Negative Pressure Unit with Group Therapy

Group 9

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Abstract

This paper describes negative pressure units (NPUs) that can carry out mental health treatments for mentally ill people infected with respiratory diseases such as COVID-19. The video of Dr. Nam Yoon-young of the National Center for Mental Health explaining negative pressure units (NPUs) for patients with mental illness and feedback on this design from people of various genders and ages was referenced. There were two alternatives, and the alternatives were evaluated according to whether mental treatment was possible safe enough to group treatment, and immediate response in case of emergency. The highest-scoring alternative was selected as the final design. This allows mentally ill people with respiratory diseases to receive mental health care safely in a communal treatment space.

Table of Contents

1. **Problem Statement**

In February 2020, 101 out of 102 patients with mental illness were confirmed COVID-19 in CheongdoDaenam mental Hospital. Roughly a month after in the Second Miju Hospital, 133 were confirmed COVID-19, and 127 of them were from the psychiatric department. These rapid spread of coronavirus in psychiatric hospitals demonstrate the necessity for hospitals equipped with NPU for patients with mental illness. In reality, among 5 national psychiatric hospitals, only one is equipped with NPU, and it can accommodate only up to 24 patients.
Psychiatric patients need psychiatric treatments and the facilities that aid it. One of such treatments is group therapy, which helps patients to break free from isolation, and recover by socializing with others. However, conducting group therapy that involves psychiatric patients with coronavirus is impossible. Therefore, we propose a hospital design that enables patients with both mental illness and COVID-19 to receive the necessary mental treatment in a negative pressure environment.

2. **Background information of a Negative Pressure Unit (NPU)**

Definition

A negative pressure unit (NPU) is an isolation ward that maintains negative pressure to prevent respiratory infections. The inside of the negative pressure maintains a lower atmospheric pressure (negative pressure) than the atmospheric pressure of the outside, preventing the internal contaminated viruses from escaping and spreading.

Principle

A negative pressure unit uses pressure difference to prevent the spread of viruses. The central control negative pressure and automatic control system. The pressure is gradually lowered in the order of a non-negative pressure isolation ward, a hallway front room, an interior hallway, a front room of the hospital room, a hospital room, and a toilet. The pressure between each zone is theoretically 2.5Pa different. However, in practice, it maintains a pressure of 15Pa for safety. Even if the automatic control system stops because of blackout etc., a backdraft damper can prevent air from flowing backward.

Contaminated air in the hospital room is released outside after the virus is removed through the HEPA filter of the exhaust pipe. HEPA (Highly Efficient Particulate Air) filter can decontaminate more than 99% of 0.3mm of particles.

Construction

A negative pressure unit should have at least a front room, a negative pressure isolation room and an attached toilet and should be strictly separated from the general ward. Also, a disposal room, a shower room and a changing room for medical staff can be additionally configured.

a. Front room

A front room connects the internal negative pressure room with the negative pressure hallway, preventing spread of contaminated air. Patients are not allowed to enter the front room, but medical staff use this room to enter the negative pressure room. Medical staff may wear protective equipment here.

b. Negative pressure isolation room

A negative pressure room is an area for treatment of patients. Airtight construction is required to prevent air leakage. Also, a window for medical staff to check inside the room can be set up.

c. Attached toilet

An attached toilet is literally a toilet attached to the negative pressure room, and patients in the room can enter the toilet without any protective equipment. There is a call button for emergency situations.

d. Disposal room

A disposal room is a place to dispose of waste generated in a room, maintaining a lower negative pressure than the internal negative pressure hallway.

e. Shower room and changing room for medical staff

A Shower room and a changing room is where medical staff can take a shower and wear safety equipment before entering the hospital room.

f. Doors

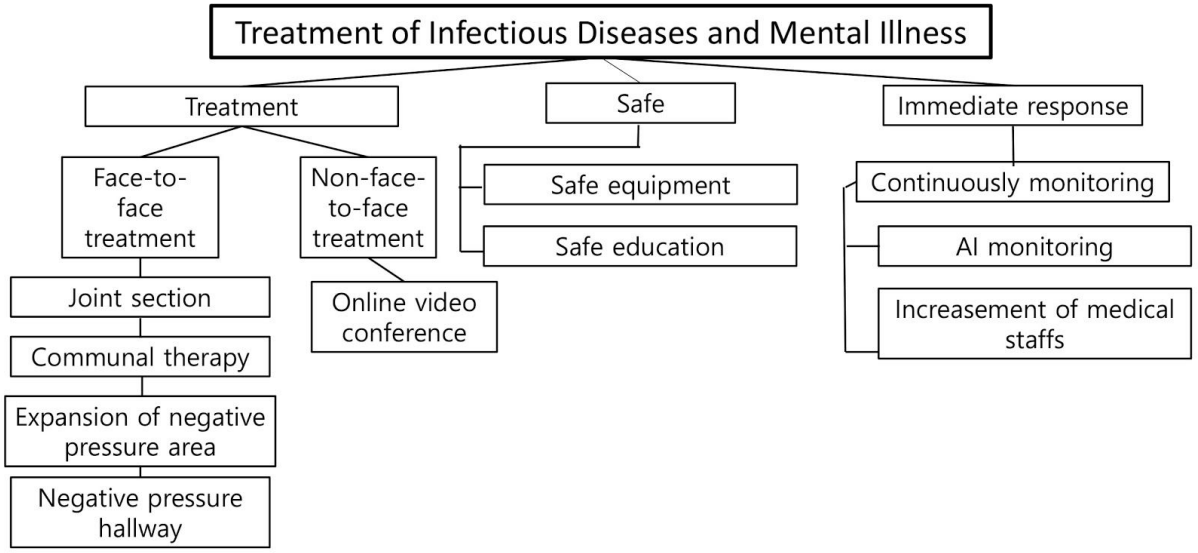
All the doors are automatic to minimize contact. The doors do not open and close at the same time, and the door starts to be opened after the other side is fully closed.

3. **Conceptual Design**

1. Objectives

There were three main objectives that we considered important in our design: group therapy, safety, and immediate response. In order to conduct group therapy, there must be a physical room that is safe, in other words, safe from spreading the disease. Not only that, since all patients have mental illness, immediate response for any unexpected behavior should be possible. With these objectives in mind, we made the following objective tree.

Objective Tree



The order of importance among the objectives were decided by the aggregated PCC.

Aggregate PCC

Win/Lose	Treatment	Safety	Immediate Response	Sum/Win
Treatment		0+0	1+0	1
Safety	4+0		4+0	8
Immediate Response	3+0	0+0		3
Sum/Lose	7	0	5	

2. Metrics with Constraints

Also, our team developed metrics to evaluate the achievements of our objectives. The metrics include constraints to determine if the design does provide each objective.

Objective: There should be a room for group therapy

Units: Rating assessment of how well the room serve its needs, from 0 (worst) to 100 (best)

Metric:

- The room accommodates a group (> 10) of patients. (100)

- The room accommodates some (5 < x < 10) of patients. (50)
- The room does not accommodate a group (< 5) of patients. (0)

Objective: The environment of the whole unit is safe
Units: Rating assessment of safety in the unit, from 0 (worst) to 100 (best)
Metric:

- Spread of virus is very less likely (100)
- Spread of virus is possible (50)
- Virus spreads (0)

Objective: The unit should provide immediate response to emergencies
Units: Rating assessment of readiness and responsiveness, from 0 (worst) to 100 (best)
Metric:

- Response in less than a minute (100)
- Response in 1~3 minutes (50)
- Response in more than 3 minutes (0)

3. Functions and means

For the function of our design, we combined group therapy and safety, so there are two main functions: safe place for group therapy and immediate response. For these, we generated a morphological chart to provide some candidates of the means.

Morphological Chart

MEANS FUNCTION	1	2	3	4	5
Provide a safe place to gather	Negative pressure hallway	Communal NPR	strict equipment	patient-only elevator	Online video conference

Emergency Response	Additional staff	Monitoring station	AI monitoring	regular virus diagnostic check	-

The design chosen in the problem, which says that group treatment required by mental patients is impossible face-to-face, is to create a space where group treatment is possible.

First function – It can provide a safe place for many people to get together.

1) Negative pressure hallway – hallway with negative pressure that moves the patient to the common NPR.

2) Communal NPR – A space equipped with negative pressure for co-treatment. The negative pressure level of this space is the same as that of normal NPR. (Basic design to prevent additional infections in case patients have to stay in this space for a few hours.)

3) Strict equipment – Strict equipment is essential for both medical staff and patients because the Common NPR can accommodate not only patients but also medical staff.

4) Patient only-elevator – Patient-only elevators are required because there are floors where the Common NPR is not located.

5) Online video conference – It enables not only face-to-face co-treatment but also non-face-to-face co-treatment.

Second function - It is possible to respond quickly to emergencies in the Common NPR.

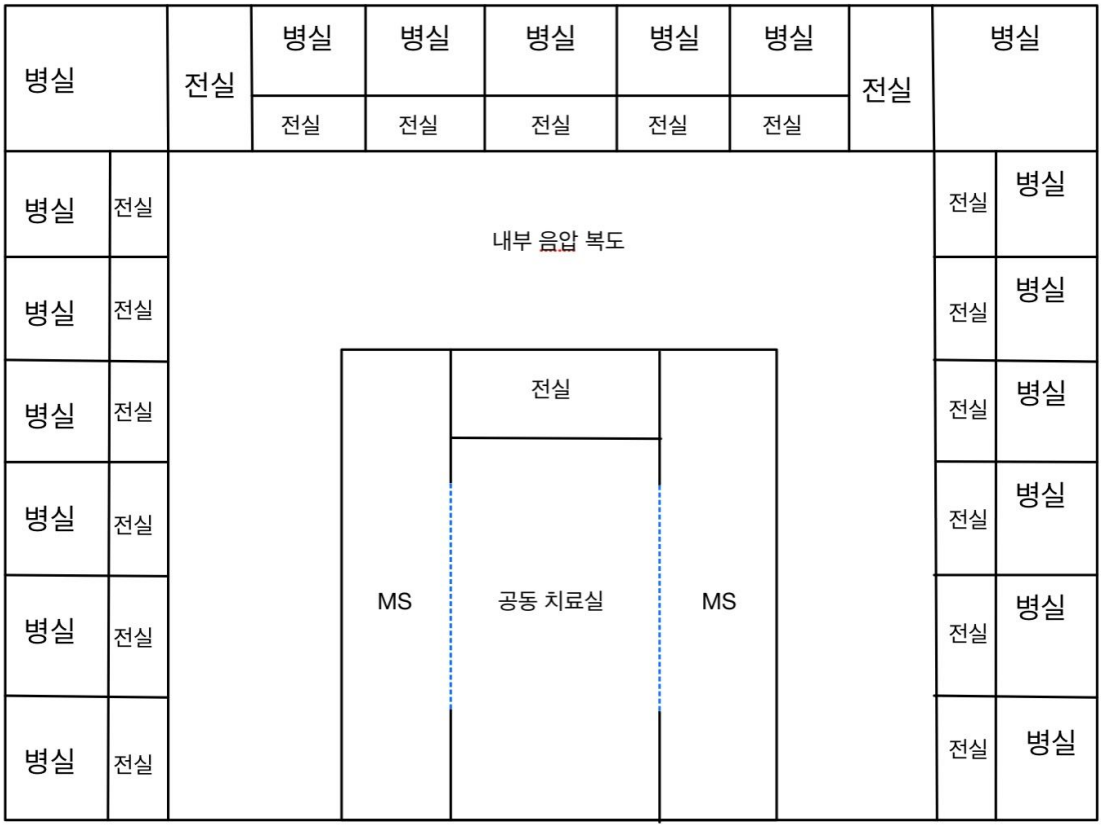
1) Additional staff – hiring additional medical staff to focus on monitoring.

2) Monitoring Station – a space equipped with negative pressure to prepare for emergencies. Medical staff should be wearing strict equipment and monitoring patient movements.

3) AI Monitoring – Precision monitoring through AI because there are limits to human monitoring.

4. **Preliminary Design**

1. Design alternatives
    a. Make the whole unit negative pressure environment

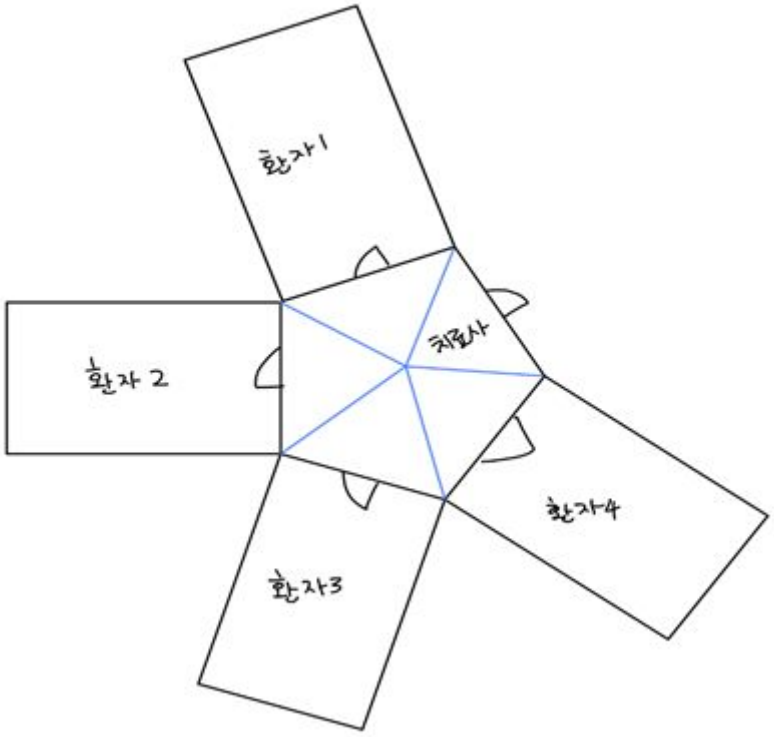


A common treatment room with a negative pressure environment will be created where patients can easily access and respond quickly. The space that surrounds both sides of this space is MS. MS is a monitoring station that allows medical staff to wear equipment and monitor patients for a certain amount of time to stay in the common treatment room. In addition, the space in the common treatment room is made of mirrors, so it can be monitored in a realistic way and lively way through the mirror as well as the monitor. The mirror->MS can see the inside of the common treatment room, but the common treatment room can’t see the MS and it just looks like a simple mirror.

Flow of human traffic & Procedure

I. Patients wear strict equipment in the front room of the hospital room.
II. Patients move to the front room of the group treatment room through the negative pressure hallways.
III. The medical staff inspects the patient's equipment in the front room of the group treatment room.
IV. When leaving the group treatment room, the patient goes to the inner negative pressure hallways through the front of the group treatment room, enters the front of the negative pressure room, and removes the equipment.

b. Glass wall for group treatment



If the structure of a typical negative pressure room had a bathroom and a front room, this structure has a total of three spaces, including a patient-only treatment space equipped with a negative pressure environment. Patients in each sound pressure room cannot be directly contacted by other patients or medical staff, but this structure is made of glass walls and can be group treated. The advantages of this design are that patients do not have to go through strict procedures to wear the equipment, and their movements are short and medical staff can take care of the patients independently. it is more stable and easier for medical staff to move for group treatment. The disadvantage is that group treatment can be carried out, but since this structure is still a closed space, it can be adversely affected to mental patients. In addition, direct contact is not possible, which is limited in treatment, inappropriate space for activities, and inefficient use of space.

2. Evaluation of design alternatives

Metrics *Design*	Possible treatment of mental illness	Safe space for group treatment	Immediate response for emergency	**Rank**
Whole unit negative pressure environment	100	100	immediate	**1**
Glass wall for group treatment	50	100	slow	**2**

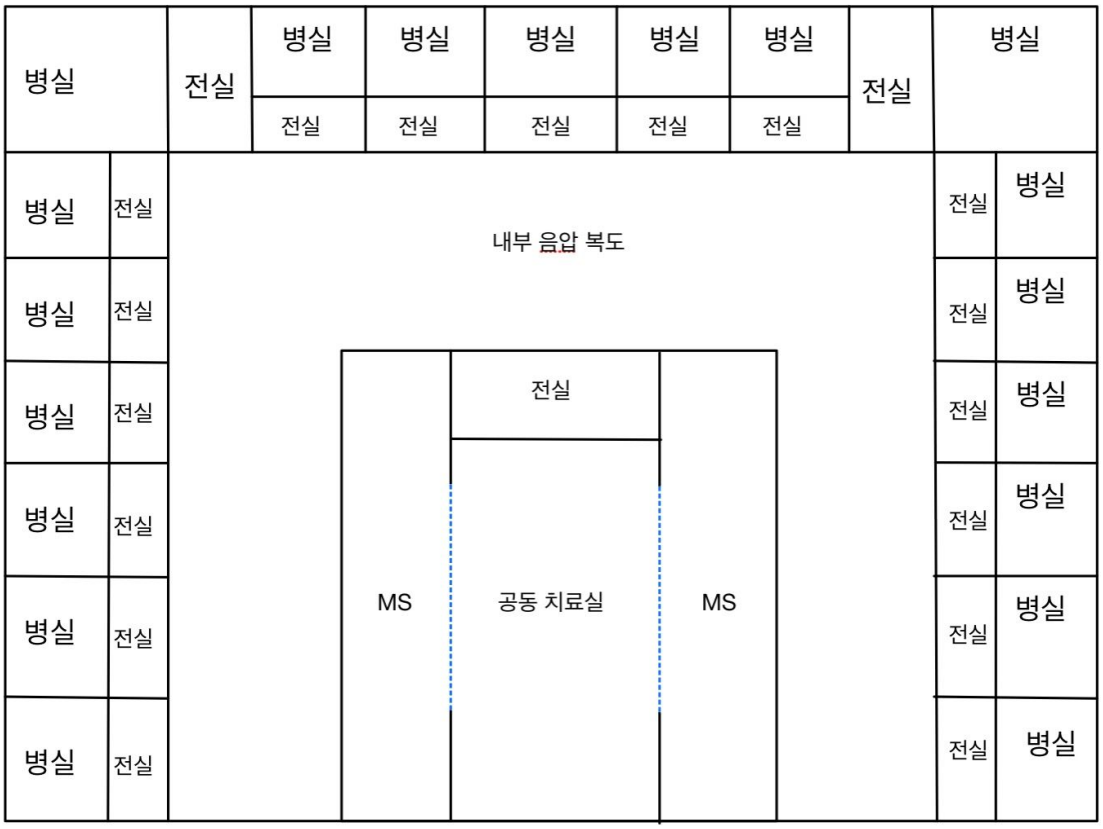
Possible treatment of mental illness:

The design below can be treated, but there may be limitations of mental treatment in a closed space called a single room. In comparison, the above design allows direct contact and communication with medical staff and other patients, and has relatively no restrictions on activity space, allowing them to receive group treatment variously and effectively.

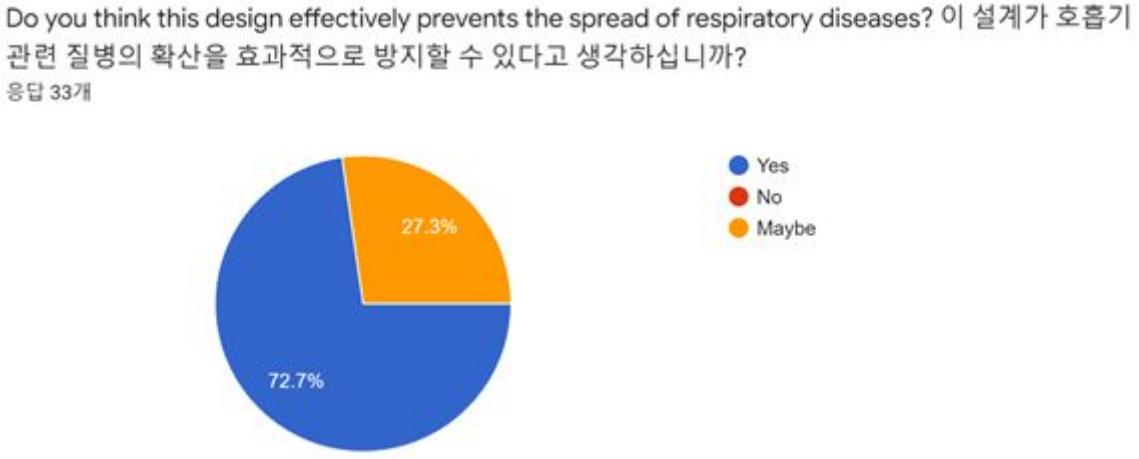
Immediate response for emergency:

The design below is difficult to respond quickly because patients and medical staff are not wearing strict equipment, which takes time to wear the equipment in case of an emergency.

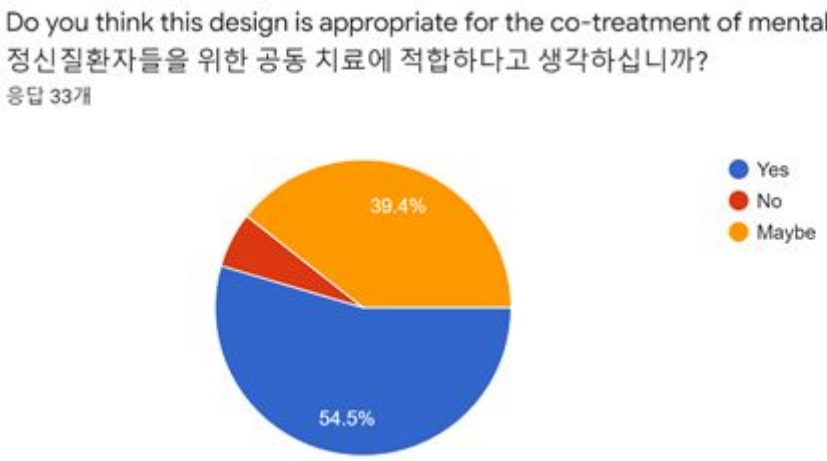
3. Prototype of chosen design



In order to evaluate our design prototype suitability, we conducted a survey.

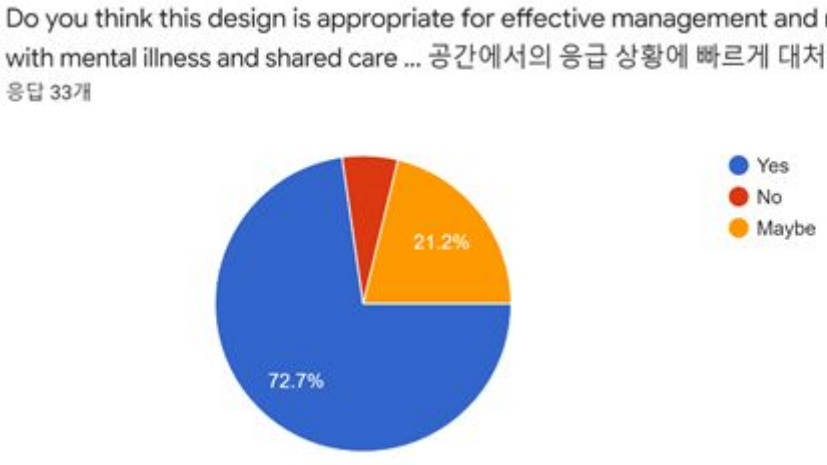


Twenty-four out of 33 said they could effectively prevent it, and nine said they were not sure but probably. No one responded that it was impossible to prevent.



Eighteen out of 33 respondents said the design was appropriate for mentally ill patients, while 13 respondents said they were unsure but probably. Two people are not suitable. One of them described the closed space as a fear for mentally ill patients, and the other described that the glass wall between the common treatment room and MS could feel pressure for surveillance.

-> By accepting opinions, the problem of closed space widens the area of the common treatment room to make it pleasant, and the problem of the glass wall changes the plan to the mirror wall so that MS can see the inside of the common treatment room but not the inside of the common treatment room.



Twenty-four out of 33 respondents said they could manage effectively and respond quickly in the common treatment space, and seven responded that they were unsure, but probably. Only two responded that they could not.

The reason is that both of them cannot enter the common treatment room without going through the front room even if an emergency occurs.

-> It is inevitable not to go through the front room due to the negative pressure system. However, to reduce time consumption, medical staff monitor MS by putting on strict equipment. In the event of an emergency, medical staff can access the common treatment room directly through the front room without having to wear and check the equipment.

Paragraph explaining if it keeps the constraints

1. Time limit for common negative pressure space
2. Strict equipment to prevent medical staff infection
3. facility standards in common treatment space

1) Moving in and out of the common negative pressure space is time-consuming because it has to go through strict equipment and other procedures, and because medical staff has to stand by 24 hours on MS. So, it is designed to set a time limit.

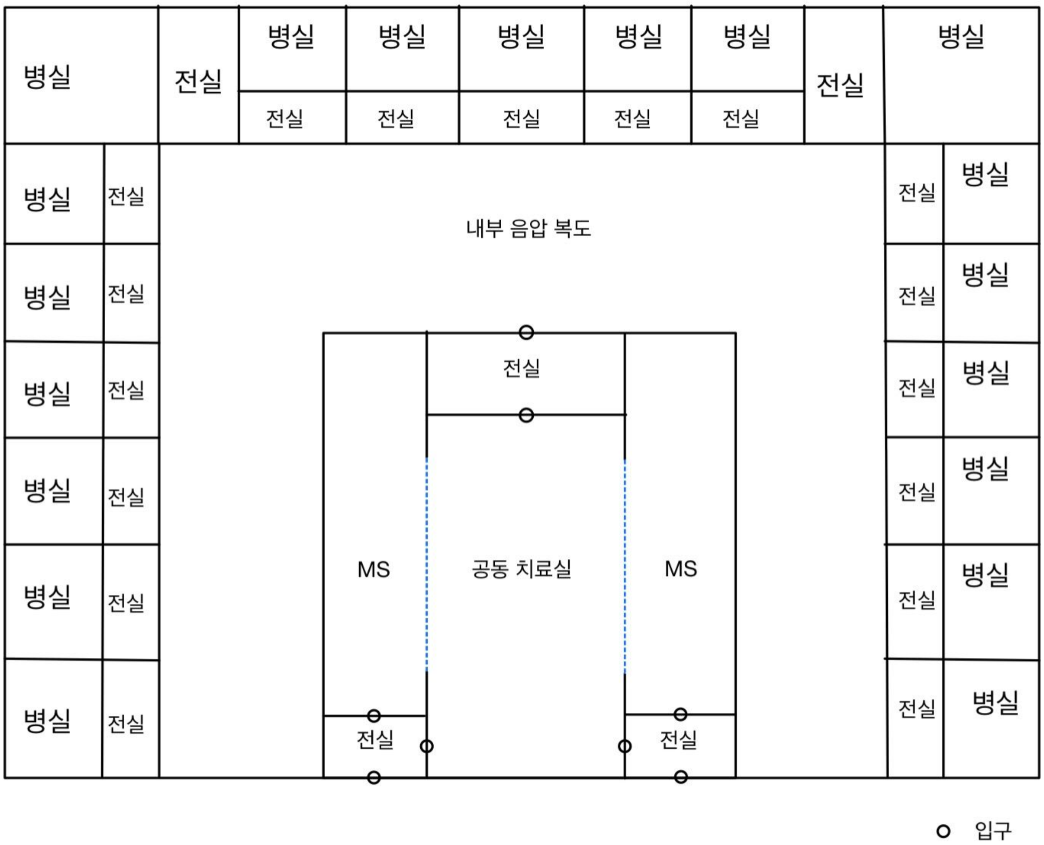
2) Patients will be put on equipment in the front room of the negative pressure room and will be checked once more in the front room of the common negative pressure space. The contaminated equipment will be disposed of immediately in the waste room.

3) The height of the common treatment space is based on the living room. According to the living room facility standards, the height of the ceiling must be 2.1 meters or higher to be a pleasant space. Area follows the standards of the residential area of a french sociologist named Chombard de Lawve.

I. Pathology standards (8㎡/person or less): adversely affecting residents' physical and mental health.
II. Limit standard (14㎡/person or less) : Unable to guarantee flexibility of individual and family residence
III. Standard standard (16㎡/person or less): Proper residential area

Since the number of people who can enter the common treatment space is based on at least five to a maximum of eight people, a minimum of 80 meters square to 128 meters square is appropriate for the area of the common treatment room.

5. **Final design**



Purpose

This design was intended to create a safe group treatment space for the treatment of mental illness for mentally ill people who are infected with respiratory diseases such as COVID-19. Through this design, the anxiety of the mentally ill can be relieved a little bit, and it can be expected to have a good effect on treating infectious diseases and mental illnesses.

Construction

Although the construction is like the existing negative pressure ward, it is different in that there is a communal treatment space and MS.

In particular, the window of the communal treatment space was changed to one way mirror, accepting feedback that it could give patients a negative feeling of being monitored.

a. Front room of the communal treatment space (for patients)

Front room of the communal treatment space is similar to the common front room. This place is where all patients can disinfect before entering the communal treatment space. Only patients and dedicated medical staff can use this room.

b. Front room of the communal treatment space (for medical staffs)

Front room of the communal treatment space for medical staff is where medical staff can disinfect before entering the communal space. Also, in an emergency, medical staff can enter the communal space fast through this room.

c. Communal treatment space

Communal treatment space is where patients and medical staff gather to treat mental illness. Negative pressure facilities in the communal space operate well like the negative pressure facilities in other general negative pressure rooms. There is a window which can be seen in MS but not in the communal treatment space on either side of the communal room so that medical staff can observe the inside of the room. The window is designed to be invisible from the inside for the patients' psychological stability.

d. MS (Monitoring Station)

MS is where medical staff can manage communal treatment space. MS is also a negative pressure area that maintains the same negative pressure as a negative pressure room. All medical staff in this station must be on standby wearing protective equipment so that they can be put on site immediately in case of an emergency.

e. Moving line

The medical staffs dedicated to each patient enter the negative pressure room wearing protective equipment to all patients. Afterwards, one by one, with the help of the medical staff, the patients will go through the front room of the communal treatment space and then move to the communal treatment space. During the treatment time, the medical staff manages the situation between MS and the co-treatment space. In case of an emergency, the medical staff within MS immediately enter the common room to handle the situation. After treatment, patients go to the negative pressure room with the help of the dedicated medical staff. After patients safely move to the negative pressure room, all medical staff also can move to the general ward through the negative pressure hallway.

6. **Appendix**

Works Cited

https://www.bbc.com/korean/news-51640056

http://www.mindpost.or.kr/news/articleView.html?idxno=3509
https://www.monews.co.kr/news/articleView.html?idxno=209733
[생활속 기계설비이야기] 음압격리병실, 인공바람이 부는 병원 [웹사이트]. (2020). URL: http://www.kmecnews.co.kr/news/articleView.html?idxno=4173

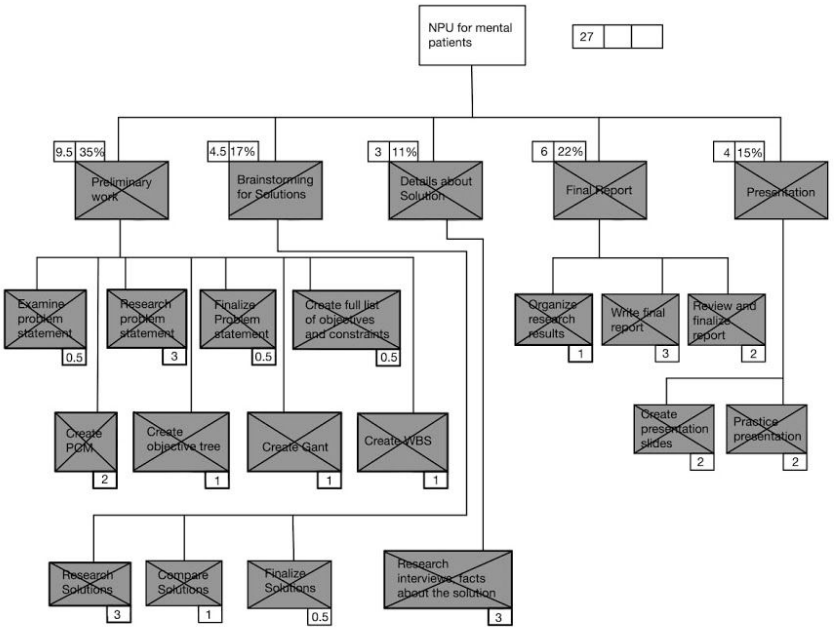
[특별기고] 음압병실 이해와 시설 기준 [웹사이트]. (2020). URL: https://www.kharn.kr/news/article.html?no=12426

한국의료복지건축학회. (2018). *의료기관 건축설계 가이드라인 연구 - 일반병동, 격리병실, 중환자실, 신생아실, 신생아중환자실, 인공신장실, 수술부, 병원공조 등을 중심으로* – (문서 번호: 11-1352000-002445-01). : 보건복지부.

WBS

1. Preliminary work
   a. Examine problem statement (30min)
   b. Research problem statement (3hrs)
   c. Finalize Problem statement (30min)
   d. Create full list of objectives and constraints (30min)
   e. Create PCM (2hrs)
   f. Create objective tree (1hr)
   g. Create Gant chart (1hr)
   h. Create WBS (1hr)
2. Brainstorming for Solutions
   a. Research solutions (3hrs)
   b. Compare solutions (1hr)
   c. Finalize solution (30min)
3. Find details about the Solution
   a. Research interviews or facts about solution (3hrs)
4. Final Report
   a. Organize research results (3hr)
   b. Write final report (6hrs)
   c. Review and finalize report (3hrs)
5. Presentation
   a. Create presentation slides (2hrs)
   b. Practice presentation (2hrs)

PCM



Gant Chart

Solution for patients with mental illness

Group 9

https://www.vertex42.com/ExcelTemplates/simple-gantt-chart.html

Project Start: Mon, 11-9-2020

Display Week: 1

TASK	ASSIGNED TO	PROGRESS	START	END
Preliminary work			11-9-20	11-9-20
Examine problem statement		100%	11-9-20	11-9-20
Research problem statement		100%	11-9-20	11-9-20
Finalize Problem statement		100%	11-9-20	11-9-20
Create full list(OB, CS)		100%	11-9-20	11-15-20
Create PCM	Yean Kim	100%	11-9-20	11-15-20
Create objective tree	Jimin Jeong	100%	11-9-20	11-15-20
Create Gant chart	Minju Shin	100%	11-9-20	11-15-20
Create WBS	Juwon Park	100%	11-9-20	11-15-20
Brainstorming for Solutions			11-16-20	11-22-20
Research solutions	Minju Shin, Jimin Jeong	100%	11-16-20	11-22-20
Compare solutions	Juwon Park	100%	11-16-20	11-22-20
Finalize solution	Yean Kim	100%	11-16-20	11-22-20
Find details about the Solution			11-23-20	11-29-20
Research interviews or facts ab	Group9	100%	11-23-20	11-29-20
Final Report			11-9-20	12-13-20
Organize research results	Group9	100%	11-9-20	11-22-20
Write final report	Group9	100%	11-23-20	12-13-20
Review and finalize report	Group9	100%	12-7-20	12-13-20
Presentation			11-30-20	12-7-20
Create presentation slides	Minju Shin, Juwon Park	100%	11-30-20	12-7-20
Practice presentation	Jimin Jeong, Yean Kim	100%	11-30-20	12-7-20

Contribution

In preparation of the final report, each individual researched information on principal information like objectives, functions, metrics, design alternatives, and final design with its prototype. These information combined, we decided what the final design should be and also the information that should be included in this report. Likewise, we together conducted the survey and made the prototype.

In actual writing of the final report and presentation (according to the table of contents):

21600293 Park Joo-won

Problem statement, conceptual design

21900151 Kim Ye-ahn

Presentation slide, presentation and Q&A

21900394 Shin Min-ju

Preliminary design

22000698 Jung Ji-min

Background information, final design