The Great East Japan Earthquake Disaster: a Compilation of Published Literature on Health Needs and Relief Activities, March 2011-September 2012

May 13, 2013 · Research article
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Ochi S, Murray V, Hodgson S. The Great East Japan Earthquake Disaster: a Compilation of Published Literature on Health Needs and Relief Activities, March 2011-September 2012. PLOS Currents Disasters. 2013 May 13 [last modified: 2013 May 14]. Edition 1. doi: 10.1371/currents.dis.771beae7d8f41c31cd91e765678c005d.

Abstract
Objective
To provide an overview of the health needs following the Great East Japan Earthquake Disaster and the lessons identified.

Methods
The relevant of peer review and grey literature articles in English and Japanese, and books in Japanese, published from March 2011 to September 2012 were searched. Medline, Embase, PsycINFO, and HMIC were searched for journal articles in English, CiNii for those in Japanese, and Amazon.co.jp. for books. Descriptions of the health needs at the time of the disaster were identified using search terms and relevant articles were reviewed.

Findings
85 English articles, 246 Japanese articles and 13 books were identified, the majority of which were experience/activity reports. Regarding health care needs, chronic conditions such as hypertension and diabetes were reported to be the greatest burden from the early stages of the disaster. Loss of medication and medical records appeared to worsen the situation. Many sub-acute symptoms were attributed to the contaminated sludge of the tsunamis and the poor living environment at the evacuation centres. Particularly vulnerable groups were identified as the elderly, those with mental health illnesses and the disabled. Although the response of the rescue activities was prompt, it sometimes failed to meet the on-site needs due to the lack of communication and coordination.

Conclusion
The lessons identified from this mega-disaster highlighted the specific health needs of the vulnerable populations, particularly the elderly and those with non-communicable diseases. Further research is needed so that the lessons identified can be incorporated into future contingency plans in Japan and elsewhere.

Funding Statement
The authors report no source of funding to support the work on this manuscript.

Introduction

Effective disaster preparedness can be achieved by taking a comprehensive and panoramic view of a disaster. So far no paper has reviewed an overall health impact neither from an urban disaster nor from an earthquake.

The Great East Japan Earthquake Disaster (GEJED) in 2011 was one of the greatest natural disasters that occurred in modern society. An earthquake with a magnitude 9.0 on the Richter scale and the subsequent five to six tsunamis, reaching up to 38 m from sea level and flooded 561 km$^2$ of the coastal area, killed more than 15,000 people in Japan.\(^1\) The GEJED was different from past earthquakes in many ways. Firstly, the unprecedented size of both the earthquake and the associated tsunamis were beyond the scope of even the most recent regulatory and operational projections. For example, the Fukushima Nuclear Power Plant to were prepared for an earthquake with magnitude 7.6,\(^5\) which turned out to be insufficient in this case. Secondly, this disaster had the distinct features of an urban disaster, typified by extensive power and water supply failures. Thirdly, recovery of infrastructure took much longer than anticipated in the current disaster management platform in Japan.\(^3\) Finally, the areas most affected were cities with a predominantly elderly population (30% above 60 years-old).\(^1\)

The aim of this research is to understand what happens when a mega-disaster hit modern society. To achieve this objective, this paper reviews the available peer reviewed and ‘grey literature’ publications between March 2011 and September 2012, and summarises the health impacts at the time of the GEJED. Although the effect of the earthquake and the tsunamis impacted on the accident at the Fukushima-Daiichi nuclear power plant, this is specifically excluded in this literature review. This is because the health needs and health impacts related to the radiation exposure is very different from those related to the earthquake and tsunamis.

Methods

Publicly available information written in English or Japanese was obtained from the following sources. The relevant literature was analysed and descriptions of the health needs and relief activities at the time of the GEJED were identified. As stated above, because health needs/impact related to radiation exposure is different from earthquake and tsunamis, articles mainly focus on nuclear issues were excluded in this review.

Identification

1) Academic and ‘grey literature’ English journals

The key health journal databases (Medline, Embase, PsycINFO, and Health Management Information Consortium (HMIC)) were searched via OvidSP. As many different names are used for the GEJED in English articles, the keywords used were ‘earthquake’ [AND] ‘Japan’ [AND] ‘health’ in all fields; ‘earthquake’ [AND] ‘Japan’ [AND] ‘hospital’ in all fields; or ‘earthquake’ [AND] ‘Japan’ [AND] ‘medicine’ in all fields.

2) Academic and ‘grey literature’ journals and books in Japanese

The literatures written in Japanese are often searchable in Japanese words. Therefore, the review was conducted on the database provided by the National Diet Library in Japan (CiNii), using search term ‘東日本大震災 (GEJED)’ [AND] ‘病院 (Hospital)’; or ‘東日本大震災 (GEJED)’ [AND] ‘医療 (Healthcare)’. Amazon.co.jp was searched for the books published in Japan from March 2011 to September 2012. The search term used were: ‘東日本大震災 (GEJED)’ [AND] ‘病院 (Hospital)’; or ‘東日本大震災 (GEJED)’ [AND] ‘医療 (Healthcare)’. Books that write about hospitals, healthcare, and hospital staff in the time of the GEJED were obtained.
Eligibility criteria

1) Inclusion criteria
Articles were included in the review if they were: (i) written either in English or in Japanese; (ii) published from March 2011 to September 2012, and (iii) describing the experiences and interviews of rescue teams, on-site health needs, or the prevalence or characteristics of specific diseases, at the time of the GEJED.

2) Exclusion criteria
Articles and papers were excluded if they were: (i) the bulletins from universities or private organisations; (ii) abstracts for conferences or lectures; (iii) about clinical interventions or basic science; and (iv) only on the radiation exposure or explosion of nuclear power plant.

Results
Figure 1 describes the search strategy. The literature search was conducted in September 2012. 85 articles in English, and 246 articles and 13 books in Japanese, were eligible for inclusion in the review (Appendix 1). The 85 English and the Japanese journal articles were categorised according to types and topics, with some articles addressing more than one. With respect to article types (Fig.2A), for the journals in Japanese, the majority were about the experiences in providing relief activities. The epidemiological research and case reports represent about a third of the articles in English but a lower proportion of the articles in Japanese. As for topics (Fig.2B), many of the English literature wrote on psychiatric care and specific diseases, while disaster medicine was the major topic in Japanese articles.
Patients’ needs

Patients’ needs were assessed by the chronology of health impacts, chronic disease, vulnerability and other issues.

Chronology

The chronology of impacts are described by the documented effects within 24 hours, 2-10 days, 10-30 days, and more than 30 days. Table 1 summarises the changes in the patients’ needs over time.
In Ishinomaki City, the patients with chronic pulmonary failure were especially vulnerable to these infections, which may have contributed to a large number of shelter-acquired pneumonia (SAP).

At this time it was found that respiratory tract diseases spread both in hospitals and an evacuation centre in Miyako City. The sludge from the tsunami was found to be highly contaminated with chemical and bacteria, which may have contributed to a large number of shelter-acquired pneumonia (SAP) and allergic reactions.

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### Table 1. Chronology of the major health impacts.

| Days from the disaster | Main healthcare issue |
|------------------------|-----------------------|
| **Within 24 hours**    | Few injuries**4**     |
| **2-10 days**          | Hypothermia**4-5** Endogenous diseases**4** Burning**4** ‘Tsunami-lung’**5** Psychiatric shock**4** Cardio-pulmonary arrest (CPA)**6** Coronary syndrome**6** Cerebro-vascular diseases**7** ‘drug-refugees’**25** |
| **10-30 days**         | Respiratory diseases**8-9-11** Gastritis**8-9** Pressure ulcers**39** Exacerbation of chronic conditions**24** Allergic reactions to tsunami debris**8** |
| **>30 days**           | Children with allergy**13** Musculoskeletal disease**2-17-38** Deep venous thrombosis (DVT) and pulmonary embolism**15-16** |
| **Throughout**         | Non-communicable diseases**24** (hypertension, diabetes, chronic renal failure, cancer, etc.) Pregnancy hypertension**4-8** Oxygen-dependent management**11-42** Insomnia**6** Skin-related disorders**18** |
| **Suspected**          | Mental health (depression, posttraumatic stress disorder (PTSD), and cognitive disorder among the elderly)**41** |

**<24 hours**

The number of patients seeking healthcare was relatively small on the actual day of the disaster. This can be explained by the fact that the majority of the victims were killed immediately after the earthquake with the injury to death ratio for the disaster being was remarkably low (0.372).**4**

**2-10 days**

The day after the disaster, the number of hospital admissions surged, though injuries remained fewer than anticipated. For example in the Ishinomaki Red-Cross Hospital, among the patients seen within 48 hours of the disaster, injury and crush syndrome represents only 22% of patients.**5** Instead, the medical teams were preoccupied with saving patients with chronic diseases. This hospital and the Iwate Medical University hospital reported that hypothermia and tsunami-lung (allergic reaction and pneumonia by immersion) were the main severe diseases that were treated.**5-6**

In the Tohoku University hospital, the incidence of acute coronary syndrome and cardio-pulmonary arrest (CPA) sharply increased.**7** Freezing temperature, stresses from evacuation and frequent aftershocks may have over-activated patients’ sympathetic nervous system, leading to hyper viscosity and hypertension. Additionally, the Ishinomaki Red-Cross hospital determined that the incidence rate of cerebro-vascular diseases also increased compared to the previous year.**8**

**10-30 days**

At this time it was found that respiratory tract diseases spread both in hospitals**9** and an evacuation centre in Miyako City.**10** The sludge from the tsunami was found to be highly contaminated with chemical and bacteria, which may have contributed to a large number of shelter-acquired pneumonia (SAP)**12** and allergic reactions.**8** In Ishinomaki City, the patients with chronic pulmonary failure were especially vulnerable to these infections.**13**
A month after the earthquake, deterioration of allergic conditions among children was reported by Miura et al.\textsuperscript{14} Poor hygienic status due to a very limited water supply,\textsuperscript{15} prolonged mental stress, and exposure to the allergen such as mites, the sludge from the tsunamis, and household pets at the evacuation centres, were the main cause of the deterioration.\textsuperscript{14} Among the adults, deep venous thrombosis (DVT) resulting from long-term immobility and dehydration was a concern at the evacuation centres. On-site screening rounds by university hospitals revealed high prevalence of DVT (10-25%),\textsuperscript{15, 16} especially in those who had received leg injuries.\textsuperscript{16} Living on the floor at the evacuation centres also worsened the trend.\textsuperscript{15} Chronic subdural hematoma (CSH) and unstable pelvic fractures after immersion were also reported by Numagami et al\textsuperscript{8} and Ishii.\textsuperscript{17}

Throughout the disaster period

An increase in non-fatal conditions was reported in some articles. For example, 15\% of the patients who visited temporary clinics had skin problems.\textsuperscript{19} Others noted an increase in muscle pain, constipation,\textsuperscript{18} insomnia, headache,\textsuperscript{7} and vision problems.\textsuperscript{20} As these patients often refrained from seeing doctors due to the lack of transportation infrastructure, the numbers might be underestimated.\textsuperscript{20}

Success in infection prevention

The poor hygienic status due to lack of water for hand-washing and the crowded living conditions raised concerns about outbreaks of highly contagious infections. Although sporadic cases of gastroenteritis, a case of measles in an otherwise healthy foreigner,\textsuperscript{8} several cases of tetanus,\textsuperscript{7} and increase in the latent tuberculosis due to the dysfunction of negative pressure rooms\textsuperscript{21} were reported, only one outbreak of influenza\textsuperscript{21} had been reported up to September 2012. This might be attributed to the vigorous public health efforts, including the Daily Surveillance for Outbreak Detection,\textsuperscript{23-24} which was a collaborative activity in a university hospital with infectious disease clinical consultation. This included infection control educational programmes and training and infection control interventions. When these were reported to the local government regions, it assisted in defining actions required against infectious diseases that were identified.

Non-communicable diseases

Most of the patients who visited temporary clinics presented with non-communicable diseases\textsuperscript{25} One reason was the aging profile of the population in the disaster area, many of whom had pre-existing diseases. Another reason was a huge number of ‘drug refugees’,\textsuperscript{26} people who had their medication and prescriptions washed away. Adding to this, living in the evacuation centres caused exacerbation of existing illnesses.

Hypertension

Hypertension including pregnancy hypertension\textsuperscript{9} was a significant problem within a few days of the disaster. In addition to the pre-existing disease, it is thought that activation of the sympathetic nervous system by frustration and disruption of circadian rhythm through poor sleep quality\textsuperscript{27} may have led to the poor blood pressure control.

Diabetes

Deterioration of glycaemic control in diabetes after the disaster was reported by Ogawa et al\textsuperscript{28} in part due to loss of medication, even though the average body mass index (BMI) decreased among non-insulin dependent diabetics. The deterioration was more significant when patients were affected by the tsunami, suggesting that psychological effects and loss of prescription were part of the reason for this poor outcome.

Problems in the supply of foods

For patients with hypertension, diabetes, and chronic renal failure usually on special diets, the enforced diet in the evacuation shelters which was high in sodium and potassium worsened their conditions.\textsuperscript{29} For the diabetic patients, taking drugs that may cause hypoglycaemia put patients at increased risk in situations where meals
were supplied at infrequent intervals. Children with food allergies also suffered with the lack of low-allergenic foods.\textsuperscript{14}

Problems with living environments

As Japanese people are used to sleeping on the floor, most of the evacuation centres were not equipped with beds. However, in crowded environment without heating systems, living on the floor increases the risks of hypothermia and muscle stiffness. These conditions may have contributed to the high prevalence of disuse syndrome, muscle weakness as a result of inactivity, which affected 30% of the evacuees\textsuperscript{3}

Psychological reactions

A huge disaster poses a concern about psychiatric disorders such as depression, post-traumatic stress disorder (PTSD), and cognitive disorder among the elderly. However, no articles so far report the actual incident rate of these illnesses in the disaster area, though an increase in the complaints of anxiety, irritation, and fatigue\textsuperscript{80} and a worsening in a psychological distress score\textsuperscript{31} were reported.

Vulnerable people

In a disaster, ‘a harvesting effect’, that is, a selective mortality among the frailest individuals\textsuperscript{32} often occurs. The government had set up guidelines on the provision of designated shelters for those in need of care\textsuperscript{33} However, in the GEJED, the number of the vulnerable far exceeded the capacity of these shelters. As a result, the care of these people became a serious issue in the disaster area.

The elderly

In the GEJED, many of the victims were those requiring health and social care. Among the healthcare facilities destroyed by the tsunamis, 40% were special elderly care nursing homes presumably because they had been located at areas at higher risk.\textsuperscript{34} Yoshioka\textsuperscript{35} reported that 316 people in social welfare facilities died with 178 people missing, two-thirds of whom were above 60. Other disabled elderly living alone were found deceased at home.\textsuperscript{36} Even for those who reached evacuation shelters, living on the floor without heating system\textsuperscript{37} seemed very difficult. For instance 85% of the tsunami-related pneumonia patients who needed hospitalisation were over 70, 45% of whom were from evacuation centres.\textsuperscript{38} Many of these patients had both prolonged swallowing reflex and low sensitivity to cough reflex,\textsuperscript{9-11} which are the risk factors of aspiration pneumonia. Secondary immobility also became a problem. Around 60% of the elderly in the shelters were reported to be suffering from disuse syndrome a month after the disaster.\textsuperscript{39} In the week following the earthquake, 7.7% of patients in one hospital developed severe pressure ulcers.\textsuperscript{40} Dementia, depression, and disquiet were also observed and the authors stated that this may have been due to an inability to adapt to changes in lifestyle\textsuperscript{39}

The mentally ill

Many hospitals with psychiatric care beds were severely affected: 3 hospitals collapsed and were destroyed and 5 were closed.\textsuperscript{41} The National Center of Neurology and Psychiatry (NCNP) promptly transported the inpatients out of the earthquake/tsunami damaged region. They also supplied drugs, provided information, and dispatched mental health care teams to the disaster struck area.\textsuperscript{41} However, many outpatients were left untreated because of loss of medical records, loss of patients’ family members who had cared for them, and the disruption of transportation.\textsuperscript{42} In some places, stigma attached to mental illness remained deeply rooted, which prevented patients in evacuation centres from seeking help.\textsuperscript{42}

Those with disabilities

Others who were often neglected were those with disabilities, who were found to be two times more at risk of losing their lives compared with healthy people.\textsuperscript{43} Those who needed home oxygen therapy\textsuperscript{12} and respirators\textsuperscript{43} suffered from the long-term disruption of power supply. In some areas, a registration system for those who
need relief in times of disaster had been established, but some of the staff in charge did not make contact with those who had registered, for unknown reason.44

Others

There were concerns about pregnant women, patients with cancer, and even overseas nationals living in the earthquake/tsunami region,39 but no reports so far have been made on the needs amongst these groups.

**Successes and future improvement in rescue activities**

The Disaster Medical Assistance Teams (DMATs), aimed at deploying medical rescue teams to a disaster area within 48 hours, were established in 2005, based on the lessons from the Great Hanshin-Awaji Earthquake (1995).3 Their response was prompt, and 15,000 professionals in total were dispatched to Tohoku area within 2 days of the quake.45 Other Japanese medical teams were also dispatched as rescue teams in the early stage of the disaster.

Even so, coordination between the local healthcare staff and the rescue teams was often reported to be poor.37 Lack of the communication tools due to power outages caused confusion in handovers between these teams, reducing the appropriate mobilisation of resources.38 Another problem was that most of the teams aimed at providing emergency care only for the first three days, even though there was a significant need for primary care and care for chronic conditions.24 The medical rescue teams' tasks were often limited: for example, they were not allowed to prescribe.46 Responding to this situation, the Japan Primary Care Association dispatched in total 678 staff to provide primary care without task limitations from March to September in 2011.47 So far this response has not had a published evaluation, but it is thought that the numbers of staff to support primary care may not have been sufficient.

**Discussion**

This is the first literature review of the health needs at the time of GEJED. To collect richer information on the needs among the vulnerable population, the ‘grey’ literature written in the local language (Japanese) were useful. However, few hard facts and figures were available in either language.

In addition, there were relatively small numbers of published articles focusing on building evidence-base knowledge on the impact of the GEJED. Both researchers and public health authorities should consider taking up the challenge of conducting retrospective research as well as prospective surveillance to obtain a more complete picture of the GEJED in order to prepare for future mega-disasters in Japan or other countries worldwide.

The greatest success in this disaster was the prompt reactions of the medical rescue teams. Even so, belated recognition of the health needs and health impacts were often reported. Above all, the most vulnerable were the least risk-assessed. As can be seen in Figure 2, only 27 out of 331 articles addressed issues about the vulnerable population including geriatric care and care for the disabled. This lack of recognition may have led to the underestimation of the size of these populations in contingency plans prior to the GEJED. Considering the increasing number of elderly and mentally ill, these people should be identified as a major target for relief activities. Therefore, to ‘develop systems of indicators of disaster risk and vulnerability...that will enable decision-makers to assess the impact of disasters’, as is stated in the Hyogo Framework of Action 2005-2015: Building the Resilience of nations and Communities,47 is strongly recommended.

The complexity of crisis management in this disaster posed the need for an assessment of health system capacity and public health emergency preparedness.8 It is strongly recommended that future plans should put more focus on collecting data both from within and outside of the health sector during, and in the recovery from, a disaster. A comprehensive guideline for this system-wide approach, such as the toolkit for assessing
health-systems capacity for crisis management by WHO Regional Office for Europe\textsuperscript{50,51} will be useful to share the knowledge with global and multi-disciplinary teams.

The proposed recommendations based on this literature review are listed in Box 1.
We gratefully acknowledge the support of Dr Masaru Sasaki, Director of Metropolitan Hiro-o Hospital, Tokyo.

**Acknowledgements**

We gratefully acknowledge the support of Dr Masaru Sasaki, Director of Metropolitan Hiro-o Hospital, Tokyo, Japan, Carla Stanke and Katie Carmichael of Health Protection Agency, and Mr Roy Clements at Imperial College London English Language Support Programme, for giving advice for this research and revising the paper.

**APPENDIX 1**

Box 1. Recommendations for future preparedness.

| Recommendations |
|-----------------|
| 1. Public health research after disasters frequently lack baseline data from before the event. Disease risk reduction for health needs requires baseline data and health system to provide information as for disaster preparedness, maintaining, analysis and eventual evaluation of the health impacts. |
| 2. Health needs of the vulnerable including the elderly and those with chronic conditions can predominate the health care needs after disaster. To enhance capacities for the most vulnerable populations, health impact data at the time of the disaster should be analysed with regard to the socio demographic background of the patients. |
| 3. Lack of shared information systems could have reduced cooperation between relief teams. For effective and timely disaster response, a robust data collection and dissemination system should be established so that the resources are appropriately allocated, even at times of power outages and water supply failures. |
| 4. Few scientific peer reviewed papers on health needs at the time of the disaster have been identified in this review. Public health researchers and authorities should be encouraged to take the initiative to fill gaps between academic knowledge and onsite needs at the time of disasters. |

**Limitations**

The articles in this literature review came from only a short time period of March 2011 to September 2012. Little objective data, such as epidemiological surveillance or studies, was found making the recognition of the full health impact difficult to assess. In addition, this review might have failed to establish needs of the so far undocumented minorities, such as the overseas nationals and those with rare diseases. It is recommended that in-depth surveillance and quantitative analysis are conducted to overcome these limitations.

**Conclusion**

This paper is the first literature review on the health needs and relief activities following the GEJED. It has demonstrated the huge array of peer review and grey literature already published on the health impacts of the GEJED in the Japanese and English literature. The review has identified a chronology of patients’ health needs from the immediate (i.e. within 24 hours) needs to those identified up to 30 days or longer. The range of needs identified included relatively little treatment for immediate crush injury or trauma, the tsunami-lung health impacts, SAP issues, DVT risks and the significant impact on non-communicable diseases including hypertension, diabetes, renal disease and mental health. However, concern about the need for a public health leading health systems approach has been identified because of the complexity of crisis preparedness.

Accumulation of experience, evaluation of the rescue activities, and the establishment of new contingency plans that fit the health needs, will be the key to more efficient and effective relief activities in the future.

**Competing interest**

The authors have declared that no competing interests exist.
Appendix 1. List of the referred literature

I. Journal articles written in English

(1) Japan Earthquake Linked to Blood Pressure Rise in CKD. Nephrology Times 2012 September;5(9):3.

(2) Mental health care and East Japan Great Earthquake. Psychiatry & Clinical Neurosciences 2011 April;65(3):207-212.

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