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*News and Views*

# The 2024 Noto Peninsula Earthquake and the Strategy of Medical Assistance from the Tohoku University Hospital

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A moment magnitude (Mw) 7.5 earthquake (the Global IDentifire (GLIDE) number: # Q-2024-000001-JPN) struck the Noto Peninsula of Ishikawa Prefecture on 1 January 2024 at 16:10 (Japan Standard Time). The reversed fault, 150 km in length and subducting beneath the peninsula, resulted in maximum seismic intensity 7 shaking, triggered the tsunami, destroyed over 43 thousand buildings, and disrupted roads and lifelines. The disaster claimed 236 deaths, including 15 indirect disaster deaths as of Jan. 28, 2024. There were Disaster Base Hospitals (DBHs) in the region, which survived structurally but suffered from impaired functions and the surge of medical needs of affected people. The disaster medical system of Japan immediately responded and coordinated the hundreds of emergency medical teams (EMTs), i.e., the Japan Disaster Medical Assistance Team (DMAT), from all over the country. Tohoku University Hospital, which had the experience of the 2011 Great East Japan Earthquake (GEJE), joined the coordinated response, dispatching a chain of DMATs, which helped the medical and public health coordination in Wajima City. The medical and public health needs included injuries, non-communicable diseases, infectious diseases, mental health issues, and maternal and child health issues, which were similar in the affected communities in GEJE. Although the actual damage far exceeded expectations, the structural retrofitting and business continuity plans of DBHs and the coordinated response of the national disaster medical system enhanced the effectiveness of medical and public health response.

**Keywords:** disaster medicine; hospital business continuity; logistics; medical coordination; medical response
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## Introduction

Japan is an earthquake-prone country, not only because Japan is situated on the convergent boundaries between the Pacific, Philippine Sea, Okhotsk, and Amurian Plates, but also because there are more than 2,000 active faults throughout the country, which can cause sharrow inland earthquakes. A moment magnitude (Mw) 7.5 earthquake

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(the Global IDentifire (GLIDE) number: # Q-2024-000001-JPN) struck the Noto Peninsula of Ishikawa Pref. on 1 January 2024, at 16:10 (Japan Standard Time) (Fig. 1). The reversed fault, 150 km in length and subducting beneath the peninsula, resulted in maximum seismic intensity 7 shaking, triggered the tsunami, destroying more than 43,000 buildings in the most affected Ishikawa Prefecture (as of Jan. 28) (Ishikawa Prefecture 2024), and disrupting roads and lifelines. The Japan Meteorological Agency (JMA) officially named this earthquake the 2024 Noto Peninsula Earthquake. The human damage was 236 deaths, including 15 indirect disaster deaths, 311 severe injuries, and 867 minor injuries, in Ishikawa Pref. (as of Jan. 28) (Ishikawa Prefecture 2024). There were no deaths in other affected prefectures, including Niigata, Toyama, or Fukui (as of Jan. 26), although the shake was vigorous and tsunami attacked in these prefectures. There were five severely injured patients in Niigata and four in Fukui (Cabinet Office, Government of Japan 2024).

## Mechanism

Toda and Stein reported that "This earthquake is unusual in two key ways. First, it was preceded by an extremely active three-year-long seismic swarm accompanied by continuous ground uplift in the epicentral region. Some researchers suspect the swarm results from the upward migration of crustal fluids through existing fault networks. Second, the shaking produced by the earthquake was much larger than expected for an earthquake of its size and depth. Why it shook so strongly is unclear, but it may be due to the concentrated burst of fault slip beneath the Noto Peninsula" (Toda and Stein 2024). As a result, the northwest coast of the Peninsula was uplifted 4 m above the sea level, leading to shore moved seawards about 200 m, making the tsunami detector unable to measure the correct height of the wave.

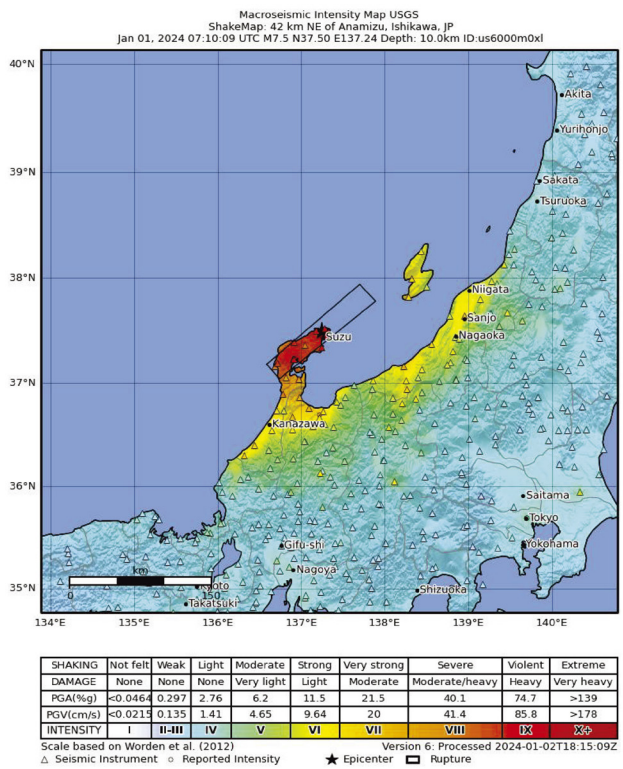


Fig. 1. United States Geological Survey (USGS) Shakemap. Credit: U.S. Geological Survey, Public Domain. Available at: https://en.wikipedia.org/wiki/File:2024-01-01_Japan_M7.5_earthquake_shakemap_(USGS).jpg

## Tsunami

The uplifted peninsula and disruption of the sea floor are considered to be the mechanism of tsunami generation. Tsunami warning was issued to all west coast of Japan immediately after the earthquake (Fig. 2). The arrival of the tsunami to Suzu City, which was the closest city to the epicenter, was immediate after the shake due to the close proximity of the fault to the coast or a possible submarine landslide in Toyama Bay. The movement of tsunami was modified by the complex geography of the peninsula, Toyama Bay, Japan Sea and the sea floor. The tsunami warning was issued until 10:00 (JST) on Jan. 2, 2024 (18 h) (Cabinet Office, Government of Japan 2024). The actual inundation depth of the tsunami was 4.3 m at the Iida Port in Suzu (Japan Meteorological Agency 2024), which attacked within one minute after the shake (The Japan News by Yomiuri Shinbun 2024a). At the Wajima Port located on the north coast, the measured tsunami inundation was 2.9 m, but there is a possibility that 4 m elevation of

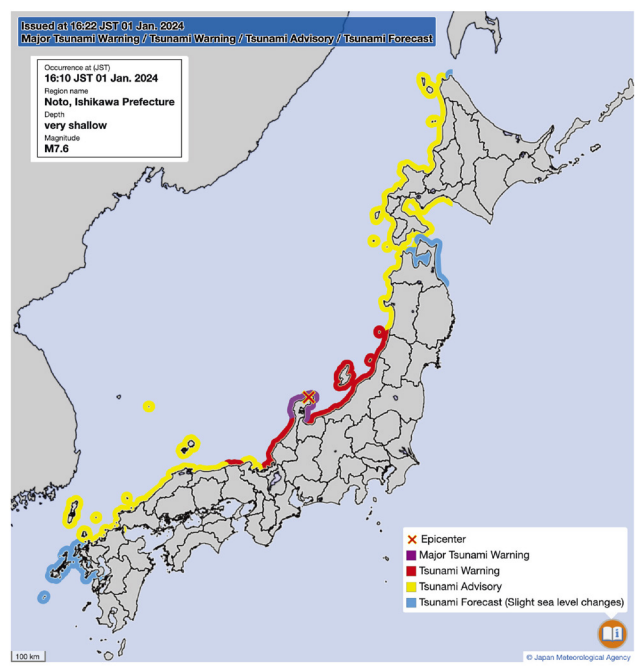


Fig. 2. Map of Tsunami Warnings issued by the Japan Meteorological Agency at 1 January 2024 16:22JST. Credit: Japan Meteorological Agency, 2024, CC BY-NC-ND 4.0 DEED. Available at: https://en.wikipedia.org/wiki/File:JMA_Tsunami_Warnings_1_January_2024_en.png

the coast prevented the damage than expected (The Japan News by Yomiuri Shinbun 2024b). A tsunami of 3 m high attacked the Shika Nuclear Power Plant, which is located at the west end of the peninsula, about two hours after the shake (Kyodo News 2024). The nuclear power plant was located at 11 m above the sea level and had a 4 m sea wall, which protected the plant from inundation. The power plant has not been operating since 2011 but has to cool the spent nuclear fuel. The power plant lost the function of power transformers of the reactors by the strong shake, which was immediately substituted by emergency power transformers and there was no radiological material leakage (Hokuriku Electric Power Company 2024).

The tsunami was augmented at the coast of Joetsu City in Niigata Prefecture. The deepest inundation exceeded 5.8 m run-up. Beach houses, fishing vessels, and coastal facilities were flashed away (Japan Meteorological Agency 2024).

## Damage of Critical Infrastructures

The vigorous shaking disrupted the roads and water supply. The road damage made it extremely difficult for the rescuers and responders to reach the affected area. More than 50 parts were closed due to collapse and landslides (as of Jan. 26) (Cabinet Office, Government of Japan 2024). The water supply was lost in more than 130,000 households in vast areas in Ishikawa, Niigata, Toyama, and Fukui prefectures. The water disruption was recovered within a week or so in the areas where the damage was limited to the distributing pipe. However, most of the municipalities in the peninsula are still suffering from severe damage to distributing pipes and facilities, and 44,960 households (max 75,300 households) are still suffering from the disruption of water supply (as of Jan. 26) (Cabinet Office, Government of Japan 2024). The sewage system was also damaged, which will harm water sanitation and hygiene (WASH), a critical problem for the health and life of the affected people (Sphere Association 2018). As of Jan. 26, 3,700 households are still suffering from power outages due to the problems with power distribution equipment, which is severe in Wajima and Suzu Cities (Cabinet Office, Government of Japan 2024). The mobile communications also suffered from overcrowding and disruption of services. Because the base stations for mobile phones were damaged by the shake in Wajima and Suzu Cities, the careers dispatched the vehicle stations to cover the disrupted areas (Cabinet Office, Government of Japan 2024).

## Medical Response of Tohoku University Hospital

The Japan Disaster Medical Assistance Team (DMAT) immediately set up a coordinated response on New Year's Day. The disaster medical system in Japan is described elsewhere (Egawa et al. 2021). Briefly, the headquarters of Japan DMAT investigates the situation and coordinates the dispatching of DMATs from the nearest regions of the affected area. Every information and command are shared using the emergency medical information system (EMIS). There are disaster medical coordinators in each prefecture so that local incident command system (ICS) is possible (Egawa et al. 2017). The DMAT in Tohoku University Hospital (TUH-DMAT; 2 doctors, 3 nurses and 3 logisticians) also prepared for the dispatch, and following the order from the DMAT headquarter, they started in a hospital ambulance car at 3:55 a.m. on Jan. 6, 2024. They arrived at the headquarter in Noto General Hospital to join the coordinated response. The assigned task was to support the Wajima Municipal Hospital establishing the coordination mechanism. Additionally, because of the WASH problem, portable toilets were delivered to an evacuation center close to the Wajima Municipal Hospital. Because of the road conditions, it took more than three hours on the 52 km distance even by a prioritized vehicle from the Noto General Hospital to the Wajima Municipal Hospital. The TUH-DMAT joined the headquarter of Wajima Municipal Hospital and shared the situational information. The DMAT nurses helped the ward nursing at midnight so that the original staff could take a rest. Understanding the difficulties of finding a hotel and food in the affected area, TUH-DMAT slept in the hospital meeting room and ate brought food. A backup team supported the TUH-DMAT in terms of logistics including accommodation and information sharing.

On the following day (Day 2), TUH-DMAT was divided into three missions, i.e., hospital headquarter support, patient transportation support, and municipal public health support. The hospital headquarters support team assisted the WASH coordination, task shifting of the ward nurses, and establishing the continuous support system. The patient transportation team assisted in managing the prioritized patients list and finalizing the transportation by other DMATs. Because of snow, the main road was closed and the patient transportation was not completed as planned. The municipal public health support team assisted the coordination in establishing the evacuation center assessment for future assistance by the line of emergency medical teams (EMTs) and preventing the outbreak of infectious diseases.

On Day 3, after confirming the health condition of the members, TUH-DMAT further continued the given three missions. The hospital headquarter support team joined the hospital directors' meeting to share information. A reduction in the number of admissions was suggested because the outbreaks of infectious diseases in the evacuation centers would increase the number of patients who need admission. The food security and WASH tasks were shifted to the dieticians in the hospital and municipality personnel. The patient transportation team directed the other DMATs to transport the inpatients by the aircraft of Self Defense Force (SDF) or other transporters. The municipal public health support team assisted in establishing the evacuation center assessment.

On Day 4, assuring the health condition of members,

TUH-DMAT continued the mission. The number of inpatients in the hospital was reduced by transportation as much as possible to reduce the workload of hospital staff. TUH-DMAT assisted the business continuity and support receiving capability of the hospital (Sasaki et al. 2020). Thirty inpatients were transported by an SDF aircraft to Fukui Airport so that secondary transfer to other hospitals become possible. The municipality was performing the evacuation center assessment. The TUH-DMAT shared the information with the successive DMAT from other prefectures and stayed in Kanazawa on the way home.

## Discussion

The disaster medical system was established after the 1995 Great Hanshin-Awaji Earthquake (GLIDE # EQ-1995-000003-JPN), and refined after the 2011 Great East Japan Earthquake (GEJE, GLIDE # EQ-2011-000028-JPN) (Egawa et al. 2021). It is aiming at the reduction of the "preventable disaster deaths" (Yamanouchi et al. 2017). Most of the collapsed houses, however, were built before the current building code. The tsunami reached the nearest coast before the tsunami warning was issued. These facts indicate the importance of disaster risk reduction and expecting the unexpected.

The coordinated disaster medical response is a result of active researches through practices including the 2011 Great East Japan Earthquake, the 2016 Kumamoto Earthquake (#EQ-2016-000033-JPN), and the 2018 West Japan Torrential Rain (#FL-2018-000082-JPN) (Egawa 2021). The Japanese Association for Disaster Medicine (JADM) promotes research, building capacities, and improving the disaster medical system. The transportation of patients is the strategic and efficient way to save lives in a resource-rich environment. The hemodialysis liaison quickly assisted the transportation of patients in Noto Peninsula who need hemodialysis to a distant area because the disruption of water supply and electricity was critical to their life. The Disaster Psychiatric Assistance Team (DPAT) assists psychiatric patients and facilities. The Disaster Health Emergency Assistance Team (DHEAT) is assisting the public health operations of the affected municipalities. Therefore, the improvement of the disaster medical system was definitely implemented in Japan and actually preventing the "preventable disaster deaths." It is also true that every disaster is different and exceeds the expectations. Though the remarkable increase of the frequency of seismic activities in Noto Peninsula (Toda and Stein 2024), the prediction and early warning of the size of this earthquake was not well understood and translated into the policy. On the other hand, the possible magnitude to create a tsunami caused by this fault (F43) was correctly predicted as Mw 7.6 in 2014 (Ministry of Land, Infrastructure, Transport and Tourism 2014).

There were 15 indirect disaster-related deaths (as of Jan. 28) (Ishikawa Prefecture 2024). Ishikawa Pref. speculates that these people died of the exacerbation of injury by the earthquake, or the physical burden after the earthquake. The living environment of the evacuation center is not still sufficient. Ishikawa Pref. recommends the affected people to move to another evacuation center in a distant place with better living environments as the secondary evacuation. Communication between the local government and affected people is slowly but steadily improving the secondary evacuation. The recovery of the water distribution, electricity, building the temporary housing is on-going. Although it may take months and years, the hope for the future will empower the well-being of the affected people.

After the 2011 GEJE, the most frequent medical needs of the affected Minamisanriku Town, that lost all medical facilities, was non-communicable disease, followed by infectious disease, mental health issues and minor injuries (Suda et al. 2019). Tsuboi et al. (2023) revealed that the initial contact with the medical assistance was 5.2 days later in the evacuation at home compared to the people in evacuation center. Thus, it is important to encourage the people with chronic diseases to be prepared before the disaster, so that they can survive and help themselves during the acute phase of disaster. Long-term cohort analyses were conducted and revealed the persistence of posttraumatic stress reaction and psychological distress. Longitudinal environmental and personal change including relocation from temporal to eternal housing conditions may affect the psychological well-being of the affected people (Kunii et al. 2022). Thus, the cohort study is an important strategy for the research on better recovery and reconstruction after disaster (Egawa et al. 2021).

## Limitation

It is not easy to grasp the whole picture of health response to a large-scale earthquake because various stakeholders are committing nationwide, and it will be further difficult to understand the interdisciplinary coordination. The International Research Institute of Disaster Science (IRDeS), Tohoku University organized a symposium on Jan. 9, 2024, to report the investigations on the 2024 Noto Peninsula Earthquake from the viewpoints of seismic scientists, tsunami scientists, architects, health scientists, education scientists, and humanity scientists (https://irides.tohoku.ac.jp/research/prompt_investigation/2024noto-eq.html). No single paper can describe the whole aspects of a disaster, but a holistic approach is necessary to find the gaps and good practices to improve the resilience of human and community.

## Conclusion

In the 2024 Noto Peninsula Earthquake, the coordinated disaster medical response is working well. Though the disaster exceeds expectations, strategic preparedness and capacity building of health responders are imperative.

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## Author Contributions

S.E. concepted and drafted the manuscript. H.F., M.F., Y.A., A.S. and K.O. were dispatched to the affected area and reported the summary. T.I., Y.I., and H.S. back-upped the operation. T.I., H.H., M.T., S.K. and H.S. supervised the manuscript. All authors reviewed and agreed the manuscript.

## Conflict of Interest

The authors declare no conflict of interest.

## References

Cabinet Office, Government of Japan (2024) The 2024 Noto Peninsula Earthquake Damage Report as of Jan. 26. https://www.bousai.go.jp/updates/r60101notojishin/r60101notojishin/pdf/r60101notojishin_24.pdf [*Accessed*: January 29, 2024] (in Japanese).

Egawa, S. (2021) Progress of disaster medicine during ten years after the 2011 Great East Japan Earthquake. *Tohoku J. Exp. Med.*, **253**, 159-170.

Egawa, S., Sasaki, H., Suppasri, A., Tomita, H., Imamura, F., Nagami, F., Kanatani, Y., Eto, A., Koido, Y., Kubo, T., Kato, H., Kim, Y., Mashino, S. & Kayano, R. (2021) Historical developments in Health EDRM policy and research: the case study of Japan. *WHO Guidance on Research Methods for Health and Disaster Risk Management,* Geneva, Switzerland.

Egawa, S., Suda, T., Jones-Konneh, T.E.C., Murakami, A. & Sasaki, H. (2017) Nation-wide implementation of disaster medical coordinators in Japan. *Tohoku J. Exp. Med.*, **243**, 1-9.

Hokuriku Electric Power Company (2024) Current situation of Shika Nuclear Power Plant facilities as of Jan. 12, 2024. https://www.rikuden.co.jp/outline1/shika_noto.html [*Accessed:* January 28, 2024](in Japanese).

Ishikawa Prefecture (2024) Damage report. https://www.pref.ishikawa.lg.jp/saigai/documents/higaihou_70_0128_1400.pdf [*Accessed*: January 29, 2024] (in Japanese).

Japan Meteorological Agency (2024) Results of the on-site investigation of the tsunami conducted by the Japan Meteorological Agency Mobile Survey Team (JMA-MOT) in the 2024 Noto Peninsula Earthquake. https://www.jma.go.jp/jma/press/2401/26a/20240126_tsunamichousakekka.pdf [*Accessed:* January 31, 2024] (in Japanese).

Kunii, Y., Usukura, H., Utsumi, Y., Seto, M., Hamaie, Y., Sugawara, Y., Nakaya, N., Kuriyama, S., Hozawa, A., Tsuji, I. & Tomita, H. (2022) Review of mental health consequences of the Great East Japan Earthquake through long-term epidemiological studies: the Shichigahama health promotion project. *Tohoku J. Exp. Med.*, **257**, 85-95.

Kyodo News (2024) 3-meter tsunami reached nuclear plant after powerful Japan quake. https://english.kyodonews.net/news/2024/01/4a6a87405642-3-meter-tsunami-reached-nuclear-plant-after-powerful-japan-quake.html [*Accessed*: January 30, 2024].

Ministry of Land, Infrastructure, Transport and Tourism (2014) Summary Report of the Investigation and Study Committee on Major Earthquakes in the Sea of Japan. https://www.mlit.go.jp/river/shinngikai_blog/daikibojishinchousa/houkoku/gaiyo.pdf. [*Accessed*: January 29, 2024] (in Japanese).

Sasaki, H., Maruya, H., Abe, Y., Fujita, M., Furukawa, H., Fuda, M., Kamei, T., Yaegashi, N., Tominaga, T. & Egawa, S. (2020) Scoping review of hospital business continuity plans to validate the improvement after the 2011 Great East Japan Earthquake and Tsunami. *Tohoku J. Exp. Med.*, **251**, 147-159.

Sphere Association (2018) *The Sphere Handbook: Humanitarian Charter and Minimum Standards in Humanitarian Response*, fourth ed., Geneva, Switzerland.

Suda, T., Murakami, A., Nakamura, Y., Sasaki, H., Tsuji, I., Sugawara, Y., Hatsugai, K., Nishizawa, M. & Egawa, S. (2019) Medical needs in Minamisanriku Town after the Great East Japan Earthquake. *Tohoku J. Exp. Med.*, **248**, 73-86.

The Japan News by Yomiuri Shinbun (2024a) Analysis Shows Tsunami Hit Suzu 1 Minute After Quake. https://japannews.yomiuri.co.jp/society/noto-peninsula-earthquake/20240105-160060/ [*Accessed:* January 31, 2024].

The Japan News by Yomiuri Shinbun (2024b) Tsunami Damage Focused on Noto Peninsula's East Coast; Experts Say Ground Lift May Have Created Protective Barrier. https://japannews.yomiuri.co.jp/society/noto-peninsula-earthquake/20240111-161357/ [*Accessed:* January 31, 2024].

Toda, S. & Stein, R.S. (2024) Intense seismic swarm punctuated by a magnitude 7.5 Japan shock. https://temblor.net/temblor/intense-seismic-swarm-magnitude-7-5-japan-earthquake-15891/ [*Accessed*: January 29, 2024].

Tsuboi, M., Sasaki, H., Park, H., Usuda, Y., Hanashima, M., Saito, M., Takahashi, S., Sakisaka, K., Hibiya, M., Kiyota, K., Hatsugai, K., Nishizawa, M., Sugawara, Y., Tsuji, I. & Egawa, S. (2023) Evacuation at home delayed the first medical intervention in Minamisanriku Town after the 2011 Great East Japan Earthquake. *Prehosp. Disaster Med.*, **38**, 301-310.

Yamanouchi, S., Sasaki, H., Kondo, H., Mase, T., Otomo, Y., Koido, Y. & Kushimoto, S. (2017) Survey of preventable disaster deaths at medical institutions in areas affected by the Great East Japan Earthquake: retrospective survey of medical institutions in Miyagi Prefecture. *Prehosp. Disaster Med.*, **32**, 515-522.