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Extensive Data Collection in an In-Hospital Disaster Response Exercise for Evaluating Disaster Resilience

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ABSTRACT

This paper aimed to describe extensive data collection during a disaster-response exercise at a hospital in Kanagawa Prefecture, Japan. For this study, an annual exercise for a mass casualty incident, assuming a massive earthquake was considered. We collected data on the following three aspects of the exercise: judgement and decision-making, like triage, diagnosis, and treatment; in-hospital flow of patients and medical instruments within the hospital; and flow of information in and among different areas and rooms. Furthermore, this paper describes preliminary analyses of the data recorded during the exercise, including accuracy of the 1st and 2nd triage, details of patient flow, and length of stay in each area. Finally, this paper describes the data analysis required for the next step, like network analysis of inter-area communication and task analysis of the activities in each area. Furthermore, it also discusses the possibility of replicating the exercise using an agent-based simulation based on the data for a better understanding of the entire in-hospital disaster medicine process.

Keywords: Business continuity plan, Disaster, Medicine process, Task analysis, Agent-based simulation

INTRODUCTION

Disaster base hospitals in Japan, designated by local governments, are expected to play a pivotal role in regional disaster medicine (Ministry of Health, Labour and Welfare, 2019). They are required to formulate a business continuity plan (BCP) and conduct training and exercise at least once a year. Through these training and exercises, they are expected to master the necessary response procedures and identify problems in the BCP (The Small and Medium Enterprise Agency, 2022). However, it is not easy to evaluate the performance of training and exercises, especially as the scale of training and exercise increases. To solve this problem, it is necessary to record events and activities during training and exercise as much as possible and analyze them from various perspectives.

DISASTER RESPONSE EXERCISE AND DATA COLLECTION

For this study, we collected various data described in this section during a disaster response exercise at a major hospital in Kanagawa Prefecture, Japan. The hospital considered for this study, is one of the largest in the region and is designated as a disaster base hospital. The target exercise for this study is an annual exercise for a mass casualty incident, assuming a massive earthquake, in which 46 injured patients are transported to the hospital. The exercise lasted for two hours and involved approximately 50 hospital staff. The first patient arrived at the hospital 15 minutes after the start of the exercise. Immediately after the exercise started, various areas and stations were set up, including disaster response headquarters, medical command posts, triage areas, red, yellow, green, pink, fever, and waiting areas for hospitalization and surgery.

The red, yellow, and green areas represented treatment areas, the color of which indicated the severity of the patient's injuries. The red area represented the most severely injured patients, and the green area represented the least severely injured patients. The hospital prepared a pink area to treat pregnant patients. The fever area was prepared for patients with fever, assuming that there were patients suspected of being infected with COVID-19. Each area had a leader, medical doctors, nurses, and support staff. The area leader communicated with representatives of other areas, and the support staff coordinated the equipment, kept records, and sometimes played the role of a messenger. Every patient who arrived at the hospital first went to the triage post and was then triaged to an appropriate treatment area. In the treatment area, patients received a diagnosis and rapid treatment before moving on to the next step. Secondary triage was also performed in each treatment area if necessary. If primary triage was deemed inappropriate, patients were transferred to an appropriate area.

We collected data on the following three aspects of the exercise: judgment and decision-making, like triage, diagnosis, and treatment; flow of patients and medical equipment in the hospital; and flow of information in and between different areas and rooms. For data on judgment and decision-making, we collected documents used in the exercise, like triage tags and medical charts. For other data, we used action cameras attached to hospital staff, station cameras to observe activities in specific areas, IC recorders attached to patients and several key hospital staff, PHS-IC recorders attached to area leaders to record inter-area communications, zoom recordings for online communications, and observers to record inter-area patient transfers.

DATA ANALYSIS

This section describes the preliminary analysis of the data.

Accuracy of Triage

Tables 1 and 2 show the accuracies of the first and second triage, respectively. These tables represent the expected triage made by an exercise planner and the actual triage performed during the exercise. Over-triage implies that the actual triage is higher than the expected triage, and under-triage implies the

Table 1. Result of the first triage.

		Expected triage					Over-triage
		Red	Yellow	Green	Pink	Fever	
Triage in the exercise	Red	14	2				2
	Yellow	1	9	2			2
	Green		1	11			
	Pink				3		
	Fever			2		1	
Under-triage		1	1				

Table 2. Result of the second triage.

		Expected triage					Over-triage
		Red	Yellow	Green	Pink	Fever	
Triage in the exercise	Red	11		2		1	2
	Yellow		10	2			2
	Green			15		1	
	Pink			1			
	Fever					3	
Under-triage							

opposite. The results showed that most of the triages were accurate, with four over-triage cases in each of the first and second triage, and two under-triage cases in the second triage. Although over-triage is relatively unproblematic, under-triage is extremely serious as the delay in treatment due to unnecessary area transfer increases the risk of preventable death. When we look at the details of these two under-triage cases, one involved a yellow-area patient who was transferred directly for hospitalization and the other involved a red-area patient who was discharged. While the first case was practically appropriate, the second case was obviously a triage error. Therefore, we need to further investigate why this under-triage occurred.

Patient Flow

Figure 1 shows the time-series behavior of the number of patients in the triage post and three treatment areas. The red area was overcrowded during the last 30 mins. Since the capacity of the red area is approximately eight patients, it indicated that the red area could not handle all patients in the last 30 mins. Further observation of the video recordings revealed that the area leader was busy communicating with representatives of other areas and thus, was unable to provide appropriate instructions to the staff in a timely manner. In other areas, the patients were not observed during the exercise, and all patients were processed by the end of the exercise.

Length of Stay

Table 3 provides a summary of the length of stay in each area, which includes various information regarding the exercise's performance evaluation. For example, triage is expected to be completed within 30 seconds or a few minutes; however, in this exercise, it took over seven minutes on an average. Therefore, it is necessary to further investigate why triage took a long time

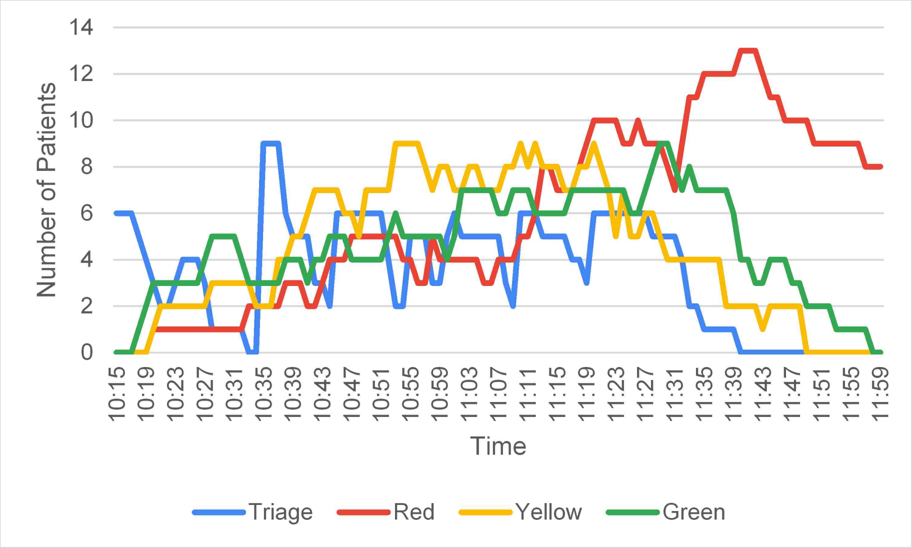

Figure 1: Number of patients in triage and treatment area.

Table 3. Length of stay (in mins.).

	Triage	Green	Yellow	Red	Pink	Waiting	Exam	Fever
Mean	7.8	30.2	31.1	30.1	15	28.8	2.1	25
Median	7	30	35	28.5	5	35	2	23.5
Max.	20	56	46	87	37	46	5	43
Min.	2	5	5	7	3	11	1	10

during this exercise. Regarding the length of stay in the treatment areas, it was found that the average length of stay did not vary between different areas. Furthermore, it was found that there was a large variance in the duration of treatment depending on patient characteristics.

For the Evaluation of Disaster Resilience

We plan to conduct further analysis of the collected data to evaluate the performance of the exercise, through ways like content analysis of the communication during the exercise, network analysis of communication between different areas, and detailed task analysis to clarify coordination. However, although it is important to analyze the exercise records from various aspects to evaluate the response performance and BCPs, it is not sufficient to assess whether the participants performed and how well they did in the exercise that can be effective in an actual disaster because there were many unrealistic assumptions and constraints in the exercise scenario. Additionally, it is difficult to conduct an exercise frequently with different scenarios and assumptions to evaluate performance and BCPs under different conditions. To overcome these limitations of the exercise-based evaluation of response performance and BCPs, we are currently developing an agent-based simulation to replicate response activities in a disaster exercise. In future, we intend to conduct a simulation using the data collected during the exercise and under realistic conditions without time reduction so that we can more accurately assess the response performance of the exercise (Umemoto et al., 2023).

CONCLUSION

In this paper, we described the extensive data collection during a disaster response exercise at a large hospital, with the goal of analyzing data from multiple perspectives to evaluate and identify problems in the hospital's response performance and BCPs. Furthermore, we also presented some preliminary results of the analysis, like triage accuracy, patient flow, and length of stay. The results of the analysis identify points that need to be closely examined, like the under-triage case and congestion in the red area. Further analysis will focus on communication and coordination between different areas, for example, through content analysis of recorded conversations and detailed task analyses of interarea interactions.

However, exercise-based assessment of response capabilities and BCPs is limited in terms of the realism of exercise scenarios and cost-effectiveness. A promising alternative is an agent-based simulation with a realistic model that allows us to run simulations under various assumptions and conditions. We are currently developing a simulation model based on detailed task analysis using collected data and interviews with subject matter experts, including exercise planners. We will assess the response performance and BCPs by integrating the exercise data analysis and agent-based simulations.

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