



Original Research Article

Improvised designing of dental care service centres can prevent Nosocomial infections

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ABSTRACT

Infection control and prevention are critical aspects of healthcare, especially in hospitals where patients are vulnerable to acquiring infections during their stay. Hospital-acquired infections, also known as nosocomial infections, have become a major concern in recent years and got more attention after widespread of the recent COVID-19 pandemic. In terms of a dental healthcare facility, it is important to understand the types of infections present in the facility environment and the associated risks with them along with their cross-transmission risk. A dental hospital has different working zones which are interdependent which increases the chances of infection propagation. To avoid the propagation of these infections, standard protocols, and preventive measures have been discussed widely but one of the most important factors which is the designing and planning of the healthcare facilities has not been discussed much from the aspect of propagation of infections which could largely decrease the propagation of the infections from different areas within the facility and infecting a different group of peoples in it. The prime focus of the study was on reviewing infectious pathogens related to nosocomial infections, pathogenicity, the risks associated, and ways to reduce the propagation through the implementation of architectural planning movement flow and designing of a dental hospital.

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1. Introduction

Nosocomial infections, also known as hospital-acquired infections (HAI), are a significant problem in healthcare facilities. These infections can lead to increased morbidity and mortality, as well as increased healthcare costs. There are several factors that can contribute to the spread of nosocomial infections. These include:

Healthcare staff - Healthcare staff can spread infections from patient to patient if they do not properly follow infection control practices, such as hand hygiene and proper

use of personal protective equipment.

Contaminated equipment and surfaces - Equipment and surfaces in healthcare facilities can become contaminated with bacteria and viruses, which can then be spread to patient.

Airborne transmission - Some infections can be spread through the air, such as tuberculosis, measles, chickenpox and Corona Virus Disease 2019.

External factors - Patients may bring infections into the hospital with them, or they may be exposed to infections in the community. In addition, environmental factors such as poor ventilation or overcrowding can contribute to the spread of infections.

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Patient factors - Patients who are immunocompromised, such as those undergoing chemotherapy or organ transplantation, are at increased risk of acquiring nosocomial infections.

Preventing the spread of nosocomial infections requires a multi-faceted approach that includes proper infection control practices, appropriate use of antibiotics, and vaccination. By implementing these strategies, healthcare facilities can reduce the incidence of nosocomial infections and improve patient outcomes.

The dental care centers or offices where dental treatment is been carried out are at higher risk for cross-infection.^{1,2} Cross-infections are significantly concerning in clinical practices, it occurs when infectious agents are transmitted between patients and healthcare workers in a clinical environment. There are several ways that a dental hospital can be a medium for the transmission of various infections. Such as through air droplets, blood, saliva, and contaminated dental instruments. Preventing cross-infection in clinical practice requires a multi-faceted approach that includes proper infection control practices, appropriate use of personal protective equipment, effective cleaning and disinfection of surfaces and equipment, and appropriate use of antibiotics. By implementing these strategies, healthcare workers can minimize the risk of cross-infection and provide safe and effective care to their patients. Occupational exposure to blood-borne pathogens is a significant concern for healthcare workers. Healthcare workers may be exposed to blood-borne pathogens such as Human immunodeficiency virus (HIV), hepatitis B virus (HBV), hepatitis C virus (HCV), Mycobacterium tuberculosis, Herpes simplex virus Type 1 and type 2, Staphylococci, and other potentially infectious agents during the course of their work. Dentists can be exposed to blood-borne pathogens through needlestick injuries, sharps injuries, contact with contaminated body fluids, or exposure to contaminated surfaces or equipments.³ By implementing the strategies to prevent occupational exposure, healthcare workers can minimize the risk of occupational exposure to blood-borne pathogens and protect their own health and the health of their patients.

Cross infections in dental practice became a public health concern, especially during the COVID-19 pandemic.² The hospital provides a great platform for the retention of disease which can cause illness in patients whose immunity is low. Also, the amount of infectious diseases present in the hospital is too much which could easily infect healthy people in the facility. Nosocomial Infections prevention readiness is usually seen in general hospitals and is overlooked when in dental hospitals or private clinics. Hence this paper aims to elucidate the pathogenicity and disease burden of nosocomial infections in dental facilities and thereby derive the planning of the dental hospital which will reduce the propagation of these infections.

2. Materials and Methods

A literature review was carried out and the scientific papers published in Scopus, PubMed and web of science were considered. Secondary data were reviewed from the guidelines published by the Dental Council of India. Parallel, analyzing, adapting and implementing the social distancing norm and preventive measures laid by WHO for nosocomial infections were also taken into consideration. Results were exported to citation manager—Zotero and Microsoft Excel after the removal of duplicates.

3. Results

3.1. Pathogenicity and disease burden

3.1.1. Viruses

3.1.1.1. Herpes virus. Herpes Simplex Virus (HSV) is a highly contagious virus that can be transmitted through direct contact with infectious secretions or through contact with a blister or ulcer caused by the virus. HSV-1 is commonly associated with infections in the oral region, such as cold sores, while HSV-2 is more commonly associated with genital infections. However, both types of viruses can cause infections on any part of the body. Without adequate protection, there is a risk of exposure to herpes infections through skin-to-skin contact or contact with infected bodily fluids. Healthcare workers, including practitioners and dental hygienists, are particularly at risk of cross-infection, and Herpes whitlow is a common example of an HSV infection that can occur in the nails of these professionals. Therefore, it is essential for healthcare workers to take appropriate measures to prevent the spread of HSV, including the use of personal protective equipment and proper hygiene practices¹.

3.1.1.2. Human immunodeficiency virus. In India, the prevalence of HIV was estimated to be 0.3% in 2016, which may appear low in comparison to many other middle-income countries, but due to the country's large population of 1.32 billion, it translates to a substantial number of 2.1 million people living with HIV, according to UNAIDS data from 2017⁴. The risk of HIV transmission in a dental hospital is relatively low since HIV is unlikely to be transmitted through saliva due to low viral titers. However, there is still a potential risk of percutaneous exposure to HIV, which is estimated to be 0.3%. Therefore, it is essential for dental healthcare workers to follow standard infection control protocols, including the use of personal protective equipment such as gloves and masks, proper handling and disposal of sharp objects, and adherence to safe injection practices to prevent the risk of exposure to HIV and other bloodborne pathogens. Additionally, dental professionals should be educated about the modes of transmission of HIV and the importance of prevention to ensure the safety of both patients and healthcare workers¹.

3.1.1.3. Hepatitis B virus. Hepatitis B is a significant public health concern worldwide and is the tenth leading cause of death globally. In India, the prevalence of HBsAg (hepatitis B surface antigen) among the general population varies from 2-8%, and the country has the second-largest pool of chronic HBV infection globally, with an estimated 50 million cases⁴. Percutaneous occupational exposure is a major route of transmission for healthcare workers in developing countries, accounting for 40-50% of HBV infections. Several studies have highlighted that healthcare workers have a four times higher risk of contracting Hepatitis B compared to the general population. Therefore, it is crucial for healthcare workers, particularly those working in high-risk settings such as dental hospitals, to adhere to strict infection control measures such as the use of personal protective equipment, proper handling and disposal of sharps, and adherence to safe injection practices to prevent the risk of exposure to Hepatitis B and other bloodborne pathogens. Vaccination against Hepatitis B is also essential for healthcare workers to protect themselves from the disease. Education and awareness among healthcare workers about the modes of transmission of Hepatitis B and the importance of prevention are vital to ensure the safety of both patients and healthcare workers.⁴

3.1.2. Bacteria

3.1.2.1. Mycobacterium spp. Mycobacterium tuberculosis is a bacterial pathogen that causes Tuberculosis (TB), a contagious disease that primarily affects the lungs. Despite concerted efforts to control TB, it remains a major health burden in India, with a high incidence of multidrug-resistant TB. M. tuberculosis is transmitted through the air and can remain suspended within small droplets for several hours, increasing the risk of transmission within healthcare settings. While the likelihood of TB transmission within a dental setting is low, patients with active TB are immunocompromised and susceptible to other infections, which can lead to further complications. Therefore, proper infection control measures should be implemented to minimize the risk of transmission of all infectious agents, including M. tuberculosis, within healthcare facilities.²

3.1.2.2. Pseudomonas spp. Pseudomonas aeruginosa form biofilms in DUWLs and its association with water sources in the hospital environment. Proper maintenance and regular disinfection of DUWLs, as well as the use of sterile or filtered water for patient care procedures can help prevent the growth and spread of water-borne pathogens in the dental setting. Dental professionals should be aware of the potential risks associated with these pathogens and take appropriate measures to protect themselves and their patients from cross-infection.⁵

3.1.2.3. Legionella Spp. Legionella is typically found in water sources such as cooling towers, hot water systems,

and decorative fountains, which are typically present in dental clinics. It is important for dental clinics to regularly monitor and maintain their water systems to prevent any potential bacterial growth and reduce the risk of infection for patients and staff.⁶ Alike Pseudomonas aeruginosa, Legionella spp. are also capable of colonizing in wet and moist environments, and can form biofilms in dental unit waterlines (DUWLs) and other water sources in a dental hospital. These biofilms can serve as a source of infection and contribute to the risk of cross-infection.⁶ Humphreys Et Al. have documented a case of Legionnaires disease acquired in connection with dental treatment.⁷

3.2. Designing criteria by DCI (Dental Council of India)

DCI was integrated under The Dentists Act, 1948 primarily to manage and synchronize dental education and profession across India which include multiple departments like X-ray Panoramic/Cephalometric, Oral Surgery, Minor Procedure Room, etc. for which the recommended sizes for the different kinds of spaces within the dental hospital for a few of the foremost common configurations are mentioned in Table 1. Apart from the recommended area, additional space is required for the employees' storages, staff washrooms, lounge, etc which are not incorporated in the article.

3.2.1. Dental hospital support areas

3.2.1.1. Multifunctional treatment rooms. Dedicated areas for the same should be designed in a way that is feasible for the dentist to carry out dental procedures in them. The total provided treatment rooms depend upon the primary dentist as per the count of OPDs and the number of dental services that will be delivered. To achieve maximum efficiency, all the dedicated treatment rooms should be provided of the same area size with the same architectural layout having the same or identical equipment. Similar treatment areas provide flexibility to the dentist to perform any regular treatment in any room/space/area. In addition, circulation space for the professionals to displace different equipment without any hindrance should be necessarily provided alongside Infection control and plumbing requirements should be considered. Recommended width is 4.5m and above.

3.2.1.2. Sterilization and storage area. These areas must be kept in mind while planning any dental clinic. However, it also depends upon the activities and services carried out in that particular space. L or U-shaped counter space is recommended for the sterilization area. To achieve efficiency, a dedicated large amount of storage space proportionate to the services is recommended. This designed storage will ensure the materials and sterilization equipment are sorted.

Table 1: Area recommendations by DCI

S.No.	Department/Spaces	Recommended Area in Sqm by DCI
1	Operatories	10.2/operatory (generally 3mx3.3m)
2	X-Ray Panoramic	2.78
3	Combination of Cephalometric/Panoramic	4.64
4	Cephalometric X-Ray	9.29
5	Clean up Alcoves for O. Cs	
	Two to Three	8.36
	Four to Eight	9.29
	Nine to Twelve	13.93
6	Laboratories for O. Cs	
	Two to Three	5.57
	Four to Eight	7.43
	Nine to Twelve	11.14
7	Dark Room for O. Cs with AD	
	Two to Eight	5.57 (1AD)
	Nine to Sixteen	8.36 (2AD)
8	U. S. A for O. Cs	
	Two to Three	3.71
	Four to Eight	7.43
	Nine to Twelve	11.14
9	R.A for O. Cs	
	Two to Four	9.29
	Five to Eight	11.14
	Nine to Twelve	22.29 (2R.A)
10	Offices	
	Director	11.14
	Manager/Supervisor	9.29
	Non-Supervisor	7.43+3.71(for every added dentist)
11	Toilet for Eight to Twelve O. Cs	4.64**
12	W.A for O. Cs	
	One to Four	11.14
	Five to Seven	16.72
	Eight to Thirteen	22.29
13	Janitor Closet	3.71

*O. Cs: Operatory Clinics *AD: Automatic Developer *U. S. A: Unit Supply Area *R.A: Reception Area **Less than six staff members can use and unisex staff washroom.

4. Discussion

The study explains that the chances of the spread of nosocomial infections in oral healthcare centers are a public health concern and is adding up to the burden of the infectious diseases cloud. The study reveals that apart from blood-borne infections, another common medium of cross-infection is an airborne infection which is of significant concern as it is a major mode of transmission in a dental practice. Aerosols are defined as liquid or solid particles suspended in the air by humans, animals, instruments, or machines. Bio-aerosols are aerosols consisting of any particles of any kind of organism.³ Dental procedures have been shown to generate bacterial aerosols predominately Streptococcus and Staphylococcus spp.⁸ Other bacteria include Mycobacterium Tuberculosis, found as aerosols generated by a high-speed handpiece used during simulated dental procedures on patients with active tuberculosis.

Although the oral cavity is probably the major source of bacterial contamination in dental procedures, dental unit waterlines have also shown a potential to act as a reservoir of bacteria, including Legionella pneumophila and M tuberculosis, staph aureus etc. A study done in Karnataka for microbial assessment of dental units in waterlines identified a host of bacteria from the samples collected from a water tube supplying an air-rotor and three-way syringe. The bacteria included Acinetobacter spp., Bacillus spp., E. coli, Enterobacter spp., Klebsiella spp. and Pseudomonas spp.⁵. Despite their low pathogenicity, these pathogens have been recognized as opportunistic infections mainly in immunocompromised patients and hospitalized patients.^{9,10}

4.1. Flow diagram for a dental hospital

The architectural planning of healthcare facilities has an important contribution in minimizing of propagation and impact of nosocomial infections on people present not only in the facility but outside also as it breaks the chance for the infected people to leave the facility providing the base for greater propagation.

Designing of dental healthcare facility should ensure minimal chances of transmission of nosocomial infection to the patient or to the healthcare providers or assistants working in the dental office. The entrance area must connect to the main reception/inquiry area which should be connected with the registration and the records section. Once the registration procedure is over the patient walks in towards the examination and treatment room which should directly connect with the investigation corner. It is recommended that if the treatment procedure is over, then the patient should leave from a different rear exit from the main entrance without crossing the whole traffic flow of the dental facility. Also, If the patient needs to be admitted then they could directly be transferred from there to the admission section or could be taken to the hospital through that separate outlet attached to the same room. Adequate waiting areas depending on the facility and population size should be provided. In addition, criteria on social distancing have to be followed to avoid airborne diseases (Diagram 1).

The functionality of the dental facility depends upon the work for which it is designed in relation to the public which is going to be the main concern. The traffic flow should be uniform and unidirectional to avoid any kind of contact between the people and as spread as possible with minimum contact to one other to avoid any kind of transmission of diseases irrespective of the medium type from one person to another. It also limits the settling of diseases on the different surfaces of the object which are used by the different kinds of traffic groups in the dental facility. Chances of getting infected in more in the waiting area which is more likely to be crowded. Hence waiting rooms should always be designed as big as possible with ample natural ventilation and sunlight. If not possible due to any reason, then HVAC systems should be installed after consulting the professionals to counter the effect. (Diagram 2).

Systematic medical waste management (BWM) according to the government's available guideline parameters should be implemented as it will rapidly become the medium and source of the spread of infections. Placement of the surgery department should be planned as deeply as possible planning wise or a dedicated secluded zone/area/space is recommended in comparison to the other departments of the facility. The temperature should be thoroughly checked and maintained to break and eliminate, countering the bacterial/pathogenic flow working alongside the installed HIPPA filters or better technological systems present at that time to eliminate viruses and bacteria.

Nevertheless, as per the guidelines formulated by the ICMR, the prevention of nosocomial infections to counter spread is to wash hands regularly. To make it a regular practice, scrubs or washbasins should be provided at uniform distances. Application of PPE eliminates the immense possibility of the spread of pathogens for which an interconnected change room/donning and doffing area or at least a separate storage for aprons and gloves should always be provided in hospitals which should be actively followed.

5. Conclusion

Although wearing personal protective equipment reduces the level of exposure to micro-organisms however when an individual comes in contact with the surfaces of the dental healthcare center it is much more likely to get a nosocomial infection when contaminated. As large numbers of pathogens persisted in the dental facility on different components like furniture, walls, etc. which were disseminated into the air during dental procedures.

Many individuals may be unaware of the risk of airborne dissemination of microbes. Some enteric viruses could persist in the air in the form of aerosols which may be acquired after inhalation and swallowing. Hence, it becomes obligatory that a dental healthcare setup must follow the guidelines by indulging certified professionals throughout its course from designing, planning, and construction to reducing the upsurge in nosocomial infections.

6. Conflict of Interests

All the authors declare that there are no conflict of interests.

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