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# Risk Factors for Surgical Site Infections in Childhood

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## Abstract

**Background:** The cost of managing surgical wounds complicated by Surgical Site Infection (SSI) is worrisome to patients and their care providers. The impact of SSI can be devastating and can leave the patient with a long-lasting morbidity.

**Objectives:** The aim of this study is to identify the risk factors that predispose paediatric surgical patients to SSI in our environment.

**Materials and Methods:** A total of 330 children aged 0-15years, were prospectively observed at the University of Maiduguri Teaching Hospital (UMTH). The information collected was the class of wound, grade of wound infection and duration of surgery. The data was analysed using the SPSS version 16.0. The p value for significance was set at $p < 0.05$.

**Results:** The overall incidence of surgical site infection among the 330 children over a 12- month period was 14.5%. The incidence according to the class of wound contamination was: clean 10.4%, clean contaminated 16.7%, contaminated 27.1%, and dirty wounds 45.8%. Infection rates were found to be more rampant with emergency procedures 60.4% than in elective - 35.6% ($p<0.05$). Independent predictors of SSI in multiple logistic regression analysis were prolonged duration of hospital stay before surgery ($\beta= -0.355$, $p = 0.027$), duration of surgery longer than 2 hours ($\beta= -0.474$, $p = 0.003$) and the presence of low serum albumin ($\beta= -0.424$, $p = 0.001$).

**Conclusion:** The incidence of SSI was high among our children. Preoperative duration of hospital stays, duration of surgery longer than two hours, low serum albumin was found to be the independent risk factors for the development of SSI in this study.

**Keywords:** Duration of Surgery; Risk Factors; Surgical Site Infection

## Introduction

The cost of managing surgical wounds complicated by Surgical Site Infection (SSI) is worrisome to patients and their care providers, and the impact of SSI can be devastating that the patient can be left with a long-lasting morbidity. Surgical site infections are an important cause of nosocomial infections and can account for about 24% of all acquired infections especially in developing countries [1], and it can be the second commonly encountered complication in surgery [2], a major cause of morbidity, prolonged hospital stay and increased health care cost especially in Africa where health resources are limited and there is a high level of poverty [3]. Though, substantial advances have been made in studying the epidemiology, understanding the pathogenesis and prevention of surgical site infections, it still continue to occur and remain a significant cause of disability among patients especially in the developing countries and remained a major setback in advancing the horizons of surgery [4]. In one USA report, approximately 500,000 children out of the 27 million children undergoing surgery annually develop SSI [5]. Therefore, as long as patients are being operated upon there will always be the risk toward developing surgical site infection even in the developed places.

Though, the risks for development of SSIs are variable the patient's age, the patients' disease state and environmental factors are still some of the dominant risk factors. In this study, we would elucidate the risk factors of surgical site infections that are peculiar to our environment.

## Materials and Methods

**Study Design:** This was a hospital-based prospective observational study, from February 2014 to January 2015, to elicit the risk factors associated with surgical site infections in children at the University of Maiduguri Teaching Hospital, Maiduguri, (UMTH), Borno state, Nigeria.

**Study Area:** University of Maiduguri Teaching Hospital (UMTH) is a major referral hospital in the northeastern part of Nigeria and has a 530-bed capacity. The hospital serves as a referral centre not only for patients from the six states in the northeastern region of Nigeria (Adamawa, Bauchi, Borno, Gombe, Taraba and Yobe) but also for patients from neighboring Cameroun, Chad and Niger republics.

## Study Population

### Inclusion Criteria

- The study included pediatric in-patients between the ages of 0 and 15 years requiring a surgical operation in the UMTH operating theatre under general or local anesthesia.
- Only patients who were admitted into the hospital for more than one day were included.

### Exclusion Criteria

- Patients undergoing circumcision and drainage of cutaneous abscesses.
- Patients who had surgery elsewhere before being referred to UMTH.
- Patients' parents/guardians who refused to give consent for the study.

### Ethical consideration

- Informed consent was obtained from patients' parents or guardians for the study.
- Ethical clearance approval was obtained from the hospital ethical and research committee.

## Procedure

Patients data was collected and entered into a protocol tool designed for this study. Entries were made at presentation, after the surgical operation, at discharge and during follow up. Information collected included the patient's age, sex, weight and height at the time of admission, diagnosis, cormorbid conditions, use of urethral and nasogastric catheters, the American Society of Anesthesiologists (ASA) score, nature of the surgery (emergency or elective), type of anesthesia, cleaning agents used to prepare the skin before the operation, usage and timing of antibiotic prophylaxis.

Other data collected included: duration of ICU stay, the procedures performed, duration of surgery (time between skin incision and skin closure), the placement of drains and implants, the pre- and post-procedure length of hospital stay, wound cultures for all patients with suspected SSI and types of microorganisms isolated, including the antibiotic sensitivity patterns of the isolated organism, and patient's outcome including cause of death.

In this study, we defined class of wound contamination as follows: clean - (no breach of body cavity or hollow viscus), clean contaminated - (a breach of a body cavity or hollow viscus other than the intestine), contaminated - (a breach of a body cavity or hollow viscus including the intestine), dirty - (when there was purulent contamination or colonic surgery in a poorly prepared bowel with spillage of colonic contents). All incisional wounds were routinely closed primarily, including dirty incisional wounds, which were copiously irrigated with normal saline before primary closure. The grade of surgical site infections was defined as follows: superficial incisional, deep incisional, organ/space SSI. The patient's outcome after the surgical procedure was also recorded. The patient's cause of death was recorded, be it attributable to SSI or not.

The wounds of patients who had surgery in a contaminated and dirty field were inspected on the second postoperative day by the ward nursing staff, senior resident and the consultants for evidence of erythema, increased pain at wound site, increase in body temperature above 38oC, pulse rate, respiratory rate and discharge from the incision. Clean and clean contaminated incisional wounds were inspected on the 7th and 5th postoperative days respectively. Patients adjudged to have developed SSI were managed by taking a wound swab for microbiology (Culture and Sensitivity); this was sent to the laboratory within an hour of collection in order to increase the possibility of isolating gram-negative anaerobes. A few or all the stitches were removed depending on the length of the wound to allow for free drainage of infected fluid or pus. The wounds were also cleaned with saline and pure honey applied. In the presence of fever antibiotics were added. Patients who had already been discharged were instructed to report back immediately if they noticed clinical features suggestive of SSI before their outpatient clinic follow up appointment was due. Parents/guardians of such patients were usually educated about the signs and symptoms of what constituted SSI before discharge home.

Surgical site infection is defined in this study as infection of surgical wounds evident by the presence of fever, inflammation at the wound site, wound discharge, purulent collection in an organ/space, and excessive pain at operation site, temperature greater than 38oC, bleeding from the wound and gaping of wound edges.

The patients without implants were followed up for one month and those patients with implants for 12 months after discharge.

## Data Analysis

Data obtained was entered into a computer to generate a computerized database. This was then analyzed using the SPSS program, version 16.0 (SPSS Inc. Chicago IL). Categorical variables were analyzed using chi-square and continuous variables using the independent t-test. Multivariate logistic regression analysis was used to find independently associated risk factors. The Odd Ratios (OR) and their Confidence Interval (CI) of 95% was calculated. The p value for significance was set at <0.05.

## Results

There was a total of 330 surgical procedures, performed on children aged between 0 and 15 years with a mean ± Standard Deviation (SD) for age of 3±1.4, during the 12 months of the study period for all classes of wounds. Of these 218 (66.1%) were males, and 112 (33.9%) were females, with a male to a female ratio of 1.9:1.

The weight in kilograms was normalized to a z score for age and the mean (±SD) score was 2.6±1.8. Surgical site infections occurred in 48 (14.5%) children. Children aged 1-12yrs made 46.4% of the study population, out of these 24 (7.3%) of the total population developed SSI, (p > 0.508) (Table 2). There was SSI rate of 26 (54.2%) in male children compared to 22 (45.8%) in female children (p > 0.060). Most diagnoses (43, 89.6%) of SSIs were made before the patients were discharged with a median time to diagnosis of SSIs of 2.2 days. In 29 (60.4%) patients the diagnosis of SSIs was established within 4 to 7 days of surgery, in the remaining 19(39.6%) patients the diagnoses of SSI were established after the 7th day of surgery. The infection rate was 10.4% in clean wounds, 16.7% clean contaminated wounds, 27.1% contaminated wounds, and 45.8% in dirty wounds. The incidences of clinical grades of infections identified were as follows: superficial incisional 32 (66.7%), deep incisional 13 (27.0%), and organ/space SSI 3 (6.3%). All the children with superficial surgical site incisional infections and 10 cases with deep incisional infections healed with secondary intention with minimal scar formation; the three remaining cases with deep incisional SSIs had delayed primary wound closure done. The cases with organ/space SSIs were re-operated for drainage of intra-abdominal abscesses in two children and closure of a complete burst abdomen in one child.

| Characteristics | All patients | SSI (negative) | SSI (positive) | p-value |
|---|---|---|---|---|
| | N = 330 (%) | N = 282 (%) | N = 48 (%) | |
| Patient demographics | | | | |
| **Age** | | | | |
| Neonates (≤30 days) | 19(5.7) | 14(5.0) | 5(10.4) | |
| Infants (>30days but ≤1yr) | 31(9.4) | 27(9.6) | 4(8.3) | |
| Child (>1yr but≤12 yrs) | 153(46.4) | 129(45.7) | 24(50.0) | |
| Adolescent (>12yrbut ≤15yrs) | 127(38.5) | 112(39.7) | 15(33.3) | |
| **Total** | 330(100.0) | 282(85.5) | 48(14.5) | 0.508 |
| **Gender** | | | | |
| Male | 218(66.1) | 192(68.1) | 26(54.2) | |
| Female | 112(33.9) | 90(31.9) | 22 (45.8) | |
| **Total** | 330(100.0) | 282(85.5) | 48(14.5) | 0.06 |
| **BMI** | | | | |
| ≤18 | 83(25.2) | 48(17.0) | 19(39.6) | |
| >18 to ≤24 | 215(65.2) | 209(74.1) | 22(45.8) | |
| ≥24 | 32(9.6) | 25(8.9) | 7(14.6) | |
| **Total** | 330(100.0) | 282(85.5) | 48(14.5) | 0.003 |
| **Skin preparation solution** | | | | |
| Cetrimide/ alcohol | 190(57.6) | 175(62.1) | 15(31.3) | |
| Cetrimide /alcohol/ povidone iodine | 73(22.1) | 61(21.6) | 12(25.0) | |
| Cetrimide/ normal saline/ alcohol | 46(13.9) | 31(11.0) | 15(31.3) | |
| Normal saline only | 5(1.5) | 4(1.4) | 0(0.0) | |
| Cetrimide/Normal saline | 16(4.8) | 11(3.9) | 6(12.4) | |
| **Total** | 330(100.0) | 282(85.5) | 48(14.5) | 0 |
| **ASA score** | | | | |
| Class I | 26(7.9) | 24(8.5) | 2(4.2) | |
| Class II | 118(35.7) | 110(39.0) | 8(16.7) | |
| Class III | 121(36.7) | 108(38.3) | 13(27.0) | |
| Class IV | 65(19.7) | 40(14.2) | 25(52.1) | |
| **Total** | **330(100.0)** | **282(85.5)** | **48(14.5)** | **0** |

**Table 2:** Patient demographics and univariate analysis of 330 patients with and without surgical site infection

Twenty-one of the 330 children died, giving an overall mortality rate of 6.4%. Fifteen (15, 5.3%) of the deaths occurred in 282 patients with no surgical site infection. While (6, 12.5%) of the 48 patients with SSI died, and these were the deaths directly attributable to SSI. The distribution of mortality directly related to SSI

were as follows: meningitis following venticuloperitoneal shunt site infection in two children, anastomotic dehiscence with septicemia in three children after open laparotomy for a gangrenous bowel due to intussusceptions and one child who developed necrotizing fasciitis after laparotomy for multiple penetrating abdominal injuries. The most frequent clinical feature of SSIs was superficial abscess in 16 cases. This was followed by skin hyperemia at the wound site in 10 cases and skin necrosis at the wound site in four cases (Table 1). A majority of the children had an ASA classification of II and III. The SSI rate increased with higher ASA classification and this was statistically significant ($p<0.05$). So also does the choice of skin preparation agents and low BMI were found to correlate with the development of SSI. Table 2 summarizes the univariate analysis of differences in characteristics of patients with and without SSI.

| Clinical features | Number of patients (%) |
|---|---|
| Superficial abscesses | 16(33.3) |
| Hyperaemia of the skin | 10(20.8) |
| Necrosis of the skin | 4(8.3) |
| Purulent discharge from the wound | 3(6.3) |
| Localized swelling at the incision site | 3(6.3) |
| Spontaneous partial gapping of the wound | 3(6.3) |
| Undue tenderness at the incision site | 3(6.3) |
| Spontaneous bleeding from the wound | 3(6.3) |
| Complete wound dehiscence | 2(4.1) |
| Necrotizing fasciitis | 1(2.0) |
| **Total** | **48(100%)** |

**Table 1:** Summaries of the clinical features in the 48 children with SSI.

Table 3 shows the details of the relationship of SSI with some of the variables. There were 25(7.6%) children with low serum albumin, of whom 17(68.0%) developed SSI, which was (35.4%) of the total 48 patients who developed SSI, whereas 31(64.6%) children with normal serum albumin developed infection. Low serum albumin was statistically a significant risk factor for the development of SSI ($p<0.000$). There were 41(12.4%) children with low packed cell volume, of these 14(34.1%) developed surgical site infection. This represented 29.2% of the 48 patients who developed SSI. There were 289 (87.6%) children with normal packed cell volume out of whom 34, representing 70.8% of the 48 patients who developed SSI. Thus, low packed cell volume was an important risk factor for the development SSI ($p< 0.000$).

A pre-surgical hospital stays for more than one week before surgery had an increased risk of developing SSI in our patients (Table 3). There were six children with an associated co-morbidity. Five of these children had sickle cell disease with the 6th child presenting with congenital heart disease (VSD). No significant correlation was found between co-morbidity and risk for developing SSI ($p > 0.882$). Three hundred and seventeen (317, 96.0%) of the operations were done under general anesthesia, 47 (14.8%) developed SSI, which is about 97.9% of the 48 patients who developed SSI. Thirteen (13, 4.0%) children were operated using xylocaine local infiltration for venous cut downs, excision biopsies of subcutaneous lipomas, lymph nodes and skin papilliomas. Out of these 1 (7.7%) developed SSI. Also, the type of anaesthesia, had not clinically influenced the risk of SSI ($P > 0.475$). The mean (±SD) duration of surgery was 75±4.3 minutes. It was observed that the duration of surgical procedure greater than two hours had a direct influence on development of SSI ($p<0.000$), and regarding the nature of surgery (196, 59.4%) operations were done on elective basis, (134, 40.6%) on emergency basis. Infection readily occurs during the emergency surgeries 29(21.6%) which was about 60.4% of the 48 patients who developed SSI ($p < 0.003$). The rate of development of SSI in the elective surgical operations was 9.7%.

In terms of blood transfusion, 66 (20%) children were transfused with blood, 23(34.8%) of whom developed SSIs. Whereas out of the 264 (80.0%) children who were not transfused blood 25(9.5%) developed SSI. Children who were transfused were more likely to develop SSI ($p<0.000$). The overall mean (±SD) duration of hospital stay was 13.9±17 days. But it was 18.3±18.1 and 15.8±23.1 days respectively for those with and without surgical site infections. Duration of hospital stay was not found to be statistically significant between patients with and without SSIs in this study (CI -10.819 ─ 5.944, $p > 0.761$). Surgical drain, urethral catheter and nasogastric tube were used in 25.2% of the children. Perhaps a surrogate association was what observed with placements of these devices and the risk of infection but rather ($p <0.013$).

| Variables | Study population | Percent of | infection | $X^2$ | df | p | 95% CI |
|---|---|---|---|---|---|---|---|
| | N (%) | Negative N (%) | Positive N (%) | | | | OR(lower-upper) |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Serum albumin | | | | 62.181 | 1 | 0 | 0.053(0.021-0.133) |
| >35g/l | 305(92.4) | 274(97.2) | 31(64.6) | | | | |
| ≤35g/l | 25(7.6) | 8(2.8) | 17(35.4) | | | | |
| **Total** | 330(100.0) | 282(85.5) | 48(14.5) | | | | |
| Packed cell volume | | | | 14.471 | 1 | 0 | 0.257(0.123-0.538) |
| >30% | 289(87.6) | 255(90.4) | 34(70.8) | | | | |
| ≤30% | 41(12.4) | 27(9.6) | 14(29.2) | | | | |
| **Total** | **330(100.0)** | **282(85.5)** | **48(14.5)** | | | | |
| Comorbidity | | | | 0.022 | 1 | 0.882 | 1.179(0.135-10.315) |
| absent | 324(98.2) | 277(98.2) | 47(97.9) | | | | |
| present | 6(1.8) | 5(1.8) | 1(2.1) | | | | |
| **Total** | **330(100.0)** | **282(85.5)** | **48(14.5)** | | | | |
| Presurgical hospital stay | | | | 49.987 | 1 | 0 | 8.824(4.504-17.284) |
| ≤2wks | 253(76.6) | 235(83.3) | 18(37.5) | | | | |
| >2wks | 77(23.4) | 47(16.7) | 30(62.5) | | | | |
| **Total** | **330(100.0)** | **282(85.5)** | **48(14.5)** | | | | |
| Type of anaesthesia | | | | 0.511 | 1 | 0.475 | 2.089(0.265-16.445) |
| general | 317(96.0) | 270(95.7) | 47(97.9) | | | | |
| local | 13(4.0) | 12(4.3) | 1(2.1) | | | | |
| **Total** | **330(100.0)** | **282(85.5)** | **48(14.5)** | | | | |
| Nature of surgery | | | | 9.14 | 1 | 0.003 | 0.389(0.308-0.727) |
| elective | 196(59.4) | 177(62.8) | 19(35.6) | | | | |
| emergency | 134(40.6) | 105(37.2) | 29(60.4) | | | | |
| **Total** | **330(100.0)** | **282(85.5)** | **48(14.5)** | | | | |
| Prophylactic antibiotics | | | | 12.327 | 1 | 0 | 0.114(0.052-0.480) |
| yes | 250(75.7) | 204(61.8) | 46(13.9) | | | | |
| no | 80(24.2) | 78(23.6) | 2(0.6) | | | | |
| **Total** | **330(100.0)** | **282(85.5)** | **48(14.5)** | | | | |
| Duration of surgery | | | | 6.214 | 1 | 0.013 | 2.232(1.174-4.241) |
| >2hrs | 95(28.8) | 57(20.2) | 38(79.2) | | | | |
| ≤2hrs | 235(71.2) | 225(79.8) | 10(20.8) | | | | |
| **Total** | **330(100.0)** | **282(85.5)** | **48(14.5)** | | | | |
| Blood transfusion | | | | 27.36 | 1 | 0 | 0.196(0.102-0.376) |
| transfused | 66(20.0) | 43(15.2) | 23(47.9) | | | | |
| not transfused | 264(80.0) | 239(84.8) | 25(52.1) | | | | |
| **Total** | **330(100.00** | **282(85.5)** | **48(14.5)** | | | | |
| $p < 0.005$(Level of Significance), $x^2$= Chi square, df = Degree of Freedom, OR = Odds Ratio | | | | | | | |

**Table 3:** Relationship between SSI and some variables among the 330-study population.

The distribution of SSI according to the procedures performed is detailed in (Table 5). Exploratory laparotomy for various indications (Typhoid Perforation - 15, Intussusception – 13, Abdominal Trauma - 10, Ruptured Appendicitis - 6, Malrotation - 5 and Intestinal Atresia – 3 patients) were the most common procedures performed and had the highest SSI rate of infection as (19, 39.6%) of the patients who had exploratory laparotomy developed SSI.

| Surgical procedure | Wound infection | | Total N (%) |
|---|---|---|---|
| | Negative N (%) | Positive N (%) | |
| Exploratory laparotomy | 33(11.7) | 19(39.6) | 52(15.8) |
| Herniotomy | 47(16.7) | 1(2.0) | 48(14.5) |
| Lithotomy for urinary stones | 26(9.2) | 1(2.0) | 27(8.2) |
| Uncomplicated appendicectomy | 19(6.7) | 5(10.4) | 24(7.3) |
| Excisional biopsy of superficial lumps | 17(6.0) | 2(4.2) | 19(5.8) |
| Umbilical herniorrhaphy | 16(5.7) | 5(10.4) | 21(6.4) |
| Posterior sagittal anorectoplasty | 10(3.5) | 3(6.3) | 13(4.0) |
| Ventriculo-peritoneal shunt | 10(3.5) | 1(2.0) | 11(3.3) |
| Colostomy creation | 8(2.8) | 2(4.2) | 10(3.0) |
| Repair of neural tube defect | 6(2.1) | 2(4.2) | 8(2.4) |
| Closure of bladder exstrophy | 6(2.1) | 4(8.3) | 10(3.0) |
| Full thickness rectal biopsy | 8(2.8) | 0(0.0) | 8(2.4) |
| Contracture release | 8(2.8) | 0(0.0) | 8(2.4) |
| Urethroplasty | 5(1.8) | 2(4.2) | 7(2.1) |
| Orchidopexy | 7(2.5) | 0(0.0) | 7(2.1) |
| Nephroureterectomy | 6(2.1) | 0(0.0) | 6(1.8) |
| Swenson's pull through for Hirschsprung's Disease | 5(1.8) | 1(2.0) | 6(1.8) |
| Colostomy closure | 6(2.1) | 0(0.0) | 6(1.8) |
| Pyloromyotomy | 6(2.1) | 0(0.0) | 6(1.8) |
| Thyroidectomy | 3(1.1) | 0(0.0) | 3(1.0) |
| Others | 30(10.6) | 0(0.0) | 30(9.1) |
| **Total** | **282(85.5)** | **48(14.5)** | **330(100.0)** |

**Table 4:** Frequency distribution of SSI according to the surgical procedures of the study population

Forty-six samples were collected with swab sticks, while two samples were collected as aspirates using needle and syringe. All the samples yielded bacterial growth.

| Culture-positive | **Antibiotics Sensitivity Pattern** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Microorganism | n (%) | Amik | Aug | Ceftr | Ceftz | Cipro | Pen | CTM | Tetra |
| Staphyloccocus aureus | 19(39.6%) | S | R | S | R | - | R | - | - |
| Klebsiella species | 12(25.0%) | - | S | S | - | S | R | - | - |
| Escherichia coli | 8(16.7%) | R | S | S | - | - | R | - | - |
| Pseudomonas aeroginosa | 4(8.3%) | S | - | R | S | S | - | - | - |
| Mixed growth- (Pseudomonas aeroginosa+Klebsiella species) | 4(8.3%) | variable | | | | | variable | | |
| Peptococcus | 1(2.1%) | - | - | - | - | S | R | - | S |
| Amik = Amikacin, Aug = Augmentin, Ceftr = Ceftriaxone, Ceftz = Ceftazidime, Ciprox = Ciprofloxacine, CTM = Cotrimaxazole, Tetra = Tetracycline, Pen = Penicillin, R = Resistant, S=Sensitive | | | | | | | | | |

**Table 5:** Bacterial isolates and their antimicrobial sensitivity pattern among the 48 patients with SSI.

Multiple logistic regression analysis of potential risk factors for SSI showed, the duration of surgery ($\beta = 0.474$, $p = 0.003$), duration of hospital stays before surgery ($\beta = -0.355$, $p = 0.027$) and low serum albumin ($\beta = -0.424$, $p = 0.001$) as the predominant risk factors independently associated with a significant difference in rates of occurrence of SSI. The other factors: nature of surgery, packed cell volume, prophylactic antibiotic, pre-surgical hospital stay and blood transfusion that were associated with the development of SSI in the univariate analysis became non-significant in the multivariate analysis. This is shown in (Table 6).

| Variables | $\beta$ | p-value |
|---|---|---|
| Age | 0.12 | 0.514 |
| Gender | -0.171 | 0.177 |
| Weight (Kg) | 0.229 | 0.18 |
| Duration of hospital stay before surgery | -0.355 | 0.027 |
| Packed cell volume | -0.066 | 0.624 |
| Requirement for blood transfusion | -0.173 | 0.265 |
| ASA class | 0.096 | 0.482 |
| Type of cleaning solution | 0.063 | 0.632 |
| Serum albumin level | -0.424 | 0.001 |
| Co-morbidity | -0.053 | 0.642 |
| Nature of surgery | 0.341 | 0.641 |
| Class of wound contamination | 0.104 | 0.495 |
| Duration of surgery | 0.474 | 0.003 |
| Surgical procedure | 0.023 | 0.575 |
| Antibiotic prophylaxis | 0.014 | 0.902 |
| Use of surgical drains | 0.086 | 0.476 |
| Post-operative ICU admission | 0.078 | 0.463 |
| p = Level of Significance <0.005, β = Standard Coefficient | | |

**Table 6**: Simultaneous multiple regression analysis of independent risk factors in this study.

## Discussion

Despite improvements made in the delivery of health care services, nosocomial infections still pose a great threat to patients and health care service providers. Though, total elimination of surgical site infection may not be possible, at least reduction of the incidence of SSIs will reduce cost, morbidity and mortality for the patient, pressure on the surgeon and his team and the burden on the hospital facilities [6-8].

This is study has documented a high overall incidence 14.5% of SSIs over a 12-month period among pediatric surgical patients in all wound classes. It has also shown that the rate of SSI for clean, clean-contaminated, contaminated and dirty wounds is 10.4%, 16.7%, 27.1%, and 45.8% respectively, which is in conformity with earlier reports by Ameh et al [9] in northwestern Nigeria, and from some parts of Sub Saharan Africa [10,11], Asia [12], and South America [13], which were typical of incidences of SSIs from developing countries, which hitherto are still battling infection relayed surgical conditions. Relative inconsistency in standardized definition criteria for SSIs in most developing countries [14], could also account in some variation in incidence of SSIs in developing in addition to the nature of our health care services as seen from most reports [15-17]. While, the overall incidence of SSIs from developed countries like U.S.A, Europe and Japan has consistently remained at 2.5-6.8% and 1.7-3.7% respectively, because of consistency in defining risk factors for SSI [18-20]. Incidence of SSIs can also be extrapolated to its economic burden, which according to one report about $ 1.6 billion dollars are expended in extra hospital charges every year in about 2-5% of patients undergoing surgical procedure [21]. Though we did not assess the economic burden of SSIs in our patients but expectedly, this can be a huge financial burden for patients especially in countries where the Government has no adequate support in the health care system.

Regarding predisposing factors of SSIs, there was high rate (40.6%) of infection in emergency operations in our study, probably because 15.8% of the emergency operations were performed on the gastrointestinal tract most often for dirty complicated wounds, as 39.5% of those children who had emergency exploratory laparotomy developed SSI. The effect of emergency surgery on the rate of SSI have been considered by other studies [22,23], who concluded that complicated and dirty gastrointestinal conditions often result in SSIs. Furthermore, there was high rate 45.8% of infection with the dirty surgeries which was not unexpected as majority of literatures reported high rate of SSIs for dirty operations as we have also observed in our study [24,26], Though, Horwitz et al [27] had a low incidence 2.6% of SSIs in dirty-infected operations and a higher rate 64.5% of SSIs for clean operations. Before closing the dirty wounds, we copiously irrigate them normal after closing the fascial layer with non-absorbable suture and the skin incision were closed primarily with interrupted sutures. Though, a time only tagging sutures were put on the skin, yet this has not reduced the rate of infection in our dirty surgeries. Hopefully, a delayed primary closure of dirty wounds should have been a better option as studied by Bhattachayya, et al. [28] in 676 post-operative wounds.

Studies have observed relative increased risk to infection among neonates and infants, because of inherent relative immunodeficiency [29,30]. The rate of infection among the neonates in this study was low, probably, because our sample size for neonates was small.

When considering the effect of coexisting disease processes or congenital anomalies on the risk of developing SSIs, we have not observed significant risk in this study compared to previous reports [31,32]. But there was increased tendency towards development of SSIs in children with low serum albumin, those children who received blood transfusion because of low packed volume and in those children whose surgeries lasted more than 2 hours. About 10.4% of the children were found to have low serum albumin and this was seen to increase the risk of SSI in 35.4% of the overall number of the children who developed SSI. Common to these children with low serum albumin, low packed cell volume is that they had emergency exploratory laparotomy for complicated and dirty gastrointestinal conditions. These categories of patients are often very sick and thus increased risk of SSI was frequently observed with them. Hence a rate of development of SSI was found high among this group of children ($p \leq 0.000$) with low serum

albumin. Gorse et al. [33] similarly observed increased risk for the development of SSI in some of the seriously sick patients with low packed cell volume who also had multiple blood transfusion. Those children with low serum albumin, in addition to duration of hospital stay beyond one week before surgery and duration of surgery beyond two hours were independently associated with development of SSI using the multivariate analysis. The rate of infection was found to be 15 times higher for patients whose operations last more than two hours. This is in agreement with previous studies which found that prolonged surgery increased the rate of infection [34,35].

The ASA score was chosen in this study to indicate the severity of disease before operation. It was found to be significantly associated with SSI when univariate analysis was performed. Garibaldi, et al. [36] also observed this similar finding in a study of 1852 adults. Regarding placement of drains and ICU admission, we found no increased risk for development of SSI among our patients who drains placed but in those admitted in to the ICU. Contrary to Bucher et al [37] who reported increased infection rate among their patients with drains, implantable devices and in those who had post-operative ICU admission. Furthermore, no much significant relationship was established in terms of the patients' weight, gender, skin cleaning solutions in rate of development of SSI.

Antibiotics were routinely given as prophylaxis before induction or after induction of anesthesia in all clean contaminated, contaminated, dirty wounds and in clean wounds that involved the central nervous system. Despite the use of perioperative antibiotics in all clean contaminated, contaminated and dirty wounds, the rate of infection was still high, and this is the experience of others [38]. All the same, there are studies that still showed the protective role of prophylactic antibiotics in susceptible incisions [39].

## Conclusion

It should not be bewildering that some of the risk factors for surgical site infection highlighted in this study are still having gruesome effect on our patients. This could not far be fetch from the state of health care in our environment and in most developing countries, where patients are more likely predispose to high of surgical site infection compared to what was obtainable in western literatures.

### Limitations

- The time interval between collection of specimens and inoculation of the culture media has significantly reduced the sensitivity to isolate anaerobic organisms.
- This study has not taken into cognizance the experience and skill of the surgeon, and the theatre environment (humidity, air circulation), which could be important confounding risk factors for the development of SSI.
- Frequent change of residential addresses by some of the patients affected follow up of these patients.

### Recommendations

Based on the findings in this study, the following recommendations can be made:

Dirty wounds should not be closed primarily considering the high incidence of SSIs in this report and other available reports from developing countries and the paucity of data of SSIs in children from most developing countries, there is the need for a collaborative research and clinical initiative to address the burden of SSIs in children in underdeveloped countries.

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