Chapter

Disaster Management Process Approach: Case Study by BOSS for Disaster Response under COVID-19

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Abstract

Comprehensive disaster response processes need to be managed and progress communicated to avoid ineffective management such as duplication with stakeholders, amendments as a result of leaders' incomplete instructions, and waiting without instruction from the EOC (Emergency Operation Center). As there is existing research on standardization and systematization of disaster response processes, a pure paper-based SOP (Standard Operation Procedure) is challenging to use in actual and practical situations concerning the standard workflow based on the SOP. For effective disaster management, this study developed a Business Operation Support System (BOSS). The BOSS characteristics have the standard workflow chart based on the related documents and experiences, such as the SOP, concerning manuals/documents, past experiences, and knowledge. The overview, checkpoints, necessary documents, related information systems linked to the disaster management plan, and document formats are defined in every workflow. Even for the young or non-experienced individuals, the BOSS can support the responders through the processes for necessary actions during disasters. This research aims to compare the effect of responses to the 2019 massive rain disaster in Kawasaki city, with or without the BOSS. First,a comprehensive workflow focusing on shelter management under the Coronavirus Disease 2019 (COVID-19) workshop with Kawasaki city staff and community people in the BOSS was created. Second, experiments (with or without the BOSS) were carried out to analyze the differences and the BOSS effect. "With the BOSS" means that the responders can follow the workflow in the BOSS for shelter management. "Without the BOSS" means that the conventional paper-based manuals are used for the operations. Two types of manuals in Kawasaki city were used; one guides the expected shelter management points, and the other contains the explanation about COVID-19. Members of both teams comprise one leader and two staff. As a result of the experiments, the big difference between the two teams is the leader's behavior. Because the BOSS team leader instructed the different staff works following the BOSS workflow, the BOSS team responded to more kinds of works compared to the manual team. The role of all members of the BOSS team was evident. On the other hand, the manual team responded to one work by all members, including the leader, without the leader's instruction. Due to no instruction from the leader, a period of waiting was observed in the next work manual. This research obtained that the leader's instructions' effect caused the effective responses by quantitative analysis of the demonstrative experiment. For future research, the leader's behavior and decision-making should be analyzed for BOSS's effective operation and team-building.

Keywords: BOSS, process management, disaster management, disaster response, COVID-19

1. Introduction

COVID-19 is prevalent all over the world. Different countries applied a large-scale lockdown [1], and although the lockdown is currently relaxed and economic activities have started again, the expected second wave of infection has occurred. Re-expansion occurred [2], and it has continued.

In Japan, a disaster-prone country, there is concern about the COVID-19 as it spreads. Particularly in recent years, disasters such as the 2011 Tohoku-Pacific Ocean Earthquake-tsunami disaster, the 2016 Kumamoto Earthquake disaster, and the 2018 massive rain disaster in western Japan have become more severe and frequent.

It is necessary to manage the entire disaster response processes in such a situation. Also, it is essential to manage the disaster response work process and effectively communicate the disaster response work so that there is no duplication, rework, or waiting by concerning human resources in an organization.

Regarding the operation of shelters among various disasters, schools and public halls become shelters for many displaced residents [3, 4], and various operations may coincide with the potential high risk of infection among the crowded residents. In the current COVID-19, outbreaks of infectious diseases at shelters can occur. There is currently no mention of the Basic Act on Disaster Countermeasures in Japan requiring improved living conditions in evacuation centers, such as distributing food, clothing, medicines, and healthcare services (Article 86–6). Therefore, there is an urgent need to establish an evacuation center management system that incorporates measures against infectious diseases.

As there is a concern that the COVID-19 outbreak will result in a lack of human and physical resources, the following five components are essential for sufficient disaster response work: (1) Standard workflow for disaster response, (2) Information sharing and distribution to understand the situation of dispersed evacuation centers, (3) Effective allocation and management of human resources for various kinds of situations, (4) Information management and distribution of materials and equipment, (5) Continuous follow-up on measures/policies against infectious diseases.

Regarding the standard workflow for disaster response, research on standardization and systematization of disaster response has been conducted to realize effective disaster response. The author developed a Business Operation Support System (BOSS) for effective disaster management. BOSS is a workflow system with a database that summarizes disaster response works in a workflow chart.

In this study, the BOSS was used to create a comprehensive workflow focus on shelter management for COVID-19, and the created workflow was verified in the situation of the scenario disaster. In particular, we compared the responses for shelter management with the BOSS or without the BOSS (with a conventional paper manual) and analyzed the effect of using BOSS. This study verified shelter management operations in Kawasaki City, Kanagawa Prefecture.

2. Literature review

2.1 Research on infectious diseases during disasters

Infectious diseases are often prevalent after the occurrence of natural disasters [5]. There are many cases of infectious diseases and psychological stress caused by a

massive change in the living environment due to the way of life in evacuation centers [6], food shortages, and unsanitary environments increase the risk of infectious diseases [5]. Also, an unspecified number of people live together in evacuation centers, but the area per person is small, and the rate of infections spread is high in dense evacuation centers [7]. Medical workers get tired during disasters, and they may be affected, and insufficient medical resources provision compared with typical phases contributes to the spread of infection [6].

There were many acute respiratory symptoms and acute gastrointestinal symptoms in the 2011 Great East Japan Earthquake disaster [8]. During the 2016 Kumamoto earthquake disaster, infectious gastroenteritis due to Norovirus was prevalent [9]. After natural disasters, although not limited to Japan, the outbreak of infectious diseases such as aspiration pneumonia, skin, and wound infections occurred during the 2004 tsunami disaster in Indonesia [10], and the hurricane Katrina in 2005. At that time, Norovirus infection spread in evacuation centers [11].

2.2 Research on disaster response work

Local governments often create manuals as a prevention measure. Since many disaster response works are performed in parallel and complicated activities, omissions occur in manuals [12]. Due to detailed descriptions [13], many studies have been conducted to clarify effective manual creation methods. Also, [14, 15] clarified the effects of the new system replacing manuals in the form of empirical experiments. From the operational perspective, according to [16, 17], the actual disaster response work is quantitatively analyzed.

However, although all of these analyzes actual disaster response, the effects of documents such as manuals created in advance are not mentioned.

Therefore, in this study, using an evacuation shelter case as an example, shelter operation using the BOSS under COVID-19 was conducted to quantitatively clarify the effect of the BOSS by comparing the evacuation shelter operation manual (with or without the BOSS).

3. Disaster response workflow model under COVID-19

3.1 Overview of disaster response process management system BOSS

The disaster response process management system BOSS was developed to support a disaster response process. The BOSS has a database of disaster response procedures not only during disasters but also the preparedness. It visualizes the whole image of disaster response workflow by processing knowledge related to all disaster countermeasures. By constructing a checklist of workflow, the responders can realize a comprehensive disaster response processes. Besides, although there are various disaster prevention plans in local governments, by associating the workflow with the disaster prevention plan, the relevant part of the regional disaster prevention plan can be linked and the contents of the plan can be quickly grasped. Every work has a working detail sheet that describes the implementation method (who, when, what, how), and the contents can be easily understood. Also, since it is possible to share the work details sheet by associating manuals, guidelines, past issues, and lessons, etc. which are distributed to each work, it is easy to take over the points for responses even if the person in charge of disaster prevention was changed. Since in the disaster mode of the BOSS, it is possible to mutually understand all operations' progress at the disaster response headquarters and on-site. By making the disaster response work into a flowchart style, the point of decision-

making becomes clear simultaneously, and the decision-making process can be shared among concerning stakeholders.

A process consists of three layers: large process, middle process, and small process (specific procedure). A large process is a process expressed and mainly comprises "organizations" such as departments and groups. The middle process refers to a medium-scale process expressed and mainly represents "resources" such as humans and machines and "things" such as materials. A small process is described as a small-scale process expressed in units, and mainly represents one decision-making by a single resource or an action that ends with one work [18].

3.2 How to build evacuation center operations

This research created a shelter operation workflow on the BOSS based on the Kawasaki city shelter operation manual. As a result, 244 kinds of intermediate processes were prepared (**Figure 1**).

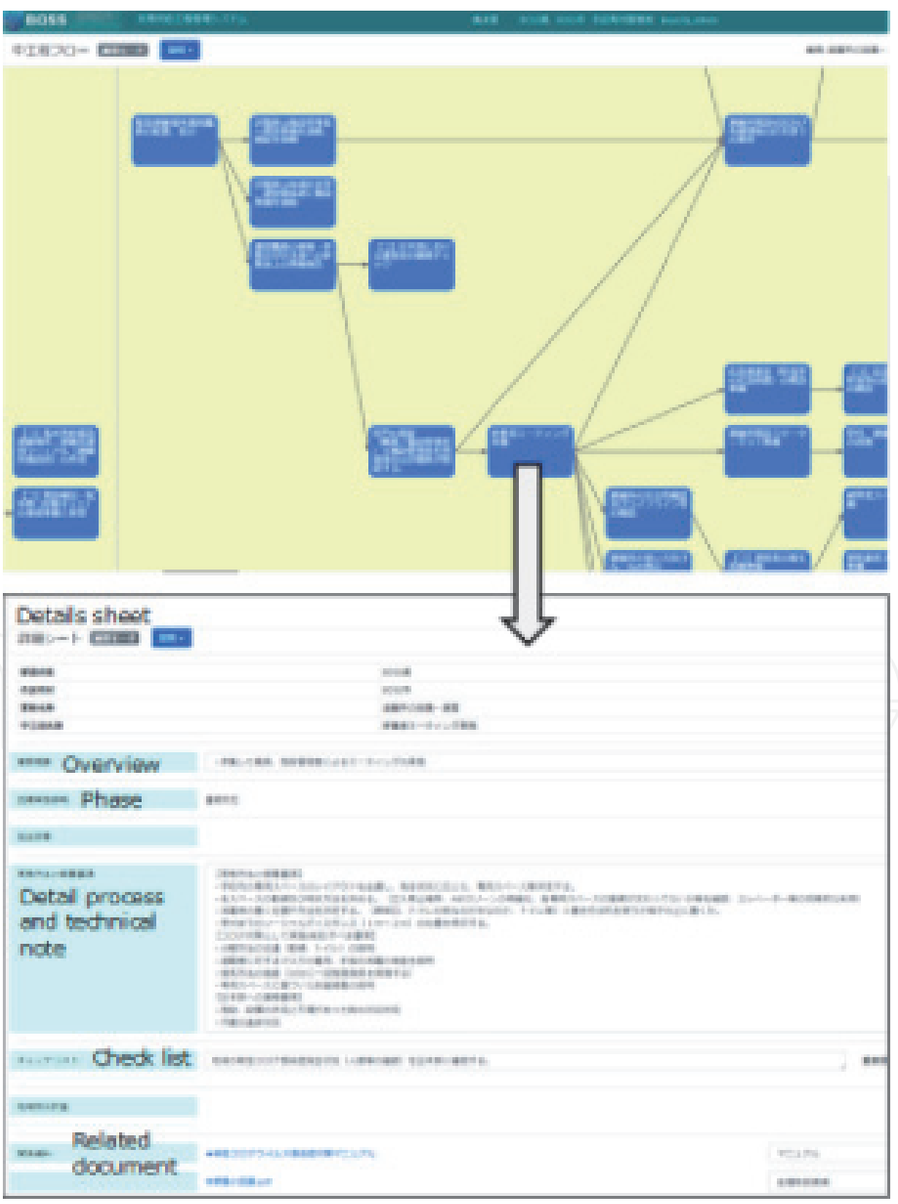

Figure 1.
Evacuation center management workflow built-in BOSS. (upper row: Workflow, lower row: Detail sheet).

As a procedure for creating the evacuation shelter, first, the shelter operation manual of Kawasaki City and the Cabinet Office's shelter operation guideline was used to list the conventional shelter operation work for each phase.

Necessary activities were extracted to construct a flow chart on the BOSS according to the workflow by the workshop with Kawasaki city members.

The following operations have been added as specific operations related to COVID-19 [19, 20].

a. Zoning inside the evacuation center. Depending on the conditions of the evacuees, zoning for non-concentrated space, vulnerable people shall be performed, and each space shall be set up for special attention, such as the position of toilets.

b. Response at reception. At the reception, it is necessary to check the physical condition of the evacuees. Temperature checks will be carried out, and self-reported physical conditions will be assigned to each space.

c. Hygiene equipment. Masks, goggles, gloves, and protective clothing are required to maintain responders' health who come into contact with an unspecified number of evacuees. If it is difficult to obtain them, alternative options should be used.

d. Securing social distance. Evacuees should be kept at a distance of more than 1 meter between each space—furthermore, the waiting line at the reception to prevent the spread of the infection.

e. Regular disinfection and ventilation. Hand sanitizers are necessary to prevent contact infection at various places in the evacuation shelter, such as at the reception, each living space, and around toilets. Regularly disinfect handrails and doorknobs. It is necessary to change the air by deciding the interval and time, such as performing ventilation for 10 minutes.

Regarding the created flowchart in the BOSS, a detailed sheet explaining the work details was also created (**Figure 1**). In this detailed sheet, each work's know-how was designed by describing the work outline, response phase, detailed procedures and notes, checklist, and related documents. The BOSS includes various manuals such as Operation manual for emergency evacuation in case of different hazards such as COVID-19 countermeasures in evacuation center operation (plan) in Kawasaki City.

4. Outline of the experiment

This study compared and verified evacuation shelters' operations with or without the BOSS in the case of flood disaster in Kawasaki City, Kanagawa Prefecture under COVID-19. Kawasaki City managed a large-scale disaster for the first time due to the 2019 East Japan Typhoon, subject to the Disaster Relief Act. During the typhoon, Kawasaki city analyzed the weather information and used a disaster warning system two days before the typhoon was closest. The city prepared and responded with the attitude of "thinking the worst-case and doing everything that should be done." However, as a result, various kinds of issues became apparent, such as the fact that information on the site was not reported to the headquarters (EOC, emergency operation center).

Based on this experience, the BOSS can be used to improve disaster response and verify how to change the operations.

Verification experiments will be conducted twice, and the differences will be discussed.

4.1 First experiment: June 24, 2019 (Wednesday)

4.1.1 Overview

On June 24 (Wednesday), 2020, at the Kawasaki City Higashi-Kokura Elementary School Gymnasium, the experiment about operations of the evacuation center with the BOSS or without BOSS (with conventional paper manual) were performed.

In the experiment, at the scenario setting, the number of people who tested positive for COVID-19 was increasing in Kawasaki City for several days, and heavy rain fell due to the linear rainbands around noon on that day. Level 3 evacuation preparation was organized at 14:10. The evacuation was issued for vulnerable people such as the elderly. It was set to prepare for the establishment of an evacuation center.

4.1.2 Verification category

In the experiment, the team was divided into two groups: the manual team (without the BOSS) and the BOSS team (with the BOSS), and both teams operated the shelter simultaneously. Each team consisted of three members. The manual team was staffed by the Saiwai Ward staff of Kawasaki city, and the Kawasaki City Crisis Management Office staffed the BOSS team. The structure of the three-members teams consists of one leader and two staff.

Also, the gymnasium of Higashi-Kokura Elementary School was divided into two spaces, the left side of **Figure 2** was the manual team, and the right side was the BOSS team.

Two manuals were used by the manual team as the shelter operation manual for wind and flood damage (Manual 1) and COVID-19 countermeasures in evacuation center management (Manual 2). The former is an evacuation shelter operation manual in the event of a typhoon disaster. However, as the manual does not include measures for COVID-19, the latter manual was also used to supplement the points of infectious disease. **Tables 1** and **2** show the principal works of each manual.

4.1.3 Characteristics of each team

The characteristics of each team member are described here. The manual team leader is a staff member in his second month, who joined the Kawasaki city office as a new graduate this year and is in charge of the disaster management department. The other members are staff members in their fifth and fourth years and contribute to promoting the city development department at the Saiwai Ward government office of Kawasaki city office. All of them are new graduates and have no experience as business/private company members. They have received training on storm and flood disasters this year but have no experience in operating shelters during real disasters.

On the other hand, the BOSS team leader is a staff member who has been working for the Kawasaki city office for five years. After working at the ward office for three years, the leader was transferred to the Kawasaki City disaster management department and has short-term experience in operating evacuation centers during typhoons in the 2019 East Japan typhoon disaster. Members consisted of the

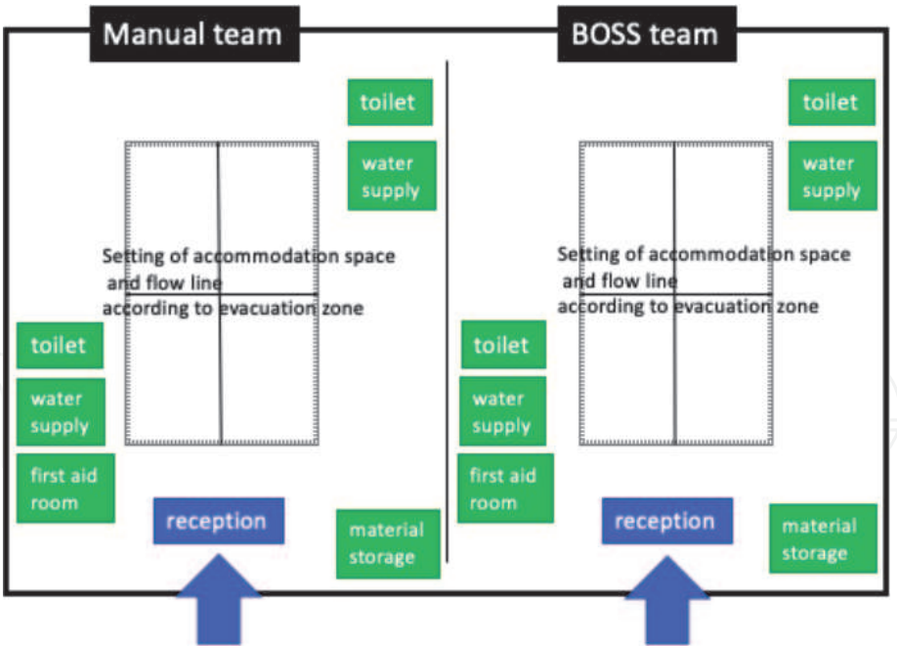

Figure 2.
Gymnasium classification.

Work Description	Specific Content
Meeting	Confirmation of work to be performed on a time series basis
	Division of roles
Reception	Reception card
Improvement of acceptance environment	Pet, animal space
	Simple air mat in space for people who need consideration
	Toilet paper
	LED lantern
Confirmation of communication	Contact to ward headquarters

Table 1.
Contents of the emergency evacuation center operation manual in case of wind and flood damage (manual 1).

Work Description	Specific Contents
Securing evacuation space exclusively for levers	separating evacuation space
	Separating toilets and flow lines
Confirmation of goods	Thermometer
	disinfection liquid
	Mask
	Goggles
	Tape for social distancing

Table 2.
Contents of measures for COVID-19 in evacuation centers (manual 2).

mid-career members. One member has passed two years at the disaster management department after twelve years of working with a private company. The other has passed seven years working for the Kawasaki city office. All members had

training on HUG (Hinanzyo Unei Game, shelter management imagination game) education several times.

Besides, the BOSS installed a personal computer at the evacuation center's reception desk and arranged to check the BOSS flowchart to operate the works (**Figure 3**).

Both teams confirmed the response of a young leader with relatively little experience in real disasters.

4.2 Second experiment: Tuesday, august 4, 2020

4.2.1 Overview

Under COVID-19, both teams tried to operate evacuation shelters at Kawasaki City Nakanoshima Elementary School with shelter management committee members, school staff, and ward office staff held at Nakanoshima Elementary School in Kawasaki city on Tuesday, August 4, 2020.

Table 3 summarizes the positioning of each experiment. In the first experiment, although the BOSS team leader has limited experience in actual shelter management, the BOSS team is more advantageous. Therefore, in the second experiment, the leader of the BOSS team should be a new employee who has no experience of actual shelter operation and how to utilize BOSS, and the members should be senior staff rather than the leader. Also, verify that young leaders can effectively direct older members. On the other hand, the leader is a staff member who has experience operating shelters for the manual team.

In the first experiment, the BOSS team leader was a young staff member with experience, but the leader can be instructed by the BOSS with past knowledge.

4.2.2 Verification category

As in the first session, participants were divided into a manual team and a BOSS team, and each team carried out evacuation center operations at the same time. The number of people in each team consisted of 5 people, with 1 leader and 4 members.

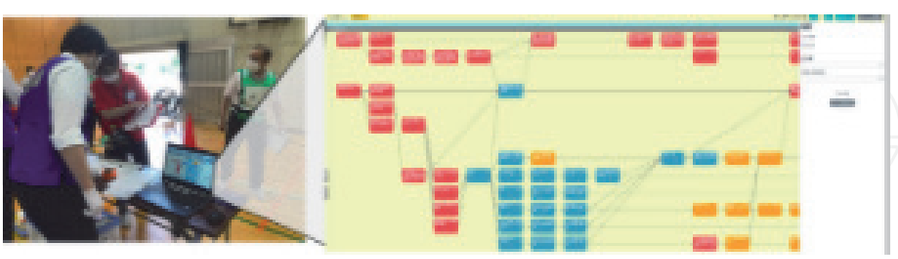

Figure 3.
How the BOSS team uses BOSS.

Experiment eases	Team type	Leader	Member	Preparation
First experiment	Manual team	Inexperienced young	Inexperienced young	None
	BOSS team	Experienced young	Inexperienced young	None
Second experiment	Manual team	Experienced mid-level	Experienced mid-level	Prepared before the experiment
	BOSS team	Inexperienced young	Inexperienced mid-level	none

Table 3.
The positioning of each experiment.

The manual team is a staff member of the Tama Ward, the evacuation center staff member at Nakanoshima Elementary School. The BOSS team is a staff member of the Kawasaki City Crisis Management Office, but a staff member different from the first member was assigned. The manual team also set up a reception area near the staff entrance on the first floor, and the BOSS team set up a reception at the adjoining doorway for children.

4.2.3 Characteristics of each team

The manual team leader is instructed by a mid-level staff who has experience in disaster response and gives them instructions. On the other hand, the BOSS team leader is in charge of the young staff member who had no disaster response experience, and the member is a middle-ranked staff member. This research confirmed whether a young leader without know-how could instruct members using BOSS.

4.2.4 Preparation

In the second experiment, the manual team conducted similar training a day before the experiment to confirm the flow of the experiment's day. On the other hand, the BOSS team had no experience establishing shelters and only checked the manual and BOSS in advance.

The manual used by the manual team was the shelter operation manual at the time of storm and flood damage (**Figure 4(a)**) in the first instance, and the content was mainly text. However, in the second instance, the storm and flood damage kit (As shown in **Figure 4** (b) was used as a mission to understand the work even by paper-based documents.

4.3 Contents of verification experiment and verification method

In the first experiment, both teams carried out preparations to open an evacuation center, accept evacuees, and cooperate with the evacuation center and the disaster response headquarters. Regarding cooperation with the disaster response headquarters, it was requested to contact the ward headquarter while the shelter

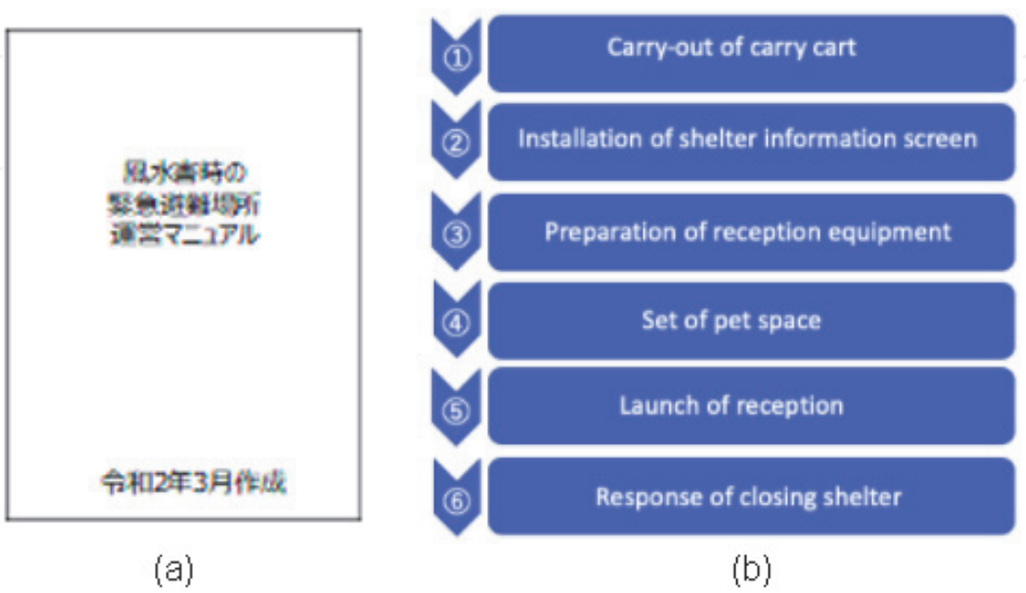

Figure 4.
(a) Emergency evacuation site operation manual in case of wind and flood damage (cover). (b) Flood damage kit (workflow).

was opened. The scenario, such as "for home-care patients with a positive PCR test, contact a medical institution. I started to carry it" was prepared in this experiment. Both teams need to report and share the situation with the ward headquarters that it is ready.

On the other hand, in the second experiment, the teams did not contact the ward headquarters, only the evacuation shelter was opened, and the differences between the manual and BOSS teams were analyzed.

Regarding the use of the facilities in the experiment, the first team was to use only the gymnasium, and the equipment such as classrooms, toilets were set up virtually.

The following five suggestions were used in the verification process. (1) For time, the minimum unit was 30 seconds = 0.5 minutes, and work-hours were recorded. (2) Regarding the operator's movement, a fixed video camera was installed, and the operator's movement was confirmed. (3) Regarding the leader's instructions, the activities were recorded with a voice recorder including the leader's statement. (4) Regarding the omissions of work, the manual and BOSS contents were compared with the contents of work performed during the verification test. (5) Regarding the participants' impressions and opinions, this research conducted a questionnaire survey and grasped the work's impressions.

5. Results of the first experiment

For the first experiment, the manual team had 23.5 minutes to complete the work, and the total number of work was 17. On the other hand, the BOSS team had 20.5 minutes to complete the work, and the total number of work was 24. The BOSS team carried out more works than the manual team.

The hypothesis is that manual teams do not take instructions from the leader and everyone tends to do the same work and duplicate the work. While on the other hand, the BOSS team leader gives instructions to the members, and each person works in parallel at the same time. It is conceivable that the work was achieved while being aware of the division of roles. Here, this research will verify the hypothesis by analyzing the leader's actions and each member while comparing the manual team and the BOSS team centering on the Gantt chart.

5.1 Gantt chart

Figure 5 shows the Gantt chart of three members in a manual team. The horizontal axis is the time (minutes), the vertical axis is the working name, yellow is the working time to complete a task by one person, orange is the work done by multiple people simultaneously. Gray represents the waiting time. Once all three members of the manual team finish the same work, they do the same work again in the second half, and there is much rework. However, time is running out.

On the other hand, **Figure 6** is a Gantt chart of three BOSS teams. Mr. C and Mr. D (like Mr. C and Ms. D for convenience in this research) have finished the work they started once and then moved on to the next work, and there is almost no rework. Incidentally, after 19 minutes, Mr. C seems to have accumulated from the start of the work because he was waiting for other members to finish their works. After that, contact sharing was started, and the work status was confirmed as a whole. Overall, the BOSS team did not see any rework in simple work and did not observe any waitings.

The big difference between the manual team leader and the BOSS team leader is that the manual team leader tends to do the same work as the member, but the

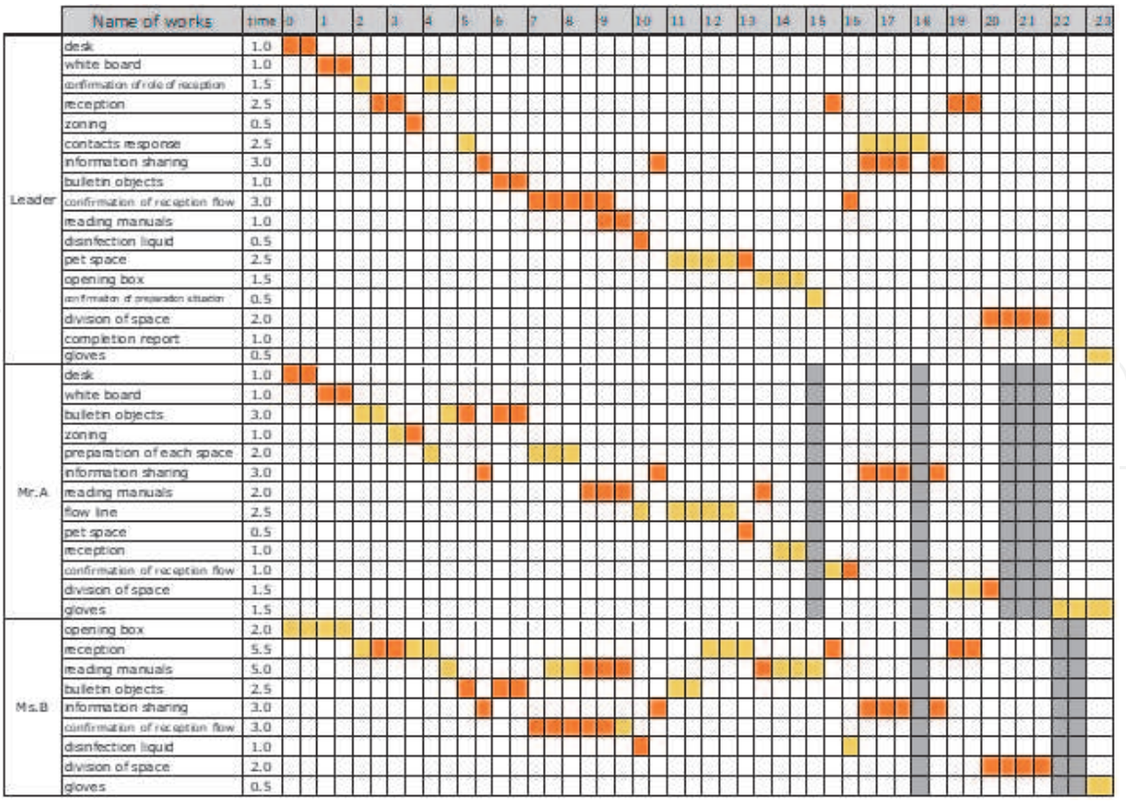

Figure 5.
Gantt chart of three people in a manual team (min.)

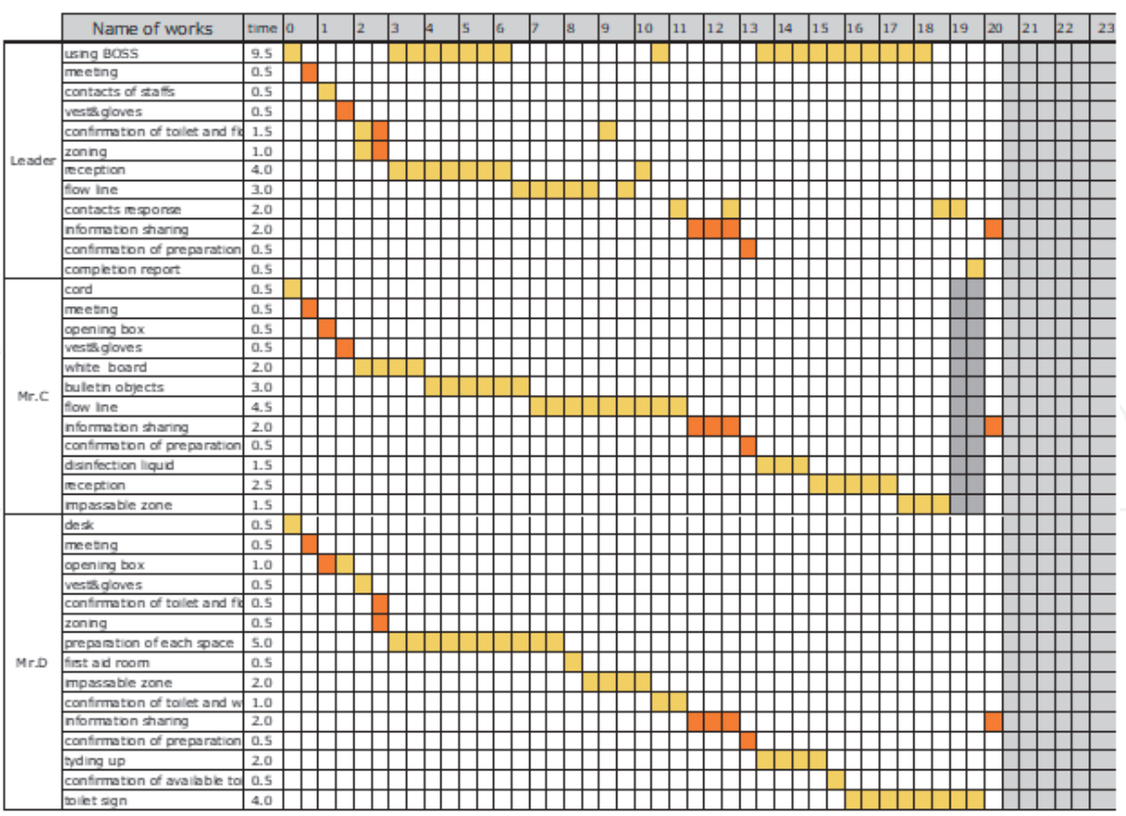

Figure 6.
Gantt chart of three people in a BOSS team (min.)

leader of the BOSS team instructs the members to work. The BOSS team leader tended to be around receptions to operate the BOSS, manage overall progress, and give instructions to members.

5.2 Waiting time

Next, analyze the waiting time. **Figure 7** shows each team's waiting time. **Figure 7(a)** shows the manual team waiting time, and **Figure 7(b)** shows the BOSS team waiting time.

Two members observed the waiting time in the manual team due to waiting for the leader's instructions. On the other hand, since the leader responded while instructing each member of the BOSS team, there was almost no waiting time. Although Mr. C's waiting time was observed, he has completed all the instructed work and is waiting for other members' work to be completed.

Comparing the two teams shows that the manual team has a long waiting time than the BOSS team. The manual team did not receive any instructions from the leader and thought about what kind of action to take in each case centered on the leader. So, since there was no instruction, a waiting time occurred. Also, regarding the three members' actions, there was a tendency to simultaneously perform the same work, and no clear division of roles was observed. On the other hand, the BOSS team leader gave instructions to the members while confirming the workflow of the BOSS, and the members reported to the leader when the instructed work was over and received the next instruction. Since the leader instructed the work while checking the BOSS, the leader did not hesitate to wonder which work to carry out.

5.3 Number of works

When comparing the manual team and the BOSS team, the manual team members performed the same work with all three members without explicit instructions from the leader, so the manual team worked more than the BOSS team. Therefore, here, the number of works was focused on and compared.

Figure 8(a) shows the number of works performed by three manual team members. Here, the work was classified as "response work (simple work), contact/confirmation, and see manual." The works are directly related to the evacuation center establishment; contact/confirmation is contact with the ward headquarter. This result refers to sharing information and confirming the content of work.

Among the three members, the number of work done by the leader was the largest. The reason is that the leader carries out the response work by himself. It was also seen that three members were doing the same work simultaneously by multiple members.

Figure 8(b) shows the number of works performed by the three members of the BOSS teams. Like the manual team, the work was categorized into three types:

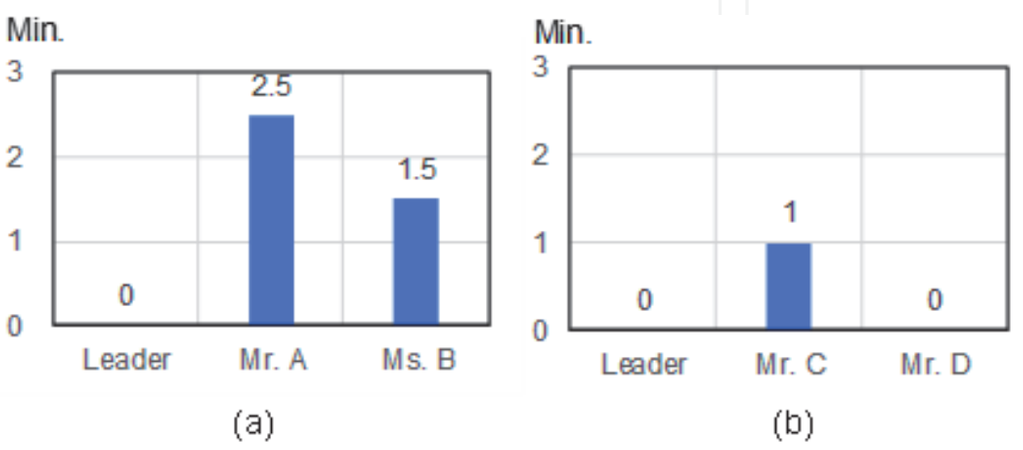

Figure 7.
(a) Manual team waiting time (unit:Minute). (b) Boss team waiting time (unit:Minute).

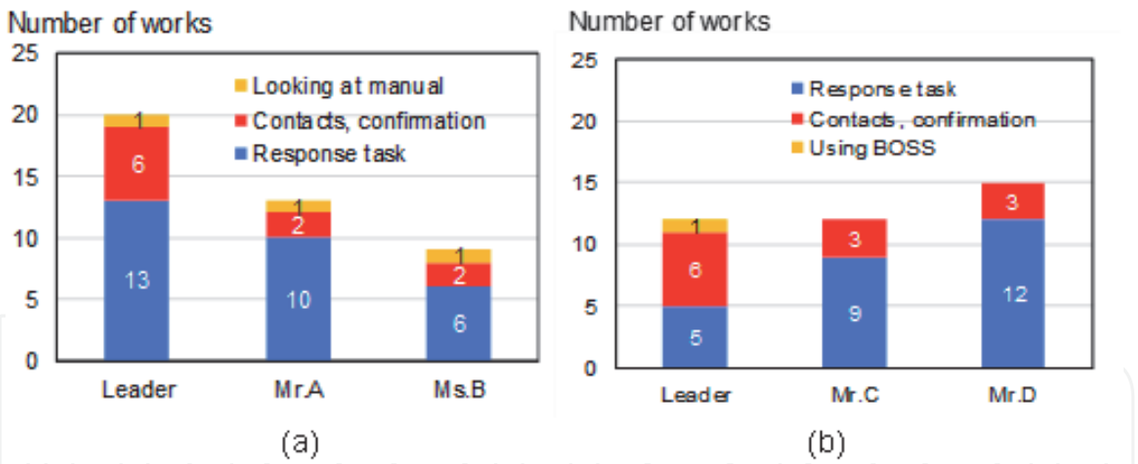

Figure 8.
(a) Number of works performed by 3 people in the manual team. (b) Number of works performed by 3 people in the BOSS team.

"response work (simple work), contact/confirmation (meeting), and BOSS operation." As a result, the number of tasks performed by the leader is the same as the number of tasks performed by Mr. C, but the number of tasks for simple tasks is the smallest. This result indicates that the leader mainly acted on instructing the members, and the members were performing the instructed work. The leader also operated the BOSS alone, shared the BOSS screen with the members, and managed the progress while telling the members the current position in the overall workflow.

5.4 Number of works by number of people

The manual team was observed to have three members doing the same work simultaneously, but here, this research analyzes to what extent multiple people were doing the same work.

Figure 9(a) shows the working time by the number of manual team members. The "1, 2, 3," on the horizontal axis means the number of people who simultaneously worked on the same task. According to this, the total number of working time by one person and the total number of working time by two persons are almost identical. The number of contacts/confirmations is more significant in the tasks performed by two people than in the tasks performed by one person. Besides, the time for simple work by two or three people is significant.

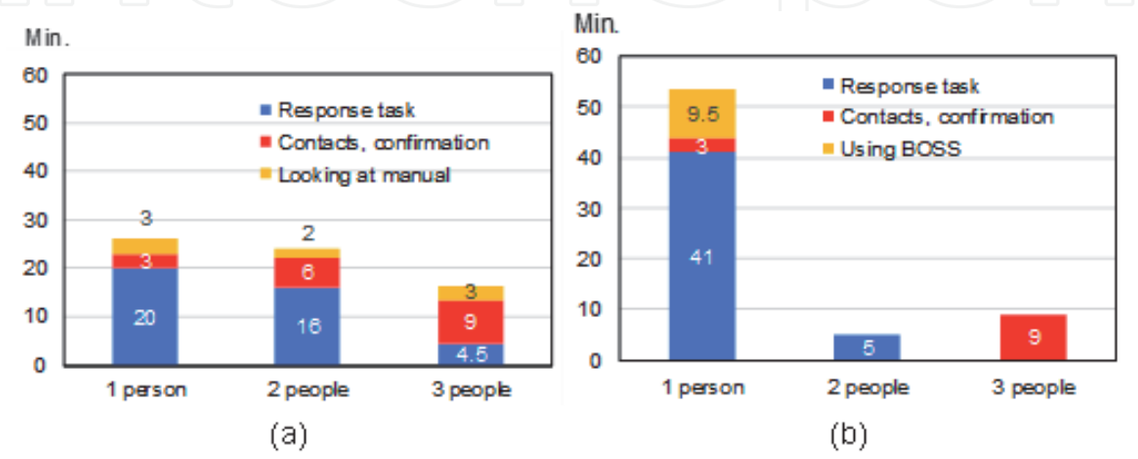

Figure 9.
(a) Working time by the number of the manual team. (b) Working time by the number of the BOSS team.

Figure 9(b) shows the work-hours by the number of members in the BOSS team. As shown in **Figure 9(a)**, while the manual team spends much time working with multiple people, members of the BOSS team almost always worked alone. It was also observed that multiple people did not perform simple work together because the three people's work was for sharing the situation, such as the meeting.

In other words, the manual team worked on a single task by multiple people simultaneously, but the BOSS teams simultaneously carried out different tasks in parallel.

5.5 Working time by business

Figure 10 shows the working time of each team. **Figure 10(a)** shows the working time by the manual team's work. The preparation for a reception is the time consuming, and three people work together. The next task that took a long time was information sharing. In terms of information sharing, it was often used as a time when the three members were considering what to do next. Also, "confirmation of reception flow" in the third was used to examine the reception flow. Regarding the top 5 works with the most work time, there was a strong tendency that three people were doing the same work simultaneously or with a certain amount of time.

On the other hand, **Figure 10(b)** shows the working time by the work of the BOSS team.

Like the manual team, it takes time to prepare for reception and share information. Since three people gather to share the situation, it means that three people work together, but for other things, there are many tasks that one person does, such as setting up "each space" and "flow line (reception)". The tasks performed by the three people were contact sharing, sanitary equipment, confirmation of preparation status, and meetings, all of which can be said to be tasks that should be performed by all.

In other words, it can be said that the BOSS team was working independently, except for those who were required to respond to multiple people.

Figure 11 shows the working time by both teams. Regarding the working time by business, it can be seen that the BOSS team generally performs various types of works in a short time. On the other hand, the manual team has a longer work time

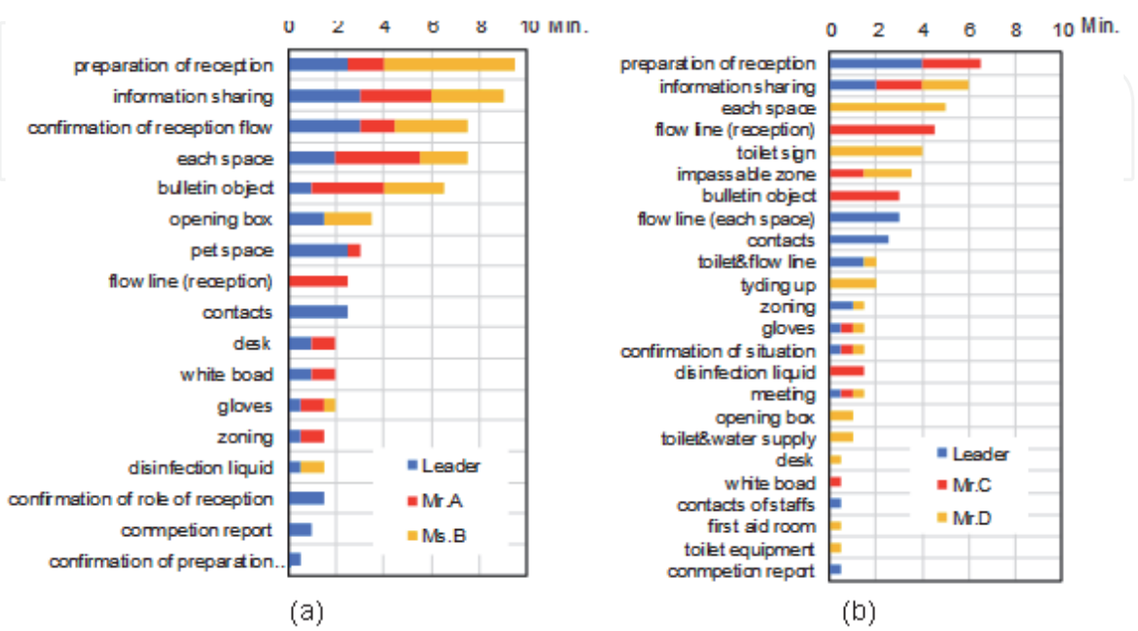

Figure 10.
(a) Work-hours by work of the manual team. (b) Work-hours by work of the BOSS team.

for each work because the manual team often works with multiple people, so the sum of the entire team's working time increases.

Regarding the kind of work, the manual team's work, but the BOSS team did not respond: "Confirmation of reception flow, the setting of pet space, confirmation of the role of reception." The manual team spends much time confirming the reception flow, and they were doing shelter opening work while discussing the next reception each time. While the pet space was set up according to the shelter opening kit, the BOSS team carried out the work according to the BOSS workflow because there was a note on the detailed sheet of the BOSS workflow.

The BOSS team did not set up a pet space because the set up of a pet space was not included in the workflow.

Also, the tasks that the BOSS team did were to display the toilet guidance and the impassable zone, clean up the opening kit, check the location of the toilet and water system, but the manual team did not carry out these tasks. In comparison, the number of operations performed by the BOSS team is larger than the manual team. All of these works are registered in the BOSS. In other words, if works are not registered in the BOSS, responders may omit the responses, so it is necessary to enhance the flowchart in the BOSS.

5.6 Omission of work

Table 4 shows the manual team's work during the verification test concerning the work content described in the manual. Many Xs indicate that the work was not performed and that many of the work had been omitted.

On the other hand, **Table 5** shows the BOSS contents and the BOSS team's work during the experiment. If both the start and end of the work are entered, it is considered that the work is completed. Besides, when nothing is inputted, it is regarded as non-performing work and is represented by X. The work indicated by the diagonal lines was excluded because it was set to be already performed in the experiment scenario. As a result, one work has been omitted.

5.7 Leader's statement

Table 6 shows the statements of the leaders of both teams. The manual team leader seemed to ask other members for their opinions and think while working

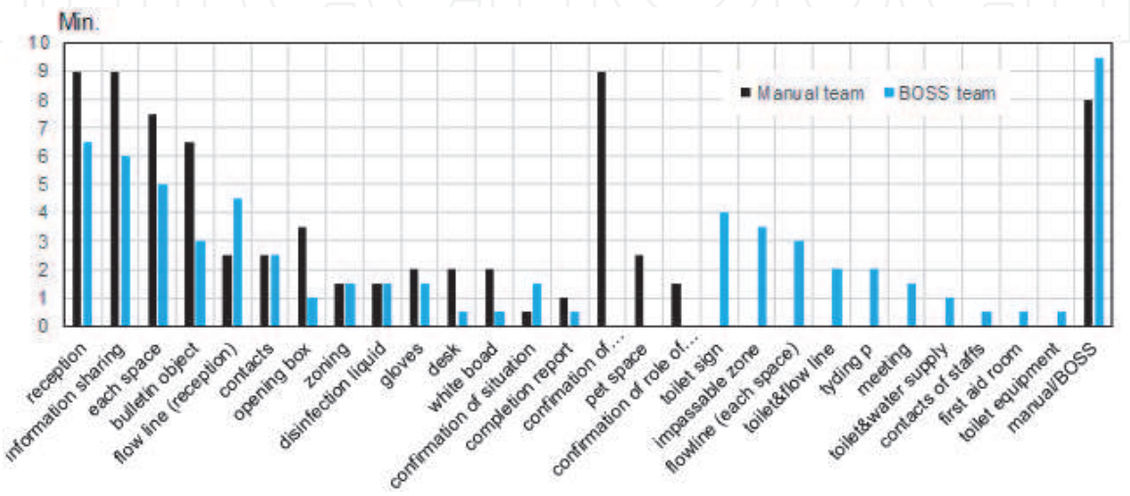

Figure 11.
Working time of each team by business (unit: Minutes).

Name of the works	Specific content	Whether or implement
Meeting	Confirmation of work to be performed on a time series basis	×
	Division of roles	×
Reception	Reception card	○
Improvement of acceptance environment	pet space	○
	Simple air mat in space for people who need consideration	×
	Toilet paper	×
	LED lantern	×
Confirmation of communication	Contact to ward headquarters	Δ(start×, end○)
Information guidance	Shelter information screen	○
	Arrow sign	○
	Reception	○
	Rules of evacuation life	○
Securing evacuation space exclusively for fevers	Separating evacuation space	○
	Separating toilets and flow lines	×
Confirmation of goods	Thermometer	○
	Disinfection liquid	○
	Mask	○
	Goggles	×
	Tape for social distancing	○

Table 4.
Manual contents and tasks performed by the manual team during the verification test.

together. Also, since he is speaking while considering the next action, he often asks the members questions or confirms the questions asked.

On the other hand, the BOSS team leader, while checking the workflow in the BOSS, thinks about who will do what and cuts it, so he gives instructions to the members. While confirming whether it has been done, the next work instruction is given.

Since the work contents are organized as a workflow in the BOSS, it is possible to decide the responses while looking at the overall image. So, there are a few omissions. Also, since all members can confirm the same workflow, it gives the impression that activities can be performed with the same purpose in one team.

6. Results of the second experiment

Based on the results of the first experiment, we conducted the second experiment.

6.1 Difference between the first and second experiments

6.1.1 BOSS contents and usage manual

Table 7 shows the contents of the manuals used by the manual team in the second experiment. In the first experiment, the conventional evacuation shelter

Name of the works	Whether or implement
Transport of necessary materials from the stockpiling warehouse	/
Confirmation of evacuation shelter safety and lifeline	/
Meeting	○
Opening box	○
Confirmation of the place of use in the facility	/
Bulletin object	×
Installation of a reception desk and shelter information board	○
Preparation of hygiene equipment for the operator	○
First aid room	○
Preparation of dense contactor space	○
Preparation of space for people with fever and poor physical condition	○
Preparation of space for people who need consideration	○
Preparation of space for healthy people	○
Disinfection liquid	○
Confirmation of the number of available toilets and equipment	○
Installation of guide signs for available toilets	○
Completion report	○

Table 5.
BOSS contents and tasks performed by the BOSS team during the verification test.

Manual team	BOSS team
-You have to secure a flow line for this. Where do you want to go?	-First of all, please Mr. C will make decisions about the classroom.
-I'd like to attach a little glue to the intervals when I was waiting at the shelter.	-First of all, Mr. D, please overhang the bulletin board.
-Mr. A, do you want to guide? At B's reception.	-Mr. C, is it OK to secure a space for those who need attention?
-Arc you going to separate it roughly? What do you do? Then, do you want to do it all, for the time being?	-Mr. D, may I ask you to check the toilet equipment?

Table 6.
Statements (instruction) of leaders to the staffs.

operation manual and COVID-19 countermeasure manual were used. However, in the second experiment, one manual that summarizes evacuation shelter operation in flood damage under the COVID-19 was used.

Table 8 shows the number of works registered with the BOSS in the first and second experiments.

Based on the first proof experiment, the content of work for the immediate response and the initial response was updated, and the number of works increased. In the initial response, four works were added between the first and second rounds, and in the immediate response, there were changes, including slight changes in work names, but 20 works were added overall. Specifically, the work was revised, as shown in **Table 9**. For one work, there are a variety of other works because the work was set to be performed sometimes in the same workflow. For example, there

Work Description	Specific Contents
Carry-out of carry cart	Transport from stocking warehouse
Installation of shelter information screen	Installation of shelter information screen
	Confirmation of reception place
Preparation of reception equipment	Non-contact thermometer
	Disinfection liquid
	Mask
	Gloves (if necessary)
	Face guard (if necessary)
	Pet card
	Cheek sheet
	Reception card
	User list for people who need consideration
	Health check-list
Pet space	Bulletin object
	Blue sheet

Table 7.
Contents of manual.

Phase	First experiment	Second experiment
Prevention	54	54
Preparedness	90	110
Initial response	28	32
Emergency response	66	66
Reconstruction/Recovery	6	6
Total	244	268

Table 8.
Number of operations in the BOSS for the first and second experiment.

is "(Periodical) Ventilation and disinfection" because the leader and members gradually became less aware of the infectious disease during the first experiment. They contacted each other and treated the evacuees politely. To maintain the basic principles against common infectious diseases (such as dense avoidance, hand washing, disinfection, ventilation.), tasks such as "Ventilation and disinfection" and "Thorough avoidance of three dense situations in evacuation shelters" were performed to raise awareness of infectious disease control regularly.

In the first experiment, the manual team carried out the "installation of pet space" in the immediately preceding response, but the BOSS team did not, and the reason was that the BOSS was not in good condition. Since it is considered, the task of "setting up pet space" was added to the BOSS.

6.2 Results of the second experiment

As a result of the second experiment, the manual team had 32.5 minutes to complete the work, and the total number of works was 10. On the other hand, the

Phase	Name of the works	First experiment	Second experiment
Preparedness	(Regularly) Ventilation and disinfection	—	4
	If a dense contact person who knows in advance arrives, it will be accepted into the accommodation space once	1	—
	If a dense contact person who knows beforehand arrives, it will be accepted into the accommodation space	—	2
	If the symptom worsens, request emergency transportation	2	—
	Physical condition management and follow-up	1	2
	Wearing masks properly and thoroughly disinfecting fingers		1
	Evacuee receptionist: Preparation for confirming the health status of evacuees	1	—
	Thorough avoidance of three Cs situation in evacuation shelter	—	2
	Pet space	—	1
	Transport request to medical institution	1	—
	Disinfection of frequently contacted bans (handrails, doorknobs, etc.)	—	2
	If the symptom worsens and the urgency is high, call 119 and contact the ward headquarters	—	4
	If the symptom worsens, request an emergency transportation	1	—
	Final confirmation of set location	—	1
	Situation management of dense contactor space	—	1
	Dense contact person transportation completion report	1	2
	Providing information to evacuees, updating from time to time	1	—
	Set of information equipment (TV, whiteboard) for evacuees	1	—
	Provision of information provision equipment (TV, whiteboard) to evacuees, provision of information *Updated thereafter	—	1
	Confirming the number of evacuees	—	4
	Installation of evacuation center information screens, etc.	—	1
	Thorough avoidance of three Cs situation in evacuation shelter	—	2
Initial response	(regularly) Ventilation and disinfection	—	1
	Confirming the number of evacuees	—	1
	Thorough avoidance of three Cs situation in evacuation shelters	—	2

Table 9.
Descriptions of works in the BOSS modified between the first and second experiment.

BOSS team had 36 minutes to complete the work, and the total number of works was 15. This result means that the BOSS team carried out more jobs because the manual team has 0.31 work/minute and the BOSS team has 0.42 work/minute in terms of unit time.

6.2.1 Gantt chart

Figure 12 is a Gantt chart showing the work performed by five people in the manual team and the required time. The horizontal axis represents the time taken (minutes). The vertical axis represents the work done. Yellow is the work time for one person, orange is the time performed by multiple people simultaneously, and the gray shows the waiting time.

In the first half, it can be seen that work once completed can be resumed later. The waiting time is seen in the middle stage and the latter half. Some works were completed in the intermediate stage, and the members were unsure what to respond to next. A member who finished early waited for other members to complete their work in the second half.

One characteristic of the manual team is that the leader took the initiative and delivered it to other members.

Figure 13 is a Gantt chart showing the work and time required by the five members of the BOSS team.

There is almost no rework, and each work is completed before moving on to the next work. Therefore, less waiting time is seen. In the latter half, some waiting time occurs. The time taken for all members to complete their works was defined as the work completion time by the team; the person who completed his work earlier waits for other members to finish theirs.

6.2.2 Waiting time

Figure 14 shows each team's waiting time. **Figure 14(a)** shows the waiting time for the manual team, and **Figure 14(b)** shows the waiting time for the BOSS team.

It could be seen that the manual team had a longer waiting time than the BOSS team. In particular, according to the Gantt chart (**Figure 12**), Mr. E, Ms. G, and Ms. H continue to wait without any instructions during the work.

Also, regarding the BOSS team's waiting time, although Mr. K had a waiting time in the middle stage, the waiting time was not long (**Figure 14(b)**).

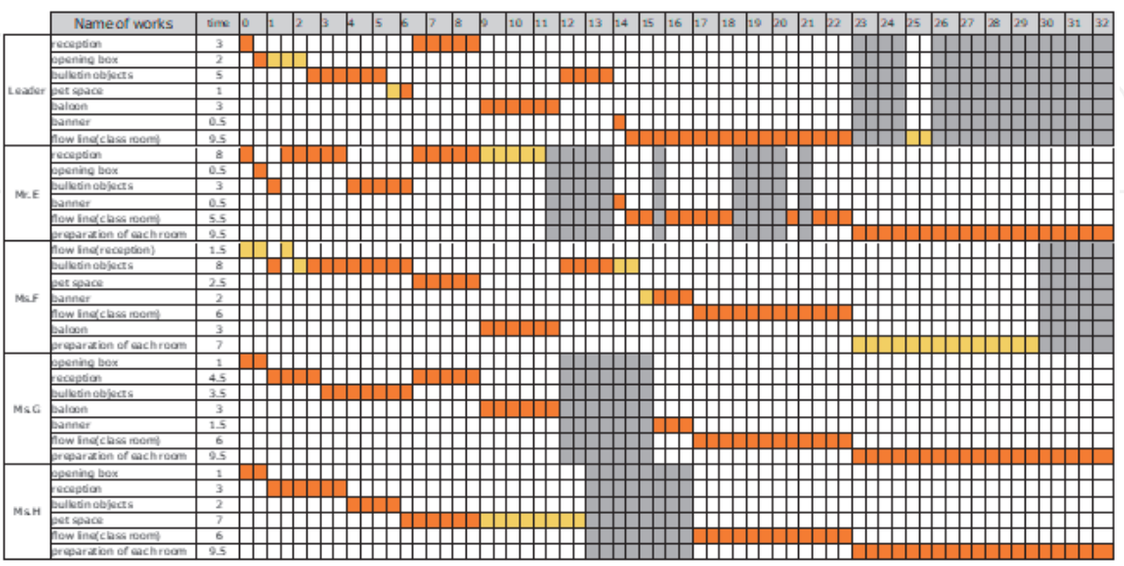

Figure 12.
Gantt chart of five people in the manual team (min.).

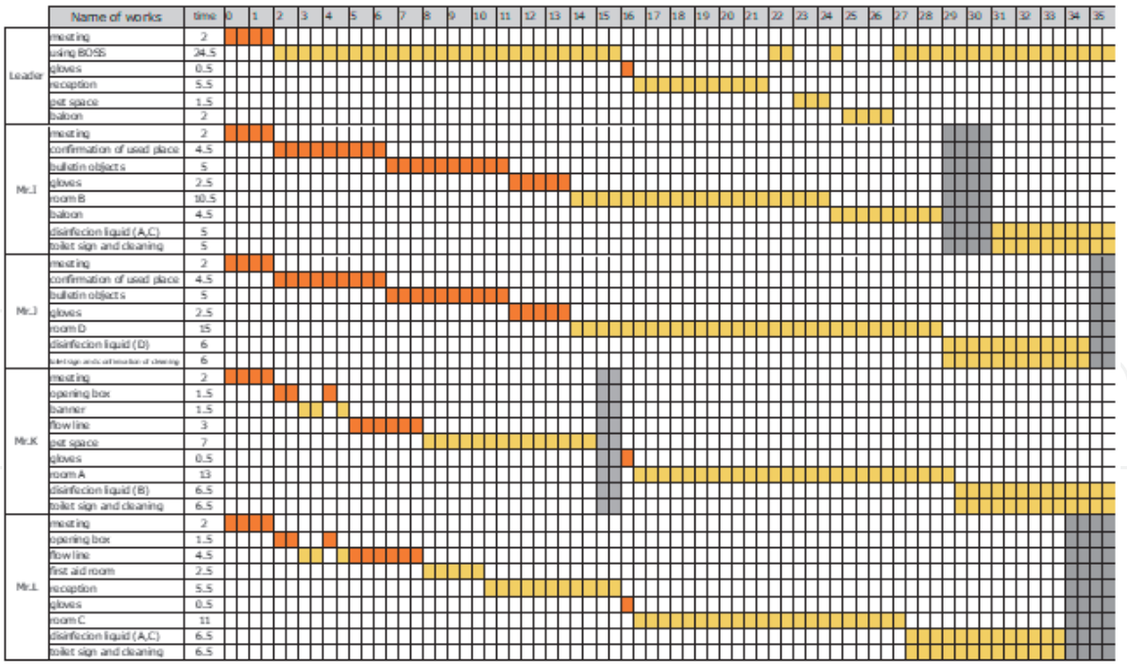

Figure 13.
Gantt chart of five people in the BOSS team (min.).

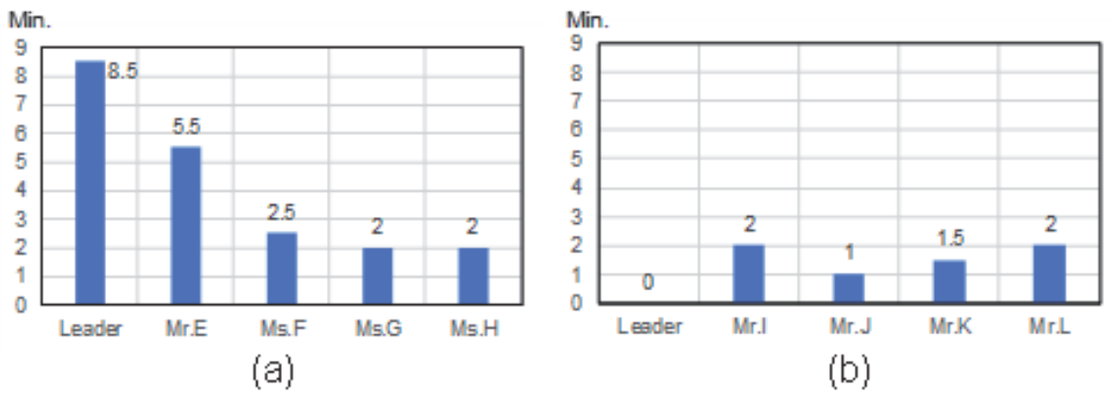

Figure 14.
(a) Waiting time of the manual team (unit:Minute). ***Figure 14(b)*** *Waiting time of the BOSS team (unit: Minute).*

6.2.3 Number of operations

Figure 15(a) shows the number of tasks performed by the five members of the manual team. The number of tasks performed by the leader and the number of response tasks (simple tasks) is the largest. The leaders and members are working while discussing for the next task. The leader was not looking at the manual, but Ms. G and Ms. H checked occasionally. This is because the manual team prepared the works a day before the experiment (in advance), and the leader took the initiative.

Looking at the Gantt chart, the manual team started the experiment without having a meeting to share the leader's response plan and instructions. In contrast, the BOSS team had time to hold a meeting with members to confirm the work content.

Figure 15(b) shows the number of operations performed by the BOSS teams. The number of tasks performed by the leader and the number of simple tasks is the

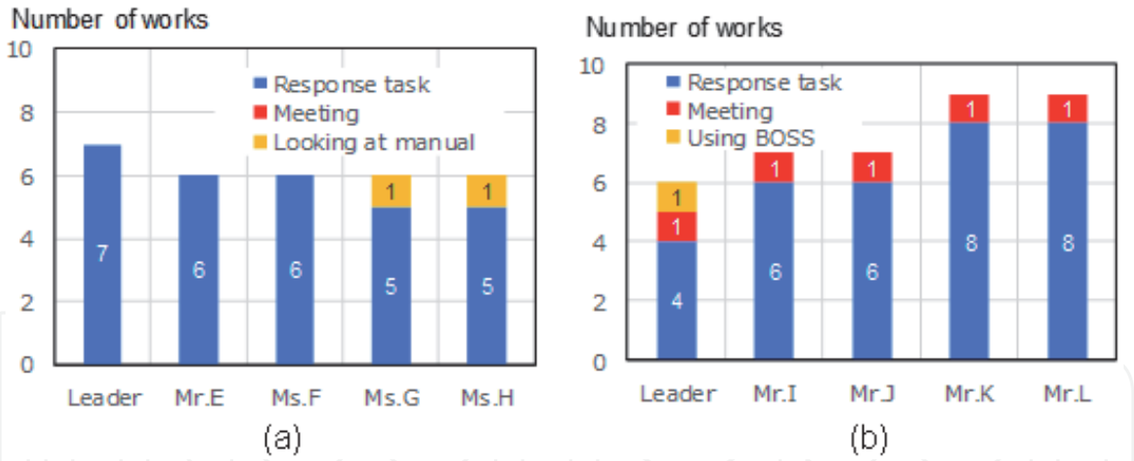

Figure 15.
(a) Number of tasks performed by 5 people in the manual team. (b) Number of tasks performed by 5 people in the BOSS team.

smallest. The leader instructed the members about the work contents by having a meeting with the members and only the leader performed the BOSS operations.

6.2.4 Working time by the number of people

The manual team received few instructions from the leader and worked while appropriately considering the members, and the leader took the initiative in responding. Hence, it is probable that multiple people worked. Therefore, this research analyzes how various people work at the same time.

Figure 16(a) shows the working time of each member of the manual team.

The same work was carried out by 4 members most often, and all members often did the same work. The response task (simple work) consisted of 1 to 5 people.

Figure 16(b) shows the working time of each member of the BOSS team. According to the table, one of the members did the most work. Although there are times when three members work at the same time, they did different works separately. The same type of work was not performed by four people simultaneously, and the work performed by all members at the same time was only the meeting.

6.2.5 Working time by business

Figure 17(a) shows the working time of each task performed by the manual team.

It took time to prepare the classroom and set the flow line to the classroom. This result includes the time required to move from the reception to each classroom.

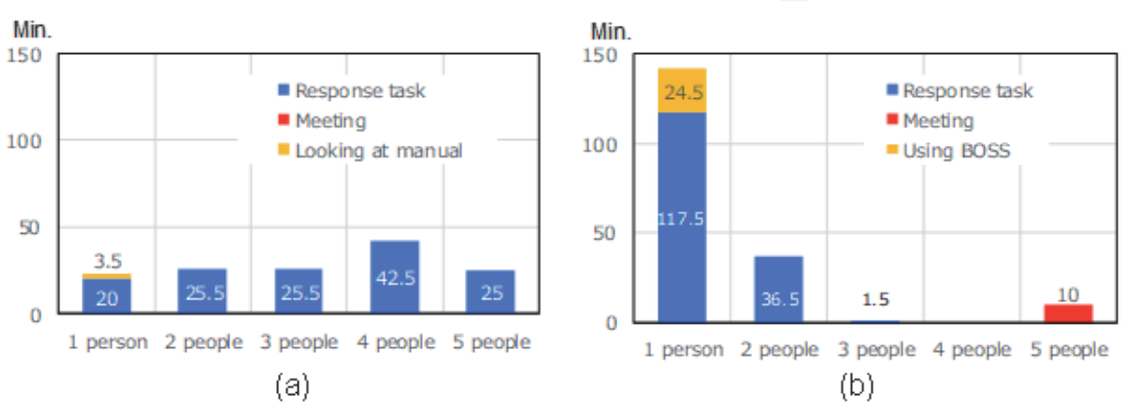

Figure 16.
(a) Working time by the number of the manual teams. (b) Working time by the number of the BOSS teams.

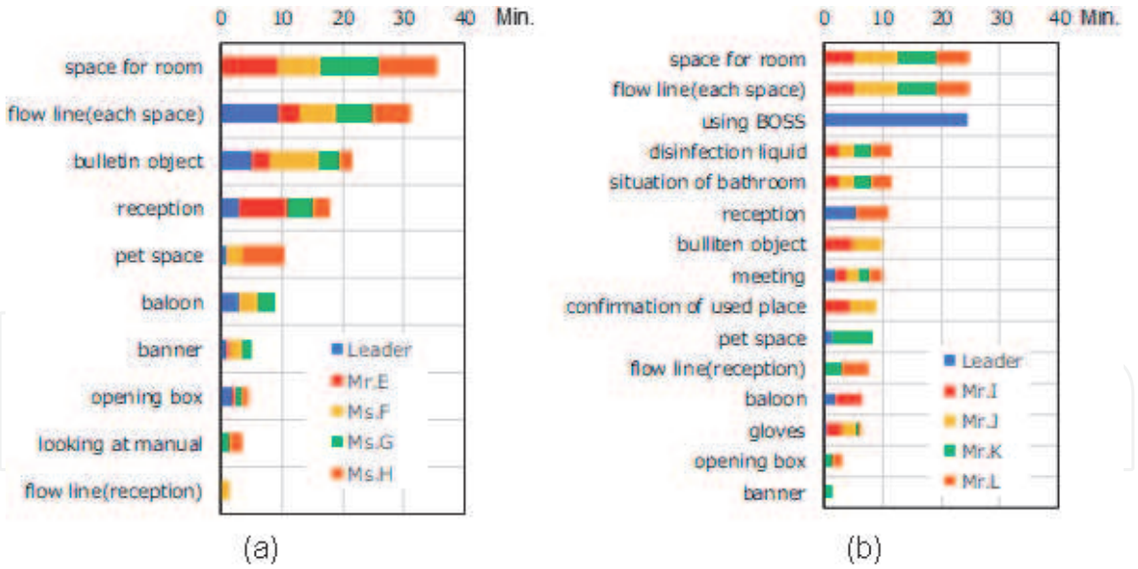

Figure 17.
(a) Work-hours by the manual team (unit: Minutes). (b) Work-hours by the BOSS team (unit: Minutes).

Besides, the leader is often involved in simple work and heads the classroom. All five people set the flow line and overhung the bulletin board. Furthermore, multiple people respond to the same work.

Figure 17(b) shows the working time of each task performed by the BOSS team. As with the manual team, it took time to prepare the classroom and set the classroom flow line. While operating the BOSS, this research focuses on grasping the work's progress by receiving instructions and work completion reports from other members. Furthermore, suppose multiple people do the same work. Work-hours are the same for the classroom preparation, setting of the flow line toward the classroom, installation of the disinfectant in each classroom, and confirmation of the toilets' status by the leader's instruction.

Figure 18 shows the working time of each task performed by both teams.

The manual team spends more time on each task.

On the other hand, the total number of tasks performed by the BOSS team is enormous: the BOSS team performs all functions carried out by the manual team. It then confirms the toilet's status and the facility use location not performed by the manual team. All of these tasks are included in the BOSS.

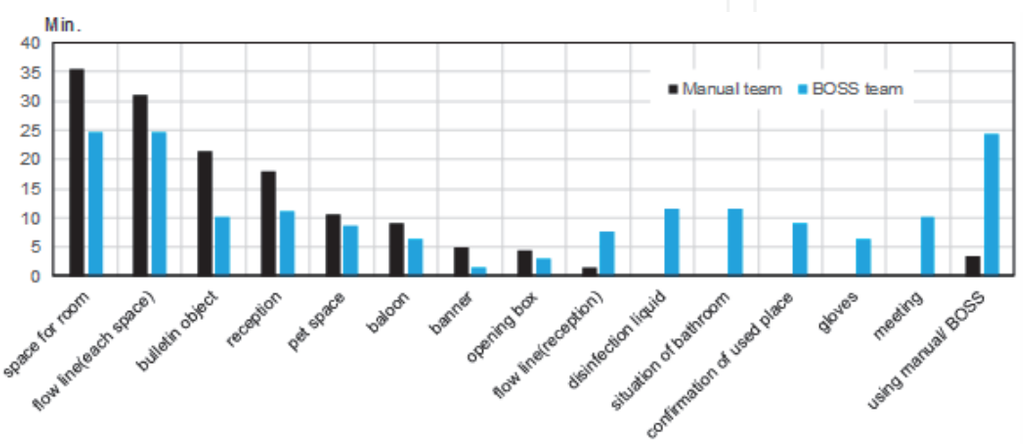

Figure 18.
Working time of each team by business (unit: Minutes).

6.2.6 Omission of work

Table 10 shows the manual's contents and the manual team's work during the experiment test. Gloves and face guards were not prepared. It was stated, "If necessary," and it may have been decided that it is not necessary.

Table 11 shows the BOSS contents and the work performed by the BOSS team during the verification experiment. If both the start and end of the work are entered, it means that the work is completed and represented as ○. However, if the work is started but it is not completed, it is represented as △. All works in the BOSS contents were carried out, and no omissions occurred.

6.2.7 Leader's statement

Table 12 shows the statements of the leaders of both teams.

While the manual team leader performs the task, instructions were to the nearby member in the form of handing over the task. The leader is not aware of who should do the task. The team leader gives instructions while confirming what work should be done by other members.

On the other hand, the BOSS team leader specifies who will do what task and add a description of the specific work content. Besides, while confirming the completion of work, the next work instruction will be given.

7. Opinions of participants

Table 13 shows the opinions of the participants obtained from the questionnaire.

Participants' opinions as seen by their work can be regarded as subjective opinions, while visitors as objective opinions comparing both the manual and the BOSS team.

Name of the works	Specific contents	Remark
Carry-out of carry cart	Transport from stocking warehouse	○
Installation of shelter information screen	Installation of shelter information screen	○
	Confirmation of reception place	○
Preparation of reception equipment	Non-contact thermometer	○
	Disinfection liquid	○
	Mask	○
	Gloves_(if necessary)	×
	Face guard_(if necessary)	×
	Pet card	○
	Cheek sheet	○
	Reception card	○
	User list for people who need consideration	○
	Health check-list	○
Pet space	Bulletin object	○
	Blue sheet	○

Table 10.
Manual contents and tasks performed by the manual team during the verification test.

Name of the works	Remark
Transport of necessary materials from the stockpiling warehouse	○
Confirmation of evacuation shelter safety and lifeline	○
Meeting	○
Opening box	○
Confirmation of the place of use in the facility	○
Installation of evacuation center information screens, etc.	○
Bulletin object	○
Installation of a reception desk and shelter information board	○
Preparation of hygiene equipment for the operator	○
First aid room	○
Preparation of dense contactor space	○
Preparation of space for people with fever and poor physical condition	○
Preparation of space for people who need consideration	○
Preparation of space for healthy people	○
Disinfection liquid	○
Confirmation of the number of available toilets and equipment	○
Installation of guide signs for available toilets	○
Pet space	○
Final confirmation of set location	Δ
Completion report	Δ

Table 11.
The BOSS contents and tasks performed by the BOSS team during the verification test.

Manual team	BOSS team
-Let us create a reception first.	-Mr.K and Mr.L, please prepare the opening box.
-Let us put a mask on the entrance	-Next, Mr. K and Mr. L, please prepare the sanitation equipment of the operator. Prepare masks, gloves, face guards, and ponchos.
-The flow line is the one with the arrow. Is it okay if I put it on the floor?	

Table 12.
Statements of the leaders of both teams.

From these opinions, it is considered that the BOSS has a significant advantage since it can grasp the whole flow.

Since the work can be grasped in the form of a flow chart, it is easy to understand the work to be performed next, and the instructions of the leader are apparent. It can be said that the instructions can be given while prefetching the flow. Clear instructions from the leader lead to a sense of security for the staff who act upon receiving the instructions and can prevent confusion at the worksite.

8. The BOSS effect

As shown in **Table 14**, the effects of the BOSS are summarized in terms of quality, cost (burden), and period (working time).

Administrator
• As the person in charge of the command confirms, the next work to be done is precise, and if there is a shortage or mistake in the work I did, it will be pointed out immediately and as a position to engage in the shelter for the first time.
• It is easy to understand because it is organized into a workflow, and the activities arc organized. Also, since the start and end can be discriminated by color, there is a little omission of what to do.
• Because everyone sees one workflow, I felt that I could act with the same purpose. Also, I felt that the quickness and efficiency of contacting the headquarters increased, and that the collection of information at the headquarters was significant.
• While confirming the overall flow chart, I gave work instructions, and if there was room, I could look at two ahead and work based on the progress situation.
• The instructions from the leader of the BOSS team were clear, I have followed them strictly, there was no confusion about what to do at the site, and a smooth setup was possible.
Visitor
• The workflow of the evacuation shelter is chronological, so it is easy to grasp.
• The fact that the evacuation shelter's operation status is known at the headquarters, leads to a sense of security at both the headquarters and the evacuation shelter. It will lead to the simplification of regular reports and quick support from the headquarters.
• When preparing for the shelter's opening, the BOSS team seemed to be conducting instructions efficiently with the conductor looking ahead to a few hands.
• The staff is older than the leader, but the leader gave appropriate instructions.

Table 13.
Opinions of participants.

Category	Overview
Quality	• Q depends on (1) priority of work and (2) difficulty of work (necessity of qualification and experience). • Based on this, we will provide the necessary support concerning the effective allocation of staff. Concerning the assignment of tasks to support staff from other local governments, a system will be created to secure and allocate human resources in consideration of priority and difficulty.
Cost	• C depends on (1) operations that require a large number of human resources, and (2) equipment purchases and expenditures to residents. • It is a work that requires a large number of workers, such as the operation of shelters, management of supplies, emergency risk assessment of buildings, and building disaster investigation. The load analysis of the entire work is performed to determine the concentration and distribution of personnel. Secure financial resources for processing government expenditure (other than personal expenses). Or try to minimize spending. The evaluation of cost-effectiveness due to advanced measures is also related to this.
Delivery	• D depends on (1) process length, (2) stagnation between processes, and (3) gap between supply and demand. • To understand whether the work period ends in a short time frame or takes a long time frame to improve the bottleneck. For operations that require an extended period, such as restoration and reconstruction, building an organizational system based on this is possible. • For the waiting between processes, the difference between the end and the start of each process is discovered, and the shortage of personnel, materials/equipment, and information that cause the waiting are eliminated. • The demand difference between supply and demand is that the need disappears due to the difference between the demand generation timing and the actual supply time point. It is the situation that supplies cannot be kept due to the changing needs of supplies.

Table 14.
Opinions of the BOSS effect.

8.1 Improvement in work quality by increasing the number of works (Q: Quality)

In both the 1st and 2nd cases, the BOSS team performed more tasks than the manual team as a whole. In both cases, the BOSS team spent less time doing the same job with multiple people. Since many tasks were performed, it is considered that the number of functions that could be performed increased by sharing the jobs efficiently. Also, many jobs might have been performed because there were few omissions of works. For the BOSS team only, members' tasks include checking the status of the toilet and setting up an emergency room, which will improve the quality of life of evacuees.

8.2 Reduction of the burden on the operator (C: Cost)

The use of the BOSS clarified the instructions of the leader. Under clear instructions, it is considered that the staff can move quickly, and it is unlikely that there will be a difference in movement due to experience. Therefore, it will be easier to grasp the workflow of the whole work, and it will be possible for even inexperienced leaders to give appropriate instructions. Thus, the BOSS workflow, which is the axis of action, can be useful and can reduce the mental burden on the operator.

8.3 Reduction of working time (D: Period)

The BOSS team used fewer work-hours to complete their tasks. This is because the number of people engaged in one work is reduced by appropriately sharing the work under the leader's direction, and the work as a team is small. Also, in both cases, the BOSS team spent less time doing no work and had less rework. By eliminating waste and increasing efficiency, the overall working time could be shortened. The BOSS team's general work-hours for evacuation centers were shorter for the first experiment and longer in the second experiment than for the manual team. By doing so, the BOSS team achieved a reduction in overall working time, even though it does more work than the manual team. Although in the first appearance, the manual team had previously trained in the same workflow and remembered the workflow well, so it was impossible to see the effect of shortening the overall working time in the BOSS team.

9. Conclusions

This study compared and verified the disaster response process management system BOSS activities, or without BOSS, the manual for evacuation shelter management operations under COVID-19. Two experiments were conducted to clarify the effects and issues of using the BOSS.

As a result, by utilizing the BOSS, the leader gave instructions to the members to clarify their roles. The members shared the work efficiently without duplication, waiting for instructions, and what to do next. The BOSS team had little waiting time (retention) without hesitation about what to do, there were few omissions of work, and many kinds of works were completed during the experiment time compared to the manual team. The leader's remarks were instructed and commanded for the members. It was also found that even young leaders who have no actual disaster response experience can take the minimum response by checking the BOSS workflow.

It was also found that it is necessary to include the minimum required functions in the BOSS. It was also found that it is necessary to devise ways to mechanically check important functions matters on the system, such as creating a checklist.

As a future issue, it is possible that omissions will occur if the BOSS is not entered as a workflow.

Acknowledgements

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