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The Infection Control Risk Assessment And Appropriate Design Methods for Optimizing Healthcare-associated infections In Outpatient Departments of Hospitals

Rita Milad Adly * [1] ; Ahmed Atef [1]; Ashraf M Nessim[1].
[1] Departmant of Architecture Engineering, Faculty of Engineering, Ain shams University , Cairo, Egypt..
[*] Corresponding Author.
E-mail: ritamilad22@gmail.com; ahmedfaggal@gmail.com; ashrafnessim@gmail.com

Abstract: Architectural design has a great impact on humans because it controls the risk of infection transfer to achieve environments that can contribute to patients' healing, recovery, and well-being [1]. Therefore, health is a very important need for humans and keeps it as well, however, it is common to be infected by the illness through going to therapeutic and medical places which is called healthcare-associated infection (HAIs). Infections occur during people receive treatment in healthcare facilities for other diseases or any other Health complaint. As part of this approach, the interior design of the outpatient area is considered a major vital element in the whole life cycle of, a healthcare building. In recent years, healthcare facilities have suffered from hospital-acquired infections, AS 5% of anyone admitted to healthcare facilities can contract with an HAI and 1 in 20 patients in the U.S. acquired a healthcare-associated infection per year [2] of Appropriate design methods. The role of infection control mentioned in this study is to review and approve the role of applying passive techniques for improving the comfort and satisfaction of healthcare patients and occupants in their working environments as a place feel them by health and safety, Clarify the effect of passive techniques on infection control risk assessment (ICRA), improving the different designs of outpatient areas, and deducing more vision into the post-occupancy evaluation and suggesting the best building interior design considerations for the healthy environment to future healthcare designs. The result of this study was to determine Appropriate design methods for optimizing infection risk possibilities.

Keywords: Passive techniques, Outpatient areas, Healthcare-associated infection (HAIs), Healthy Environment, Infection control risk assessment (ICRA).

1. INTRODUCTION

Nowadays, it's crucial for countries to prioritize patient safety and protection. They should develop and strengthen evidence-based systems to improve patient security and the quality of healthcare. This focus on safety and quality will encourage countries to create national standards and guidelines to ensure that medical and healthcare practices are safe.

Although the World Health Assembly and regional committees have repeatedly urged countries to prioritize safe healthcare practices, none of their decisions have specifically addressed the complex and interconnected issue of infection prevention and control programs in healthcare. [3]. There's still a lack of a consistent and comprehensive plan to prevent and fight healthcare-associated infections (HAIs) across all stages of patient care.

Healthcare-associated infections (HAI), also known as nosocomial or hospital-acquired infections, these infections weren't present when the patient was first admitted. They can also include illnesses that develop after the patient leaves the hospital or infections that healthcare workers get on the job. [4].

Infection Control Risk Assessment (ICRA) is a process that helps identify and manage potential risks of infection. It's important to conduct an ICRA to prevent unexpected infections, promote well-being, reduce healthcare-associated infections (HAIs), and improve safety. ICRA combines ideas from fields like environmental psychology, architecture, neuroscience, and behavior.

2. Outpatient department [5]

Outpatient clinics provide medical care, including diagnosis, treatment, and follow-up, to patients who visit the clinic without staying overnight. These clinics are designed for patients who can walk or use a wheelchair with minimal assistance. They are not meant for patients who need to be transported on a trolley or stretcher, which are typically used in emergency rooms and urgent care situations.

2.1 Patient's journey through the outpatient department:

- Patients who arrive at the outpatient are categorized into four groups:

1. Patients with minor illnesses, go to the reception desk then the clinic then the pharmacy then they go outside hospitals.
2. Patients with minor illnesses but with specific conditions, go to the reception desk then the clinic then they go outside hospitals. Ex: physical therapy and speech clinic…. etc.
3. Patients with more severe illnesses or complex conditions, who primarily visit doctors then transported to the Department of Radiology and Analysis for further evaluation.
4. Patients with more severe illnesses or complex conditions, who primarily visit doctors then transported to the Department of Radiology or Analysis for further evaluation then they go back to the doctor's clinic on the same day.

2.2 General functional requirements for Outpatient departments' design

2.2.1 Privacy

To protect patient privacy during medical treatment, it's essential to consider their right to privacy from both sounds and visual distractions [6].

2.2.2 Relationship to the diagnostic and therapeutic departments

The outpatient department is divided into three sections: Main entrance and exit, reception, waiting and reservation area. The main section is for all patients, the second section is for Detection and treatment for patients and includes radiology and Laboratory areas, and the third section is service zone includes Pharmacy, sub wait, Wcs, baby change, and infant feeding, as shown in (Fig 1) [1].

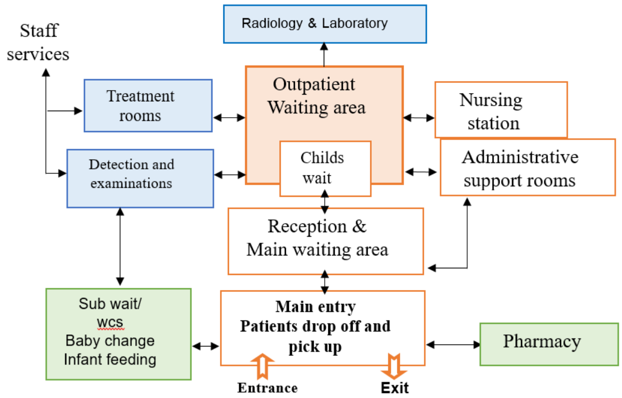

FIG 1. Relations between outpatient department area, Source: Author

2.2.3 Main Outpatient department spaces

Based on national & international codes the following table summarizes OPD spaces.

TABLE 1. Outpatient department main spaces

Space	Action
Entrance and exits	- Patients should be able to easily see signs from the moment they enter the hospital until they reach the outpatient clinic area. -To ensure safety during a fire, the main waiting area should have at least two separate exits that are located some distance apart. These exits should lead directly to the outside of the building [5].
Reception area	The waiting area should be large enough to comfortably accommodate all patients who visit the outpatient clinics [5].
Waiting & services	The waiting area should be large enough to accommodate all patients who visit the outpatient clinics. It should have a cafeteria, restrooms, and a wheelchair-accessible restroom. There should also be comfortable seating options for patients. [5][6].
Examination	The examination rooms should be located directly after the reception area. These rooms are where patients are examined and diagnosed. Each room is approximately 8 square meters, excluding doors, closets, storage spaces, and restrooms [8].
Treatment room	Each treatment room should be at least 12 square meters, excluding bathrooms, cupboards, storage spaces, and entrances. Importantly, each side of the room should be at least three meters long [7].

Movement paths and doors	The minimum width of any main pathway should be at least 1.50 meters. The following doors should not be this narrow: - Doors leading to patient examination rooms should be at least 1.10 meters wide. - Doors for administrative areas, services, and bathrooms should be at least 0.90 meters wide [7].
Diagnostic Radiology	- Ideally, the outpatient clinic should have direct access to the hospital's diagnostic radiology department, or at least some key parts of the department, such as an ultrasound and X-ray room, should be located nearby [7].
Nursing station	The hospital's departments, such as medical records and examination rooms, should have a communication system, a reception desk, a computer, and a designated area for writing reports and maintaining daily records [5].
Clean supplies store	Examination and treatment rooms should have cabinets filled with sterile instruments and supplies. Additionally, there should be a separate clean supply storage room [6][7].
Toiletries rooms	There should be a designated room with a large, low-height washbasin and areas for storing hygiene-related supplies and tools [5].
Plastering room	Rooms for reducing and casting fractures and dislocations should include a sink [7].
Supporting services	The hospital should have storage areas for supplies, stationery, hazardous materials, medical gases, linens, wheelchairs and trolleys, and waste disposal. Additionally, there should be an archive and an interview room [7][8].

3. Hospital-acquired infections

There are arguments for two perspectives of HAIs definition: medical and environmental. It highlights infection transmission issues and indicates how they are transmitted in terms of suitable medical and architectural forms for control purposes, building strong links between architectural issues and medical issues [9].

3.1 The classification of Hospital-acquired infections

The fear of nosocomial infections has grown in the 21st century because hospitals now admit many patients who are already sick and have weakened immune systems. Additionally, the increased use of outpatient treatments means that hospitalized patients are generally more seriously ill than in the past. There is a classification of HAI fields as shown in (Fig 2).

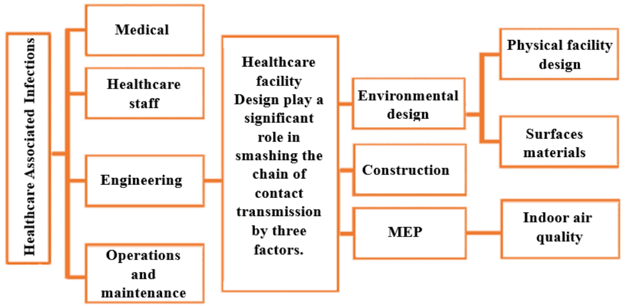

Fig 2: The classification of HAI according to the infection transfer.

3.2 Role of surveillance in reducing HAI [10]

Surveillance is crucial for overall quality management. The primary goal of collecting reliable data is to enhance quality within a service or facility. This data can motivate change and help evaluate the effectiveness of interventions. For example, hand hygiene standards can be improved by tracking compliance and the rate of bloodstream infections and sharing this information within the facility. Balaji V. (2016) [10] argues that surveillance of healthcare-associated infections (HAIs) gathers information about the cause, the affected person, the environment, and risk factors from various data sources. This surveillance:

- Provides basic information about the frequency and types of HAIs.
- Helps identify weaknesses in infection prevention and control measures.
- Enables timely investigations and the implementation of appropriate infection prevention and control measures.

3.3 Review of research on the modes of infectious diseases transmission

There are different ways that infectious diseases can spread as shown in (Table 2), and these methods must be studied to find ways to reduce the risk of transmission to new people.

TABLE 2. Modes of infectious diseases transmission

I. Contact transmission		
Contact is the most common way that infections spread. This can be through direct contact, indirect contact, or contact with droplets [11]		
Direct contact	Indirect contact	Contact with droplet transmission
Direct contact refers to the spread of microorganisms from one person to another when they physically touch each other.	Indirect contact occurs when a susceptible person touches a contaminated object, material, or piece of equipment. This can be minimized through specific design features for easy cleaning.	When a person with an infectious disease releases infected fluids into the air, the droplets can travel up to 1 meter.
II. Airborne transmission		
When tiny particles in the air, like dust or those containing pathogens, remain suspended for a long time and are carried by air currents, they can be inhaled and cause infection. These microbes can multiply in various indoor environments and, if released into the air, can lead to healthcare-associated diseases [12].		
III. Waterborne transmission		
When hospitals use contaminated water from the municipal water supply, it can become a source of infectious germs. Some of these germs are new types of bacteria that have found a suitable environment to grow in drinking and hot water systems [11].		

4. Appropriate design methods for optimizing infection risk possibilities

Sustainable architecture techniques focus on using natural resources to optimize buildings' performance, comfort, and energy use. Surface design and selection should align with organizational policies and cleaning procedures. Literature suggests that operations, people, and the physical environment are all crucial factors in infection prevention. as shown in (Fig 3).

4.1 Appropriate Architectural design

Sustainable architecture is a design approach that focuses on integrating buildings with their natural environments. It often involves using natural resources to control the indoor climate and reduce energy consumption [13]. This type of architecture can be categorized as appropriate, adaptive, or evolutionary. Jean-Nicolas-Luis Durand, a renowned French architect, emphasized the importance of solidity, health, and comfort in appropriate architectural design. However, many modern hospital designs overlook the critical connection between climate change and emerging infectious diseases.

4.1.1 Flexible architecture

Robert Kronenberg [14] studied flexible architecture. These are buildings designed to adapt and change over time, responding to different uses, operations, or locations. He described flexible architecture as dynamic, responsive, and adaptable rather than static or resistant to change [15].

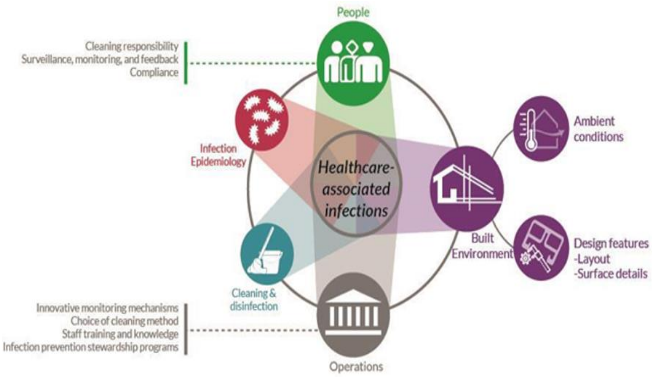

Fig 3: The Systematic approach to infection control [9].

4.1.2 Adaptive modelling

Adaptive modeling in entropy evolution is a design approach that can be used to create sustainable architecture. The goal of evolutionary architecture is to mimic the symbiotic behavior and metabolic balance observed in nature, applying these principles to the built environment [16].

4.1.3 Evolutionary architecture

Evolutionary architecture emphasizes gradual and controlled changes in both the number and quality of its components. This approach applies to various aspects of the design. Time is considered a valuable resource in evolutionary architecture.

4.2 Functional relation zoning

Clear and modular planning can make it easier to replace entire sections of a building. This approach allows for flexible changes to technological systems, ensuring they meet infection prevention requirements. To accommodate new technology, it's important to have well-defined functional areas and space layouts that allow for easy adjustments to traffic flow [11].

Recommendation

we suggest the following architectural changes that can be implemented while designing a new hospital facility or redesigning an existing one as shown in (Table 3).

TABLE 3. Functional relation zoning methods [11].

Method	Application
4.2.1Changes in the Design of Building, Location, Spaces and Sizes of the Rooms in the Healthcare Facility [17]	
I. Zoning	We recommend creating a **Green Zone** where patients are guaranteed to be infection-free, a **Blue Zone** for infected patients, and an **Amber Zone** for those awaiting test results.
II. Reduction of People Landing in the Entrance Lobby	The entrance lobby should have minimal waiting, gathering, and seating areas, with strict social distancing measures in place for disabled people, pregnant women, and sick patients.
III. Defined Protocol for Flow	Create a proper and well-defined protocol for the flow of patients, staff, and material within hospitals.
IV. Segregation of Patients	Create virtual barriers and segregate patients by zoning.
V. Separate Entries	To reduce the rush of patients and attendants at a single point.
VI. Personal Protective Care (Sanitizer Stations /Face Masks/Shoe Covers Dispensers)	To protect healthcare workers, we must provide them with personal protective equipment like gloves and masks and plan designated areas for putting them on and taking them off. Additionally, we need to set aside spaces for hand sanitization throughout the hospital.
VII. Lesser Horizontal Surfaces	By minimizing horizontal surfaces, such as reception counters, wash basins, and tables, we can reduce the spread of infection and create a cleaner environment.
VIII. Facilities for Staff	Spaces should be designed to maintain social distancing and be smaller in size but more numerous to prevent overcrowding.
IX. Barriers and Vestibules	To prevent air mixing between zones, air curtains and vestibules with double doors should be installed.
4.2.2Waiting Lobbies	These areas are designed for patients and visitors to wait while using hospital services. Here are some suggestions for redesigning waiting rooms and public spaces:
I. Individual Seats	Individual seating should be prioritized to ensure social distancing.
II. Sub-waiting Lobbies	Instead of large waiting lobbies, hospitals should design smaller, sub-waiting lobbies. For example, instead of a single OPD lobby with 200 seats, create separate sub-lobbies of around 30 seats each, serving one or two OPD rooms.
III. Minimize Interaction with Others	To reduce exposure between sick patients and others, hospitals should create smaller, enclosed waiting areas with individual seating clusters of 2-3 chairs. These clusters should be separated by 5-foot acrylic or glass partitions.
IV. Outside Waiting	Patients and families should be encouraged to wait outside or in their cars, rather than in the lobby.
III. Screening Areas	Healthcare workers can examine patients through a glass partition, wearing gloves, without direct contact. This allows for the identification of highly contagious patients at the entrance, enabling isolation or restricted access.
VI. Acrylic or Glass Partitions 	Make a proper 1829 mm high acrylic or glass partition at the top of the staff counter or desk and ensure that the staff is always on the other side of the partition (Figure 4)

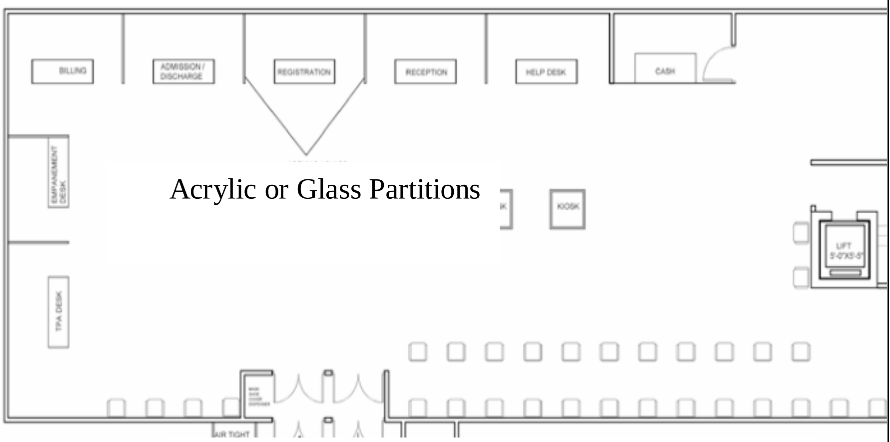

Fig 4: Acrylic or Glass Partitions in OPD [18].

4.3 Application of medical computerized information system[18]

4.3.1 Improving Infection Prevention

Hospitals should prioritize infection control, including cross-infection and nosocomial infection. The Outpatient Department design needs to be revised to prevent the spread of infection. To achieve this, the following factors in (Table 4) should be considered:

TABLE 4. Application of medical computerized information system [18]

4.3.1 Entrance Lobbies	Entrance lobbies are the first areas that patients, staff, and visitors encounter. The following technological advancements can help reduce infection spread in these areas:
I. Portal Technology	Online portals can simplify registration, report collection, inquiries, and bookings without requiring a visit to the hospital.
II. Self-service Kiosks	Portals can help patients pay hospital bills, verify identification numbers, sign consents and paperwork, and complete other registration requirements without interacting with anyone.
III. Adopting a Token System	To reduce crowding in waiting lobbies, a token system should be implemented. Patients and visitors receive a token at registration and can wait elsewhere, checking their status on LCD screens throughout the hospital. Advanced technology can be used to send SMS alerts directly to token holders when their turn arrives.
4.3.2 Outpatient Department	The Outpatient Department (OPD) should be modified to maintain social distancing and avoid direct contact with patients. Acrylic or glass partitions can be used to separate staff from patients, with a two-way audio system for communication.
I. Use of Touch-Free Medical Devices	To minimize contact with patients, medical devices such as BP apparatus, stethoscopes, pulse oximeters, and thermometers should be updated to wireless and touch-free versions.
II. OPD Consultation Rooms with Video conferencing Solutions	In the future, patients may avoid visiting hospitals unless necessary. This will likely change the layout and design of OPD consultation rooms, which will need to incorporate more video conferencing features.
III. Creating Virtual OPD	The concept of a Virtual OPD, facilitated by IT infrastructure, will involve patient-to-doctor and doctor-to-staff communication through AV controls.
IV. Sterilization and Pressure	The OPD should be equipped with UV-C light disinfection and sanitization systems. Additionally, positive pressure should be maintained in the OPD.
V. Telemedicine Impact	Initial consultations can be conducted via videoconferences, and test results can be shared electronically. Only patients requiring procedures would need to visit the

	hospital. All tests can be completed within 15 minutes using point-of-care diagnostics, and medications can be dispensed automatically through machines.
VI. Mobile Health	Physicians and service providers can utilize mobile health tools to place orders, document patient information, and search for additional patient details.

4.4 Environmental control measurements

4.4.1 Design for social distancing

To promote social distancing, maintain a distance of at least 1000mm between individuals in waiting areas, corridors, hallways, stairs, and the entrance lobby. This will help reduce contact transmission and create a safe environment, as current research suggests that aerosol droplets travel only a short distance of 1000mm to 2000mm before settling [19]. Corridors should be designed to discourage informal conversations by eliminating nooks with benches or ledges fig 5. This will help to reduce the spread of infection and maintain social distancing.

The "ledge corridor" design, previously introduced by Carthey [20], was intended to encourage interaction among team members. However, closed-end lobbies, waiting areas, double-bank corridors, and other spaces with limited airflow should be avoided.

Given the current need for social distancing, corridor and lobby design must be reevaluated to accommodate not only wheelchairs, crouches, trolleys, and beds but also maintain safe distances fig 6. The UK Department of Health's recommended corridor width of 1500 mm is insufficient for social distancing. This study suggests a minimum corridor width of 2600 mm to allow for a 1000 mm social distancing interval and 300 mm on each side for maneuvering as shown in (fig 6).

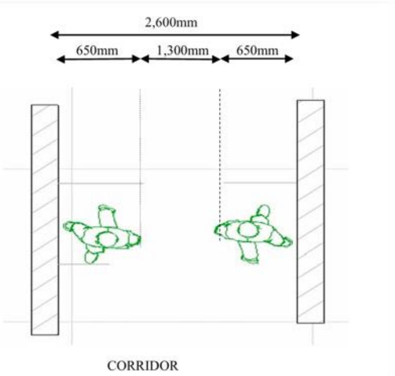

Fig 6: suggestion a minimum corridor width.

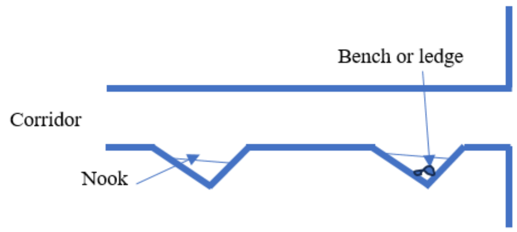

Fig 5: Corridors with nook

4.4.2 Design to enhance natural ventilation.

Ventilation, the movement of air within a space, is crucial for reducing nosocomial and other infectious diseases. Studies have shown that proper ventilation rates can significantly decrease the risk of airborne infections in healthcare facilities and public areas. [22, 23] Natural ventilation can provide a higher ventilation rate than mechanical ventilation while being more energy-efficient. A study of isolation wards in Chinese hospitals found that those with a higher percentage of openable windows were more effective in preventing the spread of SARS among healthcare workers compared to other designs. [24] Ventilation rate, often measured in air changes per hour (ACH), is a critical factor in preventing the spread of airborne infections. The CDC recommends a ventilation rate of 12 ACH [25] for many healthcare settings. This means that the entire volume of air in a space is replaced 12 times per hour. A Study by Huaetal. [23] demonstrated a strong relationship between ventilation rate and the decay of droplet nuclei concentration. Decay Time: The study found that increasing the ventilation rate from 12 ACH to 24 ACH significantly reduced the time required for droplet nuclei concentration to decay to 1.8%. Specifically, it decreased from 20 minutes to 10 minutes.as shown in table 5

TABLE 5. Thedecayof droplet nuclei concentration for different ventilation

rates and duration of time in a room. [23]

Time (min)	Ventilation rate (%)			
	6 ACH	12 ACH	18 ACH	24 ACH
0	100	100	100	100
5	60.7	36.8	22.37	13.5
10	36.8	13.5	5.0	**1.8**
15	22.3	5.00	**1.1**	0.3
20	13.5	**1.8**	0.3	0.03
25	8.2	0.7	0.06	0.00
30	5.0	0.3	0.01	0
40	**1.8**	0.03	0	0
50	0. 7	0	0	0
60	0.3	0	0	0

In another study, Escombe, Eduardo, Victor, Manuel, & David [26] study used a carbon dioxide tracer-gas technique to analyze the impact of ventilation on TB transmission risk in a consulting room and waiting room. The results showed a significant decrease of 72% in estimated TB transmission risk for both patients and healthcare workers. This suggests that adequate ventilation can be a powerful tool in preventing the spread of infectious diseases like COVID-19 in various settings, including hospitals, schools, offices, and public spaces.

- Adequate cross ventilation in healthcare facilities is necessary.

Corridors for Optimal Ventilation: For proper air circulation, prioritize open-ended corridors as seen in Figure 7. Minimize closed-end designs whenever possible.
Enhancing Airflow: To further improve ventilation, consider incorporating upper windows in hallway dividing walls and ventilation louvers on doorsteps to reduce hot air buildup.

To enhance ventilation and reduce infection risk in hospital buildings, integrate courtyards into the overall design. Utilize courtyards as ecological exchange spaces and create an integrated ventilation channel. Open-end corridors and courtyards (fig 8) in significantly increase ventilation rates. When natural ventilation is insufficient, combine it with mechanical ventilation. While mechanical ventilation hasn't been proven to spread infection, regular maintenance is essential to prevent the growth of microorganisms in vent outlets [26].

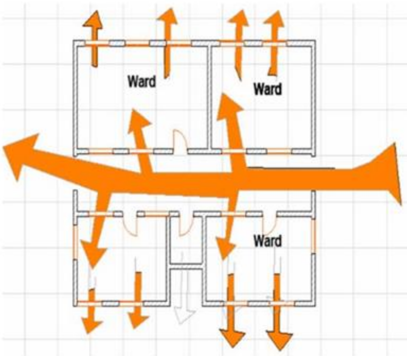

Fig 7: Example of Open-end Corridor

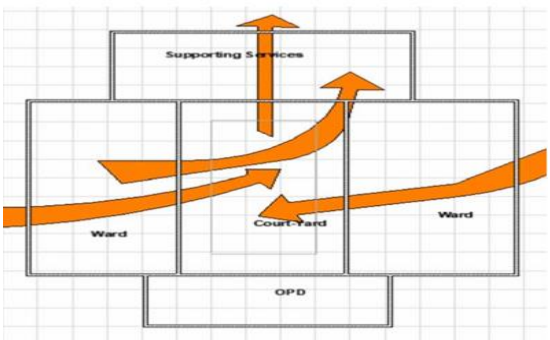

Fig 8: Example of Court-Yard approach

4.4.3 Design to Enhance Daylight or Sunlight

Adequate fenestration and daylight can affect the spread of airborne pathogens. Prior to antibiotics, ventilation and sunlight were thought to be significant safeguards against infectious diseases [27]. Solly [28] found that direct sunlight can kill bacteria, like bacillus, within minutes or hours, depending on the thickness of the bacterial layer. Diffuse sunlight near windows can also kill bacteria, though it may take longer (5-7 days). Advanced studies have shown that sunlight can effectively kill various bacteria, including anthrax and tuberculosis [29]. Strong's study [30] revealed that diffused sunlight from a north window can kill hemolytic streptococci in just thirteen days without antibiotics. The same bacteria survived for 195 days in the dark. This indicates that daylight has germicidal properties and can help prevent infection [5]. According to Lytle and Sagripanti[31], sunlight, specifically solar radiation (UV), is a primary natural virucide. The UV index measures sunlight intensity, and UVC radiation, with a peak effectiveness at 260-265 nm, is particularly effective at killing viruses [32, 33]. The most effective and commonly used wavelength for ultraviolet germicidal irradiation (UVGI) is ultraviolet C [34]. Unfortunately, only a small percentage of it reaches the Earth’s surface as most are absorbed by the ozone layer [35]. To prevent the spread of infection, hospitals should have enough openings to allow daylight into rooms, offices, corridors, and stairwells. Designing buildings with more exposure to sunlight and outdoor air can help reduce the survival and transmission of infectious agents, leading to better health outcomes.

4.4.4 Recommendation

I Hybrid Design of Building

To improve ventilation, natural light, and energy efficiency in hospitals, adopt a more climate-sensitive and natural-light-friendly design. Shift away from traditional box-shaped buildings and incorporate courtyards, building offsets, and outdoor spaces. This approach can reduce the need for artificial lighting and air conditioning, improve indoor air quality, and create a more pleasant environment for patients.

In essence, hospitals should adopt the concept of "green building" to create sustainable, healthy, and energy-efficient facilities.

II Isolation Areas/Units/Rooms [17]

To avoid the spread of infection, negative pressure isolation rooms should be grouped together in a specific area of the hospital.

III HVAC and Air Handling System [17]

HVAC systems are crucial in hospitals for maintaining comfortable temperatures and humidity levels, as well as a clean and germ-free environment. This contributes to patient well-being and prevents the spread of disease. Medical equipment is sensitive to temperature and humidity and requires precise air control for accurate and uninterrupted operation.

Therefore, designing HVAC systems for hospitals requires careful consideration of specific factors.

5. CONCLUSION

Conclusion, the paper surveys literature review on how design strategies, particularly zoning, natural ventilation and daylight, can help prevent infections in healthcare facilities. After coronavirus pandemic, a multidisciplinary approach is essential, Architects and engineers involved in healthcare facility design and construction. Architects must play a crucial role in preventing the spread of coronavirus through careful design, specification, and construction.

As a result, part two of the paper began with analyzing the physical design of healthcare facilities for better infection control by four main methods: Appropriate Architectural design, Functional relation zoning, Application of medical computerized information system and finally use the Environmental control measurements for infection prevention as illustrated in the following points:

First recommendation for zoning:

1. **Defined Protocol for Flow by** create a proper and well-defined protocol for the flow of patients, staff, and material within hospitals.
2. **Separate Entries** to reduce the rush of patients and attendants at a single point.
3. **Design Personal Protective Care areas** for using sanitizer and gloves for putting them on and taking them off.
4. **Individual seating** should be prioritized to ensure social distancing.
5. **Sub-waiting Lobbies**, instead of large waiting lobbies, hospitals should design smaller, beside each clinic.
6. **Acrylic or glass partition at** the top of the staff counter

Second using medical computerized information system:

1. **Portal Technology** Online portals can simplify registration, report collection, inquiries, and bookings without requiring a visit to the hospital.
2. **Self-service Kiosks** Portals can help patients complete their registration requirements without interacting with anyone.
3. **OPD Consultation Rooms** with Video conferencing Solutions.
4. **Creating Virtual OPD** will involve patient-to-doctor and doctor-to-staff communications.

Third by focusing on natural ventilation and daylight, healthcare facilities can create a healthier environment:

The amount of daylight in buildings can significantly impact indoor microbial communities. Integrating daylight into hospital building design offers several benefits:

- Infection control: Daylight can help inhibit bacterial and viral infections.
- Energy conservation: Reduced reliance on artificial lighting leads to energy savings.
- Environmental sustainability: Promoting natural light contributes to a more sustainable environment.

While UVC radiation is effective for infection control, only a small percentage reaches Earth. This emphasizes the importance of maximizing natural daylight in healthcare facilities, schools, and indoor spaces.

REFERENCES

[1] [Mitrione, 2007] Mitrione, S. (2007). Design, landscape and health. Implications, 5(4):1–8.

[2] “CDC" National and State Healthcare-Associated Infections Progress Report, Available at: https://www.cdc.gov/healthcare-associated-infections/index.html

[3] World Health Organization. (2010). Infection prevention and control in health care: time for collaborative action, Regional Office for the Eastern Mediterranean, Available at: Fifty-seventh Session, EM/RC57/6, available at: https://apps.who.int/iris/handle/10665/122923

[4] World Health Organization (WHO), (2019). Health care-Associated Infections Fact Sheet: clean care is safer care, Available at: https://www.who.int/gpsc/country_work/burden_hcai/en/./. Accessed October 20, 2019.

[5] Egyptian Design standards for hospitals and health facilities, 2022.

[6] The National Health Service (NHS) code for emergency care, 2013, England.

[7] American Institute of Architects, 2006. "Evidence-Based Design of Healthcare Facilities", pp. 558-574.

[8] The Egyptian Code for the Design of External Spaces and Buildings for the Use of the Disabled, National Center for Housing Research, Vol 1, December 2003.

[9] Rutali Joshi, Ellen Taylor, (2019). Contact Transmission, Part 1: The Role of Surfaces in Healthcare-Associated Infections, An Issue Brief on Infection Control, The Center for Health Design.

[10] Balaji V., (2016). Hospital Infection Control Guidelines. https://www.researchgate.net/publication/316272093_Hospital_Infection_Co ntrol_Guidelines

[11] Khai T., (2016). Adaptive Architecture and the Prevention of Infections in Hospitals. Transactions of the VŠB – Technical University of Ostrava, Civil Engineering Series., 16, 165 - 172.

[12] Damani N. N. (2006) Excerpt Principles of Infection Control, a research project of the University of Cambridge in the U., - Manual of Infection Control Procedures, 2nd Edition, Cambridge University Press 0521687012.

[13] M. Cimons, Infectious Diseases Like It Hot: How Climate Change Helps Cholera and Salmonella Outbreaks (2015).

[14] R. Kronenburg, Flexible architecture. (2019).

[15] Sehulster, Lynne & Y.W. Chinn Raymond (HICPAC) Guidelines for Environmental Infection Control in Health-Care Facilities.

[16] N. N. Damani, Excerpt: Principles of Infection Control, a research project of the University of Cambridge in the UK, - Manual of Infection Control Procedures, 2nd Edition, Cambridge University Press 0521687012 (2003).

[17] Manual of Hospital Planning and Designing For Medical Administrators, Architects and Planners, under exclusive license to Springer Nature Singapore Pte Ltd. 2022 Page 64 -69

[18] S.Hoffman, Employing E-Health: The Impact of Electronic Health Records on the Workplace (2010).

[19] Baker J, Stevens D, Bloomfield S. Spread and Prevention of Some CommonViralInfections in Community Facilities and Domestic. J Appl Microbiol. 2001;91(1):7–21. https://doi.org/10.1046/j.2365 2672.2001.01364.x.

[20] Carthey J. Reinterpreting the Hospital Corridor- Waste Space or Essential multdisciplinary Clinical Care? Autumn 2008;2(1):1729. https://doi.org/10.1177/193758670800200103.

[21] United Kingdom Department of Health (UKDH). Health Building Note 00-04-Circulation and Communication. London: UKDH. 2013

[22] Zhao B, Jiang Y, Li X, Yang X, Zhang Y. Investigating a safe ventilation rate for the prevention of indoor SARS transmission :an Attemp based on simulation approach. Build Simul. 2009;2: 281–9.

[23] Hua Q, Yuguo L, Seto W, Patricia C, Ching W, Sun H. Natural Ventilation for reducing Airborne Infection in Hospital. Build Environ. 2010;45(3):1651–8.

[24] WangJ,HuangL,JiangS,ChenX,WuW,YinS,etal.Ventilation of wards and Noscomial outbreak of severe acute respiratory Sydrome among health workers. Chin Med Journal. 2003;116(9): 1293–7.

[25] NinomuraP,Bartley J.New Ventilation Guidelines for Health-Care Facilities. ASHRAE Journal. 2001;43(6):29–33.

[26] Escombe A, Eduardo T, Victor C-P, Manuel E, David, A.. Improving Natural Ventilation in Hospitals Waiting and Consulting Rooms to Reduce Nosocomial Tuberculosis Risk in a Low Resources Setting. BMC Infectious Diseases 2019;19(1). https://doi.org/10.1186/s12879-019-3717-9.

[27] NightingaleF.Notesonhospitals3rded.London:Longman, Robert &Green; 1868.

[28]SollySE.Ahandbookonmedicalclimatology.LeaBrothers&Co: Philadelphia anf New York; 1897.

[29] Hockberger P. The damaging effects of sunlight on bacteria. J Photochem Photobiol. 2000;58:155–91.

[30] Strong P. Daylight Benefit in Healthcare Buildings. Designing Buildings-BR group. 2020.https://www.designingbuildings.co.uk/w/images/2/22/David_Strong_(2of2)Daylight_Benefits_in_Healthcare_buildgs-BRGroup. Accessed 23 May 2020.

[31] Lytle D, Sagripanti J-L. Predicted Inactivation of Viruses of Relevance of Biodefence by Solar Radiation. J Virol. 2005;79(22):14244–142252. https://doi.org/10.1128/JVI.79.22.14252.

[32] RauthAM.The physical state of viral nucleic acid and the sensitivity of viruses to ultraviolet light. Biophys J. 1965;5(3):257–73. https://doi.org/10.1016/s0006-3495(65)86715-7.

[33] Seyer A, Sanlidag T. Solar ultraviolet radiation sensitivity of SARS-CoV-2. Lancet Microbe. 2020;1(1):e8–9. https://doi.org/10.1016/S2666-5247(20)30013-6.

[34] Kowalski WJ. Ultraviolet germicidal irradiation handbook. Springer; Berlin: 2009. https://doi.org/10.1007/978-3-642-01999 9_2.

[35] Pozo-Antonio JS, Sanmartín P. Exposure to artificial daylight or UV irradiation (a, B or C) prior to chemical cleaning: an effective combination for removing phototrophs from granite. Biofouling. 2018;34:851–69.