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RESEARCH

Healthcare-associated infections among patients in a surgery ward: cross-sectional study

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ABSTRACT

Background. Healthcare-associated infections (HAIs) among patients in surgical wards are serious complications that do not only affect surgical outcomes, but also increase medical care costs.

Objective. To determine the proportion of patients with HAIs in surgery wards and identify factors associated with HAIs.

Design. Cross-sectional study.

Setting. Department of Surgery, Southern Philippines Medical Center, from January 2016 to December 2016.

Participants. 182 patients from different surgical wards.

Main outcome measures. Presence of HAI; prevalence odds ratios (POR) of having an HAI for selected factors.

Main results. There were 182 patients (122 males and 62 females; mean age 34.89 ± 20.56 years) included in this report. Seventeen patients (9.34%) developed HAI during admission. Among patients who underwent surgery (n=126), having an HAI was significantly associated with: operation time >180 minutes (adjusted POR=15.18; 95% CI 3.92 to 58.69; p=0.0001), >4 surgical team members (adjusted POR=5.42; 95% CI 1.37 to 21.41; p=0.0158), general anesthesia (adjusted POR=10.46; 95% CI 1.29 to 84.63; p=0.0278), and use of inhalational anesthesia (adjusted POR=11.81; 95% CI 1.45 to 96.08; p=0.0210).

Conclusion. In this study, 9.34% of patients had an HAI during admission. Long hospital stay, use of indwelling medical devices, long surgical procedures, high number of surgical team members during surgery, general anesthesia, and use of inhalational anesthesia are all associated with having an HAI.

Keywords. Surgical site infection, nosocomial infection, pneumonia, general anesthesia, indwelling medical devices

INTRODUCTION

Healthcare-associated infections (HAIs), acquired by patients while staying in a health facility, appear 48 hours or more after admission, or within 30 days after discharge from the facility.[1 2] Among patients admitted in a surgery ward, HAIs are serious complications since they can affect the outcomes of the surgical procedures, as well as increase hospital stay and raise medical care costs.[3]

In a surgical ward, approximately one-third of admitted patients do not undergo any surgical operations, and some patients have infection- and hospital provider-related events. Many of these complications are related to general ward management.[4] Among patients who undergo surgical procedures, the most common complications that arise are surgical infections. Infections have greater impact on prognostic outcomes when patients undergo surgical procedures than when they do not.[5] Postoperative HAIs are estimated to occur in 11.9% of surgical patients, with a mortality rate of 14.5%.[6 7] Surgical infections are affected by factors such as primed inflammation and immune suppression after a surgical procedure,[8] the invasiveness and duration of the procedure, anesthetic technique, ischemia and reperfusion, transfusion, and exposure to specific pathogens.[9 10]

Although there are several published studies regarding HAIs in urban hospitals in

> **IN ESSENCE**
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> Healthcare-associated infections (HAIs) that occur among patients in the surgical wards are serious complications that lengthen hospital stay and complicate surgical outcomes.
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> In this cross-sectional study among 182 patients admitted at the surgical ward, 9.34% of patients developed HAI during admission. Hospital LOS of >7 days, the use of indwelling medical devices, surgical procedures longer than 180 minutes, procedures with more than 4 surgical team members, the use of general anesthesia, and the use of any inhalational anesthetic agents are significantly associated with having an HAI.
>
> Identification of the risk factors that increase the risk of HAI will help improve the quality of existing infection prevention and control policies and HAI surveillance guidelines in the health facility.

the Philippines,[11 12] infections that are specifically associated with surgical patients during admission are not well-documented. A deeper understanding of the factors that contribute to HAIs within this subgroup of patients will help improve the quality of existing infection prevention and control policies and HAI surveillance guidelines in the health facility. We did this study to determine the prevalence of HAIs among hospitalized patients in a surgery ward. We also wanted to identify the factors that contribute to HAIs among these patients.

METHODOLOGY

Study design and setting

We conducted a retrospective, cross-sectional study among patients previously admitted at the Department of Surgery of Southern Philippines Medical Center from January 2016 to December 2016. The department admits 4,000 to 5,000 patients annually.

Participants

All patients admitted at the Department of Surgery for at least 48 hours from January 2016 to December 2016 were eligible for the study. We estimated the minimum sample size for this study using StatCalc from Epi Info™ 7.1.4.0 based on the assumptions that 22.2% of patients who overstay (>4 days hospitalization) will have a surgical site infection—a form of HAI—and that 2.2% of patients who did not overstay will have a surgical site infection.[13] In a computation for cross-sectional odds ratio to determine the association of selected demographic and clinical factors with HAI, carried out with <5% level of significance, a total sample size of 182 patients will have 80% power of rejecting the null hypothesis—no significant increase or decrease in cross-sectional odds ratio—if the alternative holds. From the list of 9,259 eligible participants, we randomly selected the 182 patients using the online random number generator https://www.randomizer.org/.

Data collection

From the medical records of each patient, we collected data on age, sex, history of smoking and alcohol drinking, admitting diagnosis, and comorbidities. For patients who underwent surgical procedures during their hospitalization, we collected data on duration of surgery, number of personnel during the surgical procedure, urgency of the procedure, type of surgery, anesthetic technique used, anesthetic agent used, and reoperation during hospital stay. We also collected data on blood transfusion and use of indwelling medical devices. The main outcome for this study was the presence of HAI. A patient was considered to have developed an HAI if fever of at least 37.8 degrees Celsius and at least one of the following were present at least 48 hours after admission: erythema, discharges and/or pain on the surgical site, cough, dysuria, urine discoloration, tachypnea, leukocytosis, difficulty in weaning from mechanical ventilator, bacteriuria on urinalysis, and presence of pulmonary infiltrates on chest x-ray.

Statistical analysis

We summarized continuous variables as means and standard deviations, and compared means using t-test. We summarized categorical variables as frequencies and percentages, and compared proportions using chi-square test or Fisher's exact test. We also performed univariate logistic regression to determine the unadjusted associations of the selected clinical factors with the presence of HAI. Association of variables were expressed as prevalence odds ratios (POR) and their 95% confidence intervals. We also explored the associations of the variables after adjusting for age, and sex. We used Epi Info™ 7.2.1 for all our statistical tests.

RESULTS

A sample of 182 patients admitted in our Department of Surgery were included in the analysis for this study. There were 122/182 (67.03%) males and 60/182 (32.97%) females. The patients had an overall mean age of 34.89 ± 20.56 years. Of the 182 patients, 126 (69.23%) underwent a surgical procedure, and 17 (9.34%) developed HAI during admission. Table 1 shows the sociodemographic and clinical profile of the patients in the study, with comparison between those who had HAI and those who did not. The two groups of patients were comparable in terms of mean age, sex distribution, history of smoking and alcohol drinking, and distribution of comorbidities.

The baseline characteristics of patients in both intervention groups are shown in Table 1. The two groups were comparable in terms of mean age, sex distribution, mean duration of illness, and comorbidities.

Table 2 shows the comparison of pre-

Table 1 Sociodemographic and clinical characteristics of all patients

Clinical factors	n	Total	n	With HAI	n	Without HAI	p-value
Mean age ± SD, *years*	182	34.89 ± 20.56	17	40.88 ± 23.48	165	34.27 ± 20.22	0.2075
Sex, *frequency (%)*	182		17		165		0.4495
Male		122 (67.03)		10 (58.82)		112 (67.88)	
Female		60 (32.97)		7 (41.18)		53 (32.12)	
Smoker, *frequency (%)**	81	17 (20.99)	9	2 (22.22)	72	15 (20.83)	1.0000*
Alcoholic beverage drinker, *frequency (%)*	73	11 (15.07)	9	0 (0.00)	64	11 (17.19)	0.3383*
Comorbidities, *frequency (%)†*	94		10		84		
Asthma		1 (1.06)		0 (0.00)		1 (1.19)	1.0000*
Anemia		2 (2.13)		(0.00)		2 (2.38)	1.0000*
Diabetes Mellitus		6 (6.38)		1 (10.00)		5 (5.95)	0.5008*
Chronic obstructive pulmonary disease		1 (1.06)		(0.00)		1 (1.19)	1.0000*
Hypertension		17 (18.09)		3 (30.00)		14 (16.67)	0.3802*
Hydrocephalus		1 (1.06)		(0.00)		1 (1.19)	1.0000*
History of stroke		1 (1.06)		(0.00)		1 (1.19)	1.0000*
Hypothyroidism		1 (1.06)		(0.00)		1 (1.19)	1.0000*
Hyperthyroidism		2 (2.13)		(0.00)		2 (2.38)	1.0000*
Pulmonary tuberculosis		2 (2.13)		1 (10.00)		1 (1.19)	0.2025*
Multiple injuries		4 (4.26)		0 (0.00)		4 (4.76)	1.0000*

* Fisher's exact test
† One patient may have more than one
HAI=healthcare-associated infections

Table 2 Preoperative clinical profiles of all patients

Characteristics	Total (n=182)	With HAI (n=17)	Without HAI (n=165)	p-value
Diagnosis classification, *frequency (%)*				
Trauma	46 (25.41)	4 (23.53)	42 (25.61)	1.0000*
Vascular problems	4 (2.20)	0 (0.00)	4 (2.42)	1.0000*
Soft tissue/extremities disorders	7 (3.85)	0 (0.00)	7 (4.24)	1.0000*
Abdomen	90 (49.45)	9 (52.94)	81 (49.09)	0.7624
Urology	12 (6.59)	1 (5.88)	11 (6.67)	1.0000*
Thoracic problems	2 (1.10)	0 (0.00)	2 (1.21)	1.0000*
Breast disorders	7 (3.85)	2 (11.76)	5 (3.03)	0.1306*
Head and neck disorders	8 (4.40)	1 (5.88)	7 (4.24)	0.5510*
Congenital anomalies	6 (3.30)	0 (0.00)	6 (3.64)	1.0000*
Had any surgical procedure, *frequency (%)*	126 (69.23)	12 (70.59)	114 (69.09)	0.8987
Use of any indwelling medical devices, *frequency (%)†*	86 (47.25)	12 (70.59)	74 (44.85)	0.0429‡
Endotracheal tube	76 (41.76)	12 (70.59)	64 (38.79)	
Urinary catheter	84 (46.15)	12 (70.59)	72 (43.64)	
Central venous pressure catheter	4 (2.20)	2 (11.76)	2 (1.21)	
Chest tube	9 (4.95)	2 (11.76)	7 (4.24)	
Internal jugular catheter	4 (2.20)	0 (0.00)	4 (2.42)	
Abdominal drain	3 (1.65)	1 (0.61)	2 (11.76)	
Tracheostomy tube	1 (0.55)	0 (0.00)	1 (0.61)	
Blood transfusion, *frequency (%)*	33 (18.13)	2 (11.76)	31 (18.79)	0.7417*
Mean length of hospital stay ± SD, *days*	9.76 ± 8.87	18.24 ± 9.48	8.88 ±8.36	<0.0001‡

* Fisher's exact test
† One patient may have more than one indwelling medical device
‡ Significant at p<0.05

Table 3 Intraoperative and postoperative clinical profiles of patients who underwent surgery

Characteristics	Total (n=162)	With HAI (n=12)	Without HAI (n=114)	p-value
Mean duration of surgery ± SD, *minutes*	100.94 ± 94.11	209.75 ± 101.69	89.48 ± 86.03	<0.0001*
Mean number of personnel ± SD	4.26 ± 1.40	5.00 ± 1.13	4.18 ± 1.41	0.0552
Urgency of surgery, *frequency (%)*				0.8356
Emergency	77 (61.11)	7 (58.33)	70 (61.40)	
Elective	49 (38.89)	5 (41.67)	44 (38.60)	
Type of surgery, *frequency (%)*				
Minimally invasive surgery	24 (19.05)	2 (16.67)	22 (19.30)	0.8252
Open surgical procedure	79 (62.70)	9 (75.00)	70 (61.40)	0.5326†
Appendectomy	32 (40.51)	1 (11.11)	31 (44.29)	
Gastrointestinal	16 (20.25)	2 (22.22)	14 (20.00)	
Gynecologic	1 (1.27)	0 (0.00)	1 (1.43)	
Head and neck	5 (6.33)	1 (11.11)	4 (5.71)	
Inguinal hernia	4 (5.06)	1 (11.11)	3 (4.29)	
Neurosurgery	1 (1.27)	0 (0.00)	1 (1.43)	
Trauma	11 (13.92)	3 (33.33)	8 (11.43)	
Urologic	6 (7.59)	1 (11.11)	5 (7.14)	
Vascular	1 (1.27)	0 (0.00)	1 (1.43)	
Gastrointestinal and thoracic	1 (1.27)	0 (0.00)	1 (1.43)	
Gastrointestinal and urologic	1 (1.27)	0 (0.00)	1 (1.43)	
Breast surgery	4 (3.17)	1 (8.33)	3 (2.63)	0.3333†
Minor surgical procedures	17 (13.49)	0 (0.00)	17 (14.91)	0.3672†
Orthopedic surgery	2 (1.59)	0 (0.00)	2 (1.75)	1.0000†
Surgical wound classification, *frequency (%)* ‡				
I	17 (13.49)	1 (8.33)	16 (14.04)	1.0000†
II	55 (43.65)	5 (41.67)	50 (43.86)	0.8842
III	29 (23.02)	2 (16.67)	27 (23.68)	0.7318†
IV	25 (19.84)	4 (33.33)	21 (18.42)	0.2532†
Anesthetic technique, *frequency (%)*§				
General anesthesia ‖	71 (56.35)	11 (91.67)	60 (52.63)	0.0121*†
Regional or local anesthesia	68 (53.97)	2 (16.67)	66 (57.89)	0.0121*†
Anesthetic agent, *frequency (%)*§				
Bupivacaine	50 (39.68)	2 (16.67)	48 (42.11)	0.1224†
Lidocaine	12 (9.52)	0 (0.00)	12 (10.53)	0.6034†
Inhalational anesthetic agents¶	67 (53.17)	10 (83.33)	57 (50.00)	0.0342*†
Propofol	2 (1.59)	0 (0.00)	2 (1.75)	1.0000†
Unspecified general (inhalation) anesthetic agent	2 (1.59)	1 (0.88)	1 (8.33)	0.1821†
Unspecified regional anesthetic agent	5 (4.39)	0 (0.00)	5 (4.39)	1.0000†
Reoperation, *frequency (%)***	6 (3.53)	2 (16.67)	4 (3.51)	0.1008†

* Significant at p<0.05
† Fisher's exact test
‡ Surgical Wound Class (SWC): I - clean, SWC II - clean/contaminated, SWC III - contaminated, SWC IV - dirty
§ One patient may have had more than one anesthetic technique or anesthetic agent
‖ Administered by inhalation and/or intravenous route
¶ Isoflurane or sevoflurane
** Patients with at least two operations done during the same admission

operative clinical profiles of the patients with HAIs and those without. Compared to the group without HAI, the group with HAI had a significantly higher proportion of patients who used any indwelling medical device (12/17, 70.59% versus 74/165, 44.85%; p=0.0429). Patients with HAI also had a significantly longer mean length of

Table 4 Logistic regression analysis showing the association of hospital acquired infection and selected clinical characteristics among all patients

	Unadjusted		Adjusted for age and sex	
Characteristics	Prevalence odds ratio (95% CI)	p-value	Prevalence odds ratio (95% CI)	p-value
Smoker	1.09 (0.20 to 5.78)	0.9217	0.59 (0.10 to 3.66)	0.5734
Comorbidities				
Diabetes mellitus	1.76 (0.19 to 16.76)	0.6217	1.19 (0.11 to 12.57)	0.8834
Hypertension	2.14 (0.49 to 9.31)	0.3093	1.46 (0.29 to 7.31)	0.6405
Pulmonary tuberculosis	9.22 (0.53 to 160.41)	0.1273	5.85 (0.30 to 114.59)	0.2448
Diagnosis				
Trauma	0.89 (0.28 to 2.89)	0.8513	1.21 (0.34 to 4.31)	0.7694
Abdomen	1.17 (0.43 to 3.17)	0.7626	1.11 (0.40 to 3.06)	0.8400
Urology	0.88 (0.11 to 7.22)	0.9013	0.79 (0.09 to 6.92)	0.8339
Breast disorders	4.27 (0.76 to 23.91)	0.0987	3.57 (0.54 to 23.51)	0.1857
Head and neck disorders	1.41 (0.16 to 12.20)	0.7540	1.13 (0.13 to 10.05)	0.9140
Length of stay >7 days	27.28 (3.53 to 210.79)	0.0015*	26.25 (3.39 to 203.40)	0.0018*
Use of any indwelling medical devices	2.95 (0.99 to 8.76)	0.0511	3.03 (1.01 to 9.07)	0.0475*
Blood transfusion	0.58 (0.13 to 2.65)	0.4809	0.50 (0.11 to 2.35)	0.3803
Any surgical procedure	1.07 (0.36 to 3.20)	0.8998	1.08 (0.36 to 3.25)	0.8912

* Significant at p<0.05

Table 5 Logistic regression analysis showing the association of hospital acquired infection and selected surgical characteristics among patients who underwent surgery

	Unadjusted		Adjusted for age and sex	
Characteristics	Prevalence odds ratio (95% CI)	p-value	Prevalence odds ratio (95% CI)	p-value
Emergency operation	0.88 (0.26 to 2.95)	0.8357	1.09 (0.30 to 3.99)	0.8989
Surgical procedure of >180 minutes	15.54 (4.10 to 58.87)	0.0001*	15.18 (3.92 to 58.69)	0.0001*
More than 4 surgery team members	5.55 (1.42 to 21.65)	0.0137*	5.42 (1.37 to 21.41)	0.0158*
General anesthesia†	9.90 (1.24 to 79.17)	0.0307*	10.46 (1.29 to 84.63)	0.0278*
Use of any inhalational anesthetic agents‡	10.62 (1.33 to 84.91)	0.0260*	11.81 (1.45 to 96.08)	0.0210*
Minimally invasive surgery	0.84 (0.17 to 4.09)	0.8255	0.63 (0.12 to 3.33)	0.5872
Open surgery	1.88 (0.48 to 7.33)	0.3618	2.40 (0.58 to 9.88)	0.2253
Breast surgery	3.37 (0.32 to 35.16)	0.3105	2.98 (0.26 to 33.74)	0.3774
Reoperation§	5.50 (0.89 to 33.84)	0.0658	5.18 (0.82 to 32.87)	0.0809
Surgical wound class III or IV‖	1.38 (0.42 to 4.52)	0.6002	1.57 (0.46 to 5.41)	0.4706

*Significant at p<0.05
† Administered by inhalation and/or intravenous route
‡ Isoflurane or sevoflurane
§ Patients with at least two operations done during the same admission
‖ Surgical wound class (SWC) III - contaminated, SWC IV - dirty

hospital stay (LOS) compared to those without HAI (18.24 ± 9.48 days versus 8.88 ± 8.36 days; p<0.0001). Other variables such as distribution of diagnosis, proportion of patients who had blood transfusion, and proportion of patients who had surgery were comparable between the two groups.

The intraoperative and postoperative clinical profiles of the 126 patients who had surgery, and a comparison between patients with HAI and those without within this subgroup, are shown in Table 3. The mean duration of surgery was significantly higher among patients with HAI (209.75 ± 101.69 minutes) than among those without HAI (89.48 ± 86.03 minutes; p<0.0001). The proportion of patients who had general anesthesia (i.e., general endotracheal anes-thesia, total intravenous anesthesia, or combined endotracheal and intravenous

Table 6 Characteristics of hospital-acquired infections in 17 patients from the surgery ward

Characteristics	Values n=17
Hospital acquired infection, *frequency (%)**	
Hospital-acquired pneumonia	9 (52.94)
Ventilator-associated pneumonia	4 (23.53)
Surgical site infection	3 (17.65)
Urinary tract infection	1 (5.88)
Phlebitis	2 (11.76)
Antibiotic administered, *frequency (%)*†	
Ceftriaxone	6 (35.29)
Ciprofloxacin	3 (17.65)
Coamoxiclav	1 (5.88)
Cefuroxime	4 (23.53)
Metronidazole	4 (23.53)
Sultamicillin	1 (5.88)
Cefoxitin	6 (35.29)
Amoxicillin	1 (5.88)
Clarithromycin	2 (11.76)
Ertapenem	1 (5.88)
Meropenem	1 (5.88)
Cefepime	1 (5.88)

* One patient may have more than one hospital acquired infection
† One patient may have more than one antibiotic administered

anesthesia) was significantly higher among patients with HAI (11/12, 91.67%) than among those without HAI (60/114, 52.63%; p=0.0121). Conversely, the proportion of patients who had regional or local anesthesia was significantly lower among patients with HAI (2/12, 16.67%) than among those without HAI (66/114, 57.89; p=0.0119). The proportion of patients who were given inhalational anesthetic agents (i.e., isoflurane, or sevoflurane) was significantly higher among patients with HAI (10/12, 83.33%) than among those without HAI (57/114, 50%; p=0.0342). There was a slightly higher mean number of personnel present during the surgical procedures of patients who had HAI (5.00 ± 1.13) than that of patients who had no HAI (4.18 ± 1.41), but the difference between the two means was not statistically significant (0.0552). The rest of the intra-operative and postoperative clinical profiles of the patients were comparable between the two groups.

Table 4 shows the associations between selected patient characteristics and presence of HAI among all patients in the surgery ward. A length of stay (LOS) in the hospital of more than 7 days significantly increased the prevalence odds ratio of having an HAI (POR=27.28; 95% CI 3.53 to 210.79; p=0.0015). After adjustments for age and sex, the PORs of having an HAI was significantly increased by LOS of >7 days (adjusted POR=26.25; 95% CI 3.38 to 203.40; p=0.0018) and use of any indwelling medical devices (adjusted POR=3.03; 95% CI 1.01 to 9.07; p=0.0475). The rest of the selected clinical characteristics were not associated with a significant change in POR of having an HAI.

The associations between HAI and selected surgery-related characteristics of patients who underwent surgical procedures are shown in Table 5. After adjustments for age and sex, the PORs of having HAI were significantly increased by: surgical procedures longer than 180 minutes (adjusted POR=15.18; 95% CI 3.92 to 58.69; p=0.0001), procedures with more than 4 surgical team members (adjusted POR=5.42; 95% CI 1.37 to 21.41; p=0.0158), general anesthesia (adjusted POR=10.46; 95% CI 1.29 to 84.63; p=0.0278), and the use of any inhalational anesthetic agents (adjusted POR=11.81; 95% CI 1.45 to 96.08; p=0.0210). The rest of the selected surgical characteristics were not associated with a significant change in POR of having an HAI.

Among the 17 patients who had HAIs, the most common infections were hospital-acquired pneumonia (9/17, 52.94%), ventilator-associated pneumonia (4/17, 23.53%), and surgical site infection (3/17, 17.65%). Among the 17 patients, the most common antibiotics administered were ceftriaxone (6/17, 35.29%), cefoxitin (6/17, 35.29%), cefuroxime (4/17, 23.53%), and metronidazole (4/17, 23.53%).

DISCUSSION

Key results

In this study, 9.34% of patients in the surgery ward developed HAI during admission. Among all patients in the surgery wards, LOS of >7 days and the use of any indwelling medical devices significantly increased the prevalence odds ratio of an HAI. Further, among patients who underwent surgical procedures, surgical procedures longer than 180 minutes, procedures with more than 4 surgical team members, general anesthesia, and the use of any inhalational anesthetic agents were all significantly associated with having an HAI.

Strengths and limitations

We were able to determine the prevalence of

HAI in admitted patients in the surgery wards and identify the different factors associated with the presence of HAIs in these patients. We believe that this is the first published study in the Philippines that documents the prevalence of HAIs in both operated and non-operated patients in the surgery wards of a hospital. While previous studies were able to specify the causative organisms common in each type of HAI, our study does not report such details. The causative organisms common in operated and non-operated patients would help clinicians develop effective preventive and curative strategies in order to decrease the incidence of infection.[14-16]

Interpretation

HAIs are commonly present in surgical patients, with a particularly high prevalence rate among trauma cases.[17] In terms of rate of infection, our findings were similar to those reported in other studies done in developing countries, which range from 9% to 13%.[18-20] Similar results were observed in a cross-sectional study in Bangladesh, which reported HAI in 8.33% of patients admitted in the surgical units (surgery, neurosurgery, urosurgery, orthopedics, gynecology, and intensive care units) of a hospital.16 In another study done in Ethiopia, the prevalence of HAIs among operated and non-operated patients in surgical wards was much higher at 37.9%.[21] A third study done in India among patients admitted in the surgical wards reported a lower incidence rate of HAIs at 4.17%.[14] The presence of underlying diseases, longer hospital stay, invasive medical procedures, presence of indwelling medical devices, and longer duration of surgical procedures all contribute to the incidence of HAIs,[20 22] and they account for most of the variations in the HAI rates across the different studies.

In our study, LOS of >7 days was associated with a significantly increased odds ratio of having an HAI. The onset of infection and duration of hospital admission are both considered risk factors and prognostic factors for the occurrence of HAI. The LOS of patients in the hospital affects the presence of HAIs,[23] and conversely, the development of HAIs among patients extends their LOS.[24] Based on reports of several studies, the average LOS among patients with HAI in different hospital wards ranges from 6 to 14 days.[21 25-27] Patients with HAI generally stay in the hospital for an average of 7-9 days longer than those without HAI.[27-29]

The intraoperative environment and the use of general anesthesia contribute to the risk of developing HAIs. In a cross-sectional study done among patients with nosocomial pneumonia after abdominal surgery, 62.63% of patients developed HAIs after induction by general anesthesia, while 37.36% acquired the infection after local anesthetics were used.[30] General anesthesia is thought to be associated with immune suppression.[31] Commonly used volatile anesthetics, such as isoflurane and sevoflurane, directly bind to and impair functions of adhesion molecule receptor leukocyte function-associated antigen-1 (LFA-1), which are used in leukocyte migration and immunological synapse formation. These general anesthetics have also demonstrated a negative effect on sepsis outcomes.[32] Another possible explanation for the occurrence of HAIs in the setting of general anesthesia is infection during induction through the contaminated hands of health care workers.[33]

The duration of the surgical procedure is also correlated with an increased risk of HAI, especially the occurrence of surgical site infection (SSI).[14 34-36] Longer surgical procedures can mean more tissue trauma during the performance of surgical techniques, longer exposure to environmental pathogens, and more opportunities for breaches in sterile techniques to happen during the procedures. In addition, prolonged exposure to anesthesia during long surgical procedures may cause different physiological changes in the body, such as hypoglycemia and hypothermia, which in turn are associated with impaired immunity and increased risk of SSI.[37-39]

A high number of personnel present during surgery enhances the risk of HAI. The excessive presence and movement of staff within the operating theater increases the amount of airborne bacteria[40] and facilitates the dispersal of potential pathogens such as Staphylococcus. aureus and Streptococcus pyogenes.[41] Healthcare facility outbreaks caused by airborne dispersal of S. aureus, known as the “cloud phenomenon,” have been associated with skin colonization and a combined viral and bacterial respiratory tract infection in mostly asymptomatic health care workers. Streptococcus pyogenes, which may be present in asymptomatic health care workers attending the surgery, has also been found to cause outbreaks of surgical site infection through airborne dispersal.[42]

Generalizability

In our study, the profiles of our patients in terms of age, sex distribution, smoking history, alcohol drinking history, comorbidities, diagnoses, and other clinical characteristics are typical of those who are admitted in general surgical wards. The results of this study are therefore applicable to most patients who are admitted in surgical wards elsewhere—whether operated or non-operated—who are admitted for at least 48 hours and who share similar demographic and clinical characteristics with the patients in our study.

CONCLUSION

Among a sample of 182 patients admitted in surgery wards, 9.34% developed HAI during admission. Hospital LOS of >7 days and the use of any indwelling medical devices are both associated with a significantly increased prevalence odds ratio having and HAI among all patients in the surgery wards. For patients who underwent surgical procedures, factors that were significantly associated with an HAI were surgical procedures longer than 180 minutes, procedures with more than 4 surgical team members, the use of general anesthesia, and the use of any inhalational anesthetic agents.

Contributors
KR and FA both had substantial contributions to the study design, and to the acquisition, analysis and interpretation of data. KR and FA wrote the original draft and subsequent revisions, and both authors reviewed, edited, and approved the final version of the manuscript. KR and FA both agreed to be accountable for all aspects of the work.

Ethics approval
This study was reviewed and approved by the Department of Health XI Cluster Ethics Review Committee (DOH XI CERC reference P15042801).

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