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Original Article

Direct Cost Implications of Managing Surgical Site Infections in Low-Income Rural Settings-Irrua, Nigeria

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BACKGROUND: Surgical site infections (SSIs) represent one of the most common nosocomial infections. They cause increased morbidity and devastating economic impact due to the cost of care on patients, and it involves the loss of billions of dollars globally. The exact direct cost of managing SSIs in our resource-constrained settings has been elusive, and there is a lack of data on this subject.

OBJECTIVE: Our objective was to determine the direct cost of managing SSIs in a rural neurosurgical setting in Nigeria.

PATIENTS AND METHODS: We conducted a 12-month prospective hospital-based randomized case-control study of patients who had clean cranial and spine surgeries excluding implant surgeries. The experimental group had intrawound vancomycin powder before wound closure, and the control group received no intrawound vancomycin. Patients with evidence of SSIs were determined using clinical, and laboratory evidence of SSIs. SSIs' direct cost implication was calculated. This was quantified in local currency (Naira and Kobo) and standardised to the United States dollars to allow for international comparison.

RESULTS: Forty–two patients were enrolled in this study. 76 % of these patients were males, and the prevalence of SSIs in the control group was 33.3% with a p-value less than 0.05, while none were seen in the experimental group. Staphylococcus aureus was the most common isolated organism, and the average cost of managing SSIs was N496, 812.50±234, 317.85(US$1,104.03 ± US$520. 71).

CONCLUSION: This study showed that the financial implications of managing SSIs are huge, and far exceeded the yearly income of average Nigerians.

KEYWORDS: Cost, Low-income, Neurosurgery; Surgical site infections, Topical vancomycin.

INTRODUCTION

Infections-related to neurosurgical procedures are on the rise globally, and more so in our environment despite progress made on asepsis and antibiotics.[1] SSIs cause significant psychological, and medical liabilities to patients, resulting in a prolonged stay in the hospital, and this may be potentially fatal due to diverse complications.[2] Management of surgical site infections is expensive for patients and the government.

Surgical site infection is on the rise with billions of public funds spent on SSIs, with the United States spending as much as sixteen billion dollars annually,[3] yet the morbidity and mortality are grievous with the demand of increasing need for more health care manpower, which is somewhat lacking in Sub-Saharan African as in the case of Nigeria and may have a huge impact on the psychosocial, and overall well being of the patients, caregivers, and health institutions.

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Historically, topical (Intrawound) vancomycin has found a useful place in neurosurgical (Cranial and spinal) procedures, until it was abandoned due to varied results.[1,4,5] Despite the re-introduction of topical vancomycin in neurological surgeries with attendant reduction in SSIs, there is a paucity of data on the direct cost implications in our environment. Vancomycin is relatively cheaper and readily affordable, and the cost is relatively not a limitation considering the huge financial burden of neurosurgical procedures and SSIs. A vial of 1 gram of vancomycin hydrochloride costs between $2 and $12 (A thousand naira – six thousand naira).[6,7] A study by Emohare et al. gave insights into the huge cost of SSIs with those groups of patients having deep SSIs post-spinal surgeries spending as much as half a billion dollars.[7] Godil et al. in a separate research showed a 13% drop in SSIs following use of vancomycin powder. About $33,705 was estimated to treat one patient who had SSI following spinal fusion. These studies above suggest the huge financial advantage of topical vancomycin powder usage.[8–11]

The direct costs of SSIs include outpatient and emergency consultations, repeated admission, prolonged hospital stay, repeated surgeries, repeated prolonged wound dressings, cost of laboratory and radiological investigations, long-term antibiotic treatment, follow-up visits, and other service charges. The indirect cost of SSIs is difficult to measure, and includes loss of functional and mental capacity, loss of productive hours of the patient and family, absence of hospital bed space, and the need for more manpower to cater to patients. The cost of SSIs has been observed to differ with the type of SSIs, and it is cheaper for those with superficial SSIs. The estimated cost of managing SSI differs widely, from less than 400 dollars per case for superficial SSI to more than 30,000 dollars per case for serious organ or space infections.[12]

A one-year multicentre study was done involving 54,233 patients who underwent surgery in 129 hospitals, The study showed that 3% developed SSIs (superficial in 74%, deep in 26%).[13] Factors that were identified to be directly linked to surgical site infections were chronic alcohol use, diabetes mellitus, chronic obstructive pulmonary disease, congestive heart failure, and emergency surgeries. The risk-adjusted costs were 1.43 times higher for those who developed SSIs (1.25 and 1.93 times higher for patients with superficial and deep SSIs, respectively) compared to those without an SSI. The estimated increase in costs was noted to be $11,876 for SSIs overall ($7,003 for superficial and $25,721 for deep infections).[14]

PATIENTS AND METHODS

The study was a prospective hospital-based, randomized, case-controlled double-blinded study at Irrua Specialist Teaching Hospital spanning March 2021 to February 2022, involving patients 18 years and above who had clean cranial and spinal surgeries. A written consent to participate in this study was obtained from the patients or relatives.

Exclusion criteria were patients with chronic medical conditions that predispose to infection such as chronic kidney failure, uncontrolled diabetes, malnutrition, patients on cytotoxic chemotherapy, vancomycin allergy which may manifest as rashes, erythema, and dizziness, pre-existing infections at or adjacent to anticipated surgical wound, and infective neurosurgical pathologies such as brain abscess, subdural empyema, and ventricular empyema, patients with cranial or spine implants, and patients undergoing day case neurosurgical procedures.

The sample size was calculated from the formula for randomized controlled trial (RCT), parallel two tail, non-inferiority test significant level of 5%, and power of 80% with an additional attrition rate of 10% accounted for. The sample size was approximated to 21 which was the minimum sample size for group A and group B, and the total number was at least 42.

The research strategies involved the use of patients' proforma, and interviews, and were the major research tools used in investigating the research questions.

The ethical approval was obtained from the Health Research and Ethics Committee of the Irrua Specialist Teaching Hospital with approval number NHREC/29/03/2017.

Eligible patients were recruited through the Accident and Emergency unit, and the outpatient neurosurgical clinic at Irrua Specialist Teaching Hospital. The patients were randomized into two groups, A (experimental) and B (control). All enlisted patients had their socio-demographic data, and history of known risk factors documented, and baseline blood tests were done. Specific investigations such as computed tomography (CT) or magnetic resonance imaging (MRI) scans for either spine or cranial pathologies were done. All patients who were operated on had standard anesthesia, prophylactic antibiotics, and povidone-iodine-based cleansing.

Group A patients (experimental group) had 1 gram of topical vancomycin application before wound closure (same product from Ciron drugs) **(Fig. 1)**, while patients in the control group (group B) had no topical vancomycin applied into the wound before closures.

Fig 1: Intra-operative topical application of Vancomycin powder into the muscle, fascial space, and subcutaneous tissue before wound closure in a group A (study group) patient who had lumbar spine decompression.

No wound drain was used for patients studied in both groups. Standard neurosurgical unit protocol at ISTH was adhered to during this study. Wounds in both groups A and B were closed in two layers with the same specific suture materials and technique. The wound was inspected and dressed on the 5th and 10th postoperative day with povidone-iodine.

During monitoring, SSIs were identified with wound site swelling, pain or tenderness, purulent discharge from superficial wounds, or isolated micro-organism(s) cultured from fluid or tissue biopsied from the superficial wounds **(Fig. 2)**. The deep surgical site infections were identified by the presence of pus or abscess from a deep cavity, dehisced deep wound or patients having systemic symptoms such as fever, while organ/space surgical site infections were identified either using radiological investigations such as MRI scan to identify pathology such as brain abscess in cranial surgeries, and epidural abscess following spine surgeries; or are seen during re-operation.

Fig 2: Superficial surgical site infection in a patient who had lumbar spine decompression.

Three wound dressings were observed to have been soaked with blood in the control group, a wound swab was obtained for microbial studies, and the wound dressing was changed, despite the initial scheduled period of wound dressing. Two patients in group B developed Cerbro spinal fistula (CSF) fistula which was managed with the aid of an inserted lumbar drain. No death was recorded among those with SSIs.

At discharge, all patients received a follow-up appointment date for wound checks within the 30-day post-operative time. Defaulting patients were followed up via phone calls and Zoom meetings. Patients with SSIs noticed following discharge were readmitted and reviewed.

Samples were transported promptly to the laboratory using Amies transport media and were processed, and cultured immediately by a dedicated medical microbiologist in the reference laboratory.

Bacteria culturing for colony characteristics followed by Gram staining, and biochemical tests were used to identify offending bacteria. Culture media that were used include the MacConkey agar, blood agar, nutrient agar, and fresh blood agar.[15] The management of different surgical site infections followed standard procedures.

The direct cost implication of SSIs was calculated by adding up several variables such as the cost of repeated admission, laboratory tests (full blood count, microscopy, culture and sensitivity, serum proteins, and other ancillary investigations), radiological investigations (CT and MRI), repeated wound dressings, antibiotics, repeated surgeries, utility charges (syringes, cannula, fluid giving set, gloves, antiseptics, bed fee, cost of feeding), and other service charges. This value was quantified in local currency (Naira and Kobo) and standardized to the United States Dollars to allow for international comparison.

Data obtained from the proforma were analyzed using the statistical package for social sciences (SPSS) version 23 software. The level of significance was set at $p < 0.05$. Descriptive statistics were analyzed using measures of central tendency and disparity, and statistical significance was assessed with a Chi-square test for categorical variables, and multivariate logical regression test for skewed distributed continuous data, and an independent student t-test for normally distributed measurement variables.

Microbiology culture was evaluated. The mean length of stay (LOS), body mass index (BMI), and other risk factors identified were compared with the post-operative colonization of the wound using the student t-test. The mean direct cost of SSIs was determined.

RESULTS

A total of forty-two (42) patients (twenty-one each into group A and group B) who met the inclusion criteria were recruited into this study with a follow-up period of 30 days. The socio-demographic characteristics of patients studied are shown in **(Table 1, Figs. 3-5)**. The age range of the patients was between 20 to 80 years. Thirty-two were males and ten females with a male-to-female ratio of 3:1 as seen in **Table 1**. The mean age of group A was 48.05 ± 17.03, with age group 41-50 years being the most populated, while group B had a mean age of 45.95±19.14, with age group 20-30 being the most populated. 66.7% of group A individuals were males and made up 85.7% of group B's.

The mean BMI of groups A and B were 23.92±5.21, and 23.21±3.99 respectively. The major site of surgery in both groups was cranial, with 57.1% in group A and 95.2% in group B **(Table 2).**

Estimated blood loss in group A was 519.05±107.87ml, and 310.24±90.17ml in group B with 28.6% of the experimental group requiring intra-operative blood transfusion and 23.8% of the control group **(Table 3).** The overall incidence of SSIs in the groups was 33.3% with none in the study group and 33.3% in the control group as seen in **(Table 4).**

Comparing the relationship between various patients and clinical parameters, the incidence of surgical site infection was not statistically significant (P>0.05) **(Table 5).** The multivariate logistic regression model to determine predictors of SSI was of good fitting but of no statistical significance (P>0.05) as seen in **(Table 6)**.

Following a cross tabulation, and chi-square analysis, topical vancomycin was shown to significantly prevent surgical site infection in neurological (cranial and spine) surgeries in the study population (FET=0.009) **(Table 7)** with no observed adverse effects.

Surgical site infection was not observed in group A and was observed in 33.3% of group B individuals. Klebsiella pneumonia (14.3%), pseudomonas aeruginosa (14.3%), and Staphylococcus aureus (28.6%) were cultured in group B individuals **(Table 8).**

Furthermore, the antibiotic sensitivity pattern for the group B individuals was Amikacin (28.6%), Ceftriaxone (14.3%), and Levofloxacin (28.6%). Cerebrospinal fluid (CSF) leak was not observed in group A individuals, while 9.5% of group B individuals developed CSF fistula. 95.2% and 81.0% of individuals in groups A and B respectively stayed in the hospital for less than a month **(Table 8).**

The mean direct cost implication of managing SSIs in the study population was N496,812.50 ± 23,4317.85 ((US$1,104.03 ± US$520. 71) which was completely due to the cases identified in group B with none observed in the experimental group **(Table 9).**

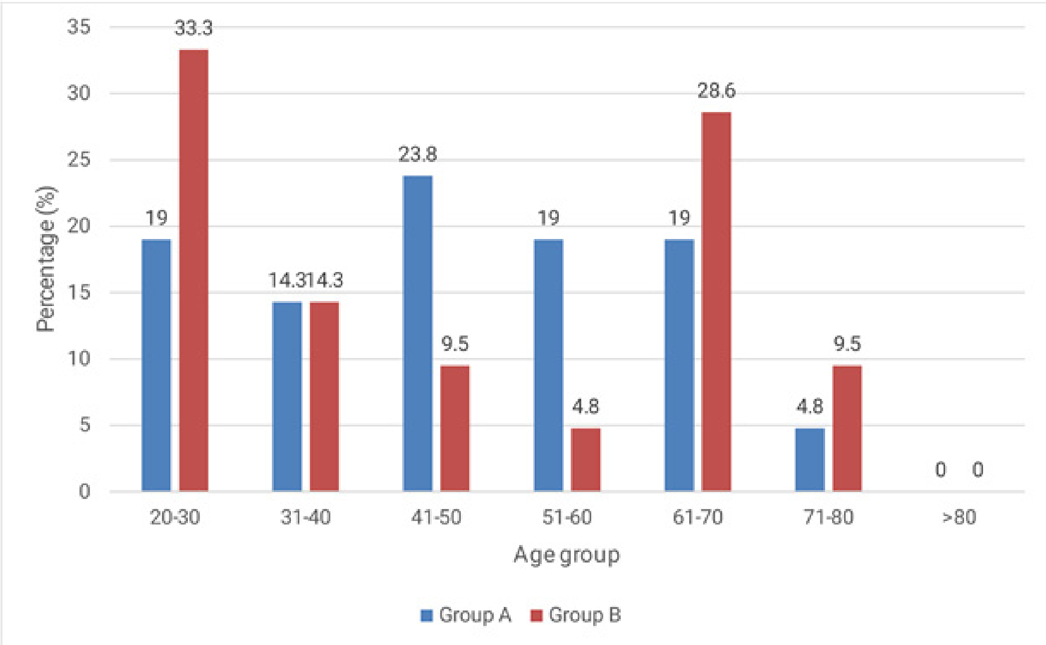
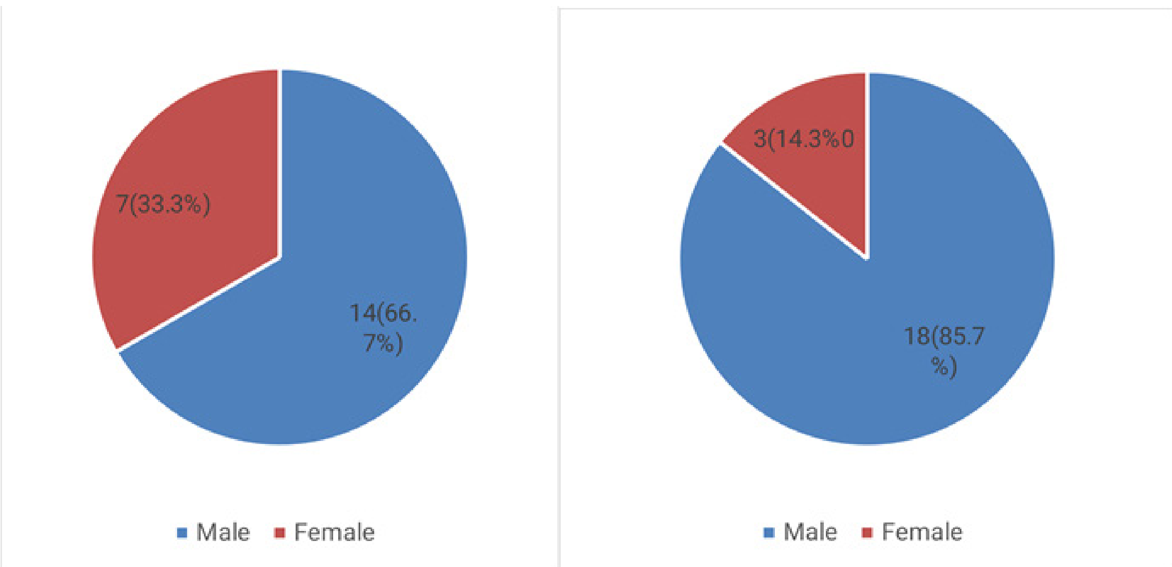


Fig 3: Bar chart showing age distribution in groups A and B.



GROUP A **GROUP B**

Fig 4: Pie chart showing gender distribution in groups A and B.

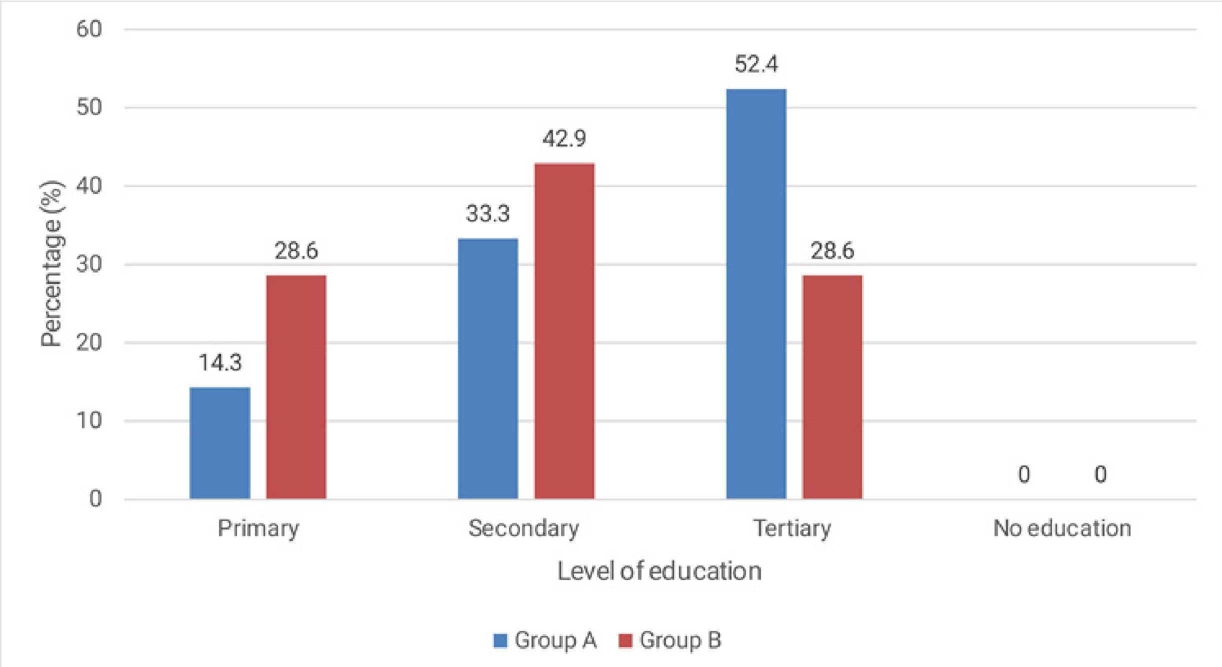


Fig 5: Bar chart showing the highest level of education in groups A and B.

Table 1: Patient characteristics and socio-demography

VARIABLE		GROUP A N=21 (%)	GROUP B N=21 (%)
Age	20-30	4 (19.0)	7 (33.3)
	31-40	3 (14.3)	3 (14.3)
	41-50	5 (23.8)	2 (9.5)
	51-60	4 (19.0)	1 (4.8)
	61-70	4 (19.0)	6 (28.6)
	71-80	1 (4.8)	2 (9.5)
	>80	0 (0.0)	0 (0.0)
Mean age		48.05±17.03	45.95±19.14
Sex	Male	14 (66.7)	18 (85.7)
	Female	7 (33.3)	3 (14.3)
Occupation	Skilled	17 (81.0)	14 (66.7)
	Unskilled	4 (19.0)	7 (33.3)
Level of education	Primary	3 (14.3)	6 (28.6)
	Secondary	7 (33.3)	9 (42.9)
	Tertiary	11 (52.4)	6 (28.6)
	No education	0 (0.0)	0 (0.0)
Tribe	Calabar	1 (4.8)	1 (4.8)
	Edo	1 (4.8)	0 (0.0)
	Esan	5 (23.8)	5 (23.8)
	Etsako	2 (9.5)	3 (14.3)
	Fulani	1 (4.8)	0 (0.0)
	Igarra	0 (0.0)	1 (4.8)
	Igbo	3 (14.3)	5 (23.8)
	Ika	0 (0.0)	1 (4.8)
	Owan	0 (0.0)	1 (4.8)
	Urhobo	1 (4.8)	0 (0.0)
	Yoruba	7 (33.3)	4 (19.0)

Table 2: Pre-operative clinical presentation/risk factors

Variable		Group A N=21 (%)	Group B N=21 (%)
1. Symptoms	Headache	12 (57.1)	17 (81.0)
	Seizure	6 (28.6)	11 (52.4)
	Vomiting	1 (4.8)	5 (23.8)
	Fever	0 (0.0)	5 (23.8)
2. Level of consciousness (GCS)	Mild (13-15)	18 (85.7)	13 (61.9)
	Moderate (9-12)	2 (9.5)	4 (19.0)
	Severe (3-8)	1 (4.8)	4 (19.0)
3. Presence of co-morbidities	Yes	9 (42.9)	8 (38.1)
	No	12 (57.1)	13 (61.9)
4. ASA Score		GRADE 1-13 (61.9)	GRADE 1-9(42.9)
		GRADE 2-8(38.1)	GRADE 2-12(57.1)
5. Immunosuppressive drugs	Yes	4 (19.0)	0 (0.0)
	No	17 (81.0)	21 (100.0)
6. Smoking	Yes	2 (9.5)	3 (14.3)
	No	19 (90.5)	18 (85.7)
7. Body mass index - BMI (mean)		23.92±5.21	23.21±3.99
8. Site of surgery	Cranial	12 (57.1)	20 (95.2)
	Spine	9 (42.9)	1 (4.8)
9. Name of prophylactic intravenous antibiotics	Levofloxacin	1 (4.8)	0 (0.0)
	Ceftriaxone	20 (95.2)	21 (100.0)

Table 3: Intra-operative clinical parameters/variables

Variable		GROUP A N=21 (%)	GROUP B N=21 (%)
Vancomycin powder use	Yes	21 (100.0)	0 (0.0)
	No	0 (0.0)	21 (100.0)
Any side effects of topical Vancomycin?	Yes	0 (0.0)	Nil
	No	21 (100.0)	Nil
Intra-operative blood transfusion	Yes	6 (28.6)	5 (23.8)
	No	15 (71.4)	16 (76.2)
Estimated blood loss in ml (Mean)		519.05±107.87	310.24±90.17

Table 4: Incidence of surgical site infection in the groups

	Group A=21 (%)	Group B=21 (%)
Incidence of SSI among the groups	0 (0.0)	7 (33.3)
The overall incidence of SSI	7 (33.3)	

Table 5: Relationship between various patient clinical parameters and incidence of Surgical Site Infection (SSI)

Parameters	SSI Present Frequency n (%)	SSI Absent Frequency n (%)	x^2	p-value
Gender				
Male	5 (71.4)	27 (77.1)	0.105	0.746
Female	2 (28.6)	8 (22.9)		
Age Categories				
20-30	3 (42.9)	8 (22.9)	9.011	0.109
31-40	0 (0.0)	6 (17.1)		
41-50	0 (0.0)	7 (20.0)		
51-60	0 (0.0)	5 (14.3)		
61-70	4 (57.1)	6 (17.1)		
71-80	0 (0.0)	3 (8.6)		
>80	0 (0.0)	0 (0.0)		
Co-morbid conditions				
Smoking				
Yes	0 (0.0)	5 (14.3)	1.135	0.287
No	7 (100.0)	30 (85.7)		
Obesity				
Yes	1 (14.3)	4 (11.4)	0.045	0.831
No	6 (85.7)	31 (88.6)		
Comorbidities (HTN, DM)				
Yes	4 (57.1)	13 (37.1)	0.968	0.325
No	3 (42.9)	22 (62.9)		
Site of surgery				
Cranial	7 (100.0)	25 (71.4)	2.625	0.105
Spine	0 (0.0)	10 (28.6)		
Use of immunosuppressives				
Yes	0 (0.0)	4 (11.4)	0.884	0.347
No	7 (100.0)	31 (88.6)		
Estimated blood loss				
<200ml	4 (57.1)	18 (51.4)	0.076	0.782
≥200ml	3 (42.9)	17 (48.6)		

Table 6: Multivariate logistic regression model to determine predictors of SSI

Parameters	Odds ratio (95% Confidence interval CI)	p-value
Age	1.062 (0.929-1.214)	0.380
Sex		
Male	8.316 (0.267-258.817)	0.227
Female		
Obese		
Yes	0.639 (0.395-1.034)	0.068
No		
Smoking		
Yes	0.000 (0.000-0.000)	0.999
No		
Use of immuno-suppresants		
Yes	0.000(0.000-0.000)	0.999
No		
Intraoperative blood loss		
<200ml	1.154 (0.068-19.505)	0.921
≥200ml		
Presence of comorbidities		
Yes	0.025 (0.000-3.425)	0.142
No		
Surgical site		
Cranial	0.000 (0.000-0.000)	0.998
Spine		

Table 7: Cross-Tabulation and Chi-Square analysis of topical Vancomycin application and presence of surgical site infection

	SURGICAL SITE INFECTION		
USE OF TOPICAL VANCOMYCIN	**Yes N (%)**	**No N (%)**	**Total**
Yes	0 (0.0)	21 (60.0)	21
No	7 (100.0)	14 (40.0)	21
Total	7	35	42

Level of significance: 0.05.

df=1; Fisher's Exact Test: 0.009.

Table 8: Postoperative outcome

Variable		Group A N=21 (%)	Group B N=21 (%)
1. **Surgical site infection**	Yes	0 (0.0)	7 (33.3)
	No	21 (100.0)	14 (66.7)
		N=0 (%)	**N=7 (%)**
2. **Wound dehiscence**	Yes	0 (0.0)	2 (28.6)
	No	0 (0.0)	5 (71.4)
		N=0 (%)	**N=7 (%)**
3. **Wound discharge**	Yes	0 (0.0)	4 (57.1)
	No	0 (0.0)	3 (42.9)
		N=0 (%)	**N=7 (%)**
4. **Skin changes around the wound**	Yes	0 (0.0)	6 (85.7)
	No	0 (0.0)	1 (14.3)
		N=0 (%)	**N=7 (%)**
5. **Organism cultured**	Klebsiella pneumonia	Nil	1 (14.3)
	Pseudomonas aeruginosa	Nil	1 (14.3)
	Staphylococcus aureus	Nil	2 (28.6)
		N=0 (%)	**N=7 (%)**
6. **Antibiotic pattern**	Amikacin	Nil	2 (28.6)
	Ceftriaxone	Nil	1 (14.3)
	Levofloxacin	Nil	2 (28.6)
		N=21 (%)	**N=21 (%)**
7. **The MCS results**	Pre-operative	Nil	s. aureus (57.1%), s. epidermidis (42.9%)
	Day 5	Nil	p. aeruginosa (14.3%), s. aureus (14.3%)
	Day 10	Nil	Nil
		N=21 (%)	**N=21 (%)**
8. **CSF fistula (leak)**	Yes	0 (0.0)	2 (9.5)
	No	21 (100.0)	19 (90.5)
		N=21 (%)	**N=21 (%)**
9. **Duration/length of hospital stay**	<1 month	20 (95.2)	17 (81.0)
	>1 month	1 (4.8)	4 (19.0)
10. **Cost of treatment of SSI (Mean)**		0±0.0	N496812.50±234317.85

Table 9: Direct cost implication of treatment of surgical site infections

Variable	Group A N=21 (%)	Group B N=21 (%)
Cost of treatment of SSI (Mean)	0±0.0	N496812.50 ± 234317.85

DISCUSSION

The cost implications of managing SSIs are on the rise, and this is worsening with the global economic meltdown. Determining the direct cost of managing SSIs is essential in proposing a way forward that could lead to improved health finances, and rigorously purpose policies and programs that could help to reduce SSIs.

In this study, a total of forty-two patients divided into two equal groups (A and B) were enrolled and followed up over 30 days. Most patients in group A were between 41 and 50 years of age, while in group B, the majority were 21-30 years of age, followed by those between 61-70 years of age **(Fig. 3)**. Fang et al.[15] noted that patients with ages above 60 years had a higher rate of SSIs. While Saeedinia et al,[16] in comparison to this study noted surgical site infection to be more common in those less than 20 or older than 50 years of age. The mean age of the patients in this study group A was 48.05 ±17.03, and that of group B was 45.95 ±19.14 of ages. In a similar study performed at the department of Neurosurgery, hospital of the University of Pennsylvania and published in the Journal of Neurosurgery, the number of patients was 150 with a mean age of 52.1 ± 16.6 years in the control group and 49.4 ± 15.6 in the treatment group.[17]

This research findings in comparison with earlier research findings showed slight variation with peak age of surgical site infections. Most of the study participants were males accounting for 14 (66.7%) in group A and 18 (85.7) in group B with male to female ratio of 3:1 as seen in **(Fig. 4).** Korinek et al.[18] noted in their study that the male sex is a non-modifiable risk factor and concluded with the findings in our research between male sex and its relationship to the occurrence of surgical site infections in this research. Seventeen (17) patients from this study had comorbid conditions ranging from hypertension, obesity, and diabetes mellitus **(Table 2).**

This study showed an incidence rate of surgical site infections of 33.3% as shown in **Table 7**. This incidence is significantly higher when compared with a study in the UK, which showed a 5% incidence rate.[19,20] Reports from studies on surgical site infections in neurosurgical patients who underwent cranial procedures were significantly lower compared to those from this study. These studies showed the rate of SSIs after craniotomy in each health institution ranges from 4% to 8.9% in the study spanning a period of 10 years,[19,21–24] However, Pakistani researchers, Sami-ur-Rehman, et al,[24] recorded a rate of 7.77% in their study on topical application of vancomycin in patients with cranial surgeries. Differences in this may be due to a clear-cut policy of surgical site infection and control in the United Kingdom in comparison to our settings, the seeming lack of institutional infection surveillance measures which appear to be a common denominator in developing nations like ours, and smaller sample size of this study compared to the UK study.[20]

The incidence rate of 33.3% in our study was alarming, as patients enrolled in this study and operated on clean surgical wounds with an expected infectivity rate of less than 5% as seen in the literature.[25,26] Studies by several authors identified numerous co-morbid and immunosuppressive conditions such as diabetes mellitus, human immunodeficiency virus (HIV), malignancy, and chronic kidney disease,[16,17,19,27–35] which often predisposed to surgical site infections. In this study, four patients represented 19.0% of the study participants and two and three patients smoked cigarettes in group A and group B respectively as shown in **Table 2**. Two patients in group B as shown in **Table 8** had CSF leak which could predispose to SSI, but the identified risk factors were insignificant. Some papers in the literature have identified cigarette smoking to be a non-modifiable risk factor in surgical site infections. Meng et al,[35] and Eren et al.,[36] have identified smoking cigarettes to be a risk factor in patients who had spine procedures. In the present study, there was no significant association between cigarette smoking and other risk factors with surgical site infections which might be that only few patients who smoked cigarettes (Five out of forty-two) that were enrolled in this study.

This study showed several risk factors as seen in **Tables 5 and 6** which could predispose to this alarming incidence rate of 33.3%, though with no mortality recorded as all patients were successfully managed. However, in this study, the Chi-square analysis and the multivariate logical regression model, as seen in **Tables 5 and 6** respectively showed a good fitting, but no significant association between the pre-, -intra-, -and post-operative risk factors with surgical site infections.

Factors accounting for this unusually high rate of surgical site infections in our study may vary and not solely due to the absence of topical vancomycin application in the control group (group B). This may be due to the smaller sample size of the patients enrolled in this study compared to those observed in the above literature, lack of clear-cut infection control policy for patient segregations in surgical ward pre- and postoperatively, non-specific dedicated theatre for cranial and spine procedures, unusual high theatre traffic, and ineffective implementation of theatre users' etiquette in the study center.

Surgical site infections come at a huge cost to everyone directly or indirectly involved. Millions of US dollars are spent during the management of SSIs. The findings from this research showed that the average cost of managing surgical site infections was N 496,812.50 ± 234, 317.85(US$1,104.03 ± US$520.71) as shown in **Table 9**. This was lower compared to studies by Emohare et al,[7] and Godil et.[8] which showed a higher cost implication. Emohare et al.[7] highlighted the huge cost implication and they estimated about US$500,000 for the management of deep spine SSIs. Godilet et al.[8] in their study showed the huge cost of over US$30,000 per patient with SSIs. Perencevich et al,[37] in their study showed that the cost of SSI was related to patients required outpatient visits, laboratory tests, radiology services, and re-admissions, and their findings showed an average total cost during the 8 weeks of monitoring after discharge was US$5,155 for patients with SSI and $1,773 for controls ($P < 0.001$). Kuhn et al.[38] revealed a US$12,600 extra cost for surgical site infection following posterior cervical surgeries and Yeramaneni et al.[39] showed costs ranging from US$15,800-US$38,700. However, findings from the work of these researchers agreed with our study as regards the huge cost burden of managing SSIs. This direct cost of managing surgical site infection is huge and far above the average monthly wages of individuals and families in Nigeria. Varrella,[40] in her research on the average income of the Nigerian population showed that N43,200 (US$111) and N137,600 (US$354) are average earnings by individuals and families respectively. The difference in cost from this study and other earlier studies above could be because of the smaller sample size of this study, more expensive tools to manage SSI in the developed world compared to the settings where this research was carried out, and different economic indices in these countries where the research was conducted.

CONCLUSION

In conclusion, the direct cost implications of managing SSIs in neurosurgical practices within our setting when compared to other studies elsewhere was alarming, and calls for further investigation. The direct cost implications of managing surgical site infections are huge and above the yearly income of most of our population.

Limitations of the study

The study was limited to aerobic media only, as this excluded the possibility of identifying anaerobic and fungi organisms, though the main organisms cultured are gram-positive aerobes as seen in most literature above. Only the direct cost implication of surgical site infections was calculated as the indirect cost of surgical site infections is unquantifiable in real financial terms.

List of Abbreviations

BMI: Basal metabolic index.
DM: Diabetes mellitus.
HIV: Human immunodeficiency syndrome.
HTN Hypertension.
LOS: Length of stay.
CSF: Cerebrospinal fluid.
CT: Computed tomography scan.
ISTH: Irrua Specialist Teaching Hospital.
MRI: Magnetic resonance imaging.
SSIs: Surgical site infections. RCT: randomized controlled trial.

Disclosure

On behalf of all authors, the corresponding author states that there is no conflict of interest in the materials or methods used in this study or the findings specified in this paper.

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