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Understanding stakeholders' needs for an Emergency Mobile Hospital at an infectious disease situation

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Our society suffers from unpredictable global pandemics such as COVID-19. Thus, the demand for emergency mobile hospitals for infectious diseases has greatly increased. However, the existing mobile hospitals have been developed mainly focusing on functional requirements. There is a lack of understanding of the needs of different stakeholders in a pandemic situation. This paper presents the stakeholders' needs for designing an emergency mobile negative pressure ward hospital to be used in an infectious disease situation. We conducted two studies with diverse stakeholders related to an infectious disease; 1) an interview study with 12 long-term patients in order to figure out the needs of patients, 2) a Co-design workshop study with 3 medical staff, 4 management staff, 3 engineers, and designers. The findings revealed three main needs for emotional support for patients in terms of reducing mental anxiety, improvement of the clinic environment, and increasing trust in the clinic. Also, there were findings related to managing mobile hospitals for reducing infection risk with delivering fast care of medical staff, effective operational support for manage staff, and designing to consider both medical staff and patient. We discuss the design insight and considerations for the design of emergency mobile hospitals for infectious diseases. Our work provides insights on how the user's perspective can be reflected in designing emergency mobile hospitals for the pandemic crisis.

Keywords: Infectious disease; Emergency Mobile Hospital; Design consideration; Healthcare

1 Introduction

Our society suffers from unpredictable global pandemics such as COVID-19, MERS, so the demand for negative pressure wards specialized in infectious diseases is increasing rapidly. It is a limitation to care for infectious diseases patients at negative pressure wards which are installed in existing hospitals (Castro *et al.*, 2020; Somani *et al.*, 2020). The importance of mobile hospital is increasing to prepare for infectious disease or biomedical accident because mobile hospital is operated by moving to disaster areas in an emergency situation.

The solution of mobile hospital provides more sickbed for infectious disease patients in order to control the infectious disease situation. However, it is hard to control the infectious disease patients in the situation where the number of infectious disease patients has exploded.

Although there are existing mobile hospital cases developed, it is difficult to effectively prepare for infectious disease situations. Especially, the studies of mobile hospital have focused on functional requirements such as air conditioning, disinfection, quarantine technical solution, etc (Park and Sung, 2014; Lee and Lee, 2017; Lee and Jeong, 2020). In other words, there is a lack of study on the design perspective based on the user experience in the special situation of infectious disease disasters. As a result, the current mobile hospital has not considered the empirical needs of the user-centered perspective.

It is necessary to understand the medical staff movement, patient behavior, and management of hospital to increase efficiency of mobile hospital in serious infectious disease situation. Therefore, we have to investigate emergency situation depending on the infectious disease patient's condition, medical care routine throughout understanding of the experience and contexts from stakeholders who related to stakeholders. To control the infectious disease situation, it is difficult to find a case of user-centered research about infectious disease that deal with the user experience of physical space, medical care, and patients' emotion.

The goal of this study understands what people want in an infectious disease context and suggest design insight in mobile hospital. This study aims to understand what people want in an infectious disease disaster situation and present design implications for stakeholders related to mobile hospital. In detail, this study figures out the implication of mobile hospital design based on diverse stakeholders as well as the needs of stakeholders(medical staff, patient, medical service manager, engineer, etc). The two research questions are formulated: 1) What are the needs of stakeholders at mobile hospital? 2) How do we design mobile hospital to increase stakeholders' satisfaction in user-centered perspectives?

2 Related works

2.1 The case of mobile hospital

The concept of mobile hospitals appeared among rapid changes in technology and related products and services in the medical field. Mobile hospital is a portable medical center equipped with necessary medical equipment (Sunder M, Mahalingam and Krishna M, 2020). Especially, the function is to provide medical care to patients in critical situations such as wars, natural disasters, infectious diseases, and so on. Also, the mobile hospital helps provide medical assistance to people who live in hard-to-reach areas of the world or who do not have easy access to traditional hospital services (Doerner, Focke and Gutjahr, 2007; Stephanie *et al.*, 2017).

There were diverse cases of mobile hospital of which the features could control the infectious disease effectively. After the COVID-19, the various types of cases developed in mobile hospital to immediately respond to infectious disease in the world such as air tent type such as Kare MCM((*KAIST News*, 2021), mobile container type such as MED-1 in the USA(*Atrium Health MED-1 Mobile Hospital Unit*, 2021), U-Project in Turkey (Evleri, 2021), Temporary mobile hospital in Canada (Schwartz, 2020), and Med Modular in the USA (Kotecki, 2020), and temporary structure type such

as Temporary hospital in Chin(LU, 2020) and . However, the cases of mobile hospital focused on the way of prefabricated building to consider construction time. Also, the existing mobile hospital required technical solutions such as air conditioning, disinfection, etc. to care for infectious disease patients.

Figure 1. The examples of installed mobile hospital; air tent type(left), mobile container type(middle), and temporary structure type(right)

Although the mobile hospital was helpful in terms of transportation, installation in infectious disease area, depending on the duration or nature of an infectious disease such as COVID-19, the mobile hospital and medical services might be changed. It is necessary to research the design implications for quickly coping with the unpredictable infectious disease disaster and the requirements in terms of user experience.

2.2 Understanding people's needs in infectious disease situation

Before the COVID-19 pandemic, the literature related to quarantine ward was researched to consider the interior perspective about the hospital (McKendrick and Emond, 1976; Bowen *et al.*, 2010; Xu and Zhou, 2017) and human movement (Park, Jeong and Hong, 2011). A case of the negative pressure quarantine hospital, which utilize the container module, was investigated to interior, movement of patients and medical staff, and simulation of negative pressure in quarantine hospital. Based on the literature, diverse cases for infectious disease focused reconfiguration of to minimize secondary infection for medica staff and composition of space in term of facilities aspect.

However, after the pandemic of the COVID-19, it was suggested that not physical aspect but other aspect such as emotional care, service, etc. because patients had treatment for an average of 17days (the rage 14 -19 days) at the quarantine hospital (Wang *et al.*, 2020). At the extended pandemic situation, it was necessary way to support medical staff and to solve the psychological problem of medical staff in order to reduce workload.

Previous studies are not enough to consider a user-centered perspective, so this study is required to support physical medical activities, sharing experiences among stakeholders, and reduce the psychological pressure on patients. Therefore, this study suggests the design consideration of mobile hospitals in infectious disease reflect on not only functional perspective but also user experience perspective in terms of stakeholders who are related to mobile hospital.

3 Study 1

3.1 Method

To figure out what needs from long-term patients in the hospital, we conducted an online semi-structured interview. Before the interview session, we designed an interview questionnaire based on desktop research which was related to long-term hospitalization and COVID-19 treatment. Throughout this session, we understand the experience of long-term hospitalization from user voice.

3.1.1 Participants

We recruited a total of 12 long-term patients who had experienced quarantine hospitalization; two are COVID-19 patients and the others are cancer patients (Male 7, Female 5, average age 44.7 max 62 min 24). They had the experience of hospitalization during an average of 19.4 days (max 63 min 7).

Table 1. The personal information of participants

Participants	Gender	Age	Disease type	Duration of hospitalization
Patient 1	Female	62	Cancer operation	28 days
Patient 2	Female	49	Plastic operation	28 days
Patient 3	Male	52	COVID-19	8 days
Patient 4	Female	59	Plastic operation	14 days
Patient 5	Male	62	Plastic operation	14 days
Patient 6	Male	30	Plastic operation	21 days
Patient 7	Male	33	Treatment of kidney stone	14 days
Patient 8	Female	54	Cancer operation	63 days
Patient 9	Male	25	COVID-19	14 days
Patient 10	Male	25	Nerve surgery	12 days
Patient 11	Male	61	Plastic operation	10 days
Patient 12	Female	24	Enterocolitis	7 days

3.1.2 Material

The interview questionnaires were designed from desktop research based on 94 data such as YouTube videos. the article, government guide, etc. The questionnaires consisted of three parts; First, interviewees were asked about current problems of hospitalization, Second, we asked about the issue of emotional statements during hospitalization, Lastly, interviewees answered the improvement and wishes of future hospitals. There were detailed questions as below:

- Could you share your hospitalization experience related to the name of a disease, current condition, and daily life in the hospital?
- What do you have difficulty with long-term hospitalization related to the ward and hospital environment?

- What is the difficulty of communication with medical staff?
- Could you talk about your emotional state during hospitalization?
- What do you want to improve in the hospital environment during hospitalization?
- What do you wish for in the future hospital?

4 RESULTS 1

4.1 Key needs of long-term patients

Descriptive coding was conducted to figure out the needs of patients from long-term hospitalization. This study revealed three key needs of long-term patients at hospitalization; reducing mental anxiety, improvement of the clinic environment, and increasing trust in the clinic.

First, long-term patients wanted to reduce mental anxiety. They needed communication with medical staff and reducing emotion related to melancholy. For example, the patient expressed their anxiety about the clinic system such as “I could not connect to my doctor until the medical staff came to me or called me [….] The only way to meet with the doctor was a phone call around 9 am.” Also, patients said, “My body was uncomfortable, my mind was very depressed […] I thought that the hospital was not the place to come, and I only wanted to go home quickly.” This patient felt uncomfortable body as well as mental at the hospital.

Second, the improvement of the clinic environment was needed for long-term patients. The environmental needs are related to the problem of medical waste and food waste in the ward. Long-term patients wanted a comfort ward. The patient said, “I had to put food waste and medical garbage together in the waste bag, and I must be put it in my ward until the medical staff removed it .” Another patient said, “There are so many machines, medicines in the ward, so I want comfortable things like plants which make me psychologically comfortable.” Patient distressed to be isolated in a ward with waste. Another patient said, “My ward would be nice if it is larger than the current space” Patient needed the minimum space not to invade their territory at the ward.

Lastly, long-term patients needed to increase trust in the clinic because they had a fear of sudden changes in health in a serious case and an absence of description of treatment results from medical staff. The patients said, “I don’t know my health because my doctor tells me how I am improving and what state of my health is.” and “I want to check my health [...] the AI speaker is good or the graphic things are good about health” Patient wanted to be treated a reliable care in quarantine hospital form medical staff.

5 STUDY 2

5.1 Method

To understand the needs of the diverse stakeholders who were related to mobile hospital, this study conducted a co-Design Focus group interview. Through gathering expert knowledge, this method was embodied the existing problem in practical field (Cho, 2016). Throughout this session, this method explored the pain point in order to formulate the needs of the mobile hospital in infectious disease.

5.1.1 Participants

We recruited 10 experts who had working experience of over 10 years and were working to control infectious diseases. The stakeholder consisted of one doctor, two infectious treatment nurses, four management staff, one engineer, two design professors. There were two expert groups that six moderators managed in order to get qualitative data.

Table 2. The profile of stakeholders

Role of stakeholder	Number of people	Position	Stakeholder position
Doctor	1	Department head of the medical treatment	Medical expert
Nurse	2	A convalescent hospital nurse, Infectious control nurse	Medical expert
Management staff	4	Chief administrator, Team leader of facility management, Manager, Team leader of patient information	Management expert
Engineer	1	Mobile hospital engineer	Engineer expert
Professor	2	Industrial design professor	Engineer expert

5.1.2 Material

The FGI session was to explore stakeholders' experiences with mobile hospital, so researchers prepared activity materials. We utilized the video clip for understanding the project and the introduction to mobile hospital. The physical scale model and blueprint were used to help participants express their needs and experience during the session. We also asked several questions so as to figure out practical experience about mobile hospital in infectious disease. There were the detailed questions of FGI below;

- What is the care routine and co-workers at mobile hospital?
- What do you share the difficulties with according to your working routine?
- Which ideas exist to improve working routine during work?
- What part of care and treatment for patients needs improvement?
- What do you think about the main goal of mobile hospital?
- How is the management of patients at mobile hospital?
- How do you handle the patients who become serious patients at mobile hospital?
- What would you like to improve for mobile hospital in the future?

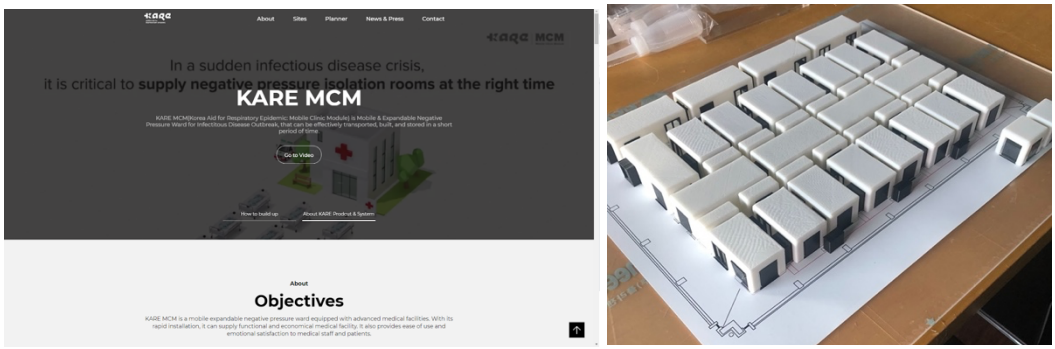

Figure 2. Video clip for mobile hospital project (left) &

a physical scale model of mobile hospital (right)

5.1.3 Procedure

The FGI was conducted during 2hours at a Human Resource Development Center. In the first step, participants introduced their work and shared their position in FGI at ice-breaking. Next, we introduced a project about mobile hospital for 20 min. To figure out the needs of the mobile hospital, participants shared their experiences and activities with workshop tools such as a blueprint, a 3D model of mobile hospital, and Lego models. Each team discussed the questions which were about current issues of mobile hospital and what they wanted medical equipment, space, and so on for 100 min. Lastly, we had a reflection session to discuss insight for 15min.

Figure 3. Focus group interview scene alpha team(left) and beta team (right)

6 RESULTS 2

To explore the needs of stakeholders, the results of the Focus Group Interview were coded from qualitative analysis in terms of medical staff's, manager staff's, and engineer's perspective. After qualitative analysis, an affinity diagram was used to categorize the needs by five researchers who consisted of one design researcher, two Ph.D. candidates, and two master course students.

First, the results of the needs of medical staff were about the difficulty responding to the serious case from mild cases, the difficulty systematically examining underlying disease or mental disorders when hospitalized, the reflection of patients' stress to medical staff, limitation about operating hospitals with limited manpower, and the difficulty in face-to-face clinics. The needs of medical staff

were related to the care service perspective in a special situation such as infectious disease, quarantine environment.

Next, the needs of the manager staff's perspective were about the reflection of mobile hospital characteristics and the necessity for extra manpower due to lack of space and system. The manager staff's needs were related to the efficient operational perspective about mobile hospital within limited manpower.

Lastly, the results from engineering were found that the effective design for waste treatment, the difficulty to systematically reflect the medical console, the difficulty dividing the infected area and the safe area, and the difficulty in designing required medical equipment and storage space. From the perspective of the engineer, they had needs that were related to design the mobile hospital according to infectious disease. They wanted not only the hospital operation like a normal hospital for medical staff but also the comfortable ward for infectious disease patients.

Table 3. The quotes examples of stakeholders; medical staff, manager staff, and engineer

Stakeholders	Needs of mobile hospital	Quotes
Medical staff	Difficulty responding to the serious case from mild cases	"There are cases in which a mild patient is converted into a serious patient [...] When patients become a a serious condition, medical staff have to care something inner ward." "There are cases of sudden deterioration among infectious disease patients. There may be situations in which CPR is suddenly needed for patients who are suddenly deteriorating."
	Difficulty systematically examining underlying disease or mental disorders when hospitalized	"It is possible to come wicked patient or self-harm commotion in hospital [...] we don't know." "There is no underlying disease even if patients type in [...] but he is diabetes. Because the booking is poor, we relocate these case [...]" "In Suwon's case, the patient has mental disorders to enter the ward [..] like a personality disorder. He opens a window, throw something, swear and jump [...] It is hard to control because of a quarantine space." "We don't know that Alcoholism or something like this[...]"
	Reflection of patients' stress to medical staff,	"There is also a case that the stress goes to the medical staff when the patients are very sad." That is harsh. It's really bad. Because of that, depression also arises, and the complaints are increasing [...] Imagine that you are also trapped. Imagine that you are trapped with someone you don't know." "What is the real pain here, patient don't know these things, [...] I tell you again, being trapped is a pain to patients."

	limitation about operating hospitals with limited manpower	"Similar to Hotel service, check-out in the morning. Check-out in the morning [...] In the meantime, there are hospitalizations through the emergency room or rapid hospitalization, but general routines have to be almost followed in the case of life treatment centers as well as special cases.
	Difficulty in face-to-face clinics	"The doctor wants to be non-face-to-face [...] want to use the phone."
Management staff	Reflection of mobile hospital characteristics	“The principle of operation is slightly different from a general hospital, so these hospitals need a routine schedule such as a detention center [...] it is important.”
	The necessity for extra manpower due to lack of space and system	"There is no office. Actually, there are usually a lot more workers arriving and working in different types of jobs. The efficiency is low. We need space due to consumption.[...] if we use the actual space, we have to have an office somewhere outside. so this kind of context arises [...]”
Engineer	Effective design for waste treatment	"As I know the law says to put waste in containers [...] so I think something that can store waste somewhere over there." "Every wastewater needs primary disinfection."
	The difficulty to systematically reflect the medical console	“How many patients are covered with One medical console?” “There is the general Hospital Medical law. This is not regulated according to the hospital but, understanding the principle, there is something like a percentage of hospital beds for each type."
	Difficulty dividing the infected area and safe area	"Then, is this space a polluted space?" "The contaminated person doesn't have to be in this space, it just has to get out of this space. They are all wearing masks, so it’s not a concept that pollutes the air.” "If you remove one negative pressure device, Is the efficiency okay? For example, if we don’t just make this part at all. We will save a lot of cost and space.
	The difficulty in designing required medical equipment and storage space	"I don't know what material to fill in the warehouse realistically [...] How do I set resources aside?" “Really, in some area, in some form of disaster, it is unavoidable that the patient has to enter for two weeks.”

7 DISCUSSION

This study figured out the design considerations for mobile hospitals for infectious disease based on the previous results. In detail, five researchers used affinity diagram to draw the design considerations which consisted of six categories in terms of long-term patients, medical staff, management staff, and engineer: Efficiency of the cold zone and hot zone, Immediate action to unpredictable patient conditions, securing space for a care zone except for the sickbed,

consideration of patient emotional aspects, practical operation based on the regulation of negative pressure ward, new type care with none face-to-face interaction.

7.1 Design Considerations

(1) Efficient route of the cold zone and hot zone

According to the results of this study, the Efficiency route of the cold zone and the hot zone is an essential element to design mobile hospital in infectious disease. It indicates that efficient motion reduces the secondary infection for medical staff and management staff. From an engineering perspective, the engineer should provide technical negative pressure not to spread the virus to other spaces without the patient's room. To control the space and to build mobile hospital rapidly, it would help to provide efficient motion of the cold zone and the hot zone for both user and supplier. For example, there is a clear graphic guideline to distinguish rooms according to the degree of risk of the virus at mobile hospital. In terms of efficiency of care, it is easy to follow the moving route for medical staff and management staff when they care the infectious disease patients.

(2) Immediate action to unpredictable patient conditions

To design the mobile hospital, immediate action to unpredictable patient conditions is able to prepare the emergency situation. In terms of medical staff, it is hard to move the diverse medical device for medical staff into patient's rooms because mobile hospital is a quarantine structure. Therefore, engineers consider providing the front room from the patient's room which is space to equip portable medical devices in. Throughout monitoring system and alarm system, it can be some solutions to deal with immediate action. Through immediate action to unpredictable patient conditions, medical staff perceives the emergency state of patients and patients reduce the anxiety of care even though they are located in quarantine space.

(3) Extra care space except for sickbed

In the infectious disease context, extra care space except for sickbed is considered to build mobile hospital. The general feature of mobile hospital accommodates unexpected patients in infectious diseases. However, improved mobile hospitals contained diverse medical devices because it is hard for medical to handle the patients who COVID-19 patients become serious state suddenly or patients may be an underlying disease such as diabetes, mental disease, etc. Therefore, mobile hospital needs a flexible care room that changes the room environment according to the repurposing situation. For engineers of mobile hospital, they consider the storage of medical devices and the space of plenty of patient supplies. In the case of COVID-19, an X-ray room is required to check the state of patients in mobile hospital. In particular, a lot of medical gas is required to care for the patients because it is a respiratory disease. Accordingly, building mobile hospital is required not only hospitalization space but also extra space such as storage, treatment space, examination room, and so on.

(4) Consideration of patient emotional aspects

Patient emotional aspects are important during hospitalization because a positive emotional state increase treatment effect (Cohen and Williamson, 1991; Clark, Drain and Malone, 2003). Due to the emotional state of the patient reflects the medical staff's emotional state directly, the mental health is worsened in the pandemic situation (Thomas *et al.*, 2021). To improve quarantine context, patients are provided a bright and pleasant environment at a mobile hospital. Even though mobile hospital space is isolated by the wall, their privacy was protected by blind to hide the window. For reducing the suspended admission of patients, mobile hospital is improved better space in terms of the environment. For example, the patient could move their body in a quarantine environment to keep daily activity in terms of recovery (Fares, 2013). Moreover, the entertainment element is provided to patients to get rid of boring in a quarantine environment.

(5) Empirical operation based on the regulation of negative pressure ward

Stakeholders provide medical service to patients and medical staff at mobile hospital through empirical operation based on the regulation of negative pressure wards. Medical staff followed a systematical care routine schedule to control the mobile hospital in the situation which is limited the number of staff. For example, they have to divide care time and disinfection time during care service. Management of medical waste is considered to design the waste disposal way in patient's rooms and the storage space out of mobile hospital from an engineering perspective, because it is important to manage the waste in terms of infection prevention (Ilyas, Srivastava and Kim, 2020). The management staff would plan the extra staff who is full-time residents of disinfection management. After the construction of mobile hospital, the empirical operation could reduce the secondary infection accident during medical service for patients.

(6) New type of care with no face-to-face interaction

In an infectious disease situation, it is necessary to adopt a new type of care with no face-to-face interaction. In terms of patients, they reduce the anxiety of disease from regular medical support during the hospitalization (Chen *et al.*, 2005). In terms of medical staff, they are not exposed to virus risk when they give treatment to infectious patients. For example, medical staff check frequently the state of patients not to enter the ward. Also, medical staff is possible to utilize the pass box in order to deliver care supplements for the patient in quarantine space.

7.2 Limitation

Although this study provides design implications for mobile hospital from diverse stakeholder perspectives as well as long-term patients, it would be risky to generalize the findings some limitations of the study. First, the study was conducted with a small size of samples about real COVID-19 patients. Next, the co-design Focus Group Interview was only on the group of experts without patients. Therefore, follow-up studies would consider the limitations so as to enhance the experience of patients' perspectives. Further studies are supposed to verify design consideration or apply to the actual project of mobile hospital.

8 CONCLUSIONS

This study aimed to understand the multiple stakeholders who were related to mobile hospital in infectious disease. Throughout the interview and focus group interview from diverse stakeholders, this study figured out six design considerations to design the mobile hospital for infectious disease situations. The first design consideration is ‘efficiency route of the cold zone and the hot zone’ which is able to reduce the secondary infection in terms of medical staff and management staff. The second is ‘immediate action to unpredictable patient conditions, so the anxiety of disease could be decreased at quarantine environment as well as medical staff could be served rapid medical action in an emergency situation at mobile hospital. Third, ‘extra care space except for sickbed’ would design flexible organization of care room for diverse medical care and would consider the storage space to contain medical waste and supplement for the patient in terms of the engineer of mobile hospital. The fourth, design consideration is ‘Consideration of patient emotional aspects’ which makes a better mobile hospital environment for infectious disease patients as well as reduces the stress of medical staff during care at mobile hospital. The fifth, ‘Practical operation based on the regulation of negative pressure ward’ is able to manage the mobile hospital with the minimum manpower and could help to understand mobile hospital environment for design in infectious disease situation. Lastly, ‘New type care with no face-to-face interaction’ is provide not only high-quality medical care for infectious disease patients but also safety from infectious disease for medical staff. In addition, through new-type interactive care, engineers could expand new design opportunities for mobile hospital.

Throughout these design considerations, this study contributes to developing mobile hospital based on diverse user perceptions in emergency situations. In other words, these considerations will be delivered to design a better direction within the mobile hospital context. Based on the outcome of this study, designers could improve the environment of mobile hospital in similar infectious disease situations and diverse stakeholders could provide clinic service for patients in mobile hospital.

Overall, the implication of this study is expected to utilize the case of the practical field in healthcare because this study puts the foundation of Co-design in order to understand diverse stakeholders who are related to mobile hospital in infectious disease situations.

Furthermore, the insights of this study are expected to figure out a meaningful contribution to design for the mobile hospital in infectious disease because of reflection from long-term patients, medical staff, management staff, and engineers. Therefore, the study could have the novelty of knowledge for healthcare perspective in controlling unexpected infectious disease situations and provide design practitioners with consideration for mobile hospitals in terms of product design perspectives as well as service perspectives.

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