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Airborne Bacterial Pollution in Clinical Environment, Sana'a - Yemen

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Abstract: This work aims to know the extent of air pollution and common bacterial species in delivery rooms in some hospitals in Sana'a city. Six randomly airborne samples from delivery rooms of three hospitals (Algmhory, Althwrah and Alsabeen hospitals). Out of 65 airborne bacteria were isolated from delivery rooms, 89.2% of them showed Gram positive bacterial isolates and 10.8% Gram negative bacteria. Bacteria isolates were identified as *Staphylococcus aureus*, *Staphylococcus epidemidis*, *Micrococcus* sp., *Bacillus* sp., *Pseudomonas aeruginosa*, *Corynebacterium* sp., *Klebsiella* sp., *Lactobacillus* sp. and *Proteus mirabilis*. The highest percentage of bacterial isolates was recorded in Alsabeen hospital as 66.2%. *Staphylococcus* was the most dominant organism isolated from the delivery rooms in all examined hospitals (37 isolates, 56.9%), while the lowest percentages were: *Lactobacillus* (two isolates, 3.1%), *Klebsiella* and *Proteus* (one isolate, 1.5%) for each.

Keywords: Delivery rooms, airborne bacteria, Sana'a hospitals, Yemen hospitals

1. Introduction

Microorganisms are found almost everywhere including in the air [1]. The air is considered a medium for the presence of bacteria transmitted from its sources (human, animal, plant, soil, food, and water), but it is not suitable for their growth [2]. Indoor air is increasingly recognized as being more influential to human health because people spend most their time indoors such as in their homes or in occupancy [3,4,5]. However, comparatively little research has been done to quantify the human health risks and effects associated with airborne bacteria. A growing increasing number of chronic illnesses, and even death, are being linked to exposure to indoor airborne contaminants according to World Health Organization [6]. The human health effect includes short- or long-effect began with flustering until chronic diseases that linked to the heart or respiratory system and cancer are associated with indoor air quality [3,7,8]. Newborns and infants are also super sensitive to air contamination or airborne microflora in delivery rooms due to weakness of their immune systems and continued quick respiration [9,10,11].

The World Health Organization [12] reported that one of the ways of spreading infection in the hospital environment, mainly in operating rooms, is through sneezing and coughing droplets that remain suspended and carried in the air for long periods and for longer distances whenever the size of the droplets and their nuclei become smaller and thus spread widely, which in turn is transmitted to patients and individuals directly or indirectly (contaminated medical equipment).

Bacterial infections in hospitals contribute significantly to the spread of diseases and more deaths annually [13], especially those pathogenic bacteria that can resist disinfection and survive for long periods of time [2]. It is worth noting that acquired infection is one of the most important causes of mortality and morbidity in hospitals, which leads to an increase in health care, whose cost is steadily increasing with the spread of causes of health risks in the community in

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general [14]. Infections acquired in hospitals, or rather delivery rooms, can be from the surrounding environment or the transmission of pathogens from one patient to another, or it may be from the bodies of those people during their admission to the hospital who are carriers of these microbes and thus be a direct source of transmission of infection to patients or to workers in the hospital [15,16]. The current paper has addressed the air pollution with the bacterial spores in the clinical environment.

2. Materials and Methods

In the hospitals in which the study was carried out (Algmhory, Alsabeen and Althwrah hospitals) laboratory methods were used for quantitative study of the air samples and done in the laboratory of microbiology, Faculty of Science, Sana'a University. All plates contained nutrient agar (NA) from Oxoid Ltd-England, were put in different places (on the ground, beds, tables, and other sites inside the delivery room), and the plates stayed opening for twenty minutes. After that closed the plates and incubated at 37°C for 24 h. Colonies were counted and isolated in pure culture [2,17].

The methods of identification and characterization for bacterial isolates include Gram stain, microscopic examination, motility, and biochemical tests were performed according to Cheesbrough [18,19,20]. Then, the isolates were identified according to Bergey's Manual for determinative bacteriology [21].

3. Results

This study was conducted for three hospitals in Sana'a city on six airborne samples from delivery rooms. The highest percentage of bacterial isolates was recorded in Alsabeen hospital as 66.2%, while the lowest was Althwrah as 13% for two air samples (Table 1).

Table 1 - The number of airborne samples, total No. of isolated bacterial colonies, and their percentage

Hospital	No. of airborne samples	Total No. of colonies	Percentage
Algmhory	1	13	20.0
Althwrah	2	9	13.8
Alsabeen	3	43	66.2
Total	6	65	100

Our study showed that gram positive bacteria isolates (89.2%) for 58 isolates were more than gram negative bacteria (10.8%) for 7 isolates which shown in table 2.

Table 2 - Distribution of isolated bacteria according to gram stain

Bacteria	Total Number of isolates	Percentage
Gram positive bacteria	58	89.2
Gram negative bacteria	7	10.8
Total	65	100

Table 3 showed that gram positive cocci were 40 isolates (61.5%), gram positive rods were 18 isolates (27.7%) and gram negative rods were 7 isolates (10.8%).

Table 3 - Distribution of bacterial isolates according to gram stain and shape

Bacteria	Total No. of bacterial isolate	Percentage
Gram positive cocci	40	61.5
Gram negative cocci	-	-
Gram positive rods	18	27.7
Gram negative rods	7	10.8
Total	65	100

Bacterial identification based on microscopic characters and biochemical tests showed that the genus *Staphylococcus* was the most dominant organism isolated from the delivery room at all examined hospitals were 37

isolates (56.9%) which including 13 isolates of *S. aureus* (20.0%) and 24 isolates of *S. epidermidis* (36.9%), 7 isolates of *Bacillus* (10.7%), 6 isolates of *Corynebacterium* (9.2%), 5 isolates *Pseudomonas* (7.7%), 3 isolates for each of *Streptococcus* and *Micrococcus* (4.6%) and 2 isolates of *Lactobacillus* (3.1%), while *Klebsiella* and *Proteus* were the lowest bacterial isolates (one isolate 1.5% for both), this results shown in Table 4.

Table 4 - Type and number of bacterial isolates

Bacteria		No. of Bacterial isolates		Percentage	
Staphylococcus	*S. aureus*	37	13	56.9	20.0
	S. epidermidis		24		36.9
Streptococcus sp.			3		4.6
Micrococcus sp.			3		4.6
Corynebacterium sp.			6		9.2
Bacillus sp.			7		10.7
Lactobacillus sp.			2		3.1
Pseudomonas aeruginosa			5		7.7
Klebsiella sp.			1		1.5
Proteus mirabilis			1		1.5
Total			65		100

Two species of staphylococcui (*S. aureus* and *S. epidermidis*) were found in all airborne hospital samples. *Stahpylococcus epidermidis* was the most dominant of staphylococci isolated from Alsabeen hospital in airborne samples no. 2, 3, and 1 which represent percentage 12.3, 9.2 and 6.4% respectively. All species of bacteria isolate for all hospitals shown in Table 5.

Table 5 - Distribution of bacterial isolates in every airborne Hospital samples

Hospital	airborne sample No.	Identification of bacterial isolates	No. of bacterial isolates	Percentage	Total %
Althwrah	1	*Staphylococcus aureus*	2	3.1%	7.7
		Staphylococcus epidermidis	2	3.1%	
		Micrococcus sp.	1	1.5%	
	2	*Staphylococcus aureus*	2	3.1%	6.1
		Staphylococcus epidermidis	1	1.5%	
		Micrococcus sp.	1	1.5%	
Algmhory	1	*Staphylococcus aureus*	2	3.1%	20
		Staphylococcus epidermidis	3	4.6%	
		Corynebacterium sp.	2	3.1%	
		Bacillus sp.	2	3.1%	
		Pseudomonas aeruginosa	3	4.6%	
		Klebsiella sp.	1	1.5%	
Alsabeen	1	*Staphylococcus aureus*	3	4.6%	21.7
		Staphylococcus epidermidis	4	6.4%	
		Corynebacterium sp.	3	4.6%	
		Pseudomonas aeruginosa	1	1.5%	
		Lactobacillus sp.	1	1.5%	
		Bacillus sp.	2	3.1%	
	2	*Staphylococcus aureus*	2	3.1%	27.5
		Stahpylococcus epidermidis	8	12.3%	
		Bacillus sp.	3	4.6%	
		Corynebacterium sp.	1	1.5%	
		Pseudomonas aeruginosa	1	1.5%	
		Lactobacillus sp.	1	1.5%	
		Proteus mirabilis	1	1.5%	
		Streptococcus sp.	1	1.5%	
	3	*Staphylococcus aureus*	2	3.1%	16.9
		Stahpylococcus epidermidis	6	9.2%	
		Micrococcus sp.	1	1.5%	
		Streptococcus sp.	2	3.1%	
Total			**65**	**100%**	

Airborne samples no. 2 and 1 of Alsabeen hospital showed the highest total percentage of bacteria isolated from delivery rooms 27.5 and 21.7% respectively. While airborne samples no. 2 and 1 of Althwra hospital showed the lowest total percentage of airborne samples 6.1 and 7.7 % respectively.

4. Discussion

The aim of this work was to know the airborne bacterial species in the delivery rooms and thus the extent of air pollution in three hospitals in Sana'a city. Sixty-five bacterial colonies were collected from the air of these delivery rooms at all examined hospitals. The highest percentage of bacterial isolates was recorded in Alsabeen hospital as 66.2% for three samples, while the lowest was Althwrah hospital as 13.8% for two samples. This may be due to the concern for cleanliness and the use of sterile materials in Althwrah hospital, as well as controlling the reception of a limited number of patients and the presence of delivery rooms in the upper suite and their small area. On the contrary, in Alsabeen hospital, it is noticed that there is a lack of attention to hygiene and the reception of a large number of patients, in addition to the fact that the delivery room is located next to the reception corner in the lower suite, and its area has grown to receive a larger number of cases. The gram positive bacterial isolates were 89.2%, while the gram negative isolates were recovered less frequently (10.8%), this result agrees with Yagoub and El Agbash [2]. Bacterial isolates were identified as *Staphylococcus aureus, Staphylococcus epidermidis, Corenyebacterium* sp., *Klebsiella* sp., *Pseudomonas aeruginosa. Lactobacillus* sp., *Bacillus* sp., *Streptococcus* sp. and *Proteus mirabilis. Staphylococcus epidermidis* was the first and most common organism isolated from the delivery rooms in three hospitals, and it showed the highest percentage at Alsabeen hospital. In this case, the sources of this contamination are usually from the skin of patients (normal flora) or from hospital staff, especially *S. epidermidis*.

Bacillus and *Corenybacterium* were the second most common isolates and it is known that these microbes are characterized by their ability to survive and spread when the moisture factor is available and they are resistant to antibiotics and common disinfectants used in hospitals, so these environments can be a source for their presence and spread of disinfectants, as well as from newborns during breastfeeding, and these bacteria are opportunistic pathogenic bacteria. It represents a source of infection in hospitals, especially in those patients who are characterized by a weak immune system.

In a comparative study conducted by Olofsson and Vasques [11] for airborne bacteria in two groups, the first group was for isolated samples from the air of delivery rooms, and the second group was for air samples from a nature reserve. Where they found an increase in the percentage of bacteria in the delivery room (51%) than those isolated from the nature reserve (18%). The highest bacterial genus present in the delivery rooms was *Staphylococcus* (22%), followed by *Micrococcus* (17%) and *Bacillus* (6%) which higher than the present study for three hospitals.

A study in Nigeria by Chikere *et al*. [22] about the possible bacterial pathogens in the hospital environments. Where it was found that solid hospital equipment (83.1%) (in hospital wards and even operating rooms) is contaminated with many bacterial pathogens. Coagulase-negative *staphylococci* (68.3%) ranked first as the highest isolates present among the samples collected, followed by *Staphylococcus aureus* (30.7%). In other studies, in Taiwan and Nigeria by Teng *et al.* [23] and Ochie & Ohagwu [24] respectively, the results were similar to previous studies on the presence of coagulase-negative *staphylococci* on the medical chart and X-ray machines.

Newly, methicillin-resistant *S. epidermidis* strains and other coagulase-negative *staphylococci*, represent pathogens in hospitals, weaken immunity, and are found as contaminants on medical instruments and devices [25].

In the present study, Gram- negative bacteria percentage was 10.8% for 7 bacterial isolates and the *P. aeruginosa*a gave the highest percentage of 7.7% for 5 bacterial isolates among isolated gram negative bacteria which are considered the main responsible for many outbreaks and a life-threatening factor, especially in hospitals.

In general, the results of this study indicate that the delivery rooms are contaminated with types of pathogenic and airborne bacteria such as *S. aureus, S. epidermidis* for gram positive *and P. aeruginosa* for gram negative. Therefore, it is necessary for the management of hospitals to take care of the delivery rooms in the hospital environment by controlling these biological factors that pose a threat to the health of patients, combating them, and eliminating them to prevent the spread of infection and avoid its transmission to mothers and newborns who are characterized by low immunity.

Another study by Yagoub and El Agbash [2] investigated air quality in both delivery rooms and nursing rooms in four hospitals in Khartoum city. The results of that study showed the presence of bacterial species: *S. aureus, Escherichia coli, Klebsiella* sp., *P. aeruginosa,* and *Bacillus* sp. Both *Staphylococcus aureus* and *P. aeruginosa* were the highest percentages of present in delivery rooms in the four hospitals, while *S. aureus* was the most present in nursing rooms in two of the studied hospitals.

Generally, the reason for the high rate of the presence of staphylococci is because staphylococci are members that are found as flora on the skin of humans and transmitted by hands or from the respiratory system to the environment during breathing or droplets by sneezing and are abundant in aerosols. Other types of bacteria that appeared, but in low isolates, maybe due to their transmission between patients or health workers in the hospital as a result of negligence [11,26].

In this study, the data and results will contribute to increasing knowledge of the hospital environment and thus the control of airborne contamination by maintaining a certain desirable level of air cleanliness in the hospital environment under routine working conditions, thus this study might serve as a guideline to feasibility.

Conclusion

The hospital administration should pay attention to the cleanliness of the hospital environment through concerted efforts between the hospital staff, including doctors and health care workers, and raise their awareness of safety procedures to avoid contamination with airborne organisms and prevent their transmission. Personal hygiene is responsible for medical staff and cleaning the delivery rooms continually by sterilization and disinfection prohibited non-medical staff to enter these rooms.

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