ASEAN Journal of Disaster Health Management https://doi.org/10.22146/ajdhm.v2i1.23635
Vol. 2 (1) 2026: 54-66

STAIRWELL-BASED MEAL DELIVERY DURING HOSPITAL ELEVATOR OUTAGES IN DISASTERS: A SIMULATION FEASIBILITY STUDY

Hiroki Kamimura[1,3], Yutaka Igarashi[1*], Yoshiko Sakai[2], Ichiro Okada[1], Yuichi Koido[3], Shoji Yokobori[1]

[1]*Nippon Medical School, Japan:* kamimura.hi@jihs.go.jp; igarashiy@nms.ac.jp; i-okada@nms.ac.jp; shoji@nms.ac.jp

[2]*Nippon Medical School Hospital, Japan:* sakai29@nms.ac.jp

[3]*Japan Disaster Medical Assistance Team (DMAT) Secretariat, Japan:* kamimura.hi@jihs.go.jp; koido@outlook.jp

**Correspondence:* igarashiy@nms.ac.jp

Submitted: 05-08-2025 **Revised**: 09-12-2025 **Accepted**: 19-12-2025

List of Abbreviations

ASEAN	: Association of South East Asian Nations
BCP	: Business Continuity Plan
B2	: Second Basement Level
B2F	: Second Basement Floor
B1F	: First Basement Floor
DMAT	: Disaster Medical Assistance Team
FEMA	: Federal Emergency Management Agency
MEXT	: Ministry of Education, Culture, Sports, Science and Technology Japan
OR	: Operating Room
t_1	: Time per tray handover for upward transport
t_2	: Time per tray handover for downward transport
3F, 4F, 5F–12F	: Third Floor, Fourth Floor, Fifth to Twelfth Floors

ABSTRACT

Introduction: Large-scale disasters can disable hospital elevators, disrupting vertical transport of supplies and meals. Ensuring continued meal provision for inpatients is critical for patient health and hospital continuity. **Objective:** We simulated a stairway-based "bucket brigade" meal delivery system to quantify the time and staffing required when elevators are out of service, informing hospital disaster business continuity planning. **Methods:** A relay of 41 staff was stationed from a basement kitchen (B2) to a ward on the 3rd floor. A load of 32 meal trays (one cart) was passed hand-to-hand up the stairs, and return descent times were measured. We extrapolated these results to higher floors (3rd–12th) for a full meal round (64 trays/ward). **Results:** Delivering 32 trays to 3F took 5 min 56 sec upward and 3 min 49 sec downward. No drops or injuries occurred. Extrapolation indicated 69 min upward and 44 min downward to supply 64 meals to all wards up to 12F, requiring approximately 130 personnel positions. **Conclusions:** Stairwell delivery is feasible but labor-intensive. Over one hour and a large multidisciplinary team would be needed to deliver meals hospital-wide during elevator outages. Hospitals should incorporate such scenarios into disaster plans to ensure continuity of care.

Keywords: Disaster Panning; Hospitals; Food Services; Simulations; Continuity of Patient Care

INTRODUCTION

Large-scale disasters can severely impair the functionality of hospitals (1, 2). In particular, when elevators become inoperative due to earthquakes or power outages, the vertical transportation of supplies and meals is significantly disrupted (3). Even under such circumstances, the stable provision of meals to inpatients remains essential for maintaining nutritional status and continuing medical treatment, and is thus a critical component of healthcare continuity (4, 5).

When elevators are unavailable, many hospitals must resort to stair-based manual transport, in which staff members relay items up and down stairwells in a coordinated manner. During previous disasters, such as the 2011 Great East Japan Earthquake and the 2016 Kumamoto Earthquake, several medical facilities experienced prolonged elevator outages and were forced to transport meals and supplies via stairs (6-9). The Federal Emergency Management Agency (FEMA) has also identified power supply and lifeline maintenance in healthcare facilities as core components of disaster preparedness, recognizing elevator failure as a serious operational concern (10).

Despite the importance of this issue; there is a paucity of empirical studies that has quantitatively evaluated, on the basis of direct measurements, the personnel and time required for stair-based transport during elevator outages. This lack of quantitative evidence has limited the development of realistic and efficient staffing strategies for disaster-related meal services within hospital business continuity plans (BCPs).

This study aims to simulate stairway-based meal delivery under conditions in which hospital elevators are unusable due to a disaster. By quantifying the required number of personnel and the time needed for delivery, we seek to provide basic operational data to support such staffing decisions in hospital BCPs and to inform disaster preparedness training.

METHODS

This simulation study was conducted at a designated disaster base hospital located in central Tokyo, serving as a tertiary medical care center with 877 inpatient beds. The hospital employs a *cook-chill* meal service system, in which food is prepared in advance, rapidly cooled, stored, and then reheated shortly before serving. Approximately 600 patient meals are delivered per session from a kitchen located on the second basement level (B2) to inpatient wards using elevators under normal conditions.

To evaluate the feasibility and human resource demands of meal delivery during a disaster scenario involving elevator outage, we conducted a simulation using stair-based manual transport. The simulation was designed to reflect real-world conditions, including the weight, volume, and stability of actual meal trays.

The transport route was set from the B2 kitchen to the ward on the third floor (3F), selected as a representative mid-level ward. One delivery unit, equivalent to a single meal cart and containing 32 meal trays, was transported. Forty-one hospital staff members were stationed at fixed intervals along the stairwell, forming a human chain to pass the trays upward and downward. To realistically simulate meal weight and spillage risk, each tray included a water-filled container representing soup (Figure 1). Transport time was recorded separately for upward delivery (B2 to 3F) and downward return (3F to B2), using a stopwatch to measure total elapsed time in each direction.

Figure 1. Meal Delivery Simulation Via Stairwell During Elevator Outage.

Source: Kamimura et al., 2026

Note: Left: Hospital staff are seen transferring meal trays from lower to upper floors in a relay manner using the emergency stairwell, simulating conditions during an elevator outage. Right: A meal tray used in the drill, containing sealed containers. To replicate the weight and behavior of liquids during transport, water was used in place of soup.

Based on the measured transport times, we extrapolated the estimated number of personnel and time required to deliver 64 meals to each inpatient ward from the 3rd to the 12th floors, excluding the 4th floor which houses the operating theater. We assumed uniform staff allocation and constant transport efficiency across all floors.

Second, we modelled a scenario in which clinically stable inpatients were discharged early or transferred to other facilities, allowing upper wards to be progressively closed and limiting active inpatient floors to between the 3rd and 11th floors. For each assumed highest occupied floor, we estimated the number of staff required and the total time needed for stair-based meal delivery.

RESULTS

In the simulation, the time required to manually transport 32 meal trays from the kitchen on the B2 floor to the 3rd floor was 5 min and 56 sec for upward delivery and 3 min and 49 sec for the downward return. No incidents such as staff falls or tray drops occurred during the operation.

Based on these findings, we then estimated the required time and manpower required to deliver 64 meals to each inpatient ward from the 3rd to the 12th floor in the event of an elevator outage. To inform this extrapolation, we assumed the following: First, we compared two delivery sequences—ascending from the 3rd floor and descending from the 12th floor—and found that starting from the top floor allowed overlapping delivery operations between adjacent floors, resulting in greater efficiency. Second, staff were positioned alternately in a pattern where each tray holder passed the meal tray to a non-holder positioned one step above or below, forming a continuous one-tray-per-step human relay system. Third, the total transport time was defined as the duration from the moment the first staff member received the first tray at the starting point to the moment the last staff member received the final tray at the destination, and was calculated based on the number of steps and the average time per handoff (Figure 2).

In general, the time (T) required for stair-based transport can be expressed as a function of the number of staff assigned per floor (p), the number of floors traversed to reach the lowest occupied inpatient floor (f), the number of trays to be transported (n), and the average time per handoff between adjacent staff (t), as follows:

$$T = 2(n-1)t + pft$$

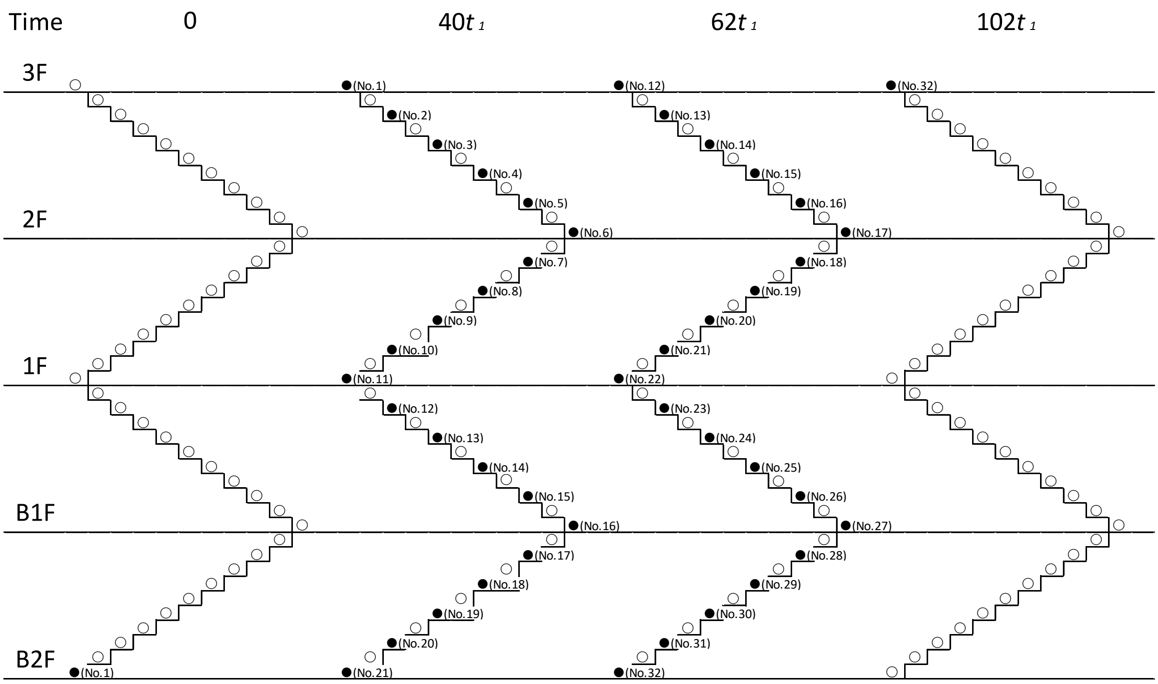

Figure 2. Illustration of Tray Handover Timing in a Stairwell-Based Manual Relay System.
Source: Kamimura et al., 2026

Note: Gantt chart illustrating the handover timing of 32 trays among 41 staff from the second basement (B2F) to the third floor (3F). Each point represents a staff member (Step 1 to Step 41), and each black point indicates the time during which a tray (No.1 to No.32) was in their possession. Staff alternated between holder and non-holder role.

Table 1. Illustrative Timeline of Stairwell-Based Manual Tray Relay from B2F to 3F, Showing the Tray Positions at Selected Time Points.

Time	B2F	B1F	1F	2F	3F	Comments
0	No.1					
$40t_1$	No.21	No.16	No.11	No.6	No.1	No.1 tray arrives at 3F
$62t_1$	No.32	No.27	No.22	No.17	N0.12	No.32 tray departs from B2F
$102t_1$					No.32	No.32 tray arrives at 3F

Note: The time to pass one tray between adjacent staff for upward transport is defined as t_1 sec. The first tray reaches the 40th staff member on the third floor at $40 \times t_1$ sec. The same staff member receives the 32nd tray at $62 \times t_1$ sec, and the final tray is completely received at $102 \times t_1$ sec. Given that $102 \times t_1 = 356$ sec, the calculated handover time per tray (t_1) is approximately 3.49 sec.

Source: Kamimura et al., 2026

The time to pass a single tray between adjacent staff is defined as t_1 sec for upward transport and t_2 sec for downward transport. Based on the simulation results, the time required to deliver 32 trays upward was equivalent to $102 \times t_1$, totalling 5 min and 56 sec (356 sec), yielding an average per-tray handoff time of $t_1 = 3.49$ sec (Table 1). Under these conditions, the estimated time required to deliver 64 meal trays to all relevant inpatient wards (from the 3rd to 12th floors, excluding the 4th-floor operating theater) was calculated as $1{,}190 \times t_1$, equivalent to 1 h 9 min 13 sec for upward transport (Table 2). This operation would require a total of 131 person-occupations for the complete operation. Assuming that tray collection (clearing) follows the same process in reverse, the time required to retrieve 32 trays was 3 min 49 sec (229 sec), resulting in a per-tray time of $t_2 = 2.25$ sec. Accordingly, the total time required to retrieve all trays was estimated as $1{,}190 \times t_2$, equivalent to 44 min and 32 sec for downward transport.

Table 2. Illustrative Timeline of Stairwell-Based Manual Tray Relay from B2F to 12F, Showing the Tray Positions at Selected Time Points.

Time	B2F	3F	4F	5F	6F	7F	8F	9F	10F	11F	12F	Comments
Meal number (No.)		513—576	(OR)	449—512	385—448	321—384	257—320	193—256	129—192	65—128	1—64	
0	No.1											
$130t_1$	No.66	No.46	No.41	No.36	No.31	No.26	No.21	No.16	No.11	No.6	**No.1**	No.1 tray arrives at 12F
$248t_1$	No.125	No.105	No.100	No.95	No.90	No.85	No.80	No.75	No.70	**No.65**	No.60	No.65 tray arrives at 11F
$366t_1$	No.184	No.164	No.159	No.154	No.149	No.144	No.139	No.134	**No.129**	No.124	Finish	No.129 tray arrives at 10F
$484t_1$	No.243	No.223	No.218	No.213	No.208	No.203	No.198	**No.193**	No.188	Finish		No.193 tray arrives at 9F
$602t_1$	No.302	No.282	No.277	No.272	No.267	No.262	**No.257**	No.252	Finish			No.257 tray arrives at 8F
$720t_1$	No.361	No.341	No.336	No.331	No.326	**No.321**	No.316	Finish				No.321 tray arrives at 7F
$838t_1$	No.420	No.400	No.395	No.390	**No.385**	No.380	Finish					No.385 tray arrives at 6F
$956t_1$	No.479	No.459	No.454	**No.449**	No.444	Finish						No.449 tray arrives at 5F
$1064t_1$	No.533	No.513	**No.508**	No.503	Finish							No.513 tray arrives at 3F
$1190t_1$		**No.576**	Finish									No.576 tray (last) arrives at 3F

Note: Each tray is passed from one staff member to the next at intervals of t_1 sec for upward transport. Tray numbers correspond to the total sequence of meals delivered, with 64 meals allocated per floor (excluding the 4th-floor operating theater). The last tray arrives at the 3rd floor at 1190 × t_1 sec. Given that t_1 = 3.49 sec, the total time required to deliver all trays is approximately 4153 sec (69 min 13 sec).

Source: Kamimura et al., 2026

As number of active wards decreased, both the required staffing and total delivery time decreased in an approximately linear fashion (Figure 3).

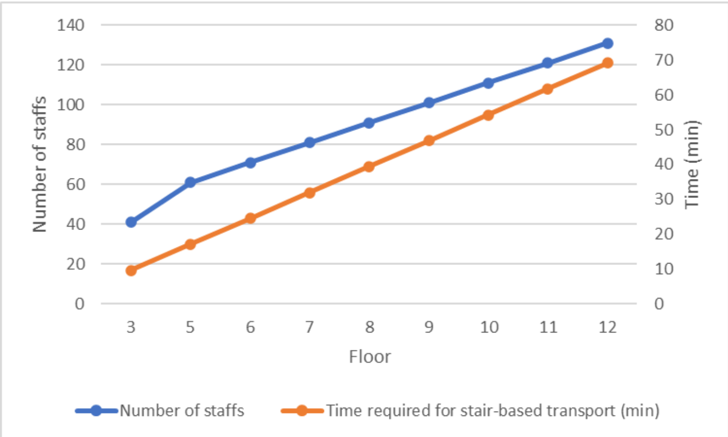

Figure 3. Estimated Staff Requirements and Transport Time for Stair-Based Meal Delivery According to the Highest Occupied Inpatient Floor During an Elevator Outage.

Source: Kamimura et al., 2026

Note: The blue line shows the total number of staff and the orange line shows the estimated time needed to deliver meals to all active wards. The number of required staff depends on the highest occupied floor, whereas the total time required depends on the lowest occupied floor.

DISCUSSION

This study is the first to quantitatively evaluate the feasibility of stair-based manual relay systems as an alternative means of meal delivery in hospitals during elevator outages caused by large-scale disasters. The results demonstrated that delivering 64 meals to multiple inpatient wards would require over one hour of transport time and the involvement of approximately 130 staff members, highlighting the substantial operational burden associated with such contingency procedures and providing a simple framework for estimating staff allocation and transport time that can also inform planning for other forms of vertical logistics during disasters.

Elevator outage during disasters can critically impair hospital functions, including patient transport, meal delivery, and the distribution of medications and blood products. Timely meal provision, in particular, should not be regarded as a low-priority task, because delayed or interrupted feeding can jeopardize glycaemic control in patients receiving insulin therapy and undermine hygiene and food-safety standards, thereby posing additional risks to patient outcomes. From a disaster-resilience perspective, maintaining reliable meal delivery is also essential for sustaining routine ward operations and overall hospital functionality during prolonged system disruption. Following the Great East Japan Earthquake in 2011, approximately 9,000 elevators (2.4%) out of 370,000 units in the affected region were reported to have sustained damage. Among disaster base hospitals in Iwate, Miyagi, and Fukushima Prefectures, 17 of 216 elevators (8%) across 62 buildings in 20 hospitals were rendered nonfunctional (11). In Miyagi Prefecture specifically, only 2 of 13 designated disaster base hospitals in Miyagi Prefecture had operational elevators on the day of the earthquake. Seven hospitals restored function by the second day, while four remained inoperative on day three, and two facilities experienced prolonged outages. At Tohoku University Hospital, elevator restoration began the day after the earthquake, but full functionality across all units was not achieved until 11 days later (6). These experiences underscore the necessity of assuming prolonged elevator unavailability in disaster preparedness planning.

Mobilizing a large number of staff for stair-based meal delivery inevitably entails redeployment from other critical duties, and the opportunity cost of such reallocation is substantial. In addition, when elevators are inoperable, other essential items must also be transported via stairwells, further increasing the human workload. Prolonged standing on narrow staircases, repeated forward bending during tray handovers, and load-bearing repetitive tasks may increase the risk of accidents such as slips, trips, and falls, as well as musculoskeletal disorders including low back pain. Our simulation was conducted under relatively idealized conditions that did not account for cumulative fatigue or occupational safety issues, and the times and staffing levels we report should therefore be interpreted as approximate upper bounds on achievable performance during an actual disaster. Consequently, hospitals should proactively simulate scenarios in which clinically stable inpatients are discharged early or transferred to other facilities, thereby reducing the number of active wards and meal recipients, to estimate the extent to which required staff and transport times can be reduced. Identifying such operational “breaking points” in advance may help institutions define realistic limits for stair-based systems and allocate scarce human resources in a way that balances staff workload and safety with the need to maintain essential services.

To mitigate the impact of elevator outages, several strategies have been proposed, including pre-positioning emergency rations on each floor (6), using disposable tableware, limiting the provision of spill-prone items such as miso soup, and temporarily relocating ambulatory patients to lower floors. However, when physical delivery remains unavoidable, our findings suggest that the associated human resource demands are considerable. Particularly during breakfast and dinner hours, staff shortages and fatigue may elevate the risk of operational errors or injury. Although implementing a two-line relay system may shorten delivery time, it would require even more personnel and carries additional challenges such as interference between movement lanes, especially in narrow stairwells. Future research should focus on optimizing staff allocation according to stairwell design and transport routes, as well as validating feasibility through repeated drills.

Internationally, the World Health Organization’s Hospital Safety Index is widely used as a composite disaster-resilience indicator that evaluates hospital structural and non-structural safety together with key functional capacities, including power supply, maintenance of lifelines, and elevator operation (12). At the national level, the importance of meal provision during disasters is also reflected in the Hospital Behavior Assessment Group Version 4, a standardized tool for evaluating hospital functionality following disaster events (13). In this system, meal service is classified as part of basic living functions, and failure to provide meals may directly impact patient health and even necessitate external support to ensure the stable supply and effective distribution of food (14). However, a nationwide survey of hospitals in Japan revealed that 109 out of 495 hospitals had not considered meal transportation during disaster (15). This finding highlights the need for hospital business continuity plans (BCPs) to extend beyond the kitchen operations and stockpiling strategies, and to incorporate detailed contingency measures for vertical transport—such as staff allocation, route design, and manual delivery systems. An illustrative scenario is presented in Table 3.

Table 3. Example of a Business Continuity Plan for Meal Delivery During Elevator Outage

Item	Details
Objective	To ensure the continued and stable provision of meals to inpatients in the event that all elevators become non-operational during a disaster.
Activation Criteria	All elevator systems are out of service with no prospect of prompt restoration.
Transport Method	Manual transport via stairways using a bucket relay system. Staff are stationed at regular intervals on stairways to hand off trays sequentially. Approximately 10

	personnel are required per floor. If insufficient personnel are available, unit-based relay transport is used.
Transport Route	Meals are carried from the hospital kitchen (Basement Level 2) to inpatient wards (3rd to 12th floors) via stairways. Delivery begins from the top floor (12th) to maximize efficiency.
Estimated Personnel Required	Up to 130 staff members
Estimated Transport Time	Upward delivery: approximately 1 h 9 min; downward return: approximately 44 min (based on delivery of 64 meals across all wards)
Meal Modifications	- Suspension of soup service in principle - Simplified menu options - Use of disposable containers
Pre-positioning of Emergency Meals	Stockpile of two emergency meals per patient (e.g., retort pouches or canned food) in each ward.
Personnel Deployment Plan	- Mobilization of staff from all departments - Assignment of transport personnel using a shift system
Training	- Conduct stair-based transport drills at least once per year - Use actual trays and containers to validate time requirements and workflow
Decision Flow	- If delivery to all wards is unfeasible, consider temporary consolidation of patients to lower floors - Prioritize patient safety and request external support to ensure the stable supply and effective distribution of food.
Recovery Measures	Once elevator function is partially restored, prioritize its use for meal delivery at the time of meal distribution.
Remarks	- Detailed personnel deployment models and training manuals are provided in separate appendices - The individual responsible for meal distribution during disasters is designated in the main BCP document

Source: Kamimura et al., 2026

In comparison, a previously reported repetitive stair-climbing delivery method required 30 staff members to transport 10 meals from the first basement to the sixth floor in 5 min 52 sec(16, 17). When there are insufficient personnel to support a continuous human chain, this method—where small teams or individuals carry meals while repeatedly ascending and descending stairs—may be employed as an alternative. However, it increases the risk of falls and physical exhaustion due to the repeated stair use. During tray collection, innovations such as stacking used tableware and consolidating leftovers may significantly reduce transport time.

The use of disposable tableware can further streamline the process, although its application is realistic only for very short durations due to the need for several thousand items per day.

The estimates of staffing and time requirements for stair-based transport generated in this study may provide practical information for hospital administrators and policy-makers when developing BCP and training exercises for disaster-related meal services under conditions of elevator outage. Moreover, in hospitals with limited staff or fragile infrastructure, particularly in ASEAN countries and other low- and middle-income settings, the same stair-based framework could be adapted on a smaller scale by restricting delivery to high-priority wards and combining it with prepositioned emergency meals on each floor.

LIMITATION

This study has several limitations. First, the findings are based on a single simulation conducted at a single institution; results may vary depending on training design, facility layout, and staff composition and therefore should not be assumed to be directly generalizable to other hospitals. Second, the model is intentionally simplified and may not be directly implemented in other settings, particularly large hospitals with multiple buildings or more complex internal routes; the simulation did not account for real-world complications such as contamination risks, cumulative fatigue or stairwell congestion. Moreover, the stair-based relay system evaluated in this study is applicable only to relatively light items and should not be extrapolated to the transfer of patients or large and heavy equipment. Future research should include multi-institutional simulations, as well as advanced modelling to evaluate workflow interference and logistical feasibility under realistic constraints.

CONCLUSION

This study is the first to quantitatively assess the operational feasibility of stair-based manual meal delivery in hospitals during elevator outages caused by disasters. Our findings highlight the substantial time and personnel demands required for such operations and underscore the importance of incorporating practical, evidence-based scenarios into hospital disaster manuals and business continuity plans. These results provide a valuable foundation for enhancing healthcare system resilience and ensuring continuity of care in future emergencies.

ORCID

Yutaka Igarashi : 0000-0002-4305-2850

Shoji Yokobori : 0000-0002-7409-704X

ACKNOWLEDGMENTS

This study was conducted as part of an association-led research initiative of the Japanese Association for Disaster Medicine. The authors would like to express their sincere gratitude to the Association for its support and guidance. This work was supported by the Ministry of Education, Culture, Sports, Science and Technology (MEXT), Japan, under the "Program for Formation of Advanced Clinical and Research Human Resource Centers (Support for Development of Physicians with Advanced Clinical and Research Capabilities)."

We also gratefully acknowledge the contributions of the following committee members who planned and implemented this training exercise: Professor Akira Fuse, Mr. Takehiko Kino, Mr. Kunio Hirai, Mr. Atsushi Inoue, Mr. Shinichiro Hinosawa, Mr. Motoi, Takagi, Mr. Shintaro Nagahara, Ms. Ayumi Kato, Mr. Eisuke Yoshii, Mr. Masayuki Ozaki, Mr. Taiga Hayakawa, Mr. Yuhei Matsumoto, Mr. Tomohiro Inoue, Mr. Akihiro Suzuki, Mr. Katsuhiro Sasaki, Mr. Kenji Higuchi, Mr. Ryosuke Ohashi, Mr. Tsukasa Takamizawa, and Mr. Takayuki Komaru.

FUNDING

This work was funded by a grant from the Research Aid Program of Japanese Association for Disaster Medicine for the 2025 fiscal year.

CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

ETHICAL APPROVAL

This study was conducted as part of a scheduled disaster preparedness training exercise. No personal or patient data was collected, and the study was deemed to be exempt from institutional ethical review.

REFERENCES

1. Barten DG, Klokman VW, Cleef S, Peters N, Tan E, Boin A. When disasters strike the emergency department: a case series and narrative review. Int J Emerg Med. 2021;14(1):49.

2. Melnychuk E, Sallade TD, Kraus CK. Hospitals as disaster victims: Lessons not learned? J Am Coll Emerg Physicians Open. 2022;3(1):e12632.
3. Klokman VW, Barten DG, Peters N, Versteegen MGJ, Wijnands JJJ, van Osch FHM, et al. A scoping review of internal hospital crises and disasters in the Netherlands, 2000-2020. PLoS One. 2021;16(4):e0250551.
4. ASPR TRACIE (Technical Resources AC, and Information Exchange),. Nutrition and Meal Plans: An Often Neglected Pillar of Healthcare Emergency Planning. Washington D.C.: U.S. Department of Health & Human Services; 2019.
5. Schuetz P, Fehr R, Baechli V, Geiser M, Deiss M, Gomes F, et al. Individualised nutritional support in medical inpatients at nutritional risk: a randomised clinical trial. Lancet. 2019;393(10188):2312-21.
6. Nakagawa A, Furukawa H, Kudo D, Abe Y, Matsumura T, Tanno H, et al. Importance of elevators in business continuity planning at Disaster Base Hospitals: Analysis of the experience of 14 Disaster Base Hospitals in Miyagi Prefecture after the Great East Japan Earthquake. J J Disast Med. 2013;18:9-17.
7. Nagata T, Himeno S, Himeno A, Hasegawa M, Lefor AK, Hashizume M, et al. Successful Hospital Evacuation After the Kumamoto Earthquakes, Japan, 2016. Disaster Med Public Health Prep. 2017;11(5):517-21.
8. Shimada J, Tase C, Tsukada Y, Hasegawa A, Iida H. Early Stage Responses of Intensive Care Units during Major Disasters: From the Experiences of the Great East Japan Earthquake. Fukushima J Med Sci. 2015;61(1):32-7.
9. Fallah-Aliabadi S, Ostadtaghizadeh A, Ardalan A, Fatemi F, Khazai B, Mirjalili MR. Towards developing a model for the evaluation of hospital disaster resilience: a systematic review. BMC Health Serv Res. 2020;20(1):64.
10. Federal Emergency Management Agency. Healthcare Facilities and Power Outages: Guidance for State, Local, Tribal, Territorial, and Private-Sector Partners. FEMA; 2020.
11. Kushimoto S, Shimoaki M. Elevator damage at disaster base hospitals during the Great East Japan Earthquake: survey results in collaboration with the Japan Elevator Association [in Japanese]. Journal of the Japanese Association for Acute Medicine. 2013;24:51-7.
12. World Health Organization, Pan American Health Organization. Hospital Safety Index: Guide for Evaluators. 2nd ed. Geneva, Switzerland: World Health Organization; 2015.
13. Anan H, Kondo H, Ymazawaki M, Takahashi R, Koido Y. Standardization of hospital disaster assessment and response using Hospital Behavior Assessment Group Ver. 4. J J Disast Med. 2023;28(3):85-8.
14. Munasinghe NL, O'Reilly G, Cameron P, De Alwis S, Herath HDB. Developing a hospital disaster preparedness evaluation tool for Sri Lanka - A modified Delphi study. International Journal of Disaster Risk Reduction. 2023;95:103866.
15. Fukuda I, Ikeuchi J. A national survey on disaster preparedness in medical facilities: Status of transportation, stockpiling, and disaster training in business continuity planning. Journal of the Japan Society for Healthcare Administration. 2022;59(4):147–56.
16. Tanaka H, Tsuchiya H, Horiuchi Y. Foods lift training in hospital by "Unit-relay method". J J Disast Med. 2014;19(1):55-9.
17. Cook N, Goodwin D, Collins J, Porter J. 'It's a constant changing environment, and we're just playing catch up': Hospital food services, food waste, and COVID-19. Nutr Diet. 2023;80(2):201-10.