Effect of multidimensional intervention to reduce surgical site infection rate after knee and hip arthroplasty

Samar Saeed Morsi[1], Abeer Omar[2], Gautam Hebbar[3], Mariam Al-Fadhli[4], Wafaa S Hamza[5,]*

Abstract

Introduction **Prevention strategies are critical to reduce infection rates in joint arthroplasty. This study aimed to investigate the effectiveness of a set of evidence-based practices to reduce surgical site infection (SSI) rates after knee and hip arthroplasty (HPRO & KPRO).**

Methods **A quasi-experimental study design (comparing pre- and post-intervention phases) was applied. Interventions were selected, adapted, and implemented in knee and hip arthroplasty procedures as a prospective practice. They consisted of 13 processes throughout the surgical encounter, including preoperative, intraoperative, and postoperative elements.**

Results **Regarding hip arthroplasty procedures, the overall SSI rate during the pre-intervention period was 11.9%, which was reduced significantly to 5.1% (57% reduction) in the intervention period (p=0.042). For knee arthroplasty procedures, the overall baseline SSI rate during the pre-intervention period was 2.7%, which was reduced to 2.0% (26% reduction) in the intervention period. However, this reduction was not statistically significant (p=0.561). Combined methicillin-resistant *Staphylococcus aureus* (MRSA) screening with appropriate decolonization and targeted prophylaxis were associated with a 50% reduction in SSI caused by MRSA in knee arthroplasty.**

Conclusions **The implementation of multidimensional evidence-based practices was associated with a reduction in SSI following knee and hip arthroplasties.**

Keywords **Evidence-based practice, hip arthroplasty, knee arthroplasty, methicillin-resistant *Staphylococcus aureus*, surgical site infection.**

Introduction

Joint diseases tend to occur more frequently among the elderly. Pain and restricted movement are both associated with such diseases, and joint injuries noticeably affect the quality of life over time. Therefore, joint replacement procedures to reduce pain and increase movement capability are among the most common surgical procedures currently applied. Although remarkable rehabilitation is typically evident in the lives of patients after joint prosthesis, possible complications have been identified.[1]

Infection represents one potential complication that needs to be minimized, and which both challenges the success of the surgical procedure and presents a burden to both the patient and the medical facility. At best, infections following hip and knee arthroplasty lead to additional pain, discomfort, and longer durations of hospitalization and treatment.[2]

Received: 20 July 2020; revised: 17 November 2020; accepted: 30 December 2020.

[1]PhD, Associate Professor at Department of Microbiology and Immunology, Faculty of Medicine, Zagazig University, Egypt, Consultant of Infection Control, Al-Razi Orthopedic Hospital, Kuwait, Sabah health region, P.O. Box: 12414 Alshamiya, Kuwait; [2]PhD, Head of Surveillance Department, at Infection Control Directorate, Ministry of Health, Sabah health region, P.O. Box: 12414 Alshamiya, Kuwait; [3]MPH, Epidemiologist at Infection Control Directorate, Ministry of Health, Sabah health region, P.O. Box: 12414 Alshamiya, Kuwait; [4]PhD, Former Director of Infection Control Directorate, Ministry of Health, Sabah health region, P.O. Box: 12414 Alshamiya, Kuwait; [5]PhD, Associate Professor at Department of Public Health and Community Medicine, Faculty of Medicine, Assiut University, Egypt, Consultant of Infection Control at Infection Control Directorate, Ministry of Health, Kuwait, Sabah health region, P.O. Box: 12414 Alshamiya.

*Corresponding author: Wafaa S. Hamza, wafaa.mohamed@med.aun.edu.eg

Published March 2021

ISSN 2248 – 2997
ISSN – L = 2248 – 2997

Furthermore, if the infections worsen, this could result in further revisions with even longer hospitalization, more surgical procedures, and higher costs.[3]

The rate of infection in patients undergoing knee and hip replacements shows considerable variation among countries. Nevertheless, the high frequency of these procedures translates these varying rates into a substantial burden of infection.[4] Prevention strategies are critical to reducing infection rates in joint arthroplasty, but evidence-based consensus guidelines on the prevention of surgical site infections (SSI) continue to be heterogeneous.[5] Numerous studies related to infections in arthroplasty have been published over the last decade, which sought to identify patients at risk for the development of SSIs, and determine methods to reduce the incidence of SSIs by altering modifiable risk factors and improving perioperative and postoperative factors.[4,5]

To the best of our knowledge, no previous studies on infections associated with hip and knee arthroplasty have been conducted in Kuwait. Hence, this study aimed to investigate the effectiveness of a set of evidence-based practices in reducing the SSI rate after knee and hip arthroplasty.

Methods

Study design

A quasi-experimental study design (comparing pre- and post-intervention phases) throughout a 36-month period was applied; the study was conducted in three stages: pre-intervention (baseline) period for 16 months from January 2014 through April 2015; preparatory period for 4 months from May to August 2015, in order to establish the elements of the intervention; an intervention period for 16 months from September 2015 through December 2016.

Study setting

The study was conducted at Al-Razi Orthopedic tertiary care hospital, which is equipped with 480 beds. It is the only specialized orthopedic hospital performing hip and knee arthroplasty in the state of Kuwait.

Data collection

Data were collected by the infection control team at the hospital through consistent, comprehensive, prospective SSI surveillance of hip and knee arthroplasties. The hospital has one full-time infection control physician and seven infection control nurses, based on its bed capacity. Data on SSIs were collected using the surveillance forms of the Kuwait National Healthcare-associated Infection Surveillance System (KNHSS), adopted from the Centers for Disease Control and Prevention National Healthcare Safety Network (CDC/NHSN) surveillance protocol of surgical site infection 2013.[6,7] The following denominator, nominator, and post-discharge SSI forms were used for the hip and knee arthroplasty surgical procedures. Patients who underwent the selected surgical procedures were prospectively and dynamically tracked for signs of SSI and followed up to 90 days after the procedure as part of the KNHSS.

Trained infection control nurses completed a surgical denominator form for each procedure performed at the study hospital. The denominator form included personal data, including name, age, sex, nationality, and hospital ID number. Additional surgery-related data included the name of the procedure, code, date and duration, surgical wound class, the American Society for Anesthesiologists (ASA) score, use of scope, emergency or not, and the category of the SSI Risk Index. Infections were identified either during the primary admission for surgery, during outpatient follow-up for the surgical incision site, or on readmission to the hospital. During post-discharge surveillance, the SSIs were detected using the following methods described below.

Diagnosis of SSI during original admission

To diagnose postoperative SSIs, which developed during the original surgical procedure, a nominator form was completed that included personal data, such as name, sex, date of birth, hospital ID number, date of admission, nationality; and procedural data, such as name, code, and date. In addition, the following data were recorded: date of infection, SSI type, signs, symptoms, results of laboratory investigation, physician's diagnosis, identified microorganism(s) and susceptibility, whether secondary bloodstream infection developed, and patient outcome (deceased or discharge).

Diagnosis of SSI after patient discharge

Post-discharge surveillance was applied to diagnose SSIs either after patient discharge or on readmission. The post-discharge surveillance form was completed for patients who returned with an SSI to the Al-Razi emergency department, outpatient clinics, primary healthcare center, or any general hospital. The post-discharge surveillance form indicated the name of the hospital at which the operation was performed, the name of the reporting hospital/clinic, as well as the patients' personal data. Sources included registers from surgery, emergency departments, outpatient clinics, and primary healthcare centers. A nominator form was also completed for these patients.

During post-discharge follow-up visits, healthcare workers examined patients for any signs of an SSI, and wound dressings were changed at a primary healthcare center or the study hospital's emergency department or clinics. In most cases, these visits were based on the previous written follow-up schedule. On a monthly basis, the infection control team actively collected all patient data using standardized post-discharge surveillance methods from the primary healthcare centers and hospitals. During the post-discharge period, all diagnosed cases at any government facility were included, and comprehensive data were gathered (nominator forms were completed). All relevant forms were made available at all government hospitals and primary healthcare centers. The nursing staff at these locations were trained to complete the relevant forms. The team collected all completed forms from all locations on a regular daily basis.

Definitions

The SSI and a patient's risk index categories definitions were based up on the CDC guideline. SSIs were categorized into three groups: superficial, involving skin and subcutaneous tissue; deep, involving muscle and fascia; and organ space**.** Wounds were divided into four classes: clean, clean-contaminated, contaminated, or dirty-infected according to the NHSN that was adjusted from the American College of Surgeons classification. The NHSN cutoff point (75th percentile) for the duration of the operative procedures was specified in minutes: 120 for hip arthroplasty (HPRO) & 119 for knee arthroplasty (KPRO) surgeries. The American Society of Anesthesiologists classified the patient's preoperative physical condition from 1-5 using the ASA classification. The NHSN surgical risk index category was calculated for all operated patients. The NHSN SSI Risk Index varies from 0 (least risk) to 3 (highest risk), and it is the summation of a number of risk factors: 1) an operation time longer than the duration cut-off point. 2) a surgical wound class of contaminated or dirty/infected; and 3) a patient with an ASA score of 3, 4 or 5; 2) Each risk factor listed was considered as one risk according to the NHSN risk index. SSIs were defined for all patients who underwent the selected surgeries during the study period at the study site and acquired an SSI according to the CDC criteria.[6]

Ethical considerations

Kuwait ministry of health standing committee for the coordination of health and medical research approved the study protocol and a copy of the research protocol after approval was circulated in the study site.

Inclusion and exclusion criteria

All patients who underwent primary HPRO and KPRO were included, while patients who had revision arthroplasty or did not have primary skin closure were excluded. In the intervention period we recruited only the cases that were fully compliant with the interventions to measure the impact of the different interventions on the rate of SSI.

Intervention characteristics

Elements of the intervention were selected, adapted, and implemented in hip and knee arthroplasty procedures as a prospective practice. The intervention consisted of 13 processes throughout the surgical encounter, including preoperative, intraoperative, and postoperative elements[8-10] (Table 1); the details of the interventions are available in a supplementary file.

Table 1. Interventions to reduce surgical site infection in hip and knee arthroplasty

Time	Intervention
A. Pre-operative	1. Active nasal methicillin-resistant *Staphylococcus aureus* (MRSA) screening[8] 2. MRSA decolonization[8] 3. Antibiotic prophylaxis[8] 4. Hair removal[8] 5. Preoperative bath[8]
B. Intra-operative	1. Hand scrub[9] 2. Skin preparation[8] 3. Use a checklist based on the World Health Organization (WHO) 4. Operative theater (OT) rolls[9] 5. Environmental cleaning of the operative theater[9]
C. Post-operative	1. Wound dressing[9] 2. Post-discharge follow up[9] 3. Feedback to the surgeons[10]

Before applying the intervention, the elements were discussed with the attending surgeons, nurses, and surgical team. The entire team was taught to effectively apply the elements in their routine practice. Monitoring of adherence to the intervention processes was achieved through direct observation of the healthcare workers by the infection control team. Observation days were randomly selected every week throughout the study period and a checklist was used.

Data analyses

Data were coded, entered, and analyzed using the SPSS statistical software package (version 18) for Windows (SPSS Inc, Chicago, IL). For quantitative variables, a simple descriptive measure was reported, as the research data were normally distributed (mean ± standard deviation), and frequency with percentage distribution was reported for qualitative variables. Continuous variables were compared between the pre-intervention and intervention periods using the two-sample *t*-test, while either the Chi squared or Fisher's exact test was used to compare categorical variables. The SSI rates per 100 surgical procedures were calculated for the baseline and intervention periods, based on the CDC/NHSN protocol 2013.[6] All p values <0.05 were considered statistically significant.

Results

Between January 2014 and December 2016, 276 primary HPRO and 697 primary KPRO procedures were studied. Patient demographics were relatively well balanced between the two periods in the two procedures with no difference in age, general anesthesia, emergency cases, ASA score, total/partial hip arthroplasty ratio ($p>0.05$). However, there was a statistically significant reduction in the median duration of HPRO procedures during the intervention period (120 minutes) compared to the pre-intervention period (135 minutes) ($p=0.001$). Twenty seven percent of HPRO procedures were following trauma in the pre-intervention compared to 47.7% in the intervention period. This difference was statistically significant ($p=0.001$) – Table 2.

Regarding HPRO procedures the overall SSI rate during the pre-intervention period was 11.9%, which reduced significantly to 5.1% in the intervention period (with 57% reduction) ($p=0.042$) – Table 3.

There was a reduction in superficial SSI rate from 5.9% in the baseline period to 1.1% in the intervention period and from 5.9% to 4% in deep SSI rate. However, none of these was statistically significant – Table 3, Figures 1A and 1B. Moreover, there was no statistically significant difference between the two periods in the SSI rates stratified by SSI risk index category or by the time of development of infection ($p>0.05$) – Table 3.

In the pre-intervention period, 66.7% of all organisms cultured were Gram-negative bacilli while 33.3% were Gram-positive cocci. An opposite distribution was seen in the intervention period with 87.5% of all organisms being Gram-positive cocci and only 12.5% being Gram-negative bacilli. However, coagulase-negative staphylococci were the most commonly cultured organisms in both periods (28.6% and 62.5% respectively) – Table 4.

Table 2. Characteristics of patients who underwent primary HPRO and KPRO procedures in the pre-intervention and intervention periods

		HPRO		
Characteristic	Total (N=276)	Pre-intervention (N=101)	Intervention (N=175)	P value
Nationality	270*	99*	171*	
Kuwaiti	132	47	85	0.547
Non-Kuwaiti	138	52	86	
Age at surgery (years), mean±SD	62.9±16.2	62.0±16.3	63.4±16.1	0.488
Gender (male), %	47%	50.4%	45.3%	0.415
ASA, N (%)				
1	47 (17.0%)	21 (20.8%)	26 (14.9%)	
2	148 (53.6%)	57 (56.4%)	91 (52.0%)	
3	68 (24.6%)	17 (16.8%)	51 (29.1%)	0.098
4	5 (1.8%)	1 (1.0%)	4 (2.3%)	
Unknown	8 (2.9%)	5 (5.0%)	3 (1.7%)	
Type of surgery (total HPRO), %	59.8%	56.3%	61.5%	0.389
Trauma (yes), %	40.1%	27%	47.7%	0.001
GA (yes), %	72.1%	66.3%	75.4%	0.105
Operative time (minutes)				0.001
mean±SD				
median (range)	131.1±45.8 120 (40-275)	143.5±48.8 135 (60-275)	124.1±42.6 120 (40-270)	
Emergency, %	1.4%	0%	2.3%	0.300
		KPRO		
Characteristic	Total (N=697)	Pre- intervention (N=299)	Intervention (N=398)	P value
Nationality	691*	297*	394*	
Kuwaiti	449	197	252	0.547
Non-Kuwaiti	270	100	142	
Age at surgery (years), mean±SD	64.6±8.6	64.3±8.7	64.8±8.5	0.437
Gender (male), %	18.7%	18.7%	18.7%	0.976
ASA, N (%)				
1	62 (8.9%)	28 (9.4%)	34 (8.5%)	
2	528 (75.8%)	228 (76.3%)	300 (75.4%)	
3	76 (10.9%)	23 (7.7%)	53 (13.3%)	0.088
4	31 (4.4%)	20 (6.7%)	11 (2.8%)	
Unknown				
Trauma (yes), %	3%	3%	0%	0.078
GA (yes), %	26.2%	23.7%	28%	0.203
Operative time (minutes)				
mean±SD	116.8±34.5	115.6±29.0	117.6±38.2	0.453
median (range)	120 (25-415)	115 (25-225)	120 (40-415)	

Chi square or fisher exact p value presented for categorical variables and two sample t test p value presented for continuous variables. *Missing; **ASA** – American Society for Anesthesiologists; GA – general anesthesia; **HPRO** – hip arthroplasty; **KPRO** – knee arthroplasty; **SD** – standard deviation.

The only isolated strain of *Escherichia coli*, 2 of 3 isolates of *Klebsiella pneumoniae*, and 1 of 2 isolates of *Proteus mirabilis* were ESBL producers while 1 of 2 isolates of *Staphylococcus aureus* was MRSA.

Regarding KPRO procedures, the baseline overall SSI rate during the pre-intervention period was 2.7%, which reduced to 2.0% in the intervention period (26% reduction). However, this reduction was not statistically significant (p=0.561) – Table 3.

Table 3. Comparison of primary HPRO and KPRO surgical site infection (SSI) rates in the pre-intervention and intervention periods

HPRO					
SSI	Pre-intervention	Intervention	p value	Relative risk (95% CI)	Odds ratio (95% CI)
Overall SSI, n/N (%)	12/101 (11.9%)	9/175 (5.1%)	0.042	2.3 (1.0-5.3)	2.5 (1.0-6.1)
SSIs by SSI risk index category, n/N (%)					
0	3/24 (12.5%)	3/69 (4.3%)	0.176	2.9 (0.6-13.3)	3.1 (0.6-16.8)
1	6/61 (9.8%)	4/77 (5.2%)	0.337	1.9 (0.6-6.4)	1.1 (0.5-7.4)
2	2/8 (25%)	2/26 (7.7%)	0.229	3.3 (0.5-19.5)	4.0 (0.5-34.5)
Superficial SSI, n/N (%)	6/101 (5.9%)	2/175 (1.1%)	0.054	5.2 (1.1-25.3)	5.5 (1.1-27.6)
Deep SSI, n/N (%)	6/101 (5.9%)	7/175 (4.0%)	0.558	1.5 (0.5-4.3)	1.5 (0.5-4.6)
Time of SSI detection, n/N (%)					
During admission	10/12 (83.3%)	5/9 (55.6%)	0.222		
Post-discharge surveillance	0/12 (0%)	1/9 (11.1%)			
Readmission to hospital	2/12 (16.7%)	3/9 (33.3%)			
KPRO					
SSI	Pre-intervention	Intervention	p value	Relative risk (95% CI)	Odds ratio (95% CI)
Overall SSI, n/N (%)	8/299 (2.7%)	8/398 (2.0)	0.561	1.3 (0.5-3.5)	1.3 (0.5-3.6)
SSIs by SSI risk index category, n/N (%)					
0	4/126 (3.2%)	1/163 (0.6%)	0.171	5.2 (0.6-45.7)	5.3 (0.6-48.1)
1	3/140 (2.1%)	6/196 (3.1%)	0.740	0.7 (0.2-2.8)	0.7 (0.2-2.8)
2	1/11 (9.1%)	1/28 (3.6%)	0.490	2.5 (0.2-37.2)	2.7 (0.2-47.4)
Superficial SSI, n/N (%)	4/299 (1.3%)	4/398 (1.0%)	0.730	1.3 (0.3-5.3)	1.3 (0.3-5.4)
Deep SSI, n/N (%)	4/299 (1.3%)	4/398 (1.0%)	0.730	1.3 (0.3-5.3)	1.3 (0.3-5.4)
Time of SSI detection, n/N (%)					
During admission	4/8 (50%)	1/8 (12.5%)	0.195		
Post-discharge surveillance	2/8 (25%)	1/8 (12.5%)			
Readmission to hospital	2/8 (25%)	6/8 (75%)			

Chi square or fisher exact p value presented for categorical variables
CI – confidence interval; **HPRO** – hip arthroplasty; **KPRO** – knee arthroplasty.

There was a reduction in each of the superficial and deep SSI rates by 23% from 1.3% in the pre-intervention period to 1.0% in the intervention period. However, these reductions were not statistically significant (p=0.730) – Table 3, Figures 2A and 2B.

Moreover, there was no statistically significant difference between the two periods in the SSI rates stratified by SSI risk index category or by the time of development of infection (p>0.05) – Table 3. Gram positive cocci were the predominant organisms in both periods. In the pre-intervention period, 71.4% of all organisms cultured were Gram-positive cocci and 28.6% were Gram-negative bacilli. In the intervention period, 60% of were Gram-positive cocci and 40% were Gram-negative bacilli – Table 4. *S. aureus* was the most commonly cultured organism (57.1%) while the most common causative microorganisms of SSI in the intervention period were *S. aureus*, coagulase-negative staphylococci, and *P. mirabilis* (20% each). In the pre-intervention period, 2 of 4 isolates of *S. aureus* were MRSA while no MRSA was reported in the intervention period (p>0.05).

Discussion

Effective prevention of SSIs requires an understanding of the associated risk factors and application of evidence-based practice interventions to deliver quality healthcare and ensure better patient outcomes. Furthermore, preventive strategies could help to sustain the continual change in healthcare practices.[11]

Several measures have been reported to reduce SSIs following knee and/or hip

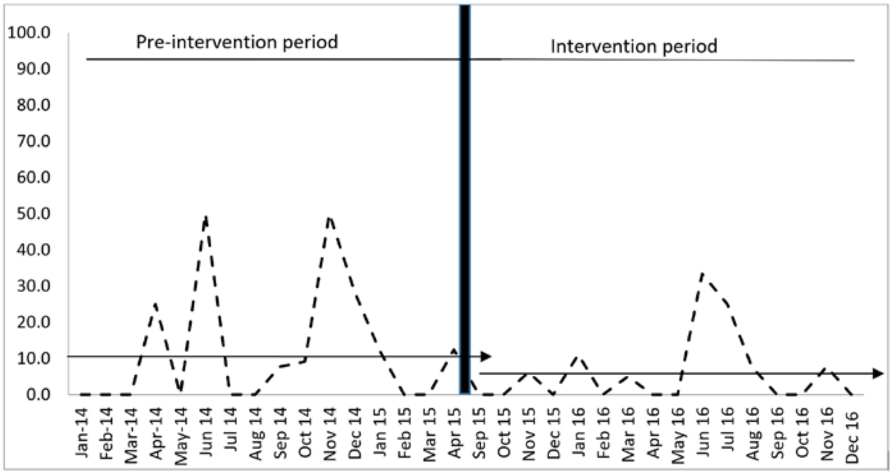

Figure 1A. Overall monthly primary HPRO SSI infection rates over time

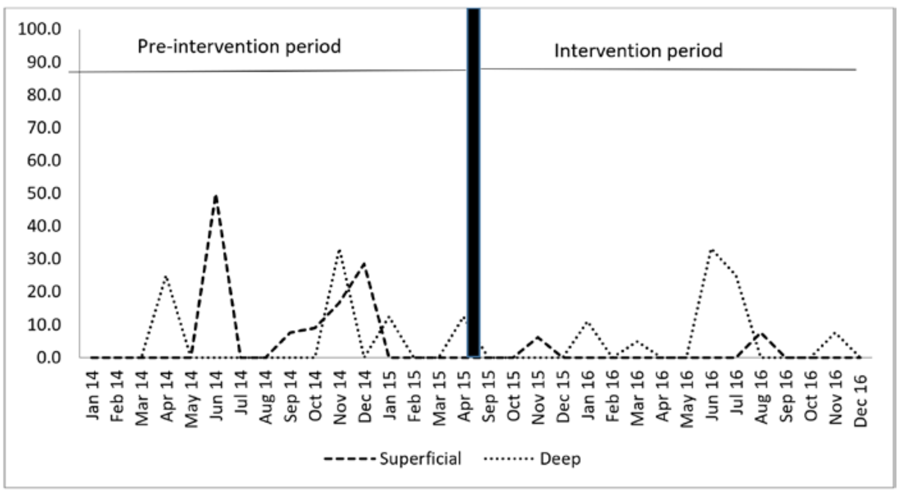

Figure 1B. Superficial and deep primary HPRO monthly SSI infection rates over time

arthroplasty. Various investigators have proposed and implemented different strategies to reduce the number of SSI complications following arthroplasty, with good results. Matt et al.[12] concluded that active surveillance with feedback to the surgical team, combined with several SSI prevention interventions aimed at training and observation, evidently lower SSI rates by 42% and 16% after hip and knee arthroplasty, respectively.

Matsen et al.[13] observed that the effectiveness of implementing a multimodal program to reduce the incidence of periprosthetic joint infection (PJI) after total joint arthroplasty resulted in a reduction in the PJI rate from 1% to 0.4%. Hogenmiller and colleagues[14] reported that the number of total hip arthroplasty (THA) / total knee arthroplasty (TKA) SSIs was reduced to zero following implementation of a best-practice strategy that included five key elements: pre-operative bathing with 2% chlorhexidine gluconate, use of skin and nasal antiseptic, patient warming 30 minutes prior to and during surgery, pre-operative antibiotic infusion and team huddle prior to patient entry into the operating room to review completion of the checklist and to coordinate start time for opening of instruments.

In the present study, we intensively applied 13 evidence-based processes, which were not consistently applied at our hospital before the intervention period. We successfully demonstrated a statistically significant reduction in the overall hip arthroplasty SSI rate. We

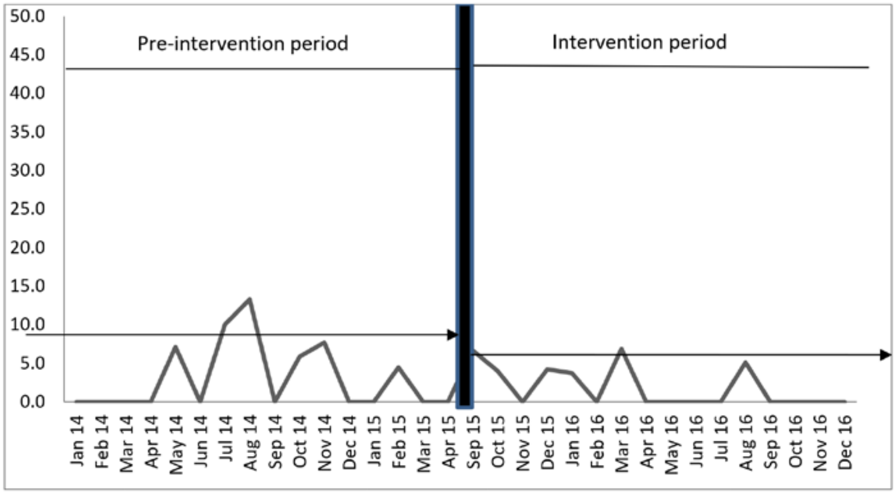

Figure 2A. Overall monthly primary KPRO SSI infection rates over time

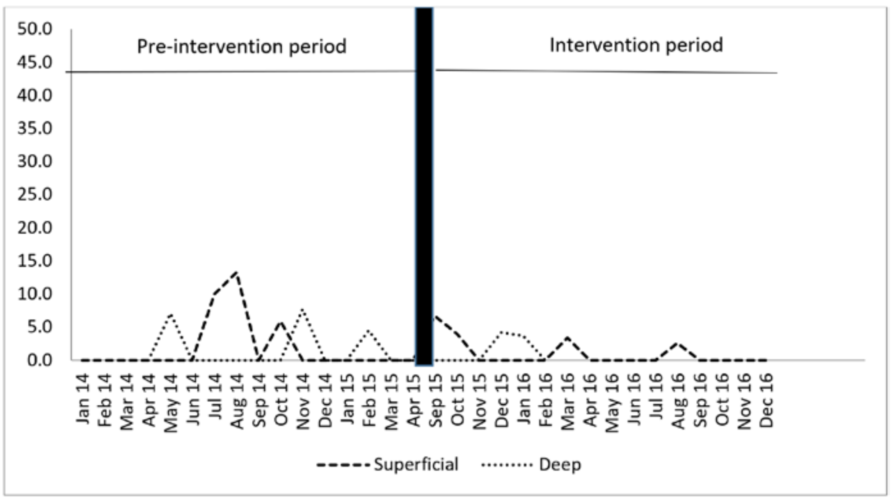

Figure 2B. Superficial and deep primary KPRO monthly SSI infection rates over time

achieved our goal of reducing the devastating complication and improving patient outcomes. Moreover, we succeeded in establishing better institutional practices, which will be implemented for future surgical procedures. However, reductions were not significant among sub-analyses by infection classification (superficial or deep), and this could be explained by the small sample size.

Prolonged operative duration is a known risk factor for SSIs in hip and knee arthroplasties.[15] Surgeon experience is also a known risk factor for SSIs and may have a direct impact on operative duration.[16] In the present investigation, the duration of hip arthroplasty procedures was found to be significantly shorter during the intervention period, in comparison to the baseline period. This factor could have played a role in the reduction of the SSI rate during the intervention period.

In knee arthroplasty procedures, SSI rates were evidently reduced by 26% after the intervention. Although this reduction was not statistically significant, we still consider it to be of clinical importance to the outcome of individual patients.

We identified Gram-positive cocci from 64.7% of SSIs associated with knee arthroplasty and 48.2% of SSIs associated with hip arthroplasty. Previous studies have reported the major role of Gram-positive cocci in SSIs following knee and hip arthroplasty.[2,17] In the

Table 4. Microorganisms isolated from primary HPRO and KPRO surgical site infections, pre-intervention vs. intervention

Pathogen name	HPRO			KPRO		
	Pre-intervention N (%)	Intervention N (%)	Total N (%)	Pre-intervention N (%)	Intervention N (%)	Total N (%)
Aeromonas hydrophila	1 (4.8%)	0	1 (3.4%)	0	0	0
Enterobacter cloacae	1 (4.8%)	1 (12.5%)	2 (6.9%)	0	1 (10%)	1 (5.8)%
Escherichia coli	1 (4.8%)	0	1 (3.4%)	0	0	0
Klebsiella pneumoniae	3 (14.3%)	0	3 (10.3%)	0	0	0
Proteus mirabilis	2 (9.5%)	0	2 (6.9%)	0	2 (20%)	2 (11.7%)
Proteus vulgaris	1 (4.8%)	0	1 (3.4%)	0	0	0
Pseudomonas aeruginosa	4 (19.0%)	0	4 (13.8%)	1 (14.3%)	1 (10%)	2 (11.7%)
Serratia marcescens	1 (4.8%)	0	1 (3.4%)	1 (14.3%)	0	1 (5.8%)
Staphylococcus aureus	1 (4.8%)	1 (12.5%)	2 (6.9%)	4 (57.1%)	2 (20%)	6 (35.3%)
Coagulase-negative *Staphylococcus*	6 (28.6%)	5 (62.5%)	11 (37.9%)	0	2 (20%)	2 (11.7%)
Enterococcus faecalis	0	1 (12.5%)	1 (3.4%)	0	1 (105)	1 (5.8%)
Streptococcus spp.	0	0	0	1 (14.3%)	1 (10%)	2 (11.7%)
Total	21	8	29	7	10	17

HPRO – hip arthroplasty; **KPRO** – knee arthroplasty.

present investigation, *S. aureus* was the most common isolate from SSIs associated with knee arthroplasty procedures; however, it accounted for only 6.9% of the isolates associated with hip arthroplasty procedures (for both pre-intervention and intervention phases). Earlier studies have also reported *S. aureus* as the most common causative organism of SSIs following hip and knee arthroplasty procedures.[2]

S. aureus is reportedly carried by 20-30% of patients who have undergone TKA or THA.[18] Compared with non-carriers, *S. aureus* carriers have a seven-fold increased risk of developing an SSI.[19] Therefore, *S. aureus* presents a real burden to patients undergoing total hip and knee arthroplasty, as they are identified as high-risk patients for SSIs.[20] Perl et al.[21] reported 84.6% of *S. aureus* infections were caused by the same identical strains of *S. aureus* isolated from the patients' nares.

Infections with MRSA have caused serious problems in healthcare settings, owing to its ability to produce a biofilm on the implant, thereby creating the perfect environment for survival and multiplication of bacteria, as well as antibiotic resistance.[7] Nasal colonization with MRSA, as documented in previous studies, is one of the major risk factors for developing an SSI, with rates reaching as high as 44% in MRSA-colonized patients, compared with only 2% in non-colonized patients.[22] These findings show that nasal MRSA colonization can lead to a higher risk of developing an SSI, especially in orthopedic patients.

In the present study, combined MRSA screening with appropriate decolonization and targeted prophylaxis was associated with a 50% reduction in SSIs caused by MRSA in knee arthroplasty. Similar findings have been reported by Bebko et al.[23] and Lamagni.[2]

Targeted use of vancomycin in patients undergoing revision TKA is effective in reducing the overall rate of PJI, and PJI resulting from methicillin-resistant organisms.[24] Based on our results, we recommend screening for *S. aureus* and appropriate decolonization of all patients undergoing hip or knee arthroplasty (both methicillin-resistant and methicillin-sensitive).

Surveillance of SSIs with appropriate feedback to surgeons has been shown to be an important element of effective approaches to reduce SSI risk. A successful surveillance program consists of the use of epidemiologically-related infection definitions and active surveillance means, stratification of SSI rates according to risk factors associated with SSI, and data feedback.[10] One of the strengths of our investigation includes the consistent surveillance methods applied to detect SSIs throughout the study period. The infection control team used the same definition and methods to identify and report SSIs during the pre-intervention and intervention periods.

Another strength of the present study is the application of post-discharge surveillance as an element of the intervention. Our aim was to identify all cases to determine the true SSI rate. As previously reported, post-discharge surveillance and extending surveillance both to outpatients and inpatients is crucial.[25]

Conclusions

The implementation of multidimensional evidence-based practices was associated with a reduction in SSIs following knee and hip arthroplasty procedures. Achieving a prolonged and continuous implementation of this approach is needed to maintain improved outcomes.

Authors' contributions statement: SSM contributed to: conceptualization, project administration, data curation, methodology, writing: original draft preparation, review & editing. AO contributed to: writing review & editing, and validation. GH contributed to: data curation and formal analysis. MAF contributed to: supervision. WSH contributed to: methodology, formal analysis, writing: original draft preparation, review & editing. All authors read and approval the final version of the manuscript.

Conflicts of interest: All authors – none to declare.

Funding: None to declare.

References

1. Widmer AF. New developments in diagnosis and treatment of infection in orthopedic implants. Clin Infect Dis. 2001;33 Suppl 2:94-106. https://doi.org/10.1086/321863
2. Lamagni T. Epidemiology and burden of prosthetic joint infections. J Antimicrob Chemother. 2014:69 Suppl 1:i5-10. https://doi.org/10.1093/jac/dku247
3. Mistry JB, Naqvi A, Chughtai M, et al. Decreasing the incidence of surgical-site infections after total joint arthroplasty. Am J Orthop (Belle Mead NJ). 2017;46:E374-E387.
4. Springer BD, Cahue S, Etkin CD, Lewallen DG, McGrory BJ. Infection burden in total hip and knee arthroplasties: an international registry-based perspective. Arthroplast Today. 2017;3:137-140. https://doi.org/10.1016/j.artd.2017.05.003
5. Ricciardi BF, Bostrom MP, Lidgren L, Ranstam J, Merollini KM, W-Dahl A. Prevention of surgical site infection in total joint arthroplasty: an international tertiary care center survey. HSS J. 2014;10:45-51. https://doi.org/10.1007/s11420-013-9369-1
6. National Healthcare Safety Network. Surgical Site Infection (SSI) Event Centers for Disease Control and Prevention; Atlanta 2013. Accessed on: 01 May 2013. Available at: http://www.cdc.gov/nhsn/PDFs/pscManual/9pscSSIcurrent.PDF .
7. Kuwait National Healthcare-associated Infections Surveillance System. Surgical site infection (SSI) event. Accessed on: 01 January 2017. Available from: www.icdkwt.com/surveillance_out/ssi/KNHSSSSIprotocol2013.pdf.
8. Goyal N, Aggarwal V, Parvizi J. Methicillin-resistant *Staphylococcus aureus* screening in total joint arthroplasty: a worthwhile endeavor. J Knee Surg. 2012;25:37-43. https://doi.org/10.1055/s-0031-1286194
9. Institute for Healthcare Improvement (IHI). How-to Guide: prevent surgical site infection for hip and knee arthroplasty. Cambridge, MA:2012.
10. Mangram AJ, Horan TC, Pearson ML, Silver LC, Jarvis WR. Guideline for prevention of surgical site infection, 1999. Hospital Infection Control Practices Advisory Committee. Infect Control Hosp Epidemiol. 1999;20:250-78; quiz 279-80. https://doi.org/10.1086/501620
11. Mori C. Implementing evidence-based practice to reduce infections following arthroplasty. Orthop Nurs. 2015;34:188-94; quiz 195-6. https://doi.org/10.1097/NOR.0000000000000157
12. Matt M, Clohisy J, Warren D, Hopkins-Broyles D, McMullen K. Decreased surgical site infection (SSI) rates for hip and knee arthroplasty following multiple infection control interventions. Am J Infect Control. 2005;33:168-9. https://doi.org/10.1016/j.ajic.2005.04.216
13. Matsen Ko LJ, Yoo JY, Maltenfort M, Hughes A, Smith EB, Sharkey PF. The effect of implementing a multimodal approach on the rates of periprosthetic joint infection after total joint arthroplasty. J Arthroplasty. 2016;31:451-5. https://doi.org/10.1016/j.arth.2015.08.043
14. Hogenmiller JR, Hamilton J, Clayman T, et al. Preventing orthopedic total joint replacement SSIs through a comprehensive best practice bundle/checklist. Presented at the APIC National Conference, Baltimore,

MD, June 2011. https://doi.org/10.1016/j.ajic.2011.04.240

15. Namba RS, Inacio MC, Paxton EW. Risk factors associated with deep surgical site infections after primary total knee arthroplasty: an analysis of 56,216 knees. J Bone Joint Surg Am. 2013;95:775-82. https://doi.org/10.2106/JBJS.L.00211
16. Lau RL, Perruccio AV, Gandhi R, Mahomed NN. The role of surgeon volume on patient outcome in total knee arthroplasty: a systematic review of the literature. BMC Musculoskelet Disord. 2012;13:250. https://doi.org/10.1186/1471-2474-13-250
17. European Centre for Disease Prevention and Control. Annual Epidemiological Report 2016 – Surgical site infections. Stockholm: ECDC; 2016
18. Courville XF, Tomek IM, Kirkland KB, Birhle M, Kantor SR, Finlayson SR. Cost-effectiveness of preoperative nasal mupirocin treatment in preventing surgical site infection in patients undergoing total hip and knee arthroplasty: a cost-effectiveness analysis. Infect Control Hosp Epidemiol. 2012;33:152-9. https://doi.org/10.1086/663704
19. Ramos N, Skeete F, Haas JP, et al. Surgical site infection prevention initiative - patient attitude and compliance. Bull NYU Hosp Jt Dis. 2011;69:312-5.
20. Mufarrih SH, Qureshi NQ, Sadruddin A, Hashmi P, Mahmood SF, Zafar A, Noordin S. Relationship between *Staphylococcus aureus* carriage and surgical site infections following total hip and knee arthroplasty in the South Asian population: protocol for a prospective cohort study. JMIR Res Protoc. 2018;7:e10219. https://doi.org/10.2196/10219
21. Perl TM, Cullen JJ, Wenzel RP, et al. Intranasal mupirocin to prevent postoperative *Staphylococcus aureus* infections. N Engl J Med. 2002;346:1871-7. https://doi.org/10.1056/NEJMoa003069
22. Pofahl WE, Goettler CE, Ramsey KM, Cochran MK, Nobles DL, Rotondo MF. Active surveillance screening of MRSA and eradication of the carrier state decreases surgical-site infections caused by MRSA. J Am Coll Surg. 2009;208:981-6; discussion 986-8. https://doi.org/10.1016/j.jamcollsurg.2008.12.025
23. Bebko SP, Green DM, Awad SS. Effect of a preoperative decontamination protocol on surgical site infections in patients undergoing elective orthopedic surgery with hardware implantation. JAMA Surg. 2015;150:390-5. https://doi.org/10.1001/jamasurg.2014.3480
24. Liu C, Kakis A, Nichols A, Ries MD, Vail TP, Bozic KJ. Targeted use of vancomycin as perioperative prophylaxis reduces periprosthetic joint infection in revision TKA. Clin Orthop Relat Res. 2014;472:227-31 https://doi.org/10.1007/s11999-013-3029-0
25. Ashraf I, Mohib Y, Hasan O, Malik A, Ahmad K, Noordin S. Surgical site infection surveillance following total knee arthroplasty: tertiary care hospital experience. Ann Med Surg (Lond). 2018;31:14-16. https://doi.org/10.1016/j.amsu.2018.04.006

Please cite this article as:
Morsi SS, Omar A, Hebbar G, Al-Fadhli M, Hamza WS. Effect of multidimensional intervention to reduce surgical site infection rate after knee and hip arthroplasty. GERMS. 2021;11(1):10-22. doi: 10.18683/germs.2021.1236

Supplementary table 1. Interventions to reduce surgical site infection in hip and knee arthroplasty

Time	Intervention
A. Pre-operative	1. Active nasal methicillin-resistant Staphylococcus aureus (MRSA) screening Preoperative nasal MRSA screening was done for elective cases. In emergency cases MRSA screening was sent and epidemiological analysis for the cases was done to decide whether there is a high risk for MRSA based on the available information (frequent hospital admission, previously MRSA was positive) and antibiotic prophylaxis was changed accordingly.[8] 2. MRSA decolonization For any positive case apply mupirocin 2% nasal ointment three times a day for five days. Daily bath with 4% chlorhexidine gluconate for five days and hair wash on day 2 and day 5. Patient's education provided through a leaflet and verbally regarding the decolonization regimen.[9] 3. Antibiotic prophylaxis The routine antibiotic prophylaxis is cefazolin for 24 hours; in case of positive MRSA screening or high-risk condition we added vancomycin.[9] 4. Hair removal We do not remove hair unless hair will interfere with the operation. If hair removal is necessary; remove it close to the time of the surgery (within 2 hours before surgery) and outside the operating room (OR) using clipping. Do not use razors.[8] 5. Preoperative bath Preoperative bathing with 4% chlorhexidine gluconate the night before and the morning of the day of the surgery. The day of surgery patients receive 4% chlorhexidine gluconate cleansing at the site of the surgery applied by healthcare workers.[8]
B. Intra-operative	1. Hand scrub Use appropriate antiseptic agent to perform preoperative surgical scrub. Scrub the hands and forearms for 2-5 minutes. Adhere to standard principles of operative room asepsis.[9] Emphasis on the proper technique and appropriate solution chlorhexidine 4% and the duration. Training of the nurses as well as the surgeons was done with emphasis on technique and duration using lectures and videos. Monitoring by direct observation of the scrub procedure using a checklist and calculation of their compliance was done weekly. Distribution of stop watches to calculate the duration of the hand scrubbing. 2. Skin preparation Wash and clean the skin around the incision site. Use a dual alcohol-based agent that is designated as skin antiseptic preparation.[8] Training was done on the appropriate method for skin preparation and timing as well as encouraging the use of only alcohol-based solutions, e.g., chlorhexidine 2% in 70% alcohol or betadine in alcohol followed by monitoring to ensure compliance. 3. Use a checklist based on the World Health Organization (WHO) The checklist was used to ensure compliance with best practices to improve surgical patient safety. 4. Operative Theater (OT) rolls Direct observation audits of operating room personnel to assess operating room processes and practices to identify infection control lapses, operative technique, surgical attire and operating room traffic was continuously done. Limiting the entrance and exit of staff during surgery. All needed equipment should be taken inside operation room. Keep OR door closed all the time during the procedure.[9] Implement a weekly checklist and calculate compliance of the team to all OT rolls. 5. Environmental cleaning of the operative theater[9] Conducted training targeting all OT personnel. Three training sessions for the nursing staff in the operation theaters to cover all shifts. One full day (4 sessions: environmental cleaning, management of blood & bodily fluids spills, waste management and needle stick injury); the training targeted all cleaners and cleaner supervisors; repeated three times to cover all cleaners in different shifts. Perform direct-observation audits of environmental cleaning practices in the operating room,

	instrument processing (sterilization), and storage facilities. Use a Ministry of Health approved hospital disinfectant to clean visibly soiled/contaminated surfaces and equipment. Created a weekly monitoring environmental cleaning checklist to observe cleaners during the cleaning steps as well as when blood/bodily fluid spill happened and methods followed in collection, segregation, storage and transport of waste and sharps. Correction of any wrong actions was done promptly. Calculation of environmental checklist compliance was done. All training sessions repeated every six months.
C. Post-operative	1. Wound dressing[9] Evaluate wound care practices. Training sessions were given to all the staff with emphasis on hand hygiene and focusing on the removal of the outside dressing, which should be done just immediately prior to the dressing procedure, not earlier. Prepared a wound dressing poster and attached it to every dressing trolley in the hospital that contains the appropriate steps of aseptic wound dressing as a continuous reminder. Monitoring aseptic wound care practices. Perform weekly direct observation audits of wound dressing using a checklist and calculate their compliance. 2. Post-discharge follow up[10] Training of the doctors and nursing staff on how to fill the post-discharge forms and on criteria for diagnosis to detect SSI in addition to distribution of the forms. On a regular basis the infection control team monitored and collected all post-discharge forms from the outpatient department and emergency rooms and recorded any infected cases in the monthly SSI surveillance. 3. Feedback to the surgeons[10] Monthly feedback report included all the patients with SSI to the treating surgeons.