

INDIRECT DISASTER-RELATED DEATH ASSOCIATED WITH COGNITIVE DECLINE AMONG OLDER PEOPLE FOLLOWING EVACUATION DURING A RADIATION DISASTER: A CASE REPORT

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List of Abbreviations

GEJE : Great East Japan Earthquake

FDNPP : Fukushima Daiichi Nuclear Power Plant

ABSTRACT

Introduction: During disasters, older adults are vulnerable to indirect health effects caused by evacuation-related environmental changes. Despite existing reports of depression and cognitive decline in this population, detailed case-based analyses during prolonged evacuations following radiation disasters remain limited. **Objective:** This case study aims to examine the impact of evacuation on cognitive function and subsequent health decline in an older adult. **Methods:** We analyzed medical records, evacuation documents, and semi-structured interviews with the bereaved family. These sources were integrated and chronologically organized to assess the health impact of prolonged displacement. **Results:** An 88-year-old man, evacuated following the Fukushima Daiichi Nuclear Power Plant accident, experienced initial delirium, a temporary recovery upon returning home, and a relapse upon re-evacuation. Continuous

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displacement and repeated environmental changes led to progressive cognitive and physical decline, ultimately resulting in a disaster-related death. **Conclusions:** This case illustrates that evacuation during disasters can have serious impacts on the cognitive function and overall health of older adults. In particular, older individuals who are at risk of cognitive decline should be promptly relocated to evacuation sites where they can receive immediate and continuous medical and social support. Such measures are essential for mitigating health risks among older populations in future disasters.

Keywords: Disaster-Related Deaths; Older People; Evacuation; Dementia; Social Capital

INTRODUCTION

Disasters can cause both direct effects, such as injury or drowning from earthquakes and tsunamis, and indirect effects, such as secondary health impacts resulting from environmental changes due to evacuation. Indirect effects may include the collapse of communities, the onset and worsening of non-communicable diseases (1, 2) due to changes in living environments, and increased mental stress (3), which may lead to disaster-related deaths. Several factors such as old or young age, disability, pregnancy, and communication difficulties due to language or cultural difference can make individuals more susceptible to these various health risks. The development of disaster response strategies to protect these groups is therefore an urgent public health issue.

Addressing the needs of older people during disasters is a pressing issue, especially in societies with aging populations. In particular, addressing cognitive decline is important for disaster responses directed at older populations. Cognitive decline among older people has been reported in natural disasters such as Hurricanes Katrina and Rita (4) and in floods (5) in Japan. Changes in the living environment owing to evacuation or community changes can trigger delirium, which is associated with the onset and worsening of dementia (6, 7). The World Health Organization predicts that approximately 78 million people worldwide will have dementia by 2030 (8). As of September 2023, the aging rate in Japan (the percentage of the population aged ≥ 65 years) is 29.1% (9). In 2012, the number of patients with dementia was approximately 4.6 million, representing 15% of the older population (10). This number is expected to rise to 4.71 million by 2025 and 5.84 million by 2040 (11). Therefore, addressing disaster-associated cognitive decline is becoming increasingly critical (12), whereas it was

higher at 24.9% in the affected Fukushima Prefecture (13), aggravating the health challenges and responses of affected older people during this disaster. Reports have indicated several negative health impacts related to evacuation (14-16) , including depression, post-traumatic stress disorder (17) , and cognitive decline (18, 19) among older people affected by the disaster. However, detailed reports on cognitive decline and related health impacts among older people during prolonged evacuations necessitated by radiation disasters remain insufficient.

In this study, we present the case of an 88-year-old man who was forced to evacuate after the FDNPP accident. Changes in his living environment due to evacuation triggered delirium. Although his condition initially improved when he returned home, his delirium relapsed following a subsequent re-evacuation. Ultimately, he developed dementia, which led to his death. This case highlights the impact of disaster evacuation on the cognitive functions of older people and the need for measures to mitigate the effects on those vulnerable to disasters. Insights from this case can be valuable for reducing the adverse effects of evacuation on older adults in future disasters.

CASE PRESENTATION

The case details were acquired from medical records, principal evacuation application documents, and interviews with the bereaved family. First, we used the medical charts and evacuation application documents provided by the bereaved family to chronologically organize the man's evacuation process and changes in his health status, thereby systematically comprehending the course of events. Next, semi-structured interviews were conducted with the bereaved family (his wife, son, and daughter) by the authors CY, TS, and KF. The interviews evaluated details regarding the man's daily routine and health status before the disaster, the circumstances and his reactions during the evacuation, and his condition throughout the evacuation period. Finally, we integrated the medical charts, evacuation application documents, and testimonies from the bereaved family, organizing the information chronologically. This enabled us to analyze the changes in his condition over time and the impact of environmental changes on his health status and cognitive function.

Namie Town

As a result of the FDNPP accident, residents of Namie Town and other surrounding municipalities in Fukushima Prefecture were forced to evacuate. Namie Town is located approximately 4 to 30 km from the FDNPP. At the time of the accident, the town had a population of approximately 21,500, with around 1,400 of those people residing in the Tsushima District (20). Following the accident, the entire town was designated as a “difficult-to-return” zone, and a complete evacuation was mandated.

After the earthquake and tsunami that struck on March 11, the Namie Town Disaster Response Headquarters issued evacuation orders on March 12 for residents within 10 km and 20 km of the FDNPP, based on national directives. As a result, residents outside of these designated evacuation zones were instructed to relocate to shelters within the Tsushima District. Then, after the hydrogen explosion at Reactor Unit 3 of the FDNPP on March 14, the town government decided on March 15 to evacuate to Nihonmatsu City, Fukushima Prefecture. With this town-wide evacuation decision, some residents also independently evacuated to various parts of the country (20) (Table 1).

Table 1. Evacuation Orders and the Evacuation Process of Namie Town Following the 2011 Great East Japan Earthquake

Day	Time	Command Source	Events
3.11	14:46	<i>Great East Japan Earthquake</i>	
	19:03	<i>Declaration of a nuclear emergency at Fukushima Daiichi Nuclear Power Plant</i>	
	20:50	Fukushima Prefecture	F1: Evacuation orders within a 2-km radius
	21:23	National Government	F1: Evacuation orders within a 3-km radius F1: Shelter-in-place orders within a 10-km radius
3.12	5:44	National Government	F1: Evacuation orders within a 10-km radius
	6:07	Namie Town	F1: Discussions on evacuation beyond a 10-km radius
	7:45	<i>Declaration of nuclear emergency at Fukushima Daini Nuclear Power Plant</i>	
		National Government	F2: Evacuation orders within a 3-km radius
		National Government	F2: Evacuation orders within a 10-km radius
	8:40	Namie Town	Evacuation using three buses to relocate from each shelter to shelters outside the 10-km radius of F1
	11:10	Namie Town	Most Namie Town residents relocated beyond the 10-km radius of F1
	13:00	Namie Town	Decision to relocate disaster response headquarters to the Tsushima Branch Office
	17:39	National Government	F2: Evacuation orders within a 10-km radius

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	18:00	Namie Town	Relocation of the disaster response headquarters to the Tsushima District
	18:25	National Government Namie Town	F2: Evacuation orders within a 20-km radius Evacuation expansion due to TV reports: evacuation of residents eastward from Hirusone District to Tsushima District; evacuating residents to Tsushima District (evacuation orders not yet confirmed by Namie Town)
3.13	4:00	Namie Town	Discussion on evacuation to areas beyond the 20-km radius of F1 Request for support from the self-defense forces for evacuees
3.14	11:01	<i>Hydrogen explosion at Fukushima Daiichi nuclear power plant unit 3</i>	
3.15	4:30	Namie town	Evacuation orders and relocation beyond the 20-km radius of F1: decision to evacuate to Nihonmatsu City
	11:00	National Government	F1: Shelter-in-place orders within the 20–30-km radius
	10:00	Namie town	Evacuation order issued by the town mayor for all areas beyond the 20km radius of F1
	13:00	Namie town	Self-evacuation begins with private vehicles Sequential relocation via town-arranged buses and other means Disaster Response Headquarters was established at the Towa Branch Office of the Nihonmatsu City Hall

Note: Fukushima Daiichi Nuclear Power Plant (F1), Fukushima Daini Nuclear Power Plant (F2)

Source: Namie Town., 2020 and 2023

Case

An 88-year-old man lived with his wife in the Tsushima district of Namie Town, Fukushima Prefecture, where they cultivated crops on their farm. Their daughter and son lived approximately 30 min away by car and visited occasionally. The patient had a history of cardiovascular disease requiring hospitalization and underwent dermatological consultations in 2005. Since 2009, he had exhibited signs of memory loss, though his daily life remained unaffected.

Following the FDNPP accident, he was evacuated on March 15, 2011 to his daughter's father-in-law's house in Utsunomiya City, Tochigi Prefecture (Figure 1). After the evacuation, he demonstrated disorientation and agitation, attempting to open furniture as if still in his own home, wandering, and repeatedly expressing a desire to return to Tsushima. Around March 27, he and his wife independently returned to Tsushima using buses, trains, and taxis, despite the area still being designated a difficult-to-return zone. His cognitive condition improved notably

upon resuming his pre-disaster lifestyle, including farming. His family visited every 1 to 2 weeks, encouraging re-evacuation, which he consistently declined.

On June 6, 2011, after persuasion by local authorities, he moved to temporary housing in Koori Town, where some former neighbors also resided. There, he repeatedly asked how he could return to Tsushima and showed increased forgetfulness. He was diagnosed with Alzheimer's disease on June 10. He exhibited repetitive behaviors, such as cutting newspapers and placing the clippings into garbage bags. The noise and activity of the temporary housing environment contributed to persistent irritability.

In January 2012, he began wandering at night. In September, he and his wife began attending day services. A critical turning point occurred in October when his wife was hospitalized for a transient ischemic attack. The following day, he became distressed and began searching for her. For safety, he temporarily entered a special nursing home and later transitioned with his wife to a long-term care facility in November 2012 and January 2013, respectively. However, his wandering behavior persisted, and he continued to ask when he could return to Tsushima. Due to residency limits, they moved again in February 2013 to a private nursing home.

Even in the new facility, he frequently asked, "How long will it take to get to Tsushima?" He showed signs of emotional instability and verbal aggression. By June, he had become largely unresponsive to verbal cues, required a wheelchair, and displayed significant mobility decline. In July, he developed bilateral leg edema and was hospitalized with a diagnosis of heart failure. He was later referred to another hospital, where multiple chronic cardiac and respiratory conditions were identified. After discharge, he returned to the nursing home.

His physical condition continued to deteriorate. In August, he developed sacral pressure ulcers, and by September, he required full assistance with toileting and other activities of daily living. His verbal responsiveness declined markedly. In November, he was hospitalized again owing to infection of the pressure ulcers and pyelonephritis. In February 2014, paralytic ileus worsened his condition, followed by severe pneumonia in March. He died on March 18, 2014 (Table 2).

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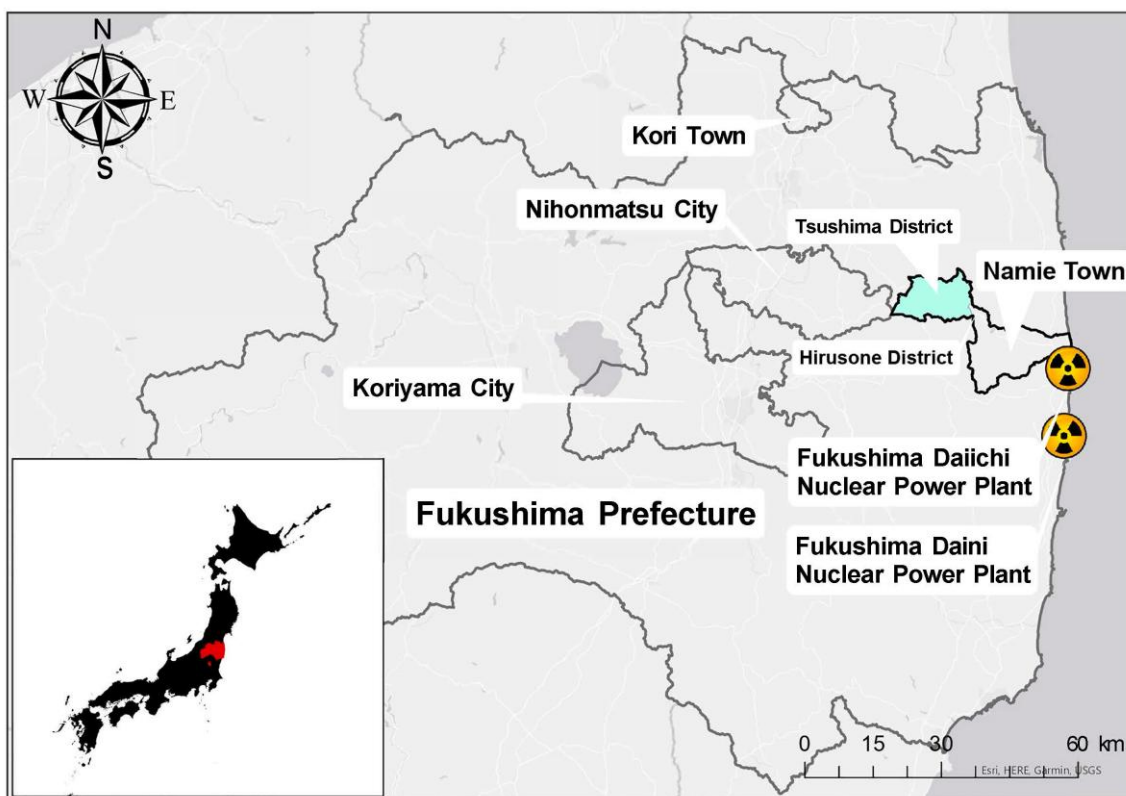


Figure 1. Tsushima, Namie Town, Fukushima Prefecture, and the Evacuation Destination Areas

Source: Arc GIS., 2024

Table 2. Timeline of Case

Date	Event	Individual's Condition
2011/03/15	Evacuated to daughter's father-in-law's home in Tochigi Prefecture following evacuation order	Showed signs of mental instability such as wandering and saying 'I want to return home'
2011/03/27	Returned to home in Namie with wife using bus and taxi	Remained in the home located in a restricted area
2011/04/10	Improvement in cognitive function	Resumed planting and farming around the home
2011/06/06	Re-evacuated to temporary housing in Koori Town, Fukushima Prefecture, due to persuasion from local government	Frequent strong desire to return to Namie, forgetfulness, mental instability
2011/06/10	Diagnosed with Alzheimer's disease	Expressed desire to return home; irritation at surrounding noise
2012/01/01	Nighttime wandering	

2012/10/25	His wife hospitalized	Behavioral and verbal changes: searched area, unable to recognize his wife's location
2012/11/01	Admitted to nursing home with his wife	
2013/02/01	Readmitted to a nursing home	Frequent requests to return home; emotionally unstable, including verbal aggression
2013/06/01	Reduced response to verbal cues	Became wheelchair-bound
2013/07/12	Hospitalized for heart failure due to leg edema	
2013/08/01	Re-entered nursing home	A decline in physical function, developed pressure ulcer on buttocks
2013/09/01	Significant decline in mobility by wheelchair	Full assistance required for toileting; reduced verbal communication and loss of vitality
2013/11/01	Hospitalized again	Repeated fevers due to ulcer infection and pyelonephritis
2014/03/01	Contracted evere pneumonia	Death

Source: The medical records, principal evacuation application documents, and interviews with the bereaved family., 2024

DISCUSSION

This case illustrates the impact of evacuation-based environmental changes on cognitive function in one older patient following the FDNPP accident, which led to the onset of dementia and associated health effects. After experiencing changes in his living environment due to the evacuation, the patient developed delirium, which later progressed to dementia. Additionally, he experienced a decline in physical function due to reduced activity levels and various conditions, such as heart failure, pressure ulcers, and infections, which led to a deterioration in his overall health and death approximately 3 years later. This case emphasizes the importance of support measures for vulnerable populations during such events.

Repeated Environmental Changes—Dementia and Overall Health Deterioration

This case illustrates how environmental changes due to evacuation following the FDNPP accident affected cognitive function in an older man. The patient developed delirium after the initial evacuation and showed temporary improvement upon returning home, but subsequently experienced a relapse in delirium after re-evacuation which progressed to dementia. The loss

of daily routines and familiar surroundings likely contributed to his cognitive decline. Previous studies have reported that stress resulting from evacuation and environmental changes is associated with worsening dementia in older adults (18, 21, 22). The loss of physical activity and social interaction in temporary housing has also been identified as a contributing factor (23).

Although depression and post-traumatic stress disorder have been reported in other studies as psychological impacts after disasters (17, 24), such symptoms were not confirmed in this case based on medical records or interviews with the family. However, the patient's behavioral changes such as repetitive actions, wandering, and verbal aggression suggest ongoing cognitive and emotional deterioration. An increase in the number of dementia patients was reported following the GEJE and the FDNPP accident (25), indicating the significant impact of disaster-related environmental stressors on cognitive function.

Furthermore, repeated evacuation and changes in living environments after the disaster led to a cascade of health problems and deterioration in the patient's overall condition. Even after being diagnosed with dementia, the patient continued to express a strong desire to return home and exhibited emotionally unstable behavior. As his physical function declined, he developed heart failure, pressure ulcers, and infections, and ultimately died of pneumonia. This course of deterioration is consistent with previous findings that long-term and repeated evacuations related to the FDNPP accident impose physical and psychological burdens (26, 27). Moreover, cognitive decline is known to be closely associated with reductions in physical function and limitations in activities of daily living (28).

Accordingly, this case illustrates that the destabilization of living environments due to disasters can negatively impact both cognitive and physical health in older adults. These findings are consistent with international recommendations regarding the support of older adults during emergencies. For instance, the World Health Organization emphasizes that maintaining continuity of medical and caregiving services, promoting social connections, and implementing early mental health interventions are essential to preventing health deterioration among older adults forced to evacuate due to disasters (29). Therefore, future disaster response planning should prioritize the continuity of living environments, the maintenance of social connections, and sustained access to medical and caregiving services to prevent negative impacts to cognitive and physical health among older adults who are forced to evacuate. Furthermore, systems for the early identification and intervention of cognitive and emotional

decline must be established. The accumulation of similar case reports will contribute to the development of evidence-based support strategies to protect vulnerable populations in future disasters.

Loss of Hometown and Dementia

Designation of one's home area as a "difficult-to-return zone" is considered a form of "ambiguous loss" (30), which is known to impose long-term psychological stress (31). In this case, the patient repeatedly expressed a desire to return to Tsushima, indicating the strong psychological impact of the displacement. While younger generations tend to rebuild their lives in new locations after disasters, older adults often strongly wish to return to their original homes (32). Although the patient's home was not physically destroyed, the psychological effects of not being able to return may have had an impact similar to that reported in studies on housing loss and cognitive decline (33).

LIMITATION

This case study had some limitations. First, this report is based on a single case study, which limits the comprehensive discussion of cognitive changes. Although it is preferable to use diverse cases or databases, information regarding disaster-related deaths caused by indirect effects in Japan is not publicly available owing to personal information protection concerns. In the future, it would be desirable to establish a database of disaster-related deaths in Japan and use it for comprehensive analysis to develop more effective countermeasures. Second, a potential for recall bias exists owing to the time lapse since the disaster; information about the details and progression of the evacuation experience may be biased. Third, the medical records have limitations. In research on disaster-related deaths, understanding the impact of mid- to long-term evacuation experiences on health conditions is crucial; however, in Japan, the mandatory retention period for medical records is set at 5 years. Therefore, obtaining sufficient medical information for studies extending beyond 5 years is challenging. For future investigations on disaster-related deaths, extending the duration of medical record retention should be considered, particularly in disaster-affected areas.

CONCLUSIONS

This case report illustrates how evacuation-related environmental changes following the nuclear disaster impacted cognitive and physical function in an older adult, contributing to delirium and ultimately leading to death. The transition from a familiar living environment to temporary evacuation settings imposed significant psychological stress, likely accelerating cognitive decline and functional deterioration.

Although direct causality cannot be confirmed from a single case, the progressive worsening observed in this individual's condition highlights the vulnerability of older adults during prolonged displacement and underscores the urgent need for structured long-term support systems. Future disaster response planning should prioritize the continuity of living environments, the maintenance of social connections, and the sustained provision of medical and caregiving services.

RECOMMENDATIONS

It is essential to establish early intervention systems for mental health care that promptly respond to initial signs of cognitive and emotional decline. Furthermore, collaboration between public health nurses and external support organizations should be strengthened to ensure continuity of care from the acute phase immediately after evacuation through the medium- and long-term phases. Additionally, to enhance disaster preparedness in an aging society, it is crucial to accumulate similar case reports and develop evidence-based strategies to mitigate health deterioration during and after evacuation.

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CONFLICTS OF INTEREST

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest. The funders had no role in the design of the study, the collection, analysis, or interpretation of data, the writing of the manuscript, or the decision to publish the results.

ETHICAL APPROVAL

Owing to the death of the patient, consent for the publication of this case report was provided by his son.

REFERENCES

1. Sun Z, Imano H, Eguchi E, Hayashi F, Ohira T, Cui R, et al. The associations between evacuation status and lifestyle-related diseases in Fukushima after the Great East Japan Earthquake: the Fukushima Health Management Survey. *Int J Environ Res Public Health*. 2022;19(9):5661. doi:10.3390/ijerph19095661.
2. Ohira T, Nakano H, Okazaki K, Hayashi F, Nagao M, Sakai A, et al. Trends in lifestyle-related diseases and their risk factors after the Fukushima Daiichi Nuclear Power Plant Accident: results of the comprehensive health check in the Fukushima Health Management Survey. *J Epidemiol*. 2022;32(Suppl_XII):S36–S46. doi:10.2188/jea.JE20210386.
3. Takahashi A, Ohira T, Okazaki K, Yasumura S, Sakai A, Maeda M, et al. Effects of psychological and lifestyle factors on metabolic syndrome following the Fukushima Daiichi Nuclear Power Plant Accident: the Fukushima Health Management Survey. *J Atheroscler Thromb*. 2020;27(9):1010–1018. doi:10.5551/jat.52225.
4. Cherry KE, Brown JS, Marks LD, Galea S, Volaufova J, Lefante C, et al. Longitudinal assessment of cognitive and psychosocial functioning after Hurricanes Katrina and Rita: exploring disaster impact on middle-aged, older, and oldest-old adults. *J Appl Biobehav Res*. 2011;16(3–4):187–211. doi:10.1111/j.1751-9861.2011.00073.x.
5. Ikeda K, Yoshida S, Okazaki Y, Miyamori D, Kashima S, Ishii S, et al. Increased care-need in older long-term care insurance users after the 2018 Japan Floods: a retrospective cohort study based on the Japanese long-term care insurance claims. *Environ Health Prev Med*. 2023;28:31. doi:10.1265/ehpm.22-00269.
6. Heller T. The effects of involuntary residential relocation: a review. *Am J Community Psychol*. 1982;10:471–492. doi:10.1007/BF00893984.
7. Buck C, Wanklin JM, Hobbs GE. Environmental change and age of onset of psychosis in elderly patients. *AMA Arch Neurol Psychiatry*. 1956;75(6):619–623. doi:10.1001/archneurpsyc.1956.02330240057005.
8. The Lancet Public Health. Reinvigorating the public health response to dementia. *Lancet Public Health*. 2021;6(10):e696. doi: 10.1016/S2468-2667(21)00215-2.
9. Statistics Bureau of Japan. 統計からみた我が国の高齢者－「敬老の日」にちなんで－(A statistical look at Japan's elderly population - in honor of respect for the aged day)[Internet]. Tokyo: Ministry of Internal Affairs and Communications; 2023, Sep 17 [accessed 2024, May 28]. Available from: <https://www.stat.go.jp/data/topics/topi1380.html>.

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OLDER PEOPLE FOLLOWING EVACUATION DURING A RADIATION DISASTER: A CASE REPORT

10. 平成21年版 高齢社会白書 (2009 White Paper on the Aging Society)[Internet]. Tokyo: Cabinet Office, Government of Japan; 2009 [accessed 2024 May 28]; Available from: https://www8.cao.go.jp/kourei/whitepaper/w-2009/gaiyou/21pdf_indexg.html
11. Ninomiya T. Prevalence of dementia and mild cognitive impairment: a survey and future estimates, in second meeting of the Dementia Policy Promotion Stakeholders Agenda. 2024]
12. Ministry of Health, Labor, and Welfare Japan. (About our country's population)[Internet]. Tokyo: Ministry of Health, Labor, and Welfare Japan; [Accessed 2024 Jun 16]; Available from: https://www.mhlw.go.jp/stf/newpage_21481.html.
13. Fukushima Prefecture. 一目でわかる福島県の指標 (Fukushima indicators at a glance 2011)[Internet]. Fukushima City: Fukushima Prefectural Office; 2013, Dec 1 [Accessed 2024, Jun 16]; Available from: <https://www.pref.fukushima.lg.jp/sec/11045b/28338.html>.
14. Tsubokura M, Hara K, Matsumura T, Sugimoto A, Nomura S, Hinata M, et al. The immediate physical and mental health crisis in residents proximal to the evacuation zone after Japan's nuclear disaster: an observational pilot study. *Disaster Med Public Health Prep.* 2014;8(1):30–36. doi:10.1017/dmp.2014.5.
15. Nomura S, Gilmour S, Tsubokura M, Yoneoka D, Sugimoto A, Oikawa T, et al. Mortality risk amongst nursing home residents evacuated after the Fukushima nuclear accident: a retrospective cohort study. *PLoS One.* 2013;8(3):e60192. doi:10.1371/journal.pone.0060192.
16. Murakami M, Ono K, Tsubokura M, Nomura S, Oikawa T, Oka T, et al. Was the risk from nursing-home evacuation after the Fukushima accident higher than the radiation risk? *PLoS One.* 2015;10:e0137906. doi:10.1371/journal.pone.0137906.
17. Li X, Aida J, Hikichi H, Kondo K, Kawachi I. Association of postdisaster depression and posttraumatic stress disorder with mortality among older disaster survivors of the 2011 Great East Japan Earthquake and Tsunami. *JAMA Netw Open.* 2019;2:e1917550. doi:10.1001/jamanetworkopen.2019.17550.
18. Hori A, Ozaki A, Murakami M, Tsubokura M. Development of behavior abnormalities in a patient prevented from returning home after evacuation following the Fukushima nuclear disaster: case report. *Disaster Med Public Health Prep.* 2021;15:804–807. doi:10.1017/dmp.2020.158.
19. Saito Y, Sato S, Nishikawa Y, Oguro F, Moriyama N, Sato K, et al. Outpatient rehabilitation for an older couple in a repopulated village 10 years after the Fukushima nuclear disaster: an embedded case study. *Fukushima J Med Sci.* 2024;70(1):49–54. doi:10.5387/fms.2023-01.
20. Namie Town. すぐわかる浪江町なみえまちの現況 (A quick guide to the current state of Namie Town)[Internet]. Namie-machi: Planning and Finance Division; 2024, Mar 15 [accessed 2024, May 28]; Available from: <https://www.town.namie.fukushima.jp/site/understand-namie/namie-factsheet.html>.
21. Ishiki A, Furukawa K, Une K, Tomita N, Okinaga S, Arai H. Cognitive examination in older adults living in temporary apartments after the Great East Japan Earthquake. *Geriatr Gerontol Int.* 2015;15(2):232–233. doi:10.1111/ggi.12290.
22. Takahashi S, Ishiki M, Kondo N, Ishiki A, Toriyama T, Takahashi S, et al. Health effects of a farming program to foster community social capital of a temporary housing complex of the 2011 great East Japan earthquake. *Disaster Med Public Health Prep.* 2015;9(2):103–110. doi:10.1017/dmp.2015.6.
23. Bassuk SS, Glass TA, Berkman LF. Social disengagement and incident cognitive decline in community-dwelling elderly persons. *Ann Intern Med.* 1999;131(3):165–73. doi.org/10.7326/0003-4819-131-3-199908030-00002.
24. Matsuoka Y, Haseda M, Kanamori M, Sato K, Amemiya A, Ojima T, et al. Does disaster-related relocation impact mental health via changes in group participation among older adults? Causal mediation analysis of a pre-post disaster study of the 2016 Kumamoto earthquake. *BMC Public Health.* 2023;23:1982. doi:10.1186/s12889-023-16877-0.
25. Miyagawa A, Kunii Y, Gotoh D, Hoshino H, Kakamu T, Hidaka T, et al. Effects of the Great East Japan Earthquake and the Fukushima Daiichi Nuclear Power Plant accident on behavioural and psychological symptoms of dementia among patients. *Psychogeriatrics.* 2021;21:709–715. doi:10.1111/psyg.12728.
26. Tsuboi M, Tani Y, Sawano T, Ozaki A, Nonaka S, Zhao T, et al. Symposium on disaster-related deaths after the Fukushima Daiichi Nuclear Power Plant accident. *J Radiol Prot.* 2022;42 (3):033502. doi:10.1088/1361-6498/ac7c9b.
27. Sawano T, Nishikawa Y, Ozaki A, Leppold C, Takiguchi M, Saito H, et al. Premature death associated with long-term evacuation among a vulnerable population after the Fukushima nuclear disaster: a case report. *Medicine (Baltimore).* 2019;98(27):e16162. doi:10.1097/MD.00000000000016162.
28. Galvin A, Helmer C, Coureau G, Amadeo B, Rainfray M, Soubeyran P, et al. Determinants of functional decline in older adults experiencing cancer (the INCAPAC study). *J Geriatr Oncol.* 2019;10(6):913–920. doi:10.1016/j.jgo.2019.03.006.

29. Hutton D. Older people in emergencies: considerations for action and policy development [Internet]. Geneva: World Health Organization; 2008. Available from <https://extranet.who.int/agefriendlyworld/wp-content/uploads/2014/06/WHO-Older-Persons-in-Emergencies-Considerations-for-Action-and-Policy-Development-English.pdf>.
30. Maeda M, Oe M. The great East Japan earthquake: Tsunami and nuclear disaster. In: Cherry KE, editor. Traumatic stress and long-term recovery: coping with disasters and other negative life events. Springer International Publishing/Springer Nature; 2015. p. 71–90. doi:10.1007/978-3-319-18866-9_5.
31. Maeda M, Oe M. Mental health consequences and social issues after the Fukushima disaster. *Asia Pac J Public Health*. 2017;29(2_suppl):36S–46S. doi:10.1177/1010539516689695.
32. Andersson A, Jordan D, Schneider G, Valent B, Lindqvist Y. Crystallization and preliminary x-ray diffraction study of 1,3,8-trihydroxynaphthalene reductase from *Magnaporthe grisea*. *Proteins*. 1996;24(4):525–527. doi:10.1002/(SICI)1097-0134(199604)24:4<3C525::AID-PROT14%3E3.0.CO;2-N.
33. Hikichi H, Aida J, Kondo K, Kawachi I. Persistent impact of housing loss on cognitive decline after the 2011 Great East Japan earthquake and tsunami: evidence from a 6-year longitudinal study. *Alzheimers Dement*. 2019;15:1009–1018. doi:10.1016/j.jalz.2019.04.016.