Calculation of Appropriate Minimum Size of Isolation Rooms based on Questionnaire Survey of Experts and Analysis on Conditions of Isolation Room Use

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Abstract. After the outbreak of the MERS (Middle East Respiratory Syndrome) epidemic, issues were raised regarding response capabilities of medical institutions, including the lack of isolation rooms at hospitals. Since then, the government of Korea has been revising regulations to enforce medical laws in order to expand the operation of isolation rooms and to strengthen standards regarding their mandatory installation at hospitals. Among general and tertiary hospitals in Korea, a total of 159 are estimated to be required to install isolation rooms to meet minimum standards. For the purpose of contributing to hospital construction plans in the future, this study conducted a questionnaire survey of experts and analysed the environment and devices necessary in isolation rooms, to determine their appropriate minimum size to treat patients. The result of the analysis is as follows: First, isolation rooms at hospitals are required to have a minimum 3,300mm minor axis and a minimum 5,000mm major axis for the isolation room itself, and a minimum 1,800mm minor axis for the antechamber where personal protective equipment is donned and removed. Second, the 15 ㎡-or-larger standard for the floor area of isolation rooms will have to be reviewed and standards for the minimum width of isolation rooms will have to be established.

1. Introduction

The MERS epidemic that spread to Korea in 2015 resulted in considerable damage, including 16,752 patients placed in isolation, 186 patients diagnosed with MERS, and 38 deaths[1]. After the outbreak, issues were raised over secondary infections caused within hospitals, hospitals’ capabilities to manage infected patients, and the appropriate treatment of infected people. The most serious issue was the lack of isolation rooms essential for treatment of respiratory infections[2]. Existing isolation rooms did not have antechambers or multiple patients were placed in one isolation room. As health laws are likely to be strengthened in the wake of MERS, so these rooms will need improvements to comply with strengthened standards.

The Korean government is planning to revise medical regulations to substantially strengthen standards for isolation rooms at hospitals[2] : one or more for a general hospital with 300 or more beds and an additional one for every 100 more beds. Considering that it is difficult to immediately improve existing isolation rooms, the government is encouraging step-by-step improvement. The government has specified that an isolation room should have a floor area of at least 15 m² and a separate
antechamber. A total of 159 hospitals, including 116 general hospitals (41% out of total 281) and 43 tertiary hospitals (total 43 tertiary hospitals with 500 or more beds) will now have to meet standards for the required isolation rooms.

This study conducted a questionnaire survey of experts who have experience in managing hospital facilities and a survey of medical staff that have treated patients in isolation rooms in order to draw suggestions for establishing standards of the size of isolation rooms.

2. Method

Please Along with the questionnaire survey of experts, a survey was also conducted on the size of equipment kept in isolation rooms and the environment of their use, in order to determine the minimum size necessary for isolation rooms.

The questionnaire survey was conducted of 27 experts on hospital ventilation systems. Basic information about those experts is shown in Figure 1. Experts in their thirties were 25% of the total; forties, 63%; and fifties or older, 13%. They have an average of 16 years of experience in the field.

![Figure 1. Experts’ age and years of experience](image)

3. Research

3.1. Estimation of minimum size of isolation rooms based on the result of questionnaire survey on experts

The minimum total size suggested by experts of an isolation room and its front room are on average 28 m$^2$ and 7 m$^2$, respectively, which is slightly larger than the standard for government-designated hospitals (15 m$^2$) as shown in Figure 2. Considering the number of staff needed when treating patients and that the number of movable medical appliances is larger for isolation rooms than for general wards, the size of new isolation rooms and their front rooms will have to be reconsidered.

![Figure 2. Size of isolation room and front room suggested by hospital ventilation system experts](image)

3.2. Estimation of the size of isolation rooms accounting for the number of devices and staff needed for treatment

The severity of a patient’s symptoms is classified as in Table 1. The manual[3] specifies that when there are not enough isolation rooms in a hospital, patients with mild or moderate-level symptoms be treated in a temporary isolation room and patients with severe symptoms (such as those that require ventilator treatment) undergo mandatory isolation in an isolation room. Therefore, respirators and
medical appliances used in an ICU, such as electrocardiograms (ECG) and cardioverter defibrillators, are required equipment in an isolation room.

Table 1. Classification of severity of symptom and necessary care unit

| Severity | Stage | Definition | Treatment Unit |
|----------|-------|------------|----------------|
| Mild     | 1     | No symptom | General care unit (Temporary isolation room) |
|          | 2     | Symptom (fever, cough, dyspnoea, hemoptysis, nausea, abdominal pain, diarrhea, etc.) | |
| Moderate | 3     | Symptom of pneumonia but no oxygen demand | General care unit (Temporary isolation room) |
| Severe   | 4     | Symptom of pneumonia and oxygen demand | ICU (Temporary isolation room) |
|          | 5     | Need for airway intubation and ventilator treatment | Isolation room |
|          | 6     | Application of ECMO | |

The essential equipment needed in an isolation room can be classified as a bed, trollies, and medical appliances. The size of a bed [4]^a is approximately 2160*1050 mm and it has to be located near the center of an isolation room. The size of medical trollies [4]^b used for storing and carrying first-aid equipment is approximately 750*470 mm on average. Trollies are used for storing medicine, holding medical devices, and attaching integrated monitors, and two to three trollies are necessary for one isolation room.

As mentioned above, multiple types of medical appliances as well as trollies are necessary in an isolation room, because of the characteristics of respiratory infections. Notably, the appliances in an isolation room are banned from being moved in and out of the room during treatment in order to prevent the spread of the pathogen; therefore, they need to be stored within the room when not in use. The size and usage of medical appliances essential for an isolation room are in Table 2. Other than those appliances, IV stand poles and reserve linens are kept in an isolation room.

Table 2. Medical appliances needed for an isolation room and their size

| Medical appliances | Usage                | Size                                      | Note                                                                 |
|--------------------|----------------------|-------------------------------------------|----------------------------------------------------------------------|
| Electrocardiogram  | ICU                  | Ranges from 320*280 mm to 410*320 mm (Need to consider the size of the stand) | Portable ones are available. These may be places on a stand at the top of the bed |
| Ventilator         | Breathing assistance | Embedded (No separate space necessary)    | Portable, so trollies can be used as the stand pole                  |
| Defibrillator      | AED                  | Portable                                 | Used for a patient whose lungs or heart is failing                   |
| ECMO               | Extracorporeal membrane oxygenation | 800 mm of minimum width (Diverse according to its shape) | |

^a There are different sizes of beds, but generally, they are manufactured between the minimum size of 2,000*900 mm and maximum size of 2,200*1,600 mm.
^b Medical trollies are classified into ones with a storage space below the bed (930*650 mm, 673*480 mm, etc.) and light-weight trollies (630*470 mm, 539*366 mm, etc.). Their average size is estimated to be 750*470 mm.
Personal protective equipment (PPE) refers to clothes or devices that are worn in order to protect people from infectious materials[5]. Medical staff treating patients with respiratory infections is required to wear PPE, which largely consists of gloves, gown or aprons, face protection, and respiratory protection.

Table 3. Type of PPE

| Components | Note |
|------------|------|
| Face, eyes, and respiratory protection | Surgical cap (head protection), Medical mask, Respirator, Goggles | The contaminated area must not contact the body or other equipment when putting on or taking off PPE |
| Skin and clothes protection | Scrubs, Apron, Overalls, Double gloves |
| Shoes protection | Boots |

(N95 mask, gloves, safety goggles, face shield, gown)

Koreans between 30 and 34 years old [6] have on average a shoulder width of 432mm for men and 384mm for women, and a chest size of 990mm for men and 863mm for women. The space occupied when a person wears PPE over general clothes is estimated to be 1.2 to 1.4 times larger than the average body size. The principle of using PPE is to put it on before contacting a patient and to take it off immediately after patient care, right out of the isolation room. It is important that PPE be taken off in the antechamber. Thus, in an isolation room 518 to 604mm and 460 to 537mm of width for movement must be guaranteed for men and women, respectively. In the antechamber, where PPE is removed, the length of the arms must be reflected in the width of the room, which needs to be at least 1800mm. Of course, a space with a width larger than the minimum will be needed in order to prevent contaminants from being smeared onto the walls of the antechamber. The treatment carried out in an isolation room is classified into general treatment such as blood collection and medication, and emergency treatment for dyspnoea or seizure. The minimum staff necessary is one or two[7] for general treatment and two to four for emergency treatment.

4. Results

4.1. Calculation of isolation room’s minimum size in consideration of physical elements

In consideration of the bed used in the room, installation of the bed and other medical appliances, and the number of patients treated in the room, the minimum width for an isolation room at a hospital is 1,050 mm for the bed; 604 mm for the shoulder width of medical personnel (sides of bed); and 800 mm for movable appliances such as trollies. The simple sum of those widths is 3,090mm, but when the space needed for movement is considered, at least 3,300mm width is required. In addition, the front room where PPE is donned and removed will need to have at least 1,800 mm width. This 1,800 mm is the width that is actually available for the movement of people and appliances and excludes the width of fixed medical appliances at the side of the room, as in the case when it contains a fixed storage of medical appliances. For the depth (the major axis) of an isolation room, at least 4,650mm of width is needed, including 2,000mm for the length of bed, 1,000mm for the space for the installation of ECMO, and 604mm aisle width for the movement of two staff. When there is a fixed medical device or storage, the total width will have to be calculated excluding the width of this equipment. In such a case, a minimum of 1.2 times minimum room width will need to be applied as a reserve space, thus bringing the minimum width of the major axis of an isolation room to an estimated 5,000mm.

c The average arm length for adult men was 585 mm (aged between 30 and 34) and 533 mm for adult women, as of 2010.

d Two nurses, one cleaner, and one assistant for dressing and undressing, according to the guidelines for infectious disease management institutions on the working-level responses to MERS ver1.3
The current standard for the size of an isolation room is 15 m². However, when the necessary minimum width calculated by this study is used to set the major axis and minor axis at 3,300 mm and 5,000 mm, the minimum floor area needed for an isolation room is 16.5 m². In addition, the criteria for the minimum width of an isolation room will have to be established in further detail.

![Figure 3. Size of an isolation room](image)

**5. Conclusion**

Because infectious respiratory diseases such as SARS and MERS break out frequently, the importance of isolation rooms in hospitals to treat respiratory diseases and prevent their further spread is increasing. This study conducted a questionnaire survey of experts and analyzed the use of isolation rooms and their necessary appliances. This analysis determined the minimum room size needed for patient treatment in order to contribute to hospital construction plans for the future.

**6. References**

[1] KCDC, The 2015 MERS outbreak in the republic of Korea, pp185, 2016.07.
[2] Ministry of Health and Welfare, Press release (201.07.27) http://www.mohw.go.kr/front_new/al/sal0301vw.jsp?PAR_MENU_ID=04&MENU_ID=0403&page=1&CONT_SEQ=333614 (in Korean)
[3] KCDC, Guidelines for infectious disease management institutions on the working-level responses to MERS ver1.3, 2015.06
[4] Medical device manufacturer, http://korean.electric-hospitalbed.com (cited 01 Feb. 2017)
[5] The korean society of infectious diseases, http://www.ksid.or.kr/mail/file/MERS01.pdf, 2016.06.
[6] Korean Agency for Technology and Standards, The 6th project of three dimensions form measurement of Korean’s body size, https://sizekorea.kats.go.kr/06_civilCenter/libraryView.asp?idx=4890&page=1, pp100-112, 2010
[7] MERS central branch medical institution, Guidelines for infectious disease management institutions on the working-level responses to MERS, 2015.06.

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