1874-2858/19

Send Orders for Reprints to reprints@benthamscience.net

The Open Microbiology Journal

Content list available at: https://openmicrobiologyjournal.com

CrossMark

RESEARCH ARTICLE

Incidence and Bacterial Etiologies of Surgical Site Infections in a Public Hospital, Addis Ababa, Ethiopia

Alem A. Kalayu[1,*], Ketema Diriba[2], Chuchu Girma[2] and Eman Abdella[3]

[1]*Department of Microbiology, Yekatit 12 Hospital Medical College, Addis Ababa, Ethiopia*
[2]*Department of surgery, Yekatit 12 hospital medical college, Addis Ababa, Ethiopia*
[3]*Department of Dermatology, Yekatit 12 hospital medical college, Addis Ababa, Ethiopia*

Abstract:

Background:

Surgical Site Infections (SSIs) are among the frequently reported healthcare-acquired infections worldwide. Successful treatment of SSIs is affected by the continuous evolvement of drug-resistant microbes. This study investigated the incidence of SSIs, identifying the major etiologic agents and their drug resistance patterns in Yekatit 12 Hospital, Ethiopia.

Methods:

A cross-sectional study was conducted on 649 patients who underwent surgery at Yekatit 12 hospital from April 2016 to April 2017. Socio-demographic and clinical data were collected from each patient on admission. After surgery, they were followed for SSI occurrence. SSI was initially diagnosed by a senior surgeon based on standard clinical criteria and then confirmed by culture. Isolates were tested for drug resistance according to the clinical and laboratory standards institute guideline.

Results:

Of the 649 study participants, 56% were females. Their age ranged from 9 months to 88 years with a median age of 37 years. The incidence of culture-confirmed SSI was 10.2% (66/649) where 73 isolates were recovered. About two-third of the isolates were Gram-positive bacteria. *Staphylococcus aureus* was the most frequently isolated (27/73, 37%) followed by Coagulase-negative staphylococci (18/73, 24.7%), *Escherichia coli* (11/73, 15.1%) and *Klebsiella* species (10/73, 13.7%). About 89% and 44% of *S. aureus* isolates were resistant to penicillin and trimethoprim-sulfamethoxazole, respectively. MRSA constituted 11% of the *S. aureus* isolates. All the Gram-negative isolates were resistant to ampicillin and trimethoprim-sulfamethoxazole but susceptible to amikacin and meropenem. *Klebsiella* species showed 70-100% resistance to ceftazidime, cefuroxime, augmentin, chloramphenicol, ciprofloxacin, cefepime and gentamicin. About 82% of *E. coli* isolates were resistant for chloramphenicol, cefepime, ceftazidime, augmentin, cefuroxime and 64% for gentamicin and ciprofloxacin.

Conclusion:

The incidence of surgical site infection in Yekatit 12 hospital is 10.2%. Most of the SSIs were due to Gram-positive bacteria. Gram-negative isolates showed high resistance to the most commonly prescribed drugs. No resistance was found for meropenem indicating the absence of carbapenem-resistant bacteria. SSI treatments should be guided by culture and drug resistance test. Better infection prevention practices and continuous surveillance of antimicrobial resistance in the hospital are recommended for better patient care.

Keywords: Surgical site infection, Antimicrobial resistance, hospitalization, Clinical isolates, Infections.

Article History	Received: September 08, 2019	Revised: December 04, 2019	Accepted: December 05, 2019

1. BACKGROUND

Healthcare-Associated Infections (HCAIs) remain a significant cause of morbidity and mortality [1]. It is estimated that about 10% of hospitalized patients in developing countries acquire at least one healthcare-associated infection. The most common of these is surgical site infection. A surgical site infection is an infection that occurs after surgery in the part of the body where the surgery took place [2]. Besides causing substantial morbidity and mortality, SSI has an economic impact due to prolonged hospitalization, additional diagnostic

* Address correspondence to this author at the Department of Microbiology, Addis Ababa, MCH building, 3rd floor, Room number, 321, Yekatit 12 Hospital Medical college, Addis Ababa, Ethiopia; Tel: +251911784037; Email: alemabrha2014@gmail.com

tests, treatment and sometimes additional surgery [3 - 5].

Most surgical site infections are preventable through the implementation of proper infection prevention and control measures [6]. For these measures to be successful, local data regarding the SSI burden, etiologies and their drug resistance pattern need to be identified before the intervention [7].

2. METHODS

2.1. Study Area and Period

A cross-sectional study was conducted on 649 study participants who underwent surgery at Yekatit 12 hospital from April 2016 to April 2017. Yekatit 12 Hospital is a public general hospital with about 500 beds and annual patient flow of greater than 150, 000. It is located in Addis Ababa, the capital city of Ethiopia.

2.2. Data and Sample Collection

Information regarding socio-demographic characteristics of study participants (age, sex, marital status, *etc*.) was collected during admission by trained nurses. The participants were then followed for the occurrence of surgical site infections for 30 days after surgery. From those who developed SSIs based on clinical criteria, swab samples were collected from the infected incision site by trained nurses. Briefly, the infected site was cleansed using normal saline and samples were collected by rotating a sterile culture swab over viable wound tissue with sufficient pressure [8]. The swab samples were placed into asterile tube containing Amie's transport medium and transferred immediately to the Microbiology laboratory of the hospital for analysis.

2.3. Culture and Identification

The samples were directly inoculated on to blood, MacConkey, and Mannitol salt agar media. The inoculated plates were then incubated aerobically at 35-37^{o}C for 24 hours and then examined for bacterial growth. Bacterial identification was performed based on colony morphology, appearance, color, hemolytic activity, Gram reaction, and different biochemical tests.

2.4. Antimicrobial Susceptibility Testing

Antimicrobial susceptibility testing was performed by the Kirby–Bauer disc diffusion method [9]. Briefly, standardized suspensions of the bacterial isolates were prepared using normal saline and the turbidity was matched with the turbidity standard McFarland 0.5. The standardized suspension was streaked onto to the Muller-Hinton Agar and allowed to air dry. Then antibiotic discs were placed on to the medium and then incubated at 35-37°C for about 18 to 24 hours. The zones of inhibition were measured using a caliper and interpreted according to the Clinical Laboratory Standards Institute, CLSI 2014 [10] criteria as sensitive, intermediate and resistant. The quality of the culture media, gram stain, and antimicrobial discs were checked using standardized reference strains of *Escherichia coli* (ATCC 25922) and *Staphylococcus aureus* (ATCC 25923).

2.5. Data Analysis

Data was entered into an excel spreadsheet, cleaned and exported to SPSS software version 20 for analysis. *P-value*<0.05 was considered as cut off point for the significant association.

2.6. Ethical Consideration

This study was conducted after approval by the Institutional Review Board of Yekatit 12 Hospital Medical College. Written informed consent was also obtained from adults, parents/guardians (for study participants less than 18 years old). Also, consent was obtained for those between 12 and 18 years old. The aim of the study, its significance, confidentiality, their rights of participation, the procedure and associated risks were explained through an information sheet. Results of the isolated organisms and antimicrobial suscept-ibility testing were promptly reported to the attending physician for better patient care.

3. RESULTS

3.1. Socio-demographic Characteristics

The 649 study participants enrolled in this study were recruited from the department of general surgery, Gynecology and Obstetrics, and ENT. Females constituted a higher proportion (364/649, 56%) compared to males (285/649, 44%). The age of the participants ranged from 9 months to 88 years, with a median age of 37 years. About 61.5% (399/649) of the study participants had elective surgery whereas 38.5% (250/649) had emergency surgery. Overall, 71/649 (10.9%) of them had clinically (SSA) and 66 (66/71, 93%) were culture-confirmed. This resulted in an overall culture-confirmed SSI incidence of 10.2% (Table **1**).

3.2. Culture Findings

There were a total of 73 bacterial isolates from the 66 culture-confirmed SSIs. Double isolates were detected from seven of the 66 study participants. Among the isolates, Gram-positive bacteria constitute a higher percentage (46/73, 63.1%). *Staphylococcus aureus* was the most frequently isolated bacteria (27/73, 37%) followed by Coagulase-negative staphylococci (18/73, 24.7%), *E. coli* (11/73, 15.1%) and *Klebsiella* species (10/73, 13.7%) (Fig. **1**).

3.3. Antimicrobial Susceptibility Profile

S. aureus showed the highest resistance to penicillin (89%) followed by trimethoprim-sulfamethoxazole (44.4%), clind-amycin (14.8%), erythromycin (8.5%) and ciprofloxacin (3.7%). Three of the 27 *S. aureus* isolates (11.1%) were MRSA based on cefoxitin resistance. No *S. aureus* isolate was found resistant to gentamicin and vancomycin (Table **2**).

All the Gram-negative isolates were resistant to ampicillin and trimethoprim-sulfamethoxazole but susceptible to amikacin and meropenem.

In addition, *E. coli* showed higher resistance to chloramphenicol (81.8%), cefepime (81.8%), ceftazidime (81.8%), augmentin (81.8%), cefuroxime (81.8%), gentamicin

(63.6%) and ciprofloxacin (63.6%). The *Klebsiella* species showed increased resistance to ceftazidime (100%), cefuroxime (100%), augmentin (100%), chloramphenicol (100%), ciprofloxacin (90%), cefepime (80%), and gentamicin (70%). Both of the *Acinetobacter* species were resistant to chloramphenicol, ceftazidime, cefuroxime, augmentin, trimethoprim-sulfamethoxazole, and ampicillin but susceptible to gentamicin, meropenem, and amikacin. In addition, both the *Enterobacter* species were resistant to gentamicin, trimethoprim-sulfamethoxazole, cefuroxime, augmentin, and ampicillin (Table **2**).

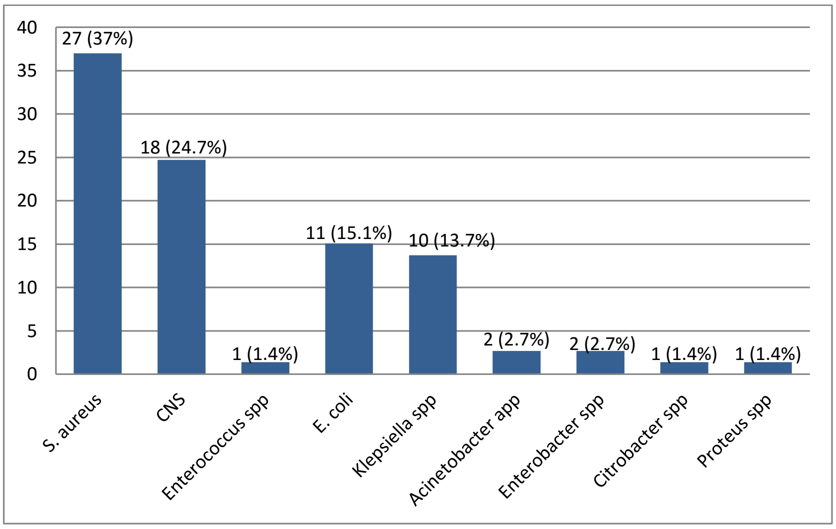

Fig. (1). Bacterial isolates from surgical site infections in Yekatit 12 Hospital, Addis Ababa, Ethiopia.

Table 1. Sociodemographic characteristics of study participants admitted for surgery in Yekatit 12 Hospital, Addis Ababa, Ethiopia.

Variables		Frequency (n)	Percentage (%)
Hospital department	General surgery	604	93.1
	Gynecology and Obstetrics	23	3.5
	ENT	22	3.4
Sex	Male	285	43.9
	Female	364	56.1
Procedure type	Elective	399	61.5
	Emergency	250	38.5
Clinically suspected SSI	Yes	71	10.9
	No	578	89.1
Culture confirmed SSI	Yes	66	10.2
	No	583	89.8

Table 2. Antimicrobial susceptibility pattern of isolates from SSI in Yekatit 12 Hospital, Ethiopia.

Antibiotic discs (Oxoid, UK)	Susceptibility pattern	*S. aureus* (n=27)	*Enterococcus* spp (n=1)	*Klepsiella* spp (n=10)	*E. coli* (n=11)	*Acinetobacter* spp (n=2)	*Citrobacter* spp (n=1)	*Proteus* spp (n=1)	*Enterobacter* spp (2)
Penicillin, 10 units	S	3 (11.1)	0 (0)	NT	NT	NT	NT	NT	NT
	R	24 (88.9)	1 (100)	NT	NT	NT	NT	NT	NT
Erythromycin, 15 µg	S	22 (81.5)	NT	NT	NT	NT	NT	NT	NT
	R	5 (8.5)	NT	NT	NT	NT	NT	NT	NT

(Table 2) contd.....

Antibiotic discs (Oxoid, UK)	Susceptibility pattern	*S. aureus* (n=27)	*Enterococcus* spp (n=1)	*Klepsiella* spp (n=10)	*E. coli* (n=11)	*Acinetobacter* spp (n=2)	*Citrobacter* spp (n=1)	*Proteus* spp (n=1)	*Enterobacter* spp (2)
Clindamycin, 2 µg	S	23 (85.2)	NT	NT	NT	NT	NT	NT	NT
	R	4 (14.8)	NT	NT	NT	NT	NT	NT	NT
Cefoxitin, 30 µg	S	24 (88.9)	NT	NT	NT	NT	NT	NT	NT
	R	3 (11.1)	NT	NT	NT	NT	NT	NT	NT
Vancomycin, 30 µg	S	27 (100)	1 (100)	NT	NT	NT	NT	NT	NT
	R	0 (0)	0 (0)	NT	NT	NT	NT	NT	NT
Gentamicin, 10 µg	S	27 (100)	NT	3 (30)	4 (36.4)	2 (100)	1 (100)	1 (100)	0 (0)
	R	0 (0)	NT	7 (70)	7 (63.6)	0 (0)	0 (0)	0 (0)	2 (100)
Trimethoprim/sulfamethoxazole, 1.25/23.75 µg	S	15 (55.6)	NT	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
	R	12 (44.4)	NT	10 (100)	11 (100)	2 (100)	1 (100)	1 (100)	2 (100)
Ciprofloxacin, 5 µg	S	26 (96.3)	0 (0)	1 (9)	4 (36.4)	1 (50)	0 (0)	1 (100)	1 (50)
	R	1 (3.7)	1 (100)	9 (90)	7 (63.6)	1 (50)	1 (100)	0 (0)	1 (50)
Chloramphenicol, 30 µg	S	NT	1 (100)	0 (0)	2 (18.2)	0 (0)	0 (0)	NT	NT
	R	NT	0 (0)	10 (100)	9 (81.8)	2 (100)	1 (100)	NT	NT
Meropenem, 10 µg	S	NT	NT	10 (100)	11 (100)	2 (100)	1 (100)	1 (100)	2 (100)
	R	NT	NT	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Cefepime, 30 µg	S	NT	NT	2 (8)	2 (18.2)	1 (50)	0 (0)	1 (100)	2 (100)
	R	NT	NT	8 (80)	9 (81.8)	1 (50)	1 (100)	0 (0)	0 (0)
Ceftazidime, 30 µg	S	NT	NT	0 (0)	2 (18.2)	0 (0)	0 (0)	1 (100)	2 (100)
	R	NT	NT	10 (100)	9 (81.8)	2 (100)	1 (100)	0 (0)	0 (0)
Amikacin, 30 µg	S	NT	NT	10 (100)	11 (100)	2 (100)	1 (100)	1 (100)	2 (100)
	R	NT	NT	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Cefuroxime, 30 µg	S	NT	0 (0)	0 (0)	2 (18.2)	0 (0)	0 (0)	NT	0 (0)
	R	NT	1 (100)	10 (100)	9 (81.8)	2 (100)	1 (100)	NT	2 (100)
Augmentin (amoxicillin/clavulanate, 20/10 µg)	S	NT	NT	0 (0)	2 (18.2)	0 (0)	0 (0)	1 (100)	0 (0)
	R	NT	NT	10 (100)	9 (81.8)	2 (100)	1 (100)	0 (0)	2 (100)
Ampicillin, 10 µg	S	NT	NT	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
	R	NT	NT	10 (100)	11 (100)	2 (100)	1 (100)	1 (100)	2 (100)

4. DISCUSSION

Surgical site infections continue to be associated with substantial mortality, morbidity and additional cost [3 - 5]. It is even worse in resource-limited settings where infection prevention and control measures are not adequate. Having local data regarding the incidence of surgical site infections, major etiologies, and their drug resistance pattern is of great importance whether to implement a better infection prevention practice and guide empirical therapy of SSIs.

The current study was conducted on 649 study participants who underwent surgery at Yekatit 12 Hospital. Sociodemographic characteristics of the study participants were collected during admission and patients were followed for the occurrence of surgical site infection for 30 days after surgery. Surgical site infection was initially diagnosed clinically by a senior physician and confirmed by bacterial culture. Then, isolates were tested for their drug resistance patterns.

In the present study, a total of 71 patients (10.9%) developed SSI based on clinical criteria. However, only 66 of them were confirmed by culture. The possible explanation for this could be because the etiologic agents might be non-bacterial or anaerobic bacteria as this study addressed only aerobic ones. The overall culture-confirmed incidence of surgical site infection was 10.2%. This is comparable with previous findings of 9.6%-14.8% in Ethiopia [11 - 13] and 10.6% in Spain [14]. In contrast, the current finding is lower than 20.6% of SSI incidence in Spain [15], 23% in Nepal [16], 17% Egypt [17], and 17%-21% in Ethiopia [18 - 20]. However, it is higher than 2.5% incidence rate of SSI in Peru [7] and Saudi Arabia [21], 3.3% in China [22], 5% in India [23] and 5.9% in Italy [24]. Such differences could be explained by variations in the distribution of pathogens and infection prevention and control practices.

The majority of the etiologies of SSIs in Yekatit 12 Hospital (63%) were Gram-positive bacteria. Among the etiologies, *S. aureus* was the most common constituting 37% of the overall isolates. This is in agreement with previous studies in Italy [25], Iran [26], Saudi Arabia [21], Egypt [27] and Kenya [28]. Similarly, previous studies in different parts of Ethiopia had also reported *S. aureus* as the most frequent isolate from SSIs [19, 20, 29]. These studies found *S. aureus* comprising from 29% to 40% of the total SSI isolates which is comparable to the finding of the present study; *i.e*. 37%.

In addition, the present study found *E. coli* and *Klebsiella* species from a significant number of patients next to *S. aureus* which constituted 15% and 14% of the isolates, respectively. Similarly, these bacteria were reported among the frequent isolates from surgical site infections elsewhere. For example, *E. coli* was the second most isolates constituting 23% of the total isolates in Iran [26]. However, in Egypt *Klebsiella pneumonia* was the second common SSI isolate [27]. Previous studies in Ethiopia also reported *E. coli* [19] and *Klebsiella* species [20] as the most frequent isolates next to *S. aureus* constituting 27% and 25% of total isolates respectively.

About 90% of *S. aureus* isolates in the present study were resistant to penicillin. This is in line with previous studies in Ethiopia that reported penicillin resistance ranging from 82-91.5% [29 - 31]. This is in line with published reports elsewhere indicating that penicillin-resistant *S. aureus* affected the continent [32, 33].

To overcome the increasing penicillin resistant *S. aureus*, methicillin was introduced in 1959. However, the first methicillin-resistant *S. aureus* (MRSA) was reported after two years of its introduction [34]. Shortly thereafter, MRSA became pandemic in many healthcare institutions worldwide [35]. The present study found MRSA in 11% of the *S. aureus* which is much lower than reports elsewhere that found 60-85% of *S. aureus* isolates as MRSA [36 - 38]. This highlights drugs in the oxacillin group could still treat most surgical site infections in the study area. Interestingly, the present study did not find any vancomycin resistance despite its use in the treatment of SSIs in the study area. This drug is recommended to treat MRSA infections [39]. The modestly lower MRSA and no vancomycin resistance in the present study urge to decrease vancomycin prescription in the treatment of staphylococcal infections in the study area.

The current investigation also found that >80% of *E. coli* isolates were resistant to chloramphenicol, cefepime, ceftazidime, augmentin and cefuroxime, and 63.6% were resistant to both gentamicin and ciprofloxacin. This is in line with previous studies by Giri *et al.* in Nepal [16] that reported 69.5% of ciprofloxacin, Hafez *et al.* in Egypt [17] reported >60% ceftazidime resistance, and Mengesha *et al.* in Northern Ethiopia [20] reported 100% ampicillin resistance by *E. coli*. In contrast, Mengesha *et al.* [20] found 0% and 100% gentamicin and augmentin resistance in *E. coli,* respectively.

The present study found that *Klebsiella* species showed alarmingly high resistance for multiple drugs; including, ceftazidime (100%), cefuroxime (100%), augmentin (100%), chloramphenicol (100%), ciprofloxacin (90%), cefepime (80%), and gentamicin (70%). A comparable finding was reported by Hafez *et al.* in Egypt where all *Klebsiella* isolates were resistant to ceftazidime. Similarly, Mengesha *et al.* [20] in Northern Ethiopia reported that 100% of the *Klebsiella* species were resistant to amoxicillin, 93.1% for tetracycline and 86.2% for ceftriaxone. The present study hasn't found any meropenem and amikacin resistance.

CONCLUSION

The incidence of surgical site infection in Yekatit 12 hospital was 10.2% which was predominantly caused by Gram-positive bacteria. The most common SSI etiology was *S. aureus*. *Escherichia coli* and *Klebsiella* species were the dominant gram negative bacteria. *S. aureus* isolates showed very high resistance (89%) to penicillin, low resistance (11%) to oxacillin and no resistance to vancomycin. Most Gram-negative isolates were resistant to multiple drugs, including those commonly used in the study area. However, no resistance was documented for amikacin and meropenem. Therefore, SSI treatments should be guided by culture and drug resistance tests or at least current data should be used to guide empirical therapy in the study area. In addition, the implementation of antimicrobial stewardship program is strongly recommended for the prevention and containment of drug-resistant organisms.

LIST OF ABBREVIATIONS

ATCC	=	American Type Culture Collection
CLSI	=	Clinical and Laboratory Standards Institute
CoNS	=	Coagulase-negative Staphylococci
MRSA	=	Methicillin-resistant *Staphylococcus aureus*
SSI	=	Surgical site infection
WHO	=	World Health Organization

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Ethical approval was obtained by the Research Ethics Review Committee of Yekatit 12 Hospital medical college before the conduct of the study and the approval number is 010/2008.

HUMAN AND ANIMAL RIGHTS

No Animals were used in this research. All human research procedures followed were in accordance with the ethical standards of the committee responsible for human experimentation (institutional and national), and with the Helsinki Declaration of 1975, as revised in 2013.

CONSENT FOR PUBLICATION

Informed consent was obtained from all the participants prior to publication.

STANDARD OF REPORTING

STROBE guidelines and methodology were followed.

AVAILABILITY OF DATA AND MATERIALS

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

FUNDING

The entire fund of this study was covered by Yekatit 12 Hospital Medical College and the grant number is YK12-336/300/7604.

CONFLICT OF INTEREST

The authors declare no conflict of interest, financial or otherwise.

ACKNOWLEDGEMENTS

We would like to thank all the study participants for their kind collaboration to participate in this study. We appreciate nurses, physicians and laboratory personnel of Yekatit 12 Hospital for their unreserved support.

REFERENCES

[1] WHO. Report on the Burden of Endemic Health Care-Associated Infection Worldwide. Geneva: World health organization 2011; pp. 1-34.

[2] Mangram AJ, Horan TC, Pearson ML, Silver LC, Jarvis WR. Guideline for Prevention of Surgical Site Infection, 1999. Centers for Disease Control and Prevention (CDC) Hospital Infection Control Practices Advisory Committee Am J Infect Control 1999; 27(2): 97-132. quiz 133-134; discussion 196

[3] Broex EC, Asselt AD, Bruggeman CA, van Tiel FH. Surgical site infections: how high are the costs? J Hosp Infect 2009; 72(3): 193-201. [http://dx.doi.org/10.1016/j.jhin.2009.03.020] [PMID: 19482375]

[4] de Lissovoy G, Fraeman K, Hutchins V, Murphy D, Song D, Vaughn BB. Surgical site infection: Incidence and Impact on hospital utilization and treatment costs. Am J Infect Control 2009; 37(5): 387-97. [http://dx.doi.org/10.1016/j.ajic.2008.12.010] [PMID: 19398246]

[5] Jenks PJ, Laurent M, McQuarry S, Watkins R. Clinical and economic burden of Surgical Site Infection (SSI) and predicted financial consequences of elimination of SSI from an English hospital. J Hosp Infect 2014; 86(1): 24-33. [http://dx.doi.org/10.1016/j.jhin.2013.09.012] [PMID: 24268456]

[6] Cosgrove MS. Infection control in the operating room. Crit Care Nurs Clin North Am 2015; 27(1): 79-87. [http://dx.doi.org/10.1016/j.cnc.2014.10.004] [PMID: 25725538]

[7] Ramírez-Wong FM, Atencio-Espinoza T, Rosenthal VD, *et al.* Surgical Site Infections Rates in More Than 13,000 Surgical Procedures in Three Cities in Peru: Findings of the International Nosocomial Infection Control Consortium. Surg Infect (Larchmt) 2015; 16(5): 572-6. [http://dx.doi.org/10.1089/sur.2014.201] [PMID: 26125113]

[8] Levine NS, Lindberg RB, Mason AD Jr, Pruitt BA Jr. The quantitative swab culture and smear: A quick, simple method for determining the number of viable aerobic bacteria on open wounds. J Trauma 1976; 16(2): 89-94. [http://dx.doi.org/10.1097/00005373-197602000-00002] [PMID: 1255833]

[9] Bauer AW, Kirby WM, Sherris JC, Turck M. Antibiotic susceptibility testing by a standardized single disk method. Am J Clin Pathol 1966; 45(4): 493-6. [http://dx.doi.org/10.1093/ajcp/45.4_ts.493] [PMID: 5325707]

[10] CLSI. M100-S24 - Performance Standards for Antimicrobial Susceptibility Testing; Twenty-Fourth Informational Supplement. Clinical and Laboratory Standards Institute 2014; 34(1): 1-226.

[11] Habte-Gabr E, Gedebou M, Kronvall G. Hospital-acquired infections among surgical patients in Tikur Anbessa Hospital, Addis Ababa, Ethiopia. Am J Infect Control 1988; 16(1): 7-13. [http://dx.doi.org/10.1016/0196-6553(88)90004-1] [PMID: 3369748]

[12] Taye M. Wound infection in Tikur Anbessa hospital, surgical department. Ethiop Med J 2005; 43(3): 167-74. [PMID: 16370548]

[13] Amenu D, Belachew T, Araya F. Surgical site infection rate and risk factors among obstetric cases of Jimma university specialized hospital, southwest Ethiopia. Ethiop J Health Sci 2011; 21(2): 91-100. [http://dx.doi.org/10.4314/ejhs.v21i2.69049] [PMID: 22434989]

[14] Acín-Gándara D, Rodríguez-Caravaca G, Durán-Poveda M, *et al.* Incidence of surgical site infection in colon surgery: comparison with regional, national Spanish, and United States standards. Surg Infect (Larchmt) 2013; 14(4): 339-44. [http://dx.doi.org/10.1089/sur.2012.043] [PMID: 23859676]

[15] Ballus J, Lopez-Delgado JC, Sabater-Riera J, Perez-Fernandez XL, Betbese AJ, Roncal JA. Surgical site infection in critically ill patients with secondary and tertiary peritonitis: epidemiology, microbiology and influence in outcomes. BMC Infect Dis 2015; 15: 304. [http://dx.doi.org/10.1186/s12879-015-1050-5] [PMID: 26223477]

[16] Giri S, Kandel BP, Pant S, Lakhey PJ, Singh YP, Vaidya P. Risk factors for surgical site infections in abdominal surgery: A study in Nepal. Surg Infect (Larchmt) 2013; 14(3): 313-8. [http://dx.doi.org/10.1089/sur.2012.108] [PMID: 23672239]

[17] Hafez S, Saied T, Hasan E, *et al.* Incidence and modifiable risk factors of surveillance of surgical site infections in Egypt: A prospective study. Am J Infect Control 2012; 40(5): 426-30. [http://dx.doi.org/10.1016/j.ajic.2011.07.001] [PMID: 21943830]

[18] Melaku S, Gebre-Selassie S, Damtie M, Alamrew K. Hospital acquired infections among surgical, gynaecology and obstetrics patients in Felege-Hiwot referral hospital, Bahir Dar, northwest Ethiopia. Ethiop Med J 2012; 50(2): 135-44. [PMID: 22924282]

[19] Kotisso B, Aseffa A. Surgical wound infection in a teaching hospital in Ethiopia. East Afr Med J 1998; 75(7): 402-5. [PMID: 9803631]

[20] Mengesha RE, Kasa BG, Saravanan M, Berhe DF, Wasihun AG. Aerobic bacteria in post surgical wound infections and pattern of their antimicrobial susceptibility in Ayder Teaching and Referral Hospital, Mekelle, Ethiopia. BMC Res Notes 2014; 7: 575. [http://dx.doi.org/10.1186/1756-0500-7-575] [PMID: 25164127]

[21] Al-Mulhim FA, Baragbah MA, Sadat-Ali M, Alomran AS, Azam MQ. Prevalence of surgical site infection in orthopedic surgery: A 5-year analysis. Int Surg 2014; 99(3): 264-8. [http://dx.doi.org/10.9738/INTSURG-D-13-00251.1] [PMID: 24833150]

[22] Li Q, Liu P, Wang G, *et al.* Risk Factors of surgical site infection after acetabular fracture surgery. Surg Infect (Larchmt) 2015; 16(5): 577-82. [http://dx.doi.org/10.1089/sur.2014.134] [PMID: 26230521]

[23] Lindsjö C, Sharma M, Mahadik VK, Sharma S, Stålsby Lundborg C, Pathak A. Surgical site infections, occurrence, and risk factors, before and after an alcohol-based handrub intervention in a general surgical department in a rural hospital in Ujjain, India. Am J Infect Control 2015; 43(11): 1184-9. [http://dx.doi.org/10.1016/j.ajic.2015.06.010] [PMID: 26231549]

[24] Di Leo A, Piffer S, Ricci F, *et al.* Surgical site infections in an Italian surgical ward: a prospective study. Surg Infect (Larchmt) 2009; 10(6): 533-8. [http://dx.doi.org/10.1089/sur.2009.008] [PMID: 19689197]

[25] Pulcrano G, Vollaro A, Rossano F, Catania MR. Molecular and phenotypic characterization of methicillin-resistant staphylococcus aureus from surgical site infections. Surg Infect (Larchmt) 2013; 14(2): 196-202. [http://dx.doi.org/10.1089/sur.2012.002] [PMID: 23530808]

[26] Alikhani A, Babamahmoodi F, Foroutan Alizadegan L, Shojaeefar A, Babamahmoodi A. Minimal inhibitory concentration of micro-organisms causing surgical site infection in referral hospitals in North of Iran, 2011-2012. Caspian J Intern Med 2015; 6(1): 34-9. [PMID: 26221495]

[27] Helal S, El Anany M, Ghaith D, Rabeea S. The Role of MDR-Acinetobacter baumannii in orthopedic surgical site infections. Surg Infect (Larchmt) 2015; 16(5): 518-22. [http://dx.doi.org/10.1089/sur.2014.187] [PMID: 26114551]

[28] Andhoga J, Macharia AG, Maikuma IR, Wanyonyi ZS, Ayumba BR, Kakai R. Aerobic pathogenic bacteria in post-operative wounds at Moi Teaching and Referral Hospital. East Afr Med J 2002; 79(12): 640-4. [http://dx.doi.org/10.4314/eamj.v79i12.8671] [PMID: 12678447]

[29] Kahsay A, Mihret A, Abebe T, Andualem T. Isolation and antimicrobial susceptibility pattern of *Staphylococcus aureus* in patients with surgical site infection at Debre Markos Referral Hospital,

Amhara Region, Ethiopia. Arch Public Health 2014; 72(1): 16. [http://dx.doi.org/10.1186/2049-3258-72-16] [PMID: 24949197]

[30] Mama M, Abdissa A, Sewunet T. Antimicrobial susceptibility pattern of bacterial isolates from wound infection and their sensitivity to alternative topical agents at Jimma University Specialized Hospital, South-West Ethiopia. Ann Clin Microbiol Antimicrob 2014; 13: 14. [http://dx.doi.org/10.1186/1476-0711-13-14] [PMID: 24731394]

[31] Mohammed A, Seid ME, Gebrecherkos T, Tiruneh M, Moges F. Bacterial solates and their antimicrobial susceptibility patterns of wound infections among inpatients and outpatients attending the university of gondar referral hospital, northwest ethiopia. Int J Microbiol 2017; 20178953829 [http://dx.doi.org/10.1155/2017/8953829] [PMID: 28386280]

[32] Sina H, Ahoyo TA, Moussaoui W, *et al.* Variability of antibiotic susceptibility and toxin production of *Staphylococcus aureus* strains isolated from skin, soft tissue, and bone related infections. BMC Microbiol 2013; 13: 188. [http://dx.doi.org/10.1186/1471-2180-13-188] [PMID: 23924370]

[33] Liu Y, Xu Z, Yang Z, Sun J, Ma L. Characterization of community-associated *taphylococcus aureus* from skin and soft-tissue infections: a multicenter study in China. Emerg Microbes Infect 2016; 5(12)e127 [http://dx.doi.org/10.1038/emi.2016.128] [PMID: 27999423]

[34] Barber M. Methicillin-resistant staphylococci. J Clin Pathol 1961; 14: 385-93. [http://dx.doi.org/10.1136/jcp.14.4.385] [PMID: 13686776]

[35] Waness A. Revisiting methicillin-resistant *staphylococcus aureus* Infections. J Glob Infect Dis 2010; 2(1): 49-56. [http://dx.doi.org/10.4103/0974-777X.59251] [PMID: 20300418]

[36] Mistry RD, Shapiro DJ, Goyal MK, *et al.* Clinical management of skin and soft tissue infections in the U.S. Emergency Departments. West J Emerg Med 2014; 15(4): 491-8. [http://dx.doi.org/10.5811/westjem.2014.4.20583] [PMID: 25035757]

[37] Maina EK, Kiiyukia C, Wamae CN, Waiyaki PG, Kariuki S. Characterization of methicillin-resistant *Staphylococcus aureus* from skin and soft tissue infections in patients in Nairobi, Kenya. Int J Infect Dis 2013; 17(2): e115-9. [http://dx.doi.org/10.1016/j.ijid.2012.09.006] [PMID: 23092752]

[38] Macmorran E, Harch S, Athan E, *et al.* The rise of methicillin resistant *Staphylococcus aureus*: now the dominant cause of skin and soft tissue infection in Central Australia. Epidemiol Infect 2017; 145(13): 2817-26. [http://dx.doi.org/10.1017/S0950268817001716] [PMID: 28803587]

[39] Cole TS, Riordan A. Vancomycin dosing in children: what is the question? Arch Dis Child 2013; 98(12): 994-7. [http://dx.doi.org/10.1136/archdischild-2013-304169] [PMID: 23956256]

© 2019 Kalayu *et al*.

This is an open access article distributed under the terms of the Creative Commons Attribution 4.0 International Public License (CC-BY 4.0), a copy of which is available at: (https://creativecommons.org/licenses/by/4.0/legalcode). This license permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.