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Research article

Post-operative site infections among surgical patients at Southern Ethiopia: A prospective cohort study

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ABSTRACT

Objective: The current study was conducted to estimate the magnitude of SSI among surgically treated patients and identify the predictors associated with it.
Background: summary: Despite the fact that surgical site infection (SSI) is still a global health care-associated infection related to patients' discomfort, morbidity, and mortality, it is the most preventable nosocomial infection if all necessary measures are taken into account.
Methods: An institution-based prospective cohort study was conducted at a large teaching hospital in southern Ethiopia. Patients admitted to the surgical ward with a non-traumatic acute abdomen were participants in the study and were followed prospectively for 30 days. The collected data was entered into Epi-Data 4 and exported to STATA 16 for analysis. A logistic regression (bi-variable and multivariable) model was computed to detect the association between SSI and predictors. In the final model, variables with a p-value <0.05 were declared statistically significant.
Results: In this study, a total of 169 patients were enrolled. More than 3/4th (78.9%) of them were male, and the mean ± SD age of participants was 42.14 ± 12.5 years. Eighteen participants (10.5%) suffered from surgical site infection (SSI). Predictors of SSI were ever smoking [AOR = 3.9; 95% CI (1.2–16.5)], American Society of Anesthesiologists score ≥3 [AOR = 8.9; 95% CI (1.7–45.5)], appendectomy [AOR = 7.7; 95% CI (1.3–45.7)], and co-morbid diabetes [AOR = 13.8; 95% CI (2.6–72.1)].
Conclusion: The magnitude of SSI was considerable in the study setting. Predictors of SSI were smoking, ASA score, appendectomy, and co-morbid diabetes. We strongly recommend that health-care professionals provide health education and patient counseling on smoking and health-seeking behaviors. Considering co-morbid conditions before surgery has paramount importance. Moreover, further large-scale studies are suggested.

1. Background

Surgical site infection (SSI) is a health care-associated global problem that occurs more frequently in low- and middle-income

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countries where there is a shortage of experienced surgeons and inadequate medical equipment [1–3]. SSI is one of the most preventable nosocomial infections in surgical patients [4]. According to World Health Organization (WHO) research, SSI affects over one-third of patients in low- and middle-income countries who have surgery [5], are the second most prevalent hospital acquired infection (HAI) in Europe and the United States [6]. In 66 countries across the world, a multicenter cohort study found that 12.3% of patients had SSI within 30 days of surgery [7]. By 2020, there had been a 5% drop in the prevalence of SSI over the previous five years [2]. According to a systematic review report, the prevalence of SSI in African nations ranges from 2.5% to 30.9% [8], and in Ethiopia, 12.3% patients developed SSI post-abdominal surgery [9].

A surgical site infection is an infection at or around the site of the incision where a surgical procedure is conducted within 30 days or after 12 months of the implant procedure [10]. According to the Centers for Disease Control (CDC) and the National Health-Care Safety Network (NHSN), SSI is broadly categorized as an incision (superficial and deep) or organ space (involving the body cavity). In order to predict who is at risk of developing an SSI, the CDC also developed the surgical wound classification system (SWC: I, clean; II, clean/contaminated; III, contaminated; and IV, dirty). SSI is superficial if the infection occurs within 30 days of the operation and involves the skin and subcutaneous tissue. If the infection occurs within a year after the implant is placed and involves fascia and muscle, it is called deep SSI [11]. The vast majority of SSI is superficial, and when deep tissue and organ space SSI are involved, morbidity and mortality increase [12]. Patients with SSI can exhibit any one of the following symptoms in either situation: pain, heat, swelling that is localized, painful, and erythematous, as well as discharge that is either severe or purulent from the surgical site [13].

Surgical site infections go beyond the quality of surgical service; they are partly associated with the patient's immunity, nutritional status, comorbidities, and others [14,15]. Consequences of SSI include wound dehiscence, increasing the length of the patient's hospital stay, lowering the pace of recovery, hastening morbidity and mortality, and adding significantly to the patient's medical expenses [12,13,16]. Common risk factors for developing SSI are longer hospital stays, subpar surgical techniques, immunocompromization, the wrong prophylaxis, and extended surgical time [6,17]. According to recent studies, the frequency of SSI after abdominal surgery ranges from 1.2% to 5.2% [16,18], and it is more common in patients who are having emergency surgery than those who are having elective surgery [19]. The percentage of SSI following abdominal surgery was shown to vary amongst distinct studies. Accordingly, the prevalence of SSI in Malaysia was 11.7% [20], China 7.5 % [16], India 12.6% [13], Iran 17.4% [3], Saudi Arabia 16.3% [21], Rwanda 8.2% [22], Uganda 20% [23], Tanzania 13.9% [24], Bahir Dar, Ethiopia 8.6% [25], East and west Gojjam, Ethiopia 25.5% [14]. Among the factors linked to surgical site infection were advanced age, male sex, diabetes mellitus, longer hospital stay, longer duration of surgery (>1 h), contaminated wound, antibiotic prophylaxis, an American Society of Anesthesiologists (ASA) score ≥3, and cigarette smoking [3,12,13,20,23,26].

To reduce infection burden post-surgical incision, it is a must to apply the WHO-recommended surgical precautions and preparations [5], and it should be applicable by all health team. Appropriate surgical wound irrigation with an antiseptic solution of chlorhexidine gluconate is of paramount importance to reduce SSI [17]. There is insufficient data on SSI following abdominal surgery, despite the greater prevalence of SSI in Africa, particularly in Ethiopia. Moreover, unlike this study, the majority of preceding studies were cross-sectional and retrospective in their study design. Hence, finding pertinent information about SSI following abdominal surgery is crucial in order to provide a foundation for its prevention and control strategies. Furthermore, when surgeries are scheduled, recognizing the risk variables that encourage SSIs may help choose the best preventive strategies and interventions.

1.1. Methods and materials

This study was conducted after receiving an approval letter from the Arba Minch University Institutional Review Board (IRB) with reference No. 552 taken in October 2018. Our study was piloted in line with the Declaration of Helsinki.

1.2. Study design, setting and period

An institution-based prospective cohort study was conducted from December 15, 2018, to February 9, 2019, in Arba Minch Hospital, Southern Ethiopia. Arba Minch is one of the areas in Ethiopia where more than 80 ethnic groups live with their diversified background characteristics. The hospital has over 200 beds and more than 250 health professionals.

1.3. Study population and eligibility

In this study, all patients admitted to the surgical ward with a non-traumatic acute abdomen were eligible to participate, and patients initially diagnosed with SSI, early-discharged patients, patients with loss of follow-up, and cards with incomplete data were excluded.

1.4. Sample size determination and sampling

Sample size was estimated by the single population proportion formula and considering the following assumptions: $p = 0.123$ [9] 95% CI, and 5% margin of error. Hence, the calculated sample size was 166. However, the size of the clients within the study period was less than 10,000. Hence, the sample size needed correction formula, $nf = n^* {}^{N}\!/_{n+N} = 166 \times {}^{1850}\!/_{166+1850} = 153$. So, this correction formula yield calculated sample size of 153. When 10% of non-response added, the total adjusted sample size was 169. Systematic sampling was applied to recruit study individuals from admitted patients who had surgical intervention.

1.5. Study variables

Dependent variables: surgical site infection (SSI)

Independent variable: Sociology-demographic characteristics (age, sex and residence), and behavioral and clinical related characteristics such as; arrival time, surgical history, ever smoking, ASA score, type of wound, co-morbidities such as diabetes, cardiac disease, acute respiratory distress syndrome (ARDS), hypertension, duration of surgery, and hospital stay.

1.6. Operation definition

Surgical site infection: an infection that occur at or near the incisions site where surgical operation is performed within 30 days or after 12 months if implant is placed inside [10].

1.7. Data collection instrument, procedure and quality control

In this study, data was gathered using techniques including structured questionnaires and client or caretaker interviews. The questionnaires included thorough information on the patients' socio-demographic, behavioral, and clinical features. The incisional site was inspected every three days, and the temperature was recorded each morning. All patients are observed in an inpatient setting, as we have explained in the eligibility session, as early discharged patients were not included. Doctors diagnosed any kind of post-operative problem, including SSI. All admitted patients were visited every morning by physicians in what we call a "patient round," and their progress was evaluated (either improved, no change, or deteriorated). If patients develop or complain about any one of the following symptoms within the last 30 days of surgical intervention, they are diagnosed with SSI: pain, heat, swelling that is localized, painful, and erythematous, as well as discharge that is either severe or purulent from the surgical site. In order to guarantee data accuracy, BSc nurses who underwent training collected the data. Following extensive review of pertinent literature, we devised techniques for collecting data. Confidentiality was maintained during the study.

1.8. Data management and statistical analysis

The data were coded, cleaned up, loaded into Epi-Data 4 for analysis, and exported to STATA 16. Frequency tables with percentages and a graphic were used to present the descriptive information. To identify the relationship between SSI and predictors, a logistic regression (bi-variable and multivariable) model was constructed. The multivariable logistic regression analysis included variables with a p-value of ≤0.25 in the binary logistic regression. The strength of association was assessed using the crude odds ratio (COR) and adjusted odds ratio (AOR) at 95% CI. Hosmer and Lemeshow, for the corresponding model fit and variance inflation factor, verified the model fitness and the variance inflation factor. Finally, p-values of less than 0.05 were used to determine which variables were statistically significant.

Table 1
Socio-demographic, behavioral and clinical characteristics of participants with abdominal surgery at southern Ethiopia.

Parameters	Categories	Number (%)	Parameters	Categories	Number (%)
Age	<20	31 (18.3%)	Sex	Female	36 (21.3%)
	20–39	46 (27.2%)		Male	133 (78.7%)
	40–59	46 (27.2%)	Residence	Rural	129 (76.3%)
	≥60	46 (27.2%)		Urban	40 (23.7%)
Arrival time	>24 h	139 (82.2%)	CLD	No	164 (97.0%)
	<24 h	30 (17.8%)		Yes	5 (3.0%)
Surgical history	No	160 (94.7%)	CKD	No	166 (98.2%)
	Yes	9 (5.3%)		Yes	3 (1.8%)
Smoking history	No	156 (92.3%)	Fever	No	119 (70.4%)
	Yes	13 (7.7%)		Yes	50 (29.6%)
Type of wound	Clean/clean-contaminated	151 (89.3%)	ARDS	No	161 (95.3%)
	Contaminated	18 (10.7%)		Yes	8 (4.7%)
Causes of surgical operation	Intestinal obstruction (SBO/LBO)	127 (75.1%)	ASA score	<3	148 (87.6%)
	Appendicitis	25 (14.8%)		≥3	21 (12.4%)
	Others*	17 (10.1%)	Diabetes	No	154 (91.1%)
				Yes	15 (8.9%)
			Leukocytosis	No	127 (75.1%)
Procedure performed	Resection and anastomosis	110 (65.1%)		Yes	42 (24.9%)
	Derotation	38 (22.5%)			
	Reduction	14 (8.3%)	Duration of surgery	<1hr	138 (81.7%)
	Diversion/stoma	7 (4.1%)		>1hr	31 (18.3%)
Hospital stay	≤7 days	58 (34.3%)	Hypertension	No	156 (92.3%)
	>7 days	111 (65.7%)		Yes	13 (7.7%)

Note; ARDS: Acute Respiratory Distress Syndrome, CKD: Chronic Kidney Disease, CLD: Chronic Liver Disease, IO: Intestinal Obstruction, LBO: Large bowl obstruction, Others* Hernia, cholecystitis, pancreatitis and undetermined causes, SBO: Small bowl obstruction.

2. Results

2.1. Socio-demographic characteristics of participants

A total of 169 surgically operated patients took part in the survey. The mean ± SD age of participants was 42.2 ± 12.5 years. More than 3/4th (78.7%) of patients were male and 129 (76.3%) clients were rural dwellers (Table 1).

2.2. Prevalence of surgical site infection post-abdominal surgery

In this study, the prevalence of surgical site infection among post-abdominal surgery is 10.5% [95% CI: 6–15%].

2.3. Behavioral and clinical characteristics of surgical patients

In the current study, the majority of participants, 139 (82.2%), arrived in the hospital after 24 h of the symptoms, and three-fourth of them, 127 (75.1%), were intestinal obstruction cases and 31 (18.3%) patients had >1hr surgical duration. 13 (7.7%) of participants had history of ever smoking. More than a quarter of the patients, 50 (29.6%), had fever, and 42 (24.9%) had an elevated WBC count. Around one-tenth, 15 (8.9%) and 13 (7.7%) of surgical patients had co-morbid diabetes and hypertension, respectively. One hundred and eleven patients (65.7%) had longer hospital stays (Table 1).

2.4. Predictors of surgical site infections in surgical patients

Potential variables such as age, sex, smoking, surgical history, ASA score, causes of surgical operation, type of obstruction, duration of surgery, diabetes mellitus, hypertension, and hospital stay had a p-value ≤0.25 in bi-variable logistic analysis. Then, in the final model of multivariable logistic analysis being a smoker, ASA score, appendectomy, and co-morbid diabetes were statistically significant predictors for SSI.

The odds of having SSI for smokers were 4 times [AOR = 3.9; 95% CI (1.2–16.5)] more likely to have SSI in contrary to nonsmokers. In comparison to those with an ASA score of <3, patients with an ASA score of ≥3 were 8.9 times [AOR = 8.9; 95% CI (1.7–45.5)] more likely to develop SSI. The odds of having SSI for appendectomy was 7.7 times [AOR = 7.7; 95% CI (1.3–45.7)] higher as compared to intestinal obstruction. Study participants with co-morbid diabetes was 13.8 times [AOR = 13.8; 95% CI (2.6–72.1)] more likely to acquire SSI to its counterpart (Table 2).

Table 2
Logistic regression analysis for predictors of surgical site infection among patients with abdominal surgery at southern Ethiopia.

Parameters	Categories	SSI		OR (at 95 CI)		*P*-value
		No	Yes	COR	AOR	
Age	<20	28	3	1	1	
	20–39	43	3	0.6 (0.1–3.4)		
	40–59	42	4	0.8 (0.2–4.2)		
	≥60	38	8	1.9 (0.4–8.0)	2.9 (0.4–25.2)	0.045
Sex	Female	32	4	1		
	Male	119	14	0.9 (0.3–3.0)		
Ever smoking	No	142	14	1	1	
	Yes	9	4	4.5 (1.2–16.5)	3.9 (0.7–21.1)	**0.04**
Surgical history	No	145	15	1	1	
	Yes	6	3	4.8 (1.1–21.3)	1.8 (0.3–14.1)	0.53
ASA score	<3	139	9	1	1	
	≥3	12	9	11.0 (3.8–34.6)	8.9 (1.7–45.5)	**0.008**
Causes of surgical operation	IO	119	8	1	1	
	Appendicitis	18	7	5.7 (1.8–17.8)	7.7 (1.3–45.7)	**0.024**
	Others*	14	3	3.1 (0.7–13.4)	3.0 (0.5–18.5)	0.23
Type of wound	Clean/clean-contaminated	140	11	1		
	Contaminated	11	7	8.0 (2.6–25.0)	2.5 (0.5–13.9)	0.28
Duration of surgery	<1hr	127	11	1	1	
	>1hr	24	7	3.3 (1.2–9.5)	1.9 (0.4–8.1)	0.045
Diabetes mellitus	No	142	12	1	1	
	Yes	9	6	7.8 (2.4–25.0)	13.8 (2.6–72.1)	**0.002**
Hypertension	No	140	16	1		
	Yes	11	2	1.5 (0.3–7.8)		
Hospital stay	≤7 days	56	2	1	1	
	>7 days	95	16	4.7 (1.0–21.2)	4.5 (0.7–29.0)	0.04

Note: ASA: American Society of Anesthesiologists, Others*: Hernia, cholecystitis, pancreatitis and undetermined causes, IO: Intestinal obstruction, 1: reference, Hosmer–Lemeshow goodness-of-fit (p = 0.479), and Variance inflation factor or VIF <5.

3. Discussion

Surgical site infection is the foremost health-care-associated problem in low and middle-income countries that fastens symptoms of comorbidities, prolongs hospital admission, lengthens patients' morbidity, and increases disease fatality. It is important to consider providing medical staff, especially those working in the surgical department, with the appropriate training, ongoing on-the-job and off-the-job education, and experience sharing, and advancing healthcare facilities with the required technology.

The present study showed that the prevalence of SSI post-abdominal surgery was 10.5%, which is in line with results from Bahir Dar, Ethiopia 8.6% [25], Rwanda 8.2% [22], India 12.6% [13], China 7.5% [16] and Malaysia 11.7% [20]. However, this magnitude is lower than east and Gojjam, Ethiopia 25.5% [14], Uganda 20% [23], Saudi Arabia 16.3% [21] and Iran 17.4% [3]. The difference might be related to sample size, the advancement of health institutions, the skill of surgeons, the applicability of infection prevention and control protocols, and patient-related characteristics.

In this study, the presence of SSI was statistically associated with ever smoking, ASA score, appendectomy and diabetes mellitus.

Participants who ever smoked were 4 times more likely to have SSI to the contra-part of nonsmokers. This is similar with that of Gojjam, Ethiopia [14] and USA [12]. Smoking may be the root of localized systemic vasoconstriction, which causes tissue hypoxia and inhibits the healing of wounds [27]. Smoking also affects a patient's immune system. One cigarette (nicotine) decreases the body's ability to provide essential nutrients for post-surgery healing. Smoking on the day of surgery substantially doubles the chance of SSI; as a result, an antibiotic that will significantly alter their skin and gut flora should be given [28].

In comparison to those with an ASA score of <3, patients with an ASA score of ≥ 3 were 8.9 times more likely to develop SSI, which is consistent with study in Jimma, Ethiopia [1]. This is possibly due to a higher ASA score worsens the patient's overall clinical conditions, extending the duration of surgery and making it more prone to infections [29]. Center for disease control (CDC) supported that an ASA score of 3 and more increases the likelihood of developing surgical site infection [30].

The odds of having SSI for post-appendectomy was 7.7 times [AOR = 7.7; 95% CI (1.3–45.7)] higher as compared to intestinal obstruction. This is similar with that of Saudi Arabia [31]. It is probably due to post-appendectomy, there is a higher mean of blood cells (WBCs) and a lower mean of albumin levels which in turn result in immunosuppression and thus for SSI postoperatively [32].

The odds of having SSI for patients with co-morbid diabetes were 13.8 times higher as compared to patients without diabetes. This is in line with Bahir Dar, Ethiopia [17], Jimma, Ethiopia [1] and Saudi Arabia [21]. This is because uncontrolled diabetes reduces immunity and affects leukocyte function, making them incapable of warding off any invasive microorganisms. Even benign bacteria can proliferate quickly and seriously injure the body [27,33]. Diabetes-related microangiopathic changes also occurred in post-operative patients, which ultimately led to tissue ischaemia and delayed wound healing [6,34].

Unlike to the present study, factors such as sex, age type of wound (clean-contaminated), antibiotic prophylaxis, duration of surgery, and longer hospital stay were associated factors for having SSI at Malaysia [20], Uganda [23], India [13], Iran [3], China [16] and Harare (Ethiopia) [26] respectively.

4. Conclusion

This study concluded that surgical site infection is still a major problem in health care settings, particularly in developing countries like Ethiopia. The magnitude of SSI in this study was considerable and needs the careful attention of all stakeholders, including healthcare providers and policymakers. The ongoing existence of SSI in surgical patients has undesirable implications, such as lengthening the patient's hospital stay, reducing the patient's readmission and re-operation, and increasing medical costs. Clear manual preparation and guidance for the patient undergoing surgery, as well as the sorting of potential risk factors pre-, during-, and postoperatively with proper wound care practice, are recommended. Smoking, ASA score, appendectomy, and comorbidities like diabetes were independent predictors of having SSI. We strongly recommend that health-care professionals provide health education and patient counseling on smoking and health-seeking behaviors. Considering co-morbid conditions before surgery has paramount importance. Further, higher-scale studies are recommended. As a limitation, this study employed at small scale or population so that generalization might be unenviable.

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Ethics approval and consent to participate

The study protocol has been examined and approved by Arba Minch University Institutional Review Board (IRB) with reference No.552. Prior to data collection, written informed consent was obtained from study participants and actual data collection was conducted after the hospital has permitted to do so. This study was done in line with the Helsinki's declaration. Confidentiality is kept throughout the study.

Consent to publication

Not applicable.

Data availability

Almost all of the data set is used in the manuscript; however, if someone wants to get the raw data, it is possible to get it from the corresponding author MAS mameabdu54@gmail.com upon rational request.

CRediT authorship contribution statement

Mohammed Abdu Seid: Writing – original draft, Software, Resources, Methodology, Investigation, Funding acquisition, Formal analysis, Conceptualization. **Misganaw Asmamaw Mengstie:** Methodology. **Assefa Agegnehu Teshome:** Software. **Kedir Abdu:** Software, Formal analysis. **Yonas Derso Abtew:** Visualization, Methodology.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Abbreviations

AOR	Adjusted odd ratio
ARDS	Acute Respiratory Disease Syndrome
ASA	American Society of Anesthesiologists
BSc	Bachelor of Science
CI	Confidence level
CLD	Chronic Liver Disease
CKD	Chronic Kidney Disease
COR	Crude odd ratio
IO	Intestinal obstruction
LBO	Large Bowel Obstruction
SBO	Small Bowel Obstruction
SD	Standard Division
SSI	Surgical Site Infection
STATA	Statistical Analysis
VIF	Variance Inflation Factor

Appendix ASupplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.heliyon.2024.e28650.

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