A meta-analysis was performed to assess the effect of surgical site wound infections and risk factors in neonates undergoing surgery. A systematic literature search up to January 2022 incorporated 17 trials involving 645 neonates who underwent surgery at the beginning of the trial; 198 of them had surgical site wound infections, and 447 were control for neonates. The statistical tools like the dichotomous or continuous method used within a random or fixed-influence model to establish the odds ratio (OR) and mean difference (MD) with 95% confidence intervals (CIs) to evaluate the risk factors and influence of surgical site wound infections in neonates undergoing surgery. Surgical site wound infections had significantly higher mortality with OR value 2.03 at 95% CI 1.40–2.95 with P-value <0.001, the longer length of hospital stay (MD, 31.88; 95% CI, 18.17–45.59, P < 0.001), and lower birthweight of neonates (MD, 0.30; 95% CI, 0.53 to 0.07, P = 0.01) compared with neonates with no surgical site wound infections undergoing surgery. However, no remarkable change was observed with surgical site wound infections in the gestational age at birth of neonates (MD, −0.30; 95% CI, −0.53 to −0.07, P = 0.01) compared with neonates with no surgical site wound infections undergoing surgery. Furthermore, evidence is needed to confirm the outcomes.
1 | BACKGROUND

Surgical site wound infections happen after surgery, where the infections occur for up to 30 days. Surgical site wound infections can be at the incision or deep, including other tissues, organs, or inside the body. Surgical site wound infections are mostly nosocomial and are the significant reasons for death and illness in all subjects, including children. Although the occurrence and threats for surgical site wound infections in adults and children were stipulated and treatment guidelines were identified, little is known about surgical site wound infections in children. In inpatient surgery, the surgical site wound infections are up to 5% in adult subjects.

As of date, the number of children who were susceptible to surgical site wound infections was up to 5.4%. The following conditions like inpatient and wound conditions, duration of surgery, or specific surgical disciplines, for example, cardiovascular, neurosurgery, orthopaedics, and general surgery, can cause a higher risk of surgical site wound infections. In addition, surgical site wound infections' risk factors comprised old age, comorbidities, surgery difficulties, risk indices, and subject weakness. An earlier study points out that surgical site wound infections in neonates and infants can reach up to 17%. Among the subjects, several conditions have been shown to increase the risk of surgical site wound infections, consisting the history of prematurity, admission to the neonatal intensive care units, low birthweight, premature birth of the baby, mechanical ventilation, comorbidities, central venous access, neutropenia, postsurgical hyperglycemia, and long-term administration of antibiotics. Hence, this meta-analysis analyzes surgical site wound infections' risk factors and effects in neonates undergoing surgery.

2 | METHODS

A methodology is established according to the epidemiology statement which is further organised into a meta-analysis.

2.1 | Study selection

The main indications of the trial were to assess the risk factors and the effect of surgical site wound infections in neonates undergoing surgery using statistical tools like mean difference (MD), odds ratio (OR), frequency rate, or relative risk at a 95% confidence interval.

The literature review was limited to the English language. However, inclusion criteria were not restricted by study type or size, and studies with no relationships were excluded from the study, for example, letters, editorials, commentary, and review articles. Figure 1 represents the model of meta-analysis.

Inclusion criteria of the analysis incorporated into the meta-analysis are given below.

1. The trial was classified into a prospective study, randomised control trial, or retrospective study.
2. Subject selected for the study was neonates undergoing surgery
3. Surgical site wound infections as intervention programs
4. The study comprised surgical site wound infections compared with those without surgical site wound infections in neonates.

The exclusion criteria adopted for the analysis were...
1. Studies that did not assess the risk factors and effects of surgical site wound infections in neonates undergoing surgery
2. Studies with management other than surgical site wound infections.
3. Studies that did not influence comparative outcomes.

2.2 | Identification

Search strategy adopted the protocol as PICOS principle the critical elements of PICOS was P (population): neonates undergoing surgery; I (intervention/exposure): With surgical site wound infections to without surgical site wound infections; C (comparison): Risk factors and effect of surgical site wound infections in neonates undergoing surgery; O (outcome): mortality, length of hospital stay, birthweight of neonates, gestational age at birth of neonates, and preoperative antibiotic prophylaxis; S (study design): without any limitation. A systematic and brief literature search was done on MEDLINE/PubMed, Google Scholar, Embase, OVID, Cochrane Library until January 2022 using search keywords like surgical site wound infections, mortality, length of hospital stay, neonates, birthweight of neonates, gestational age at birth of neonates, and preoperative antibiotic prophylaxis as depicted in Table 1. The research papers were arranged using EndNote software to exclude the duplicates. Moreover, a rigorous analysis on all title and abstracts were done to delete any data that did not indicate any risk factors or impact surgical site wound infections in neonates undergoing surgery on the outcomes studied. Related Information on this topic was collected from the remaining topics.

2.3 | Screening

A standard format was established, including the study and subject-related data. In addition, a traditional form was categorised to include the first author’s surname, place of practice, duration of the study, design of the study, sample size, patient type, demography, categories, treatment mode, qualitative and quantitative evaluation, information source, primary outcome evaluation, and statistical analysis.

“Risk of bias tool” is adopted to assess the methodological quality using Cochrane Handbook for Systematic Reviews of Interventions Version 5.1. To ensure the quality of the methodology, the corresponding author should resolve any conflicts through a discussion that arose during the collection of literature by two reviewers.
### TABLE 1  Search strategy for each database

| Database       | Search strategy                                                                 |
|----------------|---------------------------------------------------------------------------------|
| Pubmed         | #1 “surgical site wound infections”[MeSH Terms] OR “mortality”[MeSH Terms] OR “length of hospital stay”[MeSH Terms] OR “neonates”[All Fields]  
#2 “birthweight of neonates”[MeSH Terms] OR “gestational age at birth of neonates”[All Fields] OR “preoperative antibiotic prophylaxis”[MeSH Terms]  
#3 #1 AND #2                                                                 |
| Embase         | ‘surgical site wound infections’/exp OR ‘mortality’/exp OR ‘length of hospital stay’/exp OR ‘neonates’/exp  
#2 ‘birthweight of neonates’/exp OR ‘gestational age at birth of neonates’/exp OR ‘preoperative antibiotic prophylaxis’/exp  
#3 #1 AND #2                                                                 |
| Cochrane library | #1 (surgical site wound infections):ti,ab,kw OR (mortality):ti,ab,kw OR(length of hospital stay):ti,ab,kw OR (neonates):ti,ab,kw (Word variations have been searched)  
#2 (birthweight of neonates):ti,ab,kw OR (gestational age at birth of neonates):ti,ab,kw OR (preoperative antibiotic prophylaxis):ti,ab,kw (Word variations have been searched)  
#3 #1 AND #2                                                                 |

### 2.4 The different levels of risk of bias encountered in assessment criteria

In the assessment of criteria, there are three different levels of risk of bias. The bias is considered low risk when all quality parameters were met; moderate risk when parameters were only partially completed or not met; and high risk when quality parameters were not met or not included. Inconsistencies are checked by examining the paper.

### 2.5 Eligibility criteria

Risk factors and effect of surgical site wound infections in neonates undergoing surgery were considered the study’s eligibility criteria. Therefore, an evaluation of the risk factors and effect of surgical site wound infections in neonates undergoing surgery during the hospital stay, mortality of neonates, birthweight of neonates, gestational age at birth of neonates, and preoperative antibiotic prophylaxis in neonates undergoing surgery was extracted formed as a summary.

### 2.6 Inclusion criteria

This sensitivity analysis included only the risk factors and effect of surgical site wound infections in neonates undergoing surgery. In comparison, the sensitivity analysis subcategory had the risk factors and effect of surgical site wound infections compared with those without surgical site wound infections in neonates undergoing surgery.

### 2.7 Statistical analysis

The statistical analysis adopted a dichotomous or continuous method to calculate the odds ratio (OR) mean difference (MD) at a confidence interval (CI) 95% on a random influence or fixed influence model. Initially, the I² index scale was assessed between 0% and 100%, and the scale for heterogeneity was set between 0%, 25%, 50%, and 75%, which indicated scale as no, low, moderate, and high, respectively. If I² was 50%, random influence was considered, and if I² < 50%, it was regarded as fixed influence. Initial results are pooled, and subgroup analysis was done to get a P-value that is statistically significant <0.05. The Egger regression test assesses publication bias (if P ≥ 0.05) by calculating funnel plots of the logarithm of odds ratios compared with standard errors. The statistical analysis was performed by “Reviewer manager version 5.3.” (The Nordic Cochrane Centre, The Cochrane Collaboration, Copenhagen, Denmark) with two-tailed P values.

### 3 RESULTS

A total of 17 studies reported between 2005 and 2022 satisfied the inclusion criteria for the meta-analysis among the 1653 distinctive reports. This meta-analysis study included 18 872 neonates undergoing surgery at the beginning of the study; 1506 were with surgical site wound infections, and 17 366 were without surgical site wound infections as control. All studies evaluated surgical site wound infections’ risk factors and effects in neonates undergoing surgery. Six studies reported data stratified to the mortality, nine studies each reported data stratified to the length of hospital stay, gestational age at birth of neonates, and gestational age at birth of neonates, and five studies reported data stratified to the preoperative antibiotic prophylaxis. 60 to 13 589 neonates undergoing surgery were involved as study size. All information about these 17 studies is given in Table 2.

Surgical site wound infections had significantly elevated mortality (OR, 2.03; 95% CI, 1.40–2.95, P < 0.001) with no heterogeneity as 0%, hospital stay longer (MD,
with heterogeneity ($I^2 = 98\%$) compared with no surgical site wound infections for neonates undergoing surgery as shown in Figures 2–4.

| Study             | Country | Total | With surgical site wound infections | Without surgical site wound infections |
|-------------------|---------|-------|-------------------------------------|---------------------------------------|
| García, 2005      | Mexico  | 279   | 125                                 | 154                                   |
| Baird, 2012       | Canada  | 349   | 48                                  | 301                                   |
| Rojo, 2012        | Spain   | 90    | 40                                  | 50                                    |
| Lejus, 2013       | France  | 286   | 11                                  | 275                                   |
| Segal, 2014       | Canada  | 724   | 38                                  | 686                                   |
| Battin, 2016      | India   | 60    | 10                                  | 50                                    |
| Clements, 2016    | USA     | 165   | 29                                  | 136                                   |
| Prasad, 2016      | USA     | 902   | 60                                  | 842                                   |
| Bartz-Kurycki, 2018 | USA    | 13 589 | 542                              | 13 047                                 |
| Woldemicael, 2019 | UK      | 319   | 43                                  | 276                                   |
| Choobdar, 2020    | Iran    | 654   | 88                                  | 566                                   |
| Saggers, 2020     | South Africa | 319 | 152                       | 167                                   |
| Yu, 2020          | China   | 85    | 28                                  | 57                                    |
| Yang, 2021        | China   | 188   | 47                                  | 141                                   |
| Nurlaji, 2021     | Germany | 590   | 135                                 | 455                                   |
| Almeida, 2021     | Portugal | 173 | 10                                | 163                                   |
| Yamamichi, 2022   | Japan   | 100   | 100                                 | 0                                     |
| **Total**         |         | 18 872 | 1506                   | 17 366                                 |

**Table 2** Characteristics of the selected studies for the meta-analysis

[FIGURE 2] A forest plot illustrating the mortality of the surgical site wound infections compared with the control for neonates undergoing surgery.

[FIGURE 3] A forest plot illustrating the length of hospital stay of neonates of the surgical site wound infections compared with the control for neonates undergoing surgery.

31.88; 95% CI, 18.17–45.59, $P < 0.001$) with heterogeneity 98% denoted as high ($I^2 = 98\%$), and lower birthweight of neonates (MD, $-0.30; 95\%\ CI, -0.53$ to $-0.07, P = 0.01$) with high heterogeneity ($I^2 = 90\%$) compared with no surgical site wound infections for neonates undergoing surgery as shown in Figures 2–4.
However, surgical site wound infections had no significant change in the gestational age at birth of neonates (MD, 0.70; 95% CI, 0.07 to 1.46, P = 0.07) with high heterogeneity (I² = 86%), and the preoperative antibiotic prophylaxis (OR, 1.28; 95% CI, 0.57–2.87, P = 0.55) with I² = 53% denoted as moderate heterogeneity compared with no surgical site wound infections for neonates undergoing surgery as shown in Figures 5 and 6.

The pooled data has not considered the elements like group ethnicity and gender because of the lack of reports with these elements. The results of Egger regression analysis funnel plots during the quantitative measurement have not proved any publication bias (P = 0.89). However, problems like poor methodological tools were identified in the selected randomised controlled trial. Selective reporting biases were not detected during this meta-analysis.

4 | DISCUSSION

This meta-analysis comprised 17 studies that included 18 872 neonates undergoing surgery at the beginning of the study; 1506 of them were with surgical site wound infections, and 17 366 were without surgical site wound infections as control. Surgical site wound infections had significantly higher mortality, a longer length of hospital stays, and lower birthweight of neonates compared with no surgical site wound infections for neonates undergoing surgery. However, surgical site wound infections had no notable difference in the gestational age at birth of neonates and the preoperative antibiotic prophylaxis compared with no surgical site wound infections for neonates undergoing surgery. However, the selection of a low sample size forces the researcher to analyse outcomes...
with consideration, for example, 5 among the 17 studies were with ≤100 neonates as the size of the population; advocate the probability of these results or to impact confidence in the evaluation of specific parameters, for example, gestational age at birth of neonates with its low P-value close to 0.07.

In adult and paediatric subjects, the overall rate of surgical site wound infections was up to 5%, and surgical site wound infections are related to the length of hospital stay, health care cost, mortality, and morbidity.\(^2\) Risk factors for surgical site wound infections are recognised in mainly adult populations. They comprise hyperglycemia, advanced age, malnutrition, risk indices, the complexity of the surgery, comorbidities, more surgical time, subject frailty, high blood loss, and prior infections.\(^3\) Children undergoing specific cardiovascular, neuro, orthopaedics, and general surgery were highly likely to develop surgical site wound infections.\(^2\) Surgical site wound infections can considerably increase the burden (clinical, economic) due to diagnostic tests, management, and prolonged hospitalisation of the subject. Furthermore, surgical site wound infections negatively impact the subject's physical and mental health and loss of earnings during recovery.\(^27\)

The study illustrates that premature infants essentially require surgical interventions,\(^14\) which is ascertained by the occurrence of surgical site wound infections in this cohort (77%). A recent analysis by The Canadian Paediatric Surgery Network quoted an overall 15% of surgical site wound infections in neonates undergoing surgery.\(^28\)

One of the study's limitations is various bias exists as many studies are exempted from this meta-analysis as these studies are not meeting the inclusion criteria. Furthermore, there was an uncertainty in linking the factors like gender, age, and ethnicity to this analysis. The study compared the correlation between the influences of risk factors and the effect of surgical site wound infections in neonates undergoing surgery. The analysis depends on data from existing studies which can arise bias as it contains incomplete details. The meta-analysis consisted of 17 studies; 5 of them were small, ≤100. Several lost data and unpublished studies may aggregate into an influence bias. Patients used various medications, health care schemes, treatments, and doses. And also, the type of surgical site wound infections, mortality, or length of hospital stay used for neonates' treatment of the included studies varied. The major drawback was that this meta-analysis did not study the subject's hospital cost.

5 | CONCLUSIONS

Surgical site wound infections had significantly higher mortality, and lower birthweight of neonates, a longer length of hospital stays, compared with no surgical site wound infections for neonates undergoing surgery. However, surgical site wound infections had no significant change in the gestational age at birth of neonates and the preoperative antibiotic prophylaxis compared with no surgical site wound infections for neonates undergoing surgery.

4.1 | Limitations

One of the study's limitations is various bias exists as many studies are exempted from this meta-analysis as these studies are not meeting the inclusion criteria. Furthermore, there was an uncertainty in linking the factors like gender, age, and ethnicity to this analysis. The study compared the correlation between the influences of risk factors and the effect of surgical site wound infections in neonates undergoing surgery. The analysis depends on data from existing studies which can arise bias as it contains incomplete details. The meta-analysis consisted of 17 studies; 5 of them were small, ≤100. Several lost data and unpublished studies may aggregate into an influence bias. Patients used various medications, health care schemes, treatments, and doses. And also, the type of surgical site wound infections, mortality, or length of hospital stay used for neonates' treatment of the included studies varied. The major drawback was that this meta-analysis did not study the subject's hospital cost.

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CONFLICT OF INTEREST
The authors declare that there is no conflict of interest.

DATA AVAILABILITY STATEMENT
The corresponding author is bound to give the database of meta-analysis on request.

ORCID
Mohamed EA Abdelrahim https://orcid.org/0000-0003-0227-8404

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