

# A Literature Review of Health Problems among Nuclear Power Disaster Evacuees: Common Conditions, Treatment, and Rehabilitation

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Residents living close to the Fukushima nuclear power plant were forced to evacuate because of the accident caused by the Great East Japan Earthquake on 11 March, 2011. Management of health problems among evacuees became a pressing need. The aim of this study was to identify conditions among evacuees in past disasters that would require rehabilitative care. Through literature searches, we identified deep-vein thrombosis (DVT) and disuse syndrome as potential targets for rehabilitation among evacuees. For both conditions, aggressive exercise therapy was recommended following the disaster. Rehabilitation specialists should also convey correct information to evacuees about radiation in order to reduce their uneasiness.

*Key words:* radiation exposure accident, evacuee, disuse syndrome, deep vein thrombosis (DVT), rehabilitation

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## 1. Introduction

We reviewed the literature on rehabilitation of patients with large-dose radiation exposure in nuclear accidents, such as the Tokai-mura JCO criticality accident, and considered the role of rehabilitation in radiation emergency medicine. The results highlighted the effects and importance of rehabilitation of severely exposed patients, focusing on radiodermatitis and respiratory management<sup>1,2)</sup>.

Residents living close to the Fukushima nuclear power plant were forced to evacuate because of the accident caused by the Great East Japan Earthquake on 11 March 2011. As

the evacuation continued, health problems manifested among evacuees, particularly the elderly<sup>3)</sup>. We believe that it is necessary to consider not only directly irradiated patients, but also the rehabilitation needs of evacuees who live close to nuclear power plants where such accidents have occurred. However, in a report about a previous accident at a nuclear power plant, no description of the rehabilitation care of evacuees was included<sup>3)</sup>.

The aim of this study was to consider the symptoms for which rehabilitation is required, as well as the timing of care and its effects, by reviewing reports of rehabilitation care offered to evacuees during past disasters.

## 2. Research procedures and results

### 2.1. Literature review for symptoms in past disasters

#### 1) Method of literature search

We conducted a literature search to find out symptoms that were common in evacuation centers during past

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**Table 1.** Results of literature searches for medical papers on subjects related to evacuation centers

Keywords	Database					
	Ichushi Web			PubMed		Google Scholar
	original article	review article	other	original article	review article	
#1 evacuation center + disaster	88	77	83	136	25	39700
#2 evacuation center + earthquake	32	37	33	14	2	16600

**Table 2.** Incidence of deep vein thrombosis (DVT) among evacuees and victims of past Japanese earthquakes

Earthquake	Subjects	No. of cases of DVT	Incidence of DVT
None	100000	12	0.012%
Niigata Chuetsu (2004)	67	12	17.9%
Noto Peninsula (2007)	198	21	10.6%
	207	16	7.7%
Niigataken Chuetsu-oki (2007)	995	49	4.9%
Iwate-Miyagi Nairiku (2008)	113	17	15.0%

disasters. Ichushi ver. 5 (Japan Central Review Medicine, <http://search.jamas.or.jp/>) and PubMed (<http://www.ncbi.nlm.nih.gov/sites/entrez?holding=ijphirlib>) were used as reference databases of Japanese literature and English literature, respectively. In addition, Google Scholar (<http://scholar.google.co.jp/schhp?hl=ja>) was used as a Japanese and English literature common reference database. The terms “evacuation center <and> disaster” and “evacuation center <and> earthquake” were used as keywords for the search. Ichushi ver. 5 was searched for articles from 1983 to 2010 inclusive.

## 2) Results of literature search

The results of the literature search are shown in table 1. One hundred sixty-one articles (136 original articles and 25 review articles) were found in PubMed using the search term “evacuation center <and> disaster”. Sixteen articles (14 original articles and 2 review articles) were found using the search term “evacuation center <and> earthquake”. In Ichushi, 248 articles (88 original articles, 77 review articles, and 83 other articles) were found using the search term “evacuation center <and> disaster”, and 102 articles (32 original articles, 37 review articles, and 33 other) were found using the search term “evacuation center <and> earthquake”. In Google Scholar, 39,700 articles were found using the search term “evacuation center <and> disaster” and 16,600 articles were found using the other search term of “evacuation center <and> earthquake”.

## 3) Symptoms commonly observed following a disaster

In the search results we identified common symptoms from the literature on past disasters. Injury, fracture, head trauma, crush syndrome, and burns were cited as acute-phase conditions occurring less than 3 days after a disaster<sup>4-7</sup>. These conditions were directly caused by the disaster. In the Great Hanshin Awaji Earthquake, most of the conditions in the acute phase were injuries that had occurred at home, and the majority of the dead were elderly

people. Furthermore, there was a high death rate associated with the acute phase. Aspiration pneumonitis (refugee pneumonia) and dehydration, influenza outbreaks, exacerbation of chronic diseases (for example, hypertension or diabetes), deep vein thrombosis (DVT), and disuse syndrome were cited as conditions that occurred in the sub-acute phase, between day 4 and week 3 following a disaster<sup>8-10</sup>. These conditions were caused by stress after the disaster and an inferior living environment and are known as “earthquake disaster-associated diseases”<sup>3</sup>. DVT, in particular, occurred at high rates in the disasters shown in table 2; this condition must be attended to rapidly, as it can easily progress to fatal diseases such as pulmonary embolism<sup>11-16</sup>. Deaths due to earthquake disaster-associated diseases are classified among “earthquake disaster-related deaths.” The deaths from the Great Hanshin Awaji Earthquake were estimated to number from several hundred to several thousand. These disease-related fatalities account for 1-20% of all fatalities in earthquake disasters<sup>9</sup>.

Health problems due to loneliness in temporary housing, stress reactions and being housebound in elderly people were cited as conditions that occurred during the chronic phase, less than 5 years following the first month after a disaster occurred<sup>9</sup>. The reason for these problems seemed to be the rapid increase in the relative age of populations in the evacuation centers because of the departure of younger evacuees for new places.

## 2.2. Literature review of rehabilitation provided during past disasters

### 1) Method of literature search

We conducted a literature search regarding rehabilitation care provided during past disasters. The only difference from the previously described search is that we added the keyword “rehabilitation” to the search terms.

### 2) Results of literature search

**Table 3.** Results of literature searches for rehabilitation in evacuation centers

Keywords	Database						
	Ichushi Web			PubMed		Google Scholar	
	original article	review article	other	original article	review article		
#3	evacuation center + disaster + rehabilitation	6	6	6	5	0	8650
#4	evacuation center + earthquake + rehabilitation	2	3	4	1	0	4310

The results of this literature search are shown in table 3. Five articles (5 original articles and 0 review articles) were identified using the PubMed search using the search term “evacuation center <and> disaster <and> rehabilitation”. The alternative search term “evacuation center <and> earthquake <and> rehabilitation” produced 1 article.

In Ichushi, 18 articles (6 original articles, 6 review articles, and 6 other) were found using the search term “evacuation center <and> disaster <and> rehabilitation”, and 9 articles were found using the alternative search term “evacuation center <and> earthquake <and> rehabilitation”. In Google Scholar, 8650 articles were found using the search term “evacuation center <and> disaster <and> rehabilitation,” and 4310 articles were found using the alternative search term of “evacuation center <and> earthquake <and> rehabilitation”.

### 3) Characteristics of rehabilitation provided in past disasters

From the literature reports that we identified in this second search, we extracted information concerning rehabilitation care given during past disasters. Rehabilitation during past disasters was started within 3 or 4 weeks following the disaster (sub-acute phase)<sup>15-17</sup>. We found no evidence that rehabilitation had been provided for stressed or housebound elderly individuals in evacuation centers during the chronic phase.

DVT and disuse syndrome were cited as conditions targeted for treatment during rehabilitation following disasters<sup>15-17</sup>. For these conditions, prophylactic exercise therapy was chosen and was achieved by using group exercises. Healthcare professionals alluded to other earthquake disaster-associated diseases, but there was no intervention in terms of rehabilitation<sup>10</sup>.

## 3. Discussion

### 3.1. Timing of rehabilitation interventions based on phase

During disasters, demand for medical care changes. Saving lives is the top priority during the acute phase, and rehabilitation is considered most relevant during the sub-acute phase. During this phase, evacuees experience both severe mental and physical stress, such as anxiety about the disaster and their future lives in the evacuation center. Moreover, exacerbations of chronic disease are caused by treatment interruptions resulting from shortages of medical supplies<sup>10</sup>. Stress enhances sympathetic activity and induces thrombogenesis. Furthermore, the evacuees are

often forced to withhold voiding, because disruption of the water supply at the evacuation center may mean that flushing toilets are unavailable. Consequently, intravascular dehydration due to lack of fluid intake can bring about thrombogenesis. Therefore, clinicians should pay particular attention to DVT during this phase<sup>18, 19</sup>.

Additionally, the small amount of space available per person in evacuation centers leads to inactivity among evacuees. It is well recognized that treatment and management of disease and injury occurring in disasters are important and should be noted<sup>4-6</sup>.

However, simply dealing with daily inactivity is not enough. Once elderly people fall into inactivity, their muscle strength and joint range of motion decrease<sup>3</sup>. In some elderly people, just the change in living environment leads to disuse syndrome, regardless of the presence of disease or injury. Therefore, both DVT and disuse syndrome must be considered during the sub-acute phase. There has been little experience with rehabilitation in the chronic phase. However, we expect that being housebound triggers disuse syndrome in elderly people, and persistent stress triggers depression. Furthermore, as the numbers of evacuees staying in each center decline, there may be fewer people in close contact with the elderly, and any deterioration in their health may be less likely to be picked up<sup>9</sup>. Therefore, rehabilitation in the chronic phase likely needs to focus on disuse syndrome and mental health.

### 3.2. Importance of rehabilitation for DVT

Initiation of rehabilitation for DVT has been shown to be important in the sub-acute phase<sup>15-17</sup>. DVT is a clinical condition caused by the interruption of venous return, with congestion, by thrombotic occlusion in the deep veins of the leg. DVT can be associated with life-threatening conditions such as thromboembolism<sup>20</sup>.

In one guideline for the diagnosis, treatment, and prevention of pulmonary thromboembolism and DVT, aging and prolonged immobility are classified as being of intermediate risk among the additional risk factors for venous thromboembolism<sup>20</sup>. A major cause of DVT in the elderly who live in evacuation centers seems to be a decline in activity in an unfamiliar environment, as well as being in cramped positions for long periods of time. In the Niigata Chuetsu earthquake of 23 October 2004, among the evacuees there were more than 10 patients who were compelled to live in their cars and developed pulmonary thromboembolism; at least four of these patients died<sup>11</sup>.

These deaths seemed to be associated with prolonged uncomfortable posture and lack of fluid intake.

The most important strategy for DVT is prevention. Preventive measures for DVT include medication and rehabilitation<sup>20)</sup>. As supplies at the disaster site are likely to be insufficient, rehabilitation is regarded as the most effective prevention measure, and early intervention is necessary and possible. Preventive measures available for DVT include active exercise, walking, massage, and elastic stockings<sup>12, 20)</sup>. In particular, ankle dorsiflexion exercises seem to be effective in producing pumping action of the muscles and improvement of venous return in the leg<sup>21)</sup>; such exercises can be easily done in an evacuation center.

However, thrombotic isolation and pulmonary thromboembolism can in some cases be promoted by leg exercise and compression with elastic stockings. Therefore, assessment for DVT and cooperation with medical staff are required for the rehabilitation of evacuees.

### 3.3. Importance of rehabilitation for preventing disuse syndrome

Disuse syndrome is a general term for various types of mental and physical functional decline caused by prolonged inactivity<sup>22)</sup>. Among evacuees in evacuation centers, it is thought that an inactivity is a main cause of disuse syndrome.

A decrease in activity at evacuation centers triggers disuse syndrome, which leads to a decline in activities of daily living (ADL) and prolonged periods of bed rest. Decreased ADL and prolonged bed rest lead to further decline of activity, and a vicious cycle is eventually created. To break this cycle, it is necessary to encourage evacuees to stay out of bed and perform active exercise of the lower extremities as part of their rehabilitation. Exercise therapy is effective for improving muscle strength and joint range of motion. Exercise of the lower limbs promotes circulation of the blood and becomes especially important in maintaining the ability to walk<sup>23)</sup>. Therefore, an exercise program should be instituted early after the disaster.

When evacuees engage in less than 20% of maximum muscle contraction activity for a long time, disuse syndrome occurs<sup>24)</sup>. Because regular activity is important in preventing disuse syndrome, rehabilitation intervention may need to include changes to the living environment. Many evacuation centers and temporary housings do not have handrails and may include many steps<sup>25, 26)</sup>.

Installing handrails and ramps may produce an environment in which elderly people can easily become more active; this may lead to improvements in activity levels.

### 3.4. Specific considerations in nuclear power disasters

In cases in which a nuclear accident occurs in conjunction with a natural disaster, as was the case at Fukushima, evacuees experience anxiety, including uncertainty about when they can return home and fear of invisible radioactive material. This trend emerges strongly among parents with small children and among pregnant women<sup>27)</sup>. Rehabilitation

personnel should give evacuees accurate information about radiation risk to help manage their anxiety.

## 4. Conclusion

Our study reviewed the available literature to assess targets for rehabilitation care and the effect of this care, as determined from experiences in past disasters. The results of our literature review indicated that the main periods for rehabilitation care are from 4 days to less than 3 weeks (sub-acute phase) and from 4 weeks to 5 years (chronic phase) after a disaster occurs. In the sub-acute phase, exercise therapy using group exercises for prophylaxis of DVT and disuse syndrome is important. In the chronic phase, prevention of disuse syndrome and care of mental health through periodic visits by healthcare workers to temporary housing are necessary. In cases where a nuclear accident occurs in conjunction with a natural disaster, as was the case at Fukushima, evacuees are likely to harbor fears of invisible radioactive material. Rehabilitation specialists should convey correct information to evacuees concerning radiation risks in order to reduce their uneasiness.

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