ORIGINAL RESEARCH

Assessment of Indoor Air Quality in Different Areas of OPDs & IPDs in a Tertiary Care Teaching Hospital

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ABSTRACT

Introduction: HealthCare facilities can be sources of pathogenic bacteria that can lead to hospital-acquired infections (HAIs).Bacteria, mould, and viruses can grow on ventilation system, as well as on the moist ceiling and floor.The airborne transmissions are also more prevalent in healthcare surroundings due to overburdened hospitals and the presence of immune-suppressed patients. **Methods:**An institutional-based cross-sectional study design was used to assess the bacterial & fungal load in the indoor (one random sample) and outdoor patients' (before starting OPD & during OPD) area of the hospital. To determine the bacterial load, a passive air sampling technique was used. The settle plate method was used to collect datawhich involved exposing blood agar and sabouraud's dextrose agar (SDA) media to OPD & IPD rooms for 1hour. **Results:** The bacterial and fungal load was comparatively less before starting the OPDs. The area of windows and doors' are less compared to total room volume. The bacterial load in the air found to be >1000 CFU/mm^{3}in OPDduring OPD hours and IPD areas. The non-sporinggram-positive bacilli (GPB-NS) were the most common isolated microorganism followed by gram positive cocci (GPC) and Aspergillus species. **Conclusion:**The majority of the wards in the present hospital had bacterial loads in the air that exceeded WHO guidelines. Over-crowding, high temperatures, inadequate ventilation couldcontribute to a high concentration of bacteria in the indoor air. Strict visitors and infection control policy as well as environmental,construction audit is needed for infection prevention and control measures.

Keywords: air microbial load, bacteria, CFU/mm^3

INTRODUCTION

Humans require a near-constant supply of air and quality of inhaled air is important factor for determining wellbeing. However, the healthcare facilities can be sources of pathogenic bacteria that can lead to hospital-acquired infections (HAIs). According to the Centres for Disease Control and Prevention, nearly 1.7 million hospitalized patients annually acquire HAIs while being treated for other health issues, and more than 98 000 patients (1 in 17) die as a result of these infections. Bacteria were responsible for 90% of all HAIs. Bacteria, mould, and viruses can grow on the pans of the ventilation system, as well as on the moist ceiling and floor. Because most bacteria can live on dry surfaces for months and are resistant to disinfectants, their resistance has an impact on patient health. There are also airborne diseases which are caused by viruses, bacteria or fungi which may permeate through activities that give rise to aerosol particles or droplets such as coughing, sneezing etc. Chickenpox, influenza, measles, and tuberculosis are most common infections spread by air. There have been several known cases when human beings have exposed themselves to different airborne pathogens which have resulted in the emergence of epidemics of respiratory infections. [1,2]

The appropriate air quality is ensured by replacing air of a defined space in regular intervals, a measure known as "Air Changes per Hour" which indicates the

number of times the air is replaced every hour. The recommended number of air changes per hour in room depends on the type of rooms.[3]

The airborne transmissions are more prevalent in healthcare surroundings because of overburdened hospitals and the presence of immune-suppressed patients. The Government of India and the World Health Organization (WHO) have taken out guidelines for control of airborne infections. A huge gap persists in the recommended guidelines for the control and prevention of airborne infections and the existing norms adhered by hospitals. Measures have been suggested which include a threefold approach, namely, administrative control, environmental control, and personal respiratory protection measures. [4,5]

Environmental control measures include indoor patient segregation and spacing of beds, ensuring 24/7 effective ventilation in all seasons, with special attention to high-risk areas (ICUs, Operation theatre), outpatient and inpatient departments and multi-drug resistant tuberculosis wards. Strategies like natural ventilation, mechanical ventilation, air changes per hour and upper room ultraviolet light to ensure adequate ventilation are very much useful. [3]Air pollution has emerged as a potent factor related to the transmission of the coronavirus.[6] Long-lived microorganisms in the hospital environment are directly connected to the incidence of associated illnesses. Thus, it is very crucial to assess the hospital's indoor and outdoor air quality. It is also pertinent to monitor the thermal comfort, humidity, chemical contamination, ventilation and air distribution in hospitals as the detrimental effects of indoor air quality has an effect on healthcare workers as well as patients' wellbeing. [7]

Keeping this as front-runner, the present study was conducted to assess the quality of air in OPD and IPD areas in a tertiary care hospital. It would be immense help to set guideline to control microbial contamination in a healthcare setup.

METHODOLOGY

The study was conducted in a tertiary care hospital of Thane, Maharashtra after receiving the institutional ethical approval. It was a prospective study of 4 months duration. The study was conducted in a high load patient area>25 patients load og OPD & IPD. The outpatient department (OPD) included were eg. medicine, surgery, ENT, paediatric, orthopaedics, pulmonary medicine, obstetrics & gynaecology (OBGY). Two samples were collected from each OPDs; before starting the OPD in empty room and during OPD with patients and doctors.

One random sample was collected from inpatient departments (IPD) of medicine, surgery, ENT, paediatric,orthopaedics, pulmonary medicine, obstetrics and gynaecology (OBGY). One blood agar and one sabouraud's dextrose agar (SDA) plates were used for the sampling. Passive air sampling was done by settle plate method.

Sampling technique: the settle plate method was performed with (90 mm) or 9 cm diameter petri dishes on blood agar enriched with 5% sheep blood (Becton, Dickinson and Company) and SDA. Plates were left open according to the 1/1/1 method (1 m from the walls, 1 m from the floor, and for 1 hour); then covered with their lids. After one hour of exposure, the SDA & Blood agar plates were sealed and incubated at 37°C at microbiology department. Blood agar plates were incubated for 24-48 hours and reading was taken 2 hourly. Blood agar & SDA growths were subjected to gram staining and LPCB respectively.After counting the colony forming units (CFU), the CFU/m 3 was calculated using Omeliansky's equation;

$N = 5a \times 104\ (bt)-1$, Where N = microbial CFU/m2 of indoor air; a = number of colonies per petri dish; b = dish surface (cm 2);t = exposure time (minutes)

SDA plated were incubated for 3 days at 25° and reading were taken 24 hourly. Gentamicin, chloramphenicol, and cycloheximide were added to SDA to inhibit the overgrowth of both gram positive and gram-negative bacteria, and cycloheximide was added to inhibit the growth of saprophytic fungi.

The length, breadth and height of the rooms was measured in metres and the volume of the room was calculated in cubic metres. The growth on the agar plates wascalculated as CFU/mm^3. [5].

OPERATIONAL DEFINITION

Indoor air: It defined as air within a building occupied for at least 1 hour by people of varying states of health. Indoor air quality can be defined as the totality of attributes of indoor airthat affect a person's health and wellbeing.

As perWHO expert group acceptable bacterial load standard: Less than 1000 CFU/m^3.

European Commission for non-industrial premises sanitary standard for bacterial load: A bacterial load of less than 50 CFU/m^3 - considered "Very low," 50 to 100 CFU/m^3- considered "Low," 100 to 500 CFU/m^3- considered "intermediate," 500 to 2000 CFU/m^3-considered "High," and more than 2000 CFU/m^3 considered "Very high."[6]

RESULTS

Table 1: Total Area of the OPD/IPD with Doors & Windows

OPDs/IPDs	Department	Volume of the rooms (feet^3)	Total Area of the windows (feet^2)	No of windows.	Area of the doors (feet^2)	Door & windows area to Room area ^
OPDs	ENT	2887.5	10.93	1	14.39	Insufficient
	Paeds	1875	68	3	18.17	
	Medicine	1445.25	12	2	18.17	
	Orthopaedic	2079	68	3	17.57	
	OBGY	2800	192	5	17.57	
	Surgery	2079	117	1	19.34	
IPDs	Pulmonary Medicine	7411	33	2	19.34	
	Medicine	5293	164.9	6	19.34	
	Surgery	5293	164.9	6	19.34	
	Orthopaedic	5293	164.9	6	19.34	
	OBGY	5293	164.9	6	19.34	
	Paeds	3446	164.9	6	19.34	

^Atleast 1/3 of the room volume should be open windows & doors to ensure adequate ventilation

The door-window area to room area ration was insufficient as atleast 1/3rd of the total room volume to be contributed to windows and doors (Table 1).Cross ventilation referred as a natural phenomenon where wind, fresh air or a breeze enters upon an opening, such as a window or door, and flows directly through the space and exits through an opening on the opposite side of the room without any obstruction in between the airflow.

Table 2: Bacterial counts in air samples collected from different rooms of OPDs

OPDs	Before starting the OPDs: BA growth#	Colonies (CFU/mm^3)	During the OPDs: BA growth	Colonies(CFU/mm^3)	Before starting the OPDs: SDA growth	During the OPDs: SDA growth	No.of person present during sampling	Ventilation system
ENT	GPB-NS	960.3	GPB-NS	2830.4	NG	*A. flavus*	13	-Cross ventilation absent -Electric fan present
Paediatric	GPC	530.7	GPC	3917.2	NG	*A. niger*	7	
Medicine	GPB-NS	631.8	GPB-NS	3765.5	NG	*A. niger*	15	
Orthopaedic	GPB-NS, GPC	833.9	GPB-NS, GPC	5307.1	NG	*A. niger*	9	
OBGY	GPB-NS	783.4	GPB-NS	4162.3	NG	*A. niger*	9	
Surgery	GPB-NS	3436.9	GPB-NS	6494.9	NG	*A. niger*	4	
Pulmonary Medicine	GPB	353.8	GPB	935.0	NG	*A. niger*	5	

#GPB-NS = Gram Positive Bacilli Non-Sporing, GPB= Gram positive bacilli, GPC= Gram positive cocci, NG = No Growth, *A. niger= Aspergillus niger*, *A. flavus= Aspergillus flavus.*

The air microbial load was less in the empty OPD rooms before starting the OPDs compared to the microbial load during OPDs. Non-sporing gram-positive bacilli was the most common isolated microorganism followed by gram positive cocci and Aspergillus spp. There was no air-conditioning system in the OPDs and cross ventilation was absent in the OPD rooms (Table: 2)

Table 3: Bacterial counts in air samples collected from different rooms of IPDs

IPDs	No. of person present during sampling	Growth on BA: Settle plate method	CFU/mm3 on Blood agar	Growth on SDA: Settle plate method	Ventilation system
Medicine	66	GPB-NS	1945.9	*A. flavus*	Electric fan & cross ventilation wherever possible
Surgery	72	GPC	1263.6	*A. flavus*	
Orthopaedic	53	GPB-NS	1592.1	*A. niger*	
OBGY	80	GPB-NS	2021.8	*A. flavus*	
Paediatric	32	GPB-NS	1541.6	*A. flavus*	

#GPB = Gram Positive Bacilli,GPC= Gram positive cocci, NG = No Growth, *A. niger= Aspergillus niger*, *A. flavus= Aspergillus flavus*

The highest microbial load found in OBGY ward (2021 CFU/mm^3)and maximum number of patients along with visitors were present in the ward. The lowest air microbial load was found in Paediatric ward. (Table 3).

DISCUSSION

The bacterial indoor air quality reflects the sanitary conditions, overcrowding and many other factors of the health care facility. Most bacteria can survive for months on dry surfaces and are resistant to disinfectants and their resistance has an impact on patient health. Using a passive air sampling technique i.e. settle plate method it was observed that the bacterial load in the present hospital'soutdoor and indoor air was more than 500CFU/mm3.

The surgery OPD during OPD timing showed highest outdoor air bacterial concentration. However, bacterial concentration before starting OPD was comparatively less, ranging from 350-966 CFU/mm3 i.e. <1000 CFU/mm3. Gram-positive cocci, Gram-positive non-sporing bacilli, Aspergillus spp. were the most commonly identified microorganism in the present study.

The high bacterial load in these areas could be attributed to poor room cleanliness, overcrowding of rooms by Medicine and health science students, patients, and visitors, insufficient ventilation, attachment of unsanitary latrines and shower facilities, and nearby active construction work during OPD hours. Taushiba A *et al* study reported gram positive, gram negative and fungal species in indoor and outdoor passive sampling.[7] Another Sorkheh *et al* study showed that Aspergillus spp., Candida spp., Fusarium spp., and Mucorales spp. are the most common pathogens in Sari, Iran's hospitals.[9]Numerous studies have also shown the negative impact of high ambient particulate matter (PM) concentrations on hospital admission, especially for cardiac and respirational conditions. [10] Furthermore, conferring to the World Health Organization (WHO), 92% of the world's population resides in regions with annual mean PM 2.5 levels greater than 10 g/m3, which is above their air quality recommendation for PM 2.5 exposure. Recent research has looked into the impacts of PM on health from a wider range of sources, such as biomass burning, and in other geographical locations. [8,10]

In the present study, the average indoor air bacterial load ranged from 1200-2021 CFU/mm3. The high concentration of bacteria in the indoor air in this study could be attributed to poor health care engineering control, overcrowding of wards by students, patients, and visitors, and poor sanitation facilities. Furthermore, this study revealed that all wards lacked artificial ventilation and relied solely on natural and cross ventilation. However, cross ventilation is absent in the ward despite having sufficient windows. Pollutants from the waste disposal area and nearby construction site may enter the room through the windows and doors. [11]The present study also showed the inadequate number of functional windows and doors compare to volume of the rooms which could be attributed to the high bacterial count.

According to the European Commission's non-industrial premises sanitary standard for bacterial load, all the areas of OPDs & IPDs during active OPD & IPD hours had high bacterial load (500-2000CFU/m3) and very high indoor air bacterial load (>2000CFU/m3). The majority of wards were overcrowded, natural ventilation in the rooms is below WHO guidelines, and there is no artificial (mechanical) ventilation, all of which could contribute to room contamination. The patients, caregivers, and visitors were found to be in close contact with one another.

CONCLUSION

The majority of OPD & IPD had air bacterial loads that exceeded WHO guidelines and European Commission non-industrial premises sanitary standards. In the obstetrics, surgical, paediatric, gynaecological, and medical wards, mean bacterial concentrations exceeded WHO guidelines. In this study, gram-positive non-sporing bacilli and gram-positivecocci were found. Fungal growth was found in 90% of the samples. According to the observational results, the main environmental factors that contributed to this high range of bacterial load werepoor natural cross ventilation, absence of artificial ventilation (AC), humidity, soiled walls, high room temperature, and a large number of visitors and medicine and health sciences students. Therefore, regularly monitoring and evaluating indoor air bacterial load, as well as implementing infection prevention and control measures to control is important. The introduction of microorganisms into the hospital by patients, visitors, and students, in order to reduce the risk of infection for inpatients, particularly the immune compromised, elderly, and children. Furthermore, each room should be inspected on a regular basis.The OPD/IPD structural audit to be performed regularly to find out any condition or situation that may promote microbial growth, such as a leak or a sanitation problem. The hospital policy to be formulated to reduce the number of visitors and health science students in order to avoid overcrowding in the wards, OPDs and corridors. Enable for the proper use of windows in managing the temperature of the room in absence of air-cooling system leads to increase in the microbial load.

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