

Sustainable Healthcare Facility Design for COVID Treatment

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Abstract—Healthcare facility design is the need of hour due to the recent pandemic situation going on around us. It is necessary that healthcare provider and administrator should focus on the required changes in the existing healthcare facilities. The isolated healthcare facilities are the utmost requirement because of the transmission of the corona virus through is spread mainly from person-to-person, usually via close contact (within six feet), that could be via physical contact, like handshaking (if someone's hands are contaminated with the virus) or touching contaminated surfaces. Healthcare facilities are mostly prone to the spread as several patients with symptoms are admitted and there is maximum possibility of transmission of corona virus. Corona Virus is a severe acute respiratory infection and is the leading cause of morbidity and mortality from infectious disease in the world. This leads to the purposing new plans and design to the existing healthcare facilities as well as makeshift version in case the existing healthcare facilities exhaust if the number of cases increases in this pandemic situation. The increased rate of research in this field will be beneficial to the society. Healthcare staff, patient will be able to get better quality of service and up gradation of healthcare facilities will be more important in the upcoming years. This paper proposes the new plans and design to overcome the various issues discussed.

Keywords: Healthcare Facility Design, COVID-19, Pandemic, Isolated Facilities

I. INTRODUCTION

Healthcare facility is the major concern because of the ongoing pandemic situation. Several countries are facing this issue and most of them are not able to tackle the problem related to healthcare infrastructure facility [1]. Severe acute respiratory infections vary according to several factors, including environmental conditions, such as air pollutants, household crowding, humidity, hygiene, season and temperature; availability and effectiveness of medical care and infection prevention and control (IPC) measures to contain spread, such as vaccines, access to health-care facilities, and isolation capacity; host factors, such as age, cigarette-smoking, host ability to transmit infection, immune status, nutritional status,

prior or concurrent infection with other pathogens, and underlying medical conditions. As several countries are still researching for the vaccine and lockdown can be done for a limited time. Lockdown cannot be the ultimate solution and social distancing can be done till the vaccines are not developed. To ensure effective social distancing and to lessen the effect of this virus, the proposed plans and design in the healthcare facilities may help the healthcare providers and general public.

Because new infectious disease threats usually start locally, it is important to understand their dynamics in order to deny them the opportunity to spread further among people and overwhelm health systems. The dynamics of epidemic and pandemic diseases typically occur in four phases, although not all epidemic diseases necessarily go through each phase. The various phases of epidemic are shown in figure1.

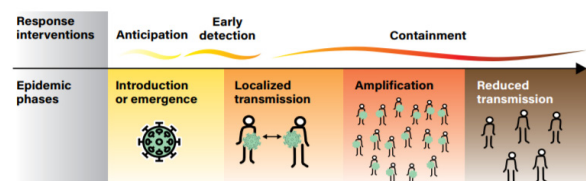


Fig. 1: Epidemic Phases

This work is about dealing with the COVID-19 Care hospitals/centre design and plans for various areas such as building design (including ventilation), restricted movement of people bound to follow by design measures, construction and management, and hygiene. It is designed primarily for use in health-care settings in precarious situations and in situations where simple and affordable measures can improve hygiene and health significantly.

II. METHODOLOGY AND DESIGN

Corona viruses (CoV) are a large family of viruses that cause illness in humans, ranging from a common cold to more severe diseases, such as Severe Acute Respiratory Syndrome (SARS-CoV). The novel corona

virus (nCoV) is a new strain, not identified in humans until 31 December 2019, in the city of Wuhan, China [2]. It is the accountability of capacity managers to take deed towards implementing the accurate anticipation and control strategy in the place of work. This lead to changes in the current infrastructure or make shift arrangement to utilize the available resources to overcome the impact of COVID-19. These changes are necessary as it may help to reduce the wide spread of infection and without disciplined population it will be very difficult to cope up with this pandemic. Lockdown can be implemented for short time and it is not the permanent solution. Industries, offices, healthcare facility, educational institutes etc cannot be sustain without the people and therefore people need to come out and perform their duties. In healthcare facility, utmost care is required as the COVID-19 patient are getting treatment and therefore several changes or modification are required in every aspect of healthcare facility management. In this paper, we have proposed some plans and design to overcome or limit the spread of corona virus.

A. Different Transmission Scenarios at Healthcare Facility

In general, patient with mild symptoms visit the primary healthcare facility centers for the checkup and healthcare staff investigates the symptoms and suggest the patient to either stay home and quarantine for 2-3 days for further process. If the symptoms are acute and needs further investigation, patients are sent to the nearby hospitals for testing and further medical tests such as chest x-rays, etc as suggested by the healthcare experts. In this journey from primary healthcare facility to hospital, patient may encounter several people who may have no infection and the patient can spread the virus without any intention. Figure 2 depicts the journey from primary healthcare facility to hospitals.

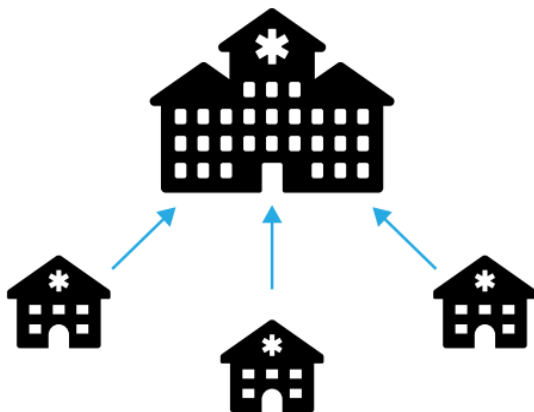


Fig.2: Patient Journey from Primary Healthcare Facility to Hospitals

For this journey we suggest, some changes for the suspected patients and dedicated corridors for their movement in the hospital. The various steps can be reducing concentration of personnel, reducing physical proximity of staff, cleaning and disinfecting, keeping everyone informed. All the steps require the modification in the signage boards, so that the suspected patients and healthcare staff/ general public can understand the seriousness of the pandemic. Various sign boards can be restricted pathway signs, dedicated washrooms, restricted movement signboards, dedicated floors for suspected patients, compulsory hygiene notices at various areas of hospitals.

This the first journey of the suspected patients at hospitals and if any patients is found Corona positive, patient need to be transferred to the COVID Treatment Hospitals. This phase of journey is more crucial and requires controlled/restricted movement of patients and is shown in figure 3.

During this journey, a dedicated team of healthcare staff, security is required as this virus does harm on physical and mental health of patients and several incidents happened in the past few months. In this journey, dedicated corridor should be developed at the primary health facility, hospitals and the departure of positive patient should be from any other gate may help in reducing the chances of corona. After reaching the COVID Treatment facility, there are various areas which are needed to be taken care off.

It is known that respiratory viruses in general are transmitted through droplets created when a carrier coughs or sneezes, or through surfaces that have been contaminated with the virus [3]. The various steps are required to spread this deadly virus. It is evident from various researches that ventilation is the key area in healthcare facility design. In general there are three methods for ventilation of building such as natural ventilation, mechanical ventilation and hybrid ventilation [4].

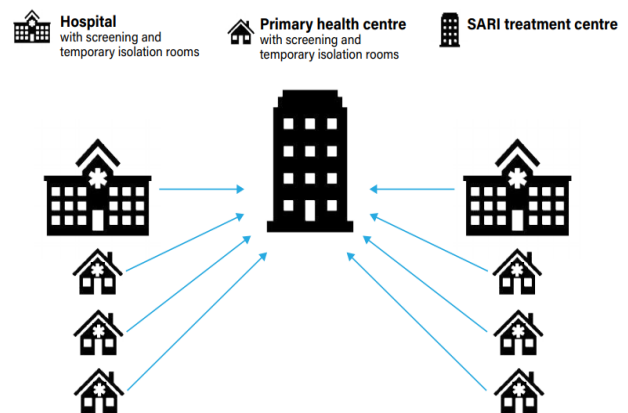


Fig.3: Patient Journey from Primary Healthcare Facility/Hospitals to COVID Treatment Facility.

Hybrid ventilation system can be used for the critical patient rooms/wards. The approach we are suggesting is the Top down hybrid ventilation with effective HEPA filter or ultraviolet light ducts. Figure 4 shows the Top Down Hybrid Ventilation with HEPA filter and UV duct Techniques. The UV type Hybrid Ventilation needs careful handling and a signboard with NO ENTRY is to be pasted at the wall. Figure 5 shows the details about HEPA and UV filters [5].

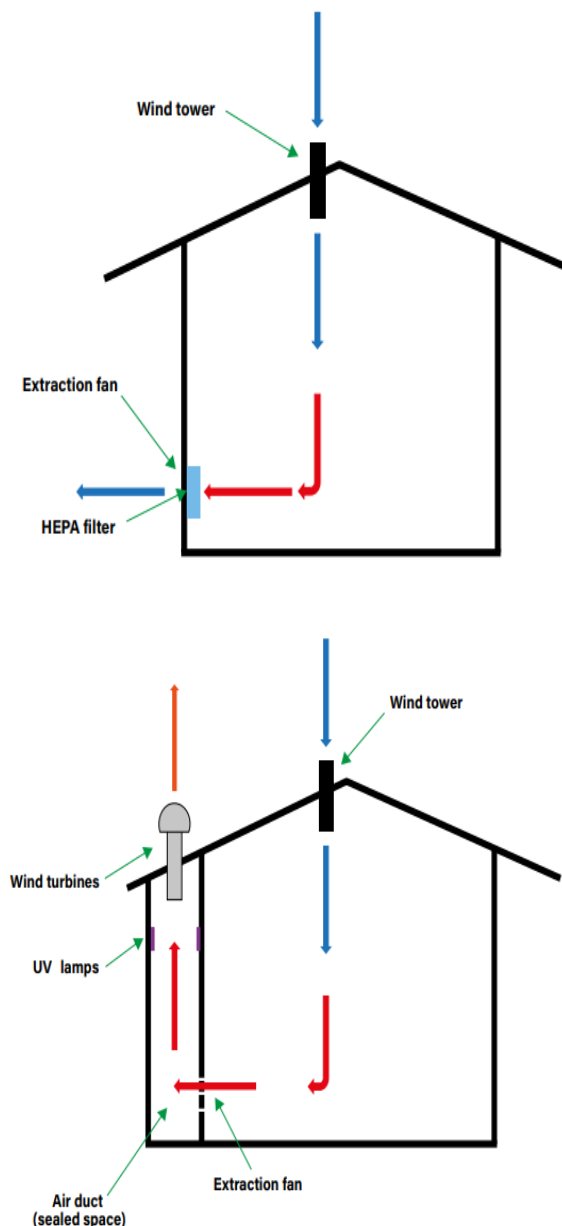


Fig.4: Top Down Hybrid Ventilation with HEPA filter and UV duct Techniques

Patient screening require a significant amount of management of resources and safety of medical staff. Two different zones can be created for screening zone 1 for staff and zone 2 for patients as shown in figure 6. There should be separated hand washing system for patients and staff. There should be distance of 2 meter between patient and staff as directed by WHO guidelines. Various sizes of tent type waiting rooms, isolation rooms etc can be created with proper natural ventilation. Figure 7 shows the temporary tent based screening plan.




	HEPA filter	Portable HEPA filter	UVGI
Image			
Description	Pleated mechanical air filter that can theoretically remove at least 99.97% of dust, pollen, mould, bacteria and airborne particles with a size of 0.3 microns (µm)	A portable HEPA filter unit equipped with the proper fittings and ducting to exhaust air from a selected room to create the required ventilation flow rate and exhausted air treatment	Electromagnetic radiation that can destroy the ability of microorganisms to reproduce by causing photochemical changes in nucleic acids. Wavelengths in the UVC range are especially damaging to cells because they are absorbed by nucleic acids
Application	Air filtration in hospitals, isolation rooms and laboratory facilities	Ventilation and air filtration in hospitals, isolation rooms and laboratory facilities	Air-cleaning measure; UVGI is effective in reducing the transmission of airborne bacterial and viral infections in hospitals, military housing and classrooms
Air extractor needed	Yes	No	Yes

Fig.5: Details About HEPA Filter and UV

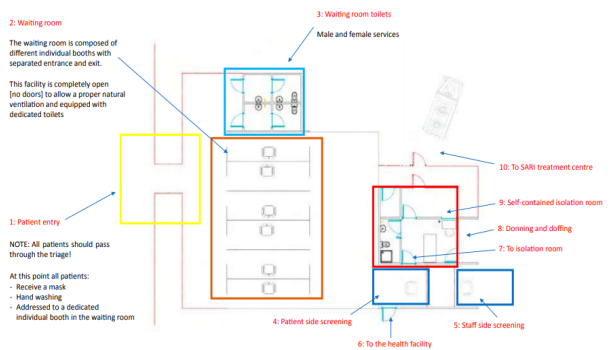


Fig. 6: Screening Plan Zone Wise for Patients and Staff.

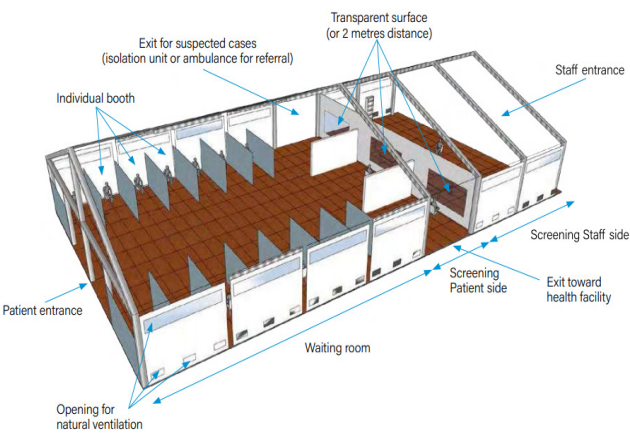


Fig.7: Temporary Tent Based Screening Plan.

As per the guidelines of ICMR and WHO, it is important to follow the protocols while site identification, selection and prior surveys also play vital role in setting up of any COVID-19 Treatment facility or centre [7]. In view of guidelines given, following practice such as ground characteristics such as good access and guaranteed security for patients, visitors and staff, meteorological characteristics like competent to adjust the design to accommodate different climatic conditions, existing resources such as use of permanent buildings and existing hospital isolation or unused ward, etc.

In any COVID-19 Treatment facility or centre, there should be bifurcation of the available area into three or four possible zones [6]. First can be Healthcare Staff or Working area, second can be patient with moderate symptoms, next can be severe cases with corona and last can be critical cases which need enhanced ventilation facility and utmost care. The patients in the various zones are classified by the healthcare experts involved in the treatment. The other reason behind the zonal separation is to ensure a clear demarcation and separation between patient and staff areas in order to reduce the risk for health-care workers and allow a rational use of protective kits. Figure 8 shows the zonal plan for the various cases discussed above. Figure 9 depict the tent type make shift arrangements for establishing a COVID-19 Treatment facility.

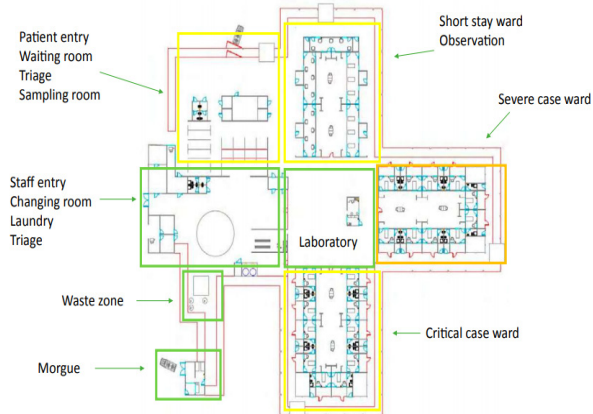


Fig.8: Zonal Plan in COVID-19 Treatment Centre

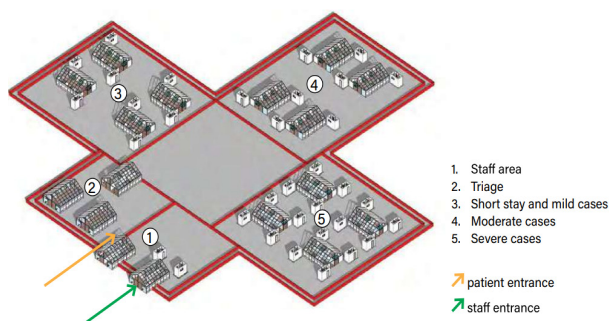


Fig. 9: Tent Type Temporary Arrangements for COVID-19 Treatment Centre

Several other areas such as waste and medical waste disposal, water treatment facility, cleaning service zone, dead bodies' storage and secured transfer facility, biomedical device sanitization, PPE kit disposal zone, etc are also part of the COVID-19 treatment Centre. The proposed plans can also be created for reduction of spread of corona virus. Several hospitals and research centre have started sanitization tunnels for healthcare staff, patients and others staff but logistic sanitization is also important aspect in hospitals. Logistic sanitization also required planned placement of the sanitization machine in the healthcare facility.

III. CONCLUSION AND FUTURE SCOPE

The proposed plan discussed in the above section shows that healthcare facility needs several modification to encounter the spread of corona virus. The management of the available resources in terms of patient transfer, screening, isolation can be effectively done by the proposed plans, if executed with utmost care. The various proposed design for modifications in the COVID-19 treatment centre as well as temporary arrangements depicts that it is necessary to separate the various types of corona patient ranging from moderate, severe, critical in zones. It may help the healthcare staff to manage the resources with more efficacies and the critical patient will be able to get the proper treatment and will enhance the possibility of their well being. The various facilities such as waste disposal, water treatment, cleaning service, dead bodies' storage and secured transfer facility, biomedical device sanitization, PPE kit disposal can also be designed with the similar set of standards. If we think about future aspect, this pandemic has taught a lot about the health hygiene and therefore it is necessary for all the governments, general public to understand the importance of various factors related to the healthcare facility. Similar type of design can be implemented for work spaces and offices, residential areas, educational institutions, common areas, sports events, etc. The main aspect of social distancing have to be followed by the public but if there are dedicated pathways with appropriate signage boards may also help the people focus the concern of people in these type of situation.

REFERENCES

- [01] Hospital preparedness for epidemics. Geneva: World Health Organization; 2014.
- [02] Coronavirus. Geneva: World Health Organization; 2020
- [03] Testing and troubleshooting of ventilation systems. Carolinas Section AIHA;
- [04] Reed NG. The history of ultraviolet germicidal irradiation for air disinfection. *Publ Health Rep.* 2010;125:15–27.
- [05] Best practices for environmental cleaning in healthcare facilities in resource-limited settings. Atlanta, GA: Centers for Disease Control and Prevention; 2019.
- [06] Wang W, Xu Y, Gao R, Lu R, Han K, Wu G, et al. Detection of SARS-CoV-2 in different types of clinical specimens. *JAMA* 2020.
- [07] Ministry of Health and Family Welfare, Government of India.COVID-19 India.