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A review of the indoor air quality of hospitals and healthcare centres

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Abstract

The elderly are more vulnerable to adverse environmental conditions, and as the population of the developed countries is ageing, they require more medical aid/hospitalisation. Globally, indoor air pollution is considered a health hazard and negatively impacts life expectancy. As patients and healthcare workers spend more time in healthcare centres, the indoor quality of hospitals and other healthcare centres is very crucial. The indoor healthcare settings (hospitals, nursing homes, private health centres, general practitioners' chambers, and elderly care centres) are contaminated with particulate matter, chemical pollutants (VOCs, CO, CO_2, ozone, and radon), and microorganisms, which results in the enhancement of hospital-acquired infections (HAI) and the development of antibiotic-resistant bacteria and genes. HAIs are posing a grave threat to society and healthcare organisations. The hospital's indoor air causes more health problems than outdoor air. The indoor air of healthcare centres globally contains *Staphylococcus* spp.*, Micrococcus* spp.*, Bacillus* spp.*, Pseudomonas* spp.*, Kocuria* spp.*, Pantoea* spp.*, bacterial* spp.*, Cladosporium* spp.*, Penicillium* spp.*, Rhodoturola, Aspergillus* spp., *Basidiomycota,* yeast, *Alternaria spp., and Eurotium* fungal genera. The bacterial genera *Staphylococcus* spp. cause more deaths than the deaths caused by acquired immunodeficiency syndrome (AIDS), tuberculosis, or viral hepatitis. The poor indoor air in health care centres not only causes respiratory illness, microbial infections, acute toxic effects, cancer, and hospital-acquired infections but also helps in developing antibiotic-resistant bacteria and multi-drug-resistant microbes. The present study aims to assess the levels of pollutants and microbial contamination in the indoor air of healthcare facilities.

Keywords: Indoor air; Bacteria; Fungus; Health care facilities; Particulate matter

1. Introduction

Any physical, biological, or chemical agents that pollute the outdoor and indoor air with alteration of the atmospheric inherent properties are termed air pollution. For patient well-being, staff productivity (as healthcare professionals, and employees spend major time in facilities), and overall health improvement, the knowledge of the indoor air quality of healthcare facilities, i.e., hospitals, nursing homes, private health centres, general practitioners' chambers, elderly care centres, and pharmacies, is essential as the indoor air contains a mixture of chemical and microbial compounds [1, 2], patients coming for treatment and/or consultation are ill, and elderly people are generally in poorer health, which can affect adversely the exposed persons. The impact of poor indoor air in hospitals and health care centres is significant to those individuals who have a compromised immune system. It is estimated that 700 million people globally are of the age 65 years or above [3], and it is expected that by 2050, the population of such persons will be 29.4% of the total global population [4]. As biological functions, including immune defences deteriorate with age, the vulnerability of elders to poor indoor air pollutants is enhanced. Exposure of the individuals to these volatile and semi-volatile compounds (respirable suspended particulates, carbon dioxide, carbon monoxide, formaldehyde, nitrogen dioxide, nitrous oxide, glutaraldehyde, allergens, and bioaerosols) is via inhalation, dermal contact, and/or ingestion [5-6]. If the indoor air is of poor quality, it causes hospital-acquired infections (HAIs) (those infections that a patient does not have before admission to the hospital) to patients or visitors within 48-72 hours of admission [7]. These infections are viral,

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bacterial, and fungal. They not only prolong the treatment time but also inflate the cost of the treatment, increasing the drug uptake and pathological tests. As per the World Health Organization's [8] report, microbial agents present in hospitals infect approximately 15% of hospitalized persons. Microbes' *staphylococcus* and *actinobacter* transmit infections via air [9-10]. As per WHO [8] studies globally, approximately 4.3 million people lost their lives due to indoor air pollutants. As per the Centers for Disease Control and Prevention (CDC) estimation, approximately 1.8 million patients who are hospitalized for treatment for other medical conditions acquire hospital-acquired infections (HAIs), and due to hospital-acquired infections, one out of 17 lose their lives [11]. As per the CDC report, 90% of hospital-acquired infections (HAIs) are due to bacteria, as the microbial pollutants i.e., bacteria, mould, and viruses, can grow on ventilation system pans and the moist ceiling and floor [12]. Besides, on dry surfaces, several bacteria survived for several months and became resistant to disinfectants adversely impacting the patient's health [13-15]. The microbial load in the indoor air of the hospital depends on several factors viz, occupants, their activities, and the ventilation system of the hospital. The bacteria are shed from the skin and respiratory tract of residents. The washbasins, drains, sinks, nebulizers, humidifiers, and cooling towers of the hospitals are contaminated with gram-negative bacilli. As per WHO [16] data, the rate of hospital-acquired infections in developing countries is 25% while in developed countries it is 5–15%. Babatola et al. [17], during studies, found that patients who stay longer in the hospital are 24 times more susceptible to HAI than patients that have shorter stays at the hospital.

As studies are scarce on the indoor air quality of care facilities (nursing homes, elderly care centres, etc.) and private healthcare facilities (general practitioner's offices, dental offices, pharmacies, etc.), the present study aimed to provide a comprehensive overview of indoor air quality with microbial contamination (bacterial and fungal) of care facilities (nursing homes, elderly care centers, etc.) and private healthcare facilities. This study will help policymakers in the health sector to develop effective control programs and reduce hospital-acquired infections and financial burdens on patients.

2. Hospitals, nursing homes, and elderly care centres Indoor air pollutants:

The common indoor air pollutants of hospitals, nursing homes, and elderly care centres are both particle and gaseous emissions such as respirable suspended particulates (PM 2.5, PM 10), carbon dioxide (CO_2), volatile organic compounds (VOCs), carbon monoxide (CO), formaldehyde (CH_2O), nitrogen dioxide (NO_2), nitrous oxide (N_2O), glutaraldehyde ($C_5H_8O_2$), allergens, and bioaerosols, and biological pollutants (i.e., mould, viruses, and bacteria) [6,18]. Relative humidity and temperature can considerably affect pollutants, specifically; bioaerosol counts in hot and humid climates [19-20].

3. Source of pollutants in the indoor air of healthcare facilities

The major sources of pollutants in the indoor air are outdoor air, as there is near-constant foot traffic and vehicles. Other sources are equipment, furnaces, lighting systems, and generators; cleaning equipment; office equipment (printers, fax machines, and photocopiers). Sterilization activities and disinfection activities, chemical pollutants (TVOC, formaldehyde) enter the indoor air. Housekeeping activities, activities of patients, doctors, visitors, and hospitals positively impact the number of pathogens in hospital indoor air. Anaesthesia gases used in operation theatre and smoke gases used for radiotherapy also pollute the indoor air of hospitals. Hospital interior construction works also pollute the indoor air of the hospitals [5, 21-22].

4. Adverse Impact of Pollutants on Humans

Several indoor air pollutants impact human health adversely. The indoor pollutants may be inorganic, organic, radioactive, or biological. The health impact of these pollutants is as follows:

4.1. Particulates Matters (PM)

In the indoor air, the particulate matter (PM 2.5 and PM 10) is due to the outdoor environment, burning of candles, stoves, heaters, and cleaning activities. The WHO guidance limit for PM 2.5 and PM 10 is 5 and 15 ug/m^3, respectively. The survey of the data denotes that PM 2.5 and PM 10 in the indoor air of hospitals, and elderly care centers varied from 1-148 and 1-1000 [Table 1]. When the concentration of particulate matter exceeds the limit for a long period, it causes aggravated asthma, impaired lung function, irritation of the airways, coughing, difficulty in breathing, nonfatal heart attacks, irregular heartbeat, and neurodegenerative diseases [48-49] and also cause premature death of the people who have pre-existing lung and/or heart diseases [50]. As per WHO [16] reports, globally, 6.7 million people lose their lives per year due to PM.

Table 1 Indoor air quality of Hospitals and Health care centers

Centre		**Country**	**PM2.5 ug/m³**	**PM10 ug/m³,**	**CO ppm**	**CO2 ppm**	**Volatile organic compounds mg/m3**	**Formal dehyde mg/m³**	**Bacterial Population (CFU/m³)**	**Fungal Population (CFU/m³)**	**Bacterial/Fungal genera**	**Reference**
Hospital I	X-ray area	Delhi, India	006		416	1396	2.178	0.453				[19]
	All ICU		010		853	2170	4.404	0.811				
	OT		001		923	2492	5.997	1.020				
	Blood Bank		004		483	1543	3.62	0.699				
Hospital	X-ray area	Gurgaon, India	006		396	1349	1.97	0.421				
	ICU		005		543	1669	3.45	0.668				
	OT		010		920	2490	6.94	1.167				
	NICU		005		543	1669	3.38	0.64				
Hospital	ICU	Jaipur, India	006		920	2490	7.23	1.15				
	OT		012		943	2533	8.23	1.17				
	Dialysis Unit		009		396	1630	2.44	0.51				
Hospital II	ICU	Delhi, India	009		843	2240	6.39	1.09				
	OT		009		860	2309	7.19	1.15				
	Cosmetic Surgery		006		396	1349	1.94	0.41				
Health Promoting Hospital		Thailand	46.1	87.5	4.3	491	ND	ND	217	493		[23]
Early Childhood Hospital			49	112.1	3.1	614	ND	ND	515	548		
Health Club		Greece	1.6-479.3	1.9-988.5		122-6914	0.06-5.34					[24]

University Hospital Medical Clinic	Medical Clinic I	Malaysia			0.21-0.55	1551-1769	0.00	0.00-0.03	160-302	9-18		[25]
	Medical Clinic II			0.02-0.03	0.38-0.53	1395-1614	0.00	0.01-0.02	140-394	8-16		
Al-Shamia Hospital		Iraq	109-148	096-162		880-1075	0.36-6.55	0.09-0.25				[26]
Al-Hamza Hospital			065-116	077-096		660-988	0.147-0.240	0.08-0.125				
Al-Furat Hospital			65-95	60-98		575-1400	0.28-1.29	0.079-0.180				
Al-Hussein Hospital			75-95	89-105		890-16836	0.112-0.150	0.07-0.099				
Diwaniya Hospital			79-128	75-121		880-1048	0.181-3.687	0.14-1.186				
Afak Hospital			88-100	70-150		650-920	0.25-9.999	0.38-1.60				
Women & Children Hospital			40-93	65-98		622-939	0.255-0.861	0.04-0.069				
Hospital		Mongolia					0.04-0.078	0.016-0.0554				[27]
Hospital	Otorhinolaryngology	Republic of Korea	49.6			1020	0.312					[9]
	Orthopaedics		20			670	0.268					
	Reception		20.5			528	0.11					
PHC		Thailand	9-10.4		1.6-2.5	668-777						[28]
Health care facilities		France	9				0.412	0.017	14	7	*Staphylococcus*, *Bacillus*, and *Micrococcus*	[6]
Hospital	Indoor air	Iran	25-51	11-152					0-257			[7]

Hospital	Indoor air	Lebonan	10-54	10-65					20-134			[29]
Hospital	Indoor air	Iran	23-54	33-90					19-356			[30]
Hospital	Corridor	Puducherry, India	3.4-42	7.1-54		421-940	0.1-18.5	0.02-20.1				[31]]
	Operation Room		1-39	2-57		408-955	0.2-14.2	0.02-2.4				
	Near Surgical team Without active Cautery use		1-46	2-60		409-978	0.2-29.4	0.02-3.4				
	Near Surgical team With Cautery use		0-1986	0-2430		545-1604	0.5-33	0.07-5.0				
	Anesthesia workstation inside OR		1-714	3-806		409-1604	0.06-29.8	0.01-24				
Hospital	OPD	Sri Lanka	32	55.5			0.19	0.04				[32]
	Emergency		25.6	47.9			0.38	0.08				
	Outdoor		28.7	49.4			0.12	0.03				
Namazi hospital		Iran	5	114-12	1.16	796-913						[33]
Hospital		Rwanda	54-117	60-124								[34]
Qatar University Health Center	Indoor	Qatar							100		*Staphylococcus, Acinetobacter, Bacillus, and Pseudomonas*	[35]
	Outdoor								499.6			
Umm-Ghuwailina Health Center	Indoor								459.1			
	Outdoor								200.8			

Old Airport Health Center	Indoor								329.6			
	Outdoor								291.6			
Al-Rayyan Health Center	Indoor								364.1			
	Outdoor								377.1			
Women Surgery Ward	Bedding	Iran								37.1-84.3 (CFU/plate)	*Aspergillus,Rhizopus, Cladosporium, Penicillium,Scopulariopsis , Chrysosporium*	[36]
	Food Table									42.4-58.2		
	Bed Railing									38.5-39.5		
	Nurse's Station									29.5-41.2		
	Keyboard									32.5-35.1		
	Mouse									11-25		
	Pillow									46-81		
	Serum holder									4.2-36		
	Corridors									40-70		
Men Surgery Ward	Bedding									64-94.4		
	Food Table									32.7-39.7		
	Bed Railing									29-80.7		
	Nurse's Station									29-37.3		
	Keyboard									24.5-33		
	Mouse									11-13.5		
	Pillow									30-39.5		
	Serum holder									22-30		
	Corridors									18-59		
ICU	Bedding									76-86.5		
	Food Table									26-157.6		
	Bed Railing									23-85.7		

	Nurse's Station									11.5-17.5		
	Keyboard									15.3-29.5		
	Mouse									23-25		
	Pillow									68.5-81		
	Serum holder									24.5-46		
	Corridors									31.5-42.2		
Indoor air Hospital	TB Chest	India							982-1179	65-157	*Candida, Staphylococcus aureus*	[37]
	Medicine (Male)								655	65	*GPC, GPB, Aspergillus*	
	Medicine (Female)								655-786	52-131	*Staphylococcus aureus, Candida, Aspergillus, Bacillus*	
	ICCU								786-1048	65-131	*Staphylococcus aureus, Candida*	
	NICU								327-524	ND	*Staphylococcus aureus, GPB*	
	Surgery (Male)								327	ND	*Staphylococcus aureus, E.coli*	
	Surgery (Female)								655	39	*Staphylococcus aureus, Candida, GPB*	
	ENT								524	ND	*Staphylococcus aureus, Micrococci, GPB*	
	Casualty								786	196-262	*Staphylococcus aureus, Candida, Aspergillus, Pseudomonas, Klebsiella spp.*	
	Gynaecology								131	23-26	*Staphylococcus aureus, Candida, Diptheroids*	
	Orthopaedics (Male)								262	65	*Staphylococcus aureus, Candida*	

	Orthopaedics (Female)								196	26-39		
	Ophthalmology								393	104-131	*Staphylococcus aureus, Candida, Closstridium*	
	Nephrology								65	ND	*Staphylococcus aureus, Coccobacilli*	
	Paediatrics								524	26-39	*Staphylococcus aureus, Candida, Aspergillus*	
	Central Clinical Lab								655-786	65-104	*Staphylococcus aureus, Candida, GPC, GPB, Klebsiella*	
	Surgery (Male)	Ethiopia							980-1325		*Gram-negative cocci and Gram-positive rod bacteria*	[11]
	Surgery (Female)								970-1060			
	Obstetrics								990-2195			
	Pediatrics								7885-2200			
	Emergency								680-1250			
	NICU								300-510			
	Gynaecology								640-2140			
	Orthopaedics								700-1150			
	Medicine								850-2120			
Hospital	Before Covid	China							246-1343	88.1-207.6	*Staphylococcus aureus, E.coli*	[38]
	After Covid								99-541	28.7-134.9		
Hospital	Urban	Portugal				658-787			420		*Micrococcus, Staphylococcus aureus*	[39]
	Rural					1120-1442			448			
Hospital	Emergency	Ghana							4824	1705	*Staphylococcus aureus, E.coli, Bacillus subtilis,*	[40]
	Children								4622	1427		

	ICU								2572	956	*Aspergillus spp. Alternaria spp.*	
	Surgical								3582	1521		
	OPD								5395	2021		
	Theatre Ward								492	277		
	Administrative								969	974		
	Outside								4787	1796		
Hospital	OPD	Thailand				553-2859			97-2261		*Staphylococcus aureus, Staphylococcus spp.*	[41]
Hospital	General								191-2645	6-147	*Staphylococcus xylosus , Kocuria marina Kocuria rosea , S. hominis, S. haemolyticus Micrococcus luteus , Arthrobacter oxydans*	[42]
	Neurosurgery								338-485	15-103		
	G. Surgery								514-896	59-73		
	Trauma								1491-632	15-29		
	Post-Operative								647-2136	6-73		
	Resuscitation								338-544	44-147		
	Septic block								441-529	44-103		
Hospital	Surgical	Ethiopia							2166		*Staphylococcus aureus, E.coli, Bacillus spp., Klebsiella spp*	[43]
	Medicine								2133			
	Gynaecology								2542			
	Paediatric/NICU								2535			
	Optometry								2033			
	OPD								1536			
	Staff office								1355		*Staphylococcaceae, Enterobacteriaceae, Psedomonadaceae and Bacillaceae*	[44]
Hospital	General	Egypt							62.4-640			
		Jordan							29.3-212.3			
		Palestine							780			
		Yaman							350-1190			

Dental School Clinic		Iran	20-27	22-48		650-952	1.84-2.37		153-332	46-198	*Micrococcus spp., Bacillus,Streptococcus,Staphylococcus, Penicillium, Aspergillus, Cladosporium*	[45]
Hospital	CCU				0.0-0.2	389-490	0.2-9.3	0.0-0.09				[46]
	ICU				0.0	304-361	0.1-2.8	0.0-0.08				
	OTs				0.0	338-471	0.0-0.5	0.0-0.01				
	Anesthesia room				0.0	498	1.3	0.0				
Hospital		Ethiopia							280-6369		*Staphylococcus,spp, Bacillus spp,E.coli, Klebsiella spp*	[47]

4.2. Carbon monoxide

Carbon monoxide gas is in indoor air and originates from the incomplete combustion of fuel (petrol, natural gas, etc.) from generators, other gasoline-powered equipment, tobacco smoking, and the outdoor air. The guidance limit in the indoor air is 9 ppm. The concentration of carbon monoxide in the indoor air of different wards of hospitals ranged up to 920 ppm, about 100 times greater than the guided limit (Table 1). The accumulation of CO in the indoor air in humans causes drowsiness, headache, dizziness, nausea, and permanent damage to the brain and heart [51-53].

4.3. Carbon dioxide

ASHRAE has recommended a 1000 ppm concentration of CO_2 in the indoor air. The concentration of CO_2 in the indoor environment denotes the condition of ventilation [44]. The carbon dioxide concentration in the indoor air of different wards of different hospitals varied from 490 to 2500 ppm (Table 1). Rapid heartbeat, breathing, fatigue, clumsiness, and emotional upsets are some adverse impacts on human health [21, 54].

4.4. Total volatile organic compounds

Volatile organic compounds (VOC) are gases emitted from organic solids or liquids. In the indoor air, the VOCs are due to i) human activities, i.e., smoking, cooking, use of personal care products and cleaning products; ii) generated from indoor chemical reactions such as the use of air fresheners, plastics, printers, copy machines, perfume, dry-cleaned clothes, furnishing, etc. iii) from building materials; paints, solvents, adhesives, wood preservations, polishes, etc. iv) via outdoor air penetration through ventilation system [5, 6, 51]. The guidance limit in the indoor air for VOCs is 200 ug/m^3. The indoor air of different hospitals is contaminated with 71-823 ug/m^3 of volatile organic compounds (Table 1). The uptake of these components by humans is via inhalation, skin contact, and ingestion, which depend on the form of the volatile compound [45, 46]. The accumulation of these gases in the indoor air beyond permissible limit causes eye, nose, and throat irritation, headache, nausea, and damage to the liver, kidney, and central nervous systems [5, 22, 55, 56]. Some of the gases are classified as carcinogenic [21]. Individuals are exposed to volatile organic compounds (VOCs) and semi-volatile organic compounds (SVOCs) through inhalation, skin contact, and ingestion, depending on their gaseous or particulate form [57, 58].

4.5. Formaldehyde

The formaldehyde in the indoor air is released from furniture and wooden products such as plywood, particle board, and panelling, insulating materials, which contain urea-formaldehyde resins, from the laboratories where it is used as a fixative, detergents, disinfectants, liquid soaps, shampoos, nail varnishes, softeners, carpet cleaners, wallpaper, cardboard, and paper products also contain formaldehyde [51]. The guidance limit for the formaldehyde is 16.3 ppb, while in the indoor air of different hospitals; it is 7 times the limit (Table 1). Prolonged exposure to a high concentration of formaldehyde causes eye, nose, throat, and respiratory irritation. In the nasal respiratory mucosa, formaldehyde forms DNA-protein cross links. For humans, formaldehyde is also carcinogenic [46].

4.6. Nitrogen dioxide

The guidance limit of nitrogen dioxide in indoor air is 10 ug/m^3. Nitrogen dioxide enters the indoor air via heating appliances. Most of the indoor air samples of hospitals contain more nitrogen dioxide than the permissible limit. When humans are exposed for a longer period to a high concentration of nitrogen dioxide, it causes respiratory damage and makes them more susceptible to respiratory infections, and enhanced asthma [16,59].

4.7. Ozone

Photocopying, air purifiers, disinfecting devices, and outdoor air contribute ozone to the indoor air. The maximum recommended limit in the indoor air is 100 ug/m^3. Exposure of humans to an elevated concentration of ozone for a longer period causes DNA damage, lung damage, asthma, sore throat, and retarded respiratory functions [16].

4.8. Microorganisms

The abundance and diversity of microbial species in the indoor air depend on moisture, relative humidity, temperature (abiotic factors), human activities, and their occupancy (bacterial DNA increases with human occupancy) as human skin sheds billions of cells daily, enhancing the microbial population. Besides, by talking, breathing, coughing, sneezing, etc., the oral and respiratory fluid becomes aerosolized which spreads bacteria and viruses. Activities of patients, doctors, visitors, and hospital staff also positively impact the number of pathogens in hospital indoor air. Dust is composed of hair, cotton fibers, bacteria, moulds, and other particulate matter; the microbes present in the dust (suspended into indoor air and entering the body via inhalation) [7, 60-61]. In the air of hospitals in underdeveloped countries and in

developing countries, the bacterial count was much higher than the guided limit of 1000 CFU/m^3. The bacterial count in the indoor air of hospitals varied from ward to ward, and the concentration was much higher in the air of underdeveloped countries than in developing countries and was least in the developed countries (Table 1). The literature survey [37, 40, 62] denotes that the hospital indoor air may contain 70 bacterial species of 40 genera and 30 fungal species of 20 genera. The main bacterial genera are *Staphylococcus* spp*. (S. hominis, S. epidermidis, S. saprophyticus, and S. chromogenes), Micrococcus* spp*., Bacillus* spp. *(B. cereus and B. licheniformis),* and *Pseudomonas* spp*., Kocuria* spp*., Pantoea* spp*.* [47, 63). The fungal genera were *Cladosporium* spp*., Penicillium* spp*., Rhodoturola, Aspergillus* spp*., Basidiomycota, yeast, Alternaria* spp. *and Eurotium* spp. [30, 36, 64]. *Staphylococcus spp*. is the most prominent pathogen in the indoor air of hospitals. It causes skin and soft tissue infections, bloodstream infections, and sometimes life-threatening diseases. Chen et al [65] have reported that *Staphylococcus* spp. causes more death than causes by acquired immunodeficiency syndrome (AIDS), tuberculosis, or viral hepatitis.

The literature data also denotes that the gram-negative bacteria *Pseudomonas* spp. is isolated from all the wards of the hospitals, as this spp. requires moisture for growth and survival and exists in washrooms near the sampling area, cleaning and mopping during sampling. When there is a urinary tract or kidney infection, the bacteria *Pseudomonas aeruginosa* has been reported in the body [66]. The indoor air of the surgery ward also contains Enterococcus. Montazeri et al. [39] found fungi *Aspergillu*s and P*enicillium* in the indoor air of all the wards of a hospital, as these fungi are resistant to water scarcity and can survive in any part of the hospital and are m responsible for hospital-acquired fungal infections. The fungal count in the indoor air follows the same pattern as of bacteria (Table 1).

In the indoor air of Ethiopian hospitals, antibiotic-resistant bacteria, viz., methicillin-resistant *Staphylococcus aureus,* beta-lactam-resistant *Acinetobacter* sp., vancomycin-resistant *streptococc*i, and their inhalable antibiotic-resistance genes, were reported by Lee et al. [67]. Bitew et al. [68], during their research work, reported that one-fourth of the bacteria present on surfaces, medical equipment, and indoor air is multi-drug resistant. Studies have revealed that in Asian countries the number of carbapenem-resistant *Pseudomonas* is very high. The antibiotic-resistant bacteria are not only present in the indoor air of hospitals but also found in the air and the surface of a general practitioner's waiting room, causing healthcare-associated infections.

5. Conclusions

Indoor airs of health care centres, including hospitals, contain particulate matter, a mixture of chemical compounds and microbiological components. Airborne microorganisms and particulate matter are two major pollutants in the hospital's indoor air. The concentration of these pollutants in the indoor air of developing countries' hospitals is much higher than the guided limit. Microorganisms present in the air not only enhance the number of hospital-acquired infections but also become resistant to multidrug and antibiotics. For the safety of patients and health workers, continuous monitoring of indoor air is very essential.

Compliance with ethical standards

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