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Surgical site infections following caesarean sections in the largest teaching hospital in Ghana

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Background: Surgical site infections complicate up to 15% of all surgical procedures depending on surgery type and underlying patient status. They constitute 14–31% of all hospital-acquired infections, placing huge financial burdens on patients, healthcare institutions and the nation.

Objective: To determine the incidence, risk factors, microbiological aetiology and antibiotic susceptibility patterns of surgical-site infections following caesarean sections (CSs) at Korle Bu Teaching Hospital (KBTH), Accra, Ghana.

Methods: This prospective study involved 500 women who underwent CS from April to July 2017 at KBTH. Overall, 474 women completed the study with 26 women lost to follow-up or opting out of the study. Women were recruited on the first postoperative day and followed-up postnatally. Sociodemographic and obstetric data were obtained using a structured questionnaire. Swabs of infected surgical wounds were taken for culture and sensitivity testing using the Kirby–Bauer disk diffusion technique. Data was analysed using SPSS version 22.

Results: Sixty-one (61/474) women (12.8%) had SSIs after CS. Of these, 41 (67.2%) were superficial, 18 (29.5%) were deep incisional and 2 (3.3%) were organ space SSIs. Significant risk factors for SSI were: emergency CS after 8 h of active labour, midline incisions, use of stored water for surgeon's pre-operative scrubbing, maternal status being single and alcohol consumption during pregnancy. *Staphylococcus aureus* was the commonest pathogen isolated with 6 (9.8%) being meticillin resistant (MRSA). Antibiotic susceptibility was mostly to quinolones.

Conclusion: SSI occurred in 12.8% of CS wounds at the KBTH, commonly caused by *S. aureus*.

Introduction

Surgical site infections (SSIs) complicate 3–15% of all surgical procedures depending on type of surgery and underlying patient status [1–3]. They constitute 14–31% of all hospital-

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acquired infections, placing huge financial burdens on patients, healthcare institutions and the nation [1,4]. SSIs are particularly common following caesarean sections (CSs) although this surgical procedure is considered a clean one [5].

Known risk factors for SSIs following CS include prolonged rupture of membranes, multiple vaginal examinations and emergency CS [2]. Medical conditions such as diabetes mellitus, obesity and anaemia also predispose mothers to SSIs following CS [2,5]. SSIs are classified based on structures involved and depth of tissue involvement [1]. *Staphylococcus aureus* remains the most common organism isolated from infected surgical sites and the community-associated meticillin-resistant *S. aureus* (MRSA) subtype is a more virulent and commonly encountered infectious agent [1].

Available literature is scanty on SSIs following CS in Ghana. This study therefore seeks to address this important knowledge gap by determining the incidence of post-CS SSIs at the Korle Bu Teaching Hospital (KBTH) (the largest Teaching Hospital in Ghana), and to identify the risk factors, bacterial isolates and their antibiotic susceptibility patterns in our context.

Methods

This was a prospective cohort study at the Obstetric Unit of the Korle Bu Teaching Hospital, Accra (the largest teaching hospital in Ghana) from 1st April to 30th July 2017. The unit records between 10,000 and 11,000 deliveries annually with an average CS rate of about 40%. CSs are performed by Residents, Senior Residents and Specialists. Interns also perform CS under supervision by Senior Residents and Specialists. Pre-operative preparations include a perineal shave at least 72 hours prior to surgery, extensive counselling prior to surgery and admission 18–24 h prior to the surgery. Scrub-up is performed using clean running water mostly but occasionally has to be done with water stored in clean containers. Betadine or Hibitane are the scrub solutions of choice. Antibiotic prophylaxis is administered at induction of anaesthesia and urethral catheterization is performed in theatre after anaesthesia. Most CSs are approached by the Pfannenstiel incision, and the uterine incisions are placed in the lower segment. Polyglyactin-910 (Vicryl) is the suture type of choice for closure of all layers and the subcuticular suture technique is performed for skin closure.

Inclusion criteria for this study included women who had elective and emergency CS at the maternity unit of KBTH during the study period and consented to the study. Non-attendants with no hospital records, critically ill women, women who had additional surgeries (including obstetric hysterectomies and myomectomies) and women who died during the follow-up period (from causes other than SSIs) were excluded from the study. The minimum sample size for this study was obtained using the Peduzzi formula [22].

Written informed consent was given by all the participating pregnant women after the study protocol was approved by the Ethical and Protocol Review committee of the College of Health Sciences, University of Ghana (CHS–Et/M.7-P3.1/2016–2017). Women who delivered through elective and emergency CS at the unit and met the eligibility criteria were consecutively recruited into the study until the predetermined sample size was obtained.

Interviews were conducted on the first postoperative day. Two interviewer-administered data-collection forms were employed, a structured questionnaire gathered data on socio-demographic characteristics, risk factors, obstetric, labour and birth records. An SSI form gathered data from all women who developed SSIs. The surgical sites were inspected on the third postoperative day, and again during the second- and fourth-week postnatal visits for evidence of infection including induration, dehiscence, serous or purulent discharge and subcutaneous haematoma formation. Patients who displayed any of these signs or symptoms outside the specified review days also had wound swabs taken. The women were followed up for 30 days. All wounds suspected to be infected were swabbed using a sterile collection technique (the Lavine technique) and transported to the Microbiology laboratory within 2 h of collection. Cultures were performed using standard blood, chocolate and McConkey agar media and antibiotic susceptibility tested. Results were interpreted using the 'Antibiotic interpretive zone criteria for the Department of Medical Microbiology' of the KBTH developed from M100-S Vol. 26 No. 3–CLSI Standard 2016. *S. aureus* positive cultures were subjected to Oxacillin in Mueller–Hinton agar culture to detect MRSA strains.

Culture and sensitivity results were communicated to the women and attending doctors for appropriate treatment. Management of SSIs followed the Department of Obstetrics and Gynaecology (KBTH) protocols.

SSIs were classified as superficial, deep incisional and organ space using the Centers for Disease Control and Prevention's (CDC) National Nosocomial Infections Surveillance System (January 2016). Data was entered into an Excel spreadsheet and exported into SPSS version 22(IBM, Armonk, NY, USA) for analysis. Odds ratios (ORs) with 95% confidence intervals (CIs) were calculated and a $P<0.05$ was considered significant.

Results

A total of 1221 births were recorded at KBTH over the study period, of which 528 (43.24%) were by CS. Of the 500 eligible women, 474 (94.8%) completed the study with 26 women lost to follow-up or opting out of the study. Sixty-one cases of SSI were identified, giving an incidence of 12.8% (Figure 1). Thirteen (21.3%) of these were detected before discharge from hospital and 48 (78.7%) detected during post-discharge follow-up surveillance. The median day of diagnosis was seventh postoperative day. Of the 61 SSIs, 41 (67.2%) were superficial incisional, 18 (29.5%) were deep incisional and two (3.3%) were organ space infections. Mean gestational age at CS was 38.7 ($\pm$2.6) weeks. Mean age of patients who developed SSI was 28.3 ($\pm$4.4) years, significantly lower than those without SSIs 31.5 ($\pm$5.2) years (Table I).

Women with SSIs were more likely to be single and engaged in alcohol consumption (>3 L per week) whilst pregnant. Additionally, women with SSIs were more than twice as likely to have had at least one prior CS (aOR 2.58 (95% CI 1.29–5.19)) and they were significantly more likely to have been in active labour at least 8 h before CS (aOR 4.70 (95% CI 1.84–12.01)). Fifty-one (83.6%) of the SSIs occurred following emergency CS (most of which were performed during the late first stage of labour); and women who had SSIs were about four-times more likely to have had an emergency CS compared with those with

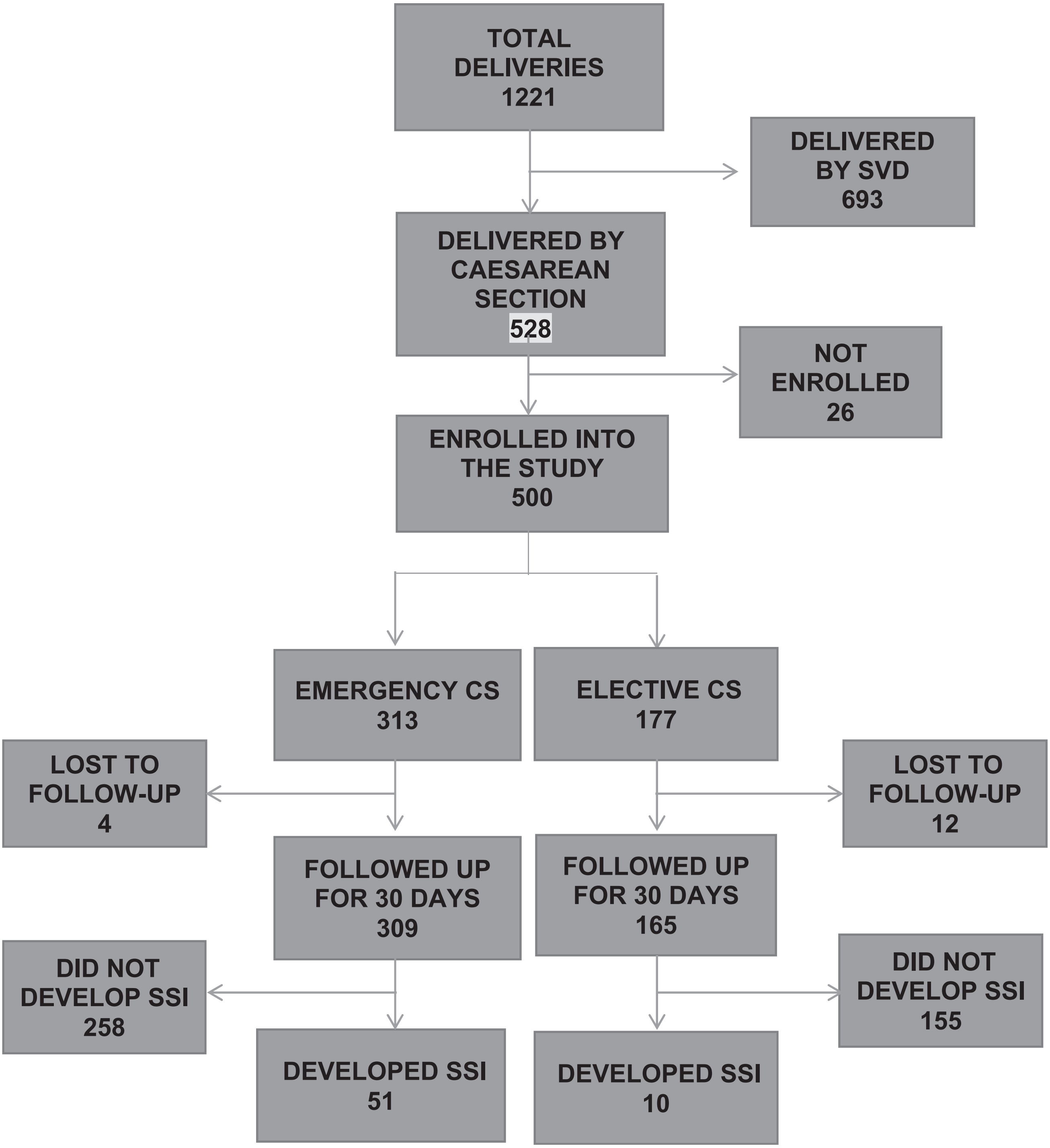

Figure 1. Activity flow chart. CS, caesarean section; SSI, surgical site infection; SVD, spontaneous vaginal delivery.

uninfected wounds (aOR 4.7 (95% CI 1.22–17.75)). SSI risk increased significantly when pre-operative scrubbing was performed using stored water compared with running tap water (aOR 2.78 (95% CI 1.41–4.48)) (Table II).

Hypertensive disorders in pregnancy (associated with other pregnancy complications) were the most common indications for emergency CS, and constituted 11 (18.0%) of the 61 CSs with SSIs. The surgeon's level of expertise or qualification was not significantly associated with the risk of developing SSI (P=0.412). Women with SSIs were about 12-times more likely to have had a midline incision (aOR 12.5 (95% CI 2.10–73.6)) compared with a low transverse (Pfannenstiel or Joel–Cohen incision). Medical conditions including diabetes mellitus, obesity, anaemia and HIV infection did not significantly increase the risk of developing SSIs. There was no significant association between prolonged rupture of membranes (at least 12 h before CS) and SSIs (Table III).

Swabs were obtained from 59/61 infected wounds, as two infected wounds had no discharge. Cultures and antibiotic susceptibility tests were performed on all wound swabs. Micro-

Table I
Sociodemographic characteristics

Variable	SSI N = 61	Uninfected N = 413	OR (95% CI)	*P*
Age group (years)				**0.041**
<20	5 (8.2)	10 (2.4)		
20–34	47 (77.0)	304 (73.6)		
≥35	9 (14.8)	99 (24.0)		
Mean age	28.3 (SD 4.4)	31.5 (SD 5.2)		**<0.0001**
Marital status			2.20 (1.22–3.97)	**0.005**
Married	41 (67.3)	338 (81.8)		
Single	20 (32.7)	75 (18.2)		
Highest level of education				0.421
No education	2 (3.3)	34 (8.2)		
Primary school	6 (9.8)	43 (10.4)		
High school (JHS/SHS)	35 (57.4)	248 (60.0)		
Tertiary and above	18 (29.5)	88 (21.3)		

CI, confidence interval; JHS, junior high school; OR, odds ratio; SHS, senior high school; SSI, surgical site infection.

organisms were isolated in 54 (91.5%) cases of SSI, while five (8.5%) yielded no bacterial growth. Eight (13.1%) cultures reported polymicrobial growth. *S. aureus* was the most common isolated organism in 26 (42.6%) cases. Six (9.8%) were MRSA (Table IV).

Most isolated bacteria (33.1%) were susceptible to quinolones, while amikacin had the broadest spectrum of activity against the isolated micro-organisms. Amoxicillin-clavulanic acid (2.6%) and clindamycin (3.0%) had very low spectrum of coverage in this study. *S. aureus* and *Escherichia coli* isolates were most sensitive to amikacin and ciprofloxacin whilst MRSA was sensitive to vancomycin in two cases and quinolones in three cases. The majority of enterobacterales isolated were sensitive to amikacin and ceftriaxone. *Pseudomonas aeruginosa* was sensitive to amikacin and norfloxacin in most cases while Enterococcus spp., Acinetobacter spp. and Citrobacter spp. were sensitive to amikacin in three cases and co-trimoxazole in one case (Table V).

Discussion

The incidence of SSI following CS in this study was 12.8%, higher than that reported in Nigeria (9.3%) [7] but similar to 12.65% in India and 11.2% in the UK [8–10]. Much lower incidences (1.4–3.7%) were reported from Oman, Brazil and Israel [11–13]. About 78.7% of SSIs in this study were identified on post-discharge follow-up surveillance, similar to findings by Dhar *et al*. (70.61%) [11].

Most SSIs we found were superficial and 3.3% were organ space SSIs, much lower than rates reported from India

Table II
Sociodemographic characteristics

Variable	SSI N = 61	Uninfected N = 413	OR (95% CI)	*P*
Residence			–	0.379
Urban	61 (100.0)	401 (97.1)		
Peri-urban	0 (0.0)	12 (2.9)		
Occupation				**<0.001**
Artisan/trader/skilled worker	36 (59.0)	330 (79.9)		
Professional	19 (31.1)	68 (16.5)		
Student	2 (3.3)	11 (2.7)		
Housewife/unemployed	4 (6.6)	4 (1.0)		
Parity				0.811
0	22 (36.1)	134 (32.4)		
1–4	38 (62.3)	269 (65.1)		
5+	1 (1.6)	10 (2.4)		
Alcohol consumption during pregnancy			7.4 (3.5–15.3)	**<0.001**
Yes	16 (26.2)	19 (4.6)		
No	45 (73.8)	394 (95.4)		
Smoking			–	1.000
Yes	0 (0.0)	2 (0.5)		
No	61 (100.0)	411 (99.5)		

CI, confidence interval; JHS, junior high school; OR, odds ratio; SHS, senior high school; SSI, surgical site infection.

Table III
Multivariate logistic regression of risk factors for surgical site infection

Variables	AOR (95% CI)	P
Age group (years)		
35+	1	
0–19	0	1.00
20–34	2.61 (0.64–10.56)	0.18
Marital status (single)	4.81 (1.21–19.17)	0.03
Occupation		
Unemployed	1	
Artisan/skilled worker/trader	1.80 (0.3–11.11)	0.78
Professional	19.57 (0.23–1634.73)	0.19
Alcohol consumption during the pregnancy	5.97 (1.32–26.98)	0.02
Previous caesarean section	2.51 (0.69–9.19)	0.16
Antenatal clinic visits (≥4)	1.25 (0.32–4.83)	0.74
Number days on admission prior to delivery	1.33 (0.94–1.90)	0.11
Duration of labour preceding caesarean section (≥8 h)	75.67 (6.61–866.24)	0.01
Urgency of caesarean section (emergency)	4.66 (1.22–17.75)	0.02
Duration of surgery (≥60 min)	3.61 (0.87–15.02)	0.08
Type of incision (midline)	12.55 (2.14–73.63)	0.05
Source of scrub water (stored water)	18.60 (3.55–97.56)	0.01
Type of anaesthesia (general)	0.26 (0.03–2.06)	0.20

AOR, adjusted odds ratio; CI, confidence interval.

(23.5%) and Vietnam (24.4%) [14,15]. Findings from these two studies were attributed to wound contamination during the CS. Labour exceeding 8 h before CS was the most important risk factor for SSIs in this study. Further, there was a four-fold increase in this risk of SSI following emergency CS. Emergency CSs following labour (especially prolonged active phase of labour) complicated by rupture of membranes (≥12 h) and multiple vaginal examinations have been associated with an increased risk of SSI [6]. Inadequate pre-operative preparations and severity of underlying indication for emergency CS have been suggested as predispositions [16]. Prolonged labour is usually associated with multiple vaginal examinations [2]. In the presence of ruptured membranes, the risk of chorioamnionitis increases significantly. Chorioamnionitis has been reported as a major risk factor for SSI due to contamination of the surgical incision during the CS [17]. Although chorioamnionitis was an indication for emergency CS in three patients (4.9%) who developed SSIs, the association was not statistically significant.

Although only 8.4% of women in this study had vertical (midline) skin incisions, these women were about 12-times more likely to develop SSIs compared with those with a transverse skin incision. This may be attributed to relatively poorer vascularity in the midline and higher risk of wound dehiscence in vertical incisions [6,11]. This study found an 18-fold increase in the risk of SSI when stored water was used for pre-operative scrub rather than running water. Running water is not always available in KBTH Obstetric theatres; this necessitates the use of stored water, thus increasing the risk of contamination.

Consistent with our findings, many authors report a previous surgical scar as a major risk factor for SSIs. This emanates from diminished tissue elasticity, changes in skin composition, poor wound edge apposition during skin closure and longer duration of surgery from adhesions and scar formation [13].

Table IV
Classification of micro-organisms isolated from infected caesarean section wounds

Gram positive isolates	*N* (%)	gram negative isolates	*N* (%)	NBG
Staphylococcus aureus	26 (32.8)	*Enterobacterales*	19 (31.7)	5 (8.1)
MRSA	6 (9.8)	*Escherichia coli*	7 (11.5)	
MSSA	20 (42.6)	Enterobacter spp	1 (1.6)	
		Proteus mirabilis	4 (6.6)	
Streptococcus spp.		*Proteus vulgaris*	2 (3.8)	
		Klebsiella pneumoniae	4 (6.6)	
Streptococcus agalactiae	1 (1.6)	*Klebsiella oxytoca*	1 (1.6)	
		Acinetobacter spp	1 (1.6)	
		Citrobacter spp	2 (3.2)	
		Enterococcus	1 (1.6)	
		Pseudomonas	4 (6.6)	

Table V
Antibiotic classes and susceptibility patterns

Antibiotic class	*N*	%
Quinolones *(Ciprofloxacin, Norfloxacin, Levofloxacin)*	26	25.2
Aminoglycosides (*Gentamicin, Amikacin)*	19	18.5
Penicillins (*Amoxicillin + Clavulanic Acid, Cloxacillin)*	17	16.5
Cephalosporins (*Ceftriaxone, Cefotaxime, Cefuroxime)*	16	15.5
Imipenems (*Meropenem*)	10	9.7
Co-trimoxazole	5	4.8
Macrolide *(Erythromycin)*	3	3.0
Lincosamide *(Clindamycin)*	3	3.0
Tetracycline	2	1.9
Vancomycin	2	1.9
Total	103	100

Alcohol consumption during pregnancy was a significant predictor of SSI in our study. This corroborates findings by Delgado-Rodriguez *et al.*, that heavy alcohol consumption increased the rate of all-site nosocomial and in-hospital SSIs in general surgery [18]. However, other large-scale trials on the association between alcohol consumption and SSIs have reported conflicting results. Another review concluded that alcohol consumption was not an independent risk factor for SSIs [19]. SSIs were not significantly associated with the level of expertise of the surgeon who performed the CS. Mpogoro *et al.*, on the contrary, reported a four-fold increased risk of SSI following CS performed by interns and junior residents [6]. Maternal infections such as HIV and Hepatitis-B did not increase the risk of SSIs in our study, contrary to findings from other studies [11,13,14].

The 'culture-positive' rate of 91.5% from our study was much higher than reported in most previous studies [2,6,10]. However, the 13.1% polymicrobial isolate rate in this study is lower than the 22.2% in Tanzania, 19.9% in Oman and 24.2% in the UK [6,11,14]. *S. aureus* was the most common isolate in this study and MRSA showed resistance patterns similar to those reported from Tanzania (16.7%) [6].

Pre-operative antibiotic prophylaxis using amoxicillin-clavulanic acid and metronidazole in KBTH is similar to practice in 64% of UK hospitals [14] and consistent with 2012 NICE guidelines. A 2014 Cochrane Review reported a 60–70% reduction in SSIs for women who receive antibiotic prophylaxis for CSs [20,21]. Low susceptibility of bacterial isolates to amoxicillin–clavulanic acid may explain the high SSI rate in our study.

In conclusion, SSIs occurred in 12.8% of CS wounds at the KBTH. Significant risk factors were being single, younger age, previous CS, use of barrel-stored water for pre-operative scrubbing, at least 8 h in labour prior to CS and midline skin incisions. The most common microbe was *S. aureus*, mostly susceptible to quinolones.

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Author contributions

C.N.O. led the research; C.N.O., P.E.S. and M.N. drafted the manuscript. K.N., M.A.N. and M.-M.O. reviewed the manuscript.

Conflict of interest statement

The authors declare no conflicts of interest.

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References

[1] Centers for Disease Control and Prevention (CDC). In: Surgical site infection (SSI) event, 1; 2016. p. 1–26.
[2] Jido T, Garba I. Surgical-site infection following cesarean section in Kano, Nigeria. Ann Med Health Sci Res 2012;2(1):33–6.
[3] Tuuli MG, Liu J, Stout MJ, Martin S, Cahill AG, Odibo AO, et al. A randomized trial comparing skin antiseptic agents at cesarean delivery. N Engl J Med 2016;374:647–55.
[4] National Collaborating Centre for Women's and Children's Health. Surgical site infection: prevention and treatment of surgical site infection, vol. 74. National Institute for Health and Care Excellence – Clinical Guidelines; 2008. p. 168.
[5] Saeed K, Greene R, Corcoran P, O Neill S. Incidence of surgical site infection following caesarean section: a systematic review and meta-analysis protocol. BMJ Open 2017;7:e013037.
[6] Mpogoro FJ, Mshana SE, Mirambo MM, Kidenya BR, Gumodoka B, Imirzalioglu. Incidence and predictors of surgical site infections following caesarean sections at Bugando Medical Centre, Mwanza, Tanzania. Antimicrob Resist Infect Control 2014;3(1):25.
[7] Ezechi OC, Edet A, Akinlade H, Gab-Okafor CV, Herbertson E. Incidence and risk factors for caesarean wound infection in Lagos Nigeria. BMC Res Notes 2009;22(2):186.
[8] Shrestha S, Shrestha R, Shrestha B, Dongol A. Incidence and risk factors of surgical site infection following cesarean section at Dhulikhel Hospital. Kathmandu Univ Med J 2014;46(2):113–6.
[9] Johnson A, Young D, Reilly J. Caesarean section surgical site infection surveillance. J Hosp Infect 2006;64(1):30–5.
[10] WHO recommendations on antenatal care for a positive pregnancy experience. Geneva: World Health Organization; 2016. p. 1–152.
[11] Dhar H, Al-Busaidi I, Rathi B, Nimre EA, Sachdeva V, Hamdi I. A study of post-caesarean section wound infections in a regional referral hospital, Oman. Sultan Qaboos Univ Med J 2014;14(2):211–7.
[12] Farret TCF, Dallé J, da Silva Monteiro V, Riche CVW, Antonello VS. Risk factors for surgical site infection following cesarean section in a Brazilian Women's Hospital: a case–control study. Braz J Infect Dis 2014;19:1–5.
[13] Schneid-Kofman N, Sheiner E, Levy A, Holcberg G. Risk factors for wound infection following cesarean deliveries. Int J Gynecol Obstet 2005;90(1):10–5.
[14] Wloch C, Wilson J, Lamagni T, Harrington P, Charlett A, Sheridan E. Risk factors for surgical site infection following caesarean section in England: results from a multicenter cohort study. BJOG 2012;119(11):1324–33.
[15] Tran TS, Jamulitrat S, Chongsuvivatwong V, Geater A. Risk factors for post cesarean surgical site infection. Obstet Gynecol 2000;95(3):367–71.
[16] Nwankwo EO, Ibe IN, Enabulele OI. Incidence and risk factors of surgical site infection in a tertiary health institution in Kano, Northwestern Nigeria. Int J Infect Control 2012;8:1–13.

[17] Killian CA, Graffunder EM, Vinciguerra TJ, Venezia RA. Risk factors for surgical site infections. Infect Control Hosp Epidemiol 2014;22(10):613—7.
[18] Delgado-Rodríguez M, Gómez-Ortega A, Sillero-Arenas M, Llorca J. Epidemiology of surgical-site infections diagnosed after hospital discharge, a prospective cohort study. Infect Control Hosp Epidemiol 2001;22(1):24—30.
[19] Shabanzadeh D, Sørensen L. Alcohol drinking does not affect postoperative SSI or anastomotic leakage: a systematic review and meta-analysis. J Gastrointest Surg 2013 Jul 9:18.
[20] National Institute for Health and Care Excellence (NICE). Caesarean section. Clinical guidelines. NICE; 2017. 2017.
[21] Smaill FM, Grivell RM. Antibiotic prophylaxis versus no prophylaxis for preventing infection after cesarean section. Cochrane Database Syst Rev 2014;10:1—53.
[22] Peduzzi P, Concato J, Kemper E, Holford TR, Feinstein AR. A simulation study of the number of events per variable in logistic regression analysis. J Clin Epidemiol 1996 Dec;49(12):1373—9.