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TEMPORAL VARIATION IN SURGICAL SITE INFECTION INCIDENCE AFTER EMERGENCY EXPLORATORY LAPAROTOMY: A PROSPECTIVE COHORT STUDY IN TWO HIGH-VOLUME TERTIARY HOSPITALS IN KISUMU CITY, KENYA.

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ABSTRACT

Background: **Surgical site infections (SSIs) continue to remain a major healthcare burden, contributing to increased morbidity, mortality, and prolonged hospital stays. While it has been hypothesized that nighttime surgeries may carry a higher risk of complications, including SSIs, existing evidence is mixed. This study aimed to assess the effect of the timing of operation on SSI incidence among patients undergoing emergency laparotomies in Kisumu City, Kenya.**

Methods: **A prospective cohort study was conducted among 145 patients at two high-volume public teaching hospitals in Kisumu County from January 29th, 2024 to January 29th, 2025. Descriptive statistics summarized demographic and clinical characteristics, while chi-square and Fisher's exact tests assessed group differences. Relative risk (RR) and adjusted RR (aRR) were estimated using univariate and multivariate models with backward stepwise selection. All analyses were performed using R and Stata.**

Results: **The overall incidence of SSI was 14.5%, higher following daytime surgery (20.3%) compared to nighttime surgery (8.5%), although the difference was not statistically significant (RR 2.4, 95% CI: 0.99–5.84, p = 0.054).**

Conclusion: **Although SSIs were more frequent after daytime surgeries, the difference was not statistically significant, indicating that the time of operation may not independently predict SSI risk. The findings suggest that larger studies are needed to confirm the role of surgical timing in SSI incidence.**

Key Words: **Surgical site infection, Emergency Laparotomy**

INTRODUCTION

Surgical Site Infections (SSIs), which are a common outcome of surgery, are a type of nosocomial infection of surgical significance. It includes infections of tissues around the incision site, organs, or spaces exposed by surgeons during an invasive procedure.

Even with advancements in surgical infection prevention methods, surgical site infections (SSIs), which make up 10% to 40% of all nosocomial infections, remain the third most common hospital-acquired disease [1,2]. It has been discovered that the incidence of SSIs varies between 0.5% and 15% worldwide[2]. The prevalence is significant in Sub-Saharan Africa (SSA), ranging from 6.8 to 26%, and patients who have had general surgical operations account for the majority of cases[3]. In Kenya, the incidence is as high as 30.8%[4].

Those with SSIs had two times the risk of dying, five times the chance of hospital readmission, and up to 60% greater odds of being sent to an intensive care unit compared to those without SSIs[5]. This explains the excess 3.7 million hospital days, the excess annual costs of almost $1.6 billion, and the excess 5.57 medication consumption[6ylim]. This negatively impacts healthcare resources.

There is a considerable risk of complications, SSI included, following emergency laparotomy, which may be attributed to several factors, including patient, operational, and environmental factors[7]. Age, sex, co-morbidities, and nutritional condition are examples of patient variables. Operative considerations include, among other factors, the diagnosis, degree of contamination, duration of surgery, preoperative period, type of surgery, American Society of Anesthesiologists (ASA) score, and use of antibiotics as prophylaxis. Microbial contamination, temperature, and humidity are examples of environmental parameters[8].

In Kenya, studies have been done on the specific determinants of SSIs among surgical patients, but none on the time of operation as a determinant of SSI among surgical patients in Kisumu County.

This study aimed to determine the effect of the timing of operation on SSI among patients undergoing emergency laparotomies in Kisumu County. The specific objective was to assess the impact of the timing of the operation on SSI incidence.

This study was conducted in Kisumu County, particularly at Jaramogi Oginga Odinga Teaching and Referral Hospital (JOOTRH), and Kisumu County Referral Hospital (KCRH). Jaramogi Oginga Odinga Teaching and Referral Hospital (JOOTRH) is a regional teaching and referral hospital. It is situated in Kisumu City, Kisumu County, Kenya, along the Jomo Kenyatta Highway and serves County, Sub-County, and Private Hospitals found in more than ten counties in the Western Kenya region, which is home to more than 5 million people. JOOTRH has 160 surgical beds and 6 operating rooms with

increased surgical capacity and a robust surgical residency program. It's a surgical center receiving trainees from multiple learning institutions, leading to increased traffic within the theatre. It has a high workload that may lead to staff fatigue and reduced availability of theatre space, thereby increasing the time to surgery. KCRH is situated along Ang'awa Street within the Kisumu City Center. It has a surgical bed capacity of twenty-five and two operating theatres

Materials and Methods

A prospective cohort study was conducted at the two high-volume hospitals, the Jaramogi Oginga Odinga Teaching and Referral Hospital (JOOTRH), and Kisumu County Referral Hospital (KCRH) between January 29th, 2024 and January 29th, 2025. The study focused on all patients hospitalized for emergency laparotomy at the KCRH and JOOTRH surgical wards.

A non-probabilistic purposive consecutive sampling technique was used. Those who qualified to be in the study were recruited based on the inclusion criteria and in order of admission. They are allotted to the daytime (07:00 to 17:59 Hours) group or nighttime (18:00 to 06:59 hours) group, based on the actual cut time. The consecutive sampling was used until the last day of the study period.

The sample size was ascertained by use of the Wang and Chow sample size calculation equation for comparing proportions[9].

$$n = \frac{\left(Z\frac{\alpha}{2} + Z_\beta\right)^2 \left(p_1(1-p_1) + p_2(1-p_2)\right)}{(p_1 - p_2)^2}$$

where $Z\frac{\alpha}{2}$ is the critical value of the Normal distribution at where $\frac{\alpha}{2}$ (e.g., for a confidence level of 95%, α is 0.05 and the critical value is 1.96), Z_β is the critical value of the Normal distribution at β (e.g., for a power of 80%, β is 0.2, and the critical value is 0.84), and p1 and p2 are the expected sample proportions of the two groups.

By considering prior research, a prospective study on the impact of nighttime emergency surgery on patients' outcome, the rates of wound infection among the Night operations - p1 were 62.2%, whereas the rates among the Daytime operations - p2 of 37.8%, it was estimated as 62 [10]. By adding 10% to cater for attrition, the final sample size was estimated at 69 (62 + 7), each for Daytime surgery and Nighttime surgery.

Patients who died during or within 24 hours after surgery, those who underwent repeat surgery for reasons other than SSI, those who, at the time of surgery, were malnourished or had a malignancy, and those who declined to provide consent to participate in the study were excluded

Data was collected using a well-structured questionnaire, and the presence of SSI was assessed according to the Centers for Disease Control and Prevention (CDC) criteria for nosocomial surgical site infection. The data collected included the participants' demographics, preoperative data, procedure data, postoperative data, and follow-up data. This was collected through patient interviews, clinical examinations, and a review of operation notes as well as clinical notes. The data were collected during the participants' stay in the ward, during outpatient follow-up, and through telephone

interviews for those who did not return for outpatient follow-up, and on the 30th day postoperatively. Data was collected by one research assistant, a clinical officer intern based at KCRH, and the principal investigator based at JOOTRH, supervised by two consultant surgeons.

Data was reviewed, coded, and entered into a secure MS Access database. To reduce errors, the database was defined with the appropriate constraints and limitations. An exploratory analysis was carried out to find anomalies and discrepancies.

Descriptive frequencies for demographic and clinical variables were generated to assess the effect of the timing of operation on the incidence of SSI following emergency laparotomy in surgical patients at two high-volume tertiary hospitals in Kisumu County. The differences were assessed using chi-square and Fisher's exact tests with a significance threshold of $p<0.05$. Both unadjusted and adjusted relative risk (RR) models were applied, with variable selection via backward stepwise selection with a 0.05 significance threshold. Key outcome measures included Relative Risks (RR), adjusted Relative Risks (aRR), and their natural logarithms (LnRR)

R statistical package (R version 4.5.0, Foundation for Statistical Computing, Vienna, Austria) was used to compute these estimates.

Ethical approval was obtained from JOOTRH – Institutional Scientific Ethics Review Committee (ISERC), approval number ISERC/JOOTRH/749/23. Research license was obtained from the National Commission for Science, Technology, and Innovation (NACOSTI), license number NACOSTI/P/24/32951

Results

A total of 145 patients were interviewed. Seventy-one (49%) of them had their surgeries performed at night, while 74 (51%) had their surgeries performed during the day. Twenty-one (14.5%) patients developed SSI. Surgeries conducted during the day had an incidence rate of 20.3% (15/74) while those conducted at night had a rate of 8.5% (6/71) as shown in Table 1 below.

Table 1: Sociodemographic and Clinical Characteristics and Surgical Site Infection Outcomes by Time of Surgery

Variable	DTS			NTS		
	SSI	No SSI	%	SSI	No SSI	%
Time of Surgery						
DTS	15	59	20.3%			
NTS				6	65	8.5%
Age Bracket						
<5years	4	11	26.7%	1	6	14.3%

5-14years	2	6	25.0%	0	4	0.0%
15-24years	2	10	16.7%	1	14	6.7%
25-44years	4	22	15.4%	0	32	0.0%
45-64years	2	5	28.6%	3	7	30.0%
>65year	1	5	16.7%	1	2	33.3%
Gender						
Female	7	20	25.9%	2	20	9.1%
Male	8	39	17.0%	4	45	8.2%
Marital Status						
Single		9	28.0%	2	31	6.1%
Married	6	31	16.2%	4	34	10.5%
Level of Education						
None	5	11	31.3%	1	7	12.5%
Primary	3	14	17.6%	3	14	17.6%
Secondary	4	23	14.8%	2	35	5.4%
College	4	23	14.8%	0	9	0.0%
SES						
Low	12	46	20.7%	5	50	9.1%
Middle	3	13	18.8%	1	15	6.3%
Preoperative Duration						
0-2 hours	2	13	13.3%	1	14	6.7%
3-5 hours	11	33	25.0%	3	36	7.7%
6-9 hours	0	4	0.0%	1	11	8.3%
>10 hours	2	9	18.2%	1	4	20.0%
Duration of Surgery						
<1 hour	1	2	33.3%	0	6	0.0%
2-3 hours	13	40	24.5%	5	36	12.2%
4-5 hours	1	17	5.6%	1	23	4.2%
Class of Wound						
Class I	1	22	4.3%	0	27	0.0%
Class II	3	7	30.0%	1	7	12.5%
Class III	9	21	30.0%	4	18	18.2%
Class IV	2	9	18.2%	1	13	7.1%
Comorbidity						
No	13	54	24%	5	62	8%
Yes	2	5	29.0%	1	3	25.0%
ASA Score						
ASA I	1	15	6.3%	0	14	0.0%

ASA II	8	31	20.5%	2	37	5.1%
ASA III	4	9	30.8%	3	12	20.0%
ASA IV	2	5	28.6%	1	2	33.3%
Antibiotic Prophylaxis						
Within 1 hour	1	5	16.7%	0	3	0.0%
On Induction	14	54	20.6%	6	62	8.8%
Surgeon Cadre						
Resident	8	40	16.7%	6	51	10.5%
Consultant	7	19	26.9%	0	14	0.0%
Assistant Surgeon Cadre						
Resident	9	44	17.0%	5	58	7.9%
Consultant	1	6	14.3%	0	0	0.0%
Others	5	9	35.7%	1	7	12.5%
Incision Type						
SUMI	1	5	16.7%	0	4	0.0%
Midline	8	39	17.0%	5	49	9.3%
Paramedian	4	10	28.6%	5	0	100.0%
Transverse	5	2	71.4%	1	7	12.5%

Abbreviation: **DTS** - Daytime Surgery; **NTS** – Nighttime Surgery; **SSI** – Surgical Site Infection; **SES** – Socioeconomic status; **ASA** – American Society of Anesthesiologists; **SUMI** – Sub-Umbilical Midline Incision.

In the unadjusted analysis, surgeries performed during the day had a 2.4 times higher risk of surgical site infection (RR = 2.40, 95% CI: 0.99–5.84, p = 0.054) compared to those performed at night (Table 2). The likelihood of developing SSI was markedly higher among patients with Class III **wounds**, even after adjustment for confounders (aRR = 2.40, 95% CI: 1.24–7.44). A paramedian incision also increased infection risk in unadjusted analysis (RR = 2.61, 95% CI: 1.04–6.51), although this effect diminished and lost statistical significance in the multivariable model (aRR = 1.78, 95% CI: 0.77–7.28)

Table 2: Analysis of the Risk factors of SSI following emergency laparotomy by time of surgery

Variable	**Univariate**			**Multivariate**		
	RR	**95% CI**	**p-value**	**aRR**	**95% CI**	**p-value**
Time of Surgery						
NTS	Ref					
DTS	2.40	0.99-5.84	0.054			

Age Bracket						
25-44years	Ref					
<5years	1.75	0.71-4.28	0.222			
5-14years	1.17	0.31-4.42	0.821			
15-24years	0.73	0.23-2.30	0.589			
45-64years	2.35	0.99-5.60	0.053			
>65years	1.59	0.44-5.79	0.481			
Gender						
Female	Ref					
Male	0.68	0.31-1.50	0.341			
Marital Status						
Single	Ref					
Married	0.95	0.43-2.09	0.894			
Level of Education						
None	Ref					
Primary	1.31	0.55-3.10	0.546			
Secondary	0.51	0.21-1.23	0.133			
Tertiary	0.88	0.28-2.76	0.832			
SES						
Low	Ref					
Middle	0.83	0.30-2.30	0.721			
Preoperative Duration						
6-9 hours	Ref					
0-2 hours	0.62	0.25-1.50	0.286			
3-5 hours	1.60	0.72-3.55	0.252			
>10 hours	1.44	0.48-4.34	0.512			
Duration of Operation						
4-5 hours	Ref					
<1 hour	0.99	0.15-6.33	0.988			
2-3 hours	3.06	0.95-9.90	0.061			
Class of Wound						
Class I	Ref			Ref		
Class II	1.66	0.63-4.38	0.306			

Class III	2.91	1.29-6.55	0.010	2.40	1.24-7.44	0.016
Class IV	1.25	0.40-3.92	0.702			
Comorbidities						
No	Ref					
Yes	2.03	0.71-5.84	0.189			
ASA Score						
ASA I	Ref					
ASA II	0.78	0.35-1.72	0.540			
ASA III	2.09	0.93-4.69	0.074			
ASA IV	2.52	0.91-6.98	0.076			
Antibiotic Prophylaxis						
Within 1 hour	Ref					
On Induction	0.56	0.22-1.48	0.245			
Cadre of Surgeons						
Resident	Ref					
Consultant Surgeon	1.31	0.57-3.01	0.521			
Cadre of Assistant Surgeon						
Resident	Ref					
Consultant Surgeon	0.99	0.15-6.33	0.988			
Other	2.24	0.97-5.13	0.058			
Incision Type						
SUMI	Ref			Ref		
Midline	0.83	0.37-1.87	0.651			
Transverse	1.44	0.48-4.34	0.512			
Paramedian	2.61	1.04-6.51	0.040	1.78	0.77-7.28	0.075

Abbreviation: **DTS** - Daytime Surgery; **NTS** – Nighttime Surgery; **RR** - Relative Risk; **aRR** – Adjusted Relative Risk; **CI** – confidence interval; **ASA** – American Society of Anesthesiologists; **SES** – Socio-economic Status; **SUMI** – Sub-umbilical midline incision.

DISCUSSION

The overall incidence of SSI in this study was 14.5%**,** comparable to the 14.9**%** reported at Thika Level 5 Hospital, Kiambu County, by Mwangi et al.[11] but notably lower than the 30.8% observed at Kenyatta National Hospital **(**KNH**)** by Miima et al.[4] The incidence of SSI was 20.3% (15/74) for daytime surgeries (DTS) and 8.5% (6/71) for

nighttime surgeries (NTS). Interestingly, this finding contrasts with that of Livingstone et al., who reported higher SSI rates following nighttime surgeries (21.9%) compared to daytime surgeries (8.6%) at a district hospital[12].

The study examined whether the timing of surgery—daytime versus nighttime—affects the incidence of surgical site infections (SSI) among patients undergoing emergency laparotomy at two referral hospitals in Kisumu City, Kenya. The null hypothesis stated that no significant association exists between time of operation and SSI occurrence. Analysis showed that SSI rates were comparable between daytime and nighttime procedures. While minor descriptive differences were noted, these were not statistically significant.

Conclusion

This study found no discernible relationship between the time of operation and the incidence of SSI following emergency laparotomy in Kisumu City, Kenya. These findings reinforce the need to focus on universal infection prevention measures rather than time-specific surgical biases.

Authors' contributions

Odera D, initiated the idea, carried out the study, and conducted data entry, cleaning, and coding. Mboya E contributed to the statistical analysis. Ogendo S, and Ogutha L supervised the study from proposal writing to the conduct to the final manuscript writing. All authors read and approved the final manuscript.

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Competing interests

The authors declare that they have no competing interests

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