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Seasonal variation and risk factors associated with surgical site infection rate in Kano, Nigeria

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Background/aim: To evaluate the seasonal variations and risk factors associated with surgical site infection (SSI) rate in Kano.

Materials and methods: A total of 5800 patients admitted for surgery, drawn from Aminu Kano Teaching Hospital and Murtala Mohammed Specialist Hospital, underwent different types of surgical procedures between January 2010 and December 2011. Out of those patients, 1463 confirmed infected cases were screened for bacterial and fungal infection by standard microbiological procedures. Questionnaires were administered after informed consent to ascertain patients' lifestyles. Medical histories were obtained from their case files.

Results: Out of 5800 patients, 1463 were confirmed to be clinically infected, giving rise to a 25.2% incidence of SSI. *E. coli* (28.0%) and *S. aureus* (19.0%) were the most frequently isolated SSIs. Over the 2 years of study in the 2 hospitals, infection rates were highest in the month of March and lowest in August. Obesity, diabetes, anemia, number of personnel in the operating room, time of surgery, and position on operation list were all significantly associated with SSI.

Conclusion: Seasonal variation in SSI rates as observed in this study is a new dimension not reported before in Kano. Further research should be carried out to evaluate this observation critically.

Key words: Seasonal variation, risk factors, surgical site infection, Kano

1. Introduction

In spite of the technological advances that have been made in surgery and wound management, wound infection has been regarded as the most common nosocomial infection, especially in patients undergoing surgery (1). Exposure of subcutaneous tissue following a loss of skin integrity (i.e. a wound) provides a moist, warm, and nutritious environment that is conducive to microbial colonization and proliferation (2). As a patient's major defense against infection, when intact skin is breached by either trauma or surgical knife, a broad avenue opens to the introduction of virulent bacteria (3).

Surgical site infection (SSI) develops in 2% to 5% of patients undergoing surgical procedures every year in the United States, resulting in at least 500,000 infections, 3.7 million excess hospital days, and $1.6 billion in extra hospital charges. SSIs are the second most common type of nosocomial infection, accounting for 20% to 25% of the total (4); they have been studied in many hospitals worldwide (5,6).

When there is no other therapeutic option besides surgical intervention, nosocomial infections from surgical wounds constitute a problem. However, it is possible to reduce this problem to a minimal and acceptable level; such a reduction will consume fewer economic resources and be of immense benefit to the patient.

While efforts are being made in Western countries through various types of surveillance systems, including regularly assessing existing definitions, to curb this problem, deaths arising from sepsis due to postoperative wound infections are still being reported in developing countries with embarrassing frequency.

The present study focuses on the variation and risk factors associated with increased SSI rates in Kano State, Nigeria.

2. Materials and methods

This study took place in the 2 major hospitals in the Kano metropolis area, Murtala Mohammed Specialist Hospital (MMSH) and Aminu Kano Teaching Hospital (AKTH).

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Both serve as referral centers for the neighboring states of Katsina, Jigawa, Bauchi, Gombe, and Zamfara.

A total of 5800 patients admitted for surgery at MMSH and AKTH between January 2010 and June 2011 were enrolled in this study. While 2920 patients were drawn from MMSH, the other 2880 patients were drawn from AKTH. Questionnaires/personal data forms were administered to the patients to obtain information regarding their lifestyles and other peculiarities that may influence surgical wound infection rate, after informed consent was obtained. Their medical history and other necessary information, such as initial diagnosis and duration of surgery, were obtained from the patient's case file in the ward. The questionnaire was validated by other researchers prior to the study.

The site of surgery was examined after about 5 days. After cleaning the surrounding skin with cotton wool soaked with 70% ethyl alcohol, any wound that was considered clinically infected by the attending physician was swabbed with a cotton wool swab stick by the physician, nurse, or researcher, as well as any discharged pus. This included all surgical wounds that discharged pus within and up to 30 days after surgery.

The swab sticks were inoculated onto blood, MacConkey, and mannitol salt agar for aerobic bacteria and incubated for 18–24 h, while another swab stick from the same patient was inoculated onto neomycin sulfate blood agar (NBA) and cooked meat medium for anaerobic bacteria. Culture plates for aerobic bacteria were incubated at 37 °C for 24 h, while cultures for anaerobic bacteria were put into an anaerobic jar (Oxoid polycarbonate anaerobic jar used with a gas generating kit, Oxoid Ltd., UK). A gas generating kit (BROO38B Oxoid) was cut open at the edge and 10 mL of distilled water was introduced into the kit, as directed by the manufacturers, and incubated for 48–72 h at 37 °C. The cooked meat medium was subcultured if the original culture on NBA yielded no growth after 72 h. All were incubated at 37 °C.

While culture plates for aerobic organisms were examined after 18–24 h of incubation at 37 °C, the plates for anaerobic incubation were examined after 48–72 h of incubation. Aerobic isolates in the study were identified by Gram staining, cultural characteristics, and biochemical tests according to the methods of Cheesebrough (7).

In the examination of the operating room and ward air, the Settle plate technique was used as described by Cruickshank et al. (8).

2.1. Statistical analysis

Chi-square analysis and Fisher exact tests were carried out using EPI Info version 6 and SPSS 17. Simple percentages were used to describe the infection rates in the study.

3. Results

Table 1 shows the number of surgical patients enrolled in the study in the 2 hospitals and the number of infected patients. There was a statistically significant difference observed ($\chi^2 = 73.2$, df = 1, $P < 0.001$) between the infected and noninfected patients.

Table 2 shows the different types of surgery and infection rate at AKTH during the period of study.

The following surgical procedures had lower infection rates when compared with abdominal surgery and debridement: elective cesarean section, herniorrhaphy, excisional biopsy, and thyroidectomy. However, these surgical procedures all entail clean wounds. There was a significant difference observed in infection rates between emergency and elective cesarean surgery ($\chi^2 = 11.6$, df = 1, $P < 0.001$).

Table 3 shows the different types of surgery and infection rates at MMSH and also the infection rate in clean wounds as observed in AKTH. The difference between elective and emergency cesarean sections was significant ($\chi^2 = 23.8$, df = 1, $P < 0.001$).

Table 4 shows the monthly infection risk factors in surgical site infection at AKTH and MMSH.

It was observed that obesity, duration of surgery, position on operation list, diabetes, anemia, and number of personnel in the operating room were all significantly associated with an increase in SSI rate.

Table 5 shows the prevalence of different types of bacteria and fungi obtained in the study and Gram staining reaction. The most frequently isolated aerobic bacteria were *E. coli* (24.3%) followed by *S. aureus* (19.0%);

Table 1. Comparison of infection rates between Murtala Mohammed Specialist Hospital (MMSH) and Aminu Kano Teaching Hospital (AKTH).

	No. of patients infected	No. of patients not infected	Total
AKTH	585	2295	2880
MMSH	878	2042	2920
Total	1463	4337	5800

$\chi^2 = 73.2$, df = 1, $P < 0.0001$.

Table 2. Types of surgeries and infection rates in surgical patients in Murtala Mohammed Specialist Hospital (MMSH).

Types of surgery	Number of surgeries	Number of infections	Infection rate (%)
Emergency c/s	971	317	32.6
Elective c/s	232	38	16.4
Mastectomy	23	2	8.7
Cystectomy	17	7	41.2
Colostomy	2	1	50
Appendectomy	172	47	27.3
Herniorrhaphy	271	22	8.1
Urethrotomy	86	22	25.6
Fistulectomy	14	6	42.9
Prostatectomy	82	19	23.2
Abdominal surgery	681	277	40.7
Excisional biopsy	98	9	9.2
Urethroplasty	80	20	25.0
Debridement	42	33	78.6
Deep laceration	27	11	40.7
Hydrocelectomy	33	8	24.2
Cystostomy	59	17	28.8
Cholecystectomy	8	1	12.5
Thyroidectomy	22	3	9.1
Total	2920	860	29.4

$\chi^2 = 209.3$, df = 18, $P < 0.0001$. c/s = cesarean section.

Table 3. Types of surgeries and infection rates in surgical patients in Aminu Kano Teaching Hospital (AKTH).

Type of surgery	No. of patients	No. of infections	Percentage infected
Emergency c/s	310	56	18.1
Elective c/s	300	26	8.7
Prostatectomy	86	19	22.1
Hydrocelectomy	46	8	17.4
Mastectomy	28	3	10.7
Abdominal surgery	1353	268	19.8
Cystectomy	140	29	14.2
Excisional biopsy	168	11	6.5
Thyroidectomy	53	4	7.5
Fistulectomy	90	33	36.6
Debridement	100	76	76.0
Urethrotomy	185	45	24.3
Cholecystectomy	21	7	33.3
Total	2880	585	20.3

$\chi^2 = 263.8$, df = 12, $P < 0.0001$. c/s = cesarean section.

Table 4. Risk factors associated with surgical wound infections at Aminu Kano Teaching Hospital (AKTH) and Murtala Mohammed Specialist Hospital (MMSH) (clean wounds).

Factors	AKTH				MMSH			
	No. in study	No. infect.	Infect. rate	P-values	No. in study	No. infect.	Infect. rate	P-values
A. Obesity								
i. Obese	30	10	33.3	Fisher exact P < 0.0001 (significant)	40	15	37.5	Fisher exact P < 0.0001 (significant)
ii. Nonobese	625	47	7.5		521	53	10.2	
B. Duration of surgery								
i. >2 h	220	40	18.1	$\chi^2 = 4.7$, df = 1 P < 0.0001 (significant)	160	30	18.7	$\chi^2 = 9.2$, df =1 P < 0.05 (significant)
ii. <2 h	435	17	3.9		401	38	9.4	
C. No. on operation list (1–6)								
i. First on the list	260	15	5.8	Fisher exact P < 0.05 (significant)	290	25	8.6	$\chi^2 = 6.9$, df = 1 P < 0.05 (significant)
ii. Last on the list	395	42	10.6		271	43	15.8	
D. Diabetes								
i. Diabetic	25	8	32.0	Fisher exact P < 0.05 (significant)	30	12	40	Fisher exact P < 0.0001 (significant)
ii. Nondiabetic	630	67	7.8		531	56	10.5	
E. Anemia								
i. Anemic	40	12	30	Fisher exact P < 0.0001 (significant)	60	15	25.0	$\chi^2 = 10.5$, df =1 P < 0.05 (significant)
ii. Nonanemic	615	45	7.3		501	53	10.5	
F. Age (years)								
i. >60	108	38	38.7	$\chi^2 = 68.4$, df = 1 P < 0.0001 (significant)	90	15	16.0	$\chi^2 = 2.1$, df =1 P = 0.15 (not significant)
ii. <60	547	39	6.7		471	53	11.3	
G. No. of personnel in operating room								
i. >6 persons	240	110	4.2	$\chi^2 = 99.4$, df = 1 P < 0.0001 (significant)	301	42	13.9	$\chi^2 = 4.6$, df = 1 P < 0.05 (significant)
ii. <6 persons	415	47	11.3		206	16	6.2	
H. Smoking								
i. Cigarette smokers	25	2	8	Fisher exact P = 0.63 (not significant)	30	4	13.3	Fisher exact P = 0.77 (not significant)
ii. Nonsmokers	630	55	8.7		531	64	12.1	

for the anaerobes, the most frequently isolated bacteria were anaerobic streptococci (2.3%) and *Bacteroides fragilis* (1.5%).

Figure 1 shows the monthly infection rates among the different types of surgical procedures performed at MMSH during the study in 2010 and 2011. Infection rates were highest in March and April, respectively, but lowest in August in both years.

Figure 2 shows the monthly infection rates in the study at AKTH in 2010 and 2011. Infection rates were highest in March for both years but lowest in July and August, respectively.

Mean bacterial counts of 205 cfu/m^3 were observed in the months of March and April, whereas July and August had counts as low as 40–50 cfu/m^3.

4. Discussion

The overall infection rate of 25.2% observed in this study is lower than the report of 41% in Lagos, Nigeria (9), although that report was mainly on acute abdominal surgeries; lower than 31.25% as published by other researchers (10); and lower than 30.7% as reported in a teaching hospital in Goa (11). The overall infection rate in the present study compares favorably with a report from other researchers

Table 5. Prevalence of different bacteria/fungi obtained in the study and their Gram stain reactions.

Bacterial isolates	No. of isolates		Total	Rate (%)
	AKTH	MMSH		
Gram-positive *Staphylococcus aureus*	97	193	290	19.0
E. feacalis	30	36	66	4.3
Streptococcus spp.	22	33	55	3.6
CoNS	15	23	38	2.4
Peptostreptococcus spp.	2	18	20	1.3
Peptococcus spp.	3	13	16	1.0
Clostridium spp.	-	2	2	0.13
Gram-negative *Escherichia coli*	128	242	370	24.3
Proteus mirabilis	60	128	188	12.3
Proteus vulgaris	58	50	108	7.0
Pseudomonas aeruginosa	75	75	150	9.8
Citrobacter freundii	30	17	47	3.1
Klebsiella pneumoniae	50	48	98	6.6
Candida albicans	-	11	11	0.6
Bacteroides fragilis	9	18	27	1.5
Fusobacterium spp.	-	8	8	0.26
Serratia marcescens	-	2	2	0.13
Enterobacter spp.	-	4	4	0.19
Morganella morganii	-	3	3	0.19
Providencia rettgeri	6	1	7	0.45
Providencia stuartii	-	1	1	0.001
Acinetobacter calcoaceticus	-	1	1	0.001
Pantoea agglomerans	-	3	3	0.19
Serratia liquefaciens	-	3	3	0.19
Salmonella arizonae	-	1	1	0.001
Salmonella choleraesuis	-	3	3	0.2
Klebsiella ozaenae	-	2	2	0.13
Acinetobacter spp.	2	-	2	0.13
Total	585	939	1524	

CoNS: coagulase negative staphylococci.

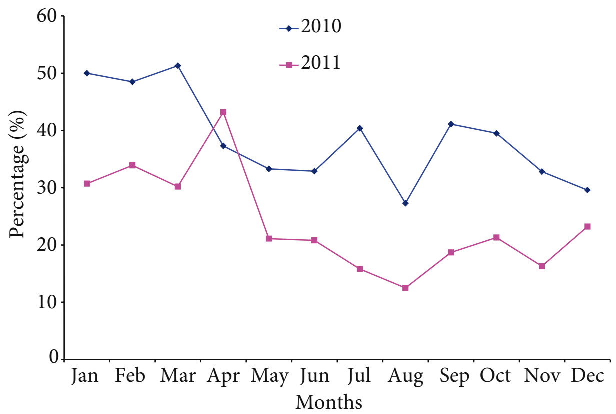

Figure 1. Monthly surgical site infection rates in patients at MMSH for 2010 and 2011.

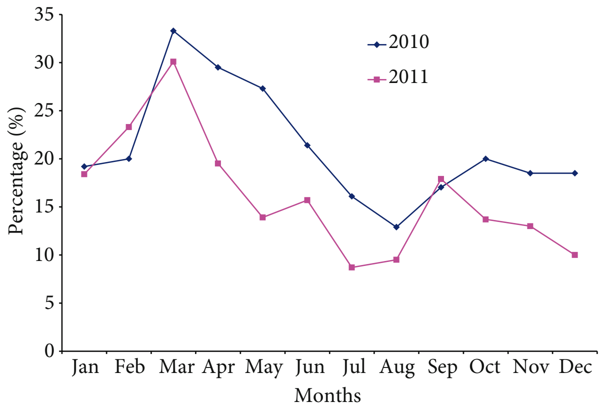

Figure 2. Monthly surgical site infection rates in patients at AKTH for 2010 and 2011.

(12) whose overall infection rate was 22.7% and another report from the University of Nigeria Teaching Hospital, Enugu (13), with an infection rate of 27.98%. However, other researchers (14–18) reported lower overall infection rates at their various centers overseas. A lower infection rate was also reported in Nigeria (19).

The mean bacterial/fungal counts of air contamination as observed in the wards and operating room were higher in the months of March and April, which coincided with the period of dusty harmattan wind. A high concentration of whitish dust particles in the atmosphere settles on surfaces, only to return immediately after cleaning. This could have created a situation where dust-laden bacterial and fungal particles suspended in the air and equally resuspended from the operating room or ward floors would have easy access to surgical wounds. This observation has never been reported in our area before. Strong evidence suggesting airborne microorganisms as the most likely source of surgical wound infection in this study was observed. This agrees with the findings and conclusions from 2 other reports (10,20).

In a report from Calabar, Nigeria (19), variations in infection rate were observed, with the highest infection rate in the months of May and August and the lowest infection rate in the month of November during the 1983–1984 study period. The studies were carried out at 2 states in the extreme south and north of Nigeria, with a very wide margin in climatic and weather conditions. Another study (21) also reported a seasonal variation in postsurgical morbidity and mortality, probably related to the cyclic influx of inexperienced trainees and vacation schedules. A significant monthly variation in the nosocomial infection rate was observed during an epidemiological study in a teaching hospital in Lagos, Nigeria (22). Some researchers (23) studied the influence of hair removal methods on wound infection and found a statistically significant difference between the use of the clipper and razor. They strongly discouraged the use of razors and reported that the adverse effect of shaving on SSI rate was found to be greatest in summer. This observation could not be verified in this study because every surgical patient was shaved with a razor.

In the present study, emergency surgical intervention was seen to be associated with an increased infection rate. This agreed with a report from Italy at a multicenter study (17). Risk factors observed to be associated with increased risk of infection included obesity, diabetes, anemia, type and duration of surgery, position on the operating list, and number of persons in the operating room. Two other reports (10,11) compare favorably with the above findings. Prolonged surgery of >2 h and a higher degree of wound contamination were reported as risk factors at a university hospital in Thailand (14), which agrees with the report in the present study.

In this report, *E. coli* was the most common species, accounting for 24.2% of all aerobic isolates. This was closely followed by *Staphylococcus aureus* (19.0%). These findings were in contrast with the reports of other researchers (24–26), who all had *S. aureus* as the most frequently isolated organism in their reports. However, it compares favorably with reports from other workers (27–29).

Seasonal variation in SSI rates as observed in this study is a new dimension not reported before from Kano. Further research should be carried out to evaluate this observation critically.

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