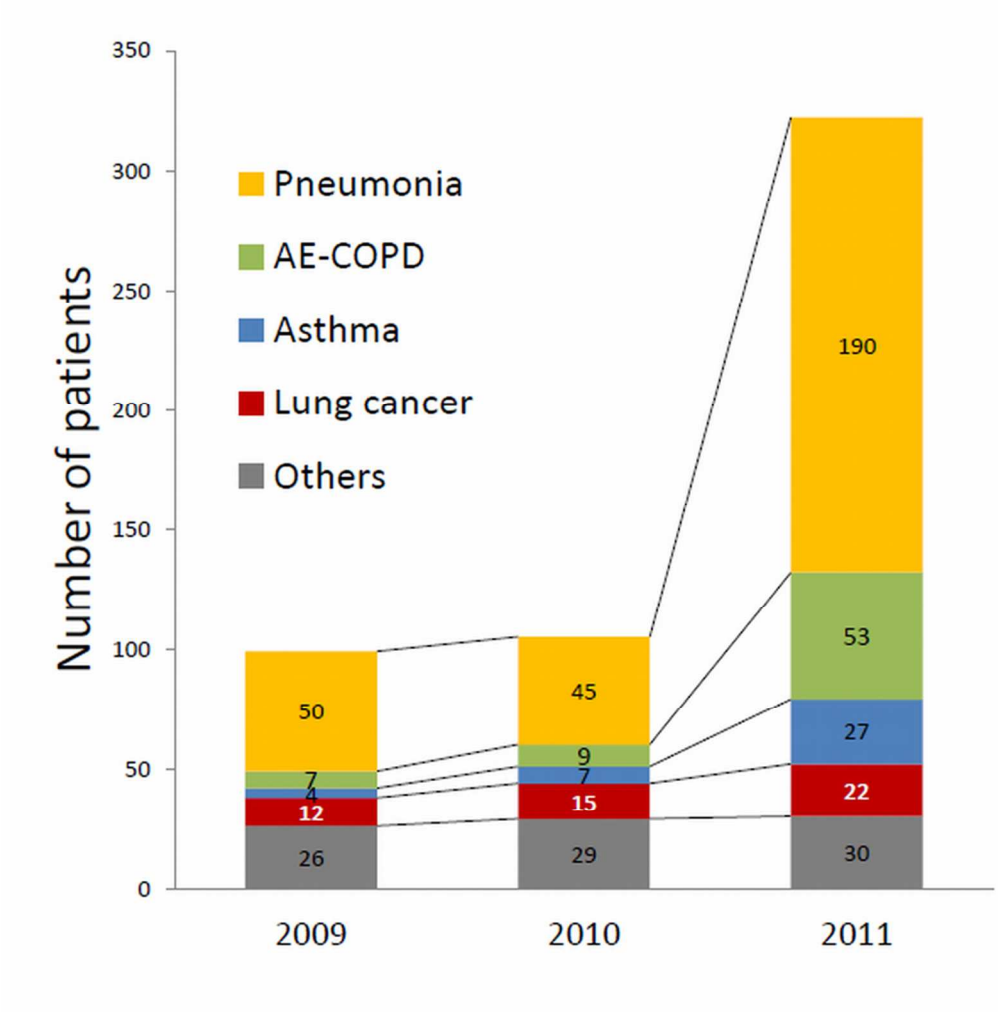

Figure 2. The number and proportion of patients hospitalized for respiratory disease from March 11 to May 9 in 2009, 2010, and 2011, presented in 10 day bins.
90x91mm (300 x 300 DPI)

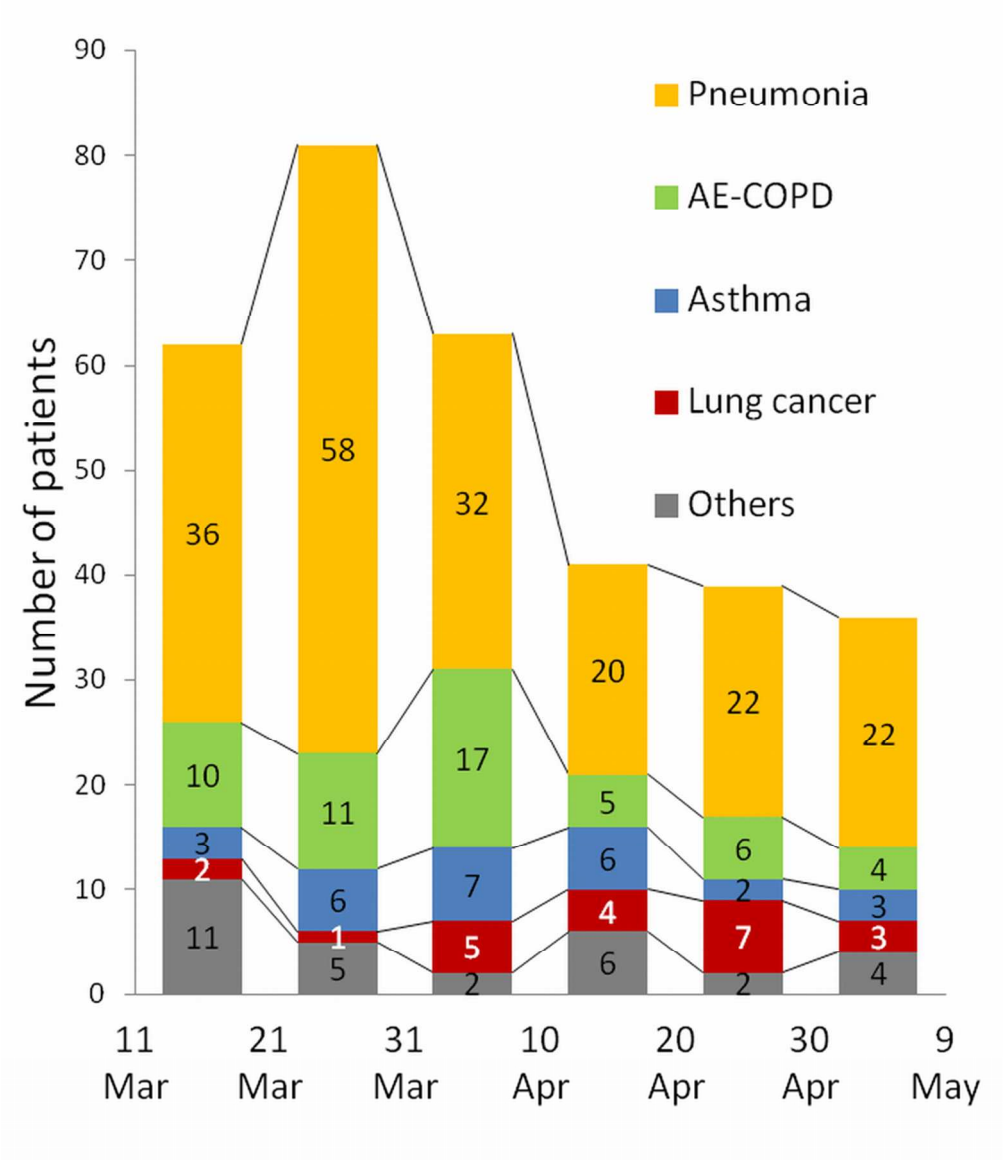

Figure 3. Distribution of patients hospitalized for respiratory disease after the Great East Japan earthquake from March 11 to May 9 in 2011, presented in 10 day bins.
90x104mm (300 x 300 DPI)

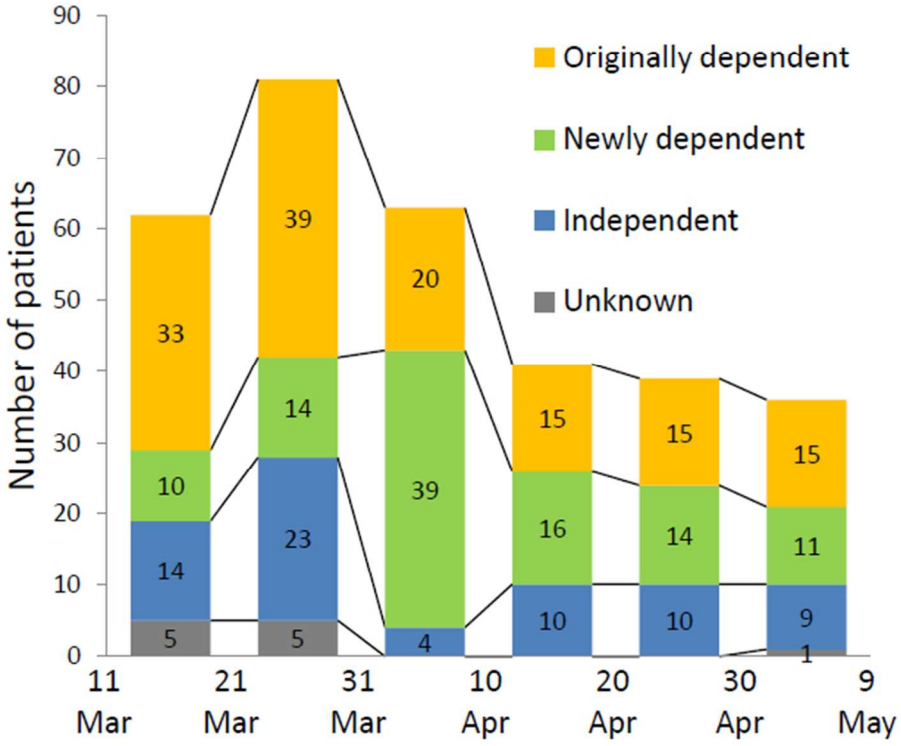

Figure 4. Influence of the disaster on ADL status and its deterioration in hospitalized patients for respiratory disease from March 11 to May 9 in 2011, presented in 10 day bins.

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2, 3
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3-4
Objectives	3	State specific objectives, including any prespecified hypotheses	3-4
Methods			
Study design	4	Present key elements of study design early in the paper	4-6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	4-6
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	4-6
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	4-6
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	4-6
Bias	9	Describe any efforts to address potential sources of bias	-
Study size	10	Explain how the study size was arrived at	4
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	4, 5
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	5, 6
		(*b*) Describe any methods used to examine subgroups and interactions	-
		(*c*) Explain how missing data were addressed	7
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	-
		(*e*) Describe any sensitivity analyses	-
Results			

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	6
		(b) Give reasons for non-participation at each stage	-
		(c) Consider use of a flow diagram	-
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	6-7 + Table 1
		(b) Indicate number of participants with missing data for each variable of interest	7
Outcome data	15*	Report numbers of outcome events or summary measures	3
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	3 + Table 2
		(*b*) Report category boundaries when continuous variables were categorized	5
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	-
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	-
Discussion			
Key results	18	Summarise key results with reference to study objectives	8
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	11
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	8, 10-11
Generalisability	21	Discuss the generalisability (external validity) of the study results	10-11
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	12

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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The impact of the 2011 Great East Japan Earthquake on hospitalization for respiratory disease in rapidly aging society: a retrospective descriptive and cross-sectional study at the disaster base hospital in Ishinomaki

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Title

The impact of the 2011 Great East Japan Earthquake on hospitalization for respiratory disease in rapidly aging society: a retrospective descriptive and cross-sectional study at the disaster base hospital in Ishinomaki

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Article summary

Article focus

The Great East Japan Earthquake attacked one of the most rapidly aging societies in the world. Respiratory medicine is the major field in gerontology. Here we address how seriously the disaster affected respiratory diseases in the most heavily stricken area, which has one of the highest ratios of elderly people in Japan.

The study gives lessons against natural disasters and aging society.

Key messages

After the earthquake and tsunami, admission from pneumonia and exacerbation of chronic respiratory disease in elderly increased.

Harsh conditions and poor ADL after the disaster may be associated with increase in hospitalization for respiratory diseases in elderly people.

Strengths and limitations of study

We could obtain detailed data of patient even in the catastrophic state.

We analyzed only hospitalized patients. But there were a great number of outpatients as well as heavy loss of lives.

Abstract

Objective

To investigate the impact of the 2011 Great East Japan earthquake on hospitalization for respiratory disease at the disaster base hospital in aging society.

Design

Descriptive and cross sectional study.

Setting

Emergency care in Japanese Red Cross Ishinomaki Hospital, a regional disaster base hospital, Miyagi, Japan.

Participants

322 emergency patients who hospitalized for respiratory disease from March 11 to May 9 in 2011, and 99 and 105 emergency patients who hospitalized in the corresponding period of 2009 and 2010, respectively.

Main outcome measures

Description and comparison of patient's characteristics and disease distribution in terms of age, time after the disaster, and activities of daily living (ADL).

Results

Total number of patients hospitalized in our hospital in the study period was 1769 (850 in 2009, 1030 in 2010), and the number of hospitalized for respiratory disease in them was 322 (99 in 2009, 105 in 2010). Among admission for pulmonary diseases, pneumonia was the most frequent disease (n=190, 59.0%), followed by acute exacerbation of chronic obstructive disease (AE-COPD) (n=53, 16.5%), attack of asthma (n=27, 8.4%), and progression of lung cancer (n=22, 6.8%). Compared with the corresponding period of 2009 or 2010, increase in absolute number of hospitalization was the highest for pneumonia, followed by AE-COPD and attack of asthma. At hospitalization, 195 patients were "dependent" and 54 patients were "partially dependent". Respiratory admission accompanied by deterioration of ADL after the disaster was more frequent in elderly and female patients.

Conclusions

After the Great East Japan Earthquake, admission for pneumonia and exacerbation of chronic respiratory disease in elderly increased at the disaster base hospital.

Introduction

On March11, 2011, at 2:46 pm Japan time, the Pacific coast of Japan's Tohoku (northeastern) region was struck by the massive earthquake (The Great East Japan Earthquake), measuring magnitude 9.0 on the Richter scale[1]. The earthquake triggered a devastating tsunami which destroyed many towns and villages near the seashore. The epicenter was estimated to be about 70 kilometers east of Oshika Peninsula of Ishinomaki in Miyagi. Officially, over 19,000 people were killed or missing and the maximum number of refugees reached more than 550,000[2].

Ishinomaki city, located in Pacific coast of Honshu Island, suffered from the largest number of victims in Japan, 3,280 people were killed and 669 people were still missing. A great number of casualties, more than 10,000 patients in the first 30 days, were treated at Japanese Red Cross Ishinomaki Hospital, a regional disaster base hospital in Ishinomaki which uniquely preserved its hospital function in Ishinomaki region during and after the disaster.

Japan is one of the most rapidly aging society in the world. 23% of Japanese citizens were age 65 or over in 2010[3]. Tohoku region is especially rapidly aging society in Japan, 26.6% of people living in Ishinomaki city were age 65 or over in 2010. Although several reports showed the significant association between age and earthquake and tsunami death[4-8], there were few reports investigating the impact of a tremendous disaster on elderly peoples in such an aging society[9 10]. Respiratory diseases are common in the elderly even in ordinary times. So, investigating the impact of the disasters on respiratory health will contribute to elucidating the problem of aging society. Thus, we performed retrospective descriptive and cross-sectional analysis of the medical and epidemiologic data of the patient required hospitalization for respiratory disease after the Great East Japan Earthquake and following tsunami.

Methods

This study was a retrospective descriptive and cross-sectional analysis of the data obtained from the medical records at Japanese Red Cross Ishinomaki Hospital. We reviewed medical records of patients admitted to the hospital for respiratory diseases during the first 60 days after the Great East Japan Earthquake, when the hospital solely accepted emergency patients. We also reviewed medical records of patients who required unscheduled hospitalization for respiratory disease in the corresponding period of 2009 and 2010.

Japanese Red Cross Ishinomaki Hospital which had 402 beds for inpatients was located at 4.5 km inland from Pacific Ocean. It has covered about 220,000 people living in its medical zone (Ishinomaki City, Onagawa Town, and Higashi-matsushima City) and assigned to a regional disaster base hospital. It has accepted almost all of the emergency respiratory patients even in the ordinary time before the disaster, because it has been the unique hospital having the

respiratory department and pulmonary specialists in the region.

Medical records were investigated in terms of date of admission, age, sex, diagnosis. We also investigated activities of daily living (ADL) at hospitalization and ADL before earthquake, and their residence before admission on the medical record of 2011 study period. For comparison, the total number of unscheduled hospitalization during the corresponding periods in 2009 and 2010 was counted.

Pneumonia was defined as the presence of the infiltration on chest radiograph along with one or more of the following symptoms or signs: fever, cough, sputum production, breathlessness, pleuritic chest pain or signs consistent with pneumonia on auscultation.

Chronic obstructive pulmonary disease (COPD) and bronchial asthma were detected by the previous spirometric data, patient's self-report, or physician's diagnosis made by patient's history, physical examination, and radiological finding. An acute exacerbation of COPD(AE-COPD) was defined as an increase in or new onset of more than one symptom of COPD (cough, sputum, wheezing, dyspnea or chest tightness) without pneumonia or pneumothorax. An attack of asthma was defined as the presentation of wheezes or severe cough in asthma patients without pneumonia. Progression of lung cancer was defined as requirement for admission for lung cancer associated condition such as dehydration, respiratory failure, or uncontrolled pain. Obstructive pneumonia due to lung cancer was considered as progression of lung cancer. Chest trauma and traumatopnea were not considered as respiratory disease but chest injury.

ADL was assessed by the information from a patient, patient's family, or patient's caregiver, and classified into three categories; "independent" who could live without particular support, "partially dependent" who could not leave their residence without any support, "dependent" who spent a day on the bed or the wheelchair and lost the ability to move for themselves. To investigate the impact of the disaster on ADL, we defined as "originally dependent" who were dependent or partially dependent before the disaster, and as "newly dependent" who became dependent or partially dependent after the disaster.

Data analysis

All data were entered into a personal computer and analyzed using Microsoft ™ Excel software and statistical analysis was performed using JMP9 (SAS Institute Inc., Cary, NC, USA). A missing value in medical record was treated as "unknown". Results were given as mean ± SD for numerical variables and as proportions for categorical variables. To analyze sequential change of the effect of the disaster, we divided 60 days of study period into six groups of ten day bins. To investigate the risk of hospitalization for respiratory disease after the earthquake and tsunami, we compared the patient's characteristics of 2011 study period with the combined

data of 2009 and 2010 corresponding period as ordinary time. We used two-sided Student's *t*-test for numerical variables and chi-square test for the categorical variables. The p <0.05 is accepted as statistically significant.

Result

All of the scheduled hospitalization was cancelled and emergency admission was solely accepted during the first 60 day after the earthquake at Japanese Red Cross Ishinomaki Hospital. 1,769 patients admitted to the hospital, and 322 of them were hospitalized for respiratory disease during the study period. In the corresponding period, total number of unscheduled hospitalization was 850 and that for respiratory disease was 99 in 2009 and 1,030 and 105 in 2010. Patients hospitalized for respiratory disease accounted for 18.2% of total hospitalization during the study period. This proportion was significantly higher than that of 2009 and 2010 (11.6% in 2009. P<0.001. 10.2% in 2010. P<0.001). While the number of total hospitalizations of this period in 2011 was about twice of that in 2009 and 2010, hospitalization for respiratory disease in 2011 reached about three times or more than that of 2009 and 2010. The total number of hospitalizations was peaked in the first ten days, but the number of hospitalization for respiratory disease kept increasing for 20 days (Figure 1A and B).

We compared the number and proportion of patients hospitalized for respiratory disease between 2011, 2010, and 2009 study periods (Figure 2). Pneumonia was the most frequent disease (n=190, 59.0%), followed by AE-COPD (n=53, 16.5%), attack of asthma (n=27, 8.4%), and progression of lung cancer (n=22, 6.8%). One case of AE-COPD and seven cases of attack of asthma were physician's diagnosis. Category "Others" included pneumothorax, restrictive thoracic disease, pleural effusion, influenza, drowning, primary pulmonary hypertension, requirement of mechanical ventilator support for neuromuscular disease, and so on. One patient diagnosed as pneumonia was complicated by attack of asthma and two patients of pneumonia exacerbated their symptom of COPD. They were treated for both conditions and counted as pneumonia. In comparison with the past two years, the increase in number of hospitalizations was the largest for pneumonia, followed by AE-COPD and attack of asthma. The number of hospitalization for progression of lung cancer and that for "others" were not so different from the past two years. 39.4% of patients were hospitalized from emergency shelters.

To investigate the disease specific effect of earthquake, age and sex of each disease were compared between the study period in 2011 and the corresponding period in the past two years. The mean age of patients hospitalized for respiratory disease was significantly higher in 2011 than in the past two years (75.7±12.5 v.s. 73.2±13.4 years old. p=0.03). Male proportion tended to be lower in 2011 than in the past two years (59.6% in 2011, 67.2% in 2010 and 2009. p=0.08).

Specifically, pneumonia patients and AE-COPD patients were significantly older in 2011 study period than in 2010 and 2009 corresponding period(77.6±11.8 v.s. 74.3±12.8 years old in pneumonia patients. p=0.03. 76.0±8.7 v.s. 69.5±15.9 years old in AE-COPD patients. p=0.03). Male population of AE-COPD was significantly higher (81.1% v.s. 50.0%. p=0.01), whereas that of asthma attack significantly lower in 2011 period than 2010 and 2009 periods (18.5% v.s. 54.6%. p=0.03).

Actual numbers of hospitalization for the main respiratory diseases in terms of every ten day bins during the study period is shown in Figure 3. Pneumonia peaked in the second 10 day bin. Following pneumonia, AE-COPD and attack of asthma peaked in the third 10 day bin.Progression of lung cancer had its peak in the fifth 10 day bin.

Next, we investigated ADL at hospitalization and ADL before the disaster among the patients hospitalized in 2011 study period. Because of confusing situation of medical activities after the disaster, ADL was not recorded in 11 patients At hospitalization, 195 patients (60.5%) were "dependent" and 54 patients (16.7%) were "partially dependent". On the other hand, before earthquake, only 86 patients (26.7%) were "dependent" and 51 patients (15.8%) were "partially dependent". To investigate the impact of ADL and its deterioration on admission for pulmonary disease in terms of time after the disaster, we counted the number of the patients who were "originally dependent", "newly dependent", or "independent throughout" during 60 days presented in 10 day bins (Figure 4). Throughout the study period, majority of patients were dependent or partially dependent patient. In the first 20 days, the majority of admissions were for originally dependent people. After 30days, there was a sharp increase in newly dependent people, as assessed by ADL. Independent patients were hospitalized mainly during first 20 days.

Table 1 showed the association of ADL category (independent throughout, newly dependent, and originally dependent) with patient's age, sex, and diagnosis. Regarding diagnosis, ratio of each disease was calculated in each category. Eleven patients whose ADL was not completely recorded were excluded from the data. Young and male patients were more frequent in order of independent, newly dependent and originally dependent. On investigation in patient's diagnosis, the proportion of pneumonia and progression of lung cancer increased in the same order, while the proportion of AE-COPD and asthma decreased.

Discussion

Summary

In this retrospective descriptive and cross-sectional study, we found substantial increase in elderly patients hospitalized for respiratory disease after the earthquake and tsunami. Pneumonia,

AE-COPD, and attack of asthma were apparently increased after earthquake. Mean age of patients hospitalized for respiratory disease after the earthquake was significantly higher than that of corresponding periods of the past two years. Majority of patients had poor ADL and many of them experienced deterioration of ADL after the earthquake.

Effect on respiratory disease

Previous reports on Hanshin-Awaji earthquake showed initial rush of patients with injury and following increase of patients with respiratory disease, especially pneumonia[11-13]. Similarly, our observation showed marked increase in pneumonia patients, although initial rush of heavy injury patients was absent in this disaster because majority of victims were drowned to death and heavily injured patients were seldom carried to the hospital.

The cause of increase in respiratory disease was different in each situation. After the 2004 Sumatra-Andaman earthquake and following tsunami, the number of lower respiratory infection in Ache was rapidly increased after the disaster and sharply declined in the second week[14]. On the other hand, after the 1995 Hanshin-Awaji earthquake, the number of patients hospitalized for pneumonia was gradually increased and kept high proportion over the two month[9 10]. This difference is ascribable to the mechanism of developing pneumonia. In Sumatra-Andaman earthquake, many of pneumonia were resulted from aspiration of tsunami-water in near-drowning events[15 16]. Those pneumonias were called "tsunami lung". On the other hand, in the Hanshin-Awaji earthquake, many patients developed pneumonia in shelters under unhealthy environment and most of them were in elderly. Those pneumonias were called ''shelter pneumonia'' [17]. In this earthquake and tsunami, we experienced few number of pneumonia directly caused by aspiration of tsunami-water even in the very acute period. A few of the patient directory came from the field, instead, most patients came from shelters, their own or relative's homes, other hospitals, or nursing homes. The mean age of them was significantly higher than that of 2010 and 2009. Therefore, we regarded most of pneumonia we treated as the same kind of ''shelter pneumonia''. We could not carry out a bacteriological examination for 14 days after the earthquake due to shortage of water, fuel, gas, and manpower. After that, we could perform bacteriological examination, bacterial culture or gram staining. We treated most of the pneumonias as "aspiration pneumonia in nursing home" because of the patients' ADL.

AE-COPD was also remarkably increased. COPD was one of the most common chronic respiratory diseases, especially in elderly people. It is well known that interruption of treatment for chronic disease will frequently exacerbate patient's condition, and it is also true after a natural disaster[14 18-20]. Many patients lost their drugs by tsunami flooding, therefore, interruption of regular medication may partly account for the increase in hospitalization by AE-COPD. Sunny and windy days lasted from the end of March and dust from the tsunami sludge was an

important component of particulate air pollution; it may have contributed to the significant increase in hospitalization by AE-COPD.

Although asthma was also one of the most common chronic respiratory diseases and had the same precipitating cause with COPD, attack of asthma was not so much increased as AE-COPD. This difference might be caused by two important differences between asthma and COPD. First, generally, patients of COPD were older than those of asthma. Therefore, baseline health condition of patients of COPD would be poorer than that of asthma[21]. As a result, COPD patients required more frequent hospitalization. In our study, mean age of AE-COPD was higher than that of attack of asthma as well. Second, bacterial respiratory infection affects patients with COPD more than those with asthma[22]. In the aftermath of earthquake, loss of hygiene and overcrowding in the shelter could increase the risk of respiratory bacterial infection and cause AE-COPD.

Hospitalization for lung cancer related symptons did not increase much and its ratio to total hospitalization for respiratory diseases rather declined. Mean age of lung cancer patients was similar to that in the past two years. Maeda et al. also reported that no increase in lung cancer related hospitalization was observed after Hanshin-Awaji earthquake[23]. Progression of lung cancer may not be influenced by environment as much as cancer growth itself. So, the disaster will not impact on lung cancer immediately. Although the interruption of chemotherapy and/or radiotherapy would worsen the prognosis, it cannot be confirmed during our study period.

Effect on ADL

In acute phase, patients with poor ADL, especially those originally dependent, were hospitalized for pulmonary diseases, typically pneumonia, although substantial number of good ADL patients was also hospitalized. After 3 weeks, there was a sharp increase in newly dependent people who deteriorated their ADL after the disaster. It was reported that physical disability was an independent risk factor for death in Hanshin-Awaji earthquake and the 1999 Taiwan earthquake[9] [10]. However, those reports investigated the mortality in acute phase, not hospitalization in subacute or chronic phase. After the earthquake and tsunami, one fourth of people in Ishinomaki region fled into shelters, many of which were also flooded by tsunami. They lacked water and food under harsh condition of cold season without heating in overcrowded quarter just letting them lie on the floor without beds. In such bad conditions, elderly people were restricted their consumption food and water, and kept still in a small space, resulting in deterioration of ADL. In addition, scarcity of water worsened oral hygiene. Both poor functional status and loss of oral hygiene were the major risk factor of pneumonia[24-27], especially in elderly people. Subsequently, many elderly people were hospitalized for “shelter pneumonia” after the earthquake. Also, poor oral hygiene induces swallowing dysfunction[28] and

swallowing dysfunction could be a risk factor of exacerbation of COPD[29]. It would be one of the reasons why AE-COPD increased especially in elderly people.

Effect on aging society

According to the report of government of Japan, 93% of the fatalities were drowning and more than 60% of them were over 60 years old in the Great East Japan earthquake. Although it was reported by many previous reports that elderly people had a greater risk of death after the earthquake, the proportion of the elderly killed by this earthquake and tsunami was extremely high in comparison to other major earthquake or tsunami in the world[4-8]. Similar finding was reported only in 1995 Hanshin-Awaji earthquake and 2004 Mid Niigata earthquake in Japan[12 17]. Moreover, 90.8% of the patients hospitalized for respiratory disease after the earthquake were over 60 years old in our study. These results suggest that elderly people were vulnerable not only immediately after the earthquake but also for a while after the earthquake.

In 1999 Taiwan earthquake, 2003 heat waves in the Czech Republic, and 2004 Sumatra-Andaman earthquake, it is demonstrated that these disasters has left decreased mortality in the stricken area, resulted from a large number of direct death by disasters among a vulnerable population such as elderly people or children[5 30 31] , called “harvesting effect”. However, our observation suggests that, in the aging society, a huge disaster not only directly kills the vulnerable people but also produces new vulnerable people. Previous reports demonstrated that prolonged harmful influence on mental health and psychological slow recovery were seen more frequently in the elderly people than young people[32-35]. Therefore, we should pay a long-term attention on those elderly people after a disaster.

Implications for policy and practice

Our observation suggests two important targets for reducing hospitalization for respiratory disease after the major disaster in aging society. One target is interruption of treatment for chronic respiratory disease and the other target is deterioration of ADL. Interruption of treatment for chronic respiratory disease was preventable by storing the drugs for a few days. However, it is necessary to establish the system of valid storage to grasp regional prescription data of each drug and patient’s personal medication data. Telemedicine system or web-based patient data storage system might be useful. Prevention of deterioration of ADL is also important. Elderly people are potentially vulnerable and easily deteriorate their ADL. In our study, remaining at shelters in stricken area for more than three weeks led increase in deterioration of ADL and hospitalization for respiratory diseases. Therefore, we propose to evacuate elderly people out of the stricken area as soon as possible.

Strengths and weaknesses of study

Our study had two important strengths. First, the Great East Japan Earthquake hit one of the most rapidly aging societies in the world[3]. As the proportion of elderly people continues to increase in not only developed but also developing countries, there is an urgent need of information and analysis on the aging society to plan countermeasures against it. Our study will give lessons against natural disaster to all the countries. Secondly, we obtained detailed data of patient's demographics, diagnosis, and ADL in a catastrophic situation. It is because that our hospital has kept its medical function, including electronic medical record system or laboratory systems, while devastating earthquake and tsunami hit Ishinomaki city and almost all medical facilities lost their function, and that stuffs in our hospital has trained for the coming earthquake and has had an strong motivation to record our experiences as memos or on digital recorders for future disaster medicine.

Our study is single center study. This might be weakness of our study, but our hospital was the only functional hospital after the earthquake in Ishinomaki medical zone which account for more than 30% of total fatalities of this earthquake in Japan. Also, it has been the only hospital which has the department of respiratory medicine and pulmonary specialists in the medical zone. Even in the ordinary time before the disaster, it accepted almost all of the serious patients with pulmonary diseases who needed hospitalization. Therefore, we think our study well represents impact of the earthquake on pulmonary diseases and describes what happened in the hospital which faced the earthquake at the front[2]. It is also weakness of our study that we analyzed only hospitalized patients. There were a great number of outpatients and a heavy loss of lives. These events will be analyzed in the future report. Another weakness of our study is that cross-sectional study cannot elucidate a causal relationship. Finally, we did not clearly define the condition of hospitalization. Because the destruction of ordinary healthcare system and poor hygiene outside the hospital, we hospitalized some patients who could be treated in outpatient setting in ordinary time. However, this was a real situation after devastating disaster.

Conclusion

The Great East Japan earthquake and following tsunami hit the one of the most rapidly aging society in the world. After the disaster, pneumonia, exacerbation of COPD, bronchial asthma attack associated with bad ADL in the elderly provoked the most part of increase in hospitalization for pulmonary diseases. These observations should be exploited in constructing emergency medical management for disasters in progressive rapidly aging society.

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Competing interests: None declared.

Ethical approval: Approval of ethical review committee of Japanese Red Cross Ishinomaki Hospital was obtained.

Contributors: SY was responsible for study design and interpretation of the data, and drafted the manuscript. MH, SK, HS, ST, and MY were responsible for collection and interpretation of the data. KN drafted the statistical analysis part in the manuscript, and provided suggestions on public health and epidemiology. MH, SK and MY were responsible for study design and revised the drafted manuscript. SY, MH, SK, HS, ST and MY treated the patients. All authors approved the final version of the manuscript.

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Table

Table 1. Association of ADL with patient's characteristics and respiratory disease.

	Independent n=70	Newly dependent n=104	Originally dependent n=137
Age	69.9±15.1	73.1±11.2	80.3±10.5
Male	49 (70.0)	63 (60.6)	69 (50.4)
Diagnosis			
Pneumonia	31 (44.3)	59 (56.7)	94 (68.6)
AE-COPD	17 (24.3)	17 (16.4)	15 (11.0)
Asthma	11 (15.7)	11 (10.6)	5 (3.7)
Lung cancer	3 (4.3)	6 (5.8)	12 (8.8)
Others	8 (11.4)	11 (8.0)	11 (8.0)

AE-COPD, acute exacerbation of COPD.

Data are mean ±SD for numerical variables and number (%) for categorical variables.

Figure legends

Figure 1. The number of unscheduled new hospitalizations for all causes (A) and for respiratory disease (B) from March 11 to May 9 in 2009, 2010 and 2011, presented in 10 day bins.

Figure 2. The number and proportion of patients hospitalized for respiratory disease pooled from March 11 to May 9 in 2009, 2010, and 2011.

Figure 3. Distribution of patients hospitalized for respiratory disease after the Great East Japan earthquake from March 11 to May 9 in 2011, presented in 10 day bins.

Figure 4. Influence of the disaster on ADL status and its deterioration in hospitalized patients for respiratory disease from March 11 to May 9 in 2011, presented in 10 day bins.

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Title

The impact of the 2011 Great East Japan Earthquake on hospitalization for respiratory disease in ~~advanced~~rapidly aging society: a retrospective descriptive and cross-sectional study at the disaster base hospital in Ishinomaki

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Article summary

Article focus

The Great East Japan Earthquake attacked one of the most ~~advanced~~rapidly aging societies in the world. Respiratory medicine is the major field in gerontology. Here we address how seriously the disaster affected respiratory diseases in the most heavily stricken area, which has one of the highest ratios of elderly people in Japan.

The study gives lessons against natural disasters and aging society.

Key messages

After the earthquake and tsunami, admission from pneumonia and exacerbation of chronic respiratory disease in elderly increased.

Harsh conditions and poor ADL after the disaster may be associated with increase in hospitalization for respiratory diseases in elderly people.

Strengths and limitations of study

We could obtain detailed data of patient even in the catastrophic state.

We analyzed only hospitalized patients. But there were a great number of outpatients as well as heavy loss of lives.

Abstract

Objective

To investigate the impact of the 2011 Great East Japan earthquake on hospitalization for respiratory disease at the disaster base hospital in aging society.

Design

Descriptive and cross sectional study.

Setting

Emergency care in Japanese Red Cross Ishinomaki Hospital, a regional disaster base hospital, Miyagi, Japan.

Participants

322 emergency patients who hospitalized for respiratory disease from March 11 to May 9 in 2011, and 99 and 105~~204~~ emergency patients who hospitalized in the corresponding ~~time~~ period of 2009 and 2010, respectively.

Main outcome measures

Description and comparison of patient's characteristics and disease distribution in terms of age, time after the disaster, and activities~~y~~ of daily living (ADL).

Results

Total number of patients hospitalized in our hospital in the study period was 1769 (~~ly 1,769~~850 in 2009, 1030 in 2010), and the ~~patients admitted to our hospital, and~~ number of hospitalized for respiratory disease in them was 322 (99 in 2009, 105 in 2010). ~~322 of them were hospitalized for respiratory disease during the first 60 days after the earthquake. Mean age of patient was 75.7±12.5 years old.~~Among admission for pulmonary diseases, p~~P~~neumonia was the most frequent disease (n=190, 59.0%), followed by acute exacerbation of chronic obstructive disease (AE-COPD) (n=53, 16.5%), attack of asthma (n=27, 8.4%), and progression of lung cancer (n=22, 6.8%). Compared with the corresponding period of 2009 or 2010, increase in absolute number of hospitalization was the highest for pneumonia, followed by AE-COPD and attack of asthma. ~~Elderly patients were more likely hospitalized after the earthquake, especially for pneumonia and AE-COPD.~~ At hospitalization, 195 patients were "dependent" and 54 patients were "partially dependent". Respiratory admission accompanied by deterioration ~~Deterioration~~ of ADL after the disaster was more frequent in elderly and female patients. ~~The mean age was 73.1±11.2 years old in the patients with deterioration of ADL and 69.9±15.1 in the patients without deterioration of ADL. The male proportion was 60.6% in the patients with deterioration of ADL and 70% in the patients without deterioration of ADL.~~

Conclusions

After the Great East Japan Earthquake, admission for pneumonia and exacerbation of chronic respiratory disease in elderly increased at the disaster base hospital.

Introduction

On March11, 2011, at 2:46 pm Japan time, the Pacific coast of Japan's Tohoku (northeastern) region was struck by the massive earthquake (The Great East Japan Earthquake), measuring magnitude 9.0 on the Richter scale[1]. The earthquake triggered a devastating tsunami which destroyed many towns and villages near the seashore. The epicenter was estimated to be about 70 kilometers east of Oshika Peninsula of Ishinomaki in Miyagi. Officially, over 19,000 people were killed or missing and the maximum number of refugees reached more than 550,000[2].

Ishinomaki city, located in Pacific coast of Honshu Island, suffered from the largest number of victims in Japan, 3,280 people were killed and 669 people were still missing. A great number of casualties, more than 10,000 patients in the first 30 days, were treated at Japanese Red Cross Ishinomaki Hospital, a regional disaster base hospital in Ishinomaki which uniquely preserved its hospital function in Ishinomaki region during and after the disaster.

Japan is one of the most rapidly ~~advanced~~ aging society in the world. 23% of Japanese citizens were age 65 or over~~years old or more~~ in 2010[3]. ~~Especially,~~ Tohoku region is especially rapidly ~~a highly advanced~~ aging society in Japan, 26.6% of people living in Ishinomaki city were age 65 or over~~years old or more~~ in 2010~~1~~. Although several reports showed the significant association between age and earthquake and tsunami death[4-8], there were few reports investigating the impact of a tremendous disaster on elderly peoples in~~–~~ such an aging society[9] [10].

Respiratory diseases are common in the elderly ~~people~~ even in ordinary times. So, investigating the impact of the disasters on respiratory health will contribute to elucidating the problem of aging society. Thus, we performed retrospective descriptive and cross-sectional analysis of the medical and epidemiologic data of the patient ~~requiring~~required hospitalization for respiratory disease after the Great East Japan Earthquake and following tsunami.

Methods

This study was a retrospective descriptive and cross-sectional analysis of the data obtained from

the medical records at Japanese Red Cross Ishinomaki Hospital. We reviewed medical records of patients admitted to the hospital for respiratory diseases during the first 60 days after the Great East Japan Earthquake, when the hospital solely accepted emergency patients. We also reviewed medical records of patients who required unscheduled hospitalization for respiratory disease in the corresponding period of 2009 and 2010.

Japanese Red Cross Ishinomaki Hospital which had 402 beds for inpatients was located at 4.5 km inland from Pacific Ocean. It has covered about 220,000 people living in its medical zone (Ishinomaki City, Onagawa Town, ~~or~~and Higashi-matsushima City) and assigned to a regional disaster base hospital. It has ~~received~~accepted almost all of the emergency respiratory patients even in the ordinary time before the disaster, because it ~~is~~has been the unique hospital having the respiratory department and pulmonary specialists in the region.

Medical records were investigated in terms of date of admission, age, sex, diagnosis. We also investigated activities~~activity~~ of daily living (ADL) at hospitalization and ADL before earthquake, and their residence before admission on the medical record of 2011 study period. For comparison, the total number of unscheduled hospitalization ~~to the hospital~~ during the corresponding periods in 2009 and 2010 was counted.

Pneumonia was defined as the presence of the infiltration on chest radiograph along with one or more of the following symptoms or signs: fever, cough, sputum production, breathlessness, pleuritic chest pain or signs consistent with pneumonia on auscultation.

Chronic obstructive pulmonary disease (COPD) and bronchial asthma were detected by the previous spirometric data, patient's self-report, or physician's diagnosis made by patient's history, physical examination, and radiological finding. An acute exacerbation of COPD(AE-COPD) was defined as an increase in or new onset of more than one symptom of COPD (cough, sputum, wheezing, dyspnea or chest tightness) without pneumonia or pneumothorax. An attack of asthma was defined as the presentation of wheezes or severe cough in asthma patients without pneumonia. Progression of lung cancer was defined as requirement for admission for lung cancer associated condition such as dehydration, respiratory failure, or uncontrolled pain. Obstructive pneumonia due to lung cancer was considered as progression of lung cancer. Chest trauma and traumatopnea were not considered as respiratory disease but chest injury.

ADL was assessed by the information from a patient, patient's family, or patient's caregiver, and classified into three categories; "independent" who could live without particular support, "partially dependent" who could not leave their residence without any support, "dependent" who spent a day on the bed or the wheelchair and lost the ability to move for themselves. ~~Furthermore~~To investigate the impact of the disaster on ADL, we defined as "originally dependent" who were dependent or partially dependent before the disaster, and as "newly

dependent" who became dependent or partially dependent after the disaster.

Data analysis

All data were entered into a personal computer and analyzed using Microsoft ™ Excel software and statistical analysis was performed using JMP9 (SAS Institute Inc., Cary, NC, USA). A missing value in medical record was treated as "unknown". Results were given as mean ± SD for numerical variables and as proportions for categorical variables. To analyze sequential change of the effect of the disaster, we divided 60 days of study period into six groups of ~~each~~ ten day~~s~~ bins. To investigate the risk of hospitalization for respiratory disease after the earthquake and tsunami, we compared the patient's characteristics of 2011 study period with the ~~that of~~ combined data of ~~2010 and 2009~~ 2009 and 2010 corresponding period as ordinary time. We used two-sided Student's *t*-test for numerical variables and chi-square test for the categorical variables. ~~We calculated the effect of age and sex on the odds ratio for hospitalization for respiratory disease after the earthquake by logistic regression models.~~ The $p < 0.05$ is accepted as statistically significant.

Result

All of the scheduled hospitalization was cancelled and emergency admission was solely accepted during the first 60 day after the earthquake at Japanese Red Cross Ishinomaki Hospital. 1,769 patients admitted to the hospital, and 322 of them were hospitalized for respiratory disease during the study period. ~~Patients hospitalized for respiratory disease accounted for 18.2% of total hospitalization during the study period.~~ In the corresponding period, total number of unscheduled hospitalization was 850 and that for respiratory disease was 99 in 2009 and 1,030 and 105 in 2010. Patients hospitalized for respiratory disease accounted for 18.2% of total hospitalization during the study period. This proportion was significantly higher than that of 2009 and 2010 (11.6% in 2009. P<0.001. 10.2% in 2010. P<0.001). ~~the corresponding period of past two years, 10.2% of 2010 and 11.6% of 2009.~~ While the number of total hospitalizations of this period in 2011 was about twice of that in 2009 and 2010, hospitalization for respiratory disease in 2011 reached about three times or more than that of 2009 and 2010. The total number of hospitalizations was ~~at peak~~peaked in the first ten days ~~and then decreased~~, but the number of hospitalization for respiratory disease kept increasing for 20 days (Figure 1A and B).

We compared the number and proportion of patients hospitalized for respiratory disease ~~disease distribution~~ between 2011, 2010, and 2009 study periods (Figure 2). Pneumonia was the most

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frequent disease (n=190, 59.0%), followed by AE-COPD (n=53, 16.5%), attack of asthma (n=27, 8.4%), and progression of lung cancer (n=22, 6.8%). One case of AE-COPD and seven cases of attack of asthma were physician's diagnosis. Category "Others" included pneumothorax, restrictive thoracic disease, pleural effusion, influenza, drowning, primary pulmonary hypertension, requirement of mechanical ventilator support for neuromuscular disease, and so on. One patient diagnosed as pneumonia was complicated by attack of asthma and two patients of pneumonia exacerbated their symptom of COPD. They were treated for both conditions and counted as pneumonia. In comparison with the past two years, the increase in ~~absolute~~ number of hospitalizations was the largest for pneumonia, followed by AE-COPD and attack of asthma. The number of hospitalization for progression of lung cancer and that for "others" ~~diseases~~ were not so ~~deferent~~different from the past two years. 39.4% of patients were hospitalized from~~stayed at~~ emergency shelters ~~before hospitalization.~~.

To investigate the disease specific effect of earthquake, age and sex of each disease were compared between the study period in 2011 and the corresponding period in the past two years ~~(Table 1)~~. The mean age of patients hospitalized for respiratory disease was significantly higher in 2011 than in the past two years (75.7±12.5 ~~years old~~ v.s. ~~in 2011,~~ 73.2±13.4 years old ~~in 2010 and 2009~~. p=0.03). Male proportion tended to be lower in 2011 than in the past two years (59.6% in 2011, 67.2% in 2010 and 2009. p=0.08). Specifically, pneumonia patients and AE-COPD patients were significantly older in 2011 study period than in 2010 and 2009 corresponding period(77.6±11.8 v.s. 74.3±12.8 years old in pneumonia patients. p=0.03, 76.0±8.7 v.s. 69.5±15.9 years old in AE-COPD patients. ~~and~~ p=0.03~~, respectively~~). Male population of AE-COPD was significantly higher (81.1% v.s. 50.0%. p=0.01), whereas that of ~~attack of~~ asthma attack significantly lower in 2011 period than 2010 and 2009 periods (18.5% v.s. 54.6%. ~~p=0.01 and~~ p=0.03~~, respectively~~).

~~Furthermore, the effect of age and sex on the odds ratio for hospitalization with respiratory disease was calculated (Table 2). We found older patients were more likely hospitalized after the earthquake, especially for pneumonia and AE-COPD. Male patients were more likely hospitalized for AE-COPD and less likely hospitalized for attack of asthma.~~

Actual numbers of hospitalization for the main respiratory diseases in terms of every ten day~~s~~ bins during the study period is shown in Figure 3. Pneumonia ~~presented its peak~~ peaked in the second ~~period~~10 day bin. Following pneumonia, AE-COPD and attack of asthma ~~presented its peak~~peaked in the third 10 day bin~~period. and p~~Progression of lung cancer had its peak in the fifth 10 day bin~~period. Attack of asthma had small peak in the same third period as AECOPD.~~

Next, we investigated ADL at hospitalization and ADL before the disaster among the patients hospitalized in 2011 study period. Because of confusing situation of medical activities after the disaster, ADL was not recorded in 11 patients ~~ADL before the disaster, ADL at hospitalization, and both ADL were not recorded in 8, 1, and 2 patients, respectively. Six of them were hospitalized for pneumonia and remaining five patients were hospitalized for AE-COPD.~~ At hospitalization, 195 patients (60.5%) were "dependent" and 54 patients (16.7%) were "partially dependent". ~~Those patients accounted for 76.9 % of the patients hospitalized after the earthquake.~~ On the other hand, before earthquake, only 86 patients (26.7%) were "dependent" and 51 patients (15.8%) were "partially dependent". ~~Those patients accounted for 42.5% of hospitalized patients after the earthquake.~~ To investigate the impact of ADL and its deterioration on admission for pulmonary disease in terms of time after the disaster, ~~We~~ we ~~analyze sequential change in~~counted the number of the patients who were "originally dependent", "newly dependent", or "independent throughout" ~~at hospitalization~~during 60 days presented in 10 day bins (Figure 4). Throughout the study period, majority of patients were dependent or partially dependent patient. In the first 20 days, the majority of admissions were for originally dependent people. After 30days, there was a sharp increase in newly dependent people, as assessed by ADL ~~Originally dependent patients were hospitalized especially in early period (first and second periods), and newly dependent patients showed its keen peak of hospitalization in the third period, the day from 21 to 30 after the earthquake, and kept high incidence of admission thereafter~~. Independent patients were hospitalized mainly during first 20 days.

Table ~~1~~3 showed the association of ADL category (independent throughout, newly dependent, and originally dependent) with patient's age, sex, and diagnosis. Regarding diagnosis, ratio of each disease was calculated in each category. Eleven patients whose ADL was not completely recorded were excluded from the data. Young and male patients were more frequent in order of independent, newly dependent and originally dependent. On investigation in patient's diagnosis, the proportion of pneumonia and progression of lung cancer increased in the same order, while the proportion of AE-COPD and asthma decreased.

Discussion

Summary

In this retrospective descriptive and cross-sectional study, we found substantial increase in elderly patients hospitalized for respiratory disease after the earthquake and tsunami. Pneumonia, AE-COPD, and attack of asthma were apparently increased after earthquake. Mean age of

patients hospitalized for respiratory disease after the earthquake was significantly higher than that of ~~ordinary years~~corresponding periods of the past two years. Majority of patients had poor ADL and many of them experienced deterioration of ADL after the earthquake.

Effect on respiratory disease

Previous reports on Hanshin-Awaji earthquake showed initial rush of patients with injury and following increase of patients with respiratory disease, especially pneumonia[11-13]. Similarly, our observation showed marked increase in pneumonia patients, although initial rush of heavy injury patients was absent in this disaster because majority of victims were ~~drawn~~drowned to death and heavily injured patients were seldom carried to the hospital.

The cause of increase in respiratory disease was different in each situation. After the 2004 Sumatra-Andaman earthquake and following tsunami, the number of lower respiratory infection in Ache was rapidly increased after the disaster and sharply declined in the second week[14]. On the other hand, after the 1995 Hanshin-Awaji earthquake, the number of patients hospitalized for pneumonia was gradually increased and kept high proportion over the two month[9 10]. This difference is ascribable to the mechanism of developing pneumonia. In Sumatra-Andaman earthquake, many of pneumonia were resulted from aspiration of tsunami-water in near-drowning events[15 16]. Those pneumonias were called "tsunami lung". On the other hand, in the Hanshin-Awaji earthquake, many patients developed pneumonia in shelters under unhealthy environment and most of them were in elderly. Those pneumonias were called "shelter pneumonia" [17]. In this earthquake and tsunami, we experienced few number of pneumonia directly caused by aspiration of tsunami-water even in the very acute period. ~~Most patients came from their own or relative's home, other hospital, nursing home, or shelter, and a~~A few of the patient directory came from the field, instead, most patients came from shelters, their own or relative's homes, other hospitals, or nursing homes.~~-~~ The mean age of them was significantly higher than that of 2010 and 2009. Therefore, we ~~thought~~regarded most of pneumonia we treated ~~was~~as the same kind of "shelter pneumonia". We could not carry out a bacteriological examination for 14 days after the earthquake due to shortage of water, fuel, gas, and manpower. After that, we could perform bacteriological examination, bacterial culture or gram staining. We treated most of the pneumonias as "aspiration pneumonia in nursing home" because of the patients' ADL.

AE-COPD was also remarkably increased. COPD was one of the most common chronic respiratory diseases, especially in elderly people. It is well known that interruption of treatment for chronic disease will ~~easily~~frequently exacerbate patient's condition, and it is also true after a natural disaster[14 18-20]. Many patients lost their drugs by tsunami flooding, therefore, interruption

of regular medication may partly account for the increase in hospitalization by AE-COPD. Sunny and windy days lasted from the end of March and dust from the tsunami sludge was an important component of particulate air pollution; it may have contributed to the significant increase in ~~We also speculate that air pollution caused by tsunami dust may raise the~~ hospitalization by AE-COPD. ~~After cold and snowy weather for ten days from the disaster, cold, sunny, and windy days covered over Ishinomaki region, and dense dust containing tsunami sediment floated in the air for the following three weeks.~~

Although asthma was also one of the most common chronic respiratory diseases and had the same precipitating cause with COPD, attack of asthma was not so much increased as AE-COPD. This difference might be caused by two important differences between asthma and COPD. First, generally, patients of COPD were older than those of asthma. Therefore, baseline health condition of patients of COPD would be poorer than that of asthma[21]. As a result, COPD patients required more frequent hospitalization. In our study, mean age of AE-COPD was higher than that of attack of asthma as well. Second, bacterial respiratory infection affects patients with COPD more than those with asthma[22]. In the aftermath of earthquake, loss of hygiene and overcrowding in the shelter could increase the risk of respiratory bacterial infection and cause AE-COPD.

Hospitalization for lung~~Lung~~ cancer related symptons~~hospitalization~~ did not increase much and its ratio to total hospitalization for respiratory diseases rather declined. Mean age of lung cancer patients was similar to that in the past two years. Maeda et al. also reported that no increase in lung cancer related hospitalization was observed after Hanshin-Awaji earthquake[23]. Progression of lung cancer may not be influenced by environment as much as cancer growth itself. So, the disaster will not impact on lung cancer immediately. Although the interruption of chemotherapy and/or radiotherapy would worsen the prognosis, it cannot be confirmed during our study period.

Effect on ADL

~~Our observation demonstrated that drastic deterioration of ADL after the disaster resulted in increase in hospitalization by respiratory diseases.~~ In acute phase, patients with poor ADL, especially those originally dependent ~~ones~~, were hospitalized for pulmonary diseases, typically pneumonia~~,~~, although substantial number of good ADL patients was also hospitalized. After 3 ~~or 4~~ weeks, there was a sharp increase in newly dependent people~~many people~~ who deteriorated their ADL after the disaster~~(newly dependent) were hospitalized for pulmonary diseases~~. It was reported that physical disability was an independent risk factor for death in Hanshin-Awaji earthquake and the 1999 Taiwan earthquake[9 10]. However, those reports investigated the mortality in acute phase, not hospitalization in subacute or chronic phase. After the earthquake

and tsunami, one fourth of people in Ishinomaki region fled into shelters, many of which were also flooded by tsunami. They lacked water and food under harsh condition of cold season without heating in overcrowded ~~room~~quarter just letting them lie on the floor without beds. In such bad conditions, elderly people were restricted their consumption food and water, and kept still in ~~one~~a small space,~~; as a result, they deteriorated their~~resulting in deterioration of ADL~~s~~. In addition, scarcity of water worsened oral hygiene. Both poor functional status and loss of oral hygiene were the major risk factor of pneumonia[24-27], especially in elderly people. Subsequently, many elderly people were hospitalized for "shelter pneumonia" after the earthquake. Also, poor oral hygiene induces swallowing dysfunction[28] and swallowing dysfunction could be a risk factor of exacerbation of COPD[29]. It would be one of the reasons why AE-COPD increased especially in elderly people.

Effect on aging society

According to the report of government of Japan, 93% of the fatalities were drowning and more than 60% of them were over 60 years old~~ or more~~ in the Great East Japan earthquake. Although it was reported by many previous reports that elderly people had a greater risk of death after the earthquake, the proportion of the elderly~~ people~~ killed by this earthquake and tsunami was extremely high in comparison to other major earthquake or tsunami in the world[4-8]. Similar finding was reported only in 1995 Hanshin-Awaji earthquake and 2004 Mid Niigata earthquake in Japan[12 17]. Moreover, 90.8% of the patients hospitalized for respiratory disease after the earthquake were over 60 years old~~ or more~~ in our study. These results suggest~~ed~~ that elderly people were vulnerable not only immediately after the earthquake but also for a while after the earthquake.

In 1999 Taiwan earthquake, 2003 heat waves in the Czech Republic, and 2004 Sumatra-Andaman earthquake, it is demonstrated that these disasters has left decreased mortality in the stricken area, resulted from a large number of direct death by disasters among a vulnerable population such as elderly people or children[5 30 31] , called "harvesting effect". However, our observation suggests that, in the aging society, a huge disaster not only directly kills the vulnerable people but also ~~newly~~ produces new vulnerable people. Previous reports demonstrated that prolonged harmful influence on mental health and psychological slow recovery were seen more frequently in the elderly people than young people[32-35]. Therefore, we should pay a long-term attention on those elderly people after a disaster.

Implications for policy and practice

Our observation suggests two important targets for reducing hospitalization for respiratory disease after the major disaster in aging society. One target is interruption of treatment for

chronic respiratory disease and the other target is deterioration of ADL. Interruption of treatment for chronic respiratory disease was preventable by storing the drugs for a few days. However, it is necessary to establish the system of~~for~~ valid storage to grasp regional prescription data of each drug and patient's personal medication data. Telemedicine system or web-based patient data storage system might be useful. Prevention of deterioration of ADL is also important. Elderly people are~~is~~ potentially vulnerable and easily deteriorate their ADL. In our study, remaining at shelters in stricken area for more than three weeks led increase in deterioration of ADL and hospitalization for respiratory diseases. Therefore, we propose to ~~transfer~~evacuate elderly people ~~to~~ out of the stricken area as soon as possible.

Strengths and weaknesses of study

Our study had two important strengths. First, the Great East Japan Earthquake hit one of the most ~~advanced~~rapidly aging societies in the world[3]. As the proportion of elderly people continues to increase in not only developed ~~countries~~ but also developing countries, there is an urgent need of information and analysis on the aging society to plan countermeasures against it. Our study will give lessons against natural disaster to all the countries. Secondly, we obtained detailed data of patient's demographics, diagnosis, and ADL in a catastrophic situation. It is because that our hospital has kept its medical function, including electronic medical record system or laboratory systems, while devastating earthquake and tsunami hit Ishinomaki city and almost all medical facilities lost their function, and that stuffs in our hospital has trained for the coming earthquake and has had an strong motivation to record our experiences as memos or on digital recorders for future disaster medicine ~~for the future~~.

Our study is single center study. This might be weakness of our study, but our hospital was the only functional hospital after the earthquake in Ishinomaki medical zone which account for more than 30% of total fatalities~~victims~~ of this earthquake in Japan. Also, it has been the only hospital which has the department of respiratory medicine and pulmonary specialists in the medical zone. Even in the ordinary time before the disaster, it accepted almost all of the serious patients with pulmonary diseases who needed hospitalization. Therefore, we think our study well represents impact of the earthquake on pulmonary diseases~~e~~ and describes what happened in the hospital which faced the earthquake at the front[2]. It is also weakness of our study that we analyzed only hospitalized patients. There were a great number of outpatients and a heavy loss of lives. These events will be analyzed in the future report. Another weakness of our study is that cross-sectional study cannot elucidate a causal relationship. Finally, we did not clearly define the condition of hospitalization. Because the destruction of ordinary healthcare system and poor hygiene outside the hospital, we hospitalized some patients who could be treated in outpatient setting in ordinary time. However, this was a real situation after devastating disaster.

Conclusion

The Great East Japan earthquake and following tsunami hit the one of the most ~~advanced~~rapidly aging society in the world. After the disaster, pneumonia, exacerbation of COPD, bronchial asthma attack associated with bad ADL in the elderly provoked the most part of increase in hospitalization for pulmonary diseases. These observations should be exploited in constructing emergency medical management for disasters in progressive ~~advanced~~rapidly aging society.

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Competing interests: None declared.

Ethical approval: Approval of ethical review committee of Japanese Red Cross Ishinomaki Hospital was obtained.

Contributors: SY was responsible for study design and interpretation of the data, and drafted the manuscript. MH, SK, HS, ST, and MY were responsible for collection and interpretation of the data. KN drafted the statistical analysis part in the manuscript, and provided suggestions on public health and epidemiology. MH, SK and MY were responsible for study design and revised the drafted manuscript. SY, MH, SK, HS, ST and MY treated the patients. All authors approved the final version of the manuscript.

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Tables

Table 1. Demographies and patient characteristics in 2011 and past two years.

	After the earthquake (2011) n=322	Past two years (2010 and 2011) n=204	p value
All cause			
age (year)	75.7±12.5 *	73.2±13.4	0.03
male	192 (59.6)	137 (67.2)	0.08
Pneumonia			
age	77.6±11.8*	74.3±12.8	0.03
male	111 (58.4)	63 (66.3)	0.20
AE-COPD			
age	76.0±8.7*	69.3±15.9	0.03
male	43 (81.1) *	8 (50.0)	0.01
Asthma			

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age	68.7±19.7	67.2±19.4	0.83
male	5 (18.5) *	6 (54.6)	0.03
Lung cancer			
age	74.3±12.1	73.2±16.0	0.79
male	16 (72.7)	18 (66.7)	0.65
Others			
age	70.4±11.6	73.8±11.3	0.19
male	17 (56.7)	42 (76.4)	0.06

AE-COPD, acute exacerbation of COPD.

Data are mean±SD for numerical variables and number (%) for categorical variables. *p<0.05.

Table 2. Association of age and sex with hospitalization for respiratory disease after the earthquake.

	Hospitalization for respiratory disease after the earthquake	
	Unadjusted OR (95% CI)	*Adjusted OR (95% CI)
All cause		
age (year)	1.01† (1.00-1.03)	1.02† (1.00-1.03)
male (reference: female)	0.72 (0.50-1.04)	0.71 (0.19-1.03)
Pneumonia		
age	1.02† (1.00-1.04)	1.02† (1.00-1.04)
male	0.71 (0.42-1.19)	0.74 (0.44-1.23)
AE-COPD		
age	1.05† (1.00-1.11)	1.05 (1.00-1.11)
male	4.30† (1.30-14.66)	4.17 † (1.21-14.84)
Asthma		
age	1.00 (0.97-1.04)	1.00 (0.96-1.05)

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male	0.19 † (0.04-0.85)	0.19 † (0.04-0.85)
Lung cancer		
age	1.01 (0.97-1.05)	1.00 (0.96-1.05)
male	1.33 (0.39-4.76)	1.30 (0.37-4.83)
Others		
age	0.97 (0.94-1.01)	0.97 (0.93-1.01)
male	0.40 (0.15-1.05)	0.39 (0.15-1.03)

AE-COPD, acute exacerbation of COPD; OR, odds ratio; CI, confidence interval.
*Adjusted for age and sex with each other. †p<0.05

Table 13. Association of ADL with patient's characteristics and respiratory disease.

	Independent n=70	Newly dependent n=104	Originally dependent n=137
Age	69.9±15.1	73.1±11.2	80.3±10.5
Male	49 (70.0)	63 (60.6)	69 (50.4)
Diagnosis			
Pneumonia	31 (44.3)	59 (56.7)	94 (68.6)
AE-COPD	17 (24.3)	17 (16.4)	15 (11.0)
Asthma	11 (15.7)	11 (10.6)	5 (3.7)
Lung cancer	3 (4.3)	6 (5.8)	12 (8.8)
Others	8 (11.4)	11 (8.0)	11 (8.0)

AE-COPD, acute exacerbation of COPD.
Data are mean ±SD for numerical variables and number (%) for categorical variables.

Figure legends

Figure 1. The number of unscheduled new hospitalizations~~Sequential change of the number of unscheduled hospitalization~~ for all causes (A) and for respiratory disease (B) from March 11 to May 9 in 2009~~11~~, 2010 and 2011, presented in 10 day bins~~09~~.

Figure 2. The number and proportion of patients hospitalized for respiratory disease pooled from March 11 to May 9 in 2009~~11~~, 2010, and 2011~~09~~.

Figure ~~–~~3. Distribution~~Sequential change~~ of ~~disease distribution of~~ patients hospitalized for respiratory disease after the Great East Japan earthquake from March 11 to May 9 in 2011, presented in 10 day bins.

Figure 4. ~~Influence of the earthquake on the patient's ADL.~~ Influence of the disaster on ADL status and its deterioration in hospitalized patients for respiratory disease from March 11 to May 9 in 2011, presented in 10 day bins.

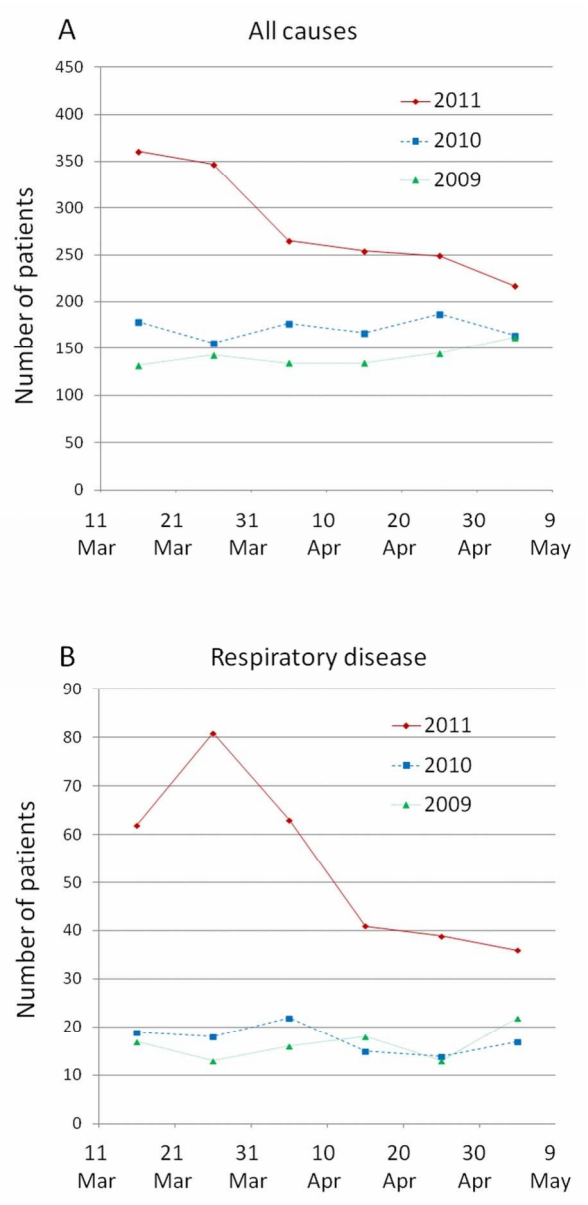

Figure 1. The number of unscheduled new hospitalizations for all causes (A) and for respiratory disease (B) from March 11 to May 9 in 2009, 2010 and 2011, presented in 10 day bins.
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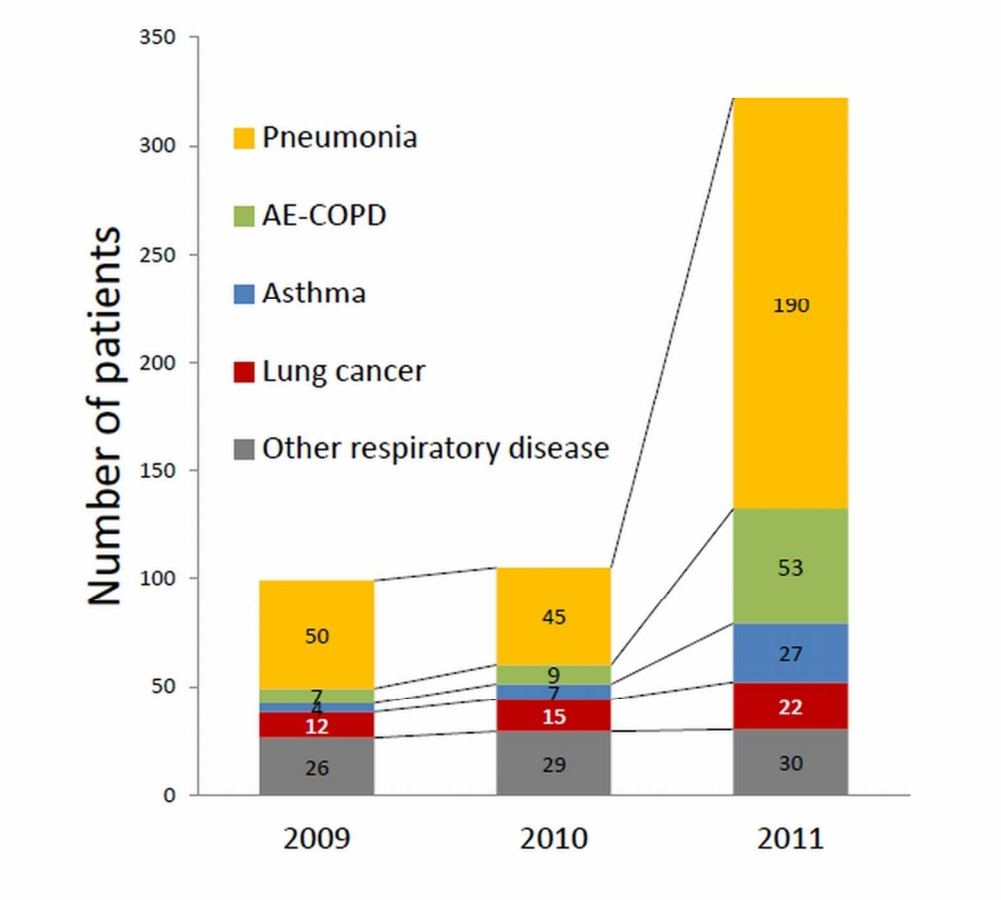

Figure 2. The number and proportion of patients hospitalized for respiratory disease pooled from March 11 to May 9 in 2009, 2010, and 2011.
99x90mm (300 x 300 DPI)

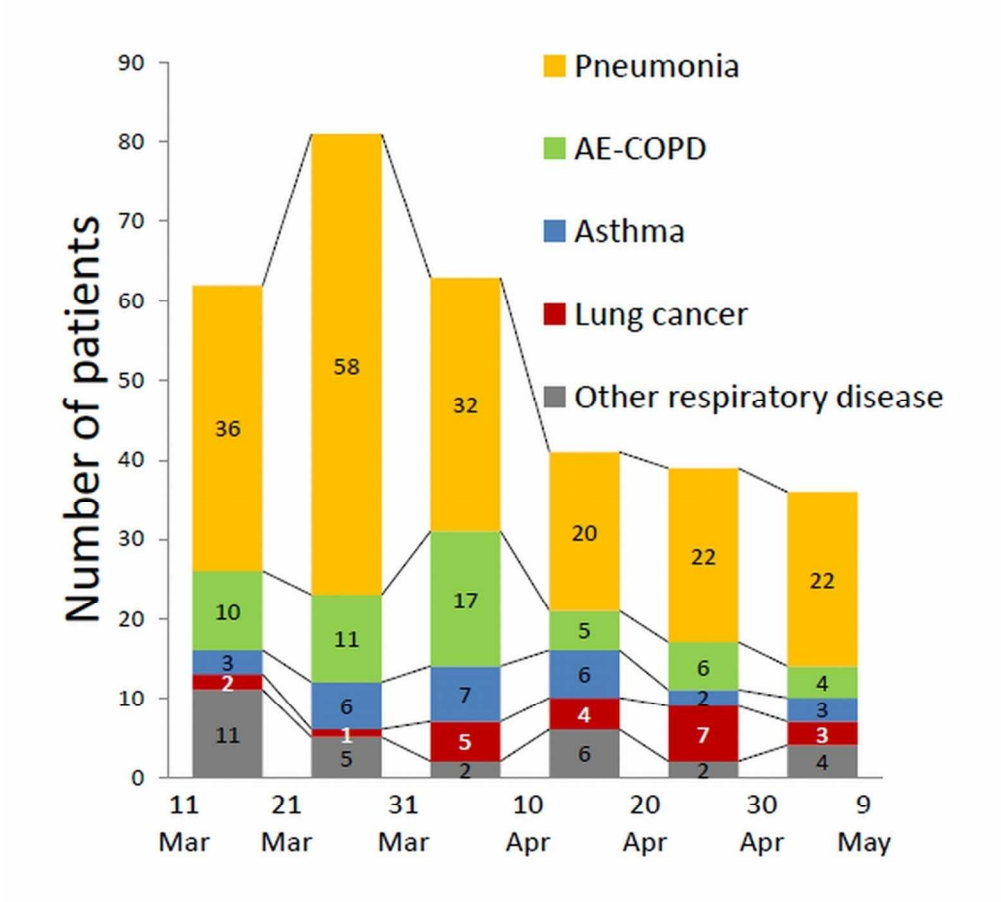

Figure 3. Distribution of patients hospitalized for respiratory disease after the Great East Japan earthquake from March 11 to May 9 in 2011, presented in 10 day bins.
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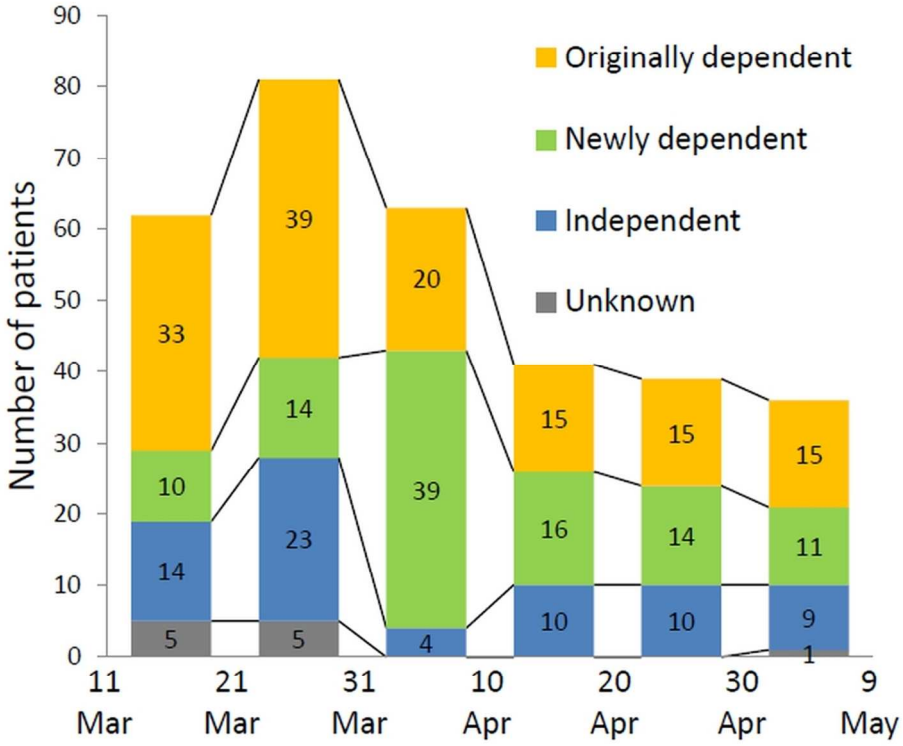

Figure 4. Influence of the disaster on ADL status and its deterioration in hospitalized patients for respiratory disease from March 11 to May 9 in 2011, presented in 10 day bins.
108x90mm (300 x 300 DPI)

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2, 3
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3-4
Objectives	3	State specific objectives, including any prespecified hypotheses	3-4
Methods			
Study design	4	Present key elements of study design early in the paper	4-6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	4-6
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	4-6
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	4-6
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	4-6
Bias	9	Describe any efforts to address potential sources of bias	-
Study size	10	Explain how the study size was arrived at	4
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	4, 5
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	5, 6
		(*b*) Describe any methods used to examine subgroups and interactions	-
		(*c*) Explain how missing data were addressed	7
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	-
		(*e*) Describe any sensitivity analyses	-
Results			

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	6
		(b) Give reasons for non-participation at each stage	-
		(c) Consider use of a flow diagram	-
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	6-7 + Table 1
		(b) Indicate number of participants with missing data for each variable of interest	7
Outcome data	15*	Report numbers of outcome events or summary measures	3
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	3 + Table 2
		(*b*) Report category boundaries when continuous variables were categorized	5
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	-
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	-
Discussion			
Key results	18	Summarise key results with reference to study objectives	8
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	11
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	8, 10-11
Generalisability	21	Discuss the generalisability (external validity) of the study results	10-11
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	12

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.