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Surgical site infections post cesarean section and associated risk factors: a retrospective case-control study at a tertiary hospital in Kenya

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Background: Surgical site infection is a common healthcare-associated infection that affects maternal health, yet it can be prevented or controlled. Caesarian sections are most likely to develop surgical site infections. The rates of delivery by caesarian section in reported to be higher that the acceptable rates in some healthcare facilities. Risk factors for surgical site infections can be identified and modified to reduce the occurrence of surgical site infections. This study aims to determine the risk factors that contribute to surgical site infections post caesarian section in a tertiary teaching hospital in Kenya.
Methods: This was a retrospective case-control (1:2 matched) study conducted between 1st November 2021 to 31st October 2022 at a tertiary hospital in Nairobi. Data was extracted on surgical site risk factors as per World Health Organization's recommended preoperative measures, for both cases and controls. Descriptive statistics was used to summarize the variables and the Chi-squared test and Fisher's Exact test were used for group comparisons.
Results: A total of 1,262 caesarian deliveries were performed, 2.1% (27/1262) of which developed surgical site infections post caesarian section. The risk factors identified were not significantly associated with surgical site infection development (gestational age P=0.152, body mass index P=0.615, premature rupture of membranes P=0.253, and antibiotic prophylaxis P=0.108).
Conclusions: There was no significant association of exposure to surgical site infection risk factors with surgical site infection despite a positive trend. Other prospective methods should also be used in addition to chart reviews to determine the level of effect each risk factor has on surgical site infection.

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Abbreviations

CS	Caesarian Section
SSI	Surgical Site Infection
BMI	Body Mass Index
NHSN	National Healthcare Safety Network
WHO	World Health Organization

Introduction

Surgical site infection following caesarian section (CS) is an infection involving the abdominal incision or deep tissue within 30 days post-surgery [1]. Delivery by caesarian section is among the most performed surgeries in women. According to WHO, the rate of delivery by CS should be 10%–15% of the total deliveries, however, rates of more than 40% have been reported by several studies [2–4]. In Africa, one in five women who has CS delivery develops surgical site infection (SSI) [5]. A recent systematic review done in Ethiopia reported an overall prevalence rate of 8.81% for SSI in Ethiopia among women undergoing CS [6]. The likelihood of infections by delivery from CS is reported to be five to 20 times compared with vaginal deliveries, causing undesired outcomes such as increased morbidity and mortalities, increased hospital stays, hospital readmissions, and increased cost of treatment [4,7]. The magnitude of SSI varies with region, with prevalence ranging from 3% to 15%, on average having been documented by studies [3,8,9]. Surgical site infections following CS can be prevented and controlled when personnel performing CS promote evidence-based interventions and reduce modifiable risk factors [10]. Factors such as the patient's comorbidities (obesity, diabetes, cirrhosis, cancer, alcoholism, smoking, poor nutrition, anemia), emergency CS, duration of ruptured membranes, duration of surgery, excessive vaginal manipulation, and surgical risk have already been identified to increase the risk of developing surgical site infections [11–14]. Information on predictors of SSI in women preoperatively helps in planning active interventions during surgical deliveries and extends post-cesarean evaluation for individualized care [11,15–17].

Active SSI surveillance and infection prevention strategies are strongly recommended for the accurate determination of SSI prevalence. Factors associated with the occurrence of surgical site infections vary as they are determined by the environment where surgeries are performed, local resources, and patient and surgery-related factors [3]. Most of these risk factors are well understood and can be modified early to eliminate or reduce the risk of surgical site infections [18]. Despite available health information on factors that increase the risk of SSI, women at risk still end up with SSI post-caesarian section. Lack of or ineffective identification, management, and follow-up of women at risk have been identified as some of the reasons for the occurrence of SSIs [19]. Some recommendations suggest adopting uniform standards for assessments and health education for groups at risk with an active process that is sustained through regular programs as reliable prevention strategies [3,20]. Apart from incorporating preventive strategies in programs to reduce the infection rate, efforts that aim to reduce the rates of CS deliveries have been strongly recommended [21]. Evaluating clinical processes and interventions for women at risk of SSI post-CS will highlight areas that can be modified before, during, and after CS to reduce the occurrence of infections [22]. More attention needs to focus on guideline-based coordinated efforts for peri-operative interventions and frequent post-operative follow-up of patients at risk of SSI to monitor for wound complications following cesarean delivery [7,14,21]. The primary gap to be addressed by this arises from the recognized challenges in identifying, managing, and following up of women at risk of SSIs post-CS. Despite the existing literature on the topic, there is a lack of uniformity in the standards for assessments and health education specifically tailored to groups at risk. This study aims to determine risk factors associated with the development of surgical site infections post-caesarian section in a tertiary teaching hospital in Kenya.

Methods

This was a retrospective matched case-control observational study performed between November 1st, 2021, and October 31st, 2022, at the Aga Khan University Hospital, Nairobi. The inclusion criteria were women who had a caesarian section of all ages, all parities, single and multiple pregnancies, elective CS, and emergency CS. Cases and controls were matched for maternal age, date of surgery, and urgency of surgery. The matching criteria were simultaneously applied to controls that fulfilled all specified conditions. For controls that did not meet all the criteria, a hierarchical approach was employed.

Surgical site infection diagnosis was based on criteria by the National Healthcare Safety Network (NHSN), patients with SSI within 30 days of the operative procedure. Both cases and controls had been followed up for thirty days for surgical site infection and surveillance report retained in the hospital database. The surveillance criteria for surgical site infections was based on three classification categories. The first, a superficial incisional SSI was characterized by the presence of at least one of the following criteria: purulent drainage, isolation of organisms, and the manifestation of infection-related signs and symptoms such as pain or tenderness, localized swelling, redness, or heat. Second, deep incisional SSI, purulent drainage, an incision that spontaneously dehisces, or deliberate opening by a surgeon, coupled with the patient exhibiting signs or symptoms such as fever (>38°C) or localized pain and tenderness. The diagnosis is entrusted to a surgeon or attending physician. And lastly organ/space SSI, involved identification of an organism cultured from endometrial tissue or fluid obtained during the operation. A surgeon or attending physician establishes the diagnosis based on the presence of at least two of the following: fever (≥38°C) with no other validated causation, purulent drainage from the uterus, and abdominal pain or uterine tenderness.

The sample size was calculated using Epi Info software version 7. Based on 80% power, 95% confidence level, 35% of the controls exposed, and an odds ratio of 0.08 from the number of caesarian sections against surgical site infections, the minimum sample size required was 69; 23 cases and 46 controls using the ratio of case to control of 1:2 (Figure 1). Medical records were obtained from the records department and all files were reviewed. Medical records with incomplete data on factors associated with SSI and CS were excluded. Data

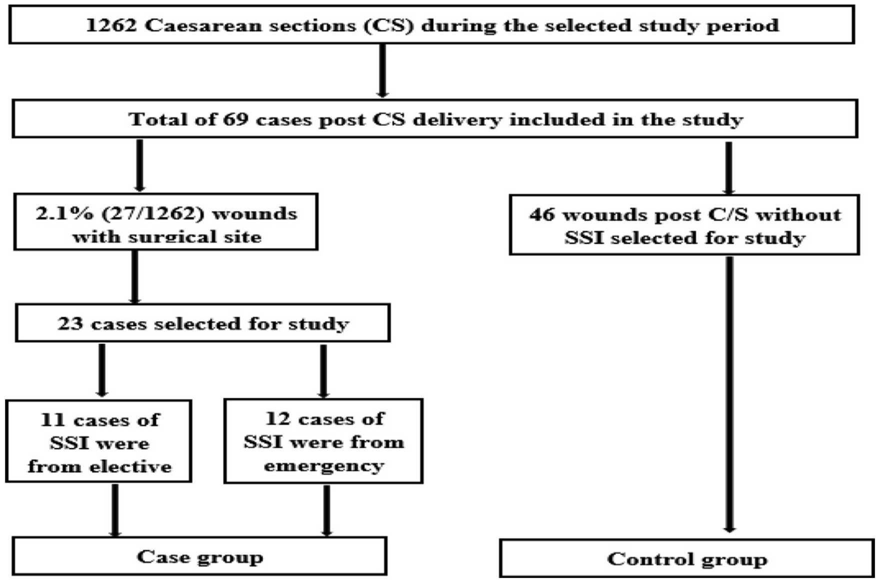

Figure 1. Flowsheet for patient selection.

abstracted were risk factors for surgical site infection which included maternal age, diabetes, hypertensive disorders, body mass index (BMI), duration of rupture of membrane, duration of rupture of membrane before surgery duration of labor, number of vaginal examinations, urgency of CS, type of CS, estimated blood loss, tissue oxygenation during CS, blood sugar control during CS, temperature monitoring during CS, surgical antibiotic prophylaxis, the timing of antibiotics, types of CS procedures, wound class, and surgical site hair removal.

Categorical data were presented as frequencies and percentages. Chi-squared test Fisher's Exact test was used to analyze the group associations based on the surgical site infections. A *P*-value less than 0.05 was considered statistically significant.

Results

The hospital had 1262 caesarian deliveries, and 2.1% [27] developed surgical site infections. Twenty three surgical site infections included in this study (85%, 23/27), four were excluded because important records were missing. This study had a total of 69 participants post caesarian section that was examined for characteristics associated with surgical site infections. Most of the participants were above 30 years of age (76.8%, 53/69), and with a BMI of above 30, (69%, 47/69). Most participants attended more than four antenatal visits (68%, 47/69), had a gestation of 37–40 weeks (80%, 55/69), and had no vaginal examinations (65%, 45/69). Elective and emergency surgeries were almost equal, 51% (35/69) and 49% (34/69) respectively. Most surgeries lasted for 30–60 minutes (74%, 51/69), estimated blood of less than 500 milliliters (71%, 49/69), and clean wound classification (84%, 58/69). Antibiotic prophylaxis was administered to almost all patients (97%, 67/69), and in most of the participants the antibiotic timing was less than 15 minutes before surgery (71%, 49/69).

There was no association between participants' age and the diagnosis of SSI (P=0.152). Other antenatal risk factors analyzed were not associated with developing SSI, gestational BMI (P=0.495), weight gain during pregnancy (P=0.686), parity (P=0.236), pre-existing diabetes (P=1.000), hypertension (P=0.468), number of antennal visits (P=0.165) and gestation age and (P=0.097) (Table I).

Risk factors during labor and surgery that are associated with surgical site infection had no significant association in this study (Table II). These included premature rupture of membranes (P=0.253), duration of labor (P=0.389), emergency caesarian sections (P=0.802), duration of surgery (P=0.490), and blood loss (P=0.532).

Surgical site infection risk factors during the intrapartum period were also found not to be statistically significant, number of vaginal examinations (P=0.781), body hair removal (P=0.569), chlorohexidine skin preparation (P=1.000), antibiotic prophylaxis (P=0.108), timing of antibiotic administration before incision, (P=0.095), blood sugar control (P=0.429) and wound classification (P=0.681). Other factors such as patient education on surgical site care and duration of hospital stay post-surgery were also not statistically significant, (P=1.000) and (P=0.426) respectively (Table III).

Surgical site-infected wounds that were classified as superficial incisional were 78.3% [18], while the rest were deep surgical site infections. The most common SSI symptom was oozing from the wound in 67% [16] cases. Only 52% [12] of infected surgical wounds had a swab taken to culture for causative organisms. Bacterial organisms were isolated in 67% [8] of the wounds that were swabbed for culture, four wound cultures were negative for any organism. *Klebsiella pneumoniae* and *Staphylococcus aureus* accounted for 50% of the organisms isolated. Most SSI events were within 14 days, 56% [13], with 39% [9] of the cases re-admitted to the hospital for management (Table IV).

Discussion

The incidence of surgical site infection post-caesarian section during the study period was 2.1%. Risk factors that were included were premature rupture of membranes, duration of

Table I
Clinical characteristics of patients who had Caesarian section

Variable		Frequencies % (*N*=69)	SSI diagnosis		*P* value
			NO (*N*=46)	YES (*N*=23)	
Age (years)	≤20	1 (1.4%)	0 (0.0%)	1 (4.3%)	0.152
	21–29	15 (21.7%)	8 (17.4%)	7 (30.4%)	
	≥30	53 (76.8%)	38 (82.6%)	15 (65.2%)	
Pre-gestational BMI (*N*=65)	≤25	13 (20.0%)	11 (23.9%)	2 (10.5%)	0.495
	25.1–29.9	27 (41.5%)	18 (39.1%)	9 (47.4%)	
	≥30	25 (38.5%)	17 (37.0%)	8 (42.1%)	
BMI at Delivery (*N*=68)	≤25	2 (2.9%)	1 (2.2%)	1 (4.5%)	0.615
	25.1–29.9	19 (27.9%)	12 (26.1%)	7 (31.8%)	
	≥30	47 (69.1%)	33 (71.7%)	14 (63.6%)	
Weight gain during pregnancy (kg) (*N*=65)	≤10	42 (64.6%)	28 (60.9%)	14 (73.7%)	0.686
	10.1–20	21 (32.3%)	16 (34.8%)	5 (26.3%)	
	20.1–30	2 (3.1%)	2 (4.3%)	0 (0.0%)	
Parity	0	17 (24.6%)	9 (19.6%)	8 (34.8%)	0.236
	≥1	52 (75.4%)	37 (80.4%)	15 (65.2%)	
Pre-existing Diabetes	No	68 (98.6%)	45 (97.8%)	23 (100.0%)	1.000
	Yes	1 (1.4%)	1 (2.2%)	0 (0.0%)	
Gestational Diabetes	No	57 (82.6%)	37 (80.4%)	20 (87.0%)	0.738
	Yes	12 (17.4%)	9 (19.6%)	3 (13.0%)	
Hypertension	No	60 (87.0%)	41 (89.1%)	19 (82.6%)	0.468
	Yes	9 (13.0%)	5 (10.9%)	4 (17.4%)	
Number of antenatal visits	0	2 (2.9%)	0 (0.0%)	2 (8.7%)	0.165
	1 to 3	20 (29.0%)	13 (28.3%)	7 (30.4%)	
	>4	47 (68.1%)	33 (71.7%)	14 (60.9%)	
Gestational age (weeks)	<28	1 (1.4%)	0 (0.0%)	1 (4.3%)	0.097
	28–36	13 (18.8%)	11 (23.9%)	2 (8.7%)	
	37–41	55 (79.7%)	35 (76.1%)	20 (87.0%)	

rupture of membranes before surgery, duration of labor, number of vaginal examinations, type of cesarean section, the urgency of cesarean section, antibiotic prophylaxis, antibiotic timing to incision, body hair removal on the surgical site, and skin preparation [1,23,24].

The results did not show statistical significance for the occurrence of surgical site infection in the group with premature rupture of membranes compared to those without. The long duration of rupture of membranes before surgery was associated with a higher occurrence but not statistically significant. This finding differs from other studies that found significant statistical associations of SSI with ruptured membranes [14,15,25]. Also, a retrospective study in Ethiopia also found that intact membranes before cesarean was a significant factor that was associated with reduced risk of SSI [22]. Another contradicting finding was the lack of significance between BMI

Table II
Labor and surgical risks factors for Wound Complications

Variables		Frequencies % (*N*=69)	SSI diagnosis		*P* value
			NO (*N*=46)	YES (*N*=23)	
Premature rupture of membranes	No	61 (88.4%)	39 (84.8%)	22 (95.7%)	0.253
	Yes	8 (11.6%)	7 (15.2%)	1 (4.3%)	
Duration of labor (hours) (*N*=20)	0–10	7 (10.1%)	4 (28.6%)	3 (50.0%)	0.389
	11–20	9 (13.0%)	6 (42.9%)	3 (50.0%)	
	> 20	4 (5.8%)	4 (28.6%)	0 (0.0%)	
Type of caesarian section	Elective	35 (50.7%)	24 (52.2%)	11 (47.8%)	0.802
	Emergency	34 (49.3%)	22 (47.8%)	12 (52.2%)	
Duration of Surgery (minutes)	≤30	7 (10.1%)	4 (8.7%)	3 (13.0%)	0.490
	31–60	51 (73.9%)	33 (71.7%)	18 (78.3%)	
	≥60	11 (15.9%)	9 (19.6%)	2 (8.7%)	
Estimated blood loss during surgery in MLS	≤500	49 (71.0%)	31 (67.4%)	18 (78.3%)	0.532
	501–1000	18 (26.1%)	13 (28.3%)	5 (21.7%)	
	>1000	2 (2.9%)	2 (4.3%)	0 (0.0%)	

Table III
Intrapartum risks factors for wound complications

Variables		Frequencies % (*N*=69)	SSI diagnosis		*P* value
			NO (*N*=46)	YES (*N*=23)	
Number of vaginal examinations	0	45 (65.2%)	29 (63.0%)	16 (69.6%)	0.781
	1–2	5 (7.2%)	3 (6.5%)	2 (8.7%)	
	3–5	16 (23.2%)	11 (23.9%)	5 (21.7%)	
	≥6	3 (4.3%)	3 (6.5%)	0 (0.0%)	
Body hair removal on surgical site (*N*=65)	No	33 (47.8%)	22 (47.8%)	11 (47.8%)	0.569
	Yes	32 (46.4%)	21 (45.7%)	11 (47.8%)	
Skin preparation	No	1 (1.4%)	1 (2.2%)	0 (0.0%)	1.000
	Yes	68 (98.6%)	45 (97.8%)	23 (100.0%)	
Antibiotic prophylaxis	No	2 (2.9%)	0 (0.0%)	2 (8.7%)	0.108
	Yes	67 (97.1%)	46 (100.0%)	21 (91.3%)	
Antibiotic timing to incision (minutes) (*N*=60)	≤ 30	56 (93.3%)	39 (95.1%)	17 (89.5%)	0.585
	> 30	4 (6.7%)	2 (4.9%)	2(10.5%)	
Blood sugar control (*N*=21)	No	2 (2.9%)	1 (6.3%)	1 (20.0%)	0.429
	Yes	19 (27.5%)	15 (93.8%)	4 (80.0%)	
Wound classification (*N*=65)	Clean	58 (84.1%)	39 (90.7%)	19 (86.4%)	0.681
	Clean contaminated	7 (10.1%)	4 (9.3%)	3 (13.6%)	
Education on surgical site care	No	2 (2.9%)	1 (2.2%)	1 (4.3%)	1.000
	Yes	67 (97.1%)	45 (97.8%)	22 (95.7%)	
Duration of hospital stay in days	0–3	46 (66.7%)	29 (63.0%)	17 (73.9%)	0.426
	≥4	23 (33.3%)	17 (37.0%)	6 (26.1%)	

and SSI, which differed with a multi-center cohort study in England that associated a BMI of 25–30 and 30 to 35 to be major independent risk factors for surgical site infection post-cesarean section and another study in Egypt that associated an increased risk of SSI with increased BMI [14,26]. Our results also found no association between the duration of labor and the occurrence of SSI, this was contrary to a five-year retrospective study in Egypt and one systematic review, whose findings strongly associated the duration of labor with SSI occurrence [25,27]. The number of vaginal examinations did not significantly influence the occurrence of SSI, contrary to findings from a previous study that associated the number of

Table IV
Epidemiology of surgical site wounds

Variable (*N*=23)		Frequencies %
SSI classification	Deep	5 (21.7%)
	Superficial	18 (78.3%)
Wound swabbed for culture	No	12 (52.2%)
	Yes	11 (47.8%)
SSI symptom	Oozing from the wound	16 (69.6%)
	Pus Collection	9 (39.1%)
	Fluid Collection	4 (17.4%)
	Fever	5 (21.7%)
	Surgical site swelling and tenderness.	13 (56.5%)
	Organism isolated from wound swab	1 (4.3%)
	Surgical site pain	12 (52.2%)
Organism isolated (*N*=8)	Acinetobacter baumannii	1 (12.5%)
	Escherichia coli	1 (12.5%)
	Klebsiella pneumoniae	2 (25.0%)
	Mixed growth	2 (25.0%)
	Staphylococcus aureus	2 (25.0%)
Duration in days before SSI	1 to 14	13 (56.5%)
	15–30	10 (43.5%)
Hospital Readmission	No	14 (60.9%)
	Yes	9 (39.1%)
SSI management	Antibiotic therapy	19 (82.6%)
	Wound care	18 (78.3%)
	Pus aspirate	5 (21.7%)
	Surgery	3 (13.0%)

vaginal examinations that was higher than 5 with SSI [23,28]. The type of cesarean section (elective or emergency) was also not significant, contradicting findings from another study that associated emergency CS with the occurrence of SSI of 5.4% compared to 0.4% occurrence in elective CS [23,29].

Administration of prophylactic antibiotic was not significant with SSI, despite a higher trend of SSI occurrence being observed among those who did not receive prophylaxis. This highlights the potential importance of antibiotic prophylaxis in reducing the risk of SSI following CS. These findings were comparable with other studies done in Brazil and Ethiopia that compared two groups, one that received antibiotics while the other did not, and found no significant association with surgical site infection [22,23]. The timing of antibiotic administration before incision had a *P*-value that suggested a trend towards a potential association but did not reach the significance threshold. Similar findings have been reported by a study done in a Brazilian women's hospital, although it noted the presence of bias associated with prophylactic or therapeutic antibiotic indications during surgery [23]. Contrary to an expert guidance document by the Society for Healthcare Epidemiology of America (SHEA), the Infectious Diseases Society of America (IDSA) and the Association for Professionals in Infection Control and Epidemiology (APIC) that prioritizes not removing body hair and skin preparation having a high quality of evidence in preventing surgical site infections, our findings did not find any association between body hair removal and skin preparation with the occurrence of SSI [30].

In contrast to our study, a study carried out in Egypt found that a parity of more than four and blood loss of more than 1000 milliliters during surgery was significantly associated with SSI incidences [27]. However, on the contrary, this study's findings were similar to findings from a study done in France which did not associate parity with SSI [8].

The incidence of surgical site infection post caesarian section during the study period was 2.1%, which is consistent with a four-year study done in Brazil that demonstrated an incidence of 1.44% [23], but contradicts a review done in sub-Saharan Africa that indicated an incidence rate of 12.5% [31]. Superficial infections were the most common wound classification, 78.3% (18/23) consistent with two regional studies that found 93% and 61.4% superficial classification of wound infection [32,33]. Wound swabbing for microbiological culture in 47% of cases was similar to the 42.2% reported in a study in a tertiary hospital in Tanzania [34]. Bacterial growth was reported in 72.7% of the wounds swabbed, which is higher than a study done in the same tertiary hospital in Tanzania [34]. Whereas NSHN lists *S.aureus*, Coagulase-negative staphylococcus, Enterococcus spp, Escherichia coli, *Pseudomonas aeruginosa*, Enterobacter spp., and *K.pneumoniae* as common wound organisms, our isolated organisms included *Acinetobacter baumannii*, *E.coli*, *K.pneumoniae*, mixed growth, and *S.aureus* [35]. Despite some overlap, the limitations in our study's sample size underscore the challenge of making direct comparisons.

Our finding on most SSI events happening within 14 days 56.5% was consistent with another finding that reported that 93% of surgical site infections happened within 15 days [34]. Hospital readmission due to surgical site infection was 39% which was much lower compared with a study in Tanzania that reported a 67.6% hospital readmission.

This study had limitations, that included limited sample size, that may have influenced the lack of notable differences in risk factors observed. Hence reducing the statistical power to detect significant associations and limit the generalizability of the findings. Also, our study's single centre, retrospective nature (and the reliance on chart reviews) inherently introduces certain bias and confounding. Chart reviews may not capture all relevant data points in patient care that could impact the development of surgical site infections. In addition, our study did not include an assessment of wound care practices and compliance to wound care education by both healthcare staff and patients. These two factors could have played a significant role in the development of surgical site infections post-caesarean section and may have contributed to the lack of statistically significant differences in observed risk factors.

Prospective methods with real-time observation of surgical practices would provide a more comprehensive and accurate assessment of risk factors. Considering these limitations, the call for better methods for future research is more pertinent. Collaborative efforts involving multiple healthcare facilities could help overcome the constraint of small sample sizes and allow for a more extensive and diverse study population. These collaborative studies would enhance the generalizability of findings and provide a more robust foundation for identifying associated risk factors that will inform preventive measures in the management of surgical site infections.

Conclusions

There were no notable distinctions in risk factors between patients who eventually developed surgical site infections and those who did not end up with surgical site infection post CS in this single hospital in Kenya. Despite the findings from this study, preventing and managing SSI remains a critical goal in surgical practice. Establishing associated risk factors may require prospective methods that will utilize real-time observation of practice to overcome limitations of retrospective chart reviews. Future research should consider enlisting multiple healthcare facilities to attain a more extensive study sample.

Ethics approval

The study was exempt from the requirement for informed consent from the Aga Khan University Hospital, Nairobi Institutional Scientific and Ethics Review Committee (ISERC) (2022/ISERC-105 (v2). Approval to undertake the study was approved by the National Commission of Science, Technology, and Innovation (NACOSTI), (NACOSTI/P/22658). All methods were carried out with relevant guidelines and regulations.

Consent for publication

Not required.

Availability of data and materials

The data that were generated and analyzed for this study are included in this manuscript.

Conflict of interest statement

Not declared.

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Authors' contributions

DO, Conceptualization, Methodology/Study design, Software, Formal analysis, Investigation, Resources, Data curation, writing original draft, Project administration. **RS**, Conceptualization, Methodology/Study design, Validation, Resources, writing review and editing, Supervision, Project administration, Funding acquisition. **AM**, Methodology/Study design, Software, writing review and editing, investigation **JS**, Software, Validation, Formal analysis, Data curation, Visualization.

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