Review Article

Epidemiology and Risk Factors of Post Operative Site Infections in Surgical Patients: A Systematic Review

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Abstract

Surgical site infection (SSI) is one of the most common and serious hospital-acquired infections all over the world. The SSI can lead to an increase in morbidity, mortality, and increase in the duration of hospital stay among patients. The present systematic review was planned to find the epidemiological features, prevalence, causative organisms, and predisposing risk factors for the development of postoperative infections among surgical patients of all the six WHO regions. Initially, 281 articles were identified through specified databases. Finally, 18 articles that fulfilled all inclusions and exclusion criteria are included. For the risk factors assessment, p-values, odds ratio were considered. In general, the occurrence rate of SSI ranges from 2% to 17.8%. Regarding causative organisms, three microorganisms are commonly reported in most of the studies were Staphylococcus aureus, Klebsiella pneumonia, and E.Coli. Among the different procedures reviewed, incidence and prevalence rates were higher among emergency surgical procedures and lower among obstetrics and gynecology procedures. Longer preoperative duration of stays in hospital decreased Hb and serum albumin level, comorbid conditions such as diabetes, hypertension are potential risk factors for the development of SSI. The occurrence rate of SSI among post-operative patients is very high, especially in developing countries. This leads to a double burden on the healthcare delivery settings during the COVID-19 pandemic. It is essential to include a strict infection control policy, fair usage of antibiotics practices to be implemented. It is also recommended to control comorbid conditions before planning for elective surgery.

Keywords: Surgical site infection, Risk Factors, Prevalence, Causative organisms

Introduction

Surgical site infection (SSI) is one of the most common and serious hospital-acquired infections all over the world [1-3]. According to the Centre for Disease Control and Prevention (CDC), surgical site infection is defined as "post-operative infections that develop in 30 days after any surgical procedure or within one year of any implants [4]. All over the world, around 300 million surgeries are performed every year. This increasing number of surgeries leads to an increase in the incidence of postoperative wound infections on surgical sites [5]. A recent report published by the World Health Organization (WHO) that surgical site infection (SSI) is one of the commonly occurring hospital-acquired infections (HAI) in low- and middle-income countries. This affects up to one-third of patients who have undergone a surgical procedure. Although SSI frequency is lower in developed countries, it remains the second most common type of HAI in the USA [6].

In the Kingdom of Saudi Arabia, several studies found the incidence of surgical site infections ranges from 6.8% to 24% [7-9]. Several studies have been done to assess the SSI of the particular site such as the ankle, breast, and more [10, 11]. The infection in a surgical wound is an indication of the disrupted host-microorganism equilibrium that leads to colonization of the bacteria on the surgical site. As a result, the wound healing process is greatly affected, and systemic response also will manifest [12].

The consequences and impact of postoperative wound infections have been published exhaustively all over the world that included an increase in morbidity, mortality, and

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increase in the duration of hospital stay. This SSI also leads to readmission of the patients, failure of primary surgical methods, and so on. This increasing incidence of SSI also impacts an additional burden on health care expenditure and the need for additional resources [13-15]. This leads to a further increase in the pressure on health care systems which is already overburdened due to the coronavirus – 19 (COVID-19) pandemics, especially in developing countries [16, 17]. Hence, it has become more important to understand the epidemiology, causative organisms, and risk factors for the SSI for the prevention of SSI.

In most post-operative infection cases, the causative organisms are endogenous in origin; the commonly found in SSI clinical isolates are Staphylococcus aureus, enterococci, E.Coli and coagulase-negative staphylococcus. Some studies have found that methicillin-resistant staphylococcus (MRSA) was also responsible for SSI [18, 19]. This scenario further makes things complicated as MRSA organisms are difficult to treat. In the past, some of the authors have made attempts to find the different risk factors for postoperative infections and commonly reported factors are the long duration of surgery, improper pre-operative preparation of the skin, type of surgery, impaired physiological states such as hypoxia, hypothermia, shock and associated co-morbid conditions (diabetes mellitus, obesity, and immune deficiency) [20-22]. Some of the authors in the past have attempted to do systematic reviews on the SSI; but with our extensive review of literature, there are limited systematic reviews available that cover the epidemiological characteristics and risk factors [23, 24]. Hence, this systematic review was planned to find the epidemiological features, prevalence, causative organisms, and predisposing risk factors for the development of postoperative infections among surgical patients of all the six WHO regions.

Materials and Methods

The present systematic review was made as per the Preferred Reporting Items for Systematic Reviews (PRISMA) reporting statements and guidelines.

Search methods and inclusion criteria

The research team made extensive literature searches from PubMed/Medline, Cochrane Library, Embase, and Database of Abstracts of Reviews of Effects (DARE). The search methods involved the keyword "post-operative infection," "surgical site infection," "prevalence of surgical site infection," "incidence of surgical site infection," "risk factor," and "causative organism". Firstly, articles published in the English language are only included and other language articles are excluded. The article was published during the last ten years; all the surgical specialties (including dental science) were included in the present review. Also, those articles must have been published in a peer-reviewed journal with an International Standard Serial Number (ISSN).

Data extraction

All the authors have collected the articles as per the inclusion criteria. After the collection and compilation of articles, two independent authors (first and second) reviewed and included articles for data extraction and synthesis. The extracted data is initially screened based on title and abstract and then eligible articles were further assessed for data extraction. The extracted data include types of study design, sample size, prevalence, potential risk factors, and causative microorganisms. The potential risk factors evidence was synthesized based on p-value and/or odds ratio (OR), while other data were synthesized based on frequency and proportion.

Results and Discussion

The below figure (PRISMA flow chart) summarizes the data extraction process for this systematic review. The number of articles included and excluded in the different stages based on the data extraction criteria is described. These articles are published in peer-reviewed journals during the past 10 years. Initially, there were around 282 articles were identified in this review. Subsequently, after exclusion from each stage, a total of 18 full-text articles were assessed for evidence synthesis.

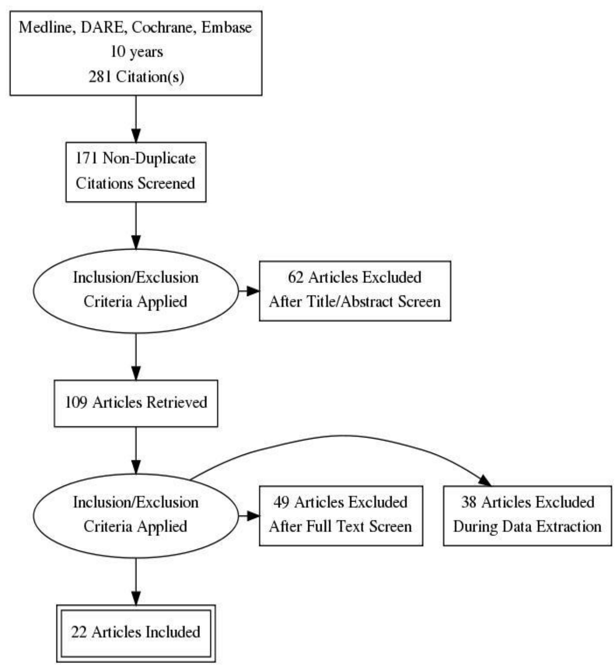

Figure 1. PRISMA Flow Chart

Table 1 describes the general characteristics included in this review in terms of WHO regions, types of study designs, and types of surgery. The present study included 4 (22.2%) articles from the Southeast region and 61.1% included articles were based on elective surgical procedures.

Table 1. General characteristics of the included study (n=18)

Characteristics	Number	%
WHO Regions		

The African Region	3	16.7
The Region of the Americas	3	16.7
The Eastern Mediterranean Region	3	16.7
The European Region	2	11.1
The South-East Asia Region	4	22.2
The Western Pacific Region	3	16.7
Type of study design		
Cross-sectional	6	33.3
Retrospective	7	38.8
Prospective/Cohort	5	27.7
Types of surgery		
Elective	11	61.1
Emergency	7	38.9

Study description, major outcomes including the prevalence of SSI in different regions of the world are presented below table. A minimum of one article is selected from each of the six WHO regions. In general, the occurrence rate of SSI ranges from 2% to 17.8%. Regarding causative organisms, three microorganisms are commonly reported in most of the studies were Staphylococcus aureus, Klebsiella pneumonia, and E.Coli. Among the different procedures reviewed, incidence and prevalence rates were higher among emergency surgical procedures and lower among obstetrics and gynecology procedures **(Table 2)**.

Table 2. Baseline characteristics of articles and their major outcome related to prevalence and microorganisms

Author, Year	Country/Region	Study description	Key findings
Lubega A et al, 2017 [25]	Uganda, the African region	Prospective study N = 114, Emergency post-operative patients	Incidence – 16.4% Klebsiella Pneumonia is the most common organism (50%) followed by S.Aureus (27.8%)
Torres S et al, 2018 [26]	Brazil, Region of Americas	Retrospective study N = 178 Craniotomy patients	Incidence – 11.6%
Kumar A et al, 2017 [27]	India, South-East Asian Region	Retrospective N = 3321 elective and 451 emergencies All general surgical unit patients	Prevalence – 17.7% in emergency surgeries and 12.5% elective surgeries
Alshammari et al, 2020 [28]	Saudi Arabia, Eastern Mediterranean Region	A 10-year retrospective study from a tertiary care hospital	The prevalence rate ranges from 20 per 1000 in 2009 to 3.5 per 1000 in 2018
Dessie W et al, 2016 [29]	Ethiopia, African Region	A cross-sectional study was done on 107 SSI patients to find the causative organisms	E.Coli was the commonest infective microorganisms (23.1%). Multi-drug resistance was highly prevalent.
Morikane K et al, 2016 [30]	Japan, Western Pacific region	A retrospective study from the nationwide database Gastric surgery patients	Rate of SSI 8.8%
Negi V, 2018 [31]	India, South-East Asian Region	Cross-sectional study N = 768	Prevalence – 17.8% The order of common organisms: *S. aureus* -50.4% *E.coli* - 23.02%, *P. aeruginosa* -7.9%
Pathak A et al, 2017 [32]	India, South-East Asian Region	Cross-sectional study N = 1173 Obstetrics and Gynecology	The rate of occurrence of SSI was 7.84%
Rouse T et al, 2019 [33]	Canada, American region	Prospective study N = 120 OBG-GYN patients	Incidence rate – 5.9%
Li Z et al, 2021 [34]	China, Western Pacific region	Prospective multicentric study N = 953 Emergency abdominal surgery	The incidence rate is 7.5% The commonest pathogen was E.coli -29.6% positivity rate.
Brennfleck FW et al, 2020 [35]	German, European summarizes the region	Retrospective	Superficial SSI – 13.5% Deep incisional – 9% Organ space – 2.4%

Table 3 potential risk factors for the development of SSI in the different study populations. The study included finding that associated risk factors were reviewed based on their p-value and/or odds ratio (OR) with the 95% confidence interval (CI). The OR value of more than one and 95% CI value does not include a null value of one is considered as a positive association. The higher the confidence interval indicates the strength of association is higher. In general, longer preoperative duration stay in the hospital, decreased Hb and serum albumin level, comorbid conditions such as

diabetes, hypertension are potential risk factors for the development of SSI.

Table 3. Summary of potential risk factors of SSI

Author, Year	Country/ Region	Study description	Risk factors
Lubega A et al, 2017 [25]	Uganda, the African region	Prospective study N = 114, Emergency post-operative patients	Wound class (p = 0.009), ↓serum albumin (p = 0.046), Type of suture material (p = 0.006), ↓Hb level (p = 0.024),
Alghamdi et al, 2021 [36]	Saudi Arabia, Eastern Mediterranean Region	Retrospective case-control study N = 221 Spinal surgery patients	Longer post-operative duration stays at hospital- p = .004, OR (95% CI) = 1.17 (1.05–1.31), Hypertension - p = .02, OR (95% CI) = 5.62 (1.19–24.47) Higher ASA score p = 0.04, OR (95% CI) = 26.0 (1.16-583.46) Blood transfusion - p <0.01, OR (95% CI) = 23.3 (4.43–122.73)
Mekhala et al, 2019 [37]	India, South-East Asian Region	Prospective cohort study N = 100 Intra-abdominal surgery patients	Diabetes, Preoperative anemia, ↓serum albumin, long duration of surgery.
Torres S et al, 2018 [26]	Brazil, Region of Americas	Retrospective study N = 178 Craniotomy patients	Surgery duration>4 hours (OR= 1.49; 95% CI, 0.96–2.30; p = 0.046), More drain time (OR= 4.67; 95% CI, 1.34–16.00; p = 0.015) Patient with reoperation (OR = 4.38; 95% CI, 1.14–16.74; p = 0.03)
Azeze et al, 2019 [38]	Ethiopia, African Region	Cross-sectional study N = 383 Post cesarian section	Rupture of membrane (aOR (95% CI) = 13.9 (2.99–64.8), Surgery duration > 30 mins (aOR (95% CI)= 4.9, (1.8–13.1), Improper skin closure methods (aOR (95% CI) = 6.29 (2.07–19.11)
Patel S et al, 2019 [39]	The United Kingdom, European region	Retrospective study N = 16513	Longer duration of surgery; p = 0.018, OR (95% CI) = 2.36 (1.16–4.79) Use of dexamethasone; p <0.01, OR (95% CI) = 3.03 (1.71–5.36) Wound; p <0.01, OR (95% CI) = 27.77 (16.36–47.15)
Carvalho et al, 2017 [40]	Brazil, Region of Americas	Non-concurrent cohort study N = 16882	More preoperative stay at the hospital (>24 hours), contaminated wounds, ASA class III and IV
Zhang X et al, 2020 [41]	China, Western pacific region	Cross-sectional study N = 1046 Colorectal surgery patients	Hypertension; P = 0.025, OR - 1.90 (95% CI= 1.09-3.32), nosocomial infection surveillance risk index score of 2 or 3; p<0.01, OR =3.84, (95% CI=1.93-7.66)
Mirzashahi et al, 2019 [42]	Iran, Eastern Mediterranean region	Cross-sectional study N=78 Aged 18 years and above	Dental caries (P = 0.016), history of dental abscess (p=0.023), and the presence of periodontal disease (P = 0.049)

The postoperative infection/SSI is one of the growing challenges for the health care delivery sectors. Prevention and control of SSI are some of the essential components for the reduction of health care delivery costs and this is now more essential as COVID-19 pandemics crippling the health care delivery, especially in developing countries. The present systematic review was aimed to identify the epidemiological characteristics and risk factors for the development of SSI in all six WHO regions.

The present review revealed that the occurrence of SSI ranges from 2% to 17.8%. These huge variations in the occurrence are influenced by several factors. Firstly, the Southeast region countries reporting a higher incidence of SSI, while Eastern Mediterranean countries reported a lower incidence of SSI. Similar to our review, a study done by Lateefa A et al in the kingdom of Saudi Arabia in 2020 revealed that the frequency of SSI occurrence is very low during the past five years [28]. In contrast to our finding, a study was done by Khan UF in Pakistan (a part of the South-east Asian WHO region) have reported a slightly higher proportion of SSI (29.8%) among the patients who undergone seven different surgical procedures [43]. This emphasizes the importance of proper implementation of SSI preventive measures in these countries so that the additional burdens faced by the COVID-19 pandemic can be reduced.

Our study revealed that postoperative wound infections are commonly caused by S. Aureus (25to 55%), E. Coli (26 to 53%), and K. Pneumonia (12 to 25%). Other reported organisms are P. Aurigonsa and gram-negative bacteria. Interestingly, a study done by Lubega A et al in Uganda has reported a very high proportion (50%) of K. Pneumonia as a causative organism among 114 emergency postoperative patients [25].

This systematic review investigated different potential risk factors for the development of SSI among post-operative patients. Consistently, co-morbidities were one of the major risk factors for the development of SSI. Several authors from different regions have reported the presence of comorbidities such as diabetes, hypertension, anemia, hypoalbuminemia, and renal impairments increase the risks of SSI [25, 36, 37]. Perioperative surgery duration is one of the important predictors of SSI development and longer the duration of surgery leads to higher risk, evidenced by the OR of 4.7 to 11 [26]. Similarly, the incidence of emergency surgical procedures has higher risks than elective surgical procedures [28, 33]. This could be due to better control of comorbidities in a planned elective pre-operative surgery than the emergencies. Some surgery categories such as obstetrics and gynecology, orthopedics are reported to have a lower incidence of SSI [36]. The role of pre-operative dexamethasone is poorly evaluated, and data is limited. Dexamethasone is an inexpensive drug used for the prevention of postoperative vomiting. However, a study done by Patel et al in 2019 revealed that the use of dexamethasone increases the risk of SSI (p <0.01, OR (95% CI) = 3.03 (1.71–5.36)).

Despite the best effort from our research team for this systematic review, certain limitations need to be considered while interpreting this systematic review. Firstly, the present study included only English-language articles. Hence, findings of non-English articles are not considered for review, this systematic review may not be applicable for global targets. The sample size of the majority of articles in this review is small. Finally, about one-third of included studies are case-control studies. Hence, the possibility of confounding bias needs to be considered while interpreting this systematic review.

Conclusion

The occurrence rate of SSI among post-operative patients is very high, especially in developing countries. This leads to a double burden on the healthcare delivery settings during the COVID-19 pandemic. Common microorganisms responsible for SSI developments are S. Aureus, E. Coli, and K. Pneumonia. Numerous potential risk factors such as the presence of comorbidities, longer perioperative duration are identified. Hence, it is essential to include a strict infection control policy, fair usage of antibiotics practices to be implemented. It is also recommended to control comorbid conditions before planning for elective surgery.

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