Maternal factors are important predictors for surgical site infection following cesarean section in Northwest Ethiopian

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ABSTRACT

Background: Surgical site infection (SSI) is a common surgical complication following cesarean section (C/S) that increases maternal morbidity, duration of hospital stay and the cost of treatment. It is more prevalent in Sub-Saharan Countries, including Ethiopia. As the best of authors knowledge, limited representative data in the study setting. Therefore, this study aimed to figure out the magnitude and factors associated with surgical site infection.

Methods: Client record review was employed from 818 mothers who underwent cesarean section in University of Gondar comprehensive specialized hospital from January 1, 2018 to January 1, 2019. Charts were selected using systematic random sampling technique. Data were entered into EPI info version 7.0 and then exported to SPSS version 20 for analysis. Descriptive statistics, bivariate, and multivariable logistic regression were applied to summarize the data. A p-value < 0.05 was a cut-off point to declare statistical significance.

Results: This study revealed that the prevalence of SSI was 12.2% with 95% CI (9.96–14.44). Chorioamnionitis [AOR = 6.46, 95% CI (1.82–22.71)], diabetes mellitus [AOR = 6.02, 95% CI (1.69–21.36)], rupture of membrane more than 12 h before cesarean section [AOR = 2.94, 95% CI (1.52–5.67)], meconium-stained amniotic fluid [AOR = 2.43, 95% CI (1.23–4.81)] and anemia [AOR = 3.44, 95% CI (1.56–7.56)] were significantly associated factors with SSI following cesarean delivery.

Conclusion: The magnitude of SSI was high, and maternal related (medical and obstetrical) factors were found significant association with it. Improvement of early identification of risk factors, and prompt treatment/control of obstetrical and medical complications are the recommendations.

1. Introduction

According to the Centers for Disease Control and Prevention (CDC); surgical site infection (SSI) is defined as infection which occurs within 30 days after surgical procedure involving skin, subcutaneous tissue, soft tissue, or any other part of the anatomy as being either incisional or organ space.¹ Incisional SSIs are divided into superficial incision those involving only skin and subcutaneous tissue, deep incisional SSI which involved the deeper soft tissue of the incision and organ/space involves any part of the anatomy other than incisional body wall layers.² SSI is common surgical complication among patients delivered with cesarean section (C/S) which increase maternal morbidity, stay of hospital and the cost of treatment.³ According to World Health Organization (WHO) global health report (2014), direct (obstetric) infections are the third

most common cause of maternal mortality, representing about 10.7% of maternal deaths, with the largest toll estimated in low-income and middle-income countries (LMICs) at 10.7% compared with high-income countries (HICs) at 4.7%.

Cesarean delivery is effective in saving maternal and infant life, but only done with obstetric indications (to mother or baby need) and the ideal rate for this procedure to be between 10% and 15%.⁴ In 2015, an estimated 29.7 million (21.1%) births globally were by CS.⁵ According to World Congress of Gynecology and Obstetrics; 6.2 million unnecessary cesareans done each year.⁶ A review study conducted in Sub-Saharan African countries showed that the overall cesarean section (CS) rate was 12.4% with a range of 1.0%–41.9%. SSIs following cesarean section in this area was 15.6%,⁷ and 93% of the infection were superficial.⁸ The incidence of SSI was consistently higher (23.2%) in

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low-human development index countries, even after adjusting for factors describing patients, diseases, procedures, safety, and hospitals.⁹ Over uses of antibiotics particularly in the postoperative period is associated with increased antimicrobial resistance and contribute for increment of SSI.¹⁰ The cost of SSI in terms of mortality, morbidity, health-care costs, and loss of productivity is enormous.⁸ Significant effect on quality of life for the patient, extended hospital stays,¹¹ and cost burden health care system as personal and family level.¹² Most SSIs are preventable. Different measures can be taken in the pre-operative phase (like; preoperative showering, avoid frequent vaginal examination, nasal decolonization, hair removal, patient theatre wear, staff theatre wear, staff leaving the operating area, hand jewellery, artificial nails and nail polish, antibiotic prophylaxis), intra-operative phase (hand decontamination, Sterile gowns, incise drapes, antiseptic skin preparation, maintaining patient homeostasis, antiseptics and antibiotics before wound closure, wound dressings, and closure methods) and post-operative phases of care (like; hanging dressings, postoperative cleansing, antibiotic treatment of surgical site infection and treatment failure) can reduce risk of infection.¹¹

Studies in different parts of the world showed that preterm delivery,¹³ multiple vaginal examination,^{14,15} mothers from rural setting,¹⁶ prolonged labor,^{15–18} prolonged rupture of membrane,^{15,17} premature rupture of membrane (PROM),¹⁶ chorioamnionitis,^{16–18} smoking,¹³ hypertensive disorder,^{14,18} severe anemia,^{14,15,17} reactive in human immune deficiency virus,¹⁶ diabetes mellitus (DM),¹⁸ increase blood loss during surgery,^{16,19} and operation performed by junior physicians^{14,17} were the independent factors frequently associated with SSI following cesarean delivery.

Post cesarean wound sepsis reduction helpful to minimize the unnecessary morbidity and associated socioeconomic consequences for the patient and her family.²⁰ Hence, finding risk factors to SSI and prevent accordingly will be vital to reduce occurrence of SSI and its consequences because majority of SSI are preventable. However, the studies regarding to this specific topic is limited in Gondar referral hospital which is cesarean section as the most common surgical procedure. Therefore, this study aimed to assess the magnitude SSI after cesarean delivery and associated factors among mothers who gave birth through cesarean section at University Gondar comprehensive and specialized hospital from January 1, 2018 to January 1, 2019.

2. Methods and materials

2.1. Study design, area, and period

A retrospective cross-sectional chart review was employed among mothers who underwent cesarean delivery in University of Gondar comprehensive and specialized hospital found in Gondar city. Gondar is one of a few metropolitan cities in Ethiopia, found about 741 Km Northwest of Addis Ababa, the country's capital city. University of Gondar comprehensive and specialized hospital is one of the biggest tertiary level teaching hospitals. According to records from the hospital's information center, every year more than 200,000 people visit this hospital. In addition, this hospital used as research and practical teaching center for Medicine and other health science students with different specialty programs. Different gynecologic and obstetric procedures including elective cesarean section, emergency cesarean section and gynecologic surgeries are done in operation rooms found at urogynecology ward, main operation theater and labor ward. The data was collected from April 1, 2019 to May 30, 2019.

2.2. Source and study populations

All mothers who gave birth by cesarean section at University of Gondar comprehensive and specialized hospital were source population, and those who gave birth by cesarean section in this hospital from January 1st, 2018 to January 1st, 2019 were study population.

2.3. Sample size determination and sampling procedure

The sample size was estimated using a single population formula with the following assumptions: confidence level of 95%; 2% margin of error; and 9.4% proportion of surgical site infection following cesarean delivery that was conducted at Felege-hiwot Specialized Hospital.¹⁸ With these assumptions, the calculated sample size for this study was 818. A total of 3210 mothers gave birth through cesarean section in this hospital for the last one year preceding to this study. Then, all mothers' chart identified and listed in ascending order by using their card numbers from operation registration book and check its completeness. Then, 2954 complete maternal charts were assured and systematic sampling technique was employed to select the candidate charts with sampling interval (K) of three.

2.4. Data collection and analysis

Data were abstracts from mothers who gave birth by cesarean section in University of Gondar comprehensive and specialized hospital from January 1st, 2018 to January 1st, 2019. A total of 818 maternal charts were abstracted to access necessary data using well-structured abstraction checklist which was adapted from similar studies conducted in various parts of the world. The checklist consisted of three main items: socio-demographic related characteristics of mothers, maternal (obstetrical medical) related factors, and surgery (anesthesia and operation) related factors were extracted from maternal charts. Six (6) trained general practitioner physicians were recruited for data extraction, and two, year two resident (R-II) physician students assigned as supervisors. Completeness of data were checked on daily basis.

The extracted data were cleaned, coded, and entered Epi-info version 7.0, then exported to SPSS version 20 for analysis. Descriptive statistics were employed, and the results were presented in text and tables. Then, bivariate and multivariate logistic regression were applied orderly to find significant variables associated with SSI with P-value <0.25 and 0.05, respectively. We also checked multicollinearity between variables by using a variance inflation factor (VIF) with the value of greater than 10 were not taken into the final model. The goodness-of-fit was checked by using the Hosmer-Lemeshow test. Finally, Variables with p-value <0.05 were considered as statistically significant.

2.4.1. Operational definition

Post cesarean section Surgical Site Infection: An infection which is developed after cesarean delivery on the operational site which is diagnosed by clinician.³

Prolonged hospital stays: hospital stay lasting more than 7 days.

Prolonged operation time: defined as cesarean section lasting more than 1 h from skin incision to last skin stitch.

3. Results

3.1. Socio-demographic characteristics

A total of 818 women's chart were enrolled in this study. The mean age of the women was 27.2 years with SD of ± 5.9 years, and 590 (72.2%) were with the age range of 20–34 years followed by 136 (16.6%) ≥ 35 years of age. Four-hundred sixty-four (56.7%) of the participants were living in an urban area, and 806 (98.5%) of them were married.

3.2. Maternal (obstetric and medical) related factors

Two-fifth (39.9%) of the women were Primi-para and 726 (88.8%) of the mothers had ANC follow up history. About 396 (48.4%) of them had rupture of membrane prior to the surgery. Of these, 92 (23.3%) of them had rupture of membrane more than 12 h and 100 (14.6%) of women were having more than 24 h of duration of labor. Around two-third of

women having term pregnancy and one-fourth of participants (27.6%) had meconium-stained amniotic fluid. Related to medical diseases, eighty-seven (10.6%) mothers developed pregnancy-induced hypertension, 65 (7.9%) mothers had anemia and 19 (2.3%) women were HIV positive (Table 1).

3.3. Anesthesia and operation-related characteristics

All women underwent cesarean delivery were given prophylaxis antibiotics within 30 min before operation. About 688 (84.1%) cesarean sections were emergency and 742 (90.7%) of skin closure technique was subcuticular. All the cesarean sections were finished within 1 h, almost all 98.8% and 99% were having estimated blood loss less than or equal to 1 L and taken spinal anesthesia respectively (Table 2).

3.4. Magnitude of SSI and indications for cesarean section

The overall magnitude of surgical site infection in this study was 100 (12.2%). Regarding the type of surgical site infection; about 88 (88%) of infections were superficial and 12(12%) were deep. Of 100 mothers who developed SSI following cesarean delivery, 60% were detected after discharge when mothers came back for follow up or complain. All of SSIs were detected within two weeks of post-operative days.

Table 1

Obstetrical and medical related characteristics of women underwent cesarean section at University of Gondar comprehensive and specialized hospital, Amhara Regional State, Ethiopia, 2019 (n = 818).

Variables	Category	Frequency	Percentage (%)
Parity	Primipara (para1)	326	39.9
	Para 2-4	366	44.7
	Grand multipara (≥5)	126	15.4
ANC Follow up	Yes	726	88.8
	No	92	11.2
If “yes” Number of visits(n = 726)	1 time	10	1.4
	2-4 times	494	67.7
	≥5 times	226	31
Onset of labor	Induced	128	15.6
	Spontaneous	558	68.2
	No labor	132	16.1
Duration of labor in hours (n = 686)	< 24	586	85.4
	≥24	100	14.6
Duration of ROM before C/S in hours (n = 396)	< 12	304	76.8
	≥12	92	23.2
Gestational age	Preterm	72	8.8
	Term	524	64.1
	Post-term	82	10
	Unknown	140	17.1
Presence of meconium	Yes	226	27.6
	No	592	72.4
Presence of chorioamnionitis	Yes	15	1.83
	No	803	98.17
Pregnancy-induced hypertension	Yes	87	10.6
	No	731	89.4
Anemia	Yes	65	7.9
	No	753	92.1
Diabetes mellitus	Yes	28	3.4
	No	790	96.6
HIV/AIDS	Yes	19	2.3
	No	799	97.7
On HAART	Yes	17	89.4
	No	2	10.6
Pneumonia	Yes	34	4.2
	No	784	95.8
UTI	Yes	26	3.2
	No	792	96.8

Abbreviations: ANC; Antenatal Care, ROM; Rupture of Membrane, C/S; Cesarean Section, HIV/AIDS; Human immunodeficiency virus, HAART; Highly Active Antiretroviral Therapy, UTI; Urinary Tract Infection.

Table 2

Anesthesia and operation-related characteristics of women underwent cesarean section at University of Gondar comprehensive and specialized hospital, Amhara Regional State, Ethiopia, 2019 (n = 818).

Variable	Category	Frequency	Percentage (%)
Circumstance of surgery	Emergency	688	84.1
	Elective	130	15.9
Type of anesthesia	Spinal	810	99
	General	8	1
Type of skin incision	Pfannenstiel	726	88.8
	Midline	92	11.2
Type of skin closure	Interrupted	76	9.3
	Subcuticular	742	90.7
Thickness of subcutaneous tissue	≤2 cm	778	95.1
	> 2 cm	40	4.9
Level of surgeon	Year 4 resident	230	28.1
	Year 3 resident	273	33.3
	Year 2 resident	316	38.6
Post-operation hematocrit	≥30%	753	92.1
	< 30%	65	7.9
Intra-operative blood loss	≤1000 ml	816	99.8
	> 1000 ml	2	0.2

Among mothers who underwent cesarean section, non-reassuring fetal heart rate pattern 194 (23.7%) was the most common indication followed by previous cesarean section scar 138(16.9%) and latent first stage of labor or early active phase of first stage of labor grade 2 or 3 meconium-stained amniotic fluid 122 (14.9%) (Fig. 1).

3.5. Factors associated with surgical site infection

There were 9 independent variables in binary logistic regression which had $p < 0.25$ and became candidate for multivariable regression: duration of labor, rupture of membrane before surgery, chorioamnionitis, diabetes mellitus, HIV/AIDS, pregnancy-induced hypertension, anemia, meconium-stained amniotic fluid, and circumstance of surgery. After controlling all confounders in the multivariable analysis maternal (obstetric and medical) factors like: chorioamnionitis, diabetes mellitus, anemia, meconium-stained amniotic fluid, and duration of rupture of membrane more than 12 h before cesarean section were significantly associated with $p < 0.05$.

Mothers who had chorioamnionitis were 6.46 times more likely to develop surgical site infection as compared to their counterparts [AOR = 6.46, 95% CI = 1.82–22.71]. Those mothers who had diabetes mellitus were 6.02 more likely to develop surgical site infection than non-diabetic mother [AOR = 6.02, 95% CI = 1.69–21.36]. Mothers who were having more than 12 h of rupture of membrane before cesarean section were 2.94 times more likely at risk for surgical site infections than less than 12 h of rupture of membrane [AOR = 2.94, 95% CI = 1.52–5.67]. Mothers who had meconium-stained amniotic fluid (MSAF) during labour delivery and being anemic were 2.43 and 3.44 times more likely to develop SSI following CS compared to their counterparts with [AOR = 2.43, 95% CI 1.23–4.81] and [AOR = 3.44, 95% CI = 1.56–7.56] respectively (Table 3).

4. Discussion

The magnitude of surgical site infection following cesarean section in this study was 12.2% with [95% CI (9.6–14.44)]. The magnitude of SSI in this study was in line with the study finding at Tanzania (10.9%)¹⁴ and various parts of Ethiopia: Hawassa (11%), Mekelle (11.7%), and Jimma (1.4%).^{16,17,21} The similarities could be due to the study setting, patients' background and surgeons who performed the operations. However, the finding was higher than the value obtained from United States 5.5%,¹³ and Oman (2.66%).²² It was also higher than the endogenous findings of Bahirdar (9.4%),¹⁸ Miachew (6.8%),³ and Assela (9.4%).²³ The reason may be due to the difference of socio-economic status, quality of care and level awareness between developing and

Fig. 1. This graph shows the distribution of indications for cesarean section done at University of Gondar comprehensive and specialized hospital, Amhara Regional State, Ethiopia, 2019.

Abbreviations: NRFHR; Non reassuring fetal heart rate pattern, MSAF; Meconium-stained amniotic fluid, CPD & OL; Cephalo-pelvic disproportion and obstructed labour, APH; antepartum hemorrhage and others; Sever oligohydramnios, cervical arrest, cord prolapse, fetal macrosomia and previous fistula repair.

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Table 3

The bivariate and multivariable association of surgical site infections and independent factors among women who underwent cesarean section at University of Gondar comprehensive and specialized hospital, Amhara Regional State, Ethiopia, 2019.

Characteristics	Surgical site infection		COR (95%CI)	AOR (95%CI)	P-value
	No	Yes			
Meconium-stained amniotic fluid					
No	545(92%)	47(8%)	1.00	1.00	0.011**
Yes	173(76.5%)	53(23.5%)	3.55(2.31–5.45)	2.43(1.23–4.81)	
Chorioamnionitis					
No	712(88.7%)	91(11.3%)	1.00	1.00	0.01**
Yes	6(37.5%)	9(62.5%)	11.7(4.68–37.14)	6.46(1.82–22.7)	
Circumstance of surgery					
Emergency	592(86%)	96(14%)	5.10(1.85–14.15)	1.08(0.89–1.19)	0.999
Elective	126(96.9%)	4(3.1%)	1.00	1.00	
Post-operative hematocrit					
≥33%	677(89.9%)	76(10.1%)	1.00	1.00	0.002**
< 33%	41(63%)	24(37%)	5.21(2.99–9.00)	3.44(1.56–7.56)	
Diabetes mellitus					
No	700(88.6%)	90(11.4%)	1.00	1.00	0.005**
Yes	18(64.2%)	10(35.8%)	4.32(1.93–9.65)	6.02(1.69–21.36)	
HIV/AIDS					
No	704(88.1%)	95(11.9%)	1.00	1.00	0.09
Yes	14(73.6%)	5(26.4%)	2.64(0.93–7.51)	2.96(0.84–10.4)	
Pregnancy induced hypertension					
No	647(88.5%)	84(11.5%)	1.00	1.00	0.101
Yes	71(81.6%)	16(18.4%)	1.76(0.96–3.12)	2.11(0.86–5.17)	
Duration of labor in hours					
≤24	522(88.3%)	66(11.7)	3.39(2.05–5.55)	1.26(0.62–2.58)	0.52
> 24	70(70%)	30(30%)			
Duration of rupture of membrane before cesarean section in hours					
≤12	266(87.5%)	38(12.5%)	1.00	1.00	0.001**
> 12	60(66.7%)	30(33.3%)	3.73(2.16–6.45)	2.94(1.52–5.67)	

Note: ** Significantly associated variables with P value < 0.05, 1.00: reference variable.

developed countries. Whereas, the difference with endogenous findings could be due to flow of patients. In fact, university of Gondar hospital delivery report showed that there were around 1000 deliveries per month which was not comparable with the number of beds the hospital had. So that, patient overcrowding might have an impact for spreading of causative agents for infections. On the other side, this finding was lower than the value obtained from Uganda (16.4%),²⁴ and Malaysia (18.8%).¹⁹ This discrepancy could be due to the study design. We have used charts to access the data but the above-mentioned studies used observational follow-up study design. Therefore, observational follow-up study helps to get more patients who developed SSIs after discharge and those who visited other health facilities for the infections.

There were five independent maternal related factors (three obstetrical and two medical) were significantly associated with SSI. Duration of rupture of membrane more than 12 h before cesarean section was an independent risk factor for surgical site infection. This finding is supported with study conducted in Oman.²² It is also similar with the study done in Ethiopia Miachew, Mekelle, Hawassa, and Assela.^{3,16,17,23} The possible explanation could be, membrane is one of protective barrier for ascending infection. When membrane rupture, this protection is lost and poly-microbial organisms easily ascend during vaginal examination and cause infection during uterine and skin incision. Diabetes mellitus was noted to be another independent risk factor for surgical site infection. It was supported by other studies done in Oman and India.^{22,25} Also, similar with the findings of Ethiopia, Bahirdar and Assela.^{18,23} This may be due to increasing glucose level in the blood exerts multiple opposing effects on well recognized cellular immunity. Most importantly, acute, short-term hyperglycemia affects all major components of innate immunity and impairs the ability of the host to combat infection. In case of long-standing diabetes mellitus; vascular complications that impairs adequate tissue perfusion, and oxygenation is crucial factor for wound healing process.

In this study chorioamnionitis was also another independent factor associated with surgical site infection. This finding is consistent with the study conducted in Ethiopia; Mekelle, Bahirdar, Jimma, and Assela.^{16,18,21,23} This might be explained by the fact that once the amniotic fluid is contaminated, during cesarean section this fluid will have leakage and contamination with peritoneum and skin incision which predisposed the incision site to be infected. The presence of meconium-stained amniotic fluid was strongly associated with increased risk of surgical site infection. This finding was consistent with the study done in Jimma.²¹ The plausible explanation is that contaminated incision site with thick meconium serves as good media for bacterial proliferation.

Finally, post-operative hematocrit less than 33% (anemia) was significantly associated with surgical site infection. This finding was agreed with the study done in Oman,²² Tanzania,¹⁴ Hawassa,¹⁷ and Assela.²³ In general, low hematocrit concentration reduces the oxygen tension in the wound and increases the risk of wound infection by compromising the activity of macrophages and impeding wound healing progress.

4.1. Limitation

This study has all drawbacks of cross-sectional study design and using secondary data. In addition, patients were not followed after being discharged from the hospital.

4.2. Prior evidences and added value of this study

The problem's magnitude and the risk factors from the previous studies were heterogenous. Infrastructure (facility) and socio-demographic related factors were frequently influenced the occurrence of surgical site infection following cesarean delivery. Involving multiple sectors effort and working for long time are needed to prevent the aforementioned factors. However, in this study, only maternal

(obstetrical and medical) factors were identified as influencing factors that are easily preventable. The obstetrical factors (prolonged PROM, chorioamnionitis, and meconium-stained amniotic fluid) can be prevented by proper risk assessment and management during ANC follow up and within care providers scope of management skill. Additionally, this study proves the prior studies and helps to reach scientific consensus, which factors come to the clinicians' mind when they provide obstetrical care to prevent infections. Again, this finding is new (up-to-dated) compared with the previous national and international reports.

5. Conclusion

The magnitude of surgical site infection following cesarean section was high compared to the standard CDC guidelines of surgical site infection. Maternal related factors including obstetrical (prolonged rupture of membrane prior to cesarean section, chorioamnionitis and meconium-stained amniotic fluid), and medical factors (diabetes mellitus and anemia) were found significantly associated with surgical site infections following cesarean section. Improvement of early identification of risk factors, and prompt treatment/control of obstetrical and medical complications are the recommendations. To understand more about the nature of the problem, further observational studies set as recommendation as well.

Ethical approval and consent to participate

Ethical clearance was obtained from institutional ethical review board of University of Gondar (Ref No: SOM/1368/2019). Consent for the record of review was obtained from institute review board and University of Gondar comprehensive specialized hospital. Records were coded and kept confidential. The data were not be used for any purpose other than the study aims. Lastly, we confirm that this study was conducted in accordance with the Declaration of Helsinki.

Availability of the data and materials

The datasets used and/or analyzed during the current study are available from corresponding author upon on reasonable request.

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Declaration of competing interest

The authors declare that they have no competing interests.

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Abbreviations

ANC	Antenatal care
AOR	Adjusted odds ratio
CI	Confidence interval
COR	Crude odds ratio
CS	cesarean section
PROM	premature rupture of membrane
ROM	Rupture of membrane
SSI	Surgical site infection

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