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Microbial contamination of air and protective wears in the operating theatre and surgical wards of two tertiary hospitals in Kano, Northwestern Nigeria

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Abstract

Bacterial airborne contamination and other fomites in the operating theatre are major causes of nosocomial infection.

This study was to evaluate the bacterial and fungal pathogens contaminating the air and protective wear in the theatre and surgical wards of two tertiary hospitals in Kano, Aminu Kano teaching hospital (AKTH) and Murtala Mohammed specialist hospital (MMSH). A total of 960 samples were collected from air, theatre gowns, facemasks and hand gloves.

The air sampling in the operating theatre and surgical wards was done fortnightly for 15 months by the settle plate technique, while theatre gowns were sampled by the sweep plate method. Samples from face masks and hand gloves were collected by swabbing large representative areas. Isolation and identification of bacterial and fungal pathogens were carried out by standard microbiological procedures.
The most frequently isolated bacteria were *Micrococcus* and coagulase negative staphylococcus while *Rhizopus* spp. was the most common fungus isolated.

Six bacterial genera and 2 fungal species were observed in the theatre air while 9 bacterial genera and 2 fungal species were observed from the ward air. Also seven bacterial genera were observed on face masks, theatre gowns and hand gloves respectively after surgery. Bacterial counts obtained by exposed plates after two hours of surgical procedure were 120cfu/m^3 in MMSH and 90cfu/m^3 in AKTH, while an increased count

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>80cfu/m^3 was also observed one hour after the presence of visitors in the evenings in the surgical wards of both hospitals.

The presence of nosocomial pathogens confirmed in this study portends danger for surgical site infection in patients.

Keywords: Air pollution, indoor; Surgery department, hospital; Cross infection; Protective clothing.

Introduction

Contamination of operating theatres is one of the most life-threatening sources of nosocomial infection for patients, especially in transplant surgery, heart surgery, cystoscopy and transurethral resection of prostate and bladder tumours.[1] Multiple reservoirs have been reported as being responsible for hospital contamination, particularly the operating theatre, including unfiltered air, ventilation systems and antiseptic solutions.[2]

Medical staff still represent an exogenous contaminant source in operating theatres[3] and personnel move back and forth between the operating theatre and other parts of the hospital without changing their gowns or slippers.

The importance of the estimation of the quantity and types of airborne microorganisms are that these values can be used as an index for the cleanliness of the environment as well as an index of risk in relation to human health and as source of hospital-acquired infections.[4]

A report showed that 65% of the nurses who had performed patient care activities on patient with methicillin resistant *Staphylococcus aureus* (MRSA) in a wound or urine contaminated their nursing uniforms or gowns with MRSA.[5]

Some investigators have observed that there is a relationship between the bacterial air load in the operating theatres and the development of post-operative wound sepsis.[6]

The aim of this study was to evaluate the bacterial and fungal pathogens contaminating the air and protective wears in the theatre and surgical wards of two tertiary-care hospitals in Kano.

Materials and Methods

Study Setting

Murtala Mohammed Specialist Hospital (MMSH) is a tertiary health care facility in the city of Kano, Northwestern Nigeria, with about 1000 beds. It provides high level Medicare to a large population of people in a highly populated state, and renders mostly free medical services. Aminu Kano Teaching Hospital (AKTH), where medical services are mostly paid for, is a tertiary care hospital in Kano with equal bed capacity as above, and is about 10km distance from MMSH. In both hospitals the study was carried out in male and female surgical wards, maternity, gynaecology and paediatric surgical wards where both emergency and elective procedures were performed.

Samples were collected between January 2010 and March 2011 and were screened for bacterial and fungal pathogens by standard microbiological procedures.[7]

Sample Size

A total of 960 samples were collected as follows: operating rooms (6) 180 Samples, surgical wards (6) 180 samples, face masks (5) 150 samples, gown (5) 150 samples and hand gloves (5) 300 samples. Numbers in parenthesis represent the number of rooms from where samples were evaluated.

Air Sampling

Operating theatre air was sampled before and during surgery by settle plate technique.[8] Samples were collected fortnightly for 15 months during clean surgical procedures. The mean bacterial count was obtained for a particular time of exposure throughout the period of sample collection and converted into colony forming units (cfu/m^3). Two Sabouraud dextrose, MacConkey and blood agar plates each were placed in the immediate vicinity of the surgical procedure

and about 50cm above the ground so that they were at about the same level with the surgical field. Culture plates were placed 30 minutes before the beginning of surgery and withdrawn at 30 minutes interval for two hours during surgical procedures. There were a minimum of six persons and a maximum of 18 persons in the theatre during surgical procedures.

Surgical ward air was also sampled by the settle plate technique in the mornings when only the hospital staff moved around, and in the evenings when both hospital staff and visitors who came to visit the patients were also around. Cultures plates were exposed for a total of two hours in the morning and two hours in the evenings and withdrawn at 30 minute intervals. They were kept at strategic places not more than one metre from the patient, 50cm above the ground.

Protective Personal Equipment

Protective wear sampled include face masks, hand gloves and gowns. The gowns were sampled by the sweep plate method.[8] Swab sticks manufactured by (Sterilin UK) were made slightly wet with physiological saline and used to swab large areas of the face masks and hand gloves before surgery. They were then inoculated on Sabouraud's dextrose, MacConkey and blood agar plates.

While culture plates for bacterial isolation were incubated at 37°C for 18-24 hours, fungal culture plates were incubated at room temperature for 48-72 hours. Gram staining, morphological characteristics and biochemical tests were used for identification of bacterial pathogens while morphological characteristics, hyphae and lactophenol cotton blue mount were used to identify the fungal pathogens.

Bacterial colonies were counted and converted to colony forming units (cfu/m^2).

Results

Table I shows the distribution of airborne microorganisms in the different operating rooms in AKTH/MMSH. Six bacterial genera and two fungal species were isolated.

Table I. Distribution of airborne microorganisms in the different operating rooms in AKTH and MMSH

Bacterial and fungal Isolates	Frequency of occurrence (%)					
	Main theatre (30 exposures) N = 30		Maternity/postnatal theatre (30 exposures) N = 30		Gynae theatre (30 exposures) N = 30	
	MMSH	AKTH	MMSH	AKTH	MMSH	AKTH
Gram Positive						
Micrococcus	25(83.3)	10(33.3)	20(66.6)	15(50)	10(33.3)	8(26.6)
CoNS	25(83.3)	17(56.7)	26(86.7)	13(43.3)	8(26.6)	8(26.6)
B. sphaericus	28(60)	8(26.6)	10(33.3)	10(33.3)	8(26.6)	5(16.6)
Streptococcus spp	8(26.6)	5(16.6)	3(10)	2(6.6)	0(0)	0(0)
B. circulans	20(66.6)	10(33.3)	15(50)	10(33.3)	10(33.3)	8(26.6)
Gram Negative						
P. putida	5(16.6)	3(10.0)	8(26.6)	0(0)	2(6.6)	0(0)
Alcaligenes spp	4(13.3)	1(3.3)	3(10)	5(16.6)	1(3.3)	0(0)
Fungi						
Rhizopus spp	10(33.3)	4(13.3)	15(50)	8(26.6)	15(50)	10(33.6)
Aspergillus spp	5(16.6)	1(3.3)	1(3.3)	1(3.3)	6(20)	1(3.3)

CoNS – Coagulase negative Staphylococcus; Gynae - Gynaecology

Coagulase negative staphylococcus (CoNS) was the most frequently isolated organism in the air of the operating theatre. The fungus *Rhizopus* spp. was commonly isolated in all theatres.

Table II shows the distribution of airborne microorganisms in different surgical wards in AKTH/MMSH. Coagulase negative *Staphylococcus* spp. (CoNS) was the most frequently isolated bacterium in the surgical wards. Bacteria known to cause nosocomial infections such as *Acinetobacter* spp, *Proteus* spp, *Streptococcus* spp, *Pseudomonas* spp, *Klebsiella* spp, were isolated. Nine bacteria genera and two fungal species were isolated. *Penicillium* and *Aspergillus* spp. were also seen.

Table III shows the distribution of different isolates and frequency of recovery from fomites before surgery in AKTH/MMSH. *Bacillus* spp. was the most frequently isolated organism followed by coagulase negative staphylococcus. Enterobacteriaceae were not isolated.

Table IV shows the distribution of different isolates and frequency of recovery from fomites after surgery in AKTH/MMSH. *Staphylococcus aureus* was most frequently isolated from hand gloves and least isolated from gowns. Coagulase negative *Staphylococcus* was most commonly isolated from all the protective personal equipment investigated, while no fungal organisms were isolated.

Table II. Distribution of airborne microorganisms in different surgical wards in AKTH and MMSH

Bacterial and fungal Isolates	Frequency of occurrence (%) Maternity/postnatal ward (30 plate exposures) N = 30		Gynae ward (30 plate exposures) N = 30		DWM/MSW (30 plate exposures) N = 30	
	AKTH	MMSH	AKTH	MMSH	AKTH	MMSH
Gram Positive						
CoNS	18(60)	23(76.7)	6(20.0)	5(16.7)	16(53.3)	20(66.7)
Micrococcus spp.	8(26.6)	10(33.3)	4(13.3)	1(3.3)	8(26.6)	10(33.3)
B. circulans	10(33)	15(50)	5(16.6)	8(26.6)	6(20)	8(26.6)
B. pumilus	12(40)	10(33.3)	3(10)	5(16.6)	2(6.6)	7(23.3)
Streptococcus spp.	6(20)	5(16.6)	1(3.3)	2(6.6)	2(6.6)	1(3.3)
Non haem strept	8(26)	15(50)	5(16.6)	2(6.6)	6(20)	8(26.6)
B. sphaericus	12(40)	10(33.3)	8(26.6)	10(33.3)	11(36.6)	10(33.3)
Gram Negative						
Acinetobacter spp.	0(0)	1(3.3)	0(0)	0(0)	1(3.3)	0(0)
Klebsiella spp.	0(0)	0(0)	0(0)	1(3.3)	0(0)	1(3.3)
Pseudomonas spp.	1(3.3)	3(10)	0(0)	0(0)	2(6.6)	3(10)
Proteus spp.	2(6.6)	5(16.6)	0(0)	0(0)	1(3.3)	4(13.3)
Alcaligenes spp.	1(3.3)	0(0)	0(0)	1(3.3)	4(13.3)	6(20)
Fungi						
Penicillium spp.	5(16.6)	3(10)	2(6.6)	3(10)	5(16.6)	4(13.3)
Aspergillus spp.	4(13.3)	6(20)	4(13.3)	2(6.6)	5(16.6)	6(20)

CoNS – Coagulase negative *Staphylococcus* spp.; Gynae - Gynaecology

Table III. Distribution of different isolates and frequency of recovery from formites before surgery in AKTH/MMSH

Organisms	Face Masks (N = 30)				
			MMSH		AKTH
	Matern	Gynae	Main	Gynae	Main
Gram Positive					
CoNS	3(60)	0(0)	1(20)	0(0)	1(20)
Micrococcus spp.	1(33.3)	1(33.3)	0(0)	0(0)	1(33.3)
S. aureus	2(50)	1(25)	1(25)	0(0)	0(0)
Bacillus spp.	4(40)	2(20)	2(20)	1(10)	1(10)
Streptococcus spp.	0(0)	0(0)	1(50)	0(0)	1(50)
Gram Negative					
P. aeruginosa	1(100)	0(0)	0(0)	0(0)	0(0)
E. coli	0(0)	0(0)	0(0)	0(0)	0(0)
Proteus spp.	0(0)	0(0)	0(0)	0(0)	0(0)

Organisms	Gown (N = 30)				
			MMSH		AKTH
	Matern	Gynae	Main	Gynae	Main
Gram Positive					
CoNS	1(50)	0(0)	1(50)	0(0)	0(0)
Micrococcus spp.	0(0)	0(0)	0(0)	0(0)	0(0)
S. aureus	0(0)	1(100)	0(0)	0(0)	0(0)
Bacillus spp.	2(28.6)	0(0)	1(14.3)	2(28.6)	2(28.6)
Streptococcus spp.	2(40)	1(20)	1(20)	0(0)	1(20)
Gram Negative					
P. aeruginosa	0(0)	0(0)	0(0)	0(0)	0(0)
E. coli	0(0)	0(0)	0(0)	0(0)	0(0)
Proteus spp.	0(0)	0(0)	0(0)	0(0)	0(0)

Organisms	Hand Gloves (N = 60)				
			MMSH		AKTH
	Matern	Gynae	Main	Gynae	Main
Gram Positive					
CoNS	4(40)	2(20)	2(20)	1(10)	1(10)
Micrococcus	1(50)	1(50)	0(0)	0(0)	0(0)
S. aureus	3(37.5)	1(12.5)	2(25)	0(0)	2(25)
Bacillus spp.	3(60)	1(20)	0(0)	0(0)	1(20)
Streptococcus spp.	2(50)	0(0)	1(25)	0(0)	1(25)
Gram Negative					
P. aeruginosa	0(0)	0(0)	1(100)	0(0)	0(0)
E. coli	0(0)	0(0)	0(0)	0(0)	0(0)
Proteus spp.	0(0)	0(0)	0(0)	0(0)	0(0)

Table IV. Distribution of different isolates and frequency of recovery from formites after surgery in AKTH/ MMSH

Organisms	Face Masks (N = 30)				
			MMSH		AKTH
	Matern	Gynae	Main	Gynae	Main
Gram Positive					
CoNS	10(40)	3(12)	5(20)	3(12)	4(16)
Micrococcus spp.	3(30)	2(20)	3(30)	0(0)	2(20)
S. aureus	6(33.3)	4(22.2)	4(22.2)	0(0)	4(22.2)
Bacillus spp.	4(26.7)	2(13.3)	6(40.0)	1(6.7)	2(13.3)
Streptococcus spp.	2(20)	3(30)	2(20)	2(20)	1(10)
Gram Negative					
P. aeruginosa	0(0)	0(0)	2(40)	1(20)	2(40)
E. coli	0(0)	1(50)	0(0)	1(50)	0(0)
Proteus spp.	2(100)	0(0)	0(0)	0(0)	0(0)

Organisms	Gown (N = 30)				
			MMSH		AKTH
	Matern	Gynae	Main	Gynae	Main
Gram Positive					
CoNS	4(26.7)	1(6.7)	5(33.3)	2(13.3)	3(20)
Micrococcus spp.	2(40)	0(0)	0(0)	2(40)	1(20)
S. aureus	0(0)	1(33.3)	1(33.3)	0(0)	1(33.3)
Bacillus spp.	3(25)	0(0)	3(25)	2(16.7)	4(33.3)
Streptococcus spp.	2(25)	3(37.5)	1(12.5)	0(0)	2(25)
Gram Negative					
P. aeruginosa	0(0)	2(100)	0(0)	0(0)	0(0)
E. coli	0(0)	0(0)	2(100)	0(0)	0(0)
Proteus spp.	0(0)	2(100)	0(0)	0(0)	0(0)

Organisms	Hand Gloves (N = 60)				
			MMSH		AKTH
	Matern	Gynae	Main	Gynae	Main
Gram Positive					
CoNS	12(34.3)	5(14.3)	8(22.9)	4(11.4)	6(17.1)
Micrococcus spp.	1(20)	1(20)	2(40)	0(0)	1(20)
S. aureus	10(33.3)	4(13.3)	10(33.3)	2(6.7)	4(13.3)
Bacillus spp.	6(30)	4(20)	4(20)	2(10)	4(20)
Streptococcus spp.	2(20)	2(20)	3(30)	0(0)	3(30)
Gram Negative					
P. aeruginosa	0(0)	0(0)	2(100)	0(0)	0(0)
E. coli	1(100)	0(0)	0(0)	0(0)	0(0)
Proteus spp.	0(0)	0(0)	1(50)	0(0)	1(50)

Figure 1 presents a bar chart of mean bacterial count converted to cfu/m^3 against time of culture plate exposure before and during surgical procedure. The highest number of cfu/m^3 was observed at $2^1/_2$ hours during surgery while the lowest count was observed before surgery when human presence in the operating theatre was almost zero.

Figure 2 presents a bar chart indicating the level of bacterial count converted to cfu/m^3 in the air of the surgical wards. The count was higher for different exposure times in the evening when there was influx of visitors to see the patient than in the morning when only the staff was with patients and movements were reduced.

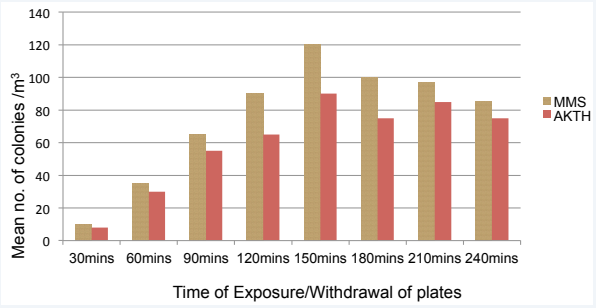

Figure 1. Distribution of Airborne contamination of the operating theatre of AKTH/MMSH

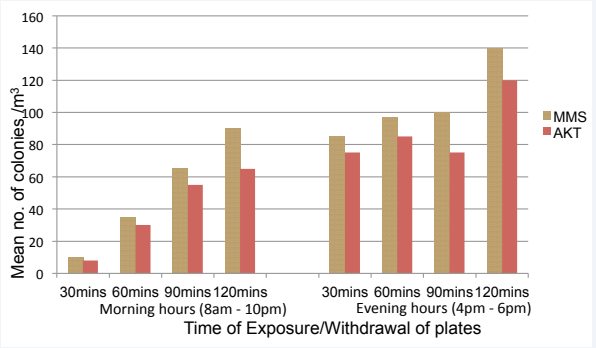

Figure 2. Airborne contamination in the surgical wards

All cultures made from the sterile protective personal equipment before surgery did not yield any significant bacterial and fungal growth, hence cultures were made from the same after surgery since it was expected they would be contaminated from the environment and personnel during surgery.

Discussion

In today's operating environment, more than half of surgical site infection pathogens originate from nosocomial skin flora of patients and staff.[9] Bacteria on skin squames, lint and other dusts get into the air in the operating theatre and by turbulent air currents deposit on surfaces. They are also spread by direct contact between carrier and wound, but the importance of airborne bacteria as a source of infection remains a subject of debate among professionals in infection control.[10]

The present study showed that the operating theatre and surgical wards including fomites are contaminated with microorganisms, some of which are established nosocomial pathogens. Fomites such as face masks, hand gloves and gowns used as protective wear by hospital staff especially in the operating theatre were found to be contaminated by microorganisms. *Pseudomonas aeruginosa* and *Staphylococcus aureus* were among the bacterial pathogens observed. These findings agree with earlier reports on this subject.[11,12,13] The presence of some species of fungi indicates that outside air enters the theatre. This was also observed by Njoku-Obi and Ojiegbe.[14] Transmission of bacteria which might occur within the healthcare environment has significant clinical implications for infection control practices within the operating room environment.[15] The findings that coagulase negative staphylococcus was most frequently isolated from both the operating room and surgical wards air was also reported by other workers.[12,15]

A linear relationship between air counts of bacteria in operating rooms and surgical site infection or wound contamination rate has been reported by many investigators.[16,17] Whyte *et al.*[16] suggested that settle plates showing bacterial surface contamination represents a more relevant indicator of the wound contamination rate than air counts.

Although there is no specific consensual standard for airborne microbial contamination within the operating room, the risk is perceived to increase as airborne microbial counts exceed 35 – 150cfu/m^3 of sampled air.[18] This observation compares favorably with the findings in the present study, especially as surgical procedures which lasted beyond two hours where mean bacteria colony counts exceeded 120cfu/m^3 had increased contamination and infection rate: AKTH 20.3%, MMSH 30.1%. The report of some researchers which showed a 28% infection rate also indicated that the level of air contamination of surgical wards influenced the rates of post operative wound sepsis, in agreement with the present study.[14]

Human activity and the number of persons influenced the air microbial count both in the operating theatre and in the surgical wards – the more the number of persons increased in these areas, the higher the microbial air count. Such human activity included walking, talking, sneezing, and even laughing. Skin squames shed by the theatre staff during surgery also contributed to the bacteria load of the air. Other researchers also made this observation at their centers.[19] In the present study, the surgical wards witnessed a higher bacterial count in the evenings than in the mornings because of the influx of visitors who came to see the patients in the evenings. This high bacterial count could put the lives of the immunocompromised patients at danger as they risk infection with nosocomial pathogens.

In this study, gown, hand gloves, and face shields worn by theatre staff were intended to protect the patient from contamination by endogenous sources in the theatre including the staff. However, these fomites were found to be contaminated by potential nosocomial pathogens before surgery. Other researchers have confirmed this finding in their report.[11]

Although there was no linkage between the bacterial isolates from the air and the other fomites in post operative wound sepsis in this study, several studies had shown a reduced number of infection when orthopedic surgery is performed in operating theatres with ultra clean air facilities.[20]

Murtala Mohammed Specialist Hospital is patronized by patients of low socioeconomic status due to free services. This creates high human traffic in most departments including surgery. As a result, aseptic conditions in most cases seem to be compromised. This could be the probable reason why higher values were obtained in MMSH than in AKTH in all areas of the study. AKTH is a teaching hospital and is patronized by mostly elites and referred cases where services are charged appropriate fees. From the observations made, we advocate that movement and number of persons in the operating theatre should be kept to a minimum during surgical procedures as well as influx of visitors to the surgical wards.

The controversy surrounding the wearing of facemasks in the operating theatre notwithstanding, it should be encouraged to protect the theatre staff from blood splashes and other exudates during surgery even if it does not protect the patient from cross infection. The increasing incidence of blood borne infections such as HIV and hepatitis B makes this protection inevitable.

It will be necessary to employ equipment that can guarantee ultraclean air in the operating theatre where open heart and brain surgery, and procedures such as total hip replacement surgery are carried out, as any infection could be potentially fatal; this may not be very necessary in other operating theatres. This has been reported to reduce airborne microbes and infection rates in orthopaedic implant surgery.[18]

The large area (volume of air) involved in evaluating ward air creates a seemingly lower bacteria count when compared with an enclosure if the same number of colonies are obtained. It is very possible for multiresistant microorganisms to gain entry into mild non extensive cuts and abrasions in the skin, and to cause more severe infection by settling on open wounds during dressing.

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