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Research Article

Incidence of Post-cesarean Section Wound Infections in Emergency and Elective Cases at a Tertiary Healthcare Center in Egypt

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Abstract

Introduction: Infections at the site of a cesarean section (CS) can lead to longer hospital stays, increased medical costs, and a range of other health complications, including higher mortality rates. For women who experience postoperative wound infections, the recovery process after a cesarean delivery becomes significantly more challenging.

Objectives: The purpose of this study was to compare the incidence of postoperative wound infections between emergency and elective cesarean cases at a tertiary healthcare center in Egypt.

Patients and Methods: This prospective cohort study included 220 patients who underwent either elective or emergency CSs. The patients were divided into two groups: those who underwent emergency CSs and those who underwent elective CSs. Each patient was monitored for 8 weeks post-surgery, with regular wound inspections. An audit form was used to document the occurrence of both minor and major wound infections to track infection rates.

Results: Surgical site infections (SSIs) were identified in 28 patients. Of these, 13 patients (11.82%) were in the emergency CS group, and 15 patients (13.64%) were in the elective CS group. The difference in infection rates between the two groups was not statistically significant. Multiple logistic regression analysis identified rural residence, hypertension, membrane rupture, general anesthesia, blood loss ≥500 ml, and low postoperative hemoglobin levels as significant independent predictors for the incidence of SSIs ($P < 0.05$).

Conclusion: The study identified significant independent predictors of postoperative SSIs following CSs, including rural residence, hypertension, membrane rupture, general anesthesia, blood loss ≥500 ml, and low postoperative hemoglobin levels. Furthermore, no significant difference in the risk of SSI was observed between emergency and elective CSs.

Keywords: post cesarean section, wound infections, emergency CS, elective CS, SSI

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1. Introduction

Cesarean sections (CS) are one of the most commonly performed surgical procedures worldwide, particularly in situations where vaginal delivery poses risks to the mother or child [1]. Understanding the complications associated with this procedure, such as surgical site infections (SSIs), is crucial for improving maternal health outcomes. According to international reports, CS rates typically range from 5–25% of all births, reflecting global health recommendations. However, certain countries, like Egypt, show significantly higher rates. In 2015, Egypt was identified as having one of the highest cesarean rates globally, at 51.8%, highlighting a substantial deviation from the international norm [2]. Although the reasons for the rising rates of cesarean deliveries are not entirely clear, this trend is evident globally and raises concerns about possible overuse [3].

SSIs are a common and serious complication following CSs, with reported rates worldwide between 3–20%. The major differences in SSI rates can be attributed to varying study populations, risk factors, and healthcare practices. A study conducted at a tertiary referral hospital in Egypt revealed that the incidence of SSI after cesarean delivery was 5.34%. Considering Egypt's inflated cesarean rate, this statistic is concerning and emphasizes major issues within the nation's healthcare system. However, it is important to mention that this SSI rate is relatively low compared to other developing countries [2].

After a CS, SSI can arise from several risk factors, which are typically divided into three categories: procedure-related, patient-related, and healthcare provider-related factors [4]. Patient-related factors encompass conditions such as diabetes, obesity, socio-economic status, and prolonged rupture of membranes (PROM) [2]. Procedure-related factors include issues like blood loss, urinary catheter usage, and surgery duration. Provider-related factors involve inadequate surgical experience and non-compliance with infection control protocols [5]. Addressing and understanding these risk factors is essential for effectively reducing the incidence of SSI in Egypt.

Preventing SSI following a CS necessitates a comprehensive approach involving pre-operative, intra-operative, and post-operative strategies. Pre-operative measures aim to improve the patient's health and reduce infection risks. This may include managing blood sugar levels in diabetic patients, treating any existing infections, and providing suitable antibiotic prophylaxis. While weight management is advised for obese patients, further studies are necessary to establish its effectiveness in lowering SSI risk [1]. Patient education is critical, focusing on the importance of hygiene, early ambulation, and the ability to recognize infection symptoms. Implementing these strategies can greatly decrease the risk of SSI [2].

During the intra-operative phase, it is essential to strictly follow surgical antimicrobial protocols. This includes proper skin preparation, appropriate surgical attire, and minimizing the duration of the surgery. The choice of antiseptic solution and the timing of antibiotic administration are also important factors. Antibiotics should be administered before making the skin incision rather than after cord clamping, as this method effectively lowers post-cesarean infections. Post-operative care, which involves wound management, early removal of urinary catheters, and monitoring for early signs of infection, is critical [1].

Although negative pressure wound therapy (NPWT) shows potential, particularly for obese patients, more research is required to confirm its overall effectiveness. These measures are critical for lowering the risk of SSI following cesarean delivery [6].

In the last thirty years, the incidence of SSI has considerably decreased due to improvements in hygiene standards, antibiotic prophylaxis, sterile techniques, and other clinical practices. Nonetheless, the risk of SSI could rise again due to ongoing challenges. Delivering high-quality care and implementing early interventions to prevent wound infections are foundational aspects of patient safety initiatives [7].

The aim of this study was to compare the incidence of post-cesarean wound infections between emergency and elective cases at El-Hossien Hospital, a tertiary healthcare center in Egypt, and identify predictive factors related to wound infection.

2. Patients and Methods

2.1. Study Design and Setting

This prospective cohort study was conducted at the Obstetrics and Gynecology Department of El-Hossien Hospital, a tertiary healthcare center in Egypt, from May 2023 to May 2024. The study adhered to the strengthening the reporting of observational studies in epidemiology (STROBE) guidelines. Ethical approval was obtained from the local ethical committee (Approval Code: 596), and written informed consent was obtained from all participants.

2.2. Study Population

The study included 220 women aged 18 years or older with a body mass index (BMI) below 25 kg/m^2 who underwent CSs. These patients were evenly divided into two groups: 110 women who underwent emergency CSs and 110 women who underwent elective CSs.

2.3. Exclusion Criteria

Exclusion criteria were patients with immunodeficiency or diabetes, bleeding disorder, previous uterine surgery other than CS, malignancy, and refusal to participate.

2.4. Study Procedures

All patients underwent a thorough assessment, which included taking a complete medical history—covering personal details, current complaints, obstetric history, menstrual history, past medical and surgical history, as well as family history. Additionally, a general examination was performed, assessing vital signs

such as blood pressure, temperature, heart rate, and respiratory rate, along with calculating the BMI. CS was performed using the Pfannenstiel or midline approach and wound closure was based on Altman et al., [8]. Laboratory investigations were also performed (CBC and urinalysis).

2.5. Surgical Procedure

CS procedures were performed using either the Pfannenstiel or midline approach, with wound closure techniques following the standardized methods described by Altman et al., [8]. The surgical process involved making a Pfannenstiel or midline incision to access the peritoneal cavity and a transverse incision in the lower uterine segment for delivery. After the infant was delivered and the placenta was removed, the uterus was closed in multiple layers. The abdominal layers were then sequentially closed using absorbable sutures for the internal layers and non-absorbable sutures for the skin. Finally, a sterile dressing was applied to the incision site, and patients were monitored for 8 weeks post-surgery to evaluate recovery.

2.6. Outcome Measures

The primary outcome of the study was the incidence of post-CS wound infections in both groups. Secondary outcomes included wound-related complications such as dehiscence, seroma, and hematoma, as well as the length of hospital stay, intensity and duration of surgical site pain, antibiotic usage (type, frequency, and duration), patient satisfaction with the procedure and recovery, and maternal morbidity, including wound breakdown, fever, sepsis, and prolonged hospitalization.

2.7. Sample Size Calculation

The sample size was calculated using Epi Info STATCALC, based on prior research by Jasim et al., [9]. A 95% confidence level, 80% power, and α error of 5% were applied to detect an absolute difference of 8% points in SSI incidence between the two groups. The required sample size was 100 per group, which was increased to 110 per group to account for potential dropouts.

3. Data Management and Analysis

3.1. Data Collection

Information gleaned from medical histories, clinical examinations, laboratory investigations, and outcome measures underwent a systematic coding process. This coded data were subsequently entered into Microsoft Excel for organized management.

3.2. Statistical Analysis

Statistical analysis was performed using SPSS v26 (IBM Inc., Armonk, NY, USA). Quantitative variables were expressed as means and standard deviations (SD) and compared between the two groups using an unpaired Student's *t*-test. Qualitative variables were presented as frequencies and percentages, analyzed using the Chi-square test or Fisher's exact test as needed. A two-tailed P-value of less than 0.05 was considered statistically significant. Logistic regression is used to estimate the relationship between a dependent variable and multiple independent variables to identify independent predictors of surgical site infections (multiple).

4. Results

Table **1** shows an irrelevant difference among both studied groups regarding the baseline characteristics (age, family history, weight, height, BMI, residence, gestational age, and gravidity and parity), comorbidities (dyslipidemia and hypertension), vital signs (pulse, SBP, DBP, RR, and temperature), and laboratory investigations (WBCs and PLT).

Table 1: Baseline characteristics, comorbidities, vital signs, and laboratory investigations of the studied groups.

		Emergency CS Group (n=110)	Elective CS Group (n=110)	P-value
Age (years)	**Mean ± SD**	28.4±1.88	28.5±1.19	0.732
	Range	22-33	26-31	
Weight (kg)	**Mean ± SD**	67.3±10.92	67.9±10.12	0.696
	Range	50-85	50-85	
Height (m)	**Mean ± SD**	1.7±0.03	1.7±0.03	0.800
	Range	1.65-1.75	1.65-1.75	
BMI (kg/m^2)	**Mean ± SD**	23.5±3.99	23.6±3.61	0.775
	Range	16.65-24.5	17.04-24.98	
Residence	**Urban**	62 (56.36%)	57 (51.82%)	0.498
	Rural	48 (43.64%)	53 (48.18%)	
Family history		27 (24.55%)	24 (21.82%)	0.631
Gestational age (weeks)	**Mean ± SD**	38.1±0.89	38±0.95	0.510
	Range	36-39	36-41	
Gravidity	**1**	44 (40%)	29 (26.36%)	0.095
	2	31 (28.18%)	40 (36.36%)	
	3	35 (31.82%)	41 (37.27%)	
Parity	**Nullipara**	39 (35.45%)	46 (41.82%)	0.332
	Multipara	71 (64.55%)	64 (58.18%)	

Table 1: Continued.

		Emergency CS Group (n=110)	Elective CS Group (n=110)	P-value
Dyslipidemia		16 (14.55%)	34 (30.91%)	0.118
HTN		32 (29.09%)	35 (31.82%)	0.627
Pulse (bpm)	**Mean ± SD**	98.9±1.84	98.7±1.38	0.408
	Range	95-104	96-102	
SBP (mm/Hg)	**Mean ± SD**	124.4±10.09	125.6±9.82	0.344
	Range	110-140	110-140	
DBP (mm/Hg)	**Mean ± SD**	75.6±9.14	76.5±9.44	0.514
	Range	60-90	60-90	
RR (breath/min)	**Mean ± SD**	15.4±1.81	15.6±1.7	0.516
	Range	13-18	13-18	
Temperature (°C)	**Mean ± SD**	36.9±0.14	36.9±0.1	0.367
	Range	36.6-37.2	36.7-37.1	
WBCs (*10^9/L)	**Mean ± SD**	8.3±1.55	8.1±1.55	0.434
	Range	5.7-11	5.7-11	
PLT (*10^9/L)	**Mean ± SD**	284.3±44.41	275±44.12	0.118
	Range	200-350	200-348	

Data are presented as mean ± SD or frequency (%). BMI: Body mass index, HTN: Hypertension, SBP: Systolic blood pressure, DBP: Diastolic blood pressure, RR: Respiratory rate, WBCS: White blood cells, PLT: Platelet count.

Obstetric data (rupture of membrane), procedural-related characteristics (type of anesthesia used, and duration of procedure, skin closure technique, type of skin incision, blood transfusion, and estimation of blood loss), postoperative data (postoperative hemoglobin level, incidence of postoperative fever, postoperative maternal tachycardia, and pain), wound complication (wound dehiscence, seroma, and hematoma), and length of hospital stay were irrelevantly different among both groups as shown in Table **2**.

Table 2: Obstetric data, procedural-related characteristics, postoperative data, wound complication, and length of hospital stay of the studied groups.

		Emergency CS Group (n=110)	Elective CS Group (n=110)	P-value
Rupture of membrane		29 (26.36%)	35 (31.82%)	0.373
Number of vaginal examinations	**None**	37 (33.64%)	110 (100%)	-
	1–3 times	33 (30%)	-	
	≥4 times	40 (36.36%)	-	
Onset of labour	**Induced**	31 (28.18%)	-	-
	Spontaneous	79 (71.82%)	-	
Type of anesthesia used	**General**	40 (36.36%)	39 (35.45%)	0.405
	Spinal	70 (63.64%)	71 (64.55%)	
Duration of procedure	**≤60 min**	77 (70%)	87 (79.09%)	0.121
	>60 min	33 (30%)	23 (20.91%)	

Table 2: Continued.

		Emergency CS Group (n=110)	Elective CS Group (n=110)	P-value
Type of skin incision	**Pfannenstiel**	97 (88.18%)	94 (85.45%)	0.549
	Midline	13 (11.82%)	16 (14.55%)	
Skin closure technique	**Interrupted**	34 (30.91%)	23 (20.91%)	0.090
	Subcuticular	76 (69.09%)	87 (79.09%)	
Blood transfusion		10 (9.09%)	5 (4.55%)	0.181
Estimation of blood loss	**<500 ml**	92 (83.64%)	99 (90%)	0.163
	≥500 ml	18 (16.36%)	11 (10%)	
Postoperative Hb (g/dL)	**Mean± SD**	10.8±1.43	11.0±1.28	0.403
	Range	6-13	6-12.9	
Postoperative fever		3 (2.73%)	4 (3.64%)	0.700
Postoperative maternal tachycardia		3 (2.73%)	2 (1.82%)	0.651
Pain		8 (7.27%)	11 (10%)	0.471
Postoperative offensive vaginal discharge		0 (0%)	0 (0%)	-
Wound complications	**Wound dehiscence**	2 (1.82%)	4 (3.64%)	0.564
	Seroma	3 (2.73%)	6 (5.45%)	
	Hematoma	5 (4.55%)	4 (3.64%)	
Length of hospital stay	**< 2 days**	97 (88.18%)	94 (85.45%)	0.549
	> 2 days	13 (11.82%)	16 (14.55%)	

Data are presented as mean ± SD or frequency (%). Hb: Hemoglobin.

SSI was reported in 28 patients, 13 (11.82%) patients in the group of patients underwent emergency CS and 15 (13.64%) patients in the group of patients underwent elective CS, with no significant difference between both groups as shown in Table **3**.

Table 3: Incidence of SSI of the studied groups.

	Emergency CS Group (n=110)	Elective CS Group (n=110)	P-value
SSI	13 (11.82%)	15 (13.64%)	0.387

SSI: Surgical site infection.

Regarding the incidence of SSI, residence was significantly different between SSI and no SSI groups ($P < 0.001$), indicating higher incidence in rural areas compared to urban areas. Hypertension and rupture of membrane, general anesthesia, and estimation of blood loss (≥ 500 ml) were substantially higher in the SSI group in relation to no SSI group ($P < 0.001$), with no substantial difference among both groups regarding dyslipidemia. The SSI group had a considerably longer procedure time (> 60 min) than the no SSI group ($P = 0.006$). The SSI group had significantly lower postoperative hemoglobin levels compared to the no SSI group ($P < 0.001$). Other baseline characteristics (age, family history, and parity), number of vaginal examinations, onset of labor, type of skin incision, skin closure technique, and blood transfused were irrelevantly different among both groups as shown in Table **4**.

Table 4: Baseline characteristics, comorbidities, obstetric data, procedural-related characteristic, and postoperative Hb of the studied groups regarding SSI incidence.

		SSI (n=28)	No SSI (n=192)	P-value
Age (years)	**Mean± SD**	28.4±2.79	28.5±1.31	0.726
	Range	22-33	26-32	
Residence	**Urban**	6 (21.43%)	113 (58.85%)	< 0.001*
	Rural	22 (78.57%)	79 (41.15%)	
Family history		4 (14.29%)	47 (24.48%)	0.232
Parity	**Nullipara**	14 (50%)	71 (36.98%)	0.186
	Multipara	14 (50%)	121 (63.02%)	
Comorbidities	**Dyslipidemia**	7 (25%)	43 (22.4%)	0.758
	HTN	21 (75%)	46 (23.96%)	< 0.001*
Rupture of membrane		13 (46.43%)	51 (26.56%)	< 0.001*
Type of anesthesia used	**General**	17 (60.71%)	62 (32.29%)	0.003*
	Spinal	11 (39.29%)	130 (67.71%)	
Duration of procedure	**≤60 min**	15 (53.57%)	149 (77.6%)	0.006*
	>60 min	13 (46.43%)	43 (22.4%)	
Type of skin incision	**Pfannenstiel**	24 (85.71%)	167 (86.98%)	0.853
	Midline	4 (14.29%)	25 (13.02%)	
Skin closure technique	**Interrupted**	9 (32.14%)	48 (25%)	0.420
	Subcuticular	19 (67.86%)	144 (75%)	
Estimation of blood loss	**<500 ml**	19 (67.86%)	173 (90.1%)	0.001*
	≥500 ml	9 (32.14%)	19 (9.9%)	
Blood transfused		4 (14.29%)	11 (5.73%)	0.093
Postoperative Hb (g/dL)	**Mean± SD**	10.2±1.85	11±1.15	< 0.001*
	Range	6-13	9-13	

*: statistically significant as P value < 0.05, SSI: surgical site infections and HTN: hypertension, Hb: hemoglobin.

Table **5** identifies significant independent predictors of SSIs based on multivariate logistic regression analysis. Rural residence (OR = 11.77, 95% CI: 3.57–38.76, P = 0.015) is a significant risk factor, indicating that patients from rural areas are more likely to develop SSI compared to those from urban areas. Hypertension (OR = 91.49, 95% CI: 21.30–393.03, P < 0.001) also significantly increases the risk of SSI, as does rupture of membranes (OR = 61.49, 95% CI: 11.20–337.63, P < 0.001). General anesthesia (OR = 14.79, 95% CI: 1.27–172.62, P = 0.031) is a risk factor compared to spinal anesthesia, while blood loss of ≥500 ml (OR = 19.82, 95% CI: 3.44–114.28, P = 0.001) significantly elevates the risk of SSI. Lastly, low postoperative hemoglobin (OR = 12.15, 95% CI: 4.21–19.61, P = 0.002) is a strong risk factor, with each unit decrease in hemoglobin level is associated with increased SSI incidence. These results underscore the importance of addressing modifiable risk factors such as optimizing blood loss management and postoperative hemoglobin levels to mitigate SSI risk.

Table 5: Multivariate logistic regression analysis for prediction of SSI.

	Odds ratio	95% CI	P value
Residence (rural)	11.7693	3.5740 to 38.7565	**0.015***
HTN (Yes)	91.4922	21.2983 to 393.0278	<**0.001***
Rupture of membrane (Yes)	61.4949	11.2005 to 337.6303	<**0.001***
Type of anesthesia (General)	14.7863	1.2666 to 172.6202	**0.031***
Skin closure technique (Subcuticular)	7.2497	0.2266 to 231.9303	0.262
Estimation of blood loss (≥500 ml)	19.8188	3.4370 to 114.2797	**0.001***
Low postoperative Hb (g/dL)	12.1524	4.2136 to 19.6124	**0.002***

Hb: hemoglobin, SSI: surgical site infections, HTN: hypertension, CI: confidence interval, *: statistically significant as P value < 0.05.

5. Discussion

Infections affecting the abdominal incision or deeper tissues within 30 days after CS surgery are referred to as SSIs [10].

Compared to vaginal births, the risk of infection during CS delivery is eight times higher, leading to unfavorable consequences including higher treatment costs, longer hospital stays, and more deaths and morbidity [2]. Incidence estimates for SSI range from 3–15% across different regions, according to the available research [11].

Factors that can raise the risk of SSIs include the patient's history of certain medical conditions (e.g., obesity, diabetes, cirrhosis, cancer, alcoholism, smoking, poor nutrition, or anemia), the number of emergency CSs performed, the amount of vaginal manipulations performed, the severity of the surgery itself, and the length of time that has passed since the ruptured membranes were closed [12].

Preoperative knowledge of factors that increase the risk of SSIs in women allows for more targeted treatment after CSs and more active intervention during surgical deliveries. For an accurate assessment of SSI incidents, it is highly advised to implement active surveillance and infection prevention measures [13, 14].

Women who are at risk for SSI still experience it after a CS, even when there is health information accessible about the variables that raise the risk. One of the reasons SSIs happen is because women at risk are not properly diagnosed, managed, or followed up with. One set of suggestions is to implement consistent evaluation criteria and health education programs for vulnerable populations as a proactive measure that can be maintained over time [15].

In this study, no significant differences were observed between the emergency and elective CS groups regarding the length of hospital stay or wound complications such as dehiscence, seroma, and hematoma. SSIs occurred in 13 patients (11.82%) in the emergency CS group and in 15 patients (13.64%) in the elective CS group, with no statistically significant difference between the groups. SSI incidence was notably higher in women from rural areas, hypertensive patients, and those with membrane rupture ($P < 0.001$). Other

factors, including age, family history, parity, dyslipidemia, skin closure technique, and blood transfusion, were not significantly associated with SSI.

In this study, general anesthesia was significantly more common in the SSI group compared to the no SSI group (P = 0.003). Additionally, a prolonged procedure duration (>60 minutes) (P = 0.006), higher blood loss (≥500 ml) (P = 0.001), and lower postoperative hemoglobin levels (P < 0.001) were all significantly associated with SSI. Multivariate logistic regression analysis identified rural residence, hypertension, membrane rupture, general anesthesia, blood loss ≥500 ml, and low postoperative hemoglobin levels as independent predictors of SSI, each significantly increasing the risk. Other variables were not found to be significant predictors of SSI.

Similarly, Odada et al. conducted a retrospective case-control study at a Kenyan tertiary teaching hospital to investigate the causes of SSIs following CSs. Of the 1262 CSs performed, 27 cases (2.1%) developed SSIs. The study found no significant difference in the duration of hospital stay between the SSI and non-SSI groups [16]. Likewise, Mezemir et al. carried an observational cohort study to assess the incidence, bacterial profile, and contributing factors of SSIs after CS in public and private referral hospitals. Among the 741 women studied, 86 developed SSIs, yielding an incidence rate of 11.6% (95% confidence interval) [17].

In agreement with our findings, Abdallah et al. [18] examined 500 women who underwent elective CSs and found that SSI was more common in rural areas than urban areas (P = 0.05). In contrast, Odada et al. [16] determined that the incidence of SSIs was not significantly different between groups with early membrane rupture and those without. Although a longer duration of membrane rupture prior to surgery was linked to a higher incidence of SSIs, this association was not statistically significant. Hypertension was present in both the SSI and non-SSI groups, but the difference was not statistically significant.

In line with our study, Gomaa et al. [2] conducted a retrospective observational study at a tertiary hospital to identify the incidence, risk factors, and management of SSIs following CS. Among the 15,502 CSs performed during the study period, 828 cases resulted in SSIs. A significant association between SSIs and both hypertension (5.0%) and PROM (43.6%) was observed (P < 0.001). Similarly, Rose et al. [19] evaluated the incidence, causes, and treatment of infections at the CS site in Ethiopia through a retrospective analysis. Among 247 women, the study identified intact membranes before CS as a key protective factor against SSIs.

Consistent with previous research [12, 14, 20], our results demonstrated that SSIs were significantly more common in patients with ruptured membranes. However, in contrast to our study, Gomaa et al. [2] found no statistically significant variation in patient residency between SSI and non-SSI groups.

In parallel with our findings, Odada et al. [16] reported that the SSI group had slightly higher values for age, parity, and the number of vaginal exams per participant. Similarly, Dessu et al. [21] found no statistically significant difference between groups who received blood transfusions after CS and those who did not (P = 0.308) in their case-control study on SSIs in public hospitals in Eastern Ethiopia. However, they observed that the SSI group had older participants and more vaginal exams per person (P = 0.0001).

Consistent with our results, a study conducted in France on 1520 patients undergoing CS found no association between parity and SSI [11]. In contrast, Gomaa et al. [2] found that parity greater than four was significantly associated with higher SSI incidence, but their study revealed no significant difference between SSI and non-SSI groups concerning age.

In parallel with our findings, Gomaa et al. [2] reported that blood loss exceeding 1000 milliliters during surgery, longer CS duration (>1 hour), and prolonged labor (≥24 hours) were significantly associated with SSI. Similarly, Getaneh et al. [20] conducted a systematic review and meta-analysis at the national level, identifying prolonged operation duration and anemia (low hemoglobin) as significant factors increasing the odds of SSI after CS.

In agreement with our study, Abdallah and Rafeek [12] analyzed risk factors for infectious morbidity among 1500 women and found that prolonged surgery duration was associated with SSI, with an odds ratio (OR) of 1.048. However, in contrast to our results, Odada et al. [16] reported that neither surgery duration nor estimated blood loss showed significant differences between SSI and non-SSI groups (P = 0.490 and P = 0.532, respectively).

In accordance with our findings, Wondmeneh and Mohammed [22] conducted a meta-analysis and systematic review on SSI among Ethiopian women who underwent cesarean deliveries, examining 23 studies. They found that SSIs were more common in patients living in rural areas, those who had general anesthesia, those with postoperative hemoglobin levels below 11 mg/dL, and those with membrane rupture lasting 12 hours or longer. Similarly, Mezemir et al. [17] studied 741 women and identified factors such as PROM, type of incision, number of vaginal examinations, and postoperative hospital stay as significant predictors of SSI.

Additionally, Adane et al. [23] performed a prospective cohort study with 336 women and found that the SSI rate was 7.74%. Significant risk factors included preoperative membrane rupture, labor lasting more than 24 hours, and postoperative hemoglobin levels below 11 g/dL. These results were consistent with Ali et al. [24] who evaluated 818 women in a retrospective study and found that the duration of membrane rupture before CS was a significant predictor of SSI, though hypertension was not.

Carbonnel et al. [11] similarly identified pre-eclampsia (hypertension) and early membrane rupture as independent risk factors for SSIs. Alemye et al. [25] found that general anesthesia, rupture of membranes, prolonged hospital stay, and blood transfusions were linked to a higher likelihood of post-CS SSI.

In line with our study, Gomaa et al. [2] found significant risk factors for SSI, including PROM (P ≤ 0.001), blood loss >1000 ml (P = 0.011), high parity (P = 0.031), and hypertension (P = 0.020). Additionally, Abdallah et al. [18] demonstrated that skin closure technique was a significant predictor of SSI (P = 0.01), while age, BMI, parity, and blood transfusion were not significant.

This study contributes new knowledge regarding the predictors of SSIs following CSs and highlights the importance of considering a combination of clinical and demographic factors when evaluating post-operative outcomes. Our findings suggest that greater attention should be paid to managing conditions like hypertension and monitoring membrane status prior to surgery, as these factors may significantly

influence infection rates. Furthermore, the implication for clinical care is clear: enhancing pre-operative assessment and preparation, particularly in patients at higher risk due to their clinical history, may reduce the incidence of SSIs and improve overall maternal outcomes. Future research should explore targeted interventions aimed at these risk factors to further delineate their impact on surgical outcomes.

This study's limitations include the relatively small sample size which inevitably lowered the statistical power of the analysis. We did not collect the socio-economic data of patients and type of CS. Our study did not include comprehensive data on maternal factors such as prenatal care, gestational diabetes, and other health conditions that could influence infection rates. Additionally, it is a single-center study making the results less generalizable. We failed to determine the operating team's total experience. It was not possible to identify the bacteria that caused CS wounds. Factors pertaining to the antiseptics utilized for patient preparation and the procedures followed to sterilize equipment were omitted.

6. Conclusion

The incidence of SSIs was similar between elective and emergency CSs, with no significant difference between the two groups. SSI incidence was notably higher in women from rural areas, hypertensive patients, and those with membrane rupture. The significant independent predictors of SSI were rural residence, hypertension, membrane rupture, general anesthesia, blood loss ≥500 ml, and low postoperative hemoglobin levels. These findings emphasize the need for targeted preoperative care for CS patients at higher risk due to factors such as residence, blood pressure, or membrane rupture. To reduce SSI rates, healthcare providers should focus on structured risk assessment and management, including anesthesia protocols, skin closure techniques, and minimizing blood loss. Future research should investigate the effectiveness of specific strategies to address these risk factors and improve surgical outcomes and maternal health.

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Statement of Ethics

This study adhered to the ethical principles outlined in the World Medical Association Declaration of Helsinki, ensuring that all human participants were treated ethically throughout the planning, conducting, and reporting of the research.

Ethical Approval and Consent to Participate

The ethics committee of the faculty of medicine at Al-Azhar University approved the study (Approval code: 596, Date: 24/6/2023), and all participants provided written consent to participate.

Conflict of Interest

The authors declare that there is no conflict of interest.

AI Disclosure Statement

During the preparation of this study, the authors utilized Grammarly to assist with language and grammar revision. Following the use of this AI tool, the authors thoroughly reviewed and edited the content, assuming full responsibility for the publication.

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Author Contributions

All authors contributed to the study conception and design. Material preparation and data collection and analysis were performed by Ahmed A. Hussein and Muhamed A. Abdelmoaty. The first draft of the manuscript was written by Ahmed A. Hussein and Muhammad M. Jebril, and all authors commented on previous versions of the manuscript. All authors read and approved of the final manuscript.

Availability of Data and Materials

Data sets are not publicly available due to privacy and security concerns. However, they are available upon request from the corresponding author.

Study Registration

This study was registered at ClinicalTrials.gov (NCT06491381) during participant recruitment.

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