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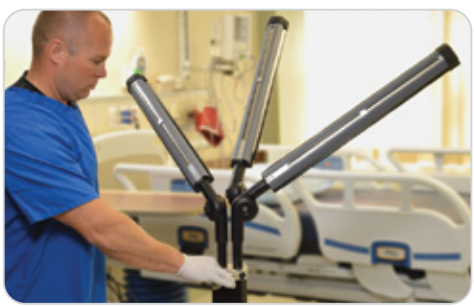

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ORIGINAL ARTICLE

Hip arthroplasty: Incidence and risk factors for surgical site infection

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ABSTRACT

Background: The number of surgical procedures for total hip arthroplasty has increased worldwide, in a direct proportion to the increase in life expectancy of the population. Surgical site infection is the main complication, with several related factors for its occurrence. The objective of this study was to evaluate the incidence of surgical site infection in patients undergoing elective total hip arthroplasty in a tertiary hospital in Brazil, and to identify possible risk factors involved in surgical site infections within the context of Brazilian healthcare.

Methods: A total of 130 patients who have undergone total hip arthroplasty, performed by two surgeons, between June of 2015 and April of 2017 were studied. The Cox regression model was used to identify which covariates among those surveyed influenced the follow-up time, and the hazard ratio was calculated.

Results: The incidence of SSI within 90 days after surgery was 5.4%, with all identified infections classified as superficial. A multivariate survival analysis indicated diabetes and previous hip surgery as risk factors for surgical site infection.

Conclusions: The knowledgement of the epidemiological aspects of orthopedic surgical site infection, are important for management of actions for infection prevention.

KEY WORDS:
Prognosis; risk factors; surgical wound infection; arthroplasty replacement hip

INTRODUCTION

Total hip arthroplasty (THA) is the treatment indicated for the functional restoration of degenerated joints, mainly caused by osteoarthrosis (1). The number of THA performed each year has been increasing worldwide, in a direct proportion to the increased life expectancy of the population (2). By 2030, is expected the rate of surgical site infection (SSI) in patients undergoing hip joint arthroplasty will increase from 2.18% to 6.5% (2,3).

Despite the advances achieved in recent years in relation to preventive measures for SSI, both in surgical practices (3) and in the quality of articular implants, some of the factors that contribute to the increased incidence of infections are the increase in the prevalence of conditions such as: obesity, senility, diabetes, and microbial multiresistance (4). The risk factors that favor the development of SSI are associated to the patient, surgical team, environment, or the technique used in the procedure. Although there are factors upon which professionals can intervene, such as nutritional status, tobacco use, antibiotic prophylaxis, and surgical technique, the conditions associated to patients often cannot be modified, such as age, sex, and most comorbidities (4,5).

The impact of *infectious complications* in hip arthroplasty affects social, occupational, and economic aspects, and is a major challenge for health professionals, patients, and the health services (6). Pain and the inability for locomotion limit activities of daily living and work, generating psychic and economic dependence and damages for patients (7,8). For the health services, the costs can increase by more than 300%, related mainly to the use of high cost antibiotic therapy, and the long hospital stay (8).

Acknowledgements: This study is part of the doctoral thesis entitled, Preoperative Bath in patients submitted to hip arthroplasty: a randomized clinical trial, and was funded by the State of Minas Gerais Research Support Foundation (FAPEMIG), according to Case APQ-01446-13.

Thus, the main strategy for SSI reduction and promotion of surgical patient safety is intervening on modifiable risk factors, (9) which make the identification of these factors a priority in research. Several studies have described the risk factors involved in the development of SSI, but methodological differences and sample size issues in the current research prevent a definitive conclusion on the issue. Factors such as the involved joint, drainage of secretion, and the diagnosis of superficial infection of the surgical wound are conditions associated with periprosthetic joint infection (10). A systematic review which collected 512,208 patients undergoing total joint arthroplasty, (11) identified several conditions (diabetes, rheumatoid arthritis, immunosuppressive and steroid use), previous joint surgery, and high body mass index (BMI) as risk factors for infection. On the other hand, the presence of drains, age, and alcohol consumption (11,12) remains controversial subjects.

Thus, the objective of this study was to evaluate the incidence of SSI in patients undergoing elective total hip arthroplasty in a tertiary hospital in Brazil, and to identify possible risk factors involved in surgical site infections within the context of Brazilian healthcare.

MATERIAL AND METHOD

One hundred and thirty patients undergoing elective THA surgery were studied. The procedures were performed by two orthopedic surgeons, between June of 2015 and April of 2017, in a large public hospital in Belo Horizonte, Minas Gerais (Brazil). It was the same population included in a clinical trial registered on *www.clinicalTrials.gov* (NCTO3001102).

The sample suitability for the proposed analysis was evaluated by applying the rule of Green (1991) (13). Thus, the 130 patients enrolled during the 22-month period of the clinical trial, previously described, allowed an analysis of SSI associated factors with a power of 88%, and precision of 8%, based on the SSI incidence rate of 12.8%, defined in a previous study conducted at this hospital (14).

The patients included were 18 years of age or older, of both sexes, underwent elective THA, primary or revision surgery, and had no infection at the surgical site at the time of surgery.

According to hospital protocol, and as a prerequisite prior to surgery, all patients underwent a cardiac and anaesthesia evaluation, including measurement of blood glucose levels. At this time, the need for referral to an intensive care unit postoperatively was defined, depending on the risk of complication estimated for each patient. Patients were hospitalized on the same day of surgery, and antibiotic prophylaxis was performed using cephalozine. The first dose was administered at the beginning of the anesthetic induction, with repetition every three hours while the surgical procedure lasted, and then every eight hours in the first 24 hours after surgery. Both antisepsis of the patient's skin and the preparation of the surgeon hands were performed with povidone-iodine antiseptic solution. All prostheses were fixed using polymethylmethacrylate (orthopedic cement). Due to the clinical study, during the study period, all patients were instructed by a research nurse, in a pre-surgical appointment, not to remove hair at the surgery site, and to take two baths, in the 24 hours before the surgical procedure.

For the patient's thermal control during the surgery, warm blankets were used covering the patient's trunk, and body temperature measured using trans-esophageal digital thermometers (central temperature), in patients undergoing general anesthesia, or external mercury thermometers, for patients with regional anesthetic block by spinal anesthesia. Hypothermia was considered to be temperatures below 36ºC and 36.5ºC (15) for peripheral and central measurement, respectively.

Detailed information about the patients, characteristics of their joint involvement, their comorbidities and all the procedures performed in the operating room were collected on a specific form by the researchers (nurse researcher and previously trained scientific initiation fellow), who were present throughout the procedure.

The criteria for definition of SSI were based on the NHSN/CDC-2017 recommendations (16), with the observation period for infectious complication being 90 days from the date of surgery. The presence of infection, identified by means of direct examination of the surgical wound during the first 30 days following surgery, was always notified by the same research nurse. After this period, telephone contact with patients was performed at 30, 60 and 90 days after surgery, and the researcher actively questioned the presence of SSI signs and symptoms, following a previously defined questionnaire. All patients were instructed to connect with the service in the event of any change in the operative wound.

Data were entered, using double entry, and analyses were conducted using the Statistical Package Social Sciences (SPSS) software, version 19. The level of significance was established at 0.05, and the confidence interval (CI) was 95%.

A descriptive analysis of the main characteristics of the population (absolute frequency, median, relative minimum and maximum values) was performed. The global SSI and topography incidence rates were calculated. Analysis of the distribution pattern of continuous variables was tested using the Shapiro-Wilk test.

For the investigation of the association between possible risk factors and SSI, a multivariate analysis was performed, including all factors that were associated with SSI in the univariate analysis, with $p < 0.20$. The COX regression model with time-dependent covariables was used to identify which covariates among those surveyed influenced the follow-up time, and the hazard ratio was calculated. The stepwise (backward) method was used to select the variables that remained in the final model ($p<0,05$).

This study (CAAE 30544114.0.0000.5149) was approved by the Research Ethics Committee of the Federal University of Minas Gerais (UFMG). The patients were only included after signing the Informed *Consent Form,* according to the norms of the National Health Council and Resolution 466/12.

RESULTS

Among the 130 elective THA surgeries studied, all were classified in terms of contamination potential as clean, and 121 (93.1%) were primary procedures. Two patients (1.5%) died in the postoperative period, due to non-infectious causes (cerebrovascular accident and arrhythmia), and the remaining 128 patients were followed for 90 days without any losses.

TABLE 1: Main characteristics of the patients and the total hip arthroplasty surgeries – Belo Horizonte, June 2015 to April 2017

Characteristics	n	%
Sex (female: male)	67:63	51:49
Age ≥ 60 years	82	63.1
BMI <18.5 kg/m²	6	4.6
≥ 18.5 BMI < 25.0 kg/m²	31	23.8
BMI ≥ 25.0 kg/m²	93	71.6
Procedures using vancomycin mixed with orthopedic cement	9	6.9
Use of bone graft	50	38.5
Type of anesthesia (general: regional blockage)	41:89	32:68
Number of comorbidities		
0	27	20.8
1 – 2	61	46.9
≥3	42	32.3
Previous surgery	22	16.9
ASA classification		
I	22	16.9
II	94	72.3
III	14	10.8
Risk index for surgical infection		
0	61	46.9
1	60	46.1
2	9	6.9
Patients referred to the ICU after THA	27	20.8
Patients who required blood transfusion	17	13.1

ASA: American Society of Anesthesiologist; ICU: intensive care unit; THA: total hip arthroplasty; BMI: body mass index

Surgeon A performed 28.5% (37/130) of the procedures, and Surgeon B performed 71.5% (93/130). The main demographic characteristics of the patients are provided in Table 1.

No difference was identified in the male: female ratio or in the lateral aspect of the operated hip (right: left). The median age of the patients was 64 (18-87) years and the BMI ranged from 15.9 to 46.1 kg/m², with a median of 27.2 kg/m².

Most patients, 79.2% (103/130), had at least one comorbidity. The main pre-existing diseases identified were: hypertension (85/130, 65.4%), dyslipidemia (45/130, 34.6%), cardio pathologies (24/130, 18.5%), thyroid diseases (18/130, 13.8%), and diabetes (17/130, 13.1%). Twenty-two patients (16.9%) reported a previous hip surgery.

All 130 patients reported a bath, in the 24 hours before the surgery. Despite the orientation not to remove hair from the surgical site, 11.5% (15/130) of the patients had done so. Shaving of the surgical area was performed in 15.4% (20/130) of the patients, always immediately before the surgery, using an electric clipper.

The body temperature (central or peripheral temperature) varied according to the type of anesthesia performed. Thus, 68.5% (89/130) and 31.5% (41/130) of patients had peripheral and central temperature measurements, respectively, monitored during the surgical procedure. At the beginning of the surgery, 76.2% (99/130) of the patients were already hypothermic; at the end of the procedure, 90.8% (118/130) of the patients had a body temperature that was below the reference values, even with the use of heated blankets with heated airflow.

The median between bath and the skin incision was 130 min (43-379 min), the median time between the antibiotic administration and the skin incision was 52 min (23-116 min) minutes and the median duration of the surgeries was 119 min (68-265 min). The median fasting blood glucose in the preoperative period was 94.5 mg/dL (66-335 mg/dL) and the median of glycated hemoglobin (HgbA1c), measured exclusively in patients diagnosed with diabetes was 7.0% (6.0-13.3%).

In relation to the length of hospital stay, the median was three (2-31) days. The longest hospital stay (31 days) was observed in a patient who developed an immediate postoperative stroke, remaining in ICU until death. Seven patients presented SSI within 90 days after surgery, representing an incidence of 5.4% (7/130), 95%CI (2.2, 10.8).

In all seven patients, SSI was considered to be of a superficial incisional type, and was diagnosed between the 12th and 29th postoperative day, with a median of 14 days. Since they were infections affecting the superficial skin plane, obtaining biological material for the etiological diagnosis of the infection was not possible in most cases, except in one, with a small subcutaneous collection that allowed the aspiration of secretion in a closed system using a syringe, and *Staphylococcus aureus*, sensitive to meticillin, was isolated.

Despite the statistical significance observed in the univariate analysis, glycated hemoglobin dosage before surgery was not included in the multivariate analysis model, considering the small number of patients with the measure available, who were only subgroups of patients diagnosed with diabetes. In addition,

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the variable "preoperative blood glucose dosage" was not included to guarantee the independence of co-variables, since "diabetes" was included in the model.

The results of the multivariate analysis using the COX regression model are presented in Table 2. The diagnosis of diabetes and the report of a previous hip surgery were identified as conditions significantly associated with SSI, with the respective hazard ratios: 10.1 (2.25- 45.20) and 4.60 (1.03-20.62), $p < 0.05$. In the same way, analyzing only patients submitted to primary THA, diabetes remained as the only factor related to the risk of infection (data not shown).

DISCUSSION

Despite extensive scientific publication on this topic, recognition of the factors related to the development of SSI after THA has not reached the level of consensus. The divergence of findings among the several studies is explained by methodological differences (especially in terms of outcome assessed, deep or superficial infections, and type of joint involved) and in the populations studied. Specifically, analysis of hip and knee procedures together may compromise the recognition of specific risk factors for each of these sites (10).

In this study, which included exclusively patients undergoing THA, no deep infections were identified, and our main contribution was confirming the influence of diabetes and previous surgery on the development of SSI.

Diabetes mellitus is one of the most common diseases in the world, with prevalence increasing in the last decades. Globally, 382 million people were living with diabetes in 2013, and this number is expected to increase to 592 million by 2035 (17). The number of diabetic patients undergoing arthroplasty has also been increasing, with an elevation in the survival of this population subgroup, with a recognized risk of developing osteoarthritis (18). According to previously published data, 18.7% of patients undergoing joint arthroplasty have some level of dysglycemia, and about one-third of them do not have

TABLE 2: Multivariate analysis of factors associated with surgical site infection in total hip arthroplasty Belo Horizonte, June 2015 to April 2017

	Univariate analysis				Multivariate analysis	
	SSI					
Covariables	Yes (n=7)	No (n=123)	HR [95%CI]	p value	HR [95%CI]	p value
Left hip surgery	6(85.7%)	61(49.6)	5.89[0.71-48.9]	0.101		
Diabetes	4(57.1%)	13(10.6%)	9.30[2.08-41.56]	0.004	10.1 [2.25-45.20]	0.003
Number of comorbidities ≥3	4(57.1%)	38(30.0%)	2.88[0.64-12.86]	0.166		
ASA ≥ 3	3(42.8%)	11(8.9)	6.47[1.45-28.95]	0.015		
Risk index for surgical infection ≥ 2	2(28.6%)	7(5.7%)	5.50[1.07-28.36]	0.042		
Hemotransfusion required	2(28.6%)	15(12.2%)	2.94[0.57-15.13]	0.198		
Previous surgery reported	3(42.8%)	19(15.4%)	4.06[0.91-18.13]	0.067	4.60 [1.03-20.62]	0.046
Axillary temperature at the end of surgery	35.1 (33.5-35)	35.1 (34.0-37.0)	0.39[0.11-1.46]	0.163		
Solution 1 used in preoperative bath	2(28.6)	42(34.1)	07.78[0.15-4.01]	0.765		
Solution 2 used in preoperative bath	3(42.9)	40(32.5)	1.47[0.33-6.59]	0.611		
Solution 3 used in preoperative bath	2(28.6)	41(33.3)	0.83[0.16-4.31]	0.831		

SSI: Surgical site infection; ASA–HR: hazard ratio; Cox regression

the metabolic disorder diagnosed prior to the procedure (19). A study involving 1,948 patients revealed that the rate of diabetes among the 101 patients with infectious complication was significantly higher (22%) than in the non-infected group (9%) (20).

In our series of cases, contrasting with 13% of diabetic patients in the total group undergoing the surgical procedure, 57.1% of these patients presenting SSI were diabetic, indicating a 10-fold increase in the risk of SSI, HR= 10.1 95%CI (2.25-45.20); p= 0.003.

According to our results, both the diagnosis of diabetes and the presence of pre-operative hyperglycemia were related to the risk of infection. At least in this population, evidence that adequate glycemic control is protective for infection was not identified, which may be related to the sample size and the poor representativeness we had of patients with inadequate glycemic control.

Our data also suggest that previous surgical manipulation of the joint represents a significant risk for superficial incisional SSI, HR=4.60, 95%CI (1.03-20.62), p=0.046. The same association was identified in a review, published in 2016, regarding the risk of deep infection RR=2.98, 95%CI (1.49-5.93) and patients who had a revision arthroplasty had a risk RR 2.26, 95%CI (1.30-3.92) (11). Several mechanisms may be involved with increased risk of infection in previously operated joints. When the surgical site is manipulated, the tissue environment around the wound may be compromised by replacement by fibrotic scar tissue, which increases surgical difficulty and the time of surgery, with a consequent increase in the risk of bacterial contamination (21).

Our results corroborate the recommendation of the International Consensus Meeting Group (ICG) on Periprosthetic Joint Infection, to routinely investigate the history of prior surgery and careful evaluation of the site to be incised (6). Based on the principle that patients should not be harmed by health care, measures that promote patient safety have taken a prominent part in quality improvement actions in several countries (22). Thus, the identification of factors related to the occurrence of surgical infections is the first step in approaching the problem, and is fundamental for its prevention.

CONCLUSION

Identification of infection risks, and knowledgement of the epidemiological aspects of orthopedic SSI, is important for management of actions for infection prevention. In this study, diabetic patients and those with prior hip surgery had an increased risk for SSI. The recognition of these conditions should increase the level of clinical suspicion of infectious complication in the postoperative period, as well as the promotion of patients with these factors to be preferred candidates for new studies evaluating prevention strategies.

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ORIGINAL ARTICLE

Multi-drug resistant ventilator associated pneumonia: risk factors and outcomes

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ABSTRACT

Background: Multi-drug resistant (MDR) ventilator associated pneumonia (VAP) may lead to inappropriate empiric antimicrobial treatment and poor outcomes. The purpose of this study was to investigate MDR pathogens' effect on the VAP patients in order to improve the treatment choice and outcome.

Methods: We retrospectively studied a collection of 132 VAP patients that confirmed the characteristics, risk factors and outcomes of pneumonia. MDR VAP patients were also compared with non-MDR VAP patients.

Results: MDR and non-MDR pathogens were found in 96 (72.7%) and 36 (27.3%) of the patients, respectively. The most common organism was *Klebsiella pneumoniae* and the most fatal MDR pathogen was *Staphylococcus aureus*. The MDR VAP was found to be associated with an increased length of stay in intensive care unit (ICU), increased hospital stay, and longer intubation time. No statistically significant association was found between prior antimicrobial use and MDR-VAP. The mortality rate of MDR VAPs was significantly higher than non-MDR VAPs.

Conclusion: Discharging patients from ICU and hospital and extubation of the patients as early as possible are two important interventions for prevention of MDR-VAP. Regarding prior antimicrobial use, no significant difference was observed between MDR and non-MDR VAPs. Administration of empiric antibiotic therapy seems to have a protective effect, decreasing mortality without evidence of contributing to multi-drug resistance.

KEY WORDS:
MDR, Outcome, Risk factor, VAP

INTRODUCTION

VAP is a major ICU infection, with an incidence that ranges from 6% to 52%. It is a major factor in high morbidity and mortality and increased financial burden in ICU (1, 2). It occurs in ICU patients after 48 hours or more of endotracheal intubation and mechanical ventilation. By invasive or noninvasive techniques the lower respiratory tract sample is collected to achieve VAP etiologies (3).

The overall rate of VAP in developing countries ICU is 13.6 per 1000 ventilator-days; it is more than four times the VAP rate in US ICUs (4). Nosocomial pneumonia has a complicated microbiological epidemiology. Gram negative bacteria and some gram positive species followed by few anaerobic species are known as the most important pathogens responsible for VAP (5,6).

Widespread antibiotic resistance among bacteria isolated from VAP patients represents a serious concern as it may lead to higher antimicrobial administration and mortality rate and prolonged stay in the ICU (7, 8). MDR organisms are strongly associated with inappropriate empiric antimicrobial therapy, an important factor of mortality in patients with VAP (1).

European center for Disease prevention and control (ECDC) refers to MDR as an organism non-susceptibility to a minimum of one agent in three or more antimicrobial classes. Based on the ATS/IDSA guideline, early and late onset VAP, are respectively defined as VAPs that occur within and after the first 96 hours of hospitalization (9).

The most prominent risk factors for developing a respiratory nosocomial infection caused by MDR organisms in ICU are: mechanical ventilation, immunosuppression, and recent antibiotic therapy, hospitalization longer than five days (10).

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The main risk factors that prompt VAP development are as follows: recent surgery, use of proton pump inhibitors, prolonged intubation and difficulty in weaning from mechanical ventilation, nasogastric tube placement, supine position of patient, recent use of antibiotic, chronic pulmonary diseases, trauma and previous septicemia, and transportation of the patient outside the ICU (11).

The present study retrospectively assesses the risk factors, responsible organisms and outcomes of MDR VAP in an adult ICU in Iran. Antimicrobial resistance patterns have also been evaluated for the VAP patients.

METHODS

We conducted a retrospective, cross sectional single center study in multidisciplinary ICU of a general hospital in Tehran-Iran. In this hospital antibiotic susceptibility testing by disc diffusion was in accordance with clinical and laboratory standard institute.

First, the lab documentation has been extracted for all tracheal samples sent for VAP between 2010- 2014. The patients, who were intubated for more than 48 hours and had the VAP criteria, were considered as VAP (T ≥38 or T≤36, profuse or purulent tracheal secretion, new or progressive chest infiltration).

Positive tracheal culture in patients with VAP clinical presentation was a major criteria for being included in this study. We excluded patients without a positive microbial diagnosis and those with fungal or poly microbial tracheal culture (Figure 1).

VAP is a variety of pneumonia that emerges more than 48 hours after endotracheal intubation. The clinical diagnosis of VAP is based on the recognition of two out of the four signs of infection (i.e., fever ≥38.5 C, leukocytosis, purulent sputum, crepitation in lungs or impaired gas exchange) developed in patients on mechanical ventilation. When occurred in the first 4 days of intubation, it was called early onset pneumonia (1).

The data extracted from patients' medical records included: demographic data, admission date, and prior antibiotic exposure (all antibiotic agents seven days before VAP infection). Antibiotic sensitivity was reviewed. Microorganisms were considered MDR if they were resistant to more than three classes of antibiotics (cephalosporins, carbapenems, beta lactam- and beta lactamase inhibitors, aminoglycosides, and fluoroquinolones) (1).

Statistical analysis was performed using IBM-SPSS version 16. Continuous variables were expressed as numbers and percentages with mean ± standard deviation. Independent t-Test was used for comparison of continuous variables and chi-square test was used to compare categorical variables. The difference between groups was considered significant if the p-values were < 0.05.

RESULT

A total of 330 tracheal aspiration (smear and culture) results were extracted, of which only 191 cases had complete documentation. Of these, 132 patients were confirmed as presenting with VAP criteria (Figure 1). One hundred and thirty two patients who were diagnosed as VAP with positive tracheal aspiration culture have been included in our study.

FIGURE 1: Flow diagram of study inclusion and exclusion of patients

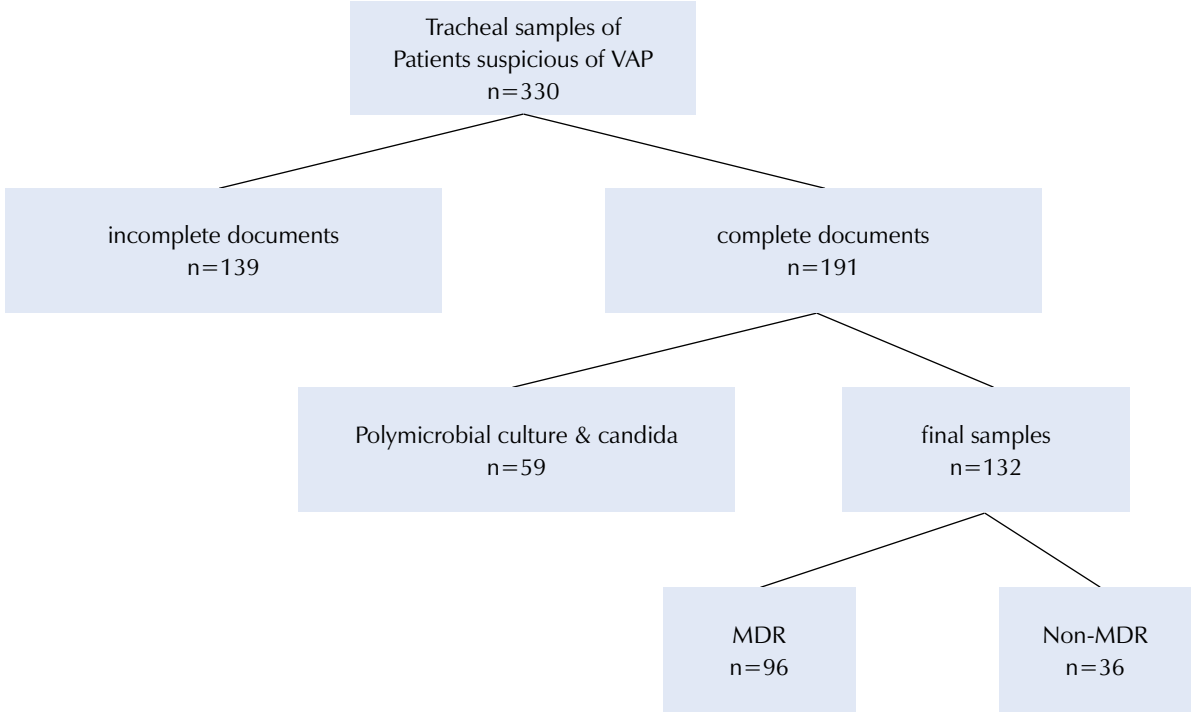

TABLE 1: Baseline characteristic of the MDR and non-MDR VAP patients				
		MDR	non-MDR	P-value
Number	132	96(72.7%)	36(27.3%)	
Age, year	54.78± 22.37	57.37±22.66	47.88±20.31	0.030
Male, n	87(65.9%)	64(66.7%)	23(63.9%)	0.762
Female, n	45(34.01%)	32(33.3%)	13(36.1%)	0.762
Intubation time, day	23.94±20.49	28.52±22.68	11.75±8.09	< 0.0001
ICU admission time, day	27.28±23.97	32.11±25.77	14.38±10.62	< 0.0001
Hospital admission time, day	30.42±22.39	35.35±23.64	17.28±10.75	< 0.0001
Antibiotic use before $_{+}$	94(71.2%)	70(72.9%)	24(66.7%)	0.480
Antibiotic use before $_{-}$	38(28.8%)	26(27.1%)	12(33.3%)	0.480

The most common organism was *Klebsiella* (26.5%); other prevalent organisms were *Acinetobacter* and *Pseudomonas aeruginosa* (15.2%). 100% of *Acinetobacter spp*., 85% of P. *aeruginosa*, 75% of *Klebsiella pneumoniae* were MDR organism (Table 2).

Patient characteristics

From 132 samples, 96 cases (72.7%) were MDR and 36 cases (27.3%) were non-MDR. Mean age of the patients was 54.76±22.37 years. The mean age in MDR group was significantly higher than non-MDR ($p<0.05$). Characteristics of patients who developed VAP are shown in Table 1. Majority of patients were male (65.9%). Patients with MDR were significantly older than non-MDR group. There was no difference between male and female in MDR and non-MDR groups ($p>0.05$; Table I).

Antibiotic use

There was no significant difference between MDR and non-MDR VAP in viewpoint of previous Antibiotic administration ($P>0.05$; Table 1).

Hospital, ICU stay and Intubation time

The total intubation, ICU and hospital stay time were 23.94± 20.49 days 27.28± 23.97 days 30.42±39 days and respectively (Table 1).

Mean time of hospital stay, ICU stay and intubation time in MDR VAP were significantly higher than non-MDR VAP ($P<0.0001$; Table 1).

Blood culture and sepsis

Positive blood culture in the MDR VAP patients (55.2%) have been significantly different from non-MDR VAP patients (19.4%) ($P<0.0001$) however, the rate of sepsis and septic shock have not been very different in these two groups.

Comorbidities

The most common comorbidity was cardiovascular diseases in both MDR and Non-MDR groups. There was no significant difference between the number of comorbidities in MDR and non-MDR VAP ($P=0.204$).

Early and Late onset VAP

Early VAP and late VAP were found to be correlated with non-MDR and MDR patients, respectively (0.012).

Outcome

Mortality rate in the MDR VAP patient (57.3%) has been significantly more than non-MDR group (33.3%) ($P=0.014$).

The mortality rate between early (30%) and late (70%) onset VAP has not been significantly different ($P=0.161$).

Acinetobacter pathogens which only were in the MDR group, showed a death rate of 45 % (i.e., 9 cases). *S. aureus* was responsible for the highest death rate (i.e., 63%; 7 cases); however 54% of this pathogen was MDR.

DISCUSSION

VAP MDR pathogens are associated with significant mortality, morbidity and rise of hospital care costs (12). The variables that the present study identified as significant risk factors for acquiring MDR VAP are: the age, intubation time, ICU and hospital admission time.

Out of the 132 tracheal samples (VAP patients), 96 cases (72.7%) were MDR and 36 cases (27.3%) were non-MDR. This high rate of MDR pathogen was similar to other studies (i.e., 51.8%-78.7%) (13,14). Notably, most of our cases were older than the other studies. Patients in the MDR group were significantly older than the non-MDR, as the previous studies indicated (14). The MDR patients' age was rarely found to be less than the non-MDR patients (15).

Some studies suggested that the prior antibiotic use is related to the occurrence of MDR VAP (3,17-19). However in viewpoint of the previous antibiotic administration, the difference between MDR and non-MDR groups was not significant enough as implied by the former studies (16,17). The present study only recorded Antibiotic use in the seven days before admission, therefore we cannot exclude the possibility that the earlier use or perhaps prolonged use of Antibiotic might have affected the microbiology of VAP (16).

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TABLE 2: Etiologic diagnosis of pneumonia in 132 VAP patients pathogens			
Pathogen N(%)	**All**	**MDR**	**Non-MDR**
Acinetobacter	20(15.2%)	20(20.8%)	
Non-Fermenting Gram negative bacilli	7(5.3%)	6(6.2%)	1(2.8%)
Citrobacter	4(3%)	2(2.1%)	2(5.6%)
Staph-coagulase negative	17(12.9%)	4(4.2%)	13(36.1%)
E. coli	3(2.3%)	2(2.1%)	1(2.8%)
Enterobacter	9(6.8%)	8(8.3%)	1(2.8%)
Gram positive cocci	5(3.8%)	2(2.1%)	3(8.3%)
Klebsiella	35(26.5%)	28(29.2%)	7(19.4%)
Proteus	1(0.8%)	1(1%)	
Pseudomonas	20(15.2%)	17(17.7%)	3(8.3%)
Staphylococcus	11(8.3%)	6(6.2%)	5(13.9%)
aureus		96(100%)	36(100%)

Patients who are in the hospital or ICU for a protracted period of time are increasingly exposed to nosocomial pathogens, therefore they are at higher risk for colonization with the organisms (i.e., the isolation of MDR pathogens). At the same time, earlier Antibiotic use that was not regarded in our study protocol, may have contributed to the increased risk of isolation of MDR organisms (15,16).

Similar to the study carried out in 2016 (20) the most common organism in our VAP patients was Gram negative organisms (Table 2). However, in the USA and Canada the responsible pathogen for VAP was Gram positive (14,26). The current study found out 85% of *P.aeruginosa* organisms to have been MDR, whereas the former studies indicated lower percentages (14,21). In the present research, 100% of *Acinetobacter spp*. pathogens were MDR, similar to the study by Dey and Bairy (17). However, in other studies, these were significantly lower, ranging between 40%-52% (12, 14, 18).

The highest mortality rate in the present study belonged to *S. aureus* (55% MDR) with 63.4% incidences. At the same time, the death rate caused by *Acinetobacter spp*. (100% MDR) was 45%. An earlier study indicated an association between the MDR status of pathogens and their mortality rate (27). However, the mortality of VAP caused by *Acinetobacter* does not look to be modulated by its MDR status (28-30).

As regard with the positive blood culture, mortality rate and late VAP, the current study found significant differences between the MDR and non-MDR groups. The MDR pathogens identified in our patients were mostly associated with the late VAP; similar finding is reported by Kuar et al (14).

This study identified no considerable difference between the mortality rate of early and late VAP, it is in contrast with previous study (14). However, in some studies *Acinetobacter* was the most common pathogen in both early and late onset VAP (17).

LIMITATION OF STUDY

1. The present study was a "single center retrospective" research. To achieve a full understanding of the role of pathogen class and MDR in VAP a multicenter prospective study is needed. 2. The present study was based on the identifying the varieties of responsible organism. More precise quantitative cultures of tracheal secretion provide higher confidence in the organisms recovered. 3. The present study utilized a small sample size. A larger sample size yields more reliable statistical numbers for each pathogen.

CONCLUSION

In regard with the prior antimicrobial use, no significant difference is observed between MDR and non-MDR VAP. Therefore administration of empirical antibiotic seems wise, to decrease the mortality, without fearing for occurrence of MDR pathogens. Also no correlation was established between the MDR status of certain pathogen and mortality of the VAP patients. Most of late VAP are linked with MDR organisms, hence, there is no significant difference between early and late VAP in viewpoint of mortality.

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ORIGINAL ARTICLE

Incidence and risk factors of surgical site infection in general surgery department of a Tunisian tertiary teaching hospital: A prospective observational study

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ABSTRACT

Background: Effective surveillance systems and identification of risk factors have been described as a preventive measure for reducing Surgical Site Infections (SSI). The purpose of our study was to determine the incidence rate and risk factors of SSIs in the General Surgery Department of Sahloul University Hospital.

Methods: We carried out a prospective observational study from January 2015 to May 2015 in the General Surgery department at the University Hospital of Sahloul in Sousse, Tunisia. We actively followed up all patients who underwent general surgical procedures and matched the inclusion criteria at 30 days of surgical procedures.

Results: Overall, 349 patients were followed to 30 days after operation. We identified 30 SSIs. The incidence rate was 8.6%, 95% Confidential Interval= [5.7% - 11.5%]. The incidence density was 12.9 cases for 1000 days of hospitalization. The superficial infections were the most frequent (14 cases/30) followed by organ/space infections and deep infection. The most common isolate identified was Escherichia Coli. In multivariate analysis, an extended length of preoperative stay and risk index NNIS superior to 1 were found to be statistically significant risk factors for surgical site infection.

Conclusion: More efficient programs are needed to decrease the SSIs rate. Hence, among means of prevention, ongoing surveillance has proven to be an independent factor for long-term reduction of SSI rates.

KEY WORDS:

Surgical site infection, risk factors, incidence, general surgery

INTRODUCTION

SSI is a severe surgical complication and is among the most frequently reported types of healthcare associated infections (HAIs) [1]. They are the most prevalent nosocomial infections in surgical clinics [2].

They represent one of the main complications in patients undergoing surgery, with major implications in terms of morbidity, including additional surgical procedures or transfer to an intensive care unit (ICU), mortality, longer duration of hospital stay, and financial burden [3, 4].

An extensive surveillance program can reduce the rates of SSI by 30 to 40%, and for its effectiveness, the real incidence of these infections and associated risk factors must be known [5].

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Thus, SSI incidence has been recommended by the Council of the European Union who made the recommendation of 9 June 2009 on patient safety, including the prevention and control of healthcare associated infections and proposed as an indicator of healthcare quality in the context of clinical governance and performance monitoring, and is therefore a target of many healthcare systems [6, 7].

For instance, in France, the implementation of national surveillance program of SSI (INCISO program) by the Inter-regional centers for the coordination of the fight against the nosocomial infections (C-CLIN), has resulted in a decrease in the rates of SSI from 4.1% in 1998 to 2.7% in 2000. In 2010, the overall incidence of SSI was 1.2% [8, 9].

In fact, surveillance itself, even without any specific intervention, has been associated with a reduction in SSI incidence, another reason to recommend implementation of national surveillance systems [10-12].

In the framework of the program of control and prevention of HAI of the university hospital of Sahloul, our department conducts each year a survey on prevalence of HAI.

Given the importance of measures for the prevention and control of SSI because of its high rates found in the two last years in our hospital (17.6% in 2014 and 12% in 2015), this study aimed to determine the incidence of SSI and its risk factors in General surgery department of university hospital Sahloul.

METHODS

Study design

We carried a prospective cohort study between January 2015 and May 2015 in General Surgical department of university hospital Sahloul, Sousse, Tunisia.

Study patients

We included all patients who underwent general surgical procedures (appendicectomy, cholecystectomy, cure of inguinal or femoral hernia, surgery of the colon sigmoid, and rectum, intervention on the peritoneum, the mesentery and the omentum, surgery of the biliary tract, liver and pancreas, of the esophagus, stomach, and of the duodenum by abdominal track), who were hospitalized at the general surgical department or hospitalized in another department and then transferred to our department, and who were followed to 30 days after operation.

We excluded from our study patients who have undergone invasive procedures for diagnostic purposes or acts of interventional radiology, who underwent non-tumoral proctology surgery, and those who already suffered from cutaneous or soft tissue infections before the study.

Procedures involving implants of prosthetic material were not considered due to the different length of post-intervention follow-up that is required (one year).

Overall, out of 316 patients, we followed 349 at 30 days after the intervention.

Definitions of variables

The main outcome variable was the occurrence of a SSI within 30 days of the operation. SSIs were further classified depending on the depth of the infection as superficial, deep incisional, or organ/space, according to the definitions of SSI retained in the French protocol monitoring of SSI (RAINSIN-2015) and which are based on the definition criteria published in 1992 by the CDC (Centers for Disease Control) [13].

Wound classification of Altemeier [14], ASA score [15] , and duration of intervention [9] were used to calculate the SSI risk index NNIS [16]. The NNIS can therefore take values of 0 (no risk factor) to 3 (all risk factors are present).

Data collection

We collected patient data using a form built on the French national protocol for the SSI surveillance of ISO-RAISAN 2015 [17] and on data from the literature.

Data included sociodemographic characteristics (age, gender, date of admission, date and mode of discharge), and intrinsic risk factors (smoking, diabetes, high blood pressure, corticotherapy, cirrhosis, multiple scars, and immune deficit).

Data were collected from patients' charts, the plug of anaesthesia of the surveillance of patient during intervention, and the interview with the patient himself, as well as with the nurse and the doctor.

Charts were reviewed by the investigators and when needed with the doctor in charge of the patient.

Patients were reviewed in the outpatient clinic in the 30 days which followed the intervention whenever they assessed the hospital for post-discharge visits, or contacted by phone to have information about the state of the surgical scar.

The forms were filled by two investigators (an internal trainee and a resident of the service of prevention and safety of care of the Sahloul hospital of Sousse) during the stay of the patient as well as during his follow-up during the 30 days following the intervention.

The bacteriological analysis of the operating site had been conducted either by a nurse, or the operating surgeon. Bacterial identification was made by manual classic methods which are based on morphological and metabolic characteristics. In addition to these methods, a phenotypic automated system of identification VITEK 2 has been used for the identification of strictly anaerobic bacteria and some other bacteria not identified by conventional methods.

An oral consent was obtained from participants in order to use information from their records, and that was approved by the ethical committee of the Faculty of medicine of Sousse – Tunisia.

Statistical analysis

Statistical analysis was done by another resident performed in statistical analyses.

Continuous variables were described as means ± standard deviations, and compared using the *Student t-test*. Categorical variables were summarized with absolute and relative frequencies, and compared using the *Chi-squared test* (or *Fisher Exact tests* where appropriate). Univariate and then multivariate regression analysis were used to examine the associations of various risk factors and SSI between patients with and without SSI. *Binair logistic regression* was performed including only variables with $p \leq 0.20$ in univariate regression. All analyses were conducted using the SPSS software version 18 with significance set at the 5% level.

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TABLE 1: Characteristics of patients with and without surgical site infection

Characteristics		Number (n) Or Mean	Frequency (%)
Age (years)		44.6±20.7	
Gender	Male	175	50.1
	Female	174	49.9
ASA score	1 and 2	335	96
	3 and 4	14	4
Tobacco use	Yes	64	18.3
	No	285	81.7
High blood pressure	Yes	70	20.1
	No	279	79.9
Diabetes	Yes	38	10.9
	No	311	89.1
Corticotherapy	Yes	10	2.9
	No	339	97.1
Multiple scars	Yes	4	1.1
	No	345	98.9
Immune deficit	Yes	8	2.3
	No	341	97.7
Cirrhosis	Yes	2	0.6
	No	347	99.4
Duration of pre-operatory stay (days)		1.7±2.4	
Pre-operatory infection	Yes	3	0.9
	No	346	99.1
Contamination class of Altemeier	Class I and II	283	81.1
	Class III and IV	66	18.9
Duration of the intervention	Over 75th percentile	39	11.2
	Under 75th percentile	309	88.88
NNIS risk index	0	251	71.9
	1	74	21.2
	2	23	6.6

RESULTS

Patient characteristics (Table 1)

Overall, 349 patients were followed at 30 days of the operation out of 365 patients included. The mean age was 44.60±20.78 years.

The population was made up of 50.1% of men and 49.9% of women.

High blood pressure was the most frequent pathology (20.1% of cases) followed by tobacco use (18.33% of cases).

The immune deficit was found in 2.3% of patients. This deficit was caused by a long course of immunosuppressive therapy in 8 cases, and in one case by an end-stage renal disease.

Pre-operatory hospital stay lasted for an average of 1.7±2.4 days.

A pre-operatory infection was present in three patients; it was a chronic peritonitis in one case, and a urinary tract infection in the other two cases.

For the skin preparation of the patient, nine patients (2.5%) had showers at home the day before the procedure, and mechanical shaving was the only depilation mode used.

The cholecystectomy and appendectomy were the most frequent surgical procedures carried out (27.2% and 26.4% respectively).

More than three-quarter of the surgeries were classified I or II

Table 2: Distribution of the SSI according to the type of intervention

Type of the intervention	SSI N (%)		Total
	Yes	No	
Surgery on the peritoneum, the mesentery and the omentum	3 (18.7)	13	16
Appendectomy	9 (9.78)	83	92
Surgery of the biliary tract, liver and pancreas	9 (13.6)	57	66
Cholecystectomy	1 (1.08)	91	92
Surgery of the colon, and rectum	5 (13.15)	33	38
Surgery by abdominal track of the esophagus, the stomach and the duodenum	2 (12.5)	14	16
Surgery of the hail	0 (0)	7	7
Herniaire surgery	1 (5)	19	20
Cure of belly feeding	0 (0)	2	2
Total	30	319	349

according to the wound classification of Altemeier which means how much does the intervention may cause infection. For the 66 cases of wound classification of III and IV, 63 have benefited from a curative antibiotic therapy on post-intervention. The associations of antibiotics such as (cefotaxime + metronidazole) and (cefotaxime + metronidazole + gentamycin) as well as the amoxicillin-clavulanic acid accounted for 84.1% of therapeutic measures used.

The average duration of intervention was 92±71 minutes, with extremes ranging from 15 to 485 minutes.

Interventions duration was greater than the 75th percentile in 39 cases (11.2%).

The risk index NNIS was equal to 0 in 71.9% of cases. No patient had an index equal to 3.

The cefazolin, cephalothin as well as the association amoxicillin-clavulanic acid were the main antibiotics used in prophylaxis with a rate of use that exceeded 90%

Surgical site infection and risk factors (Tables 2 and 3)

Overall, 30 SSIs were identified in 349 patients (every included patient had only one SSI). The incidence rate was 8.6% ($CI_{95\%}$= [11,5% – 5,7%]). The incidence density was 12.9 cases for 1000 days of hospitalization.

The superficial infections were the most frequent (14 cases/30) followed by organ/space infections (13 cases/30) and deep infections (3 cases/30) (Figure 1).

The colon and rectum surgery (13,1%), surgery on the peritoneum (18,7%) as well as the surgery of the liver and biliary tract (13,6%) generated the most SSIs (Table 2).

Of the 30 SSIs, 40% were developed during the first week and 90% before the end of the third week after the surgery, with a median time of onset of SSI after the intervention of nine days.

Among the 30 patients having a SSI, 15 had tissues analyzed. The 15 patients' cultures yielded 17 bacterial strains. In present study, *Staphylococcus aureus* accounted for only 11% of all isolated strains while the bacilli of Gram-negative bacteria represented by *Enterobacteriaceae* namely *Escherichia coli, Klebsiella pneumoniae, Morganella morganii* as well as the *anaerobic bacteria* were the germs the most frequent and represented 76% of isolated germs. The most common isolate identified was *Escherichia Coli* (5 strains/17) (Figure 2).

The study of the sensitivity revealed only one multi-resistant bacteria, it was of a strain of *Pseudomonas aeruginosa*.

Among the 14 superficial infections, four have benefited from an antibiotic therapy using amoxicillin-clavulanic acid and one case using the association of cefotaxime-metronidazole-gentamycin which has been adapted according to the results of the sensitivity. No complications were found after treatment in 29 patients. Only a single case of death has been reported which was not associated with the SSI.

Univariate analysis identified as risk factors of SSI ASA score ($p < 10^{-4}$), the length of pre-operatory stay (p=0.024), the contamination class of Altemeier (p=0.002), carcinologic surgery (p=0.03), laparoscopic intervention (p=0.009), abdominal drainage (p=0.003), duration of the intervention over the 75th percentile ($p<10^{-4}$), NNIS index = 2 ($p<10^{-4}$) and NNIS index = 1 ($p<10^{-4}$) (Table 3).

Whereas, SSI was independently associated with the length of pre-operatory stay, NNIS index = 1 and NNIS index = 2 (Table 4).

DISCUSSION

We demonstrated an average incidence of 8.6% SSIs among all patients of the General Surgical department. This number is beyond the average SSI rate of 2.61% presented by the NNIS review [18].

The digestive tract surgery is one of specialties which are the most providers of SSI in addition to the cardiovascular surgery and transplantation of organs [5, 19].

Based on the same procedures, our SSI rate was higher than the one reported in some developed countries [19-21]. It was

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TABLE 3: Univariate analysis of risk factors of surgical site infection in general surgery department of Sahloul hospital of Sousse (Tunisia)

Factor		SSI (n=30) Mean or n (%)	No SSI (n=319) Mean or n (%)	RR [CI 95%]	P
Age		48.3 ± 20.27	44,26 ± 20.8	1.01 [0.95-1.03]	0.3
Gender	Male	13 (7.5)	161 (92.5)	1.33 [0.62-2.85]	0.45
	Female	17 (9.7)	158 (90.3)		
ASA score	1 and 2	24 (7.2)	311 (92.8)	9.71 [3.1-30.3]	$< 10^{-4}$
	3 to 6	6 (42.9)	8 (57.1)		
Tobacco use	Yes	9 (14.1)	55 (85.9)	2.05 [0.89-4.73]	0.08
	No	21 (7.4)	264 (92.6)		
High blood pressure	Yes	6 (8.6)	64 (91.4)	1.004 [0.39-2.55]	0.99
	No	24 (8.6)	255 (91.4)		
Diabetes	Yes	5 (13.2)	33 (86.8)	1.75 [0.62-5]	0.35
	No	25 (8)	286 (92)		
Corticotherapy	Yes	0 (0)	10 (100)	NA	1
	No	30 (8.8)	309 (91.2)		
Multiple scars	Yes	0 (0)	4 (100)	NA	1
	No	30 (8.7)	315 (91.3)		
Immune deficit	Yes	1 (12.5)	7 (87.5)	1.53 [0.18-12.92]	0.51
	No	29 (8.5)	312 (91.5)		
Cirrhosis	Yes	0 (0)	2 (100)	NA	1
	No	30 (8.6)	317 (91.4)		
Duration of pre-operatory stay (mean ± standard deviation)		3.4 ± 4.2	1.5 ± 2.1	1.22 [1.09-1.36]	0.024
Pre-operatory infection	Yes	1 (33.3)	2 (66.7)	5.5 [0.48-62.5]	0.23
	No	29 (8.4)	317 (91.6)		
Contamination class of Altemeier	Class I and II	18 (6.4%)	265 (93.6%)	3.27 [1.48-7.18]	0.002
	Class III and IV	12 (18.2%)	54 (81.8%)		
Emergency surgery	Yes	16 (10.3)	139 (89.7)	1.48 [0.69-3.22]	0.3
	No	14 (7.2)	180 (92.8)		
Laparoscopic intervention	Yes	29 (10.7)	242 (89.3)	9.22 [1.23-68.85]	0.009
	No	1 (1.3)	77 (98.7)		
Carcinologic surgery	Yes	9 (16.7)	45 (83.3)	2.61 [1.12-6.05]	0.03
	No	21 (7.1)	274 (92.9)		
Abdominal drainage	Yes	16 (15.5)	87 (84.5)	3.04 [1.42-6.50]	0.003
	No	14 (5.7)	232 (94.3)		
Duration of the intervention	Over 75th percentile	16 (41)	23 (59)	14.65 [6.37-33.73]	$< 10^{-4}$
	Under 75th percentile	14 (4.5)	295 (95.5)		
NNIS risk index	0	7 (2.8)	244 (97.2)	1	-
	1	10 (13.5)	64 (86.5)	34.48 [16.39-71.42]	$< 10^{-4}$
	2	13 (56.5)	10 (43.5)	6.41 [3.33-12.5]	$< 10^{-4}$

TABLE 4: Multivariate analysis of risk factors of surgical site infection in general surgery department of Sahloul hospital of Sousse (Tunisia)

Factor	Adjusted RR	95% CI	P
NNIS index 1	45.45	14.70 – 142.85	$< 10^{-4}$
NNIS index 2	10.10	3.28 – 31.25	$< 10^{-4}$
Preoperative length of stay	1.20	1.06 – 1.36	0.004

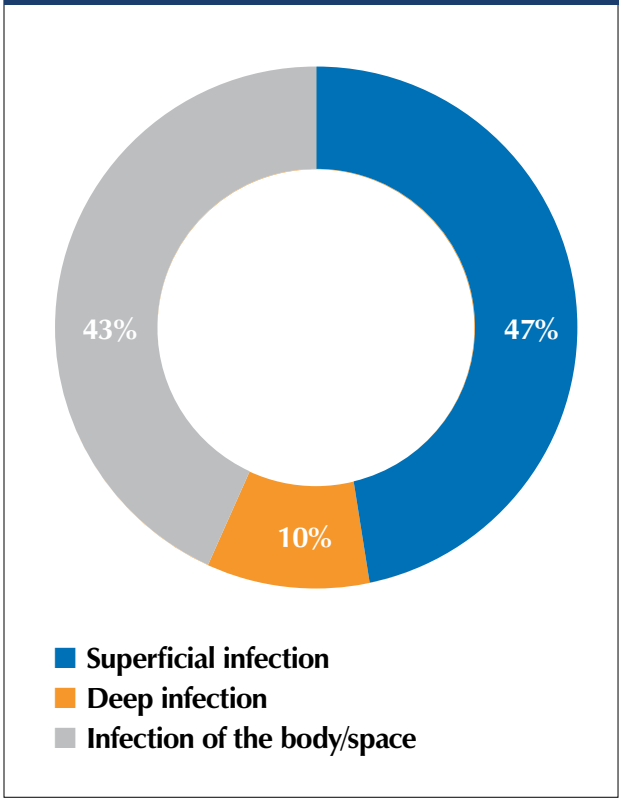
also higher than some less developed ones [22, 23], but was approaching the rates found in Spain (8.25%) and Pakistan (7.3%) [22, 24].

However, it was lower than the rates of some developing countries such as Brazil (24.5%), Peru (26.7%) [25, 26], Iran (17.4%), Nigeria (26%), and Algeria (9.8%) [27-29], and higher than that of Morocco (5.2% at the military hospital Mohamed V of Rabat) [30].

Because of the lack of epidemiological surveillance systems of SSI in Tunisia, only few studies of incidence have been carried out in some academic institutions in the east of the country, while, no investigation has been carried out in the interior of the country.

In Tunisia, our rate was higher compared to that found at the Charles Nicolle Hospital of Tunis in 2000 (5.6%) but much lower than that found at the Farhat Hached Hospital of Sousse which revealed a rate of incidence in digestive surgery of 21.8% in 2002 [31, 32].

FIGURE 1: Distribution of SSIs according to the depth of the infection



At the Sahloul Hospital of Sousse two surveys of incidence have been carried out in the general surgery department in 2003 and 2006. They have concluded at a rate of respectively 3.4% and 7.4%. Hence, there was a continued increase in the rate of SSIs in our facility, which must push to review, monitor and improve the prevention measures initiated in our hospital, which seemed to be insufficient [33, 34].

Regarding the depth of infections, our results lined with those reported by many other studies [4, 11, 35-37].

Our findings regarding bacteriological results are consistent with those of studies carried out in Morocco, Algeria, Tunisia, Japan, and United States [25, 29, 30, 36, 38].

An extended length of preoperative stay and risk index NNIS superior to one were the independent risk factors for SSI in our study.

The extended duration of surgical intervention, a class of contamination three and four, the presence of an anaemia, the presence of drain, a bad preparation of patients and an extended preoperative length of stay were identified as risk factors of SSI in one study [27].

Another study has identified the following factors: co-morbidity, the extreme age, a high NNIS index and the complexity of the intervention. In addition, the diabetes was considered as risk factors in a multivariate analysis as well as an extended duration of the intervention [39].

The extended length of preoperative stay is not negligible, due to the change in the microbial flora of the skin and digestive tract at three to four days of hospitalization, the increasing frequency of complications of supine, and the frequency of invasive explorations and treatments during this period [40].

In Morocco, the risk factors of the SSI found were: the emergency surgery, the age, the ASA score, the class of contamination of Altemeier, the type of intervention and the its duration [30]. The NNIS index established by the developed countries must be adjusted in order to be applied in developing countries [41].

Present study has a number of limitations. We did not include enough infected patients and our study was single centre. Thus, the results should not be generalized to other settings.

CONCLUSION

In present study, SSI rate was found to be within the upper international limits. This confirms the need for more efficient programs to decrease the SSIs rate since this complication increases hospitalization costs and length of stay, and impairs patient's quality of life. Surveillance allows for identification of key factors that can be targeted as benchmarks for improvement. Hence, among means of prevention, aside from ongoing surveillance, identification and control of known risk factors, has proven to be an independent factor for long term reduction of SSI rates.

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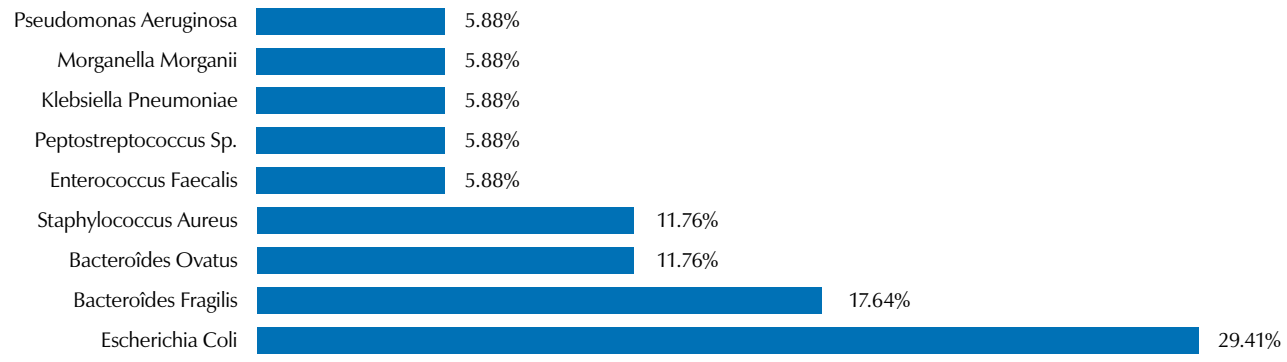
FIGURE 2: Distribution of SSI culture isolates



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ORIGINAL ARTICLE

Practice and compliance of essential handwashing among healthcare workers at a regional referral hospital in Uganda: A quality improvement and evidence-based practice

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ABSTRACT

Introduction: Hospital acquired infections (HAI) are a global public health problem. Improper hand hygiene (HH) practices serve as means of infection transmission in hospital wards and proper HH is the single most important means of reducing HAI. The WHO recommends five moments of HH, creating the pillars for effective HH.

Objectives: To assess the availability and suitability of essential hand washing facilities, assess essential hand washing practice and compliance among healthcare workers (HCWs) on surgical and medical ED, ICU, medical and surgical general wards.

Methods: A descriptive cross-sectional design was employed. HCWs providing care to patients admitted on the selected wards were recruited. Data were collected by trained research assistants (RAs) from participants who fulfilled the eligibility criteria using a checklist for HH facilities and HH observation checklist. Data were analysed using SPSS.

Results: Most of the wards had inadequate HH resources. The sink to bed ratio ranged from 1:1 to 1:33. HH resources were not always available. A total of 287 HH opportunities were observed from the five wards. The overall HH compliance before and after patient contact were 25.4% and 33.8% respectively. ANOVA showed ICU had significantly higher rates of HH than surgical ward before and after patient contact. HCWs in ICU and surgical emergency were 4.86 and 3.12 times respectively more likely to perform HH as compared to medical ward. No significant difference in HH compliance among professional categories before or after patient contact was detected.

Recommendations: The low rates of HH compliance reflect the need to put more emphasis on HH for improvement in the healthcare setting.

KEY WORDS:
Essential handwashing, practice, compliance, healthcare workers.

INTRODUCTION

Hand hygiene (HH) is a cornerstone in the prevention of hospital acquired infection (HAI) (Gordis, 2014). It has been noted that at least 25% of all infections of hospitalised patients in the developing world are health care associated (Sax et al, 2009). Studies have shown that HH compliance rates in developed and developing countries rarely exceeded 50% (Mani, Shubangi, & Saini, 2010; Maxfield & Dull, 2011). The World Health Organisation (WHO, 2006) recommends five moments of HH during health care delivery as essential for safe patient care.

HH is instrumental in the management of critically ill patients in intensive care units (ICU) and high dependence areas in clinical care settings. Frequent interaction between the critically ill patients and healthcare workers facilitates transmission of microbes from the healthcare workers (HCWs) to the patients and vice versa. Qushmaq et al. (2008) affirmed that critically ill patients were highly susceptible to nosocomial infections due to their compromised immune status and the multiple invasive lines in place. Improper HH practices serve as means of infection transmission in hospital wards (Duckro et al., 2005; Riggs et al., 2007) and proper HH is an important means of reducing nosocomial infections in hospitals.

Studies conducted in developing countries show that the adherence rates to HH among HCWs are still low. A recent study conducted in two ophthalmic units in Uganda revealed that 79% of the HH opportunities were missed in hospital A as compared to 82% missed in hospital B (Mearkle et al., 2016). Most of the studies focusing on how HH is practiced had been done in developed countries, yet the impact of HAI is greater in developing countries. Reports of HAI prevalence are high at Mbarara Regional Referral Hospital (MRRH). Despite the devastating outcomes of HAI, it has been

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Competing interests: There were no competing interests.

TABLE 1: Hand hygiene facilities available					
Ward	**Sink to bed ratio**	**Proportion of availability of hand hygiene resources /%**			
		Water	Soap	Gloves	Alcohol gel
Surgical emergency	1:7	95	75	85	70
Medical emergency	1:11	95	70	80	60
ICU	1:1	100	85	100	100
Medical ward	1:20	75	50	70	45
Surgical ward	1:33	87.5	60	70	50

observed that HH practices among HCWs do not correspond with the recommended WHO HH guidelines. This study sought to assess the availability and suitability of HH facilities in medical and surgical emergency, ICU and medical and surgical general wards, and HCWs' practice and compliance with WHO recommended HH protocols at MRRH.

METHODOLOGY

The study was conducted at Mbarara Regional Referral Hospital in southwestern Uganda. The study was conducted in the five units that specifically treat critically ill patients: medical and surgical emergency (ED), ICU, and surgical and medical general wards.

The study employed a cross sectional design and involved HCWs who were providing care to patients admitted in the selected units.

Sample size was calculated using the a priori power analysis (Buchner et al., 2009). An a priori power analysis determined sample of 247 observations were required for logistic regression model to detect an odds ratio of 1.7 with $\alpha = 0.05$, actual power of 0.95 and a prevalence of the outcome 50%.

On each observational visit, two target patients were randomly selected using simple random numbers and all healthcare workers' contacts with the selected patients were observed until the required sample size was reached. In an attempt to minimise the limitation of HCWs altering their HH behaviour as a result of being observed, the research assistants made regular visits to the wards for two months prior to data collection to allow the HCWs to become familiar to their presence. The HCWs were blinded to the study objectives and observations were concealed. The staffs were only informed that there was a quality improvement and evidence based study going on and that they would be watched as they perform some procedures, but the exact procedure under observation remained concealed.

Observations were conducted using the WHO patient safety observation form to document HCWs hand hygiene practices.

Four research assistants (RA) were trained to assist in data collection. Three of these were postgraduate health care students who assisted in collecting observation data. The RAs collected data from the wards they were not working on to avoid interruption with ward work. The fourth was a nursing officer and was engaged in collecting data using the questionnaire. All the four RAs were supervised by the principal investigator. Observation data were collected in March and April 2017 over a period of six weeks including the weekends; covering all the shifts; morning, evening and night shifts, each lasting eight hours, in all the five sites of the study.

An inter-observer reliability study was undertaken to record concordance on clinician type, use of gloves, use of soap, use of alcohol-based hand gels and essential handwashing practice. The inter-observer reliability for all data items was excellent, with an average K of 0.95 (range 0.84–1.0). To ensure quality of data, standardized checklists were used. The collected data were checked for the completeness, accuracy, and clarity by

TABLE 2: Demographic characteristics of observation data (N = 287)	
Demographic characteristic	*n*(%)
Time of observation	
Day	166(57.8)
Evening	62(21.6)
Night	59(20.6)
Professional category observed	
Nurse	117(40.8)
Physician	111(38.7)
Others[†]	59(20.5)
Gender of HCW observed	
Male	143(49.8)
Female	144(50.8)
Ward	
Surgical emergency	63(22.0)
Medical emergency	45(15.7)
ICU	86(30.0)
Surgical ward	49(17.1)
Medical ward	44(15.2)

Others[†] including physiotherapists, medical clinical officers and orthopaedic officers

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TABLE 3: Practice of essential hand washing actions taken	
Hand Hygiene action taken	n(%)
Rinsing with water only	40(13.9)
Hand washing with soap and water	20(7.0)
Using alcohol based hand gel	55(19.2)
No HH action taken	172(59.9)
Donning gloves	
No gloves	119(41.5)
Same pair of gloves for more than one patient	46(16.0)
New pair of gloves	122(42.5)

the investigator. Appropriate measures were taken for ensuring completeness before data entry. Data cleanup and cross-checking were done before analysis.

STUDY FINDINGS

The five wards were surveyed for the availability of HH facilities including all examination rooms. HH facilities in changing rooms, tutorial rooms, store rooms and other rooms were not surveyed because these were considered inaccessible during provision of patient care. The available HH facilities are shown in Table 1. In this study availability of alcohol gel means that there was an alcohol dispenser at the nurses' station or the HCWs carried their own alcohol-based hand gel.

DEMOGRAPHIC CHARACTERISTICS OF OBSERVATION DATA

A total of 287 HH opportunities were observed from the five wards. Thirty percent of the HH opportunities were from the ICU given the nature of patients admitted there and the frequent contacts between HCWs and patients. Nurses had the most HH opportunities observed (n = 117, 40%). The gender of the HCWs for each opportunity observed were divided nearly evenly (females, n = 144, 50.8%; males, n = 143, 49.8%). Most of the observation (n = 166, 57.8%), occurred during the day, as shown in Table 2.

HAND HYGIENE COMPLIANCE

Hand hygiene compliance according to the ward/unit

Chi square test was used to determine if there were differences in the rates of compliance of HH on the different wards studied both before and after patient contact and the results are shown in Table 4.

The results show that there is a statistically significant difference in HH compliance between the wards before patient contact (χ^2 (4) = 18.54, p < .001, eta = .15) and after patient contact (χ^2 (4) = 13.63, p = .009, eta = .08). Fifteen percent (15%) and 8% of the variability in HH compliance before and after patient contact respectively can be explained by the ward. Post hoc tests using one-way ANOVA showed statistically significantly higher rates of HH in the ICU than observations from medical ward before patient contact (mean difference *0.282* (95% CI .07-05) p = .003) and after patient contact (mean difference .302 (95% CI .07-.54) p = .003). HCWs in ICU were more likely to perform HH than those on medical ward.

ASSESSING VARIATIONS IN ESSENTIAL HAND WASHING PRACTICE

To assess the likelihood to perform HH before patient conduct, we conducted a logistic regression analysis using ward and professional category as the predictor variables and HH

TABLE 4: Proportion of HH moments performed before and after patient (N = 287)		
Ward	Hand hygiene moments performed before patient contact %	Hand hygiene moments performed after patient contact %
Surgical emergency	28.6	31.7
Medical emergency	26.7	28.9
ICU	38.4	46.5
Medical ward	10.2	16.3
Surgical ward	11.4	36.4
Overall undifferentiated rate of Hand hygiene	25.4	33.8
Chi square value	χ^2(4) = 18.54, p = .001, eta = .15	χ^2(4) = 13.63, p = .009, eta = .08

TABLE 5: Variation in hand hygiene practice among wards and professional categories in comparison to the medical ward			
	Odds ratio	95% CI	*p* value
Ward			
Surgical emergency	3.12	1.06 – 9.18	0.039
Medical emergency	2.84	0.91 – 8.88	0.073
ICU	4.86	1.74 – 13.57	0.003
Surgical ward	0.89	0.24 – 3.29	0.857
Professional category			
Nurses	0.78	0.38 – 1.57	0.484
Physicians	0.83	0.41 – 1.69	0.614

before patient contact as the outcome variable. The results are displayed in Table 5.

The results from the above table show that HCWs in ICU were 4.86 times (95% CI = 1.74 – 13.57, $p = 0.003$) more likely to perform HH as compared to those on medical ward. HCWs on surgical emergency were 3.12 times (95% CI = 1.06 – 9.18, $p = 0.039$) more likely to perform HH before patient contact compared to those on medical ward. There was no statistically significant difference in the likelihood to perform HH before patient contact on medical emergency and medical ward ($p = 0.073$) and surgical ward ($p = 0.857$) as compared to medical ward.

HEALTH CARE WORKERS' COMPLIANCE TO ESSENTIAL HAND WASHING

Chi square test analysis indicated no statistically significant difference in compliance to essential hand washing among the different professional categories before (χ^2 *(2) =.50, p =.78*) and after patient contact (χ^2 *(2) =1.34, p =.5*) respectively. See Table 5.

DISCUSSION

The current study found great variability of the sink to bed ratio ranging from 1:1 to 1:33. The sink to bed ratio reflects availability and accessibility of the sinks and therefore affects hand washing practice during provision of health care. Inaccessible sinks therefore impede hand washing by HCWs. This is consistent with the findings of Devnani et al. (2010) who reported that inadequate number or inaccessible sinks as well as inconveniently placed sinks is a major barrier to effective handwashing. Whereas Vernon et al. (2003) reported that accessibility to the sink greatly improves hand washing compliance, Whitby and McLaws (2004) asserts that sink accessibility does not improve compliance. Although Squires *et al.* (2014) noted that a sink to bed ratio of not more than 1:4 is considered adequate in enhancing hand washing practice in between patients, the findings of this study maybe taken to be appropriate in the low resource settings such as MRRH given the resource limitations encountered in health care settings.

ESSENTIAL HANDWASHING PRACTICE AND COMPLIANCE

From the study findings, more observations of HH opportunities were from the ICU. This larger proportion was expected given the nature of patients admitted there and the frequent contacts between HCWs and patients.

Noteworthy, most observations (40.8%) were from nurses interacting with the patients, 38.7% were from physician interactions, and the remaining 20.5% occurred when other categories of health care providers including medical clinical officers, physiotherapists and orthopaedic officers provided direct patient care. The longer and more intense direct contact that nurses have as compared to other health care providers illustrate the nurses' critical need to comply with HH protocols. This is consistent with Chavali, Menon, and Shukla (2014) who noted that nurses had the highest number of contacts (75.4%), followed by allied healthcare workers (24.5%).

The majority of the observations were conducted during the day given the fact that majority of the health worker patient contacts are seen during the day in major ward rounds and other procedures. From the study findings some HH

TABLE 5: Health care workers' Compliance to hand hygiene		
Professional category	Compliance to hand hygiene before patient contact/%	Compliance to hand hygiene after patient contact/%
Nurses	23.9	31.6
Physician	25.2	37.8
Others	23.3	30.5
Chi square value	$\chi^2(2) = .50,\ p = .78$	$\chi^2(2) = 1.34,\ p = .5$

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moments did not meet WHO definition of HH (WHO, 2006) and therefore such opportunities were considered as missed opportunities, implying that 73.8% of the HH moments were missed opportunities. This could be attributed to the fact that the sinks bed ratio in most of the wards was inadequate on medical and surgical general wards respectively. The findings of this study concur with Mearkle et al. (2016) who noted that 79% and 82% of the HH opportunities were missed in two hospitals A and B respectively in their recent study conducted in two ophthalmic units in Uganda. This is consistent with studies that have revealed that the prevalence of HAI in resource limited settings are proportionately high as a result of infection prevention practices that are non-compliant with recognised standards set by the WHO (Werne & Dieckhaus, 2015). Similarly, Devnani et al. (2010) findings support the notion that insufficient or inconsistently positioned sinks, shortage of water and soap, and unavailability of hand towels reportedly hindered effective hand washing practice.

The largest proportion of the HH moments observed were performed using a new pair of gloves, 41.5% of the HH opportunities were performed with no gloves while 16% were performed with a pair of glove previously used on at least one other patient. The overall HH compliance was 25.4% before patient contact and 33.8% after patient contact. This is consistent with other studies that have shown that HH compliance rates even in developed countries rarely exceeded 50% (Mani, Shubangi, & Saini, 2010; Maxfield & Dull, 2011; Ott & French, 2009) with 50% in USA, 42% in Switzerland, and 32% in UK (Takahashi & Turale, 2010). Omuemu et al. (2013) noted that majority of the respondents washed hands after patient contact due to a significant perceived threat that missing the HH would increase their risk of contracting disease from the patients. This is further affirmed by the fact that the same pair of gloves would be used on more than one patient as seen in 41.5% of the HH moments observed.

HCWs from ICU were statistically more likely to perform HH than HCWs from surgical ward before patient contact. This may possibly be due to the staffing levels in these units and the motivation herein coupled with the influence of the greater sink to bed ratio in ICU of 1:1 as compared to 1:33 sink to bed ratio observed on surgical ward. Also, the other HH resources such as soap, water, gloves and alcohol gel were readily and always available in ICU as opposed to surgical ward.

This study found that there was no statistically significant difference in essential hand washing compliance between physicians and nurses. This is in agreement with the findings of Dredi et al. (2016) who reported that nurses and doctors were the same as far as HH practice and compliance were concerned. However, Hosseinialhashemi et al. (2015) reported that doctors showed a significantly higher rate of HH compliance than other groups of HCWs. Also, studies found 60.9% of the nurses compared to 33.3% of the residents used some form of HH after contact with patients or patient environments and the difference between the two groups was significant [$p = 0.04$] (Qushmaq et al., 2008). It was further affirmed that HH compliance is higher among the nurses compared to the physicians and other health workers (Akyol, 2007). The failure to realise the difference in HH compliance between nurses and physicians could be attributed to the fact that the hospital does not have a well-established HH culture and there are no HH audits done routinely.

CONCLUSION

Most of the wards had inadequate HH resources and the overall HH compliance was low. Although ICU had the highest rate of HH, it was still quite low despite the resources available.

LIMITATIONS

This study had a number of limitations: hard data collection tools were used especially for collecting observation information and this could have resulted into Hawthorne effect. However, this was minimised by RAs making regular visits to the wards for two months prior to data collection to allow the HCWs become familiar to their presence, the staffs were blinded to the study objectives and observations were concealed.

Non-participant observations were used to assess HH practice. As a result, we were not able to assess practice and compliance of all the five moments of HH. This study only assessed practice and compliance to HH before and after patient contact. There is need therefore to assess practice and compliance of HH regarding the other three moments of HH.

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QI IN IPAC

Changing ICU culture to reduce catheter-associated urinary tract infections

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ABSTRACT

Background: The presence of an indwelling urinary catheter predisposes a patient to a Catheter Associated Urinary Tract Infection. Each day a catheter is left in place, the patient risk for a CAUTI increases 5%. Many characteristics of a Level II Trauma Center ICU/IMCU contribute to the routine insertion of, and reluctance to remove, indwelling urinary catheters. The aim of this project was to decrease the patient harm of CAUTI incidence by focusing on a cultural transformation around the use of indwelling urinary catheters.

Methods: A core group of nursing staff, leadership, physicians and infection preventionists within the ICU/IMCU of a regional Level II Trauma Center in the state of Colorado led this quality improvement project. The goal of the project was to clarify appropriate indwelling urinary catheter indications for use, assess organizational and cultural influences and develop a support structure around CAUTI prevention using the Plan-Do-Study-Act model of Quality Improvement. The team also participated in the "On the CUSP: STOP CAUTI" initiative sponsored by the Colorado Hospital Association.

Results: At year-end 2015, infection prevention data demonstrated an 87.5% decrease in CAUTI from 2014, as well as a decrease in utilization of 9%. A zero CAUTI rate was sustained for 394 consecutive days from May 2015-May 2016. During daily multidisciplinary rounds, nurses are now reporting the plan for urinary catheter removal before the question is asked.

Conclusion: The deliberate layering of single interventions over an extended period of time allowed for the adoption of each intervention before moving on to the next. Nurses and other members of the healthcare team supported each other in adopting the interventions. Interventions included considering alternatives to indwelling urinary catheters, aseptically inserting catheters for appropriate criteria only, removing catheters as soon as possible, improved urine specimen collection practices and enhanced care and maintenance measures for critical care patients.

KEY WORDS:

Urinary tract infection, culture, ICU, healthcare associated, infection prevention, urinary catheter, CAUTI

INTRODUCTION

The presence of an indwelling urinary catheter predisposes a patient to a Catheter Associated Urinary Tract Infection. Each day a catheter is left in place, the patient risk for a CAUTI increases by 5%. Many characteristics of a Level II Trauma Center ICU/IMCU (need for rapid assessment, resuscitation and treatment) contribute to the routine insertion of, and reluctance to remove, indwelling urinary catheters.

The aim of this project was to decrease the patient harm of CAUTI incidence by focusing on a cultural transformation around the use of indwelling urinary catheters. CAUTI events and indwelling urinary catheter utilization rates are part of Infection Prevention surveillance and are reported monthly to the National Healthcare Safety Network (NHSN) (1). In 2014, the ICU/IMCU ended the year with eight CAUTIs and a 59% catheter utilization rate which was greater than one standard deviation above the mean when compared with like units in the NHSN database. The 2014 CAUTI rate, the outdated catheter utilization practice along with the healthcare system focus on HAI reduction precipitated the need to address CAUTI in the ICU/IMCU. In addition, ICU/IMCU was offered the opportunity to participate in the Colorado Hospital Association (CHA) sponsored "On the CUSP: STOP CAUTI" project which became the starting point for the focused work on CAUTI prevention (1).

A literature review clearly identified evidence based interventions for CAUTI prevention but did not as directly speak to addressing the unit culture as an integral component of sustainability (2). The improvement project was based on initiatives designed to transform the unit culture around catheter utilization. In doing so, the team anticipated not only that CAUTI rates would decrease, but that the changes would be sustainable.

Conflict of interest: No financial conflicts of interest to disclose.
Acknowledgement: We appreciate and recognize the invaluable contributions to this project provided by the critical care nursing team and physicians at Good Samaritan Medical Center. We also recognize the collaborative support provide by our SCL Health System partners in coordinating and facilitating additional resources.

METHODS

This community hospital has 234 beds with a 24-bed ICU/IMCU. The facility is certified as a Level II Trauma Center, Chest Pain and Primary Stroke Center. At any one time, the ICU/IMCU provides care to neurosurgical, trauma, pulmonary and complex medical patients.

For this quality improvement project, the team used several incremental cycles of the Plan, Do, Study, Act (PDSA) process for assessment, review and adoption of each change which provided the opportunity for the changes to build upon each other (1,3).

The following process changes were initiated:

- Urine specimen collections were only obtained from newly inserted catheters. Catheters in place longer than 48 hours were replaced and the specimen was collected from a new catheter to remove the potential confounding factor of catheter biofilm (4).
- Because the ICU/IMCU patients were often bed bound for extended periods, changes were implemented in catheter care practice, including every four-hour perineal care and cleaning of the indwelling urinary catheter with a chlorhexidine wipe every 12 hours (5,6).
- A straight catheterization or clean catch midstream urine sample were collected if the patient was voiding (7).
- Female urinals and a new male urinary device were ordered and placed in stock (7-9).
- Two RNs were required to be present during the insertion; one RN to insert the catheter and the second RN as the observer of sterile technique. Both were documented in the EMR (10).
- The option for "reflex" urine culture from a previously collected urinalysis specimen was eliminated; requiring an assessment of patient symptoms and a new urine specimen to be sent for culture if indicated (11).
- All care sites within our hospital system implemented the following process changes:
    - The CDC approved criteria for indwelling urinary catheter insertion were added to the insertion order in the electronic medical record (EMR) (4).
    - Evidence based practice protocols were developed for bladder scanning and a new nurse driven indwelling urinary catheter removal protocol (4,8,12). With the revised bladder scanning protocol we encouraged the use of straight catheterization for retention to decrease reinsertion of the indwelling urinary catheter (7,13,14).
- Following our safety culture behaviours of "make it easy to do the right thing", Administration funded the purchase of additional and replacement bladder scanners to make the equipment more available (1, 15).

Education was provided to the ICU team including nurses, physicians and Certified Nursing Assistants (CNA) regarding the changes in catheter care, appropriate utilization and alternatives to catheter placement. Catheters were assessed for appropriate indications daily in multidisciplinary rounds and goals were set for anticipated date of indwelling urinary catheter removal (9,10,15,16,17). Encouragement was provided for the use of other non-invasive catheter alternatives. Where appropriate, toileting schedules were considered as an alternative to catheter reinsertion.

Education was provided for all staff regarding indwelling urinary catheter insertion techniques via hands on demonstration to ensure consistency of practice. Education also included draining the catheter bag at 350 ml to 500 ml or every four hours and prior to patient transport, ambulation, or transfer (16,17). When necessary, 1:1 education to physicians and nurses was provided in real time to assist in the change of practice and culture by the CNS, Unit Manager and Infection Prevention (9).

To ensure consistency with CDC insertion criteria and placement technique, the project team worked with and encouraged our ED partners to delay indwelling urinary catheter placement until the patient was assessed in the ICU/IMCU (2,18).

Daily monitoring included assessment with the expectation that the nurse identifies the plan for indwelling urinary catheter removal during multidisciplinary rounds (19). The CNS or Charge RN maintained a log on each patient identifying the indication for the catheter, date inserted and the plan for removal to communicate the information between care givers (19). The unit manager and Clinical Nurse Specialist (CNS) monitored the insertion, removal and care components. CAUTI and device utilization was monitored by Infection Prevention.

The Critical Care physicians supported the ICU/IMCU nurses when requesting primary care physician removal of the indwelling urinary catheter if no valid indication for the Foley was found. This culture shift was slow to be accepted but with persistence the physician and nurses are now proactively removing catheters that do not meet CDC approved criteria.

It was important to us to reinforce the behavior change by celebrating early wins. Intentional recognition was both individual and unit wide. Outside of daily verbal reinforcement and recognition for adoption of new behaviours, we also had formal recognition (17).

Infection Prevention created "The Golden Foley" award to call attention to clinical staff that demonstrated early adoption to the culture change (Figure 1). The inaugural award went to a bedside ICU nurse who removed the urinary catheter of an intubated patient, and began early mobility by successfully using the bedside commode and a toileting schedule. She set the expectations for her peers to continue the process moving forward (17).

FIGURE 1: Recognition

Inaugural Golden Foley Award Winner | *Golden Foley Award* | *Capture CAUTI Award*

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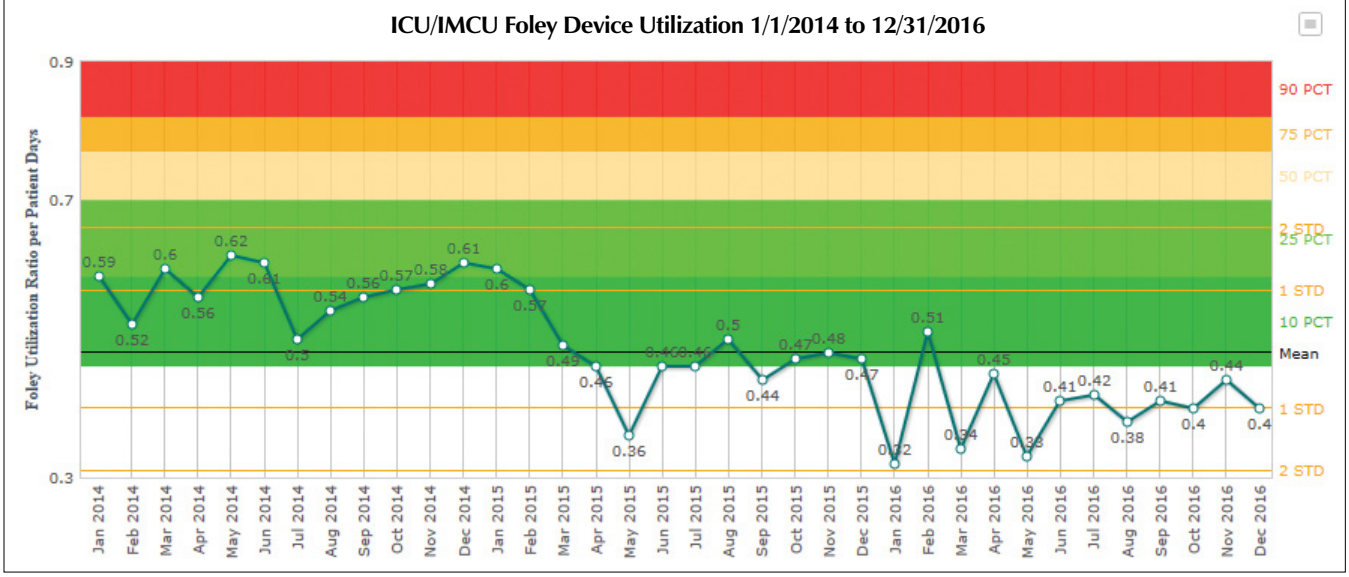
FIGURE 2: Foley Device Utilization Compared to NHSN Baseline



Infection Prevention also developed a "Capture CAUTI" award which was presented quarterly to the one unit within the hospital with the greatest decrease in Foley utilization and actual CAUTI events (Figure 1). ICU/IMCU received the inaugural and subsequent quarterly awards for 2015. After one year CAUTI free, the ICU/IMCU celebrated the accomplishment with" Zero" candy bars and a banner hung in the department recognizing the effectiveness of their hard work (17).

In addition to assessing the need for the Foley during daily interdisciplinary rounds, monthly review of Foley catheter days, CAUTIs and comparison against NHSN baselines were used to assess the impact of our interventions. Both were compared to NHSN baseline as well as historical ICU/IMCU data (Figures 2 and 3). Adherence to the new Foley and Perineal Care process was audited and reinforced with associates who were late adopters (10).

Statistical process control charts were used in the monitoring of device days and CAUTI events. The graphs and charts were examined visually by the project team and any qualitative or statistical deviations were noted and investigated. A statistically valid process shift was identified by month six in CAUTI events and device utilization.

RESULTS

Prior to the intervention, the 2014 Foley device utilization ratio (Foley days per 1,000 patient days) in the ICU/IMCU was 57%. After the implementation of our improvement process, Foley device utilization was 48% at year-end 2015. This represents an absolute decrease of 9% and a relative change in utilization of 15.78%. For the project period 2014-2016, we realized an overall absolute decrease in Foley utilization of 17% with a relative change of 29.82%, one standard deviation below the NHSN mean for similar facilities (Figure 2).

The ICU/IMCU project team demonstrated a decrease in the number of patients with an indwelling urinary catheter along with an increase in the utilization of external catheter devices (Figure 3).

FIGURE 3: ICU/IMCU Patients with a Foley and External Catheter 2014-2016

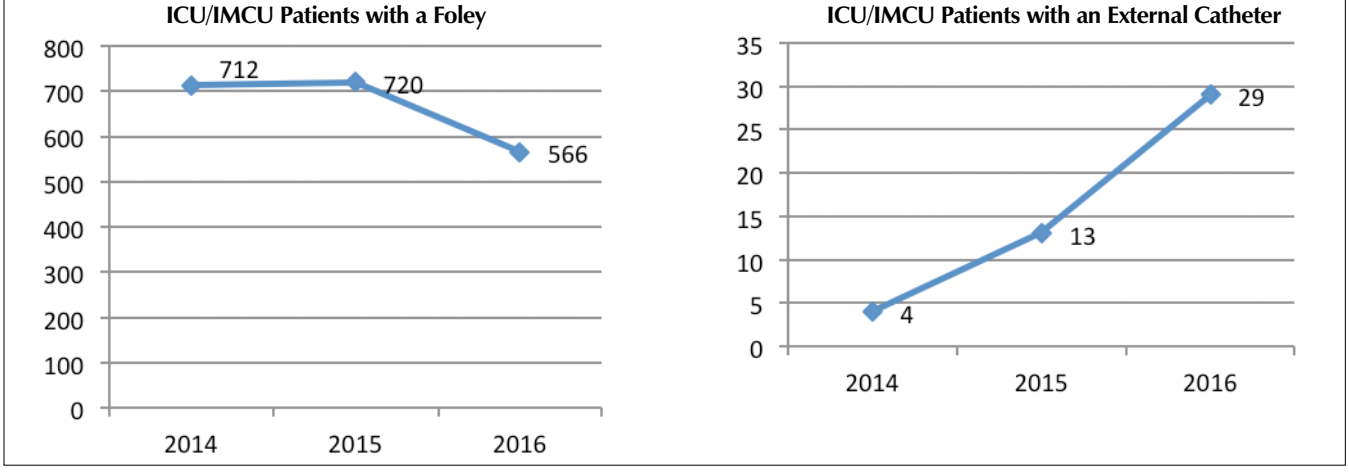
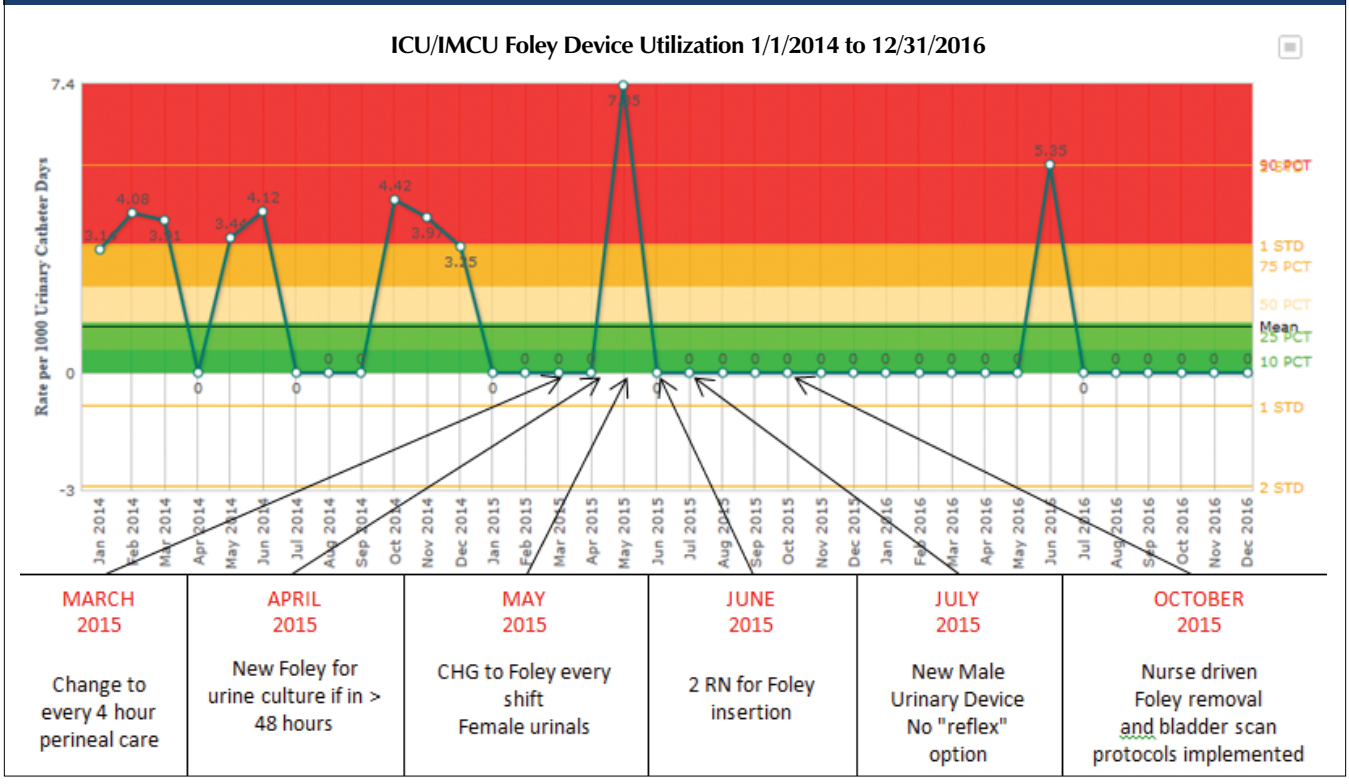


FIGURE 4: CAUTIs and 2015 Project Interventions



In 2014, ICU/IMCU had a total of 8 CAUTI. For 2015 and 2016 there was only one CAUTI identified per year. A zero CAUTI rate was sustained for 394 consecutive days from May 2015 – May 2016 (Figure 4).

Concerted effort was made to promote the process changes as a patient safety and continuous learning effort and negative or disciplinary actions were discouraged. Cultural acceptance of the change was demonstrated by bedside nursing personnel taking the initiative to challenge the status quo of routine Foley insertion for critical patients.

There were no conflicts of interest or formal ethical issues to review in this study. The seven CDC indications for Foley placement guided the insertion and removal process. For example, if a patient was placed on comfort care or hospice while catheterized they were still monitored but no aggressive attempts were made to promote Foley removal.

All patients in the ICU/IMCU that were catheterized from 1/1/2015 – 12/31/2016 were included in the study. In January of 2015, initial interventions began with focusing on appropriate insertion, consideration of alternatives and early removal hypothesizing that a decrease in utilization coupled with an increased focus on proper care and maintenance would result in a decrease in CAUTI events.

DISCUSSION

In conclusion, our improvement project demonstrated a reduction in harm to the ICU/IMCU patient while establishing best practice with indwelling urinary catheter for CAUTI prevention.

In comparison to the several other studies reviewed prior to implementing our project, we also experienced a significant reduction in Foley utilization and a corresponding decrease in CAUTI events. However, none of the other studies addressed a shift in unit culture as a specific focus in their project. As with any culture change, time plays a crucial role in sustaining the adjustment of behavior. In our study, the adoption of culture change with Foley utilization was setting the stage to use evidence-based practice and incorporate this evidence into our standard daily work.

With a concentrated effort, these interventions could be applied to other patient care areas while paying particular attention to the prevailing unit culture. The deliberate layering of single interventions over an extended period of time allowed for the acceptance, reinforcement and adoption of each intervention before moving on to the next change. This led to the shift in unit culture as our end result. By the end of our intervention cycle, nurses began reporting the plan for urinary catheter removal before the question was even asked in multidisciplinary rounds.

The authors do acknowledge that the limitations to this project include the sustainability of the process changes implemented. The success in sustaining a culture change was due in part to having consistent staffing models of both physicians and nursing personnel. Once educated and engaged, a consistent staff can reinforce and support the preferred culture with each other and new staff. The authors also recognize an additional limitation in the fact that NHSN surveillance criteria for CAUTI were revised in 2015 eliminating yeast as a pathogen

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that could be assigned to a CAUTI event. Only one of the eight CAUTI events in 2014 had yeast as the pathogen.

To sustain the level of change achieved one must continually revisit the intervention steps. Attention must also be given to stay abreast of current evidence based practice, new products and mindful onboarding of new providers and clinicians.

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EMERGING TECHNOLOGIES

UV-C light and infection rate in a long term care ventilator unit

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ABSTRACT

Background: This six-month study examined the effect of continuous ultraviolet radiation (UV-C) at the room level on incidence of healthcare-associated infection (HAI). The study, conducted in a long-term care ventilator unit, counted each antibiotic start as an infection. The primary outcome measure was infection rate, calculated as infections/1000 patient days.

Methods: Eighty-six patients were admitted from September 2015 to February 2016. Study inclusion criteria were admission to the unit, full-time mechanical ventilation and age > 18 years. One wing of the ward had two shielded UV-C units installed per patient room (VidaShield™; American Green Technology, South Bend, IN). An adjacent wing without UV-C units was the control.

Results: The overall infection rate was significantly lower in rooms with UV-C units than in those without: 12.5±-2.12 vs. 17.5±-2.81 $p=0.022$.

Conclusion: Findings suggest that continuous exposure to UV-C treated air reduces HAI. Shielded UV-C units in patient rooms may be an effective non-staff intervention dependent method for reducing HAI.

KEY WORDS:
UV-C, HAI, air purification, infection control

INTRODUCTION

The morbidity, mortality, and financial cost of healthcare-associated infection (HAI) is well established. Hospitals are penalized financially for 30-day readmissions of patients with an HAI (1). Patients in skilled nursing facilities, especially ventilator units, are at continued risk for HAI, and these facilities will also soon be penalized for readmissions (2).

HAI management and prevention efforts are complicated by the emergence and persistence of multiple drug resistant organisms (MDROs). Some of the most common MRDOs include vancomycin-resistant enterococcus (VRE), methicillin resistant *Staphylococcus Aureus* (MRSA), and *Acinetobacter*. *Clostridium difficile* (*C. difficile*) is also a significant HAI.

In an effort to improve and extend standard infection control measures, many healthcare facilities are adding germicidal ultraviolet (UV-C) lights. It is clear that UV-C can reduce circulating pathogens. But how best to deliver the UV-C? Direct prolonged exposure to UV light is unacceptable because of the known deleterious biologic effects (3, 4). The mobile emitters (the so-called robots) have been limited to room exposure when patient rooms are vacated, which can be problematical in areas such as an ICU, or a long-term ventilator unit with double-bedded rooms, such as in our study, where empty patient rooms are uncommon.

Rooms treated with mobile UV-C emitters do show reduced bacterial surface colony counts, (5) but use of the emitter depends on initial cost, its availability, the allotted time between patients, the need for staff initiative, and an unoccupied space. Our study was designed to determine if the use of continuous, shielded UV-C lights that treat and recirculate patient room air could have an impact on infection rates. A long-term care ventilator unit was chosen because it is an environment with comparatively high infection rates, particularly MDRO and *C. difficile*.

Many of the common HAIs, such as *C. difficile* and MRSA, are considered contact transmissible. However, Best et al. reported that air and sample cultures were positive for *C. difficile* in 60% of hospital rooms where patients had symptomatic *C. difficile* infections. In other words, *C. difficile* can be suspended in air, and from there can settle onto surfaces (6). Surface bound bacteria may become intermittently airborne when surfaces are agitated. The frequent movement of bed sheets would be an example, as Shiomori et al. demonstrated (7). We wondered what impact cleaning the air with UV-C might have on HAIs, including those generally considered to be contact transmissible.

Acknowledgements: UV-C units were provided by American Green Technology, South Bend, IN. Manuscript preparation support was done by Diane Laux Communications, Chicago, IL. Dr. Kane was contracted by Eventa LLC to perform the study. Ms. Finley and Ms. Brown have no conflicts of interest to report.

METHODS

This study was completed at a long-term care ventilator unit in southern Tennessee from September 2015 through February 2016. Patient inclusion criteria were admission to the ward, receiving full-time mechanical ventilation and age greater than 18 years. Patients were assigned to rooms based on availability. Eighty-six patients were admitted during the study period: 40 to the UV-C wing and 46 to the control wing. Six months of retrospective infection rate data (January 2015 – June 2015) was examined to ensure consistency and understand any variability over time.

The physical layout of the ventilator unit comprised multiple wings. In one wing, all rooms had UV-C units installed. This included 18 patient rooms, 5 shared patient bathrooms, the hallway, and a respiratory therapy utility room. An adjacent wing of 17 patient rooms had no UV-C units, and served as the control. Thirty-three of the 35 rooms in the study were double occupancy, typical for this type of facility.

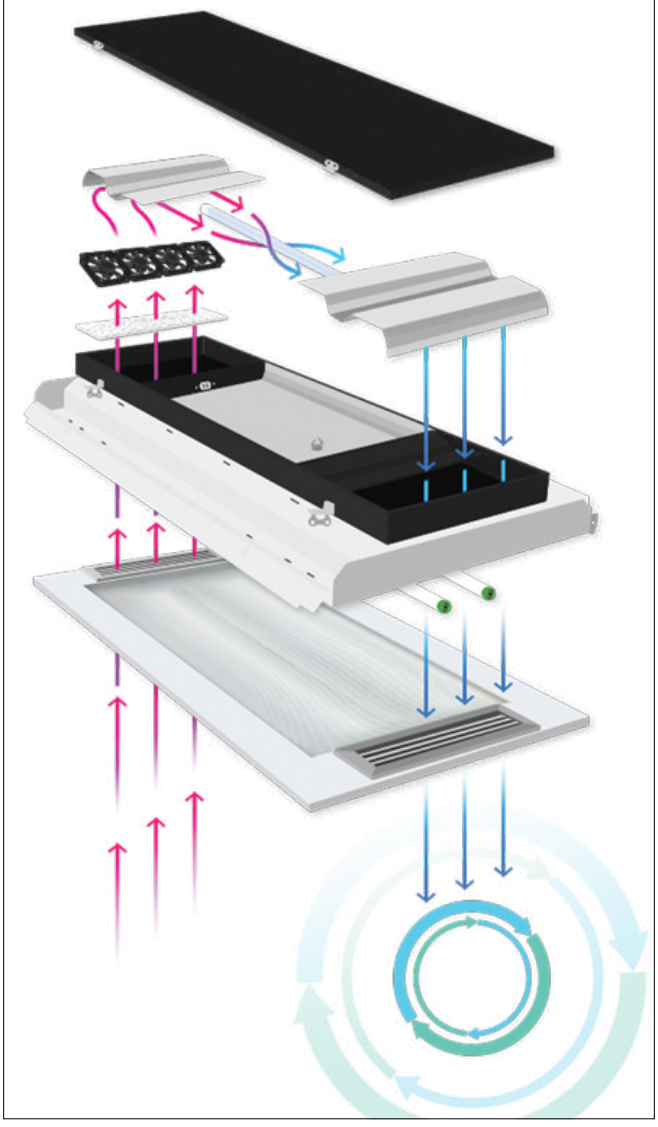
Facility staff had established housekeeping protocols for occupied patient rooms and terminal cleaning procedures upon patient discharge. They had no protocol to clean and treat the air. Because operations personnel did not have a program to validate ASHRAE air exchanges and percent air recirculation, all air in the patient unit was treated, and not just the patient rooms. Air moves freely among patient areas. Families and other visitors use patient bathrooms and leave the doors open afterwards. The hallways are consistently exchanging air with other areas, including air from outside the building. The UV-C units were installed in the biohazard room to reduce odors on the units and lessen circulating bacteria and fungus.

Two UV-C units (VidaShield™; American Green Technology, South Bend, IN) were installed in each room of one wing. The number of units was determined by room size and existing layout. One unit was installed over each patient bed. Each unit contained a fully shielded UV-C bulb. A 59 watt shielded UV lamp produced 15 watts of high output ultraviolet-C energy at a wavelength of 253.7 nanometers. Because the radiation chamber where the UV lamp is housed is enclosed and the air passes through the chamber, there is little to no distance from the lamp to the air that passes directly over the lamp. At its furthest point, the span is 6 inches. Each unit holds four small fans to create differential pressure that continuously draw air into the system at 50 cubic feet per minute. On the way to the irradiation chamber the air passes through a MERV 6 filter to remove dust and large particulates and then, once treated, the cleaned air is pushed back into the room. The intake and exhaust baffles are set at a 30 degree angle, which moves the air in a pattern that avoids repeatedly recirculating the same air (Figure 1).

The UV-C portion of the units run continuously, 24/7. There is no visible evidence of the units once they are installed, and attending physicians were not informed which wing had UV-C units installed. Clinical behaviour and decision-making were not changed in any way.

In general, an infection was counted when an antibiotic was ordered, based on patient symptoms and suspicion of a nosocomial infection. Infection site and culture results were recorded. Antibiotic orders changed within three days based on culture results or suspected lack of response were not counted as new infections. Infections within 48 hours of admission were excluded as were infections where treatment was initiated by the transferring acute care facility. Multiple infections noted at one time were counted as a single infection. Also, if a given infection required multiple antibiotics to treat it, only one infection was recorded. The type of organism was recorded.

FIGURE 1: UV-C unit



In our study, antibiotics were initiated in 99 suspected infection episodes. Of these 99, 24% were culture negative. Culture-negative infections are not uncommon. De Prost et al. reported a culture-negative sepsis rate of 40-60% for 1001 ICU admissions meeting a severe sepsis criteria (8). In a three-year study by Labelle et al., culture-negative pneumonia occurred in up to 34% of patients with healthcare-associated pneumonia (9). These studies indicate that infection can indeed be present despite negative cultures.

TABLE 1: Infection rate as number of infections per 1000 patient days

	UV-C Group				Control Group			
Month/ Year	Patient Days	Average Census	Infection (N)	Infection Rate	Patient Days	Average Census	Infection (N)	Infection Rate
Sept 15	540	18	9	16.7	510	17	13	25.5
Oct 15	660	22	11	16.7	589	19	11	18.7
Nov 15	600	20	10	16.7	551	19	14	25
Dec 15	480	16	6	12.5	372	12	5	13.7
Jan 16	527	17	3	5.7	580	20	8	13.8
Feb 16	620	20	4	6.5	620	20	5	8.1
TOTALS	3427	113	43	74.8	3222	107	56	104.8
AVERAGE	571.2	18.8	6.67	12.5	537	17.2	10	17.5

Infection rate is reported as the number of infections per 1000 patient days. Gender, age, liberation from mechanical ventilation, discharge disposition including site where deaths occurred, and readmission to an acute care facility are reported in percentage. MDRO and *C. difficile* infections are expressed as instances of infection for all patients in both groups.

A significance level of $p<0.05$ was used for all statistics. The paired t-test was applied for comparison of overall infection rates between groups. For MDRO comparisons, the Fisher's exact test was used to account for the small sample size. The Chi-square test was used for comparison of positive culture results between groups for all identified pathogens, discharge disposition, and weaning rates.

RESULTS

The overall infection rate was significantly less in patient rooms with shielded UV-C units where the rate was 12.5±-2.12 vs. the control group's rate of 17.5±-2.81 $p=0.022$, CI 1.075-8.925. The infection rate for each group was calculated as the number of infections per 1000 patient days in that wing.

Retrospective analysis of infection rates for six months prior to the study shows the infection rate during the study was not significantly different from the rate before the study ($p=0.57$). This data is shown in Table 2.

The type of infection-causing organisms were tracked, and results for four common HAIs (*Acinetobacter*, MRSA, VRE, and *C. difficile*) showed that the UV-C group had fewer MRDOs and *C. difficile* infections than did the control group, but levels did not reach statistical significance because the difference between the UV-C wing and the control wing was too small relative to total sample size. If the proportions remained constant, the results for MRSA would become significant ($p>.05$) when the sample size reached 207. This data set, at a sample size of 81, is underpowered.

Although it was not possible to truly randomize the groups (because beds were assigned based on availability), the two groups were similar in age and gender. In the UV-C group, the average age was 61, with 57% males and 43% females. The control group was moderately younger, with an average age of 53, and a gender division of 60% males and 40% females.

Weaning rates from mechanical ventilation were similar for both groups, with 16 in the UV-C group and 17 in the control group. Discharge dispositions, as shown in Table 3, demonstrate that significantly more patients in the UV-C wing were discharged home ($p=0.01$).

DISCUSSION

HAIs present a significant challenge for healthcare facilities because they result in increased morbidity, mortality, and cost. The Centers for Disease Control and Prevention report that on any given day, about 1 in 25 patients has an HAI. A 2014 study showed approximately 75,000 patients die annually resultant to an HAI. (10) Marchetti, in 2013, estimated HAIs cost $96-$147 billion annually (11). It is an enormous problem.

The presence of these dangerous microorganisms has generated increased isolation efforts, glove and gown diligence, terminal cleaning of rooms, and other infection prevention and control policies.

Using gloves, gown, mask and handwashing can reduce pathogen transmission, but compliance is often poor. McGuckin et al. reported that with education and feedback, hand hygiene compliance for ICUs rose from 26% to 37%, and for non-ICUs from 36% to 51% (12). Essentially, healthcare workers are cleaning their hands as they ought half the time or less. Gershon et al. used a confidential questionnaire of more than 1700 hospital-based healthcare workers regarding compliance with universal precautions. They reported overall compliance rates below 30% (13).

The reality is that facilities often do not benefit from this inexpensive and effective infection control method. This suggests that potential benefits of an infection prevention or control method may not be obtained unless the method is independent of worker initiation.

Healthcare facilities have begun to show interest in adapting the germicidal effects of UV-C as an adjunct to existing strategies. UV-C works against microorganisms by damaging the

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TABLE 2: Infection rate as number of infections per 1000 patient days, baseline vs. control		
Month	**Pre-study Infection Rate**	**Study Infection Rate (Control Group)**
1	13.1	25.5
2	19.0	18.7
3	17.2	25.0
4	13.3	13.7
5	20.8	13.8
6	9.7	8.1
TOTALS	93.1	104.8
AVERAGE	15.5	17.5

cells so they cannot reproduce. Many studies have shown the effectiveness of UV-C against pathogens, including mitigating TB transmission in a homeless shelter (14), using it specifically against *C. difficile,* VRE, and *Acinetobacter* (15) and also against influenza (16). The germicidal capabilities of UV-C are clear.

Healthcare facilities have adopted UV-C in a variety of ways. One way is with an automated UV-C emitter. Anderson et al. demonstrated that colony counts for VRE, *Acinetobacter* spp. and *C. difficile* are significantly reduced by this technology (15). In a retrospective study, Haas et al. reported using UV-C produced a 20% reduction in the rate of MRDO and *C. difficile* infections in a 643 bed tertiary care academic medical center (17).

The emitter, however, can't be used in occupied space because unshielded UV-C can damage skin and eyes (3). Nardell et al. showed the safety of upper room UV-C (4). The units in our study are more completely shielded than the ones Nardell discussed; people are safe in spaces where and when the units are operating.

UV-C is not a substitute for universal precautions or room cleaning. Memarzadeh et al. considered UV-C in various forms to be effective, but best used as part of a larger plan of disinfection (18). If emitters used during terminal cleaning truly result in the 20-34% reductions in HAIs reported by Anderson et al. (15) and Napolitano et al. (19) it would be of value to know if combining using the emitter with continuous UV-C at the room level would yield an even greater impact.

Maintenance on the UV-C units is minimal: replacing the MERV-6 filter quarterly and the UV-C bulb annually. This is typically done by regular facility maintenance staff without special tools or training.

The UV-C light units were in patient rooms, hallway, bathrooms, and the respiratory therapy workroom and operated 24 hours/day. We cannot verify to what degree each of these contributed to the results.

The reduced comparative infection rate in our study included all sites. Most common infections were urinary tract and respiratory. The likelihood that the shielded UV-C light units had a positive effect on infection rate in our study for organisms not generally thought to cause infection via airborne transmission suggests the possibility that cleaning the air can help reduce surface contamination.

Patients were admitted to rooms based on availability but this is not formal randomization. Study limitations include this lack of true randomization, inclusion based on need for continued mechanical ventilation without consideration for comorbidities, and lack of a standardized method for diagnosing and verifying infection. Further study with larger randomized controlled trials is needed. The study might have benefitted from a longer timeframe, which would have provided a greater patient population and thus more data points. Also, for the retrospective data collection (six months before study launch), it was not possible to determine infection rates in the rooms later selected to UV-C light installation. However, all ventilator rooms were

TABLE 3: Patient discharge disposition			
Discharge Disposition	**UV-C Group N (%)**	**Control Group N (%)**	***p* value**
Home	19 (45)	9 (19.6)	0.01
Death in the vent unit	5 (12)	2 (4.4)	0.24
Death in the hospital	1 (2.3)	1 (2.2)	1.00
Transfer off vent unit	2 (5)	2 (4.4)	1.00
Hospital readmission	4 (9.5)	1 (2.2)	0.18
Hospice	2 (4.8)	0 (0)	0.21

considered equal in terms of the admissions process, patient acuity, and staffing.

The study occurred in a long-term care ventilator facility where all care behaviours and methods proceeded unaltered by the study in order to observe the effects of continuous UV-C on HAI in a real life setting. In units like ours, where rooms are rarely vacant and using an emitter presents some challenges, our results suggest that shielded upper room UV-C in use 24/7 reduces the rate of HAIs including those caused by common MDROs and C. *difficile*. Healthcare facilities may want to consider adding this non-staff dependent infection control method to their infection prevention and control protocols.

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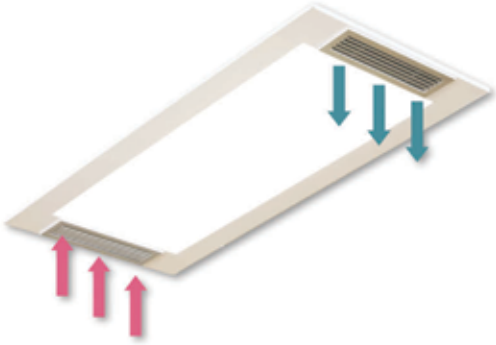

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IPAC PRACTICE

Tuberculosis exposure in an oncology clinic and hospital environment: Not all exposures are equal

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KEY WORDS
TB, healthcare, contact investigation

BACKGROUND

A. Index Case Description

A 57-year-old patient was diagnosed with pulmonary tuberculosis while undergoing routine treatment for metastatic neural endocrine cancer of the gastro-intestinal tract at a 495-bed, university-affiliated medical center. TB infection in this patient was undiagnosed for several weeks. The patient did not have any hemoptysis but had weight loss, cough and shortness of breath. Her clinical presentation and chest X-rays findings were suspected to be related to her metastatic cancer. The chest X ray revealed left upper and lower lobe cavitation. CT scan of the chest confirmed the cavitation with multiple nodules and enlarged mediastinal adenopathy. Abdominal CT revealed multiple hepatic metastases. The serial imaging was suspicious of advancing metastatic cancer. Consequently, other hospital patients in the oncology, radiology and emergency outpatient departments were exposed to TB. In response to this exposure, the Infection Prevention (IP) department conducted a TB contact investigation. **Figure 1** summarizes the timeline of the index case at the hospital. By September 21, 2015 all three sputum smears had returned from the laboratory as positive and treatment for *Mycobacterium tuberculosis (*MTB) was initiated. The patient was discharged home on September 23 after a brief in-patient stay. Her cultures were confirmed as pan susceptible MTB.

B. Contact Investigation & Need for Follow-up

The infection control department initiated a contact investigation after TB diagnosis was confirmed. A review of each patient contact using both inpatient and outpatient records from Aug. 4 till Sept. 16, 2015 was conducted. We collected exposed patients' demographics, comorbidities and risk factors to provide further insight into this cohort. The rate of TST compliance among patient contacts can provide insight into the effectiveness of the current contact notification methodology and determine if new methods should be adopted to improve outcomes.

C. Algorithm Development

There was no comprehensive TB contact investigation algorithm available for use within the study hospital system. The development of an algorithm for use by professional infection control practitioners and clinicians as a guide in future exposure was urgently needed to streamline contact investigation processes and ensure all appropriate actions are implemented to protect the health of patients and staff alike.

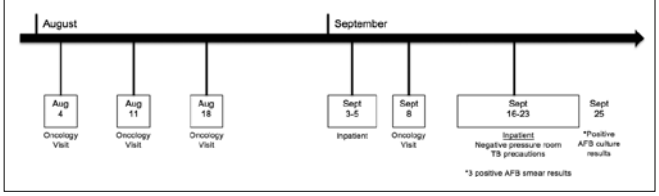
D. Background Information

Post-exposure clinical outcome

Exposure to *MTB* results in one of these outcomes: no infection, latent tuberculosis infection (LTBI), or direct progression to active disease. Spread of *MTB* is strongly related to positive *MTB* smears, cavitary lesions and the presence of cough, which occurs in subset of active TB cases but not LTBI. Immune compromised individuals with LTBI are at higher risk for developing active TB than general population (1,2). Direct progression after exposure to active disease is possible with prolonged exposure especially in immune suppressed individuals (HIV-AIDS specifically).

Conflict of interest: There was no financial support for this project.
Acknowledgement: This work was accepted as a poster presentation at national Association of Professionals in Infection Control (APIC) conference in June 2017.

FIGURE 1: Timeline of the Index Patient at the Hospital Before Diagnosis



Tuberculosis transmission in hospital settings

The World Health Organization (WHO), states that health care workers (HCW) have a 7-10 times incidence of TB infection compared to general population (3,4). Nosocomial TB is a significant risk for healthcare workers (HCW) and patients, alike (5,6). This risk certainly varies depending on the prevalence of TB in the geographic area as well as in outbreak vs. endemic conditions. TB contact investigation is an effective epidemiological method focused on breaking the chain of infection transmission. Early detection of exposed individuals using LTBI methods Tuberculin skin test (TST) or Interferon Gamma release assay (IGRA) and offering LTBI therapy is very effective in preventing active TB.

METHODS

This is an observational epidemiological study describing and analyzing a TB contact investigation that was conducted at a 495-bed health care facility (that includes an outpatient Oncology Center). The institutional review board (IRB) of the university medical system approved this project as a quality improvement study (Project ID: 682). The researchers were required to have a *Health Insurance Portability and Accountability Act* (HIPAA) agreement to maintain confidentially of any records reviewed for this study.

Contact Investigation Description

In this event, Infection Control and Employee Health Departments monitored all patients and HCWs who were potentially exposed. A list of patient's contacts was compiled by acquiring patient visitation logs according to date from the oncology, radiology and emergency departments. Exposure periods were set based on the index patient's appointment times. All those seen in the Oncology, Radiology and Emergency departments within one hour time-frame before or after the index patient's appointment in the waiting and treatment rooms were considered as contacts. Based on these criteria, infection preventionists (IP) identified potential exposure of 142 patients and 60 HCW. IP contacted all exposed patients with a notification letter sent via certified mail. The letter informed contacts about the potential exposure to TB and advised them to see their primary care physician for TST testing. On October 13, 2015, IP sent all notification letters to patient contacts, 18 days after confirmation that the index case was culture positive.

TST was performed once as it was performed at least eight weeks after exposure. The exposed patients' charts were reviewed for; age, gender, race, zip code, height, weight, BMI, exposed visitation date(s), reason for visit(s), hospital location, discharge diagnoses, Charlson Comorbidity Score (17), returned notification letter, completion of TST test, results of TST test, completion of chest X-ray, diagnosed with HIV and smoking status.

Data analysis was performed using Stata/SE 12.1. Summary and descriptive statistics are given for patient demographics and testing performed. Frequency and percentage are presented for categorical variables, including race/ethnicity, gender, TST testing and TST results. The mean is presented for continuous variables, including age, BMI and Charlson Comorbidity Index score.

RESULTS

A. Contact Investigation Results

A total of 202 individuals were identified as potential contacts. IP and Employee Health identified 142 patients 60 HCW. IP contacted 84.5% (n=120) of all patient contacts successfully; 15.5% (n=22) of the patient contacts were lost to follow up; 20 patient letters were undeliverable/returned to sender and two individuals died prior to the start of exposure notifications. The cause of death was not related to TB exposure.

Of the 120 patients successfully notified, 32.5% (n=39) completed TST testing and the remaining 67.5% (n=81) of patients did not respond. 71.8% (n=28) of patients who complied with the recommended testing had negative TST results and required no further follow-up. 20.5% (n=8) of patients who underwent TST had no results recorded in their electronic chart. We reviewed all outpatient and inpatient electronic records using their perspective software. The remaining 7.7% of test compliant patients (n=3) had positive TST results. The three patients were referred to the Infectious Disease Clinic. Upon further evaluation, all three patients were confirmed to have latent tuberculosis infection (LTBI) from previous exposures and were not a result of the recent nosocomial exposure. One patient described having a positive TST years ago, but we did not have the records. The second patient was born in China in 1952 and describes having BCG vaccination and positive TST previously. The third patient had a reaction (erythema rather than induration) was suspected to be false positive and interferon gamma release assay was negative.

Employee Health identified 60 staff members from the following departments: cancer center, radiology, emergency medicine, phlebotomy, environmental services, dietary and CT scan. All healthcare workers had a negative TST base line and the Employee Health Department confirmed there were no conversions due to the TB exposure. The results of the contact investigation conducted are depicted in **Figure 2**.

B. Patient Demographics

The mean age of the patient population is 55.1 years. The patient population has a mean BMI of 29.3; this puts the average individual at the border of overweight and obese. The mean Charlson Comorbidity Index is 4.2; this shows that this is a sick population facing numerous chronic conditions. Males represent 45.8% and females represent 54.2% of the patient population. The race/ethnicity composition of the exposed population is as follows: 16.2% African American, 81.7% white, 0.7% Asian and 1.4% not listed. Additionally, Oncology patients (n=67) represented 47% of the patient exposures.

FIGURE 2: Contact Investigation Results

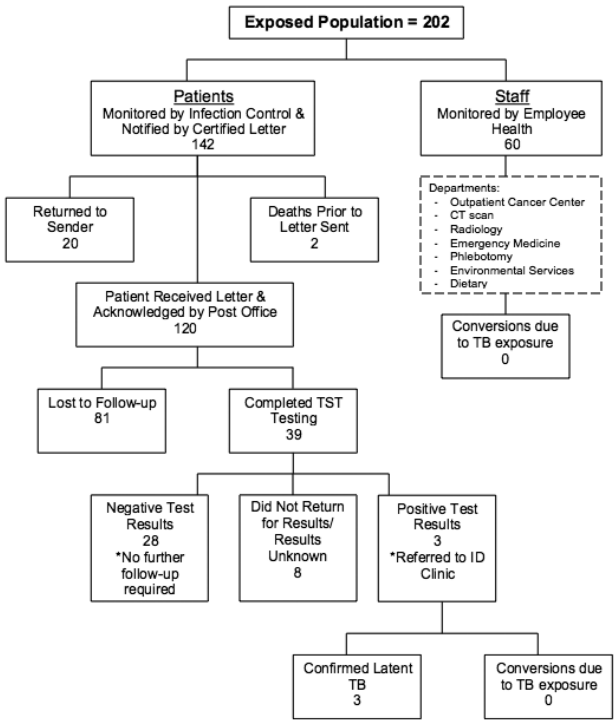
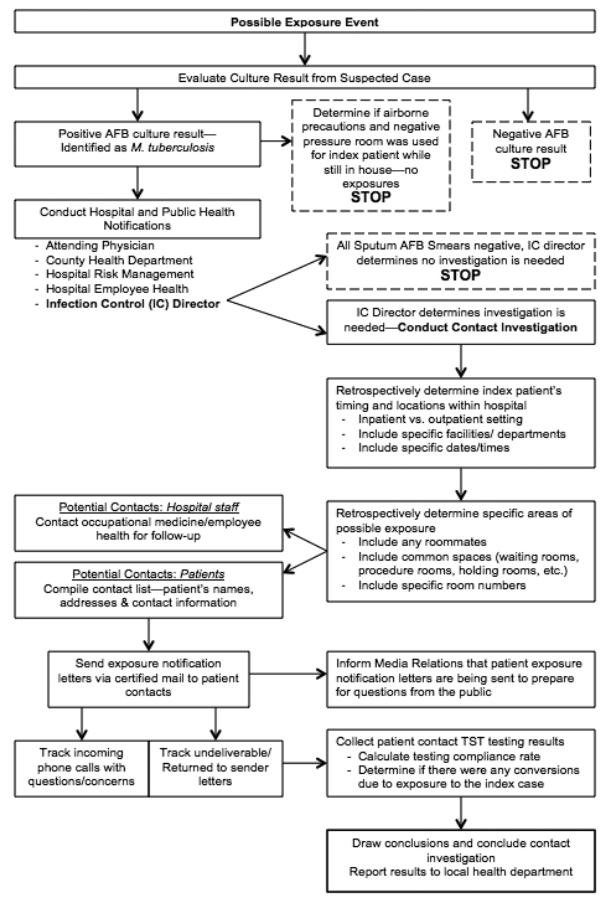


FIGURE 3: Tuberculosis Contact Investigation Algorithm



C. Testing Compliance and Conversions

Only 27.5% (n=39) of patient contacts complied with the recommended testing. However, as discussed above, 20 patient letters were returned as undeliverable and two patients died prior to the start of the investigation. Therefore, only patients who successfully received the notification letter were included in TST compliance rate calculation. When considering the 120 patients who successfully received the notification letter, 32.5% (n=39) complied with the recommended testing and 67.5% (n=81) were lost to follow-up. This information is shown in **Table 1**.

D. Algorithm Developed

The algorithm for Tuberculosis Contact Investigation was developed in response to this case study review by mapping out all activities needed to complete a thorough contact investigation. The developed outline involves stakeholders at all levels of the institution and community. It also ensures that all exposed patients are included in the investigation and incorporates the completion of a final report to conclude the contact investigation. The algorithm developed has potential to be a beneficial tool for IPs to use as guide in future exposure events in an organized and systemic manner. The algorithm is shown in **Figure 3.**

DISCUSSION

The United States (US) is classified as a low TB incidence country. Foreign-born individuals constitute the majority of TB cases with prevalence varying geographically within the US (3). Health care facilities are required to have a written facility plan for all tuberculosis infection control activities (7). According to the World Health Organization, those who live or work in congregate settings, such as hospitals, nursing homes or prisons, have a greater incidence of TB infection than the general population (8). The risk of obtaining nosocomial TB is true for both healthcare workers (HCW) and patients (9). Specifically, HCWs are at higher risk of acquiring TB than the general population (6). TB transmission within a health-care setting is risky as spread could occur via infected HCWs and morbidity and mortality is higher in patients as compared to the public. However, healthcare facilities typically have a well-defined community and expertise to run investigations effectively and quickly.

The low testing compliance rate of 32.5% limited the complete identification of all potential conversions. This finding is consistent with other published studies (10). A study of a TB exposure within an Emergency department waiting room showed that less than one-third of non-staff complied with the recommended testing. The low testing compliance of this contact investigation has a significant implication for infection control. Adoption of new methodologies for patient contact notification will allow for early detection of new TB infection. Patients' primary care providers may be able to encourage their patients to adhere to testing recommendations. Moreover, calling patients individually in addition to sending letters via certified mail may improve the number of patients successfully notified. The use of social media could be helpful to reach out to patients but needs appropriate confidentiality clearance (11).

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TABLE 1: TST Testing Compliance in exposed patients				
	Entire Population		Successfully Notified	
Completed TST Testing	Count	Percentage	Count	Percentage
YES	39	27.5	39	32.5
NO	81	57.0	81	67.5
Unable to contact*	22	15.5	--	--
Total	142	100%	120	100%

*(Letter undeliverable/died prior)

Contact investigation led to the identification of three previously unknown cases of LTBI. These three LTBI cases represent 9.67% of the patients with known testing results, which emphasizes the importance of TB screening among high-risk populations, such as oncology patients. As previously discussed, immunosuppressed patients such as those with HIV infection, undergoing chemotherapy and radiation, or transplant recipients on immunosuppression medications are at greater risk of developing active tuberculosis from a latent tuberculosis infection (LTBI) (12). This investigation emphasizes the importance of screening for LTBI to identify and treat TB infections earlier rather than later.

In this investigation, we found no detected conversions because of the exposure to the index patient. In some TB exposure data, infection was reported to be to be 25-50% (5, 13-17). The exact incidence of TB transmission within health care settings varies considerably depending on the length of exposure, air circulation and how crowded the health care facility is. This exposure was predominantly a brief outpatient exposure (oncology office) with few inpatient exposures. The contacts had mostly short exposure with very few individuals who had significantly long exposures. This may be a reason for the no conversions seen in our study. Longer hospital exposures were associated with high rate of conversions (14, 18). Latent TB patients are affected by the prevalence of TB in the community, which could have been falsely reported as due to the exposure (due to lack of base line TST / IGRA testing) (15, 17, 19).

This study has important limitations; first, this is a short-term observational study with emphasis on outpatient exposures that may not be generalizable to all healthcare settings. Second, the low compliance of patient notification – which is typical in contact investigations – could have missed important data. The main strengths of this study are related to the excellent records of patients and HCW movements and exact exposure. Second, the clinical evaluation of all individuals who had positive TST. Third, our experience may be very similar to many other facilities in the US.

Finally, contact investigation conducted was highly resource intensive, predominantly personnel time. This is similar to other reported exposures (20). We developed an algorithm to assist in the conduct of TB exposures within health care facilities. Within large TB prevention policies, this algorithm could serve as a quick reminder for how to initiate an investigation.

CONCLUSION

Our contact investigation was helpful in assuring patient safety (12). High awareness of the dangers of TB spread, decreased significantly the exposure duration and limited the spread of TB infection. This also highlights the importance of LTBI screening in high-risk populations for early detection and reduction of risk of open TB.

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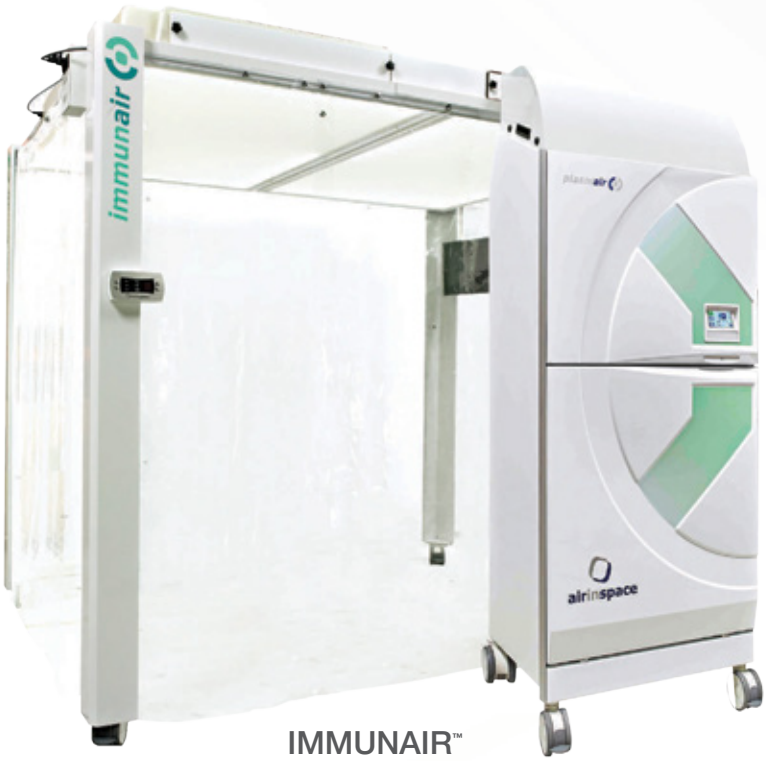

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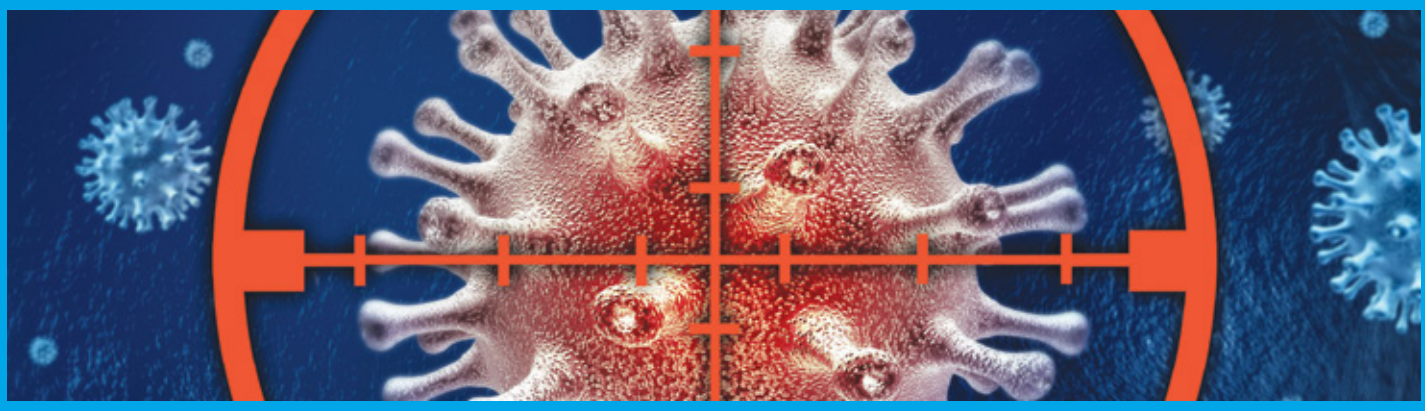

New International study reveals increased risk of infection and antibiotic prescriptions following semi-invasive ultrasound probe procedures

Released in October 2017, the Health Protection Scotland and NHS National Services Scotland government study looked at the infection risk following semi-invasive ultrasound procedures from 2010 to 2016 when low level disinfection was the primary method used for endocavitary probes.[1]

- For transvaginal ultrasound scans, the study found that in the 30 days after a scan, patients were 41% (HR=1.41) more likely to have positive bacterial cultures and 26% (HR=1.26) more likely to be prescribed antibiotics than similar patients who underwent gynaecological procedures without ultrasound ($p<0.001$).
- For transrectal scans, patients were 3.4 (HR=3.4) times more likely to have positive bacterial cultures and 75% (HR=1.75) more likely to be prescribed antibiotics ($p<0.001$).

The study strongly recommends adherence to the current NHS Scotland guidance for the high level disinfection of endocavitary ultrasound probes, which came into effect in 2016 before the new study results were known.[2]

In conclusion, the new study stated: "…failure to comply with guidance recommending high level disinfection of semi-invasive ultrasound probes will continue to result in an unacceptable risk of harm to patients."

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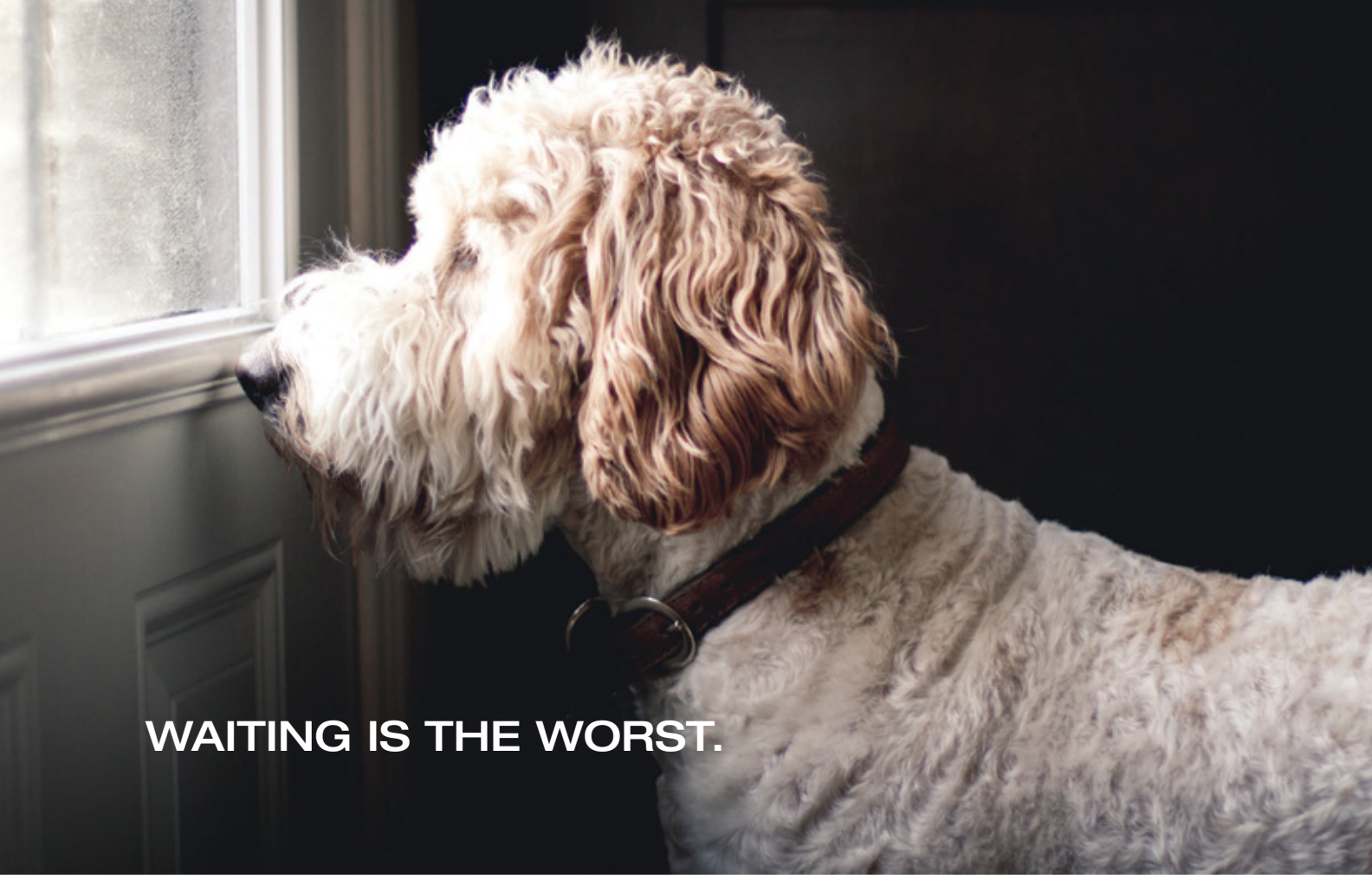

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PH SCALE													
Acidic					Neutral				Alkali				
1	2	3	4	5	6	7	8	9	10	11	12	13	14

PH 6 is 10 times more acidic than 7

PH 5 is 100 times more acetic than 7

PH 4 is 1000 times more acetic than 7

PH 3 is 10,000 times more acetic than 7

PH 2 is 100,000 times more acetic than 7

PH 1 is 1,000,000 times more acetic than 7

PH 8 is 10 times more alkaline than 7

PH 9 is 100 times more alkaline than 7

PH 10 is 1000 times more alkaline than7

PH 11 is 10,000 times more alkaline than 7

PH 12 is 100,000 times more alkaline than 7

PH 13 is 1,000,000 times more alkaline than 7

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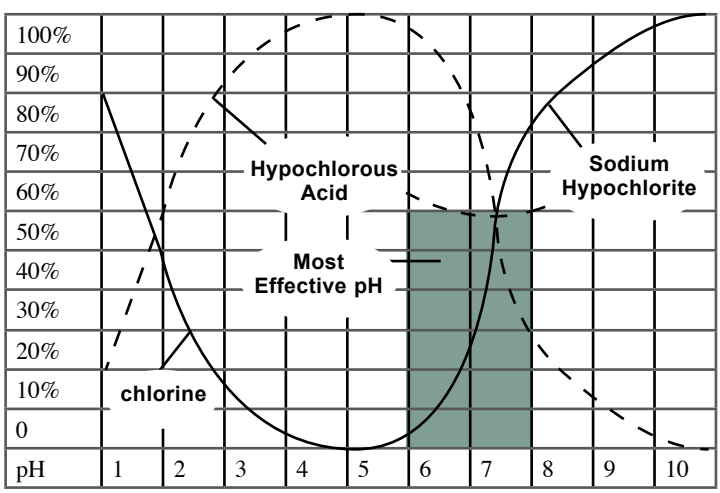

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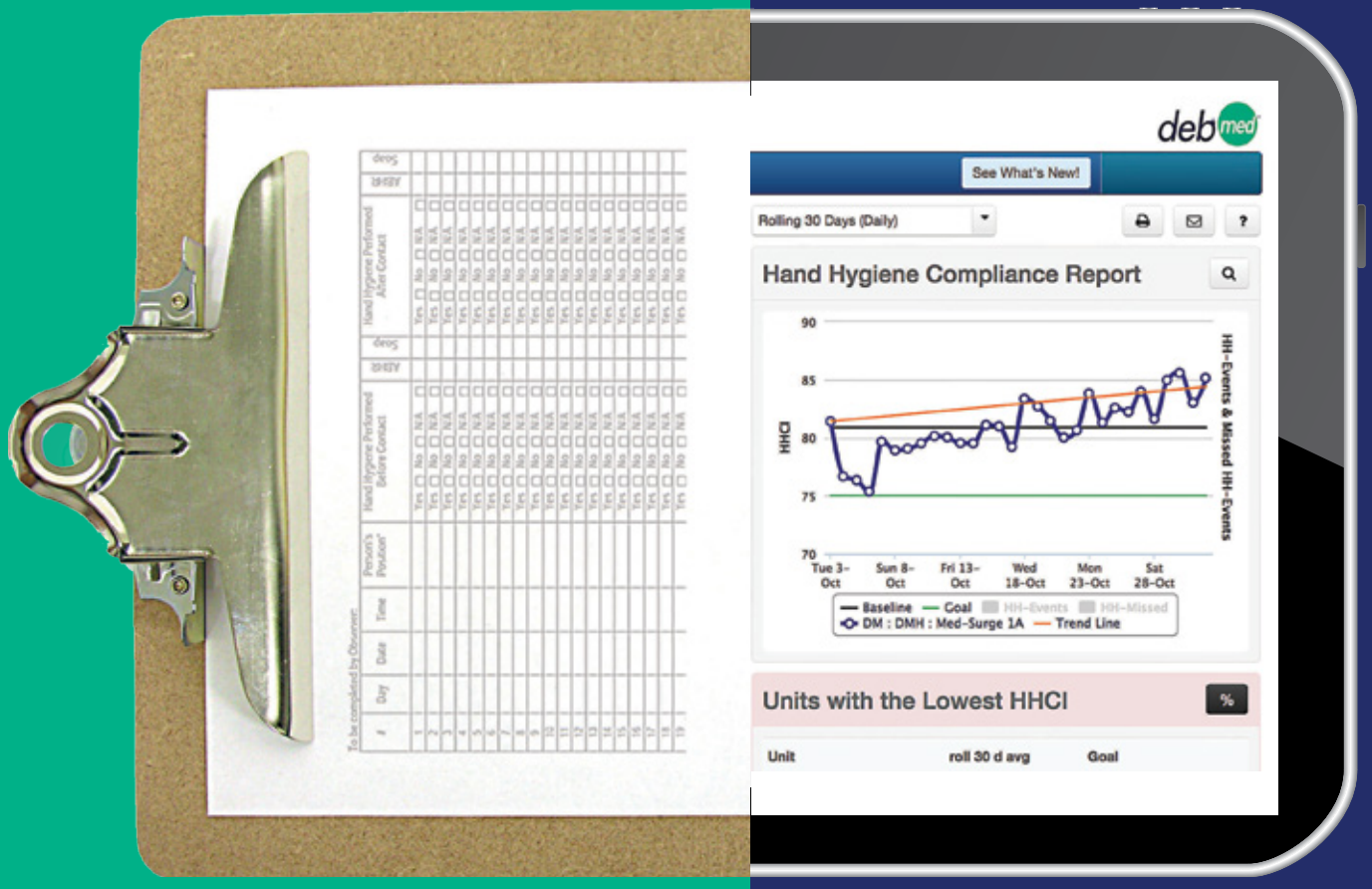

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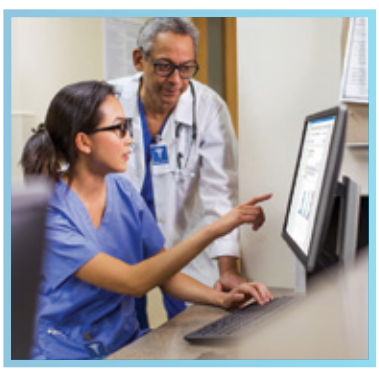

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1. Anne Bialachowski et al, "Electronic Hand Hygiene Monitoring in the Emergency Department: Charting New Territory," http://www.gojo.com/en-CA/Markets/Acute-Care/Hand-Hygiene-Education/Technical-Publications

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[2] As of January 1, 2017, in the Health Canada Drug Product Database.
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