EPIDEMIOLOGICAL, CLINICAL, BACTERIOLOGICAL, AND THERAPEUTIC ASPECT OF SURGICAL SITE INFECTIONS IN THE MATERNITY OF BATNA REGION IN ALGERIA: A PROSPECTIVE STUDY

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ABSTRACT

Surgical site infections (SSIs) are nosocomial infections occurring after surgery. SSIs contribute to the increase in maternal morbidity associated with cesarean section (CS). This research aimed to study SSIs' clinical, epidemiological, bacteriological, and therapeutic aspects for cesarean and hysterectomy surgeries performed at the Maternity Hospital of Batna Region in Algeria. We carried out a prospective and descriptive study for four months (from 1 January 2018 to 30 April 2018), with real-time data collection, in the gynecology and obstetrics department of Batna's Maternity Hospital. We included a total of 24 women who had a surgical intervention and were hospitalized with post-surgical infection. The data collection using a questionnaire allowed us to obtain information concerning the patient and the surgical procedure. Our results show that most surgeries performed were CS (95.83%) compared to hysterectomies (4.16%), among which 54.16% were planned CS. All classes of contamination were clean-contaminated. The physical status score for American Society of Anesthesiologists (ASA) 1 and ASA 2 classes was found in 83.33% and 16.66% of the patients, respectively. The SSIs in this study were concerned mainly with the surface plane (95.83%). Concerning infection, pus samples were taken from ten patients, and five germs were identified in eight patients. Escherichia coli was isolated in three patients, and Proteus mirabilis in two patients. Serratia marcescens, Acinetobacter baumanni, and Burkholderia cepacia were identified once in the three remaining patients. The most commonly prescribed antibiotherapy was Metronidazole (95.83%). We established a clinical, epidemiological, bacteriological, and therapeutic profile for SSIs at the Maternity Hospital of Batna.

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Highlights:

1. The predominance of cesarean section-related surgical site infections (SSIs) at the Maternity Hospital of Batna, with superficial infections being the most commong (95.83%) and *Escherichia coli* as the most frequently isolated pathogen.
2. The study emphasizes the high adherence to antibiotic prophylaxis and the relevance of ASA physical status in assessing SSI risk, providing important data to improve prevention strategies in gynecological surgical setting in Algeria.

INTRODUCTION

Surgical site infections (SSIs) include any infection at the operated site occurring within 30 days of surgery or a year if an implant or prosthesis has been placed[1]. Caesarean section (CS) is a lifesaving operative technique in which a fetus, placenta, and membranes are delivered through an abdominal and uterine incision[2]. A survey revealed that caesarean section procedures carry a risk of infection 5–20 times that of normal delivery[3]. SSIs constitute a significant public health problem and remain one of the leading causes of mortality and morbidity in surgery.

There are many risk factors for SSIs associated with cesarean section; the main risk factors involved are the pre-, per-, and postoperative environment surrounding the patient and the healthcare team, the host's immune defences, and especially the degree of hygiene during the surgical act. In the relentless pursuit of averting surgical site infections, a two-pronged approach unfolds, centering on identifying risk factors that collectively fall into two distinctive categories: patient-related (intrinsic) and process/procedural-related (extrinsic) factors. These risk factors, whether modifiable or non-modifiable, constitute pivotal keystones in the campaign for infection prevention[4]. Understanding the interplay between these factors is crucial for developing comprehensive strategies to reduce the incidence of SSIs.

The diagnosis of SSIs is essentially clinical; however, the etiological diagnosis requires the isolation of a bacterium after a culture of the purulent fluid is taken[5]. Bacteria inoculated into the surgical site during surgery typically cause SSIs. *E. coli* and *Enterococcus* species, respectively, cause approximately 9.5% and 5.1% of all surgical site infections[6]. Pathogens that cause infection vary by surgical location. Antimicrobial prophylaxis for caesarean section effectively reduces postoperative morbidity, cost, and duration of hospitalization[2].

SSIs are the second most reported healthcare-associated infection (HAI) globally, accounting for 19.6% of HAIs[7]. Numerous studies have reported incidence rates of post-CS SSIs, for example, 2.85% in India[8], 21% in Ethiopia[3], and in Blantyre, Malawi. The overall cumulative incidence of SSI recorded at the Queen Elizabeth Central Hospital during the study period was 9.61% (20 cases out of 208). Of these, 19 (95%) reported superficial SSI following CS[2]. The developing countries are the most affected. In Algeria, the incidence surveys were carried out in some hospitals, as Annaba's hospital had 36 (1.9%) post-CS SSIs among 1,810 patients[9].

This study was conducted to determine the clinical, epidemiological, bacteriological, and therapeutic profile of surgical site infections for caesarean and

hysterectomy surgeries performed at the Maternity Hospital of Batna and to identify risk factors for SSI after caesarean section for 4 months (from January 1, 2018 to April 30, 2018). A better understanding of predictors might improve infection control by reducing the clinical effects of post-cesarean infections. To our knowledge, no epidemiological study has been conducted on SSIs at the maternity hospital of Batna. This work is the first to study these different aspects of SSIs at this establishment.

METHODS

Patients and methods

This prospective and descriptive study was conducted in the Department of Obstetrics and Gynecology at the Hospital Maternity of Batna Region in Algeria. The analysis of files was spread over 4 months (from 1 January 2018 to 30 April 2018), including 24 women who underwent surgery such as caesarean delivery or hysterectomy during this period and were hospitalized at the Maternity Hospital. SSI diagnosis was established according to the Centers for Disease Control (CDC) criteria of Atlanta[10,11], and the surgeon validated each SSI. For bacteriological analysis, a pus sample was taken for superficial and deep infections to detect the eventual presence of microorganisms (bacteria).

Data collection

The data were collected by analysis of medical records in the obstetrics-gynecology department (data were provided anonymously by the hospital services). The data collection using a questionnaire allowed us to obtain information concerning the patient, such as age, level of education, profession …etc, and information concerning the surgical procedure: the type of surgery, the emergency or programmed intervention, the number of pregnancies (G), the epidemiological and bacteriological characteristics (classe of contamination, infection site, presence of germs), the associated risk factors and length of stay. We have performed a descriptive statistical analysis of all our patients' epidemiological and clinical characteristics.

Inclusion criteria

The recruitment was done exhaustively: systematic inclusion of all:

- Parturients who have had an emergency or planned caesarean section, for any indication.
- Primiparous or multiparous (including those who have already had a previous cesarean).

Exclusion criteria

We have excluded all of the following:

- Parturients who have given birth vaginally.
- Parturients transferred to the obstetrics-gynecology department in the postpartum period after a cesarean section performed in another establishment.

The limits of the study

Our study experienced limitations for the following reasons:

- Pus collection was not systematic for all patients.
- The operative reports were incomplete.

Statistical Analysis

This work addressed a descriptive statistical study. It evaluated the prevalence of different parameters and factors, and the results are expressed as frequency and percentage.

RESULTS

In our series, the mean age of our patients was (28.71 ± 7.049) years, with extremes of 19 and 52 years. Surgical site infections are frequent in the age group of

26-35 years (Table 1). Our results show a higher proportion, or 91.66%, of women with a good level of education. Thus, most patients are housewives (87.5%) (Table 1). This survey reveals that most of the surgeries performed were caesarean sections (95.83%) compared to abdominal hysterectomies (4.17%) (Figure1).

Table1. Clinical and Sociological Characteristics

Parameters	Frequency	Percentage (%)
Age group		
16-25	9	37.5
26-35	13	54.16
36-45	1	4.16
>45	1	4.16
Total	**24**	**100**
Level of education		
BAC	22	91.66
BEM	02	8.33
Total	**24**	**100**
Profession		
Housewives	21	87.5
Working woman	03	12.5
Total	**24**	**100**

BAC: Baccalaureate diploma.
BEM : The examinations for the middle-school certificate « l'examen du Brevet de l'enseignement moyen ou *BEM*».

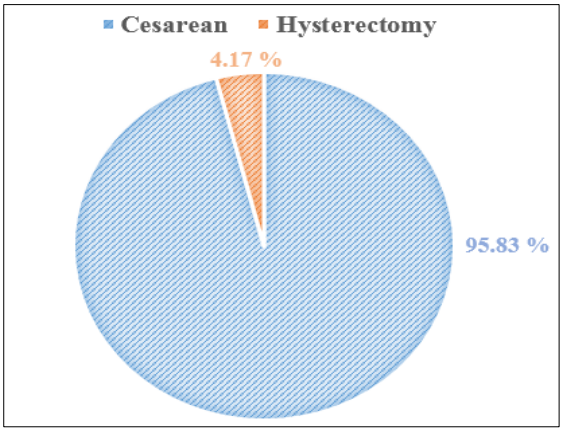

Figure 1. Distribution of patients according to the type of intervention.

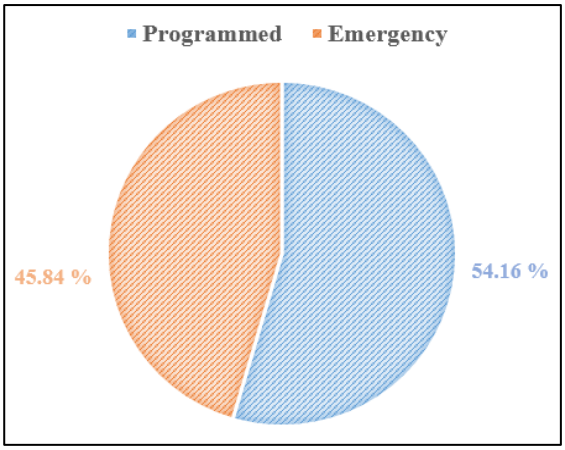

Figure 2. Distribution of patients according to the emergency or programmed intervention.

Emergency interventions constitute 45.83% of all interventions; sometimes, an emergency caesarean section may be necessary after labor has begun (Figure 2), so mainly represented by cesarean sections. 54.16% of the interventions are within the programming framework (Figure 2). A scheduled caesarean section at term is a planned caesarean section (scheduled at the request of the medical team and/or the mother), generally around 39 weeks 1 (8 and a half months of pregnancy), and not related to an emergency. It is proposed if difficulties in the circumstances of the delivery are predictable and likely to have consequences for the child (for example, the baby is considered too significant with the dimensions of the mother's pelvis or the child is poorly presented) or for the mother (such as very high blood pressure and albumin in the urine and it is better to avoid the efforts of childbirth). Additionally, 58.33% of operated women were primiparous (Figure 3).

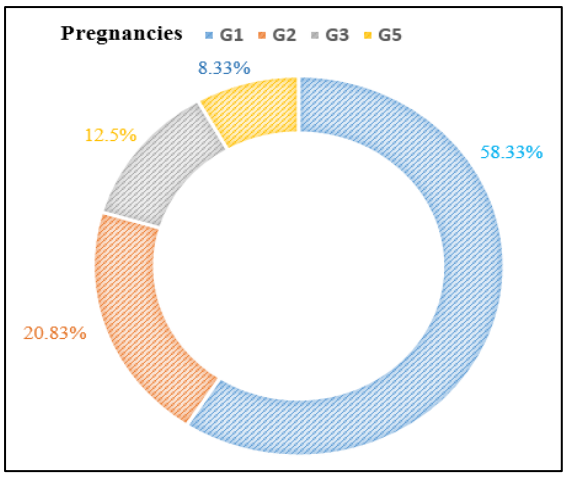

Figure 3. Distribution of patients according to the number of pregnancies (G).

In this study, the health status of the operated women is evaluated by the pre-anesthetic ASA score. The American Society of Anesthesiologists score (ASA) is a six-category physical status classification system for evaluating a patient before surgery. ASA is thus used to classify patients according to their preoperative comorbidities and can be correlated with postoperative morbidity and mortality. ASA 1 is for a normal healthy person, and ASA 2 is for patients with moderate systemic abnormalities. ASA score was determined in 24 patients; the majority of the patients, or 83.33%, have no health problems and are located at the ASA 1 score, 16.66% of the patients were in the ASA 2 class, and no woman had an ASA score 3, 4, and 5 (Table2).

As presented in Table 2, the SSIs found in this study concern, in the majority of cases, the superficial plane, with a frequency of 95.83%; only 4.16% of cases had a deep infection, and no patient had been found infected at the level of organs. Pus samples were taken from 10 patients, or 41.66% of cases, of which 5 cultures were positive. According to our results, 05 germs were identified in 8 patients (Table 2).

Table2. Epidemiological and bacteriological characteristics

Parameters	Frequency	Percentage (%)
ASA score		
ASA 1	20	83.33
ASA 2	04	16.66
Total	**24**	**100**
Infection site		
Superficial	23	95.83
Deep	01	4.16
Organ	0	0
Total	**24**	**100**
Distribution of patients according to germs		
Escherichia coli	03	37.5
Proteus mirabilis	02	25
Serratia marcescens	01	12.5
Acinetobacter baumannii	01	12.5
Burkholderia cepacia	01	12.5
Total	**08**	**100**

The bacteria identified in order of frequency are *Escherichia coli* (n=3 or 37.5%, n; number of patients infected by this bacteria), *Proteus mirabilis* (n=2 or 25%) *Serratia marcescens* (n=1 or 12.5%) *Acinetobacter baumannii* (n=1 or 12.5%) *Burkholderia cepacia* (1 or 12.5%) (Table2). Our findings show that 17 % of women present risk factors related to the patient, such as diabetes, goiter, high blood pressure, and anemia (Figure 4).

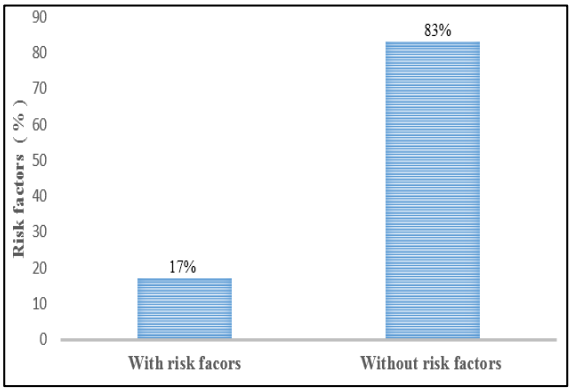

Figure 4. Distribution of patients according to associated risk factors.

DISCUSSION

Surgical site infection is a common infection in obstetrics and gynecology. It represents a significant problem when performing any surgical procedure. Age is among the factors that come into play in acquiring a surgical site infection, and it can be confounding. Our study population is predominantly young. The average age was 28.71±7.049 years, with 19 and 52 years extremes. The mean age for the women was 30.36±4.8 (range=17-45) years in the study of Jasim et *al.*[12]; this result is close to the age found in our study. In another prospective study of surgical site infections in operated patients (a caesarean section), the mean age was 31 years (± 6 years, extremes: 19 and 45 years)[13]. Jarlier and several authors estimate that the patient's high age is a factor favoring nosocomial infections due to the failure of the immune system[14].

Based on our results, most of the surgeries performed were caesarean sections compared to abdominal hysterectomies. The number of caesarean sections performed in our hospital has continued to increase in recent years. An increase in morbidity accompanied this development. During the study period, 24 patients were operated on in the gyneco-obstetrics department. The incidence rate of SSIs was five infections / in 24 patients during this period. Our rate is low compared to the rate found in other studies carried out in Algeria (7.87%) at the specialized hospital establishment (Mother and child) of Tlemcen in 2010, at the University Hospital of Oran (9.1%), and 13.6 % at Batna University Hospital. A recent study in Algeria at the Annaba hospital found 36 (1.9%) post-CS SSIs among 1,810 patients[9]. On the other hand, studies have shown a high rate of SSIs in hospitals ranging from 6.80% to 26% in Sub-Saharan Africa; a significant heterogeneity of the incidence was observed according to the type of specialty, with a pooled incidence of SSIs of 8.6% in the department of obstetrics and gynecology[15].

All the interventions, mainly represented by cesarean sections, are carried out within the programming framework. Similarly, Ngowa et *al.*[16] reported in their investigation that planned surgeries represent 88.6% of all surgeries performed. In our study, emergency interventions constitute 45.83% of all interventions. In contrast, Jasim et *al.*[12], observed that 63.25% of the patients had an emergency caesarean, whereas 36.75% had an elective caesarean. Generally, patients undergoing emergency cesarean section are at higher risk of infections[17-19]. According to Alseny-Gouly et *al.*[20] the risk of occurrence of SSI is twice as high when the caesarean section is performed urgently (OR=1.8 [1.5–3.0] ; p<0.01). This is because of inadequate preparation time owing to maternal or fetal threat[21].

The majority of our cases (58.33%) had primary caesarean sections, which is consistent with the findings of other workers[21-23] who found patients undergoing primary caesarean sections to be at greater risk of infectious morbidity compared to repeat caesarean birth. The ASA score was developed in 1945 by the American Society of Anesthesiologists. It is a universal system for classifying patients into five categories. This system assesses and communicates a patient’s pre-anesthesia medical co-morbidities like diabetes, obesity, or immunosuppression. Most patients, or 83.33%, have no health problems; they are young and in good

health and, therefore, have an ASA score of 1. In contrast, a recent Algerian study found the ASA score between II and III (33.3%)[9]. Among the factors significantly associated with the occurrence of SSIs was an ASA score>1[13]. 16.66% of our patients were in ASA class 2; several authors have demonstrated a significant association between the occurrence of SSIs and an ASA score greater than 2[24,25,20]. Preoperative monitoring of patients before a caesarean section allows for the identification of risk factors and reflection on care practices. Such an approach allows for better management of the risk of infection in the operating room.

In our series, superficial infection of the surgical site was the most frequent, with 95.83%, and only 4.16% of cases had a deep infection. This result corroborates with the findings of Brahimi et Slaouti.[26], who found that superficial infections are in the majority with a percentage of 70%, and also agrees with that of Barbut et *al*.[13]; where infections were superficial (affecting the skin and subcutaneous tissues) in 47% of cases, deep (affecting tissues or spaces located at or below the aponeurosis) in 20% of cases or organs (endometritis, pelvic abscess) in 33% of cases. Thus Ouédraogo[27]. found that the infection was superficial in 44.83% of cases, deep in 13.79%, and site and/or organ infection represented 41.38% of patients. In addition, Chadli et *al*.[28] found 16 (5.2%) women with surgical wound infections, 11 superficial wounds, five deep wounds, and one organ/site wound.

Pathogenic bacteria contaminate 90% of operative wounds during parietal closure[29,30]. In our study, the cultures realized on aerobic media isolated five bacterial species, of which Escherichia coli was the most frequently isolated microorganism from the surgical site, with 37.5%. This corresponds with several studies[31,32], which showed that Escherichia coli is among the most common germs in SSIs (23.9% and 30%, respectively).

Similarly, in an Algerian study, among 43 isolated bacteria, *Enterobacteriaceae* were the most frequent (62.8%), predominated by *Escherichia coli* strains (43.5%), a majority of which were extended-spectrum β-lactamases carriers (62.9%). Although gram-positive cocci were less frequent (37.2%), most *Enterococcus faecalis* (56.2%) were observed, and 2 strains of vancomycin-resistant *Enterococcus faecium* harboring the vanA gene were identified[9]. The organisms isolated from SSI in the study of Kumar and Anand Goud[33]. were *Escherichia coli* (22.9%), Methicillin *Staphylococcus aureus* (18.7%), *Proteus species* (16.6%), *Klebsiella species* (16.6%), *Pseudomonas aeruginosa* (8.3%), *Staphylococcus aureus* (6.2%) and mixed bacterial infections (10.4%). This germ (*Escherichia coli*) is followed by *Proteus mirabilis* with 25% in our series. Enteric gram-negative bacteria have previously been reported to be associated with severe SSI[34,35]. Contrary to our results, Mpogoro et *al*.[24] found that *Staphylococcus aureus* was the most common organism (27.3%), followed by *Klebsiella pneumoniae* (22.7%). On the other hand, Mukagendaneza et *al*.[36] found that the most common pathogens isolated were *Klebsiella spp* (55%), followed by *Escherichia coli* (15%) and *Proteus spp* (12%), *Acinetobacter* (9%), *S. aureus* (6%), and coagulase-negative *staphylococci* (3%). The most common organisms are *Staphylococcus aureus* and *Escherichia coli*[6]. Only eight germs cause eighty percent of nosocomial infections (including

surgical site infections): *Staphylococcus aureus*, *enterococci*, *Escherichia coli*, *coagulase-negative staphylococci*, *Candida spp*, *Klebsiella spp*, *Pseudomonas aeruginosa,* and *Enterobacter spp*[37,38]. Several authors reported a different distribution. Knowledge of the germs is necessary to guide prevention and treatment measures.

Our findings show that only 17% of women present risk factors such as diabetes, goiter, high blood pressure, and anemia. Another Algerian study showed that the most frequent maternal pathologies were Body Mass Index ≥30 (63.9%), scarred uteri (58.3%), and anemia (55.6%)[9]. According to Seidelman et *al*.[39], the factors associated with surgical site infection include older age, presence of immunosuppression, obesity, diabetes, effectiveness of antimicrobial prophylaxis, surgical site tissue condition (such as foreign material), and degree of wound contamination. Furthermore, specific underlying morbidities in operated patients, such as obesity, diabetes, or immunosuppression, are known to be risk factors for postoperative infection[30,40-42]. Patients should be made aware of the risk of SSI, mainly where there is a high risk due to the type of anesthesia and analgesia or known patient risk factors. This will allow patients to make better-informed decisions about whether to proceed with surgery in a maternal request caesarean.

Regarding the curative treatment used after detection of the infection**,** three antibiotics were the most commonly used and the most efficient (Metronidazole: 95.83%, Gentamicin: 87.5%, and Cefazolin: 75%), which seem to be routinely used in combination. This is explained by the fact that the isolated germs were of a gram-negative bacillus. According to our results, 91.66% of patients use at least three antibiotics to treat SSI. Postoperatively, intravenous antibiotics were given to 44 (23%) patients, and cefazolin was preferred in 29 (65.9%) patients. Oral antibiotic treatment was given to 111 (58.1%) patients when they were discharged, and in 66 (59.5%) patients, 1 g of cefazolin in the morning and evening for 7 days was approved[43].

The State of cleanliness of the operated site is related to SSI risk. In our series, all classes of contamination are clean-contaminated. This is in line with the current results of Ngowa et *al*.[16], which found that clean-contaminated surgeries were more common (76.3%) than clean surgeries (23.7%). Mpogoro et *al*.[24] found a risk of occurrence of SSI in caesareanized parturients of 2.4 for surgical wound class III. In univariate analysis, the contamination class (3,4) was related to the occurrence of infection[44]. Furthermore, in Morocco, this factor was also found to be associated with SSI in visceral surgery[28].

Surgical antibiotic prophylaxis is based on the injection of an antibiotic before the intervention and for a very short time. Antibiotic prophylaxis is recommended in all surgical site infection prevention guidelines[45-47]. Antibiotic prophylaxis is a significant method of preventing SSIs, as it can reduce the rate of these infections by up to 50%[1]. The antibiotics used must have as weak an effect as possible on bacterial resistance and differ from those used for curative antibiotic therapy. We practice antibiotic prophylaxis in clean and clean-contaminated gynecological and obstetric surgeries with Cefazolin; this fits well with the data from the literature. Therefore, all of our patients benefited from 100% antibiotic prophylaxis. Cephalosporins are the most

indicated antibiotics for antibiotic prophylaxis[48]; as either first (cefazoline) or second-generation (cefamandole, cefuroxime, cefoxitin), they are efficient against most gram-negative and gram-positive bacteria. Like the Senegalese study[49], our study confirms the efficacy of antibiotic prophylaxis in clean and clean-contaminated gynecological and obstetric surgeries.

Our patients' average length of stay in the hospital was seven days, with extremes of 04 and 39 days. This period is related to the duration of treatment and the associated risk factors. Brahimi et Slaouti.[26] found an average length of stay of 10.25 ± 8.4 days for infected patients versus 4.31 ± 3.02 days for uninfected patients. In another study, the total length of stay of infected patients (13.12 days) was significantly longer than that of uninfected (6.75 days) (p <10–5)[28]. Another Brazzaville research showed an average hospitalization length of 19.1±13.84 days[5]. The SSIs result in more extended hospital stays and a higher risk of death[50]. Thus, the length of stay in the hospital before the operation should not be neglected[51], because a high risk of SSI often accompanies this stay. Long duration of labor before cesarean section and long operation time were found as risk factors for surgical site infection following caesarean section[21]. Ideally, patients should be admitted the day before or the morning of the operation.

This study offers a prospective, real-time assessment of SSIs in a maternity setting, providing a detailed clinical, bacteriological, and therapeutic profile that is currently lacking in the region. It enhances the understanding of risk factors specific to cesarean and hysterectomy-related infections and promotes awareness of microbial patterns and antibiotic use.

However, the study is limited by a small sample size (n=24) and incomplete data in some operative reports. Additionally, not all patients underwent pus culture testing, potentially underestimating the diversity and resistance patterns of infectious agents.

CONCLUSION

This study aimed to establish a clinical, epidemiological, bacteriological, and therapeutic profile of surgical site infections for caesarean and hysterectomy surgeries performed at the maternity hospital of Batna (Algeria). Within the limits of the data obtained, the risk factors studied in this survey should be taken into account to improve the medical care of patients. Antibiotic prophylaxis compliance and efficacy measures should also be taken in clean-contaminated gynecological surgeries to limit surgical site infections. Studies in this region with a large sample size could improve our knowledge of the risk prevention of bacterial contamination and the control of multiple risk factors associated with surgical site infections.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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None.

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