

# Risk of Surgical Site Infection (SSI) in Diabetes Mellitus Patients: A Systematic Review and Meta-analysis

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## Abstract

**Background:** Much has been published in current years about the impact of diabetes on increased rates of surgical site infection (SSI) and the potentially related impact of hyperglycemia on SSI. Surgical site infections are envisioned to have an annual financial impact of extra than 3 billion dollars nationally and are the largest contributor to the general value of healthcare-associated infections. **Aim:** This work aims to determine the risk of Surgical Site Infection (SSI) in Diabetes Mellitus (DM) patients. **Materials and Methods:** A systematic search was performed over different medical databases to identify studies, which studied the outcome of the SSI group versus the Non-SSI group of DM patients. Using the meta-analysis process, either with fixed or random-effects models, we conducted a meta-analysis on the prevalence of SSI in diabetic patients as a primary outcome, and on the risk of DM in SSI patients in comparison to non-SSI patients as a secondary outcome. **Results:** Ten studies were identified involving 78489 patients, with 3518 patients in the SSI group, and 74971 patients in the Non-SSI group. The meta-analysis process revealed a pooled prevalence of SSI in diabetic patients of 26.3%. Also, there was a highly significant increase in DM in the SSI group compared to the Non-SSI group ( $p = 0.01$ ). **Conclusion:** To conclude, our results support the hypothesis of DM is an independent risk factor for SSIs for different surgical procedures. Awareness about DM control helps to improve surgical outcomes for diabetic patients.

**Keywords:** Surgical site infection; Diabetes Mellitus

## Introduction

Surgical site infection (SSI) is the second most common nosocomial infection, accounting for up to 40% of all healthcare-associated infections in the surgical population. Surgical site infections are the most common infections after colorectal surgical operation. Patients undergoing colon surgical operation represent a high-risk cohort for SSI because of inherent risk factors such as malnutrition, chronic immunosuppression, anemia, and an excessive prevalence of emergent surgery. <sup>[1]</sup>

Surgical site contamination (SSI) is one of the most serious complications following spinal surgery at some point in the early postoperative level. The prevalence of it was reported from 0.7% to 12.0%. SSI commonly requires surgical debridement and induces higher postoperative morbidity and mortality, calls for readmission, and effects in additional treatment costs. Also, it will delay the rehabilitation of patients and affect function healing of the spine. So, early identifying the risk factors for postoperative SSI and preventing them is helpful for patients' rehabilitation after spinal surgery. <sup>[2]</sup>

Statistics from the national Healthcare safety network show that SSI rates vary by form of surgery. SSI rates are estimated to be 1.7% for abdominal hysterectomy and 0.9% for vaginal

hysterectomy. However, in gynecologic oncology this rate stages from five% to thirty-five%. this alteration depends on several elements including high body mass index (BMI), low socioeconomic status, poor nutritional status, high intraoperative blood loss, prolonged operative time, the overall performance of bowel resection, perioperative blood transfusion, and patients' other medical co-morbidities. <sup>[3]</sup>

Diabetes prevalence is increasing in the United States, and the appropriate control of patients with diabetes has become increasingly important for the prevention of hospital-acquired infections. Much has been published in current years about the impact of diabetes on increased rates of surgical site infection (SSI) and the potentially related impact of hyperglycemia on SSI. Surgical site infections are envisioned to have an annual financial impact of extra than 3 billion dollars nationally and

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are the largest contributor to the general value of healthcare-associated infections. [4]

This work aims to determine the risk of Surgical Site Infection (SSI) in Diabetes Mellitus (DM) patients.

### Literature Review

Our review came following the (PRISMA) statement guidelines. [5]

#### Study eligibility

The included studies should be in English, a journal published article, and a human study describing DM patients. The excluded studies were non-English, or animal studies.

#### Study identification

Basic searching was done over the PubMed, Cochrane library, and Google scholar using the following keywords: Surgical Site Infection, Diabetes Mellitus.

#### Data extraction and synthesis

RCTs, clinical trials, and comparative studies, which studied the outcome of SSI group versus Non-SSI group of DM patients, will be reviewed.

Outcome measures included the prevalence of SSI in diabetic patients as a primary outcome and on the risk of DM in SSI patients in comparison to non-SSI patients as a secondary outcome.

#### Study selection

We found 327 records, 248 excluded based on title and abstract

review; 79 articles are searched for eligibility by full-text review; 31 articles cannot be accessed; 29 studies were reviews and case reports; 10 were not describing functional outcome; leaving 9 studies that met all inclusion criteria.

#### Statistical analysis

After the pooling of data, Odds ratios (OR), Proportions (%), with 95% confidence intervals (CI) were calculated, using MedCalc statistical software (Belgium). After the Q test of heterogeneity, the I<sup>2</sup>-statistics (either the fixed-effects model or the random-effects model) were done within the meta-analysis process.

### Results

The included studies were published between 2011 and 2020. Regarding the type of included studies, 1 studies (out of 9 studies) were prospective, while 8 studies were retrospective [Table 1]. [2,6-13]

Regarding patients' characteristics, the total number of patients in all the included studies was 78489 patients, with 3518 patients in the SSI group, and 74971 patients in the Non-SSI group [Table 1].

The mean age of all patients was (56.5 years) [Table 1].

A meta-analysis study was done on 9 studies that described and compared the 2 different groups of patients; with an overall number of patients (N=78489) [Table 2]. [2,6-13]

Each outcome was measured by:

**Table 1: Patients and study characteristics.**

N	Author	Type of study	Number of patients			Age (average years)	Type of surgery
			Total	SSI group	Non-SSI group		
1	George et al. [6]	Retrospective	556	14	542	57.7	Urologic surgery
2	Deierhoi et al. [7]	Retrospective	5750	709	5041	65	Colorectal surgery
3	Chaichana et al. [8]	Retrospective	401	21	380	56.8	Neurosurgery
4	Figuerola-Tejerina et al. [9]	Prospective	1657	72	1585	70	Cardiac Surgery
5	Krieger et al. [10]	Retrospective	41375	1521	39854	30	Cesarean surgey
6	Lai et al. [11]	Retrospective	923	26	897	54	Spine surgery
7	Gachabayov et al. [12]	Retrospective	690	164	526	61	Colorectal surgery
8	Liu et al. [2]	Retrospective	256	64	192	58	Spine surgery
9	Yang et al. [13]	Retrospective	26881	927	25954	--	Orthopaedic surgery

#Studies arranged via publication year.

**Table 2: Summary of outcome measures in all studies.**

N	Author	Primary outcome		Secondary outcome	
		SSI prevalence		OR of DM	
		SSI / DM patients		SSI group	Non-SSI group
1	George et al. [6]	14	85	5	80
2	Deierhoi et al. [7]	709	1403	195	1208
3	Chaichana et al. [8]	21	54	5	49
4	Figuerola-Tejerina et al. [9]	72	432	36	396
5	Krieger et al. [10]	1521	4623	222	462
6	Lai et al. [11]	26	399	17	382
7	Gachabayov et al. [12]	35	112	--	--
8	Liu et al. [2]	--	--	16	25
9	Yang et al. [13]	--	--	188	1730

### Proportions (%)

- For the prevalence of SSI in diabetic patients.

### Odds Ratio (OR)

- For risk of DM in SSI patients in comparison to non-SSI patients.

Concerning the primary outcome measure, we found 7 studies reported the prevalence of SSI in diabetic patients.  $I^2$  (inconsistency) was 99% with a highly significant heterogeneity Q test ( $p < 0.001$ ), so random-effects model was carried out; with a pooled prevalence of SSI in diabetic patients = 26.3% (95% CI = 15.755 to 38.507). Using the random-effects model, the meta-analysis process revealed a pooled prevalence of SSI in diabetic patients of 26.3% ( $p < 0.01$ ) [Figure 1].

Concerning the secondary outcome measure, we found 8 studies reported DM in the SSI group compared to the Non-SSI group.  $I^2$  (inconsistency) was 98.4% with a highly significant Q test for heterogeneity ( $p < 0.0001$ ), so random-effects model was carried out; with overall OR= 3.07 (95% CI = 1.304 to 7.243). Using the random-effects model, the meta-analysis process revealed a highly significant increase in DM in the SSI group compared to the Non-SSI group ( $p = 0.01$ ) [Figure 2].

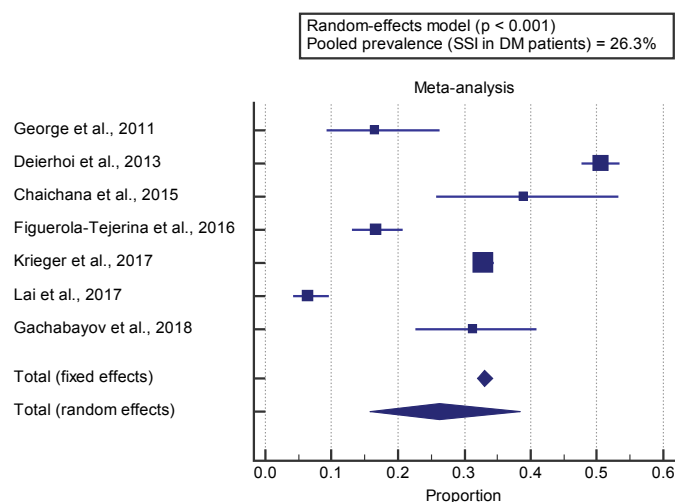
## Discussion

This work aims to determine the risk of Surgical Site Infection (SSI) in Diabetes Mellitus (DM) patients.

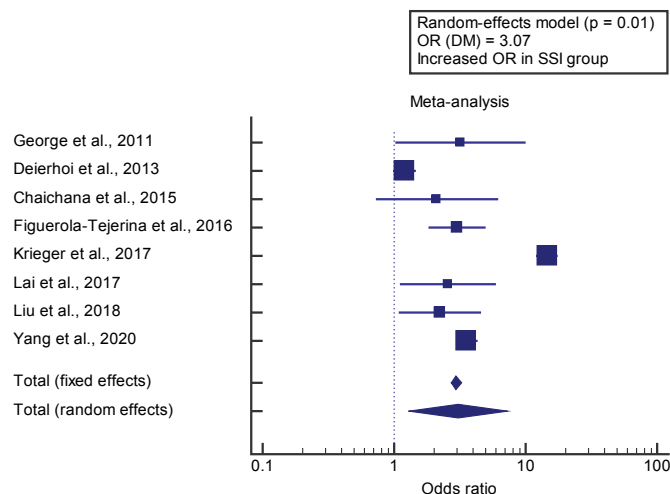
The included studies were published between 2011 and 2020. Regarding the type of included studies, 1 studies (out of 9 studies) were prospective, while 8 studies were retrospective.

Regarding patients' characteristics, the total number of patients in all the included studies was 78489 patients, with 3518 patients in the SSI group, and 74971 patients in the Non-SSI group. The mean age of all patients was (56.5 years).

A meta-analysis study was done on 9 studies that described and compared the 2 different groups of patients; with an overall number of patients (N=78489).



**Figure 1:** Forest plot demonstrating (The prevalence of SSI in diabetic patients).



**Figure 2:** Forest plot demonstrating (DM in the SSI group compared to the Non-SSI group).

We found 7 studies reported the prevalence of SSI in diabetic patients using the random-effects model, the meta-analysis process revealed a pooled prevalence of SSI in diabetic patients of 26.3% ( $p < 0.01$ ). Which came in agreement with Bhakta et al.,<sup>[1]</sup> Ghuman et al.,<sup>[14]</sup> Akhter et al.,<sup>[15]</sup> Al-Niaimi et al.,<sup>[3]</sup> Klemencsics et al.<sup>[16]</sup> and Krieger et al.<sup>[10]</sup>

Bhakta et al. reported that a within-group analysis of the use of multivariable adjustment of the three diagnoses in question becomes used to research the independent variables associated with SSI. Only obesity, diabetes mellitus, and smoking were discovered to be significantly associated with SSI. For patients with colon most cancers, male sex, obesity, diabetes mellitus, smoking had been significantly associated with SSI.<sup>[1]</sup>

Ghuman et al. reported that, the results of univariate and multivariate analysis of potential SSI risk factors. Smoking, diabetes mellitus, and incision location were found to be significant factors with unadjusted odds ratios of 3.75 ( $p = 0.004$ ), 2.75 ( $p = 0.009$ ), and 1.37 ( $p = 0.03$ ).<sup>[16]</sup>

Akhter et al. reported that a history of diabetes mellitus in patients conferred a much higher rate of SSIs, specifically, out of control serum glucose degrees inside the perioperative period, undiagnosed diabetes, and postoperative hyperglycemia inside forty-eight hours of surgical procedure had been related to a higher hazard of SSIs.<sup>[15]</sup>

Al-Niaimi et al. reported that surgical site infections have been and remain a cause of widespread postoperative morbidity and mortality inside the gynecologic oncology patient population. After controlling for perioperative antibiotic use, other studies have identified different independent hazard factors for SSI, including excessive BMI, perioperative blood transfusion, low socioeconomic status, and prolonged operative time, along with the presence of diabetes mellitus (DM).<sup>[3]</sup>

Klemencsics et al. reported that the prevalence of SSI was 3.5% and 3.9% in the test and the validation cohorts, respectively. The very last multivariable regression model predictive ( $p=.003$ ) for SSI contained the patient's age, body mass index (BMI), and the presence of 5 comorbidities, such as diabetes.<sup>[16]</sup>

Krieger et al. reported that the Pregnancies of patients who eventually developed SSI were more likely to have been complicated with hypertensive disorders of pregnancy, diabetes mellitus. [10]

Concerning the secondary outcome measure, we found 8 studies reported DM in the SSI group compared to the Non-SSI group.

Using the random-effects model, the meta-analysis process revealed a highly significant increase in DM in the SSI group compared to the Non-SSI group ( $p = 0.01$ ). Which came in agreement with Boreland et al., [17] Martin et al., [4] Akhter et al., [15] Liu et al. [2] and Meng et al. [18]

Boreland et al. reported that Serum glucose ranges  $> 200$  mg/dL in the instant ( $<48$  h) postoperative period contribute to an elevated threat of surgical site infections. Poor glycemic control previous to surgical operation contributes to poor control after hospital discharge and increases the prevalence of complications such as poor wound healing and higher rates of surgical site infections, and in the end readmission to the health facility and elevated mortality. [17]

Martin et al. reported that the overall estimate for the association between elevated blood glucose and SSI in the pre-or intra-operative period was  $OR = 1.88$ . The overall estimate for the association between elevated blood glucose in the post-operative period and SSI was 1.45. [4]

Akhter et al. reported that incidence in patients  $\geq 50$  years old was 17.8% higher than those  $< 50$  years of age (8.9%). Patients with diabetes mellitus were found to have a significantly higher incidence of SSIs of 21.1% compared with non-diabetics (8.7%). [15]

Liu et al. reported that the finding of diabetes mellitus as a risk issue for SSI was consistent with previous research. Diabetes could result in microangiopathic alternates and end in local tissue ischemia, which finally delayed the wound healing. Furthermore, the immune feature in a patient with diabetes was suppressed and it would impair the wound healing. Preoperative high serum glucose was also determined to be a hazard factor for SSI. The reasons for it were similar to those in affected persons with diabetes mellitus. [2]

Meng et al. reported that they searched the PubMed, Embase, and Cochrane library databases, and identified 25 case-control studies. The pooled results revealed that the major factors associated with infection were diabetes mellitus ( $OR 2.04$ ). [18]

## Conclusion

To conclude, our results support the hypothesis of DM is an independent risk factor for SSIs for different surgical procedures. Awareness about DM control helps to improve surgical outcomes for diabetic patients.

## Competing Interests

The authors declare that they have no competing interests. All the listed authors contributed significantly to the conception and design of study, acquisition, analysis, and interpretation of data and drafting of the manuscript, to justify authorship.

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