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Infection Prevention In Health Care Systems By Incorporation Of Well-Equipped And Designed Isolation Rooms

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ABSTRACT
In this study, we report the importance, types and design of isolation rooms in hospitals required during any pandemic situation. The outbreak of a severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) has spread across the world and have caused a global health emergency. The isolations rooms can be created in the already existing parts or can be designed using a variety of wall surfaces from vinyl-covered gypsum to nonporous Fiberglass Reinforced Plastic (FRP).With the literature review and data collection we have designed single as well as common isolation room designs with all the features to reduce the spreading of the infection.

Keywords: *Isolation Room design, ventillation system, infection control, pandemic, healthcare systems, fiber glass reinforced plastic.*

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INTRODUCTION

There was a sudden outbreak of an acute respiratory syndrome coronavirus 2 (SARS-CoV-2) , now being named as Corona Virus Disease 2019 (COVID19) occurred in Wuhan, Hubei Province, China [1–5] in early December 2019. The disease started to spread from Wuhan to other parts of China and then to the World. This coronavirus was new of its kind and was first being identified in the airway epithelial cells of a patient from Wuhan and was then considered and claimed to be the cause of COVID'19 [6]. A group of researchers "Coronavirus Study Group" from the International Committee on Taxonomy of Viruses then gave a report and designated it as a severe acute respiratory disease. The SARS-CoV-2 is the etiological agent of the coronavirus induced disease 19 (COVID-19) and this has caused a pandemic situation all over the world [1,7,8]. This disease is closely related to SARS so there was evidence of infection being transmitted from human to human especially at public places [8-14].

The corona virus disease 19 (COVID-19) caused by severe acute respiratory syndrome corona virus 2 (SARS-CoV-2), is beta (β) corona virus, a sub group of corona virus family [15, 16]. The corona virus is a 65 nm -125 nm spherical membrane that composed of three or four viral proteins. The most of spherical membrane is the glycoprotein. The spike like glycoprotein over this membrane is the composition of peplomers as shown in Figure 1. This spike like glycoprotein is mostly responsible for the quick transmission. The existence of a molecular interaction between the envelope proteins takes part in formation and composition of the membrane of a corona virus [16-18].

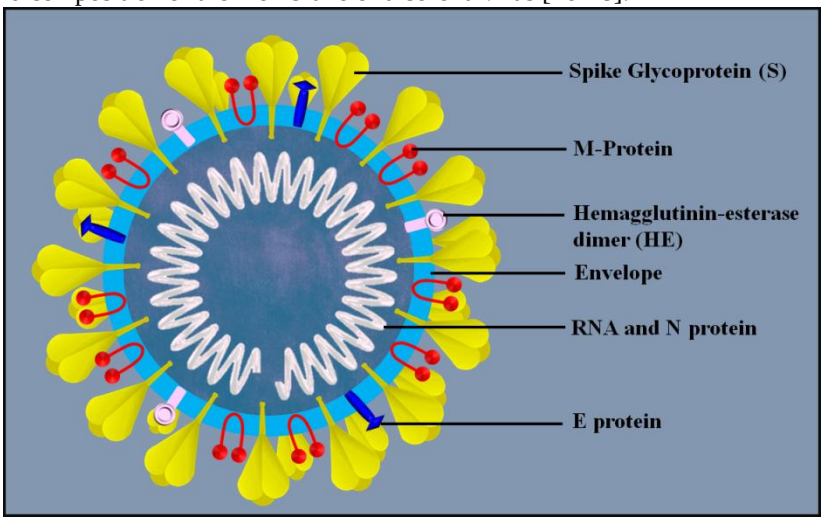


Figure 1: Structure of Corona virus

COVID-19 is a highly transmittable that transmit through respiratory droplets (Droplets comes out during sneezing or coughing) and via contact. There have been enormous amount people who were infected and dieddue to COVID-19. As per guideline of World Health Organization (WHO) COVID-19 can be transmit via contact, droplets and air. Contact can be either direct or indirect. Direct contact transmission is the physical transfer between one susceptible host and an infected/colonized person and indirect transmission is the Personal contact between a susceptible host and a contaminated intermediate object, usually inanimate. Inhalation of infective large droplet via close contact with an infected patient sneezing or coughing can cause COVID-19. By inhalation of infective small particles (< 5 μ) which once dispersed remain suspended in the air can also infect a normal person. [19]. The modes of transmission are being tabulated in Table- 1.

Table 1: Transmission of COVID-19 [20]

Modes of COVID-19 transmission		
Contact	Direct Contact	Direct physical transfer between one susceptible host and an infected/colonized person.
	Indirect Contact	Personal contact between a susceptible host and a contaminated intermediate object, usually inanimate
Droplet		By inhalation of infective large particles via close contact with an infected patient sneezing or coughing
Air born		By inhalation of infective small particles (< 5 μ) which once dispersed remain suspended in the air

There is no particular therapy or vaccine for the procurement of this disease so far. Therefore we have to depend on classical measures to prevent this disease. The major purpose of such public health measures is to stop the person to person transmission of this disease by breaking off the transmission chain. Isolation and quarantine, social distancing and community containment are the curial tools to prevent the epidemic in the present situation [21].

Quarantine means the restriction a person from his/her regular activities who is not ill but who may be bearing an infectious agent or disease. Quarantine can be useful at the individual or group level to prevent the spread of COVID-19. Social Distancing is applied to diminish communications between people in a large community, where persons may be infectious but have not yet been recognized or not in isolation. Social distancing is helpful to prevent the transmission. As these measures become insufficient to prevent a pandemic, the community containment can be applied. It is an intrusion applied to an entire community, city or region, designed to lessen personal interactions [22].

Measures to prevent the spread of COVID'19

Ensure applicable hand-washing facilities. Ensure applicable area ventilation (e.g., 12 ACH). Post aggregation on the door. Before being allowed into the isolation areas, guests ought to consult the nurse accountable, and the World Health Organization is additionally liable for keeping a traveler record. A roll of all employees operating within the isolation areas ought to even be unbroken for doable natural event investigation and make contact with tracing. Remove all non-essential pieces of furniture; the remaining furniture should be straightforward to scrub and shouldn't conceal or retain dirt or wetness inside or around it. Stock PPE offer and linen outside the isolation area.

Stock the sink space with appropriate provides for hand laundry, and with alcohol-based hand rub close to the point-of-care and area door. Place applicable waste baggage in an exceeding bin. If doable, use a touch-free bin. Dirty bins ought to stay within the isolation rooms. Place puncture-proof instrumentation for sharps disposal within the isolation area. The patient's personal belongings should be kept to a minimum. To Keep water pitchers and cups, tissue wipes, and everyone things necessary for progressing to personal hygiene inside the patient's reach. Non-critical patient-care instrumentation (e.g., medical instrument, measuring instrument, pressure cuff, sphygmomanometer) ought to be dedicated to the patient, if doable. Before use, any patient-care instrumentation that's needed to be used by alternative patients ought to be clean and disinfected. Set up a self-propelled vehicle outside the door to carry PPE. A list is also helpful to make sure that each one instrumentation is out there. Place associate degree applicable instrumentation with a lid outside the door for instrumentation that needs medical aid or sterilization.

To Keep sufficient gear required for cleaning or purification inside the detachment room/region and guarantee careful day by day tidying up of the seclusion room/region. A phone or other technique for correspondence ought to be set up in the segregation room/territory to empower patients or relatives/guests to speak with HCWs so as to limit the need for HCWs to go into the room/zone.

Wearing and removing PPE

Before entering the isolation room/area:

- Gather all gear required.
- Perform hand cleanliness with a liquor based hand rub cleanser and water.
- Put on PPE in the request that guarantees sufficient arrangement of PPE things and forestalls self-sullying and self-vaccination while utilizing PPE, and when taking PPE off.
- Leaving the segregation room/region

Leaving the isolation room/area:

Evacuate PPE either in the vestibule, or if there is no antechamber, ensure that neither nature outside the disconnection room/zone nor different people can get debased.

Evacuate PPE in a way that forestalls self-defilement or self-vaccination with polluted PPE or hands. General standards are:

- Evacuate the most sullied PPE things first.
- Hand cleanliness must be performed following glove expulsion.
- The last PPE thing to be evacuated ought to be the veil or particulate respirator by getting a handle on the ties and disposing of in waste receptacle.
- Dispose of expendable things in a shut junk container.

Isolation Rooms

Why isolation room are required?

Isolation rooms are required to reduce the risk of infection spreading. As its already known that any person can catch COVID-19 infection from a person who has the virus. Due to its severity it is important to stay more than 1 meter away from a person who is sick and follow strict measures.

The isolation rooms are kind of are environments that are especially designed to help prevent the spread of harmful pathogens and viruses. The main focus of Isolation Rooms is to create a negative pressure environment to contain pathogens in one environment. In this case, the isolation room should have a lower pressure than the surrounding rooms, keeping airborne particles from flowing outward. Used in combination with the proper gloves, gown-wear, and handwashing, isolation rooms offer hospitals and other medical facilities with a controlled space to treat highly contagious patients, while not putting others at risk [23-26].

The isolation room designs can be classified in the following four types:

- Class S—Standard pressure room
- Class N—Negative pressure room
- Class P—Positive pressure room
- Class A—Alternating pressure (negative/positive pressure)

These various kinds differ in the basic structure and mechanism of these rooms. Among all these Class A is the least preferred due to the fact that it is difficult to maintain a pressure difference and its is not suitable for many kinds of pathogens. So, depending on the severity of the disease the isolation room can be decided. The various features of these rooms are being tabulated in Table 2.

Table 2: Various features of the different kinds of isolation rooms

S.No.	Features	S Standard	N Negative	P Positive
1.	Non-hand operated hand basin in room and anteroom	Yes	Yes	Yes
2.	Ensuite bathroom (shower,toilet& hand washbasin) [25,26]	Yes	Yes	Yes
3.	Pan sanitizer (near room)	Yes	Yes	Yes
4.	Door on room with door closer)	Yes	Yes	Yes
5.	Anteroom	-	Yes	-
6.	Sealed room, door grille for controlled air flow	-	Yes	Yes
7.	12 ACHR or 145 litres per patient	-	Yes	Yes
8.	100% outside air ventilation	-	Yes	-
9.	Local differential pressure monitoring	-	Yes	Yes

10.	Independent supply air [27]	-	Yes	-
11.	HEPA filters on supply air	-	-	Yes
12.	Low-level exhaust 150 mm above floor	-	Yes	Yes
13.	Independent exhaust discharging vertically at 10m/s according to AS 1668.2Type A exhaust [27]	-	Yes	-
14.	Exhaust duct under negative pressure within building with duplex fans	-	Yes	Optional
15.	HEPA filters on exhaust for retrofit [28]	-	Optional	-

Isolation Room Features

- Quick & Clean Installation into existing facilities. The prefabricated panel & binder-post system ensures minimal on-site disruption
- Pre-installed, modular electric outlets & data hook-ups
- The Isolation Rooms are well sealed with self-closing doors
- Limitless layouts. Panel Built wall panels are designed to conform to an existing space. Our fully custom panel heights, lengths, & widths ensure the perfect fit with built-in, hidden return air chase.

Isolation Room design

Single rooms as well as common rooms with appropriate air handling and negative ventilation is particularly important for reducing the risk of micro-organisms being spread by airborne transmission from a source patient to susceptible patients and other persons in hospitals. This isolation room design helps prevent direct or indirect contact transmission, or droplet transmission of infectious agents. An infected or colonised patient can contaminate the environment, or have difficulty in maintaining infection control precautions.

The standard single and common isolation room design as shown in Figure 3 and 4. This design of a type of standard pressure room which can be used for patients requiring contact or droplet isolation. For this type of isolation normal air-conditioning is appropriate. In case of COVID'19 there is requirement of Class N isolation room i.e. the negative pressure room. Negative pressure rooms are used for patients requiring airborne droplet nuclei isolation. These kind of isolation rooms reduce the transmission of infection via airborne route due to which these kind of room can also be called as airborne infection isolation units. There is maintenance of negative pressure gradient from the room to the anteroom and the ambient air. This kind of mechanism is accomplished by incorporating a separate exhaust system which is there is each room [24].

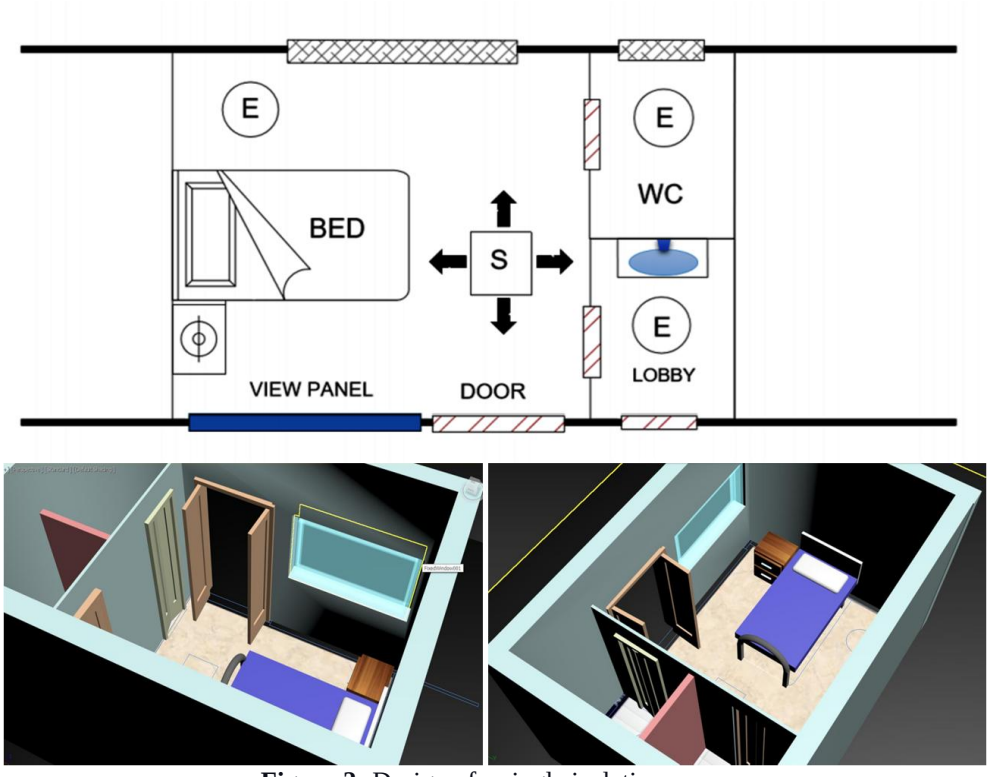


Figure 2: Design of a single isolation room

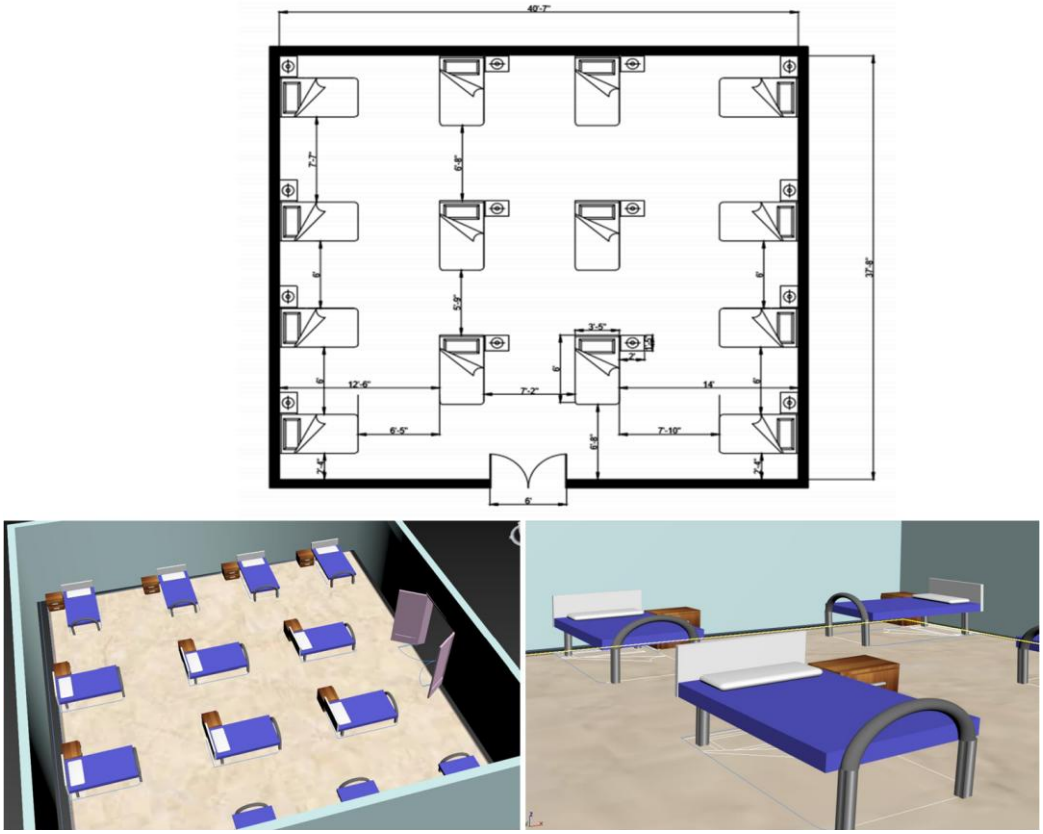


Figure 3: Design of a common isolation room

The basic elements of the standard and Class N isolation room are as under:

- A staff hand washbasin within the room.
- An ensuite bathroom. The ensuite entrance should not be in the anteroom. An ensuite is not a mandatory requirement for a NPR in an emergency department. A clinical risk assessment should be conducted to determine if the ensuite can be excluded. En-suite exhaust shall not be connected to the common building toilet exhaust system.
- A self-closing door.
- Pan sanitiser near the room.
- Label to indicate standard pressure isolation room.
- Separate exhaust air ducts from the common building exhaust air system to reduce the risk of contamination from back draught.
- Provide 100% outside air ventilation

There is a Anteroom or airlock function room in isolation rooms. Basically they have the following three functions [30]:

- a barrier against loss of pressurization and entry or exit of contaminated air into or out of the isolation room when the door to the anteroom is opened;
- a controlled environment in which protective garments can be donned without contamination prior to entry and exit of the isolation room; and,
- a controlled environment in which equipment and supplies can be transferred from the isolation room without contaminating the surrounding areas.

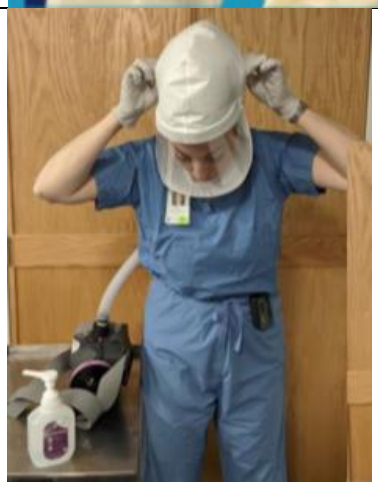
The furnishing and fittings required in the isolation rooms:

- clinical handwash basin with non-touch, fixed temperature mixer tap
- wall-mounted soap dispensers
- disinfectant hand rub dispensers
- disposable towel holders
- glove dispensers
- storage for clean personal protective equipment
- clean waste bins

- observation window in corridor wall with integral privacy blinds
- investigate the use of a pressure stabiliser above the bedroom door
- compliant exhaust system
- compliant air supply (see below)
- sliding transfer grille in room door
- sealed, monolithic ceiling with sealed access panels
- windows to the exterior to be locked shut and sealed
- provision of two-way intercommunication system between the patient's roomand the nurses' station.

Strict measures need to be taken after coming out of the isolation room, to reduce the risks of infection and therefore several steps should be taken and these are tabulated in Table 3.

Table 3: The various steps which need to be taken care of with details

S.No.	Step	Location	Detail
1.	**Gown and Gloves** Remove gown & gloves first - in a single step. To facilitate gown and glove removal, remove belt from waist. Do not turn off blower. Hang blower motor & belt on a hook or place on stable surface. Once blower motor & belt are secured, remove gown & gloves in a single step. • Roll gown into itself, peeling off gloves at the same time. • Hold gown away from your body and discard.	**Doorway**(inside or outside patient room- with door closed)	 
2.	**PAPR – Outside room or in Anteroom** Perform hand hygiene - don clean gloves. Lean forward, do not touch front of hood. • Remove and discard face shield or goggles. • Avoid touching front of face shield. • Remove hood by grasping above ears while bending forward. Lift and pull forward away from your face. • Disconnect breathing tube from blower	**Doorway**(inside or outside patient room- with door closed)	

	unit, shut off blower. Discard hood and hose. • Belt and blower unit must be wiped down with hospital-approved disinfectant and stored. Plug blower into charging cord.		
3.	Remove and discard* N-95 Respirator	Outside room	 Do NOT touch front of mask Pull bottom strap first then top strap over head- without touching respirator Discard in trash
4.	Remove gloves perform Hand Hygiene	Outside room	Alcohol-based hand rub (ABHR) or wash with soap and water (if indicated), dry, then disinfect with ABHR.

CONCLUSION

The design of a hospital premises serves as an essential component for its infection control measures so as to minimize the risk of transmission of any infectious disease. In today's era where the pandemic situation have suddenly aroused and caused lot of trouble so in a more progressive outlook towards hospital design is a fundamental requirement so that such situations can be tackled in a much better way and medical facilities can be provided on all levels. As, there have been emergence of new infectious diseases and with the outbreak of the pandemic situation, more people have become aware and cautious regarding the healthcare and therefore, consideration should be given in the planning phase itself. The existing hospitals and medical institutions can undergo renovation and upgradation where isolation rooms are then incorporated with all the necessary design specifications. The ventilation characteristics of an existing patient room must be considered when converting it into NPR where disconnection of re-circulating air system and upgradation/conversion method should be taken care of. Isolation room should be incorporated as an essential part of the hospital design in order to prevent infection in case of highly infectious diseases in order to stop spread and reduce the possibility of developing a new infection. There should be a collaboration between the architect and engineer so that all essential services of an isolation room can be designed and incorporated during planning itself.

Contributors

RM has done data collection, data analysis, data interpretation, literature search, designing of the drawings of the room structure and writing of the manuscript.

Declaration of interests

We declare no competing interests.

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