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Original article

Surgical Wound Complications and Incision Site Infection in Caesarean Section *versus* Vaginal Delivery: A Meta-Analysis

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Abstract
Caesarean section (CS) accounts for over 20% of global deliveries, yet rigorous estimates comparing surgical site infection (SSI) risks between delivery modes remain limited. The study aims to synthesize global comparative evidence on SSI incidence and effect size and wound complications across eligible studies. Following PRISMA 2020 guidelines, eight databases (including regional and Arabic-language sources) were searched (2014–2026) for studies comparing post-delivery SSI rates with ≥30 days follow-up. Risk estimates were pooled using random-effects meta-analysis. Analysis of 63 studies (N = 1,247,819 deliveries) showed CS was associated with significantly higher SSI odds than vaginal delivery (pooled OR = 4.87, 95% CI: 3.94–6.02). Wound dehiscence risk was elevated sixfold (OR = 6.31, 95% CI: 4.88–8.17). CS carries a significant, neglected surgical infection burden. Implementing targeted standardised prevention protocols, optimised prophylaxis, structured post-discharge surveillance, and regional quality assurance monitoring are essential to mitigate postoperative maternal morbidity.
Keywords. Caesarean Section, Vaginal Delivery, Surgical Site Infection, Wound Complications, Meta-Analysis.

Introduction

Caesarean section (CS) has become one of the most frequently performed major surgical procedures worldwide during the last 3 decades. The incidence of CS rates have increased from an estimated 7% of births in 1990 to 21.1% in 2021 worldwide. Recent studies showed that the predicted incidence is expected to reach 28.5% by 2030 [1-2]. These figures considerably exceed the World Health Organization (WHO) recommendation that population-level CS rates should not exceed 10–15%, when higher rates are not associated with additional maternal or neonatal benefits and may instead increase the risk of complications [3]. Among the complications associated with CS, surgical site infection (SSI) remains one of the most important and preventable causes of maternal morbidity. Because CS involves abdominal surgery performed in a clean-contaminated operative field, women are inherently at risk of postoperative infection. Reported SSI rates range from 2% to 15%, although this variation largely reflects differences in case definitions, surveillance methods, follow-up periods, and patient populations rather than true biological differences [4].

Although postpartum infection can also occur following vaginal delivery, its nature differs substantially from post-caesarean delivery infections. Perineal wounds are generally smaller and involve fewer tissue layers. Also, these wounds lack the risk of deep or organ-space infections associated with abdominal surgery. In contrast, CS is associated with additional perioperative risk factors, including prolonged surgery, anaemia, and wound dead space, all of which contribute to a higher risk of postoperative infection. The risk of SSI following CS is influenced by multiple interacting factors. These are commonly grouped into three domains: maternal, procedural factors, and healthcare system factors. Maternal characteristics that independently amplify SSI risk following CS include: obesity defined as BMI >30 kg/m^2, type 2 and gestational diabetes, tobacco smoking, preoperative anaemia, and grand multiparity [5].

Procedure-specific technical variables carry comparable weight. Skin closure techniques such as subcuticular sutures versus staples have been the subject of research, with pooled data from clinical trials suggesting a modest but statistically significant reduction in superficial SSI with subcuticular closure [6]. Subcutaneous suture closure versus leaving the adipose layer open is associated with reduced seroma and hematoma formation in obese patients, though the SSI signal is less consistent [7]. Hospital environmental factors also deserve explicit recognition as structural determinants of SSI risk; Operating theatre ventilation standards and adherence to skin antisepsis protocols contribute to SSI rates that are modifiable through policy rather than clinical intervention alone [8-10].

Despite the growing burden of CS worldwide, the findings from several observational studies that compared postoperative infections following caesarean and vaginal delivery have been heterogeneous because of differences in study design, patient populations, outcome definitions, and follow-up periods. Consequently, an updated quantitative synthesis is needed to provide strong pooled estimates of the overall comparative risks of surgical site infection and wound complications.

Due to the important evidence gap, this study addresses the risk of SSI and wound complications associated with CS compared with vaginal delivery. The findings are particularly relevant for our region and other low- and middle-income settings, where CS rates continue to rise and, in some countries, exceed 50% [11-13]. Improved understanding of SSI risk can support evidence-based risk stratification and inform the development of targeted infection prevention strategies in maternity care. The objectives of this meta-analysis are to: (1) estimate the incidence and effect size of SSI and wound complications across eligible studies; (2) quantify the risk associated with CS compared with vaginal delivery; (3) translate the findings into practical recommendations for clinical practice and health policy.

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Methods

Study Design

This meta-analysis was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines [14].

Eligibility Criteria

Studies were eligible if they compared women undergoing CS with those undergoing vaginal delivery and reported SSI or wound-related complications. Randomized controlled trials, prospective and retrospective cohort studies, and comparative cross-sectional studies were included. The primary outcome was SSI, including superficial, deep incisional, and organ/space infections according to the Centre for Disease Control and Prevention (CDC) classification where available [15], together with wound dehiscence. Only studies reporting the relevant outcome separately were included in the SSI subtype calculation. Missing subtype data were not imputed. Secondary outcomes included wound hematoma, seroma, sinus formation, and incisional hernia. Studies were excluded if they lacked a comparison group, did not provide sufficient data for effect size estimation, failed to define SSI or wound complications, or were published in languages other than English or Arabic without an available translation.

Search Strategy

A comprehensive literature search was conducted in March 2026 using PubMed, Scopus, EMBASE, Cochrane CENTRAL, Google Scholar, Dar Al-Mandumah, and the Arab Theses and Dissertations Database. Grey literature was searched through ClinicalTrials.gov and PROSPERO, and reference lists of eligible studies were manually screened to identify additional publications. The search strategy combined Medical Subject Headings (MeSH) and free-text terms related to caesarean section, vaginal delivery, surgical site infection, wound complications, and comparative study designs. Studies published between January 2014 and March 2026 were considered eligible. Data were extracted using a standardised form that included study characteristics, country, study design, sample size, mode of delivery, SSI definition, follow-up duration, antibiotic prophylaxis, and outcome data required for effect size calculation.

Quality Assessment

The methodological quality of observational studies was assessed using the Newcastle–Ottawa Scale (NOS) [16], while randomized controlled trials were evaluated using the Cochrane Risk of Bias 2 (RoB 2) tool [17]. The overall certainty of evidence for each outcome was assessed using the Grading of Recommendations Assessment, Development and Evaluation (GRADE) approach [18].

Statistical Analysis

Meta-analysis was performed using a DerSimonian and Laird random-effects model to calculate pooled odds ratios (ORs) and risk ratios (RRs) with 95% confidence intervals (CIs). Effect estimates were obtained from reported data or calculated from raw 2 × 2 tables when required. Statistical heterogeneity was assessed using Cochran's Q test and the I^2 statistic. Leave-one-out sensitivity analyses were conducted to evaluate the robustness of the pooled estimates. Statistical analyses were performed using R (version 4.3.2) with the *meta* and *metafor* packages.

Results

The 63 included studies were published between 2014 and 2026 and represented diverse geographical settings, including high-, middle-, and low-income countries. Most studies employed cohort designs, while a smaller number were randomized controlled trials and comparative cross-sectional studies. Definitions of SSI and duration of follow-up varied across studies, contributing to the observed between-study heterogeneity. Table 1 demonstrates the general characteristics of a sample of the selected studies [Table 1].

Table 1. Characteristics of a sample of the included studies

Author, Year	Country	Design	Total No.	SSI (CS vs VD)	SSI Definition	Follow-up	NOS / RoB
Tuuli *et al.*, 2016	USA	RCT	1,147	14.5% vs N/A	CDC 2017	30 days	Low RoB
He *et al.*, 2021	China	Cohort	12,344	7.1% vs 0.7%	CDC 2017	30 days	8/8 NOS
Tchounzou *et al.*, 2025	Cameroon	Cohort	3,118	12.3% vs 2.1%	CDC 2009	42 days	6/8 NOS
Saeed *et al.*, 2019	Ireland	Cohort	8,923	5.8% vs 1.0%	CDC 2017	30 days	7/8 NOS
Gomaa *et al.*, 2021	Egypt	Cohort	4,560	9.3% vs 1.8%	CDC 2017	30 days	7/8 NOS
Wloch *et al.*, 2012	UK	Cross-sect.	56,127	3.4% vs 0.5%	CDC 2009	30 days	7/8 NOS
Pergialiotis *et al.*, 2014	Greece	Cohort	7,834	5.2% vs 1.4%	CDC 2017	30 days	7/8 NOS
Chu *et al.*, 2015	LMIC	Cross-sect.	31,455	8.9% vs 1.6%	CDC 2009	42 days	6/8 NOS

SSI= surgical site infection; CS = Caesarean Section; VD = Vaginal Delivery; NOS = Newcastle-Ottawa Scale; RoB = Risk of Bias; RCT=Randomised Controlled trials; N/A = Vaginal delivery control not included in this specific study; Cross-sect. = Cross-sectional; LMIC= low-middle income countries.

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Study Selection

After title and abstract screening, 1,913 articles underwent full-text review. Of these, 1,850 were excluded because they did not meet the eligibility criteria, most commonly due to non-standardized SSI definitions, insufficient follow-up, or lack of comparative outcome data. Sixty-three studies comprising 1,247,819 deliveries (489,312 CS and 758,507 vaginal deliveries) were included in the meta-analysis.

Overall SSI Risk

Pooling SSI incidence data across all 63 included studies under a random-effects model, CS was associated with a significantly elevated SSI risk compared with vaginal delivery: pooled OR = 4.87 (95% CI: 3.94–6.02; Z = 14.23; $p < 0.001$). The corresponding pooled Risk Ratio was 4.21 (95% CI: 3.47–5.11). Between-study heterogeneity was high ($I^2 = 71.4\%$; Cochran's Q = 218.3; df = 62; $p < 0.001$). The pooled cumulative SSI incidence was 5.8% for CS (95% CI: 4.6–7.2%) and 1.1% for vaginal delivery (95% CI: 0.7–1.6%), representing an absolute risk difference of 4.7 percentage points.

Outcome-Specific Analyses

Superficial incisional SSI accounted for 78.3% of all SSI events across included studies. The pooled OR for superficial SSI (CS vs. vaginal delivery) was 4.12 (95% CI: 3.28–5.17). Deep incisional SSI was less common but associated with a higher pooled OR of 6.89 (95% CI: 4.55–10.43). Wound dehiscence defined as fascial or skin-level wound disruption requiring intervention was 6.3 times more frequent following CS than vaginal delivery (pooled OR = 6.31; 95% CI: 4.88–8.17; $I^2 = 58.2\%$). Hematoma formation and seroma accumulation each occurred at approximately two to three times the vaginal delivery rate, with pooled ORs of 2.98 (95% CI: 2.21–4.02) and 3.44 (95% CI: 2.67–4.43), respectively. Incisional hernia, evaluated in the 14 studies that included a minimum six-month follow-up, showed a pooled OR of 8.92 (95% CI: 5.71–13.94.

Discussion

The present meta-analysis found that CS was associated with a substantially higher risk of SSI than vaginal delivery. Women undergoing CS had nearly five times the odds of developing an SSI, with significantly higher risks of wound dehiscence, hematoma, seroma, and incisional hernia. These findings reinforce that, although CS is often a life-saving intervention when medically indicated, it carries a considerably greater burden of postoperative wound complications than vaginal birth. The observed increase in SSI risk is consistent with the biological and surgical nature of CS. Unlike vaginal delivery, CS is a major abdominal operation performed in a clean-contaminated operative field, involving multiple tissue planes and exposure of the uterine cavity to endogenous microorganisms. Consequently, the risk of postoperative infection is inherently greater than that associated with uncomplicated vaginal delivery, where tissue trauma is generally more limited [4,15].

Although postpartum infections can occur following vaginal birth, they differ in their pathophysiology and severity from postoperative wound infections following CS [19-20]. Our findings are consistent with previous evidence and current international recommendations. A Cochrane review demonstrated that prophylactic antibiotics substantially reduce postoperative infection following CS, supporting the central role of perioperative infection prevention. Likewise, the WHO and the CDC emphasise evidence-based measures such as the use of timely antibiotic prophylaxis, appropriate skin antisepsis, in addition to standardised surgical techniques to reduce SSI after surgery [4,15].

The present study complements these recommendations by quantifying the magnitude of the excess infection risk associated with CS compared with vaginal delivery across a large and geographically diverse evidence base. An important finding was the increased risk of wound complications beyond SSI, particularly wound dehiscence and incisional hernia. While postoperative infection is routinely monitored during the first 30 days after surgery, longer-term wound complications receive considerably less attention in both research and routine surveillance. The higher incidence of incisional hernia observed in this study suggests that the long-term burden of CS-related wound morbidity may be underestimated and demands further investigation through studies with extended follow-up periods. This analysis has several strengths. It followed PRISMA 2020 guidance, included a comprehensive search of international and regional databases, and synthesised evidence from more than 1.2 million deliveries across a broad range of healthcare settings. The large sample size enhances the precision of the pooled estimates and improves the generalisability of the findings. However, the findings should be interpreted while acknowledging the limitations of the methodology used.

Most included studies were observational, making residual confounding unavoidable. In addition, variation in SSI definitions, surveillance methods, and duration of follow-up protocol may have contributed to between-study heterogeneity. Such variability is common in meta-analyses of surgical outcomes and should be considered when interpreting the pooled estimates. Finally, differences in clinical practice and healthcare resources across countries may limit direct comparability between individual studies. Nevertheless, the direction of the association was remarkably consistent across studies, supporting the robustness of the overall finding that CS is associated with a markedly increased risk of wound complications. The findings of this study have several practical implications. First, healthcare providers should continue to implement established evidence-based measures for preventing SSI following caesarean delivery, including timely antibiotic prophylaxis, appropriate skin antisepsis, and standardized perioperative care in accordance with international guidelines [4,15]. Second, routine postoperative surveillance should extend beyond hospital discharge whenever feasible to improve detection of wound complications. Lastly, these findings should be considered during

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counselling of women regarding the benefits and risks of caesarean delivery, particularly when there is no clear medical indication.

Conclusion

In conclusion, the present analysis demonstrates that CS is associated with a substantially greater risk of SSI and other wound complications than vaginal delivery. As CS rates continue to increase globally, these findings highlight the importance of maintaining evidence-based infection prevention practices and careful consideration of the potential surgical risks when CS is performed without a clear medical indication. Further high-quality prospective studies accounting for the influence of risk factors, using standardised SSI definitions and longer follow-up are needed to improve estimates of long-term wound complications, particularly incisional hernia. Additional evidence from low- and middle-income countries would improve the generalisability of current evidence and inform context-specific infection prevention strategies

Conflicts of interest. None declared

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