



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

Journal:	<i>BMJ Open</i>
Manuscript ID:	bmjopen-2012-000865
Article Type:	Research
Date Submitted by the Author:	20-Jan-2012
Complete List of Authors:	Yamanda, Shinsuke; Japanese Red Cross Ishinomaki Hospital, Respiratory Medicine Hanagama, Masakazu; Japanese Red Cross Ishinomaki Hospital, Department of respiratory medicine Kobayashi, Seiichi; Japanese Red Cross Ishinomaki Hospital, Department of respiratory medicine Satou, Hikari; Japanese Red Cross Ishinomaki Hospital, Department of respiratory medicine Tokuda, Shinsaku; Kobe University Graduate School of Medicine, Division of Cell Biology Niu, Kaijun; Tohoku University Graduate School of Biomedical Engineering, Division of Biomedical Engineering for Health and Welfare Yanai, Masaru; Japanese Red Cross Ishinomaki Hospital, Department of respiratory medicine
Primary Subject Heading:	Respiratory medicine
Secondary Subject Heading:	Geriatric medicine, Emergency medicine
Keywords:	GERIATRIC MEDICINE, Adult thoracic medicine < THORACIC MEDICINE, ACCIDENT & EMERGENCY MEDICINE

SCHOLARONE™
Manuscripts

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

Author names

Shinsuke Yamanda *physician scientist*¹, Masakazu Hanagama *physician scientist*¹, Seiichi Kobayashi *senior physician scientist*¹, Hikari Satou *resident*¹, Shinsaku Tokuda *lecturer*², Kaijun Niu *associate professor*³, Masaru Yanai *director*¹

¹Department of respiratory medicine, Japanese Red Cross Ishinomaki Hospital, 71 Hebita Aza Nishimichishita, Ishinomaki, Miyagi, Japan

²Division of Cell Biology, Kobe University Graduate School of Medicine, 7-5-1 Kusunoki-cho, chuo-ku, Kobe, Hyogo, Japan

³Division of Biomedical Engineering for Health and Welfare, Tohoku University Graduate School of Biomedical Engineering, 2-1 Seiryō-machi, Aoba-ku, Sendai, Miyagi, Japan

Correspondence to: Shinsuke Yamanda syamanda@gmail.com

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 March 11, 2011, at 2:46 pm Japan time, the Pacific coast of Japan's Tohoku (northeastern)

1
2
3
4
5 region was struck by the massive earthquake (The Great East Japan Earthquake), measuring
6 magnitude 9.0 on the Richter scale¹. The earthquake triggered a devastating tsunami which
7 destroyed many towns and villages near the seashore. The epicenter was estimated to be about
8 70 kilometers east of Oshika Peninsula of Ishinomaki in Miyagi. Officially, over 19,000 people
9 were killed or missing and the maximum number of refugees reached more than 550,000².

10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
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 2010³. 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
death⁴⁻⁸, 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

1
2
3
4
5 their residence before admission on the medical record of 2011 study period. For comparison,
6 the total number of unscheduled hospitalization to the hospital during the corresponding periods
7 in 2009 and 2010 was counted.

8
9
10 Pneumonia was defined as the presence of the infiltration on chest radiograph along with one or
11 more of the following symptoms or signs: fever, cough, sputum production, breathlessness,
12 pleuritic chest pain or signs consistent with pneumonia on auscultation.

13
14 Chronic obstructive pulmonary disease (COPD) and bronchial asthma were detected by the
15 previous spirometric data, patient's self-report, or physician's diagnosis made by patient's
16 history, physical examination, and radiological finding. An acute exacerbation of
17 COPD(AE-COPD) was defined as an increase in or new onset of more than one symptom of
18 COPD (cough, sputum, wheezing, dyspnea or chest tightness) without pneumonia or
19 pneumothorax. An attack of asthma was defined as the presentation of wheezes or severe cough
20 in asthma patients without pneumonia. Progression of lung cancer was defined as requirement
21 for admission for lung cancer associated condition such as dehydration, respiratory failure, or
22 uncontrolled pain. Obstructive pneumonia due to lung cancer was considered as progression of
23 lung cancer. Chest trauma and traumatopnea were not considered as respiratory disease but
24 chest injury.

25
26 ADL was assessed by the information from a patient, patient's family, or patient's caregiver, and
27 classified into three categories; "independent" who could live without particular support,
28 "partially dependent" who could not leave their residence without any support, "dependent"
29 who spent a day on the bed or the chair and lost the ability to move for themselves. Furthermore,
30 we defined as "originally dependent" who were dependent or partially dependent before the
31 disaster, and as "newly dependent" who became dependent or partially dependent after the
32 disaster.

33 34 35 36 37 38 39 40 41 42 Data analysis

43 All data were entered into a personal computer and analyzed using Microsoft™ Excel software
44 and statistical analysis was performed using JMP9 (SAS Institute Inc., Cary, NC, USA). A
45 missing value in medical record was treated as "unknown". Results were given as mean ± SD
46 for numerical variables and as proportions for categorical variables. To analyze sequential
47 change of the effect of the disaster, we divided 60 days of study period into six groups of each
48 ten days. To investigate the risk of hospitalization for respiratory disease after the earthquake
49 and tsunami, we compared the patient's characteristics of 2011 study period with that of 2010
50 and 2009 corresponding period as ordinary time. We used two-sided Student's *t*-test for
51 numerical variables and chi-square test for the categorical variables. We calculated the effect of
52 age and sex on the odds ratio for hospitalization for respiratory disease after the earthquake by
53
54
55
56
57
58
59
60

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

1
2
3
4
5 period($p=0.03$ and $p=0.03$, respectively). Male population of AE-COPD was significantly higher,
6 whereas that of attack of asthma significantly lower in 2011 period than 2010 and 2009
7 periods($p=0.01$ and $p=0.03$, respectively).
8

9
10 Furthermore, the effect of age and sex on the odds ratio for hospitalization with respiratory
11 disease was calculated (Table 2). We found older patients were more likely hospitalized after the
12 earthquake, especially for pneumonia and AE-COPD. Male patients were more likely
13 hospitalized for AE-COPD and less likely hospitalized for attack of asthma.
14

15
16
17 Actual numbers of hospitalization for the main respiratory diseases in terms of every ten days
18 during the study period is shown in Figure 3. Pneumonia presented its peak in the second period.
19 Following pneumonia, AE-COPD presented its peak in the third period and progression of lung
20 cancer had its peak in the fifth period. Attack of asthma had small peak in the same third period
21 as AECOPD.
22
23

24
25
26 Next, we investigated ADL at hospitalization and ADL before the disaster among the patients
27 hospitalized in 2011 study period. Because of confusing situation of medical activities after the
28 disaster, ADL before the disaster, ADL at hospitalization, and both ADL were not recorded in 8,
29 1, and 2 patients, respectively. Six of them were hospitalized for pneumonia and remaining five
30 patients were hospitalized for AE-COPD. At hospitalization, 195 patients were “dependent” and
31 54 patients were “partially dependent”. Those patients accounted for 76.9 % of the patients
32 hospitalized after the earthquake. On the other hand, before earthquake, only 86 patients were
33 “dependent” and 51 patients were “partially dependent”. Those patients accounted for 42.5% of
34 hospitalized patients after the earthquake. We analyze sequential change in the number of the
35 patients who were “originally dependent”, “newly dependent”, or “independent” at
36 hospitalization (Figure 4). Throughout the study period, majority of patients were dependent or
37 partially dependent patient. Originally dependent patients were hospitalized especially in early
38 period (first and second periods), and newly dependent patients showed its keen peak of
39 hospitalization in the third period, the day from 21 to 30 after the earthquake, and kept high
40 incidence of admission thereafter. Independent patients were hospitalized mainly during first
41 20 days.
42
43
44
45
46
47
48

49
50 Table 3 showed the association of ADL category (independent, newly dependent, and originally
51 dependent) with patient’s age, sex, and diagnosis. Regarding diagnosis, ratio of each disease
52 was calculated in each category. Eleven patients whose ADL was not completely recorded were
53 excluded from the data. Young and male patients were more frequent in order of independent,
54 newly dependent and originally dependent. On investigation in patient’s diagnosis, the
55
56
57
58
59
60

1
2
3
4
5 proportion of pneumonia and progression of lung cancer increased in the same order, while the
6 proportion of AE-COPD and asthma decreased.
7
8
9

10 11 **Discussion**

12 **Summary**

13
14 In this retrospective descriptive and cross-sectional study, we found substantial increase in
15 elderly patients hospitalized for respiratory disease after the earthquake and tsunami. Pneumonia,
16 AE-COPD, and attack of asthma were apparently increased after earthquake. Mean age of
17 patients hospitalized for respiratory disease after the earthquake was significantly higher than
18 that of ordinary years. Majority of patients had poor ADL and many of them experienced
19 deterioration of ADL after the earthquake.
20
21

22 **Effect on respiratory disease**

23
24 Previous reports on Hanshin-Awaji earthquake showed initial rush of patients with injury and
25 following increase of patients with respiratory disease, especially pneumonia¹¹⁻¹³. Similarly, our
26 observation showed marked increase in pneumonia patients, although initial rush of heavy
27 injury patients was absent in this disaster because majority of victims were drawn to death and
28 heavily injured patients were seldom carried to the hospital.
29

30
31 The cause of increase in respiratory disease was different in each situation. After the 2004
32 Sumatra-Andaman earthquake and following tsunami, the number of lower respiratory infection
33 in Aceh was rapidly increased after the disaster and sharply declined in the second week¹⁴. On
34 the other hand, after the 1995 Hanshin-Awaji earthquake, the number of patients hospitalized for
35 pneumonia was gradually increased and kept high proportion over the two month^{9 10}. This
36 difference is ascribable to the mechanism of developing pneumonia. In Sumatra-Andaman
37 earthquake, many of pneumonia were resulted from aspiration of tsunami-water in
38 near-drowning events^{15 16}. Those pneumonias were called “tsunami lung”. On the other hand, in
39 the Hanshin-Awaji earthquake, many patients developed pneumonia in shelters under unhealthy
40 environment and most of them were in elderly. Those pneumonias were called “shelter
41 pneumonia”¹⁷. In this earthquake and tsunami, we experienced few number of pneumonia
42 directly caused by aspiration of tsunami-water even in very acute period. Most patients came
43 from their own or relative’s home, other hospital, nursing home, or shelter, and a few of the
44 patient directory came from the field. The mean age of them was significantly higher than that
45 of 2010 and 2009. Therefore, we thought most of pneumonia we treated was the same kind of
46 “shelter pneumonia”.
47
48

49 AE-COPD was also remarkably increased. COPD was one of the most common chronic
50 respiratory diseases, especially in elderly people. It is well known that interruption of treatment
51
52
53
54
55
56
57
58
59
60

1
2
3
4
5 for chronic disease will easily exacerbate patient's condition, and it is also true after a natural
6 disaster^{14 18-20}. Many patients lost their drugs by tsunami flooding, therefore, interruption of
7 regular medication may partly account for the increase in hospitalization by AE-COPD. We
8 also speculate that air pollution caused by tsunami dust may raise the hospitalization by
9 AE-COPD. After cold and snowy weather for ten days from the disaster, cold, sunny, and
10 windy days covered over Ishinomaki region, and dense dust containing tsunami sediment
11 floated in the air for the following three weeks.

12
13 Although asthma was also one of the most common chronic respiratory diseases and had the
14 same precipitating cause with COPD, attack of asthma was not so much increased as AE-COPD.
15 This difference might be caused by two important differences between asthma and COPD. First,
16 generally, patients of COPD were older than those of asthma. Therefore, baseline health
17 condition of patients of COPD would be poorer than that of asthma²¹. As a result, COPD
18 patients required more frequent hospitalization. In our study, mean age of AE-COPD was higher
19 than that of attack of asthma as well. Second, bacterial respiratory infection affects patients with
20 COPD more than those with asthma²². In the aftermath of earthquake, loss of hygiene and
21 overcrowding in the shelter could increase the risk of respiratory bacterial infection and cause
22 AE-COPD.

23
24 Lung cancer related hospitalization did not increase much and its ratio to total hospitalization
25 for respiratory diseases rather declined. Mean age of lung cancer patients was similar to that in
26 the past two years. Maeda et al. also reported that no increase in lung cancer related
27 hospitalization was observed after Hanshin-Awaji earthquake²³. Progression of lung cancer may
28 not be influenced by environment as much as cancer growth itself. So, the disaster will not
29 impact on lung cancer immediately. Although the interruption of chemotherapy and/or
30 radiotherapy would worsen the prognosis, it cannot be confirmed during our study period.

31 **Effect on ADL**

32
33 Our observation demonstrated that drastic deterioration of ADL after the disaster resulted in
34 increase in hospitalization by respiratory diseases. In acute phase, patients with poor ADL,
35 especially originally dependent ones, were hospitalized for pulmonary diseases, typically
36 pneumonia; although substantial number of good ADL patients was also hospitalized. After 3 or
37 4 weeks, many people who deteriorated their ADL (newly dependent) were hospitalized for
38 pulmonary diseases. It was reported that physical disability was an independent risk factor for
39 death in Hanshin-Awaji earthquake and the 1999 Taiwan earthquake^{9 10}. However, those reports
40 investigated the mortality in acute phase, not hospitalization in subacute or chronic phase. After
41 the earthquake and tsunami, one fourth of people in Ishinomaki region fled into shelters, many
42 of which were also flooded by tsunami. They lacked water and food under harsh condition of
43 cold season without heating in overcrowded room just letting them lie on the floor without beds.
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

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 pneumonia²⁴⁻²⁷, especially in elderly people. Subsequently, many elderly people were hospitalized for “shelter pneumonia” after the earthquake. Also, poor oral hygiene induces swallowing dysfunction²⁸ and swallowing dysfunction could be a risk factor of exacerbation of COPD²⁹. 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 world⁴⁻⁸. 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 people³²⁻³⁵. 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

1
2
3
4
5 stricken area for more than three weeks led increase in deterioration of ADL and hospitalization
6 for respiratory diseases. Therefore, we propose to transfer elderly people to out of the stricken
7 area as soon as possible.
8
9

10 11 **Strengths and weaknesses of study**

12 Our study had two important strengths. First, the Great East Japan Earthquake hit one of the
13 most advanced aging societies in the world³. As the proportion of elderly people continues to
14 increase in not only developed countries but also developing countries, there is an urgent need
15 of information and analysis on the aging society to plan countermeasures against it. Our study
16 will give lessons against natural disaster to all the countries. Secondly, we obtained detailed data
17 of patient's demographics, diagnosis, and ADL in a catastrophic situation. It is because that our
18 hospital has kept its medical function, including electronic medical record system or laboratory
19 systems, while devastating earthquake and tsunami hit Ishinomaki city and almost all medical
20 facilities lost their function, and that staffs in our hospital has trained for the coming earthquake
21 and has had an strong motivation to record disaster medicine for the future.
22
23

24 Our study is single center study. This might be weakness of our study, but our hospital was the
25 only functional hospital after the earthquake in Ishinomaki medical zone which account for
26 more than 30% of victims of this earthquake. Also, it has been the only hospital which has the
27 department of respiratory medicine and pulmonary specialists in the medical zone. Even in the
28 ordinary time, it accepted almost all of the serious patients with pulmonary diseases who needed
29 hospitalization. Therefore, we think our study well represents impact of the earthquake on
30 pulmonary diseases². It is also weakness of our study that we analyzed only hospitalized
31 patients. There were a great number of outpatients and a heavy loss of lives. These events will
32 be analyzed in the future report. Another weakness of our study is that cross-sectional study
33 cannot elucidate a causal relationship. Finally, we did not clearly define the condition of
34 hospitalization. Because the destruction of ordinary healthcare system and poor hygiene outside
35 the hospital, we hospitalized some patients who could be treated in outpatient setting in ordinary
36 time. However, this was a real situation after devastating disaster.
37
38
39
40
41
42
43
44
45
46

47 **Conclusion**

48 The Great East Japan earthquake and following tsunami hit the one of the most advanced aging
49 society in the world. After the disaster, pneumonia, exacerbation of COPD, bronchial asthma
50 attack associated with bad ADL in elderly provoked the most part of hospitalization for
51 pulmonary diseases. These observations should be exploited in constructing emergency medical
52 management for disasters in progressive advanced aging society.
53
54
55
56
57
58
59
60

Acknowledgement

We would like to express our gratitude to all the teams and volunteers from area of Japan and foreign countries for kind and warm supports. We also thank doctors, nurses, and other employees in Japanese Red Cross Ishinomaki Hospital.

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.

Data sharing statement: There is no additional data available.

Funding: This study was not funded by any research funds.

References

1. McCurry J. Japan: the aftermath. *Lancet* 2011;**377**:1061-1062.
2. National Police Agency. *Dmage Situation and Police Countermeasure*. www.npa.go.jp/archive/keibi/biki/index_e.htm (accessed 29 Dec 2011).
3. Tamiya N, Noguchi H, Nishi A, *et al*. Population ageing and wellbeing: lessons from Japan's long-term care insurance policy. *Lancet* 2011;**378**:1183-1192.
4. Liang NJ, Shih YT, Shih FY, *et al*. Disaster epidemiology and medical response in the Chi-Chi earthquake in Taiwan. *Ann Emerg Med* 2001;**38**:549-555.
5. Chan CC, Lin YP, Chen HH, *et al*. A population-based study on the immediate and prolonged effects of the 1999 Taiwan earthquake on mortality. *Ann Epidemiol* 2003;**13**:502-508.
6. Nishikiori N, Abe T, Costa DG, *et al*. Who died as a result of the tsunami? Risk factors of mortality among internally displaced persons in Sri Lanka: a retrospective cohort analysis. *BMC Public Health* 2006;**6**:73.
7. Rofi A, Doocy S, Robinson C. Tsunami mortality and displacement in Aceh province, Indonesia. *Disasters* 2006;**30**:340-350.
8. Doocy S, Rofi A, Moodie C, *et al*. Tsunami mortality in Aceh Province, Indonesia. *Bull World Health Organ* 2007;**85**:273-278.
9. Chou YJ, Huang N, Lee CH, *et al*. Who is at risk of death in an earthquake? *Am J Epidemiol* 2004;**160**:688-695.
10. Osaki Y, Minowa M. Factors associated with earthquake deaths in the great Hanshin-Awaji

- 1
2
3
4
5 earthquake, 1995. *Am J Epidemiol* 2001;**153**:153-156.
- 6
7 11. Takakura R, Himeno S, Kanayama Y, *et al*. Follow-up after the Hanshin-Awaji earthquake:
8 diverse influences on pneumonia, bronchial asthma, peptic ulcer and diabetes mellitus. *Intern*
9 *Med* 1997;**36**:87-91.
- 10
11 12. Tanaka H, Oda J, Iwai A, *et al*. Morbidity and mortality of hospitalized patients after the
12 1995 Hanshin-Awaji earthquake. *Am J Emerg Med* 1999;**17**:186-191.
- 13
14 13. Matsuoka T, Yoshioka T, Oda J, *et al*. The impact of a catastrophic earthquake on morbidity
15 rates for various illnesses. *Public Health* 2000;**114**:249-253.
- 16
17 14. Guha-Sapir D, van Panhuis WG. Health impact of the 2004 Andaman Nicobar earthquake
18 and tsunami in Indonesia. *Prehosp Disaster Med* 2009;**24**:493-499.
- 19
20 15. Chierakul W, Winothai W, Wattanawaitunechai C, *et al*. Melioidosis in 6 tsunami survivors
21 in southern Thailand. *Clin Infect Dis* 2005;**41**:982-990.
- 22
23 16. Potera C. In disaster's wake: tsunami lung. *Environ Health Perspect* 2005;**113**:A734.
- 24
25 17. Tanida N. What happened to elderly people in the great Hanshin earthquake. *BMJ*
26 1996;**313**:1133-1135.
- 27
28 18. Guha-Sapir D, van Panhuis WG, Lagoutte J. Short communication: patterns of chronic and
29 acute diseases after natural disasters - a study from the International Committee of the Red
30 Cross field hospital in Banda Aceh after the 2004 Indian Ocean tsunami. *Trop Med Int Health*
31 2007;**12**:1338-1341.
- 32
33 19. Miller AC, Arquilla B. Chronic diseases and natural hazards: impact of disasters on diabetic,
34 renal, and cardiac patients. *Prehosp Disaster Med* 2008;**23**:185-194.
- 35
36 20. Tomita K, Hasegawa Y, Watanabe M, *et al*. The Totton-Ken Seibu earthquake and
37 exacerbation of asthma in adults. *J Med Invest* 2005;**52**:80-84.
- 38
39 21. Soriano JB, Davis KJ, Coleman B, *et al*. The proportional Venn diagram of obstructive lung
40 disease: two approximations from the United States and the United Kingdom. *Chest*
41 2003;**124**:474-481.
- 42
43 22. Pauwels RA. Similarities and differences in asthma and chronic obstructive pulmonary
44 disease exacerbations. *Proc Am Thorac Soc* 2004;**1**:73-76.
- 45
46 23. Maeda H, Nakagawa M, Yokoyama M. Hospital admissions for respiratory diseases in the
47 aftermath of the great Hanshin earthquake[Article in Japanese]. *Nihon Kyobu Shikkan Gakkai*
48 *Zasshi* 1996;**34**:164-173.
- 49
50 24. El-Solh AA, Pietrantonio C, Bhat A, *et al*. Microbiology of severe aspiration pneumonia in
51 institutionalized elderly. *Am J Respir Crit Care Med* 2003;**167**:1650-1654.
- 52
53 25. Loeb MB, Becker M, Eady A, Walker-Dilks C. Interventions to prevent aspiration
54 pneumonia in older adults: a systematic review. *J Am Geriatr Soc* 2003;**51**:1018-1022.
- 55
56 26. Langmore SE, Skarupski KA, Park PS, *et al*. Predictors of aspiration pneumonia in nursing
57
58
59
60

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

home residents. *Dysphagia* 2002;**17**:298-307.

27. Terpenning MS, Taylor GW, Lopatin DE, *et al.* Aspiration pneumonia: dental and oral risk factors in an older veteran population. *J Am Geriatr Soc* 2001;**49**:557-563.

28. Yoshino A, Ebihara T, Ebihara S, *et al.* Daily oral care and risk factors for pneumonia among elderly nursing home patients. *JAMA* 2001;**286**:2235-2236.

29. Kobayashi S, Kubo H, Yanai M. Impairment of swallowing in COPD. *Am J Respir Crit Care Med* 2009;**180**:481.

30. Nishikiori N, Abe T, Costa DG, *et al.* Timing of mortality among internally displaced persons due to the tsunami in Sri Lanka: cross sectional household survey. *BMJ* 2006;**332**:334-335.

31. Kysely J, Kriz B. Decreased impacts of the 2003 heat waves on mortality in the Czech Republic: an improved response? *Int J Biometeorol* 2008;**52**:733-745.

32. Toyabe S, Shioiri T, Kuwabara H, *et al.* Impaired psychological recovery in the elderly after the Niigata-Chuetsu Earthquake in Japan: a population-based study. *BMC Public Health* 2006;**6**:230.

33. Seplaki CL, Goldman N, Weinstein M, *et al.* Before and after the 1999 Chi-Chi earthquake: traumatic events and depressive symptoms in an older population. *Soc Sci Med* 2006;**62**:3121-3132.

34. Ueki A, Morita Y, Miyoshi K. Changes in symptoms after the great Hanshin Earthquake in patients with dementia[Article in Japanese]. *Nihon Ronen Igakkai Zasshi* 1996;**33**:573-579.

35. Maeda K, Kakigi T. Manifestation of the symptoms in demented patients after the Great Hanshin Earthquake in Japan[Article in Japanese]. *Seishin Shinkeigaku Zasshi* 1996;**98**:320-328.

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.

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

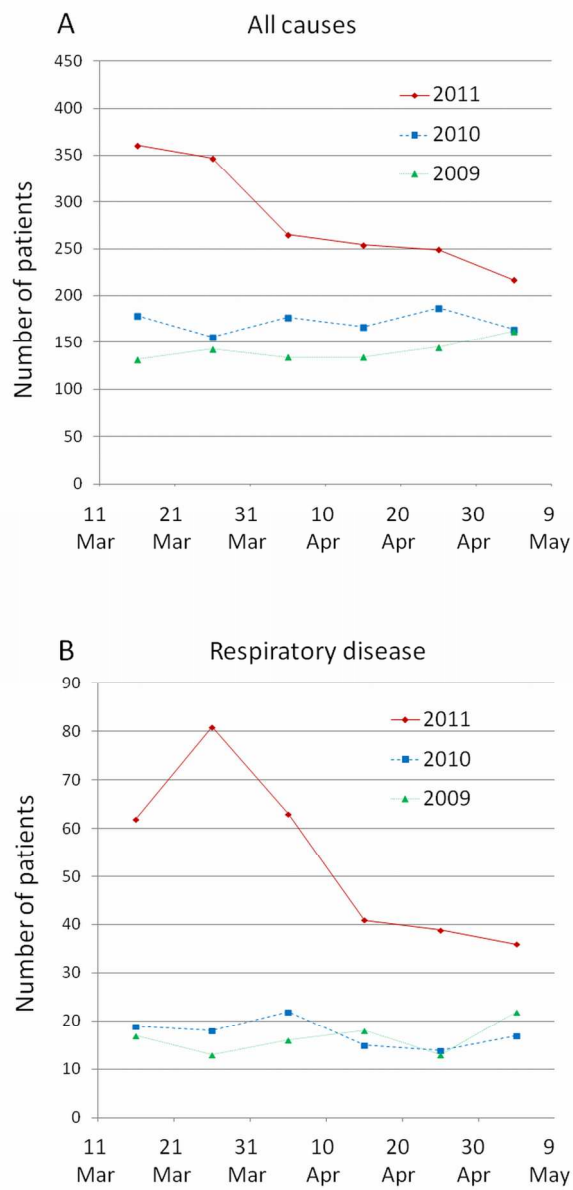
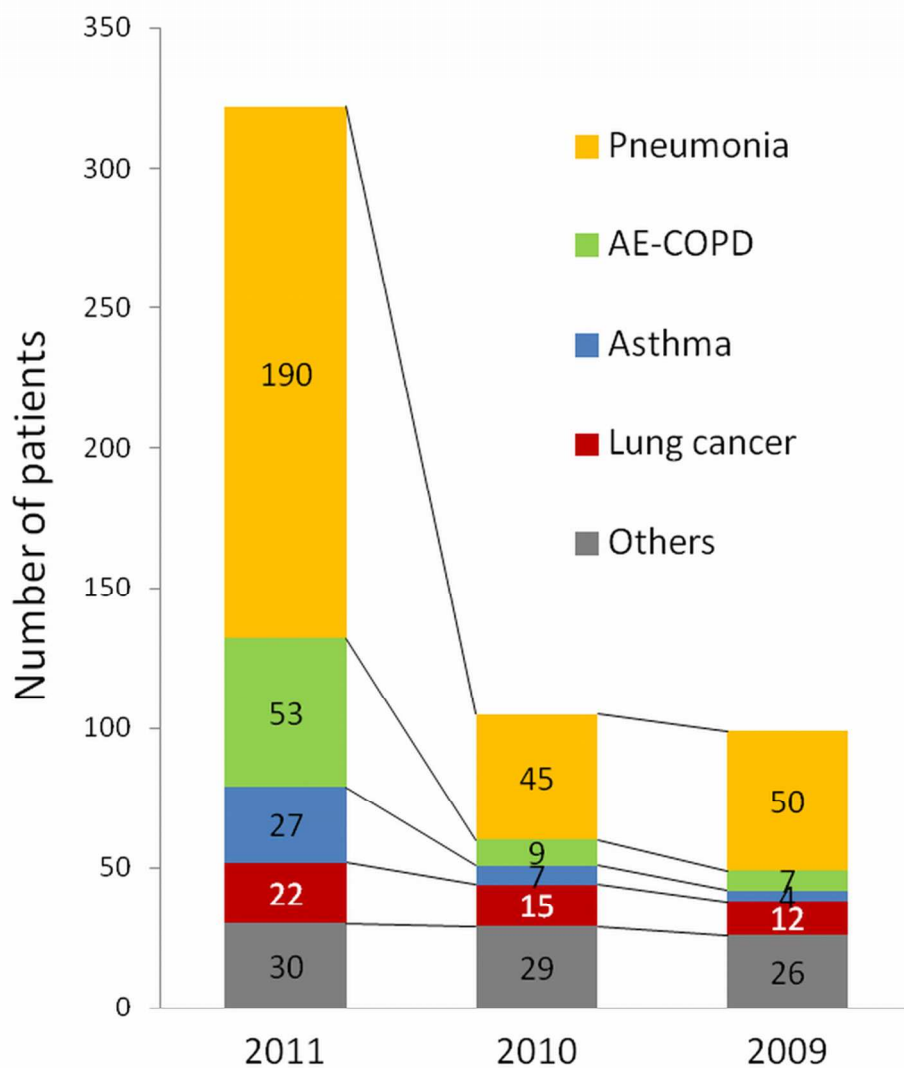


Figure 1. The number of unscheduled hospitalization for all causes (A) and for respiratory disease (B) from March 11 to May 9 in 2009, 2010 and 2011, presented in 10 day bins.
90x185mm (300 x 300 DPI)

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60



90x102mm (300 x 300 DPI)

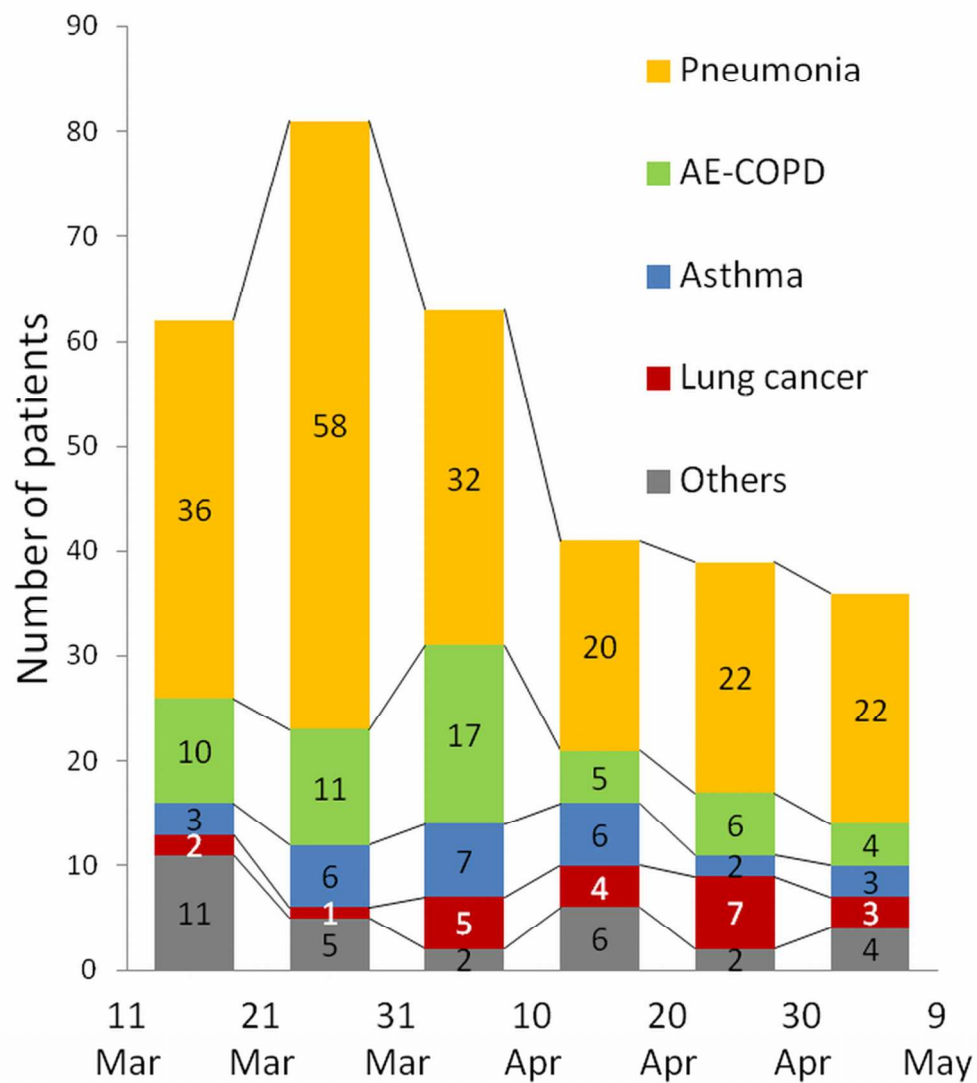
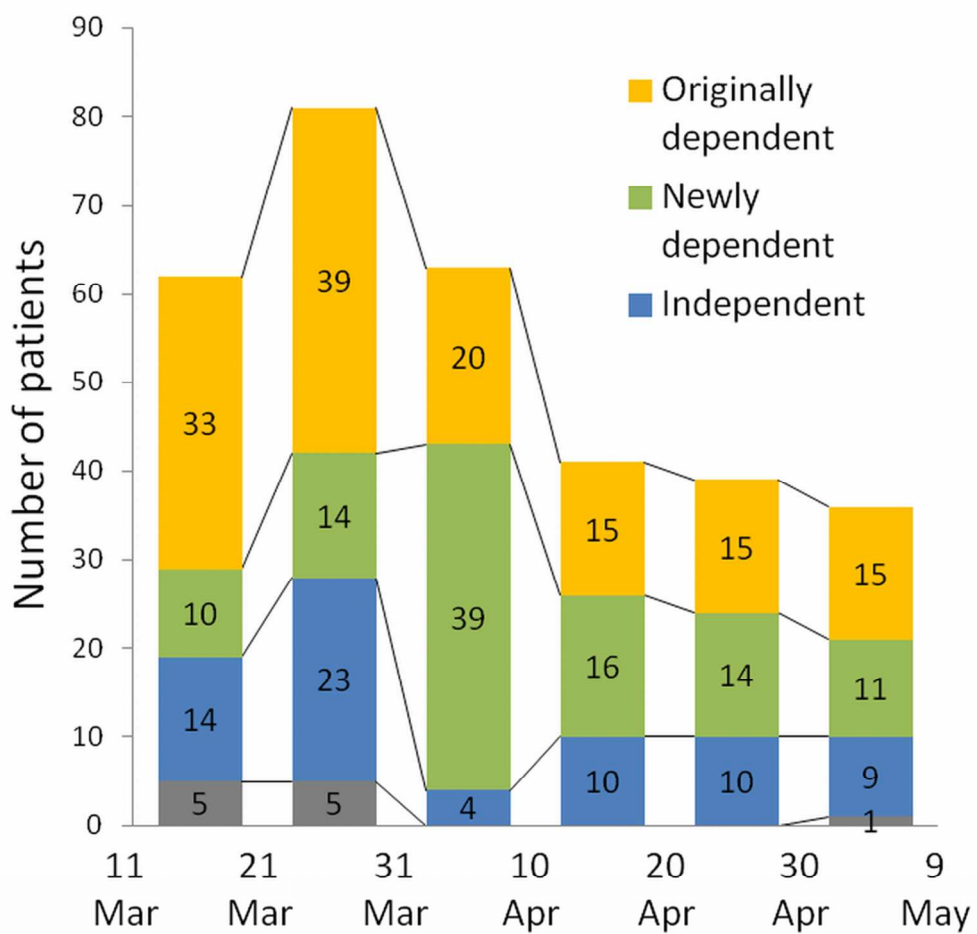


Figure 3. Distribution of patients hospitalized for respiratory disease after the Great East Japan earthquake from March 11 to May 9 in 2011, presented in 10 day bins.
90x104mm (300 x 300 DPI)



90x88mm (300 x 300 DPI)

BMJ

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

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			

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49

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.



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

Journal:	<i>BMJ Open</i>
Manuscript ID:	bmjopen-2012-000865.R1
Article Type:	Research
Date Submitted by the Author:	05-Nov-2012
Complete List of Authors:	Yamanda, Shinsuke; Japanese Red Cross Ishinomaki Hospital, Respiratory Medicine Hanagama, Masakazu; Japanese Red Cross Ishinomaki Hospital, Department of respiratory medicine Kobayashi, Seiichi; Japanese Red Cross Ishinomaki Hospital, Department of respiratory medicine Satou, Hikari; Japanese Red Cross Ishinomaki Hospital, Department of respiratory medicine Tokuda, Shinsaku; Kobe University Graduate School of Medicine, Division of Cell Biology Niu, Kaijun; Tohoku University Graduate School of Biomedical Engineering, Division of Biomedical Engineering for Health and Welfare Yanai, Masaru; Japanese Red Cross Ishinomaki Hospital, Department of respiratory medicine
Primary Subject Heading:	Respiratory medicine
Secondary Subject Heading:	Geriatric medicine, Emergency medicine
Keywords:	GERIATRIC MEDICINE, Adult thoracic medicine < THORACIC MEDICINE, ACCIDENT & EMERGENCY MEDICINE

SCHOLARONE™
Manuscripts

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1 **Title**

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

5
6 **Author names**

7 Shinsuke Yamanda *physician scientist*¹, Masakazu Hanagama *physician scientist*¹, Seiichi
8 Kobayashi *senior physician scientist*¹, Hikari Satou *resident*¹, Shinsaku Tokuda *lecturer*²,
9 Kaijun Niu *associate professor*³, Masaru Yanai *director*¹

10
11 ¹Department of respiratory medicine, Japanese Red Cross Ishinomaki Hospital, 71 Hebita Aza
12 Nishimichishita, Ishinomaki, Miyagi, Japan

13
14 ²Division of Cell Biology, Kobe University Graduate School of Medicine, 7-5-1 Kusunoki-cho,
15 chuo-ku, Kobe, Hyogo, Japan

16
17 ³Division of Biomedical Engineering for Health and Welfare, Tohoku University Graduate
18 School of Biomedical Engineering, 2-1 Seiryō-machi, Aoba-ku, Sendai, Miyagi, Japan

19
20 **Correspondence to:** Shinsuke Yamanda syamanda@gmail.com

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1 **Article summary**

2 **Article focus**

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

7 The study gives lessons against natural disasters and aging society.

8 **Key messages**

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

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

13 **Strengths and limitations of study**

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

15 We analyzed only hospitalized patients. But there were a great number of outpatients
16 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.

1 Introduction

2 On March 11, 2011, at 2:46 pm Japan time, the Pacific coast of Japan's Tohoku (northeastern)
3 region was struck by the massive earthquake (The Great East Japan Earthquake), measuring
4 magnitude 9.0 on the Richter scale¹. The earthquake triggered a devastating tsunami which
5 destroyed many towns and villages near the seashore. The epicenter was estimated to be about
6 70 kilometers east of Oshika Peninsula of Ishinomaki in Miyagi. Officially, over 19,000 people
7 were killed or missing and the maximum number of refugees reached more than 550,000².

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

13 Japan is one of the most rapidly aging society in the world. 23% of Japanese citizens were age
14 65 or over in 2010³. Tohoku region is especially rapidly aging society in Japan, 26.6% of people
15 living in Ishinomaki city were age 65 or over in 2010. Although several reports showed the
16 significant association between age and earthquake and tsunami death⁴⁻⁸, there were few reports
17 investigating the impact of a tremendous disaster on elderly peoples in such an aging society^{9 10}.
18 Respiratory diseases are common in the elderly even in ordinary times. So, investigating the
19 impact of the disasters on respiratory health will contribute to elucidating the problem of aging
20 society. Thus, we performed retrospective descriptive and cross-sectional analysis of the
21 medical and epidemiologic data of the patient required hospitalization for respiratory disease
22 after the Great East Japan Earthquake and following tsunami.

23 24 25 Methods

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

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

1 respiratory department and pulmonary specialists in the region.
2 Medical records were investigated in terms of date of admission, age, sex, diagnosis. We also
3 investigated activities of daily living (ADL) at hospitalization and ADL before earthquake, and
4 their residence before admission on the medical record of 2011 study period. For comparison,
5 the total number of unscheduled hospitalization during the corresponding periods in 2009 and
6 2010 was counted.

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

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

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

28 29 **Data analysis**

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

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

4 5 6 **Result**

7 All of the scheduled hospitalization was cancelled and emergency admission was solely
8 accepted during the first 60 day after the earthquake at Japanese Red Cross Ishinomaki Hospital.
9 1,769 patients admitted to the hospital, and 322 of them were hospitalized for respiratory
10 disease during the study period. In the corresponding period, total number of unscheduled
11 hospitalization was 850 and that for respiratory disease was 99 in 2009 and 1,030 and 105 in
12 2010. Patients hospitalized for respiratory disease accounted for 18.2% of total hospitalization
13 during the study period. This proportion was significantly higher than that of 2009 and 2010
14 (11.6% in 2009. $P < 0.001$. 10.2% in 2010. $P < 0.001$). While the number of total hospitalizations
15 of this period in 2011 was about twice of that in 2009 and 2010, hospitalization for respiratory
16 disease in 2011 reached about three times or more than that of 2009 and 2010. The total number
17 of hospitalizations was peaked in the first ten days, but the number of hospitalization for
18 respiratory disease kept increasing for 20 days (Figure 1A and B).

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

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

1 Specifically, pneumonia patients and AE-COPD patients were significantly older in 2011 study
2 period than in 2010 and 2009 corresponding period(77.6±11.8 v.s. 74.3±12.8 years old in
3 pneumonia patients. p=0.03. 76.0±8.7 v.s. 69.5±15.9 years old in AE-COPD patients. p=0.03).
4 Male population of AE-COPD was significantly higher (81.1% v.s. 50.0%. p=0.01), whereas
5 that of asthma attack significantly lower in 2011 period than 2010 and 2009 periods (18.5% v.s.
6 54.6%. p=0.03).

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

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

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

31

32

33 Discussion

34 Summary

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

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

5 6 **Effect on respiratory disease**

7 Previous reports on Hanshin-Awaji earthquake showed initial rush of patients with injury and
8 following increase of patients with respiratory disease, especially pneumonia¹¹⁻¹³. Similarly, our
9 observation showed marked increase in pneumonia patients, although initial rush of heavy
10 injury patients was absent in this disaster because majority of victims were drowned to death
11 and heavily injured patients were seldom carried to the hospital.

12 The cause of increase in respiratory disease was different in each situation. After the 2004
13 Sumatra-Andaman earthquake and following tsunami, the number of lower respiratory infection
14 in Aceh was rapidly increased after the disaster and sharply declined in the second week¹⁴. On
15 the other hand, after the 1995 Hanshin-Awaji earthquake, the number of patients hospitalized for
16 pneumonia was gradually increased and kept high proportion over the two month^{9 10}. This
17 difference is ascribable to the mechanism of developing pneumonia. In Sumatra-Andaman
18 earthquake, many of pneumonia were resulted from aspiration of tsunami-water in
19 near-drowning events^{15 16}. Those pneumonias were called “tsunami lung”. On the other hand, in
20 the Hanshin-Awaji earthquake, many patients developed pneumonia in shelters under unhealthy
21 environment and most of them were in elderly. Those pneumonias were called “shelter
22 pneumonia”¹⁷. In this earthquake and tsunami, we experienced few number of pneumonia
23 directly caused by aspiration of tsunami-water even in the very acute period. A few of the
24 patient directory came from the field, instead, most patients came from shelters, their own or
25 relative’s homes, other hospitals, or nursing homes. The mean age of them was significantly
26 higher than that of 2010 and 2009. Therefore, we regarded most of pneumonia we treated as the
27 same kind of “shelter pneumonia”.

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

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

1 same precipitating cause with COPD, attack of asthma was not so much increased as AE-COPD.
2 This difference might be caused by two important differences between asthma and COPD. First,
3 generally, patients of COPD were older than those of asthma. Therefore, baseline health
4 condition of patients of COPD would be poorer than that of asthma²¹. As a result, COPD
5 patients required more frequent hospitalization. In our study, mean age of AE-COPD was higher
6 than that of attack of asthma as well. Second, bacterial respiratory infection affects patients with
7 COPD more than those with asthma²². In the aftermath of earthquake, loss of hygiene and
8 overcrowding in the shelter could increase the risk of respiratory bacterial infection and cause
9 AE-COPD.

10 Hospitalization for lung cancer related symptoms did not increase much and its ratio to total
11 hospitalization for respiratory diseases rather declined. Mean age of lung cancer patients was
12 similar to that in the past two years. Maeda et al. also reported that no increase in lung cancer
13 related hospitalization was observed after Hanshin-Awaji earthquake²³. Progression of lung
14 cancer may not be influenced by environment as much as cancer growth itself. So, the disaster
15 will not impact on lung cancer immediately. Although the interruption of chemotherapy and/or
16 radiotherapy would worsen the prognosis, it cannot be confirmed during our study period.

17 18 **Effect on ADL**

19 In acute phase, patients with poor ADL, especially those originally dependent, were hospitalized
20 for pulmonary diseases, typically pneumonia, although substantial number of good ADL
21 patients was also hospitalized. After 3 weeks, there was a sharp increase in newly dependent
22 people who deteriorated their ADL after the disaster. It was reported that physical disability was
23 an independent risk factor for death in Hanshin-Awaji earthquake and the 1999 Taiwan
24 earthquake^{9 10}. However, those reports investigated the mortality in acute phase, not
25 hospitalization in subacute or chronic phase. After the earthquake and tsunami, one fourth of
26 people in Ishinomaki region fled into shelters, many of which were also flooded by tsunami.
27 They lacked water and food under harsh condition of cold season without heating in
28 overcrowded quarter just letting them lie on the floor without beds. In such bad conditions,
29 elderly people were restricted their consumption food and water, and kept still in a small space,
30 resulting in deterioration of ADL. In addition, scarcity of water worsened oral hygiene. Both
31 poor functional status and loss of oral hygiene were the major risk factor of pneumonia²⁴⁻²⁷,
32 especially in elderly people. Subsequently, many elderly people were hospitalized for “shelter
33 pneumonia” after the earthquake. Also, poor oral hygiene induces swallowing dysfunction²⁸ and
34 swallowing dysfunction could be a risk factor of exacerbation of COPD²⁹. It would be one of the
35 reasons why AE-COPD increased especially in elderly people.

36

1 **Effect on aging society**

2 According to the report of government of Japan, 93% of the fatalities were drowning and more
3 than 60% of them were over 60 years old in the Great East Japan earthquake. Although it was
4 reported by many previous reports that elderly people had a greater risk of death after the
5 earthquake, the proportion of the elderly killed by this earthquake and tsunami was extremely
6 high in comparison to other major earthquake or tsunami in the world⁴⁻⁸. Similar finding was
7 reported only in 1995 Hanshin-Awaji earthquake and 2004 Mid Niigata earthquake in Japan^{12,17}.
8 Moreover, 90.8% of the patients hospitalized for respiratory disease after the earthquake were
9 over 60 years old in our study. These results suggest that elderly people were vulnerable not
10 only immediately after the earthquake but also for a while after the earthquake.

11 In 1999 Taiwan earthquake, 2003 heat waves in the Czech Republic, and 2004
12 Sumatra-Andaman earthquake, it is demonstrated that these disasters has left decreased
13 mortality in the stricken area, resulted from a large number of direct death by disasters among a
14 vulnerable population such as elderly people or children^{5, 30, 31}, called “harvesting effect”.
15 However, our observation suggests that, in the aging society, a huge disaster not only directly
16 kills the vulnerable people but also produces new vulnerable people. Previous reports
17 demonstrated that prolonged harmful influence on mental health and psychological slow
18 recovery were seen more frequently in the elderly people than young people³²⁻³⁵. Therefore, we
19 should pay a long-term attention on those elderly people after a disaster.

21 **Implications for policy and practice**

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

34 **Strengths and weaknesses of study**

35 Our study had two important strengths. First, the Great East Japan Earthquake hit one of the
36 most rapidly aging societies in the world³. As the proportion of elderly people continues to

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

10 Our study is single center study. This might be weakness of our study, but our hospital was the
11 only functional hospital after the earthquake in Ishinomaki medical zone which account for
12 more than 30% of total fatalities of this earthquake in Japan. Also, it has been the only hospital
13 which has the department of respiratory medicine and pulmonary specialists in the medical zone.
14 Even in the ordinary time before the disaster, it accepted almost all of the serious patients with
15 pulmonary diseases who needed hospitalization. Therefore, we think our study well represents
16 impact of the earthquake on pulmonary diseases and describes what happened in the hospital
17 which faced the earthquake at the front². It is also weakness of our study that we analyzed only
18 hospitalized patients. There were a great number of outpatients and a heavy loss of lives. These
19 events will be analyzed in the future report. Another weakness of our study is that
20 cross-sectional study cannot elucidate a causal relationship. Finally, we did not clearly define
21 the condition of hospitalization. Because the destruction of ordinary healthcare system and poor
22 hygiene outside the hospital, we hospitalized some patients who could be treated in outpatient
23 setting in ordinary time. However, this was a real situation after devastating disaster.

24 25 **Conclusion**

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

31 32 **Acknowledgement**

33 We would like to express our gratitude to all of the relief teams and volunteers from all area of
34 Japan and foreign countries for their kind and warm supports. We also thank doctors, nurses,
35 and other employees in Japanese Red Cross Ishinomaki Hospital.

36 **Competing interests:** None declared.

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

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

9 **Data sharing statement:** There is no additional data available.

10 **Funding:** This study was not funded by any research funds.

11 12 **References**

- 13 1. McCurry J. Japan: the aftermath. *Lancet* 2011;**377**:1061-1062.
- 14 2. National Police Agency. *Dmage Situation and Police Countermeasure*.
15 www.npa.go.jp/archive/keibi/biki/index_e.htm (accessed 29 Dec 2011).
- 16 3. Tamiya N, Noguchi H, Nishi A, *et al*. Population ageing and wellbeing: lessons from Japan's
17 long-term care insurance policy. *Lancet* 2011;**378**:1183-1192.
- 18 4. Liang NJ, Shih YT, Shih FY, *et al*. Disaster epidemiology and medical response in the
19 Chi-Chi earthquake in Taiwan. *Ann Emerg Med* 2001;**38**:549-555.
- 20 5. Chan CC, Lin YP, Chen HH, *et al*. A population-based study on the immediate and prolonged
21 effects of the 1999 Taiwan earthquake on mortality. *Ann Epidemiol* 2003;**13**:502-508.
- 22 6. Nishikiori N, Abe T, Costa DG, *et al*. Who died as a result of the tsunami? Risk factors of
23 mortality among internally displaced persons in Sri Lanka: a retrospective cohort analysis. *BMC*
24 *Public Health* 2006;**6**:73.
- 25 7. Rofi A, Doocy S, Robinson C. Tsunami mortality and displacement in Aceh province,
26 Indonesia. *Disasters* 2006;**30**:340-350.
- 27 8. Doocy S, Rofi A, Moodie C, *et al*. Tsunami mortality in Aceh Province, Indonesia. *Bull*
28 *World Health Organ* 2007;**85**:273-278.
- 29 9. Chou YJ, Huang N, Lee CH, *et al*. Who is at risk of death in an earthquake? *Am J Epidemiol*
30 2004;**160**:688-695.
- 31 10. Osaki Y, Minowa M. Factors associated with earthquake deaths in the great Hanshin-Awaji
32 earthquake, 1995. *Am J Epidemiol* 2001;**153**:153-156.
- 33 11. Takakura R, Himeno S, Kanayama Y, *et al*. Follow-up after the Hanshin-Awaji earthquake:
34 diverse influences on pneumonia, bronchial asthma, peptic ulcer and diabetes mellitus. *Intern*
35 *Med* 1997;**36**:87-91.
- 36 12. Tanaka H, Oda J, Iwai A, *et al*. Morbidity and mortality of hospitalized patients after the

- 1
2
3
4
5 1 1995 Hanshin-Awaji earthquake. *Am J Emerg Med* 1999;**17**:186-191.
- 6 2 13. Matsuoka T, Yoshioka T, Oda J, *et al*. The impact of a catastrophic earthquake on morbidity
7 3 rates for various illnesses. *Public Health* 2000;**114**:249-253.
- 8 4 14. Guha-Sapir D, van Panhuis WG. Health impact of the 2004 Andaman Nicobar earthquake
9 5 and tsunami in Indonesia. *Prehosp Disaster Med* 2009;**24**:493-499.
- 10 6 15. Chierakul W, Winothai W, Wattanawaitunechai C, *et al*. Melioidosis in 6 tsunami survivors
11 7 in southern Thailand. *Clin Infect Dis* 2005;**41**:982-990.
- 12 8 16. Potera C. In disaster's wake: tsunami lung. *Environ Health Perspect* 2005;**113**:A734.
- 13 9 17. Tanida N. What happened to elderly people in the great Hanshin earthquake. *BMJ*
14 10 1996;**313**:1133-1135.
- 15 11 18. Guha-Sapir D, van Panhuis WG, Lagoutte J. Short communication: patterns of chronic and
16 12 acute diseases after natural disasters - a study from the International Committee of the Red
17 13 Cross field hospital in Banda Aceh after the 2004 Indian Ocean tsunami. *Trop Med Int Health*
18 14 2007;**12**:1338-1341.
- 19 15 19. Miller AC, Arquilla B. Chronic diseases and natural hazards: impact of disasters on diabetic,
20 16 renal, and cardiac patients. *Prehosp Disaster Med* 2008;**23**:185-194.
- 21 17 20. Tomita K, Hasegawa Y, Watanabe M, *et al*. The Totton-Ken Seibu earthquake and
22 18 exacerbation of asthma in adults. *J Med Invest* 2005;**52**:80-84.
- 23 19 21. Soriano JB, Davis KJ, Coleman B, *et al*. The proportional Venn diagram of obstructive lung
24 20 disease: two approximations from the United States and the United Kingdom. *Chest*
25 21 2003;**124**:474-481.
- 26 22 22. Pauwels RA. Similarities and differences in asthma and chronic obstructive pulmonary
27 23 disease exacerbations. *Proc Am Thorac Soc* 2004;**1**:73-76.
- 28 24 23. Maeda H, Nakagawa M, Yokoyama M. Hospital admissions for respiratory diseases in the
29 25 aftermath of the great Hanshin earthquake[Article in Japanese]. *Nihon Kyobu Shikkan Gakkai*
30 26 *Zasshi* 1996;**34**:164-173.
- 31 27 24. El-Solh AA, Pietrantonio C, Bhat A, *et al*. Microbiology of severe aspiration pneumonia in
32 28 institutionalized elderly. *Am J Respir Crit Care Med* 2003;**167**:1650-1654.
- 33 29 25. Loeb MB, Becker M, Eady A, Walker-Dilks C. Interventions to prevent aspiration
34 30 pneumonia in older adults: a systematic review. *J Am Geriatr Soc* 2003;**51**:1018-1022.
- 35 31 26. Langmore SE, Skarupski KA, Park PS, *et al*. Predictors of aspiration pneumonia in nursing
36 32 home residents. *Dysphagia* 2002;**17**:298-307.
- 37 33 27. Terpenning MS, Taylor GW, Lopatin DE, *et al*. Aspiration pneumonia: dental and oral risk
38 34 factors in an older veteran population. *J Am Geriatr Soc* 2001;**49**:557-563.
- 39 35 28. Yoshino A, Ebihara T, Ebihara S, *et al*. Daily oral care and risk factors for pneumonia
40 36 among elderly nursing home patients. *JAMA* 2001;**286**:2235-2236.

- 1
2
3
4
5 1 29. Kobayashi S, Kubo H, Yanai M. Impairment of swallowing in COPD. *Am J Respir Crit*
6 2 *Care Med* 2009;**180**:481.
7
8 3 30. Nishikiori N, Abe T, Costa DG, *et al.* Timing of mortality among internally displaced
9 4 persons due to the tsunami in Sri Lanka: cross sectional household survey. *BMJ*
10 5 2006;**332**:334-335.
11 6 31. Kysely J, Kriz B. Decreased impacts of the 2003 heat waves on mortality in the Czech
12 7 Republic: an improved response? *Int J Biometeorol* 2008;**52**:733-745.
13 8 32. Toyabe S, Shioiri T, Kuwabara H, *et al.* Impaired psychological recovery in the elderly after
14 9 the Niigata-Chuetsu Earthquake in Japan:a population-based study. *BMC Public Health*
15 10 2006;**6**:230.
16 11 33. Seplaki CL, Goldman N, Weinstein M, *et al.* Before and after the 1999 Chi-Chi earthquake:
17 12 traumatic events and depressive symptoms in an older population. *Soc Sci Med*
18 13 2006;**62**:3121-3132.
19 14 34. Ueki A, Morita Y, Miyoshi K. Changes in symptoms after the great Hanshin Earthquake in
20 15 patients with dementia[Article in Japanese]. *Nihon Ronen Igakkai Zasshi* 1996;**33**:573-579.
21 16 35. Maeda K, Kakigi T. Manifestation of the symptoms in demented patients after the Great
22 17 Hanshin Earthquake in Japan[Article in Japanese]. *Seishin Shinkeigaku Zasshi*
23 18 1996;**98**:320-328.
24 19
25 20
26 21
27 22
28 23
29 24
30 25
31 26
32 27
33 28
34 29
35 30
36 31
37 32
38 33
39 34
40 35
41 36
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1 **Table**

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

3

	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)

4 AE-COPD, acute exacerbation of COPD.

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

6

7

8

9

10

11

12

13

14

15

16

17

18

19

20

21

22

23

24

25

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1 **Figure legends**

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

4
5 Figure 2. The number and proportion of patients hospitalized for respiratory disease from March
6 11 to May 9 in 2009, 2010, and 2011, presented in 10 day bins.

7
8 Figure 3. Distribution of patients hospitalized for respiratory disease after the Great East Japan
9 earthquake from March 11 to May 9 in 2011, presented in 10 day bins.

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

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60**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

Author names

Shinsuke Yamanda *physician scientist*¹, Masakazu Hanagama *physician scientist*¹, Seiichi Kobayashi *senior physician scientist*¹, Hikari Satou *resident*¹, Shinsaku Tokuda *lecturer*², Kaijun Niu *associate professor*³, Masaru Yanai *director*¹

¹Department of respiratory medicine, Japanese Red Cross Ishinomaki Hospital, 71 Hebita Aza Nishimichishita, Ishinomaki, Miyagi, Japan

²Division of Cell Biology, Kobe University Graduate School of Medicine, 7-5-1 Kusunoki-cho, chuo-ku, Kobe, Hyogo, Japan

³Division of Biomedical Engineering for Health and Welfare, Tohoku University Graduate School of Biomedical Engineering, 2-1 Seiryomachi, Aoba-ku, Sendai, Miyagi, Japan

Correspondence to: Shinsuke Yamanda syamanda@gmail.com

Formatted

1
2
3
4
5
6
7
8 **Article summary**

9
10 **Article focus**

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

15 The study gives lessons against natural disasters and aging society.

16
17 **Key messages**

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

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

22
23 **Strengths and limitations of study**

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

25 We analyzed only hospitalized patients. But there were a great number of outpatients
26 as well as heavy loss of lives.
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54

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 activity of daily living (ADL).

Results

Total ~~number of patients hospitalized in our hospital in the study period was 1769 (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~~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". 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 March 11, 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 scale¹. 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 550,000².

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 overyears old or more~~ in 2010³. ~~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 overyears old or more~~ in 2010⁴. Although several reports showed the significant association between age and earthquake and tsunami death⁴⁻⁸, there were few reports investigating the impact of a tremendous disaster on ~~elderly peoples in-~~ such an aging society⁹¹⁰.

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 ~~requiringrequired~~ 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

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1 the medical records at Japanese Red Cross Ishinomaki Hospital. We reviewed medical records
2 of patients admitted to the hospital for respiratory diseases during the first 60 days after the
3 Great East Japan Earthquake, when the hospital solely accepted emergency patients. We also
4 reviewed medical records of patients who required unscheduled hospitalization for respiratory
5 disease in the corresponding period of 2009 and 2010.
6 Japanese Red Cross Ishinomaki Hospital which had 402 beds for inpatients was located at 4.5
7 km inland from Pacific Ocean. It has covered about 220,000 people living in its medical zone
8 (Ishinomaki City, Onagawa Town, ~~or~~ and Higashi-matsushima City) and assigned to a regional
9 disaster base hospital. It has ~~received~~accepted almost all of the emergency respiratory patients
10 even in the ordinary time before the disaster, because it ~~is~~has been the unique hospital having
11 the respiratory department and pulmonary specialists in the region.
12 Medical records were investigated in terms of date of admission, age, sex, diagnosis. We also
13 investigated ~~activities~~activity of daily living (ADL) at hospitalization and ADL before
14 earthquake, and their residence before admission on the medical record of 2011 study period.
15 For comparison, the total number of unscheduled hospitalization ~~to the hospital~~ during the
16 corresponding periods in 2009 and 2010 was counted.
17 Pneumonia was defined as the presence of the infiltration on chest radiograph along with one or
18 more of the following symptoms or signs: fever, cough, sputum production, breathlessness,
19 pleuritic chest pain or signs consistent with pneumonia on auscultation.
20 Chronic obstructive pulmonary disease (COPD) and bronchial asthma were detected by the
21 previous spirometric data, patient's self-report, or physician's diagnosis made by patient's
22 history, physical examination, and radiological finding. An acute exacerbation of
23 COPD(AE-COPD) was defined as an increase in or new onset of more than one symptom of
24 COPD (cough, sputum, wheezing, dyspnea or chest tightness) without pneumonia or
25 pneumothorax. An attack of asthma was defined as the presentation of wheezes or severe cough
26 in asthma patients without pneumonia. Progression of lung cancer was defined as requirement
27 for admission for lung cancer associated condition such as dehydration, respiratory failure, or
28 uncontrolled pain. Obstructive pneumonia due to lung cancer was considered as progression of
29 lung cancer. Chest trauma and traumatopnea were not considered as respiratory disease but
30 chest injury.
31 ADL was assessed by the information from a patient, patient's family, or patient's caregiver, and
32 classified into three categories; "independent" who could live without particular support,
33 "partially dependent" who could not leave their residence without any support, "dependent"
34 who spent a day on the bed or the wheelchair and lost the ability to move for themselves.
35 ~~Furthermore~~To investigate the impact of the disaster on ADL, we defined as "originally
36 dependent" who were dependent or partially dependent before the disaster, and as "newly

1 dependent” who became dependent or partially dependent after the disaster.

2 3 4 **Data analysis**

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

17 18 19 **Result**

20 All of the scheduled hospitalization was cancelled and emergency admission was solely
21 accepted during the first 60 day after the earthquake at Japanese Red Cross Ishinomaki Hospital.
22 1,769 patients admitted to the hospital, and 322 of them were hospitalized for respiratory
23 disease during the study period. ~~Patients hospitalized for respiratory disease accounted for~~
24 ~~18.2% of total hospitalization during the study period.~~In the corresponding period, total number
25 of unscheduled hospitalization was 850 and that for respiratory disease was 99 in 2009 and
26 1,030 and 105 in 2010. Patients hospitalized for respiratory disease accounted for 18.2% of total
27 hospitalization during the study period. This proportion was significantly higher than that of
28 2009 and 2010 (11.6% in 2009. $P < 0.001$. 10.2% in 2010. $P < 0.001$).~~the corresponding period of~~
29 ~~past two years, 10.2% of 2010 and 11.6% of 2009.~~ While the number of total hospitalizations
30 of this period in 2011 was about twice of that in 2009 and 2010, hospitalization for respiratory
31 disease in 2011 reached about three times or more than that of 2009 and 2010. The total number
32 of hospitalizations was at peak peaked in the first ten days ~~and then decreased~~, but the number of
33 hospitalization for respiratory disease kept increasing for 20 days (Figure 1A and B).

34
35 We compared the number and proportion of patients hospitalized for respiratory diseasedisease
36 distribution between 2011, 2010, and 2009 study periods (Figure 2). Pneumonia was the most

1 frequent disease (n=190, 59.0%), followed by AE-COPD (n=53, 16.5%), attack of asthma (n=27,
 2 8.4%), and progression of lung cancer (n=22, 6.8%). One case of AE-COPD and seven cases of
 3 attack of asthma were physician's diagnosis. Category "Others" included pneumothorax,
 4 restrictive thoracic disease, pleural effusion, influenza, drowning, primary pulmonary
 5 hypertension, requirement of mechanical ventilator support for neuromuscular disease, and so
 6 on. One patient diagnosed as pneumonia was complicated by attack of asthma and two patients
 7 of pneumonia exacerbated their symptom of COPD. They were treated for both conditions and
 8 counted as pneumonia. In comparison with the past two years, the increase in ~~absolute~~ number
 9 of hospitalizations was the largest for pneumonia, followed by AE-COPD and attack of asthma.
 10 The number of hospitalization for progression of lung cancer and that for ~~"others" diseases~~ were
 11 not so ~~deferent~~ different from the past two years. 39.4% of patients ~~were hospitalized from~~ stayed
 12 ~~at~~ emergency shelters ~~before hospitalization~~.

14 To investigate the disease specific effect of earthquake, age and sex of each disease were
 15 compared between the study period in 2011 and the corresponding period in the past two years
 16 (Table 1). The mean age of patients hospitalized for respiratory disease was significantly higher
 17 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
 18 and 2009, p=0.03). Male proportion tended to be lower in 2011 than in the past two years
 19 (59.6% in 2011, 67.2% in 2010 and 2009, p=0.08). Specifically, pneumonia patients and
 20 AE-COPD patients were significantly older in 2011 study period than in 2010 and 2009
 21 corresponding period (77.6±11.8 v.s. 74.3±12.8 years old in pneumonia patients, p=0.03,
 22 76.0±8.7 v.s. 69.5±15.9 years old in AE-COPD patients, ~~and~~ p=0.03, ~~respectively~~). Male
 23 population of AE-COPD was significantly higher (81.1% v.s. 50.0%, p=0.01), whereas that of
 24 ~~attack of asthma~~ attack significantly lower in 2011 period than 2010 and 2009 periods (18.5%
 25 v.s. 54.6%, p=0.01 and p=0.03, ~~respectively~~).

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

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

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

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

21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

Table 13 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

1 patients hospitalized for respiratory disease after the earthquake was significantly higher than
2 that of ~~ordinary years~~corresponding periods of the past two years. Majority of patients had poor
3 ADL and many of them experienced deterioration of ADL after the earthquake.
4

5 6 **Effect on respiratory disease**

7 Previous reports on Hanshin-Awaji earthquake showed initial rush of patients with injury and
8 following increase of patients with respiratory disease, especially pneumonia¹¹⁻¹³. Similarly, our
9 observation showed marked increase in pneumonia patients, although initial rush of heavy
10 injury patients was absent in this disaster because majority of victims were ~~drown~~drowned
11 death and heavily injured patients were seldom carried to the hospital.

12 The cause of increase in respiratory disease was different in each situation. After the 2004
13 Sumatra-Andaman earthquake and following tsunami, the number of lower respiratory infection
14 in Aceh was rapidly increased after the disaster and sharply declined in the second week¹⁴. On
15 the other hand, after the 1995 Hanshin-Awaji earthquake, the number of patients hospitalized for
16 pneumonia was gradually increased and kept high proportion over the two month^{9 10}. This
17 difference is ascribable to the mechanism of developing pneumonia. In Sumatra-Andaman
18 earthquake, many of pneumonia were resulted from aspiration of tsunami-water in
19 near-drowning events^{15 16}. Those pneumonias were called “tsunami lung”. On the other hand, in
20 the Hanshin-Awaji earthquake, many patients developed pneumonia in shelters under unhealthy
21 environment and most of them were in elderly. Those pneumonias were called “shelter
22 pneumonia”¹⁷. In this earthquake and tsunami, we experienced few number of pneumonia
23 directly caused by aspiration of tsunami-water even in the very acute period. ~~Most patients came~~
24 ~~from their own or relative’s home, other hospital, nursing home, or shelter, and a~~ few of the
25 patient directory came from the field, instead, most patients came from shelters, their own or
26 relative’s homes, other hospitals, or nursing homes. The mean age of them was significantly
27 higher than that of 2010 and 2009. Therefore, we ~~thought~~regarded most of pneumonia we
28 treated ~~was~~as the same kind of “shelter pneumonia”.

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

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

4 Although asthma was also one of the most common chronic respiratory diseases and had the
5 same precipitating cause with COPD, attack of asthma was not so much increased as AE-COPD.
6 This difference might be caused by two important differences between asthma and COPD. First,
7 generally, patients of COPD were older than those of asthma. Therefore, baseline health
8 condition of patients of COPD would be poorer than that of asthma²¹. As a result, COPD
9 patients required more frequent hospitalization. In our study, mean age of AE-COPD was higher
10 than that of attack of asthma as well. Second, bacterial respiratory infection affects patients with
11 COPD more than those with asthma²². In the aftermath of earthquake, loss of hygiene and
12 overcrowding in the shelter could increase the risk of respiratory bacterial infection and cause
13 AE-COPD.

14 ~~Hospitalization for lung~~ Lung cancer related ~~symptoms~~ hospitalization did not increase much and
15 its ratio to total hospitalization for respiratory diseases rather declined. Mean age of lung cancer
16 patients was similar to that in the past two years. Maeda et al. also reported that no increase in
17 lung cancer related hospitalization was observed after Hanshin-Awaji earthquake²³. Progression
18 of lung cancer may not be influenced by environment as much as cancer growth itself. So, the
19 disaster will not impact on lung cancer immediately. Although the interruption of chemotherapy
20 and/or radiotherapy would worsen the prognosis, it cannot be confirmed during our study
21 period.

22 23 **Effect on ADL**

24 ~~Our observation demonstrated that drastic deterioration of ADL after the disaster resulted in~~
25 ~~increase in hospitalization by respiratory diseases.~~ In acute phase, patients with poor ADL,
26 especially ~~those~~ originally dependent ~~ones~~, were hospitalized for pulmonary diseases, typically
27 pneumonia; although substantial number of good ADL patients was also hospitalized. After 3 ~~or~~
28 4 weeks, ~~there was a sharp increase in newly dependent people~~ many people who deteriorated
29 their ADL ~~after the disaster~~ (newly dependent) ~~were hospitalized for pulmonary diseases.~~ It was
30 reported that physical disability was an independent risk factor for death in Hanshin-Awaji
31 earthquake and the 1999 Taiwan earthquake^{9 10}. However, those reports investigated the
32 mortality in acute phase, not hospitalization in subacute or chronic phase. After the earthquake
33 and tsunami, one fourth of people in Ishinomaki region fled into shelters, many of which were
34 also flooded by tsunami. They lacked water and food under harsh condition of cold season
35 without heating in overcrowded ~~room~~ quarter just letting them lie on the floor without beds. In
36 such bad conditions, elderly people ~~were~~ restricted their consumption food and water, and kept

1
2
3
4
5
6
7
8 still in ~~one~~ small space; ~~as a result, they deteriorated their~~ resulting in deterioration of ADLs. In
9
10 addition, scarcity of water worsened oral hygiene. Both poor functional status and loss of oral
11
12 hygiene were the major risk factor of pneumonia²⁴⁻²⁷, especially in elderly people.
13
14 Subsequently, many elderly people were hospitalized for “shelter pneumonia” after the
15
16 earthquake. Also, poor oral hygiene induces swallowing dysfunction²⁸ and swallowing
17
18 dysfunction could be a risk factor of exacerbation of COPD²⁹. It would be one of the reasons
19
20 why AE-COPD increased especially in elderly people.

21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60

Effect on aging society

10 According to the report of government of Japan, 93% of the fatalities were drowning and more
11
12 than 60% of them were over 60 years old ~~or more~~ in the Great East Japan earthquake. Although
13
14 it was reported by many previous reports that elderly people had a greater risk of death after the
15
16 earthquake, the proportion of the elderly—people killed by this earthquake and tsunami was
17
18 extremely high in comparison to other major earthquake or tsunami in the world⁴⁻⁸. Similar
19
20 finding was reported only in 1995 Hanshin-Awaji earthquake and 2004 Mid Niigata earthquake
21
22 in Japan^{12 17}. Moreover, 90.8% of the patients hospitalized for respiratory disease after the
23
24 earthquake were over 60 years old ~~or more~~ in our study. These results suggested that elderly
25
26 people were vulnerable not only immediately after the earthquake but also for a while after the
27
28 earthquake.

20 In 1999 Taiwan earthquake, 2003 heat waves in the Czech Republic, and 2004
21
22 Sumatra-Andaman earthquake, it is demonstrated that these disasters has left decreased
23
24 mortality in the stricken area, resulted from a large number of direct death by disasters among a
25
26 vulnerable population such as elderly people or children^{5 30 31}, called “harvesting effect”.
27
28 However, our observation suggests that, in the aging society, a huge disaster not only directly
29
30 kills the vulnerable people but also newly produces new vulnerable people. Previous reports
31
32 demonstrated that prolonged harmful influence on mental health and psychological slow
33
34 recovery were seen more frequently in the elderly people than young people³²⁻³⁵. Therefore, we
35
36 should pay a long-term attention on those elderly people after a disaster.

Implications for policy and practice

31 Our observation suggests two important targets for reducing hospitalization for respiratory
32
33 disease after the major disaster in aging society. One target is interruption of treatment for
34
35 chronic respiratory disease and the other target is deterioration of ADL. Interruption of
36
37 treatment for chronic respiratory disease was preventable by storing the drugs for a few days.
38
39 However, it is necessary to establish the system offer valid storage to grasp regional prescription
40
41 data of each drug and patient’s personal medication data. Telemedicine system or web-based
42
43

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

6 7 **Strengths and weaknesses of study**

8 Our study had two important strengths. First, the Great East Japan Earthquake hit one of the
9 most ~~advanced~~ rapidly aging societies in the world³. As the proportion of elderly people
10 continues to increase in not only developed ~~countries~~ but also developing countries, there is an
11 urgent need of information and analysis on the aging society to plan countermeasures against it.
12 Our study will give lessons against natural disaster to all the countries. Secondly, we obtained
13 detailed data of patient's demographics, diagnosis, and ADL in a catastrophic situation. It is
14 because that our hospital has kept its medical function, including electronic medical record
15 system or laboratory systems, while devastating earthquake and tsunami hit Ishinomaki city and
16 almost all medical facilities lost their function, and that staffs in our hospital has trained for the
17 coming earthquake and has had an strong motivation to record our experiences as memos or on
18 digital recorders for future disaster medicine ~~for the future~~.

19 Our study is single center study. This might be weakness of our study, but our hospital was the
20 only functional hospital after the earthquake in Ishinomaki medical zone which account for
21 more than 30% of ~~total fatalities~~ victims of this earthquake in Japan. Also, it has been the only
22 hospital which has the department of respiratory medicine and pulmonary specialists in the
23 medical zone. Even in the ordinary time before the disaster, it accepted almost all of the serious
24 patients with pulmonary diseases who needed hospitalization. Therefore, we think our study
25 well represents impact of the earthquake on pulmonary diseases and describes what happened
26 in the hospital which faced the earthquake at the front². It is also weakness of our study that we
27 analyzed only hospitalized patients. There were a great number of outpatients and a heavy loss
28 of lives. These events will be analyzed in the future report. Another weakness of our study is
29 that cross-sectional study cannot elucidate a causal relationship. Finally, we did not clearly
30 define the condition of hospitalization. Because the destruction of ordinary healthcare system
31 and poor hygiene outside the hospital, we hospitalized some patients who could be treated in
32 outpatient setting in ordinary time. However, this was a real situation after devastating disaster.

33 34 **Conclusion**

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

1
2
3
4
5
6
7
8 | 1 | asthma attack associated with bad ADL in the elderly provoked the most part of increase in
9 | 2 | hospitalization for pulmonary diseases. These observations should be exploited in constructing
10 | 3 | emergency medical management for disasters in progressive advancedrapidly aging society.
11
12

13 | 5 | **Acknowledgement**

14 | 6 | We would like to express our gratitude to all of the relief teams and volunteers from all area of
15 | 7 | Japan and foreign countries for their kind and warm supports. We also thank doctors, nurses,
16 | 8 | and other employees in Japanese Red Cross Ishinomaki Hospital.
17

18 | 9 | **Competing interests:** None declared.

19 | 10 | **Ethical approval:** Approval of ethical review committee of Japanese Red Cross Ishinomaki
20 | 11 | Hospital was obtained.

21 | 12 | **Contributors:** SY was responsible for study design and interpretation of the data, and drafted
22 | 13 | the manuscript. MH, SK, HS, ST, and MY were responsible for collection and interpretation of
23 | 14 | the data. KN drafted the statistical analysis part in the manuscript, and provided suggestions on
24 | 15 | public health and epidemiology. MH, SK and MY were responsible for study design and revised
25 | 16 | the drafted manuscript. SY, MH, SK, HS, ST and MY treated the patients. All authors approved
26 | 17 | the final version of the manuscript.

27 | 18 | **Data sharing statement:** There is no additional data available.

28 | 19 | **Funding:** This study was not funded by any research funds.
29
30

31 | 21 | **References**

- 32 | 22 | 1. McCurry J. Japan: the aftermath. *Lancet* 2011;**377**:1061-1062.
33 | 23 | 2. National Police Agency. *Dmage Situation and Police Countermeasure*.
34 | 24 | www.npa.go.jp/archive/keibi/biki/index_e.htm (accessed 29 Dec 2011).
35 | 25 | 3. Tamiya N, Noguchi H, Nishi A, *et al*. Population ageing and wellbeing: lessons from Japan's
36 | 26 | long-term care insurance policy. *Lancet* 2011;**378**:1183-1192.
37 | 27 | 4. Liang NJ, Shih YT, Shih FY, *et al*. Disaster epidemiology and medical response in the
38 | 28 | Chi-Chi earthquake in Taiwan. *Ann Emerg Med* 2001;**38**:549-555.
39 | 29 | 5. Chan CC, Lin YP, Chen HH, *et al*. A population-based study on the immediate and prolonged
40 | 30 | effects of the 1999 Taiwan earthquake on mortality. *Ann Epidemiol* 2003;**13**:502-508.
41 | 31 | 6. Nishikiori N, Abe T, Costa DG, *et al*. Who died as a result of the tsunami? Risk factors of
42 | 32 | mortality among internally displaced persons in Sri Lanka: a retrospective cohort analysis. *BMC*
43 | 33 | *Public Health* 2006;**6**:73.
44 | 34 | 7. Rofi A, Doocy S, Robinson C. Tsunami mortality and displacement in Aceh province,
45 | 35 | Indonesia. *Disasters* 2006;**30**:340-350.
46 | 36 | 8. Doocy S, Rofi A, Moodie C, *et al*. Tsunami mortality in Aceh Province, Indonesia. *Bull*
47
48
49
50
51
52
53
54

- 1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
- 1 *World Health Organ* 2007;**85**:273-278.
- 2 9. Chou YJ, Huang N, Lee CH, *et al*. Who is at risk of death in an earthquake? *Am J Epidemiol*
- 3 2004;**160**:688-695.
- 4 10. Osaki Y, Minowa M. Factors associated with earthquake deaths in the great Hanshin-Awaji
- 5 earthquake, 1995. *Am J Epidemiol* 2001;**153**:153-156.
- 6 11. Takakura R, Himeno S, Kanayama Y, *et al*. Follow-up after the Hanshin-Awaji earthquake:
- 7 diverse influences on pneumonia, bronchial asthma, peptic ulcer and diabetes mellitus. *Intern*
- 8 *Med* 1997;**36**:87-91.
- 9 12. Tanaka H, Oda J, Iwai A, *et al*. Morbidity and mortality of hospitalized patients after the
- 10 1995 Hanshin-Awaji earthquake. *Am J Emerg Med* 1999;**17**:186-191.
- 11 13. Matsuoka T, Yoshioka T, Oda J, *et al*. The impact of a catastrophic earthquake on morbidity
- 12 rates for various illnesses. *Public Health* 2000;**114**:249-253.
- 13 14. Guha-Sapir D, van Panhuis WG. Health impact of the 2004 Andaman Nicobar earthquake
- 14 and tsunami in Indonesia. *Prehosp Disaster Med* 2009;**24**:493-499.
- 15 15. Chierakul W, Winothai W, Wattanawaitunechai C, *et al*. Melioidosis in 6 tsunami survivors
- 16 in southern Thailand. *Clin Infect Dis* 2005;**41**:982-990.
- 17 16. Potera C. In disaster's wake: tsunami lung. *Environ Health Perspect* 2005;**113**:A734.
- 18 17. Tanida N. What happened to elderly people in the great Hanshin earthquake. *BMJ*
- 19 1996;**313**:1133-1135.
- 20 18. Guha-Sapir D, van Panhuis WG, Lagoutte J. Short communication: patterns of chronic and
- 21 acute diseases after natural disasters - a study from the International Committee of the Red
- 22 Cross field hospital in Banda Aceh after the 2004 Indian Ocean tsunami. *Trop Med Int Health*
- 23 2007;**12**:1338-1341.
- 24 19. Miller AC, Arquilla B. Chronic diseases and natural hazards: impact of disasters on diabetic,
- 25 renal, and cardiac patients. *Prehosp Disaster Med* 2008;**23**:185-194.
- 26 20. Tomita K, Hasegawa Y, Watanabe M, *et al*. The Totton-Ken Seibu earthquake and
- 27 exacerbation of asthma in adults. *J Med Invest* 2005;**52**:80-84.
- 28 21. Soriano JB, Davis KJ, Coleman B, *et al*. The proportional Venn diagram of obstructive lung
- 29 disease: two approximations from the United States and the United Kingdom. *Chest*
- 30 2003;**124**:474-481.
- 31 22. Pauwels RA. Similarities and differences in asthma and chronic obstructive pulmonary
- 32 disease exacerbations. *Proc Am Thorac Soc* 2004;**1**:73-76.
- 33 23. Maeda H, Nakagawa M, Yokoyama M. Hospital admissions for respiratory diseases in the
- 34 aftermath of the great Hanshin earthquake[Article in Japanese]. *Nihon Kyobu Shikkan Gakkai*
- 35 *Zasshi* 1996;**34**:164-173.
- 36 24. El-Solh AA, Pietrantoni C, Bhat A, *et al*. Microbiology of severe aspiration pneumonia in

- 1
2
3
4
5
6
7
8 institutionalized elderly. *Am J Respir Crit Care Med* 2003;**167**:1650-1654.
- 9
10 25. Loeb MB, Becker M, Eady A, Walker-Dilks C. Interventions to prevent aspiration
11 pneumonia in older adults: a systematic review. *J Am Geriatr Soc* 2003;**51**:1018-1022.
- 12
13 26. Langmore SE, Skarupski KA, Park PS, *et al.* Predictors of aspiration pneumonia in nursing
14 home residents. *Dysphagia* 2002;**17**:298-307.
- 15
16 27. Terpenning MS, Taylor GW, Lopatin DE, *et al.* Aspiration pneumonia: dental and oral risk
17 factors in an older veteran population. *J Am Geriatr Soc* 2001;**49**:557-563.
- 18
19 28. Yoshino A, Ebihara T, Ebihara S, *et al.* Daily oral care and risk factors for pneumonia
20 among elderly nursing home patients. *JAMA* 2001;**286**:2235-2236.
- 21
22 29. Kobayashi S, Kubo H, Yanai M. Impairment of swallowing in COPD. *Am J Respir Crit*
23 *Care Med* 2009;**180**:481.
- 24
25 30. Nishikiori N, Abe T, Costa DG, *et al.* Timing of mortality among internally displaced
26 persons due to the tsunami in Sri Lanka: cross sectional household survey. *BMJ*
27 2006;**332**:334-335.
- 28
29 31. Kysely J, Kriz B. Decreased impacts of the 2003 heat waves on mortality in the Czech
30 Republic: an improved response? *Int J Biometeorol* 2008;**52**:733-745.
- 31
32 32. Toyabe S, Shioiri T, Kuwabara H, *et al.* Impaired psychological recovery in the elderly after
33 the Niigata-Chuetsu Earthquake in Japan:a population-based study. *BMC Public Health*
34 2006;**6**:230.
- 35
36 33. Seplaki CL, Goldman N, Weinstein M, *et al.* Before and after the 1999 Chi-Chi earthquake:
37 traumatic events and depressive symptoms in an older population. *Soc Sci Med*
38 2006;**62**:3121-3132.
- 39
40 34. Ueki A, Morita Y, Miyoshi K. Changes in symptoms after the great Hanshin Earthquake in
41 patients with dementia[Article in Japanese]. *Nihon Ronen Igakkai Zasshi* 1996;**33**:573-579.
- 42
43 35. Maeda K, Kakigi T. Manifestation of the symptoms in demented patients after the Great
44 Hanshin Earthquake in Japan[Article in Japanese]. *Seishin Shinkeigaku Zasshi*
45 1996;**98**:320-328.
- 46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22

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

Formatted: Justified

Formatted: Justified, Tab stops: Not at 2.95" + 5.91"

Formatted: Justified, Tab stops: Not at 2.95" + 5.91"

Formatted: Justified

Formatted: Justified, Indent: First line: 0 ch

Formatted: Justified

Formatted: Justified, Indent: First line: 0 ch

Formatted: Justified

Formatted: Justified

Formatted: Justified, Indent: First line: 0 ch

Formatted: Justified

Formatted: Justified, Indent: First line: 0 ch

Formatted: Justified

Formatted: Justified, Indent: First line: 0 ch

Formatted: Justified

Formatted: Justified, Indent: First line: 0 ch

Formatted: Justified

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

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.

- Formatted: Justified, Indent: First line: 0 ch
- Formatted: Justified
- Formatted: Justified, Tab stops: Not at 2.95" + 5.91"
- Formatted: Justified, Tab stops: Not at 2.95" + 5.91"
- Formatted: Justified
- Formatted: Justified, Indent: First line: 0 ch
- Formatted: Justified
- Formatted: Justified, Indent: First line: 0 ch
- Formatted: Justified
- Formatted: Justified, Indent: First line: 0 ch
- Formatted: Justified

~~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 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.

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

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~~4~~, 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~~4~~, 2010, and 2011~~09~~, presented in 10 day bins.

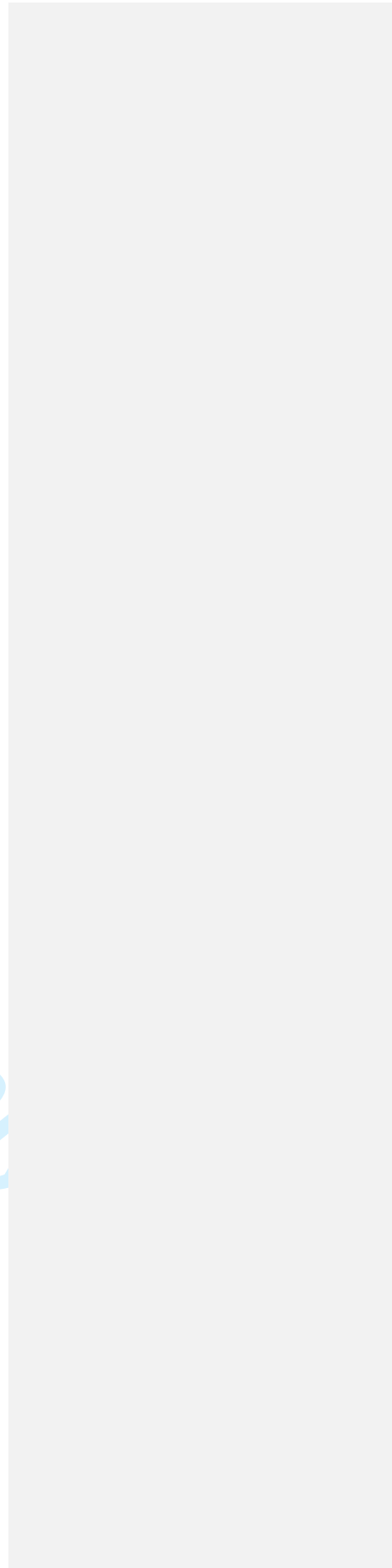
Figure ~~_~~3. ~~Distribution~~Sequential change of ~~disease distribution of~~ patients hospitalized for respiratory disease after the Great East Japan earthquake from March 11 to May 9 in 2011, presented in 10 day bins.

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.

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1 |
2

For peer review only



1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

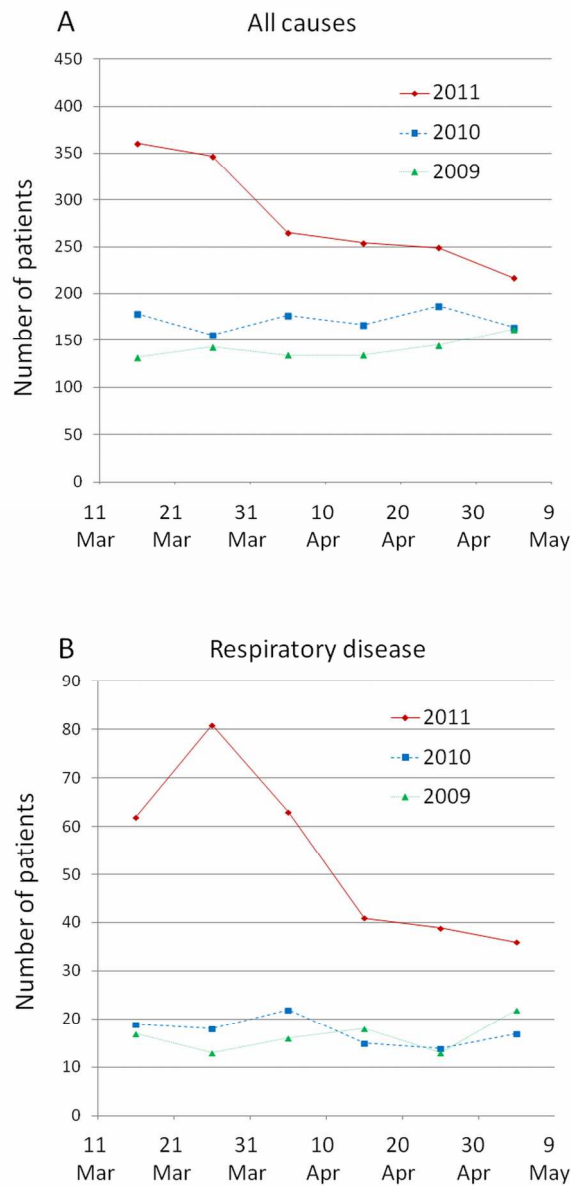


Figure 1. The number of unscheduled hospitalization for all causes (A) and for respiratory disease (B) from March 11 to May 9 in 2009, 2010 and 2011, presented in 10 day bins.
90x185mm (300 x 300 DPI)

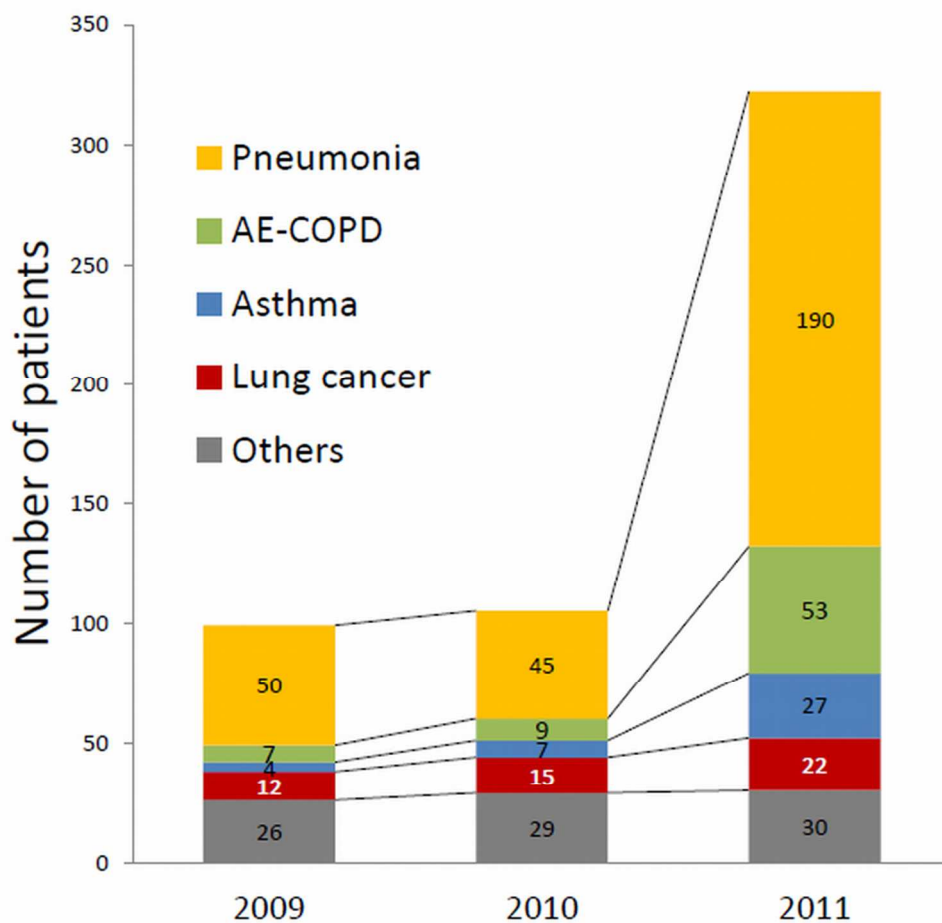


Figure 2. The number and proportion of patients hospitalized for respiratory disease from March 11 to May 9 in 2009, 2010, and 2011, presented in 10 day bins.
90x91mm (300 x 300 DPI)



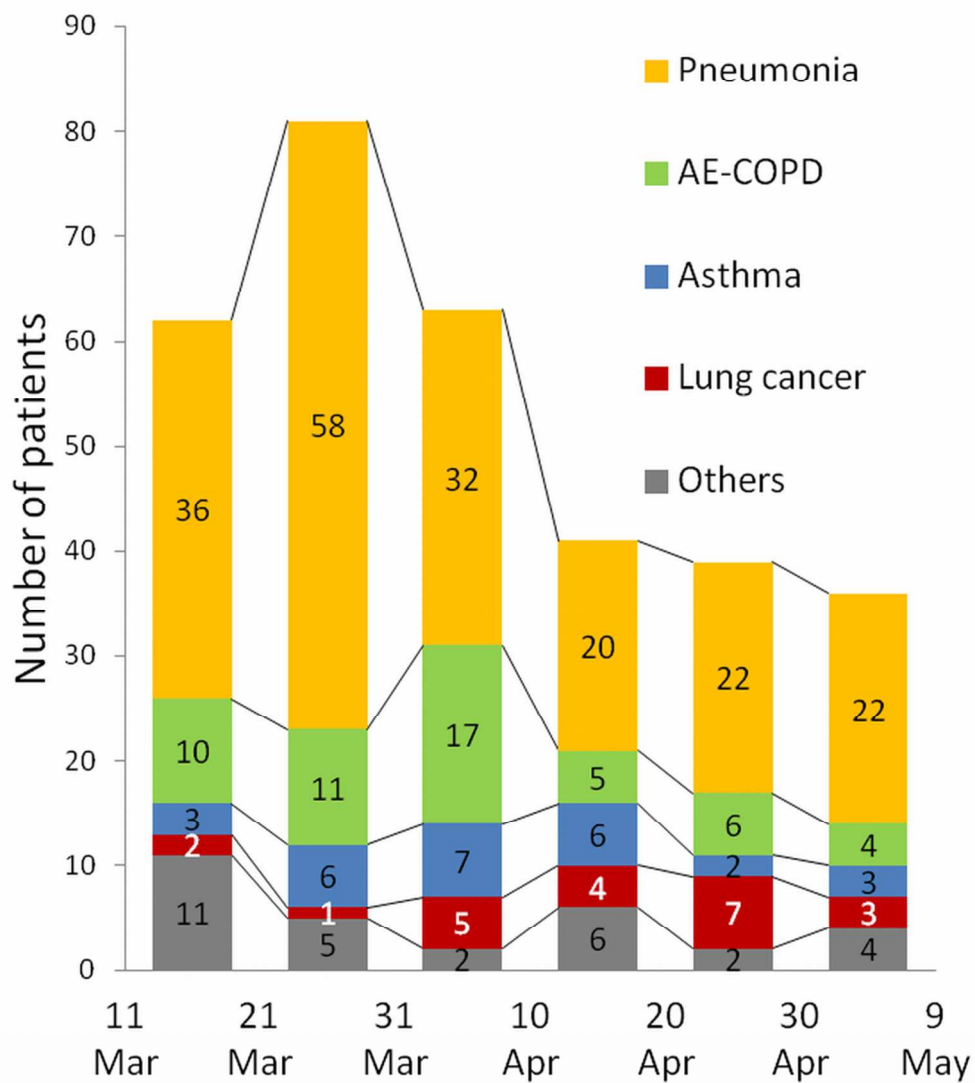


Figure 3. Distribution of patients hospitalized for respiratory disease after the Great East Japan earthquake from March 11 to May 9 in 2011, presented in 10 day bins.
90x104mm (300 x 300 DPI)

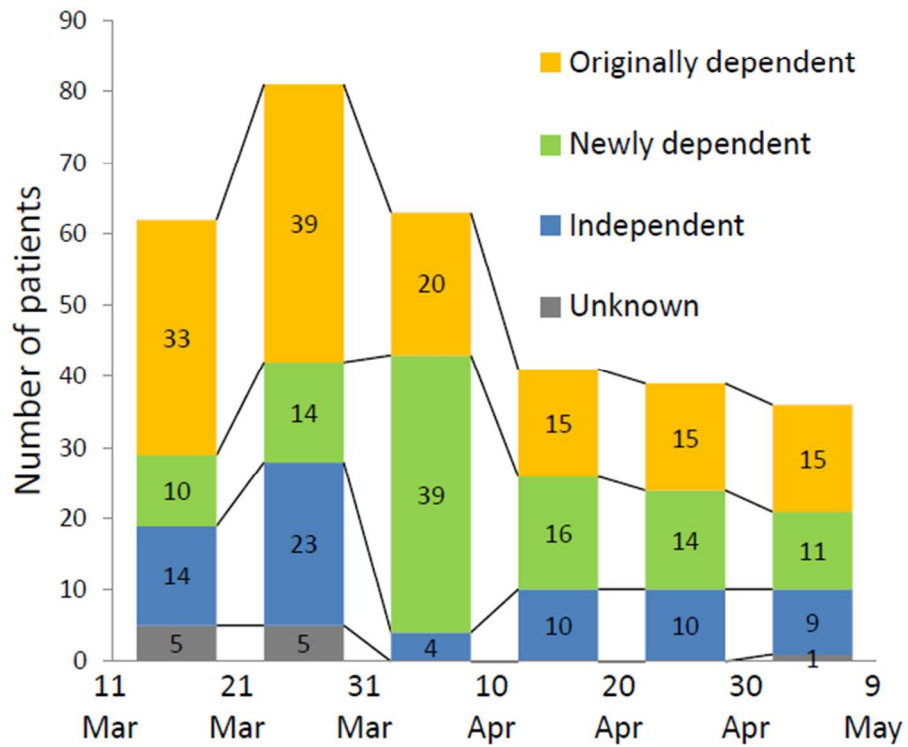


Figure 4. Influence of the disaster on ADL status and its deterioration in hospitalized patients for respiratory disease from March 11 to May 9 in 2011, presented in 10 day bins.

For peer review only

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			

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49

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.



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

Journal:	<i>BMJ Open</i>
Manuscript ID:	bmjopen-2012-000865.R2
Article Type:	Research
Date Submitted by the Author:	30-Nov-2012
Complete List of Authors:	Yamanda, Shinsuke; Japanese Red Cross Ishinomaki Hospital, Respiratory Medicine Hanagama, Masakazu; Japanese Red Cross Ishinomaki Hospital, Department of respiratory medicine Kobayashi, Seiichi; Japanese Red Cross Ishinomaki Hospital, Department of respiratory medicine Satou, Hikari; Japanese Red Cross Ishinomaki Hospital, Department of respiratory medicine Tokuda, Shinsaku; Kobe University Graduate School of Medicine, Division of Cell Biology Niu, Kaijun; Tohoku University Graduate School of Biomedical Engineering, Division of Biomedical Engineering for Health and Welfare Yanai, Masaru; Japanese Red Cross Ishinomaki Hospital, Department of respiratory medicine
Primary Subject Heading:	Respiratory medicine
Secondary Subject Heading:	Geriatric medicine, Emergency medicine
Keywords:	GERIATRIC MEDICINE, Adult thoracic medicine < THORACIC MEDICINE, ACCIDENT & EMERGENCY MEDICINE

SCHOLARONE™
Manuscripts

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1 **Title**

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

5
6 **Author names**

7 Shinsuke Yamanda *physician scientist*¹, Masakazu Hanagama *physician scientist*¹, Seiichi
8 Kobayashi *senior physician scientist*¹, Hikari Satou *resident*¹, Shinsaku Tokuda *lecturer*²,
9 Kaijun Niu *associate professor*³, Masaru Yanai *director*¹

10
11 ¹Department of respiratory medicine, Japanese Red Cross Ishinomaki Hospital, 71 Hebita Aza
12 Nishimichishita, Ishinomaki, Miyagi, Japan

13
14 ²Division of Cell Biology, Kobe University Graduate School of Medicine, 7-5-1 Kusunoki-cho,
15 chuo-ku, Kobe, Hyogo, Japan

16
17 ³Division of Biomedical Engineering for Health and Welfare, Tohoku University Graduate
18 School of Biomedical Engineering, 2-1 Seiryomachi, Aoba-ku, Sendai, Miyagi, Japan

19
20 **Correspondence to:** Shinsuke Yamanda syamanda@gmail.com

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1 **Article summary**

2 **Article focus**

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

7 The study gives lessons against natural disasters and aging society.

8 **Key messages**

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

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

13 **Strengths and limitations of study**

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

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

1
2
3
4
5 **Abstract**

6
7 **Objective**

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

10
11 **Design**

12 Descriptive and cross sectional study.

13
14 **Setting**

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

17
18 **Participants**

19 322 emergency patients who hospitalized for respiratory disease from March 11 to May
20 9 in 2011, and 99 and 105 emergency patients who hospitalized in the corresponding
21 period of 2009 and 2010, respectively.

22
23 **Main outcome measures**

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

26
27 **Results**

28 Total number of patients hospitalized in our hospital in the study period was 1769 (850 in 2009,
29 1030 in 2010), and the number of hospitalized for respiratory disease in them was 322 (99 in
30 2009, 105 in 2010). Among admission for pulmonary diseases, pneumonia was the most
31 frequent disease (n=190, 59.0%), followed by acute exacerbation of chronic obstructive disease
32 (AE-COPD) (n=53, 16.5%), attack of asthma (n=27, 8.4%), and progression of lung cancer
33 (n=22, 6.8%). Compared with the corresponding period of 2009 or 2010, increase in absolute
34 number of hospitalization was the highest for pneumonia, followed by AE-COPD and attack of
35 asthma. At hospitalization, 195 patients were "dependent" and 54 patients were "partially
36 dependent". Respiratory admission accompanied by deterioration of ADL after the disaster was
37 more frequent in elderly and female patients.

38
39 **Conclusions**

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

42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1 Introduction

2 On March 11, 2011, at 2:46 pm Japan time, the Pacific coast of Japan's Tohoku (northeastern)
3 region was struck by the massive earthquake (The Great East Japan Earthquake), measuring
4 magnitude 9.0 on the Richter scale¹. The earthquake triggered a devastating tsunami which
5 destroyed many towns and villages near the seashore. The epicenter was estimated to be about
6 70 kilometers east of Oshika Peninsula of Ishinomaki in Miyagi. Officially, over 19,000 people
7 were killed or missing and the maximum number of refugees reached more than 550,000².

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

13 Japan is one of the most rapidly aging society in the world. 23% of Japanese citizens were age
14 65 or over in 2010³. Tohoku region is especially rapidly aging society in Japan, 26.6% of people
15 living in Ishinomaki city were age 65 or over in 2010. Although several reports showed the
16 significant association between age and earthquake and tsunami death⁴⁻⁸, there were few reports
17 investigating the impact of a tremendous disaster on elderly peoples in such an aging society^{9 10}.
18 Respiratory diseases are common in the elderly even in ordinary times. So, investigating the
19 impact of the disasters on respiratory health will contribute to elucidating the problem of aging
20 society. Thus, we performed retrospective descriptive and cross-sectional analysis of the
21 medical and epidemiologic data of the patient required hospitalization for respiratory disease
22 after the Great East Japan Earthquake and following tsunami.

23 24 25 Methods

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

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

1 respiratory department and pulmonary specialists in the region.
2 Medical records were investigated in terms of date of admission, age, sex, diagnosis. We also
3 investigated activities of daily living (ADL) at hospitalization and ADL before earthquake, and
4 their residence before admission on the medical record of 2011 study period. For comparison,
5 the total number of unscheduled hospitalization during the corresponding periods in 2009 and
6 2010 was counted.

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

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

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

28 29 **Data analysis**

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

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

4 5 6 **Result**

7 All of the scheduled hospitalization was cancelled and emergency admission was solely
8 accepted during the first 60 day after the earthquake at Japanese Red Cross Ishinomaki Hospital.
9 1,769 patients admitted to the hospital, and 322 of them were hospitalized for respiratory
10 disease during the study period. In the corresponding period, total number of unscheduled
11 hospitalization was 850 and that for respiratory disease was 99 in 2009 and 1,030 and 105 in
12 2010. Patients hospitalized for respiratory disease accounted for 18.2% of total hospitalization
13 during the study period. This proportion was significantly higher than that of 2009 and 2010
14 (11.6% in 2009. $P < 0.001$. 10.2% in 2010. $P < 0.001$). While the number of total hospitalizations
15 of this period in 2011 was about twice of that in 2009 and 2010, hospitalization for respiratory
16 disease in 2011 reached about three times or more than that of 2009 and 2010. The total number
17 of hospitalizations was peaked in the first ten days, but the number of hospitalization for
18 respiratory disease kept increasing for 20 days (Figure 1A and B).

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

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

1 Specifically, pneumonia patients and AE-COPD patients were significantly older in 2011 study
2 period than in 2010 and 2009 corresponding period(77.6±11.8 v.s. 74.3±12.8 years old in
3 pneumonia patients. p=0.03. 76.0±8.7 v.s. 69.5±15.9 years old in AE-COPD patients. p=0.03).
4 Male population of AE-COPD was significantly higher (81.1% v.s. 50.0%. p=0.01), whereas
5 that of asthma attack significantly lower in 2011 period than 2010 and 2009 periods (18.5% v.s.
6 54.6%. p=0.03).

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

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

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

31

32

33 Discussion

34 Summary

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

37

38

39

40

41

42

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

5 6 **Effect on respiratory disease**

7 Previous reports on Hanshin-Awaji earthquake showed initial rush of patients with injury and
8 following increase of patients with respiratory disease, especially pneumonia¹¹⁻¹³. Similarly, our
9 observation showed marked increase in pneumonia patients, although initial rush of heavy
10 injury patients was absent in this disaster because majority of victims were drowned to death
11 and heavily injured patients were seldom carried to the hospital.

12 The cause of increase in respiratory disease was different in each situation. After the 2004
13 Sumatra-Andaman earthquake and following tsunami, the number of lower respiratory infection
14 in Ache was rapidly increased after the disaster and sharply declined in the second week¹⁴. On
15 the other hand, after the 1995 Hanshin-Awaji earthquake, the number of patients hospitalized for
16 pneumonia was gradually increased and kept high proportion over the two month^{9 10}. This
17 difference is ascribable to the mechanism of developing pneumonia. In Sumatra-Andaman
18 earthquake, many of pneumonia were resulted from aspiration of tsunami-water in
19 near-drowning events^{15 16}. Those pneumonias were called “tsunami lung”. On the other hand, in
20 the Hanshin-Awaji earthquake, many patients developed pneumonia in shelters under unhealthy
21 environment and most of them were in elderly. Those pneumonias were called “shelter
22 pneumonia”¹⁷. In this earthquake and tsunami, we experienced few number of pneumonia
23 directly caused by aspiration of tsunami-water even in the very acute period. A few of the
24 patient directory came from the field, instead, most patients came from shelters, their own or
25 relative’s homes, other hospitals, or nursing homes. The mean age of them was significantly
26 higher than that of 2010 and 2009. Therefore, we regarded most of pneumonia we treated as the
27 same kind of “shelter pneumonia”. We could not carry out a bacteriological examination for 14
28 days after the earthquake due to shortage of water, fuel, gas, and manpower. After that, we could
29 perform bacteriological examination, bacterial culture or gram staining. We treated most of the
30 pneumonias as “aspiration pneumonia in nursing home” because of the patients’ ADL.

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

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

3 Although asthma was also one of the most common chronic respiratory diseases and had the
4 same precipitating cause with COPD, attack of asthma was not so much increased as AE-COPD.
5 This difference might be caused by two important differences between asthma and COPD. First,
6 generally, patients of COPD were older than those of asthma. Therefore, baseline health
7 condition of patients of COPD would be poorer than that of asthma²¹. As a result, COPD
8 patients required more frequent hospitalization. In our study, mean age of AE-COPD was higher
9 than that of attack of asthma as well. Second, bacterial respiratory infection affects patients with
10 COPD more than those with asthma²². In the aftermath of earthquake, loss of hygiene and
11 overcrowding in the shelter could increase the risk of respiratory bacterial infection and cause
12 AE-COPD.

13 Hospitalization for lung cancer related symptoms did not increase much and its ratio to total
14 hospitalization for respiratory diseases rather declined. Mean age of lung cancer patients was
15 similar to that in the past two years. Maeda et al. also reported that no increase in lung cancer
16 related hospitalization was observed after Hanshin-Awaji earthquake²³. Progression of lung
17 cancer may not be influenced by environment as much as cancer growth itself. So, the disaster
18 will not impact on lung cancer immediately. Although the interruption of chemotherapy and/or
19 radiotherapy would worsen the prognosis, it cannot be confirmed during our study period.

21 **Effect on ADL**

22 In acute phase, patients with poor ADL, especially those originally dependent, were hospitalized
23 for pulmonary diseases, typically pneumonia, although substantial number of good ADL
24 patients was also hospitalized. After 3 weeks, there was a sharp increase in newly dependent
25 people who deteriorated their ADL after the disaster. It was reported that physical disability was
26 an independent risk factor for death in Hanshin-Awaji earthquake and the 1999 Taiwan
27 earthquake^{9 10}. However, those reports investigated the mortality in acute phase, not
28 hospitalization in subacute or chronic phase. After the earthquake and tsunami, one fourth of
29 people in Ishinomaki region fled into shelters, many of which were also flooded by tsunami.
30 They lacked water and food under harsh condition of cold season without heating in
31 overcrowded quarter just letting them lie on the floor without beds. In such bad conditions,
32 elderly people were restricted their consumption food and water, and kept still in a small space,
33 resulting in deterioration of ADL. In addition, scarcity of water worsened oral hygiene. Both
34 poor functional status and loss of oral hygiene were the major risk factor of pneumonia²⁴⁻²⁷,
35 especially in elderly people. Subsequently, many elderly people were hospitalized for “shelter
36 pneumonia” after the earthquake. Also, poor oral hygiene induces swallowing dysfunction²⁸ and

1 swallowing dysfunction could be a risk factor of exacerbation of COPD²⁹. It would be one of the
2 reasons why AE-COPD increased especially in elderly people.

3 4 **Effect on aging society**

5 According to the report of government of Japan, 93% of the fatalities were drowning and more
6 than 60% of them were over 60 years old in the Great East Japan earthquake. Although it was
7 reported by many previous reports that elderly people had a greater risk of death after the
8 earthquake, the proportion of the elderly killed by this earthquake and tsunami was extremely
9 high in comparison to other major earthquake or tsunami in the world⁴⁻⁸. Similar finding was
10 reported only in 1995 Hanshin-Awaji earthquake and 2004 Mid Niigata earthquake in Japan^{12 17}.
11 Moreover, 90.8% of the patients hospitalized for respiratory disease after the earthquake were
12 over 60 years old in our study. These results suggest that elderly people were vulnerable not
13 only immediately after the earthquake but also for a while after the earthquake.

14 In 1999 Taiwan earthquake, 2003 heat waves in the Czech Republic, and 2004
15 Sumatra-Andaman earthquake, it is demonstrated that these disasters has left decreased
16 mortality in the stricken area, resulted from a large number of direct death by disasters among a
17 vulnerable population such as elderly people or children^{5 30 31}, called "harvesting effect".
18 However, our observation suggests that, in the aging society, a huge disaster not only directly
19 kills the vulnerable people but also produces new vulnerable people. Previous reports
20 demonstrated that prolonged harmful influence on mental health and psychological slow
21 recovery were seen more frequently in the elderly people than young people³²⁻³⁵. Therefore, we
22 should pay a long-term attention on those elderly people after a disaster.

23 24 **Implications for policy and practice**

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

1 **Strengths and weaknesses of study**

2 Our study had two important strengths. First, the Great East Japan Earthquake hit one of the
3 most rapidly aging societies in the world³. As the proportion of elderly people continues to
4 increase in not only developed but also developing countries, there is an urgent need of
5 information and analysis on the aging society to plan countermeasures against it. Our study will
6 give lessons against natural disaster to all the countries. Secondly, we obtained detailed data of
7 patient's demographics, diagnosis, and ADL in a catastrophic situation. It is because that our
8 hospital has kept its medical function, including electronic medical record system or laboratory
9 systems, while devastating earthquake and tsunami hit Ishinomaki city and almost all medical
10 facilities lost their function, and that staffs in our hospital has trained for the coming earthquake
11 and has had an strong motivation to record our experiences as memos or on digital recorders for
12 future disaster medicine.

13 Our study is single center study. This might be weakness of our study, but our hospital was the
14 only functional hospital after the earthquake in Ishinomaki medical zone which account for
15 more than 30% of total fatalities of this earthquake in Japan. Also, it has been the only hospital
16 which has the department of respiratory medicine and pulmonary specialists in the medical zone.
17 Even in the ordinary time before the disaster, it accepted almost all of the serious patients with
18 pulmonary diseases who needed hospitalization. Therefore, we think our study well represents
19 impact of the earthquake on pulmonary diseases and describes what happened in the hospital
20 which faced the earthquake at the front². It is also weakness of our study that we analyzed only
21 hospitalized patients. There were a great number of outpatients and a heavy loss of lives. These
22 events will be analyzed in the future report. Another weakness of our study is that
23 cross-sectional study cannot elucidate a causal relationship. Finally, we did not clearly define
24 the condition of hospitalization. Because the destruction of ordinary healthcare system and poor
25 hygiene outside the hospital, we hospitalized some patients who could be treated in outpatient
26 setting in ordinary time. However, this was a real situation after devastating disaster.

27 **Conclusion**

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

33 **Acknowledgement**

34 We would like to express our gratitude to all of the relief teams and volunteers from all area of
35
36

1 Japan and foreign countries for their kind and warm supports. We also thank doctors, nurses,
2 and other employees in Japanese Red Cross Ishinomaki Hospital.

3 **Competing interests:** None declared.

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

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

12 **Data sharing statement:** There is no additional data available.

13 **Funding:** This study was not funded by any research funds.

14 15 **References**

- 16 1. McCurry J. Japan: the aftermath. *Lancet* 2011;**377**:1061-1062.
- 17 2. National Police Agency. *Dmage Situation and Police Countermeasure*.
18 www.npa.go.jp/archive/keibi/biki/index_e.htm (accessed 29 Dec 2011).
- 19 3. Tamiya N, Noguchi H, Nishi A, *et al*. Population ageing and wellbeing: lessons from Japan's
20 long-term care insurance policy. *Lancet* 2011;**378**:1183-1192.
- 21 4. Liang NJ, Shih YT, Shih FY, *et al*. Disaster epidemiology and medical response in the
22 Chi-Chi earthquake in Taiwan. *Ann Emerg Med* 2001;**38**:549-555.
- 23 5. Chan CC, Lin YP, Chen HH, *et al*. A population-based study on the immediate and prolonged
24 effects of the 1999 Taiwan earthquake on mortality. *Ann Epidemiol* 2003;**13**:502-508.
- 25 6. Nishikiori N, Abe T, Costa DG, *et al*. Who died as a result of the tsunami? Risk factors of
26 mortality among internally displaced persons in Sri Lanka: a retrospective cohort analysis. *BMC*
27 *Public Health* 2006;**6**:73.
- 28 7. Rofi A, Doocy S, Robinson C. Tsunami mortality and displacement in Aceh province,
29 Indonesia. *Disasters* 2006;**30**:340-350.
- 30 8. Doocy S, Rofi A, Moodie C, *et al*. Tsunami mortality in Aceh Province, Indonesia. *Bull*
31 *World Health Organ* 2007;**85**:273-278.
- 32 9. Chou YJ, Huang N, Lee CH, *et al*. Who is at risk of death in an earthquake? *Am J Epidemiol*
33 2004;**160**:688-695.
- 34 10. Osaki Y, Minowa M. Factors associated with earthquake deaths in the great Hanshin-Awaji
35 earthquake, 1995. *Am J Epidemiol* 2001;**153**:153-156.
- 36 11. Takakura R, Himeno S, Kanayama Y, *et al*. Follow-up after the Hanshin-Awaji earthquake:

- 1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
- 1 diverse influences on pneumonia, bronchial asthma, peptic ulcer and diabetes mellitus. *Intern Med* 1997;**36**:87-91.
 - 2
 - 3 12. Tanaka H, Oda J, Iwai A, *et al*. Morbidity and mortality of hospitalized patients after the
 - 4 1995 Hanshin-Awaji earthquake. *Am J Emerg Med* 1999;**17**:186-191.
 - 5 13. Matsuoka T, Yoshioka T, Oda J, *et al*. The impact of a catastrophic earthquake on morbidity
 - 6 rates for various illnesses. *Public Health* 2000;**114**:249-253.
 - 7 14. Guha-Sapir D, van Panhuis WG. Health impact of the 2004 Andaman Nicobar earthquake
 - 8 and tsunami in Indonesia. *Prehosp Disaster Med* 2009;**24**:493-499.
 - 9 15. Chierakul W, Winothai W, Wattanawaitunechai C, *et al*. Melioidosis in 6 tsunami survivors
 - 10 in southern Thailand. *Clin Infect Dis* 2005;**41**:982-990.
 - 11 16. Potera C. In disaster's wake: tsunami lung. *Environ Health Perspect* 2005;**113**:A734.
 - 12 17. Tanida N. What happened to elderly people in the great Hanshin earthquake. *BMJ*
 - 13 1996;**313**:1133-1135.
 - 14 18. Guha-Sapir D, van Panhuis WG, Lagoutte J. Short communication: patterns of chronic and
 - 15 acute diseases after natural disasters - a study from the International Committee of the Red
 - 16 Cross field hospital in Banda Aceh after the 2004 Indian Ocean tsunami. *Trop Med Int Health*
 - 17 2007;**12**:1338-1341.
 - 18 19. Miller AC, Arquilla B. Chronic diseases and natural hazards: impact of disasters on diabetic,
 - 19 renal, and cardiac patients. *Prehosp Disaster Med* 2008;**23**:185-194.
 - 20 20. Tomita K, Hasegawa Y, Watanabe M, *et al*. The Totton-Ken Seibu earthquake and
 - 21 exacerbation of asthma in adults. *J Med Invest* 2005;**52**:80-84.
 - 22 21. Soriano JB, Davis KJ, Coleman B, *et al*. The proportional Venn diagram of obstructive lung
 - 23 disease: two approximations from the United States and the United Kingdom. *Chest*
 - 24 2003;**124**:474-481.
 - 25 22. Pauwels RA. Similarities and differences in asthma and chronic obstructive pulmonary
 - 26 disease exacerbations. *Proc Am Thorac Soc* 2004;**1**:73-76.
 - 27 23. Maeda H, Nakagawa M, Yokoyama M. Hospital admissions for respiratory diseases in the
 - 28 aftermath of the great Hanshin earthquake[Article in Japanese]. *Nihon Kyobu Shikkan Gakkai*
 - 29 *Zasshi* 1996;**34**:164-173.
 - 30 24. El-Solh AA, Pietrantonio C, Bhat A, *et al*. Microbiology of severe aspiration pneumonia in
 - 31 institutionalized elderly. *Am J Respir Crit Care Med* 2003;**167**:1650-1654.
 - 32 25. Loeb MB, Becker M, Eady A, Walker-Dilks C. Interventions to prevent aspiration
 - 33 pneumonia in older adults: a systematic review. *J Am Geriatr Soc* 2003;**51**:1018-1022.
 - 34 26. Langmore SE, Skarupski KA, Park PS, *et al*. Predictors of aspiration pneumonia in nursing
 - 35 home residents. *Dysphagia* 2002;**17**:298-307.
 - 36 27. Terpenning MS, Taylor GW, Lopatin DE, *et al*. Aspiration pneumonia: dental and oral risk

- 1 factors in an older veteran population. *J Am Geriatr Soc* 2001;**49**:557-563.
- 2 28. Yoshino A, Ebihara T, Ebihara S, *et al*. Daily oral care and risk factors for pneumonia
3 among elderly nursing home patients. *JAMA* 2001;**286**:2235-2236.
- 4 29. Kobayashi S, Kubo H, Yanai M. Impairment of swallowing in COPD. *Am J Respir Crit*
5 *Care Med* 2009;**180**:481.
- 6 30. Nishikiori N, Abe T, Costa DG, *et al*. Timing of mortality among internally displaced
7 persons due to the tsunami in Sri Lanka: cross sectional household survey. *BMJ*
8 2006;**332**:334-335.
- 9 31. Kysely J, Kriz B. Decreased impacts of the 2003 heat waves on mortality in the Czech
10 Republic: an improved response? *Int J Biometeorol* 2008;**52**:733-745.
- 11 32. Toyabe S, Shioiri T, Kuwabara H, *et al*. Impaired psychological recovery in the elderly after
12 the Niigata-Chuetsu Earthquake in Japan: a population-based study. *BMC Public Health*
13 2006;**6**:230.
- 14 33. Seplaki CL, Goldman N, Weinstein M, *et al*. Before and after the 1999 Chi-Chi earthquake:
15 traumatic events and depressive symptoms in an older population. *Soc Sci Med*
16 2006;**62**:3121-3132.
- 17 34. Ueki A, Morita Y, Miyoshi K. Changes in symptoms after the great Hanshin Earthquake in
18 patients with dementia[Article in Japanese]. *Nihon Ronen Igakkai Zasshi* 1996;**33**:573-579.
- 19 35. Maeda K, Kakigi T. Manifestation of the symptoms in demented patients after the Great
20 Hanshin Earthquake in Japan[Article in Japanese]. *Seishin Shinkeigaku Zasshi*
21 1996;**98**:320-328.
- 22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1 **Table**

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

3

	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)

4 AE-COPD, acute exacerbation of COPD.

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

6

7

8

9

10

11

12

13

14

15

16

17

18

19

20

21

22

23

24

25

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1 **Figure legends**

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

4
5 Figure 2. The number and proportion of patients hospitalized for respiratory disease pooled
6 from March 11 to May 9 in 2009, 2010, and 2011.

7
8 Figure 3. Distribution of patients hospitalized for respiratory disease after the Great East Japan
9 earthquake from March 11 to May 9 in 2011, presented in 10 day bins.

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

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1 | **Title**

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

6 | **Author names**

7 | Shinsuke Yamanda *physician scientist*¹, Masakazu Hanagama *physician scientist*¹, Seiichi
8 | Kobayashi *senior physician scientist*¹, Hikari Satou *resident*¹, Shinsaku Tokuda *lecturer*²,
9 | Kaijun Niu *associate professor*³, Masaru Yanai *director*¹

11 | ¹Department of respiratory medicine, Japanese Red Cross Ishinomaki Hospital, 71 Hebita Aza
12 | Nishimichishita, Ishinomaki, Miyagi, Japan

14 | ²Division of Cell Biology, Kobe University Graduate School of Medicine, 7-5-1 Kusunoki-cho,
15 | chuo-ku, Kobe, Hyogo, Japan

17 | ³Division of Biomedical Engineering for Health and Welfare, Tohoku University Graduate
18 | School of Biomedical Engineering, 2-1 Seiryomachi, Aoba-ku, Sendai, Miyagi, Japan

20 | **Correspondence to:** Shinsuke Yamanda syamanda@gmail.com

Formatted

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1 **Article summary**

2 **Article focus**

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

7 The study gives lessons against natural disasters and aging society.

8 **Key messages**

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

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

13 **Strengths and limitations of study**

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

15 We analyzed only hospitalized patients. But there were a great number of outpatients
16 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 activity of daily living (ADL).

Results

Total ~~number of patients hospitalized in our hospital in the study period was 1769 (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~~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". 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 March 11, 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 scale¹. 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 550,000².

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 2010³. ~~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 2010⁴. Although several reports showed the significant association between age and earthquake and tsunami death⁴⁻⁸, there were few reports investigating the impact of a tremendous disaster on ~~elderly peoples in~~ such an aging society⁹¹⁰.

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

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1 the medical records at Japanese Red Cross Ishinomaki Hospital. We reviewed medical records
2 of patients admitted to the hospital for respiratory diseases during the first 60 days after the
3 Great East Japan Earthquake, when the hospital solely accepted emergency patients. We also
4 reviewed medical records of patients who required unscheduled hospitalization for respiratory
5 disease in the corresponding period of 2009 and 2010.
6 Japanese Red Cross Ishinomaki Hospital which had 402 beds for inpatients was located at 4.5
7 km inland from Pacific Ocean. It has covered about 220,000 people living in its medical zone
8 (Ishinomaki City, Onagawa Town, ~~or~~ and Higashi-matsushima City) and assigned to a regional
9 disaster base hospital. It has ~~received~~accepted almost all of the emergency respiratory patients
10 even in the ordinary time before the disaster, because it ~~is~~has been the unique hospital having
11 the respiratory department and pulmonary specialists in the region.
12 Medical records were investigated in terms of date of admission, age, sex, diagnosis. We also
13 investigated ~~activities~~activity of daily living (ADL) at hospitalization and ADL before
14 earthquake, and their residence before admission on the medical record of 2011 study period.
15 For comparison, the total number of unscheduled hospitalization ~~to the hospital~~ during the
16 corresponding periods in 2009 and 2010 was counted.
17 Pneumonia was defined as the presence of the infiltration on chest radiograph along with one or
18 more of the following symptoms or signs: fever, cough, sputum production, breathlessness,
19 pleuritic chest pain or signs consistent with pneumonia on auscultation.
20 Chronic obstructive pulmonary disease (COPD) and bronchial asthma were detected by the
21 previous spirometric data, patient's self-report, or physician's diagnosis made by patient's
22 history, physical examination, and radiological finding. An acute exacerbation of
23 COPD(AE-COPD) was defined as an increase in or new onset of more than one symptom of
24 COPD (cough, sputum, wheezing, dyspnea or chest tightness) without pneumonia or
25 pneumothorax. An attack of asthma was defined as the presentation of wheezes or severe cough
26 in asthma patients without pneumonia. Progression of lung cancer was defined as requirement
27 for admission for lung cancer associated condition such as dehydration, respiratory failure, or
28 uncontrolled pain. Obstructive pneumonia due to lung cancer was considered as progression of
29 lung cancer. Chest trauma and traumatopnea were not considered as respiratory disease but
30 chest injury.
31 ADL was assessed by the information from a patient, patient's family, or patient's caregiver, and
32 classified into three categories; "independent" who could live without particular support,
33 "partially dependent" who could not leave their residence without any support, "dependent"
34 who spent a day on the bed or the wheelchair and lost the ability to move for themselves.
35 ~~Furthermore~~To investigate the impact of the disaster on ADL, we defined as "originally
36 dependent" who were dependent or partially dependent before the disaster, and as "newly

1 dependent” who became dependent or partially dependent after the disaster.

2 3 4 **Data analysis**

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

17 18 19 **Result**

20 All of the scheduled hospitalization was cancelled and emergency admission was solely
21 accepted during the first 60 day after the earthquake at Japanese Red Cross Ishinomaki Hospital.
22 1,769 patients admitted to the hospital, and 322 of them were hospitalized for respiratory
23 disease during the study period. ~~Patients hospitalized for respiratory disease accounted for~~
24 ~~18.2% of total hospitalization during the study period.~~ In the corresponding period, total number
25 of unscheduled hospitalization was 850 and that for respiratory disease was 99 in 2009 and
26 1,030 and 105 in 2010. Patients hospitalized for respiratory disease accounted for 18.2% of total
27 hospitalization during the study period. This proportion was significantly higher than that of
28 2009 and 2010 (11.6% in 2009, $P < 0.001$, 10.2% in 2010, $P < 0.001$). ~~the corresponding period of~~
29 ~~past two years, 10.2% of 2010 and 11.6% of 2009.~~ While the number of total hospitalizations
30 of this period in 2011 was about twice of that in 2009 and 2010, hospitalization for respiratory
31 disease in 2011 reached about three times or more than that of 2009 and 2010. The total number
32 of hospitalizations was at peak peaked in the first ten days ~~and then decreased~~, but the number of
33 hospitalization for respiratory disease kept increasing for 20 days (Figure 1A and B).

34
35 We compared the number and proportion of patients hospitalized for respiratory diseasedisease
36 distribution between 2011, 2010, and 2009 study periods (Figure 2). Pneumonia was the most

Formatted: Font: Bold

1
2
3
4
5
6
7
8 frequent disease (n=190, 59.0%), followed by AE-COPD (n=53, 16.5%), attack of asthma (n=27,
9 8.4%), and progression of lung cancer (n=22, 6.8%). One case of AE-COPD and seven cases of
10 attack of asthma were physician's diagnosis. ~~Category "Others" included pneumothorax,~~
11 ~~restrictive thoracic disease, pleural effusion, influenza, drowning, primary pulmonary~~
12 ~~hypertension, requirement of mechanical ventilator support for neuromuscular disease, and so~~
13 ~~on. One patient diagnosed as pneumonia was complicated by attack of asthma and two patients~~
14 ~~of pneumonia exacerbated their symptom of COPD. They were treated for both conditions and~~
15 ~~counted as pneumonia. In comparison with the past two years, the increase in absolute number~~
16 ~~of hospitalizations was the largest for pneumonia, followed by AE-COPD and attack of asthma.~~
17 ~~The number of hospitalization for progression of lung cancer and that for "others" diseases were~~
18 ~~not so different from the past two years. 39.4% of patients were hospitalized from stayed~~
19 ~~at emergency shelters before hospitalization.~~

20
21
22
23
24
25 To investigate the disease specific effect of earthquake, age and sex of each disease were
26 compared between the study period in 2011 and the corresponding period in the past two years
27 (Table 1). The mean age of patients hospitalized for respiratory disease was significantly higher
28 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
29 and 2009. p=0.03). Male proportion tended to be lower in 2011 than in the past two years
30 (59.6% in 2011, 67.2% in 2010 and 2009. p=0.08). Specifically, pneumonia patients and
31 AE-COPD patients were significantly older in 2011 study period than in 2010 and 2009
32 corresponding period (77.6±11.8 v.s. 74.3±12.8 years old in pneumonia patients. p=0.03,
33 76.0±8.7 v.s. 69.5±15.9 years old in AE-COPD patients. -and p=0.03, respectively). Male
34 population of AE-COPD was significantly higher (81.1% v.s. 50.0%. p=0.01), whereas that of
35 attack of asthma attack significantly lower in 2011 period than 2010 and 2009 periods (18.5%
36 v.s. 54.6%. p=0.01 and p=0.03, respectively).

37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
~~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.~~

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

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

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

21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

Table 13 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

1 patients hospitalized for respiratory disease after the earthquake was significantly higher than
2 that of ~~ordinary years~~ corresponding periods of the past two years. Majority of patients had poor
3 ADL and many of them experienced deterioration of ADL after the earthquake.
4

5 6 **Effect on respiratory disease**

7 Previous reports on Hanshin-Awaji earthquake showed initial rush of patients with injury and
8 following increase of patients with respiratory disease, especially pneumonia¹¹⁻¹³. Similarly, our
9 observation showed marked increase in pneumonia patients, although initial rush of heavy
10 injury patients was absent in this disaster because majority of victims were ~~drown~~ drowned
11 death and heavily injured patients were seldom carried to the hospital.

12 The cause of increase in respiratory disease was different in each situation. After the 2004
13 Sumatra-Andaman earthquake and following tsunami, the number of lower respiratory infection
14 in Aceh was rapidly increased after the disaster and sharply declined in the second week¹⁴. On
15 the other hand, after the 1995 Hanshin-Awaji earthquake, the number of patients hospitalized for
16 pneumonia was gradually increased and kept high proportion over the two month^{9 10}. This
17 difference is ascribable to the mechanism of developing pneumonia. In Sumatra-Andaman
18 earthquake, many of pneumonia were resulted from aspiration of tsunami-water in
19 near-drowning events^{15 16}. Those pneumonias were called “tsunami lung”. On the other hand, in
20 the Hanshin-Awaji earthquake, many patients developed pneumonia in shelters under unhealthy
21 environment and most of them were in elderly. Those pneumonias were called “shelter
22 pneumonia”¹⁷. In this earthquake and tsunami, we experienced few number of pneumonia
23 directly caused by aspiration of tsunami-water even in the very acute period. ~~Most patients came~~
24 ~~from their own or relative’s home, other hospital, nursing home, or shelter, and a~~ few of the
25 patient directory came from the field, instead, most patients came from shelters, their own or
26 relative’s homes, other hospitals, or nursing homes. The mean age of them was significantly
27 higher than that of 2010 and 2009. Therefore, we ~~thought~~ regarded most of pneumonia we
28 treated ~~was~~ the same kind of “shelter pneumonia”. We could not carry out a bacteriological
29 examination for 14 days after the earthquake due to shortage of water, fuel, gas, and manpower.
30 After that, we could perform bacteriological examination, bacterial culture or gram staining. We
31 treated most of the pneumonias as “aspiration pneumonia in nursing home” because of the
32 patients’ ADL.

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

1 of regular medication may partly account for the increase in hospitalization by AE-COPD.

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

8 Although asthma was also one of the most common chronic respiratory diseases and had the
9 same precipitating cause with COPD, attack of asthma was not so much increased as AE-COPD.
10 This difference might be caused by two important differences between asthma and COPD. First,
11 generally, patients of COPD were older than those of asthma. Therefore, baseline health
12 condition of patients of COPD would be poorer than that of asthma²¹. As a result, COPD
13 patients required more frequent hospitalization. In our study, mean age of AE-COPD was higher
14 than that of attack of asthma as well. Second, bacterial respiratory infection affects patients with
15 COPD more than those with asthma²². In the aftermath of earthquake, loss of hygiene and
16 overcrowding in the shelter could increase the risk of respiratory bacterial infection and cause
17 AE-COPD.

18 ~~Hospitalization for lung~~ Lung cancer related ~~symptoms~~ hospitalization did not increase much and
19 its ratio to total hospitalization for respiratory diseases rather declined. Mean age of lung cancer
20 patients was similar to that in the past two years. Maeda et al. also reported that no increase in
21 lung cancer related hospitalization was observed after Hanshin-Awaji earthquake²³. Progression
22 of lung cancer may not be influenced by environment as much as cancer growth itself. So, the
23 disaster will not impact on lung cancer immediately. Although the interruption of chemotherapy
24 and/or radiotherapy would worsen the prognosis, it cannot be confirmed during our study
25 period.

26 27 **Effect on ADL**

28 ~~Our observation demonstrated that drastic deterioration of ADL after the disaster resulted in~~
29 ~~increase in hospitalization by respiratory diseases.~~ In acute phase, patients with poor ADL,
30 especially ~~those~~ originally dependent ~~ones~~, were hospitalized for pulmonary diseases, typically
31 pneumonia; although substantial number of good ADL patients was also hospitalized. After 3 ~~or~~
32 4 weeks, ~~there was a sharp increase in newly dependent people~~ many people who deteriorated
33 their ADL ~~after the disaster~~ (newly dependent) ~~were hospitalized for pulmonary diseases.~~ It was
34 reported that physical disability was an independent risk factor for death in Hanshin-Awaji
35 earthquake and the 1999 Taiwan earthquake^{9 10}. However, those reports investigated the
36 mortality in acute phase, not hospitalization in subacute or chronic phase. After the earthquake

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1 and tsunami, one fourth of people in Ishinomaki region fled into shelters, many of which were
2 also flooded by tsunami. They lacked water and food under harsh condition of cold season
3 without heating in overcrowded ~~room~~quarter just letting them lie on the floor without beds. In
4 such bad conditions, elderly people were restricted their consumption food and water, and kept
5 still in ~~one~~ small space; ~~as a result, they deteriorated their~~resulting in deterioration of ADLs. In
6 addition, scarcity of water worsened oral hygiene. Both poor functional status and ~~loss of~~ oral
7 hygiene were the major risk factor of pneumonia²⁴⁻²⁷, especially in elderly people.
8 Subsequently, many elderly people were hospitalized for “shelter pneumonia” after the
9 earthquake. Also, poor oral hygiene induces swallowing dysfunction²⁸ and swallowing
10 dysfunction could be a risk factor of exacerbation of COPD²⁹. It would be one of the reasons
11 why AE-COPD increased especially in elderly people.

12 13 **Effect on aging society**

14 According to the report of government of Japan, 93% of the fatalities were drowning and more
15 than 60% of them were ~~over~~ 60 years old ~~or more~~ in the Great East Japan earthquake. Although
16 it was reported by many previous reports that elderly people had a greater risk of death after the
17 earthquake, the proportion of ~~the~~ elderly ~~people killed by this earthquake and tsunami~~ was
18 extremely high in comparison to other major earthquake or tsunami in the world⁴⁻⁸. Similar
19 finding was reported only in 1995 Hanshin-Awaji earthquake and 2004 Mid Niigata earthquake
20 in Japan^{12 17}. Moreover, 90.8% of the patients hospitalized for respiratory disease after the
21 earthquake were ~~over~~ 60 years old ~~or more~~ in our study. These results suggested that elderly
22 people were vulnerable not only immediately after the earthquake but also for a while after the
23 earthquake.

24 In 1999 Taiwan earthquake, 2003 heat waves in the Czech Republic, and 2004
25 Sumatra-Andaman earthquake, it is demonstrated that these disasters has left decreased
26 mortality in the stricken area, resulted from a large number of direct death by disasters among a
27 vulnerable population such as elderly people or children^{5 30 31}, called “harvesting effect”.
28 However, our observation suggests that, in the aging society, a huge disaster not only directly
29 kills the vulnerable people but also ~~newly~~produces ~~new~~ vulnerable people. Previous reports
30 demonstrated that prolonged harmful influence on mental health and psychological slow
31 recovery were seen more frequently in the elderly people than young people³²⁻³⁵. Therefore, we
32 should pay a long-term attention on those elderly people after a disaster.

33 34 **Implications for policy and practice**

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

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

11 Strengths and weaknesses of study

12 Our study had two important strengths. First, the Great East Japan Earthquake hit one of the
13 most ~~advanced~~ rapidly aging societies in the world³. As the proportion of elderly people
14 continues to increase in not only developed ~~countries~~ but also developing countries, there is an
15 urgent need of information and analysis on the aging society to plan countermeasures against it.
16 Our study will give lessons against natural disaster to all the countries. Secondly, we obtained
17 detailed data of patient's demographics, diagnosis, and ADL in a catastrophic situation. It is
18 because that our hospital has kept its medical function, including electronic medical record
19 system or laboratory systems, while devastating earthquake and tsunami hit Ishinomaki city and
20 almost all medical facilities lost their function, and that staffs in our hospital has trained for the
21 coming earthquake and has had an strong motivation to record ~~our experiences as memos or on~~
22 ~~digital recorders for future~~ disaster medicine ~~for the future~~.

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

Acknowledgement

We would like to express our gratitude to all **of** the **relief** teams and volunteers from **all** area of Japan and foreign countries for **their** kind and warm supports. We also thank doctors, nurses, and other employees in Japanese Red Cross Ishinomaki Hospital.

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.

Data sharing statement: There is no additional data available.

Funding: This study was not funded by any research funds.

References

1. McCurry J. Japan: the aftermath. *Lancet* 2011;**377**:1061-1062.
2. National Police Agency. *Dmage Situation and Police Countermeasure*. www.npa.go.jp/archive/keibi/biki/index_e.htm (accessed 29 Dec 2011).
3. Tamiya N, Noguchi H, Nishi A, *et al*. Population ageing and wellbeing: lessons from Japan's long-term care insurance policy. *Lancet* 2011;**378**:1183-1192.
4. Liang NJ, Shih YT, Shih FY, *et al*. Disaster epidemiology and medical response in the Chi-Chi earthquake in Taiwan. *Ann Emerg Med* 2001;**38**:549-555.
5. Chan CC, Lin YP, Chen HH, *et al*. A population-based study on the immediate and prolonged effects of the 1999 Taiwan earthquake on mortality. *Ann Epidemiol* 2003;**13**:502-508.
6. Nishikiori N, Abe T, Costa DG, *et al*. Who died as a result of the tsunami? Risk factors of mortality among internally displaced persons in Sri Lanka: a retrospective cohort analysis. *BMC*

- 1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
- 1 *Public Health* 2006;**6**:73.
- 2 7. Rofi A, Doocy S, Robinson C. Tsunami mortality and displacement in Aceh province,
3 Indonesia. *Disasters* 2006;**30**:340-350.
- 4 8. Doocy S, Rofi A, Moodie C, *et al*. Tsunami mortality in Aceh Province, Indonesia. *Bull*
5 *World Health Organ* 2007;**85**:273-278.
- 6 9. Chou YJ, Huang N, Lee CH, *et al*. Who is at risk of death in an earthquake? *Am J Epidemiol*
7 2004;**160**:688-695.
- 8 10. Osaki Y, Minowa M. Factors associated with earthquake deaths in the great Hanshin-Awaji
9 earthquake, 1995. *Am J Epidemiol* 2001;**153**:153-156.
- 10 11. Takakura R, Himeno S, Kanayama Y, *et al*. Follow-up after the Hanshin-Awaji earthquake:
11 diverse influences on pneumonia, bronchial asthma, peptic ulcer and diabetes mellitus. *Intern*
12 *Med* 1997;**36**:87-91.
- 13 12. Tanaka H, Oda J, Iwai A, *et al*. Morbidity and mortality of hospitalized patients after the
14 1995 Hanshin-Awaji earthquake. *Am J Emerg Med* 1999;**17**:186-191.
- 15 13. Matsuoka T, Yoshioka T, Oda J, *et al*. The impact of a catastrophic earthquake on morbidity
16 rates for various illnesses. *Public Health* 2000;**114**:249-253.
- 17 14. Guha-Sapir D, van Panhuis WG. Health impact of the 2004 Andaman Nicobar earthquake
18 and tsunami in Indonesia. *Prehosp Disaster Med* 2009;**24**:493-499.
- 19 15. Chierakul W, Winothai W, Wattanawaitunechai C, *et al*. Melioidosis in 6 tsunami survivors
20 in southern Thailand. *Clin Infect Dis* 2005;**41**:982-990.
- 21 16. Potera C. In disaster's wake: tsunami lung. *Environ Health Perspect* 2005;**113**:A734.
- 22 17. Tanida N. What happened to elderly people in the great Hanshin earthquake. *BMJ*
23 1996;**313**:1133-1135.
- 24 18. Guha-Sapir D, van Panhuis WG, Lagoutte J. Short communication: patterns of chronic and
25 acute diseases after natural disasters - a study from the International Committee of the Red
26 Cross field hospital in Banda Aceh after the 2004 Indian Ocean tsunami. *Trop Med Int Health*
27 2007;**12**:1338-1341.
- 28 19. Miller AC, Arquilla B. Chronic diseases and natural hazards: impact of disasters on diabetic,
29 renal, and cardiac patients. *Prehosp Disaster Med* 2008;**23**:185-194.
- 30 20. Tomita K, Hasegawa Y, Watanabe M, *et al*. The Totton-Ken Seibu earthquake and
31 exacerbation of asthma in adults. *J Med Invest* 2005;**52**:80-84.
- 32 21. Soriano JB, Davis KJ, Coleman B, *et al*. The proportional Venn diagram of obstructive lung
33 disease: two approximations from the United States and the United Kingdom. *Chest*
34 2003;**124**:474-481.
- 35 22. Pauwels RA. Similarities and differences in asthma and chronic obstructive pulmonary
36 disease exacerbations. *Proc Am Thorac Soc* 2004;**1**:73-76.

- 1
2
3
4
5
6
7
8 1 23. Maeda H, Nakagawa M, Yokoyama M. Hospital admissions for respiratory diseases in the
9 2 aftermath of the great Hanshin earthquake[Article in Japanese]. *Nihon Kyobu Shikkan Gakkai*
10 3 *Zasshi* 1996;**34**:164-173.
11 4 24. El-Solh AA, Pietrantonio C, Bhat A, *et al.* Microbiology of severe aspiration pneumonia in
12 5 institutionalized elderly. *Am J Respir Crit Care Med* 2003;**167**:1650-1654.
13 6 25. Loeb MB, Becker M, Eady A, Walker-Dilks C. Interventions to prevent aspiration
14 7 pneumonia in older adults: a systematic review. *J Am Geriatr Soc* 2003;**51**:1018-1022.
15 8 26. Langmore SE, Skarupski KA, Park PS, *et al.* Predictors of aspiration pneumonia in nursing
16 9 home residents. *Dysphagia* 2002;**17**:298-307.
17 10 27. Terpenning MS, Taylor GW, Lopatin DE, *et al.* Aspiration pneumonia: dental and oral risk
18 11 factors in an older veteran population. *J Am Geriatr Soc* 2001;**49**:557-563.
19 12 28. Yoshino A, Ebihara T, Ebihara S, *et al.* Daily oral care and risk factors for pneumonia
20 13 among elderly nursing home patients. *JAMA* 2001;**286**:2235-2236.
21 14 29. Kobayashi S, Kubo H, Yanai M. Impairment of swallowing in COPD. *Am J Respir Crit*
22 15 *Care Med* 2009;**180**:481.
23 16 30. Nishikiori N, Abe T, Costa DG, *et al.* Timing of mortality among internally displaced
24 17 persons due to the tsunami in Sri Lanka: cross sectional household survey. *BMJ*
25 18 2006;**332**:334-335.
26 19 31. Kysely J, Kriz B. Decreased impacts of the 2003 heat waves on mortality in the Czech
27 20 Republic: an improved response? *Int J Biometeorol* 2008;**52**:733-745.
28 21 32. Toyabe S, Shioiri T, Kuwabara H, *et al.* Impaired psychological recovery in the elderly after
29 22 the Niigata-Chuetsu Earthquake in Japan:a population-based study. *BMC Public Health*
30 23 2006;**6**:230.
31 24 33. Seplaki CL, Goldman N, Weinstein M, *et al.* Before and after the 1999 Chi-Chi earthquake:
32 25 traumatic events and depressive symptoms in an older population. *Soc Sci Med*
33 26 2006;**62**:3121-3132.
34 27 34. Ueki A, Morita Y, Miyoshi K. Changes in symptoms after the great Hanshin Earthquake in
35 28 patients with dementia[Article in Japanese]. *Nihon Ronen Igakkai Zasshi* 1996;**33**:573-579.
36 29 35. Maeda K, Kakigi T. Manifestation of the symptoms in demented patients after the Great
37 30 Hanshin Earthquake in Japan[Article in Japanese]. *Seishin Shinkeigaku Zasshi*
38 31 1996;**98**:320-328.
39 32
40 33
41 34
42 35
43 36
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

For peer review only

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			

- Formatted: Justified
- Formatted: Justified, Tab stops: Not at 2.95" + 5.91"
- Formatted: Justified, Tab stops: Not at 2.95" + 5.91"
- Formatted: Justified
- Formatted: Justified, Indent: First line: 0 ch
- Formatted: Justified
- Formatted: Justified, Indent: First line: 0 ch
- Formatted: Justified
- Formatted: Justified
- Formatted: Justified, Indent: First line: 0 ch
- Formatted: Justified
- Formatted: Justified
- Formatted: Justified, Indent: First line: 0 ch
- Formatted: Justified
- Formatted: Justified, Indent: First line: 0 ch
- Formatted: Justified
- Formatted: Justified

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

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)

Formatted: Justified, Indent: First line: 0 ch

Formatted: Justified

Formatted: Justified, Tab stops: Not at 2.95" + 5.91"

Formatted: Justified, Indent: First line: 0 ch, Tab stops: Not at 2.95" + 5.91"

Formatted: Justified, Tab stops: Not at 2.95" + 5.91"

Formatted: Justified, Tab stops: Not at 2.95" + 5.91"

Formatted: Justified

Formatted: Justified, Indent: First line: 0 ch

Formatted: Justified

Formatted: Justified, Indent: First line: 0 ch

Formatted: Justified

Formatted: Justified

Formatted: Justified, Indent: First line: 0 ch

Formatted: Justified

Formatted: Justified, Indent: First line: 0 ch

Formatted: Justified

—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.

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

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~~.

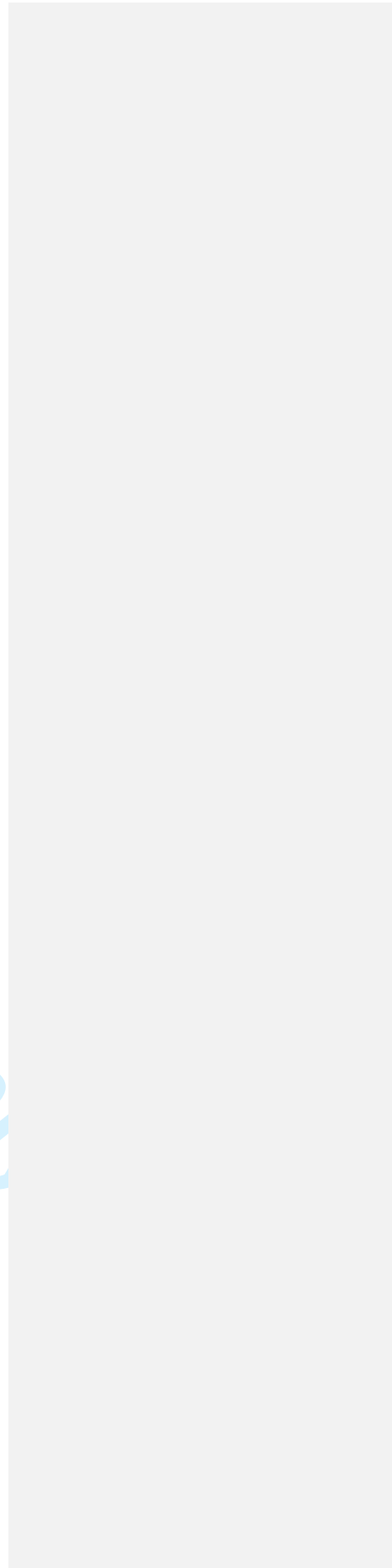
Figure 3. ~~Distribution~~Sequential change of ~~disease distribution of~~ patients hospitalized for respiratory disease after the Great East Japan earthquake from March 11 to May 9 in 2011, presented in 10 day bins.

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.

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1
2
3

For peer review only



1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

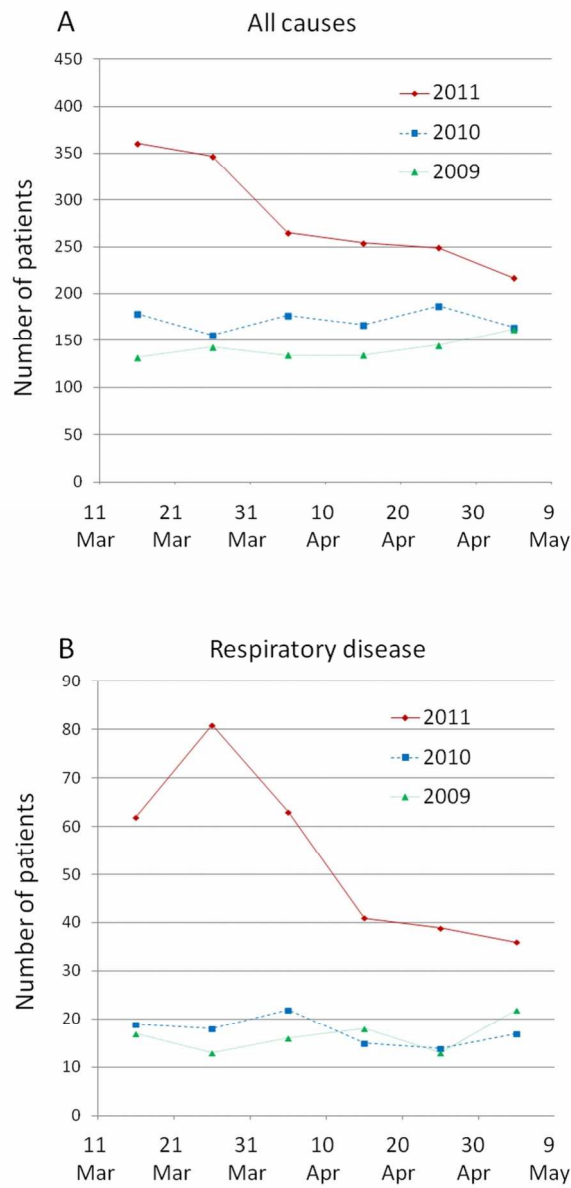


Figure 1. The number of unscheduled new hospitalizations for all causes (A) and for respiratory disease (B) from March 11 to May 9 in 2009, 2010 and 2011, presented in 10 day bins.
90x184mm (300 x 300 DPI)

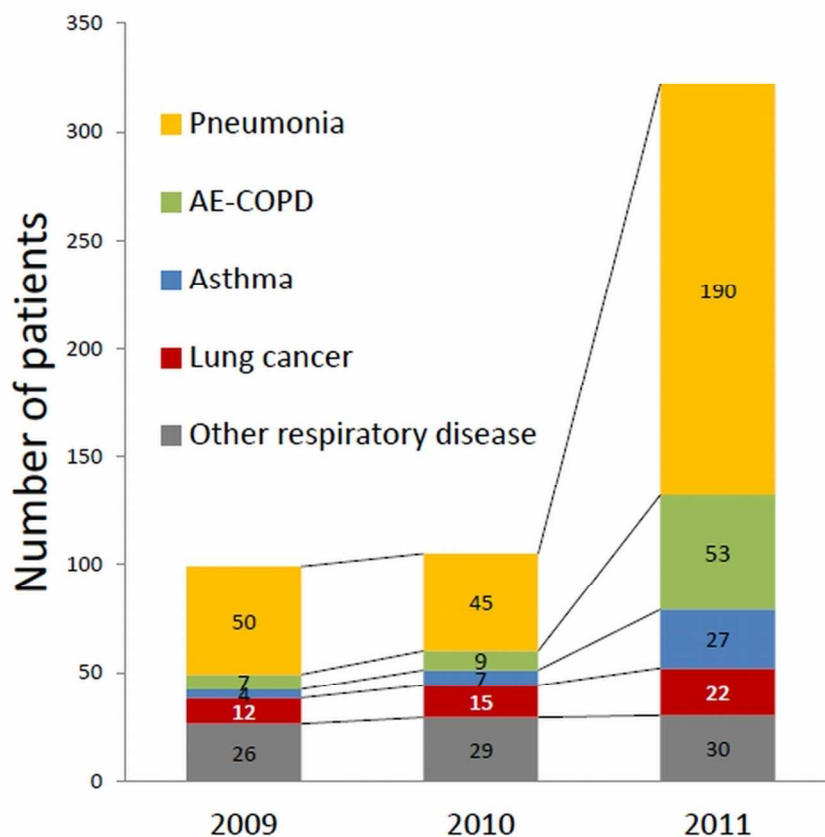


Figure 2. The number and proportion of patients hospitalized for respiratory disease pooled from March 11 to May 9 in 2009, 2010, and 2011.
99x90mm (300 x 300 DPI)

only

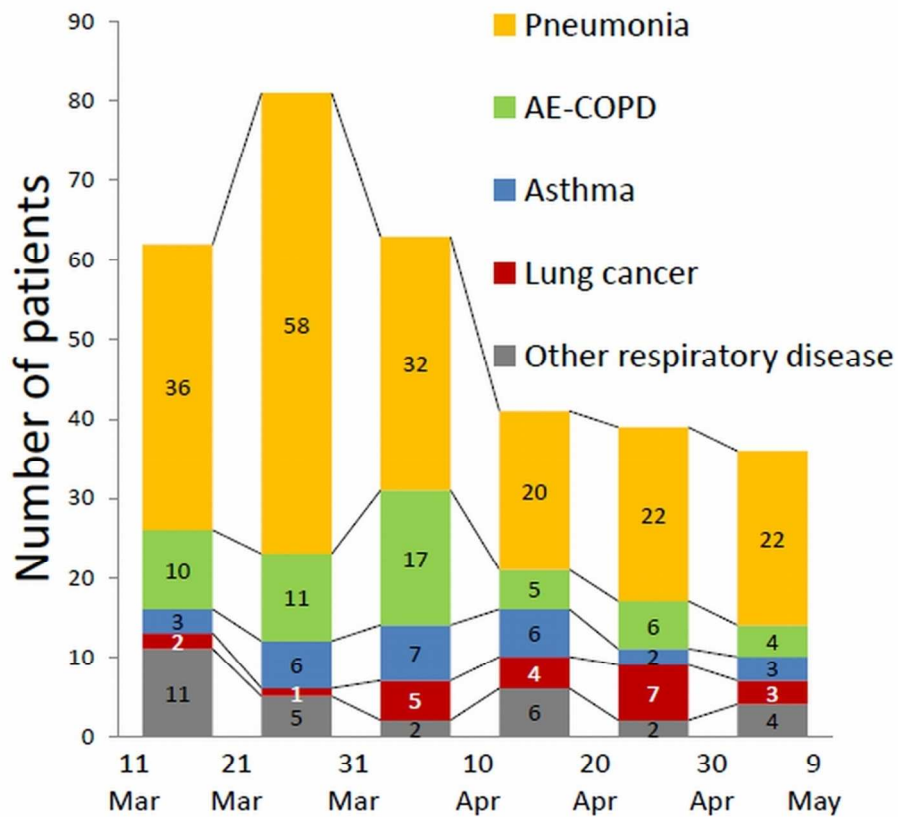


Figure 3. Distribution of patients hospitalized for respiratory disease after the Great East Japan earthquake from March 11 to May 9 in 2011, presented in 10 day bins.
99x90mm (300 x 300 DPI)

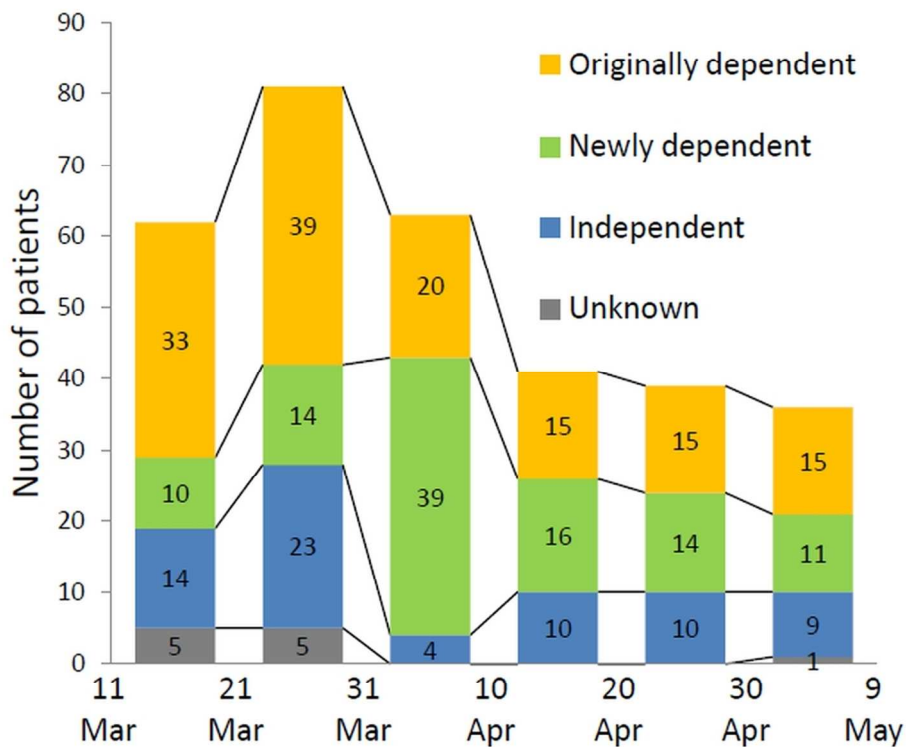


Figure 4. Influence of the disaster on ADL status and its deterioration in hospitalized patients for respiratory disease from March 11 to May 9 in 2011, presented in 10 day bins.
108x90mm (300 x 300 DPI)

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.