American Journal of Infection Control 43 (2015) 1184-9

Contents lists available at ScienceDirect

American Journal of Infection Control

journal homepage: www.ajicjournal.org

Major article

Surgical site infections, occurrence, and risk factors, before and after an alcohol-based handrub intervention in a general surgical department in a rural hospital in Ujjain, India

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Key Words:
Surgical wound infection
Developing countries
Hand hygiene
General surgery
Cross infection

Background: This study set out to determine occurrence of and risk factors for surgical site infections (SSIs) before and after implementation of an alcohol-based handrub (ABHR) intervention in general surgery wards in a rural, tertiary care hospital in India.

Methods: Patients who underwent surgery between October 2010 and August 2011 (preintervention period) or September 2011 and August 2013 (intervention period) in the department of surgery were included. ABHR was introduced in September 2011. SSI was defined as per the Centers for Disease Control and Prevention guidelines. Comparison of SSI rate between the 2 periods was performed using analysis of variance. Risk factors were determined using multiple logistic regression models.

Results: Incidence of SSI was 5% (36/720) and 6.5% (103/1,581) respectively, showing nonsignificant difference ($P = .5735$). The risk factor common for SSI in both periods was the duration of surgery (OR = 2.6 vs OR = 1.96, pre- and intervention periods, respectively). Risk factors in the intervention period were being a woman (OR = 2.18), renal disease (OR = 3.61), diabetes (OR = 4.43), smoking (OR = 2.14), preoperative hospitalization (<3 vs >15 days; OR = 3.22), and previous hospitalization (OR = 3.5). Compared with other studies, the amount of ABHR used in our study was low.

Conclusion: The amount of ABHR used might not be sufficient to interrupt the chain of contamination of microorganisms; therefore, continuation of the intervention and surveillance is recommended.

Health care–associated infections (HAIs) occur globally in countries across all socioeconomic levels.[1] In 2013, the prevalence of HAI in European hospitals was reported to be 5.7%.[2] In low- and middle-income countries (LMIC), pooled prevalence of 16% has been reported.[3] HAI leads to higher disability, death, and increased economic burden and also an increased risk of contracting antibiotic-resistant bacteria.[1] Surgical site infections (SSIs) were the most common HAI in hospitals in LMIC, with a pooled prevalence of 12%.[3] In India, the incidence has previously been reported to vary between 5% and 24% in studies from different geographic areas.[4,5] Factors associated with SSI can be patient-related factors (eg, smoking, diabetes, other comorbidities) or operation-related factors (eg, duration of surgery, preoperative skin preparation).[6]

Correctly performed hand hygiene among health care workers (HCWs) is the most important action to interrupt the chain of transmission of pathogenic microorganisms between patients and therefore reducing HAI, including SSI.[1,7] Compared with simple handwashing with soap and water, alcohol-based handrub (ABHR) has several advantages and removes pathogens more

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Funding/Support: One of the authors conducted the project as a master's degree thesis and received scholarship from The Swedish International Development Cooperation Agency (Sida). The project was funded by the Swedish Research Council and Sida.

Conflicts of interest: None to report.

http://dx.doi.org/10.1016/j.ajic.2015.06.010

effectively.[1] Implementation of hand hygiene practices has shown great advantages in many high-income countries. However, in many LMIC there are resource constraints for making hand hygiene universally available for infection control.[8]

The importance of assessing the effectiveness of hand hygiene interventions in LMICs has been empathized.[9] A systematic review of intervention studies on HAIs in LMIC found few studies in rural areas and none from India.[7] Although hand hygiene interventions have shown to be suitable in LMIC, additional research need to be performed in resource-constrained settings (eg, rural hospitals) to define the effectiveness in the context.[7] Only a few studies have been performed within general surgery wards in LMIC. Most studies were carried out in intensive care units.[7] The compliance of hand hygiene has shown to be different in intensive care units and wards.[10] Therefore, it is important to study the effectiveness of ABHR on SSI in general surgical wards in rural hospitals.

India does not have a national surveillance system to monitor HAI, and no universally accepted guidelines are available on antibiotic use for common infections. HAI and SSI have been reported as high in India.[5] The antibiotic prescribing rate has been shown to be high in the present study setting.[11] Also, the resistance rate among pathogens has been shown to be high.[12] Therefore, the current study was initiated with the aim to determine the occurrence of and risk factors for SSI after the implementation of a hand hygiene intervention in a general surgery department in a rural hospital in India and to compare the situation before the implementation of the intervention.

METHOD

Setting

The study was carried out at the department of surgery in the Chandrikaben Rashmikant Gardi Hospital (CRGH), which is situated in a rural area of Madhya Pradesh in India. The CRGH is a 600-bed teaching, tertiary care hospital within the private, not-for-profit health care sector. The department of surgery has 90 beds distributed in 3 wards.

Participants

For this study the study population was divided into 2 time periods, the preintervention period (October 2010-August 2011) and the intervention period (September 2011-August 2013). All patients admitted to the department of surgery at the CRGH in the above time periods were eligible to participate in the study. The inclusion criterion was to have undergone surgery in the department of surgery at the CRGH. The results of the preintervention period have been published elsewhere.[4] The department of surgery performs general surgery only. For the present study, operations was categorized as follows: upper and lower gastrointestinal surgery, genitourinary surgery, skin surgery and minor procedures, exploratory laparotomy, multiple operations, and other surgeries (cardiovascular surgery, neurosurgery, and cancer surgery).

Data collection

The surveillance system for SSI used in this study was as suggested by the U.S. Centers for Disease Control and Prevention (CDC).[6] Data were collected through paper forms beginning from August 2010, and the same form was used during both study periods (available on request from the authors). SSI was defined according to the CDC definition.[13] A study assistant collected information daily on admitted patients and followed them until discharge. The patients were followed-up by actual follow-up in the surgical outpatient department or by mobile phone within 30 days postoperatively for SSI surveillance.[14] The patients that were suspected to have SSI on follow-up phone call reported back to the surgical outpatient department for culture confirmation of SSI. Therefore, all included cases of SSI were culture confirmed according to CDC guidelines.[6]

Design

A 1-group pretest (preintervention) posttest (intervention) design was used. Data obtained from after the introduction of the intervention (September 2011-August 2013) were analyzed and compared with results of a previous study from the same setting with data obtained from the preintervention period (October 2010-August 2011).[4]

Intervention

The World Health Organization (WHO) hand hygiene intervention was adopted.[1] The intervention was introduced in September 2011 and is ongoing. It was carried out in the surgical wards and did not include the operation theaters. The intervention was defined as availability and distribution of ABHR, display of posters containing reminders for hand hygiene, and continuing education sessions for the HCWs. The details of the intervention are described elsewhere.[15] ABHR dispensers were placed in the wards, and posters displaying instructions on the correct method of use of ABHR were placed at the wall close to the dispensers. ABHR was prepared at the CRGH according to the formula developed by the WHO.[1] The amount of ABHR used was recorded monthly and reported as liters per 1,000 patient days. Monthly training sessions for the HCWs were conducted. HCWs of all categories participated, including nurses ($n = 36$), nursing students ($n = 6$), surgeons ($n = 4$), residents-postgraduate registrars ($n = 10$), and cleaning staff ($n = 4$). Each training session lasted for about 2 hours and contained information and training on appropriate use of ABHR as recommended by the WHO.[1]

Statistical analyses

Data were entered using EpiData Entry (version 3.1; EpiData Software, Odense, Denmark), and statistical analyses was performed using Stata (version 13.0; StataCorp, College Station, TX). For continuous variables, range, mean, and SD were calculated. Analysis of variance (ANOVA) was used to determine difference of incidence of SSI between the preintervention and intervention periods. Data for incidence of SSI were also analyzed by introducing lag periods of 1, 2, and 3 months to capture any delay in the onset of hand hygiene and education intervention. Potential risk factors from the preintervention and intervention periods were compared. Categorical independent variables were investigated using Pearson χ^2, with the dependent variable being SSI (yes or no). Logistic regression was used to further investigate each independent variable, and odds ratios were derived.

Independent variables included for analysis were as follows: age in years (<18, 19-35, 36-50, 51-65, or ≥65 years), sex (male or female), chronic disease (yes or no, yes if tuberculosis, heart disease, renal disease, or hepatic disease is present), tuberculosis (yes or no), heart disease (yes or no), renal disease (yes or no), hepatic disease (yes or no), diabetes mellitus type 2 (yes or no), history of smoking (yes or no), immunosuppression (yes or no), American Society of Anesthesiologists classification (classes 1-2 or classes 3-6),[16] days spent at hospital preoperatively (0-3, 4-7, 8-14, or ≥15), previous hospitalization within the past 2 weeks (yes or no), preoperative finding of infection (yes or no), duration of surgery (<60 or >60 minutes), drains inserted (yes or no), antibiotic administration (yes or no), wound classification (clean and clean-contaminated or contaminated and dirty), days spent at hospital postoperatively (0-3, 4-7, 8-14, or ≥15), nature of surgery (elective or emergency), preoperative shower (yes or no), hypoxia during surgery (yes or no), and oxygen administered during surgery (yes or no). A backward multiple logistic regression was performed to obtain adjusted odds ratios, and *P* value of <.05 was regarded as significant. The final model was adjusted for age and sex.

Ethical considerations

The ethic committee of the Ruxmaniben Deepchand Gardi Medical College gave their approval for the study (approval no. 114/2010).

RESULTS

The final cohort consisted of 1,581 patients operated on at the CRGH from September 2011-August 2013. Details of sex and age distribution of the patients are shown in Table 1. Upper and lower gastrointestinal surgeries were the most common (38.3%) type of surgeries performed (Table 2). The highest proportion of SSI occurred in the category of exploratory laparotomy (12.2%). This was also the category where most (49.3%) emergency operations occurred (Table 2). Important differences and similarities in the preintervention and intervention periods are highlighted in the discussion.

Incidence of SSI

The incidence of microbiologically culture–confirmed SSI as defined by the CDC was 103 per 1,581 (6.5%; 95% confidence interval, 5.3-7.7) compared with the preintervention period where the incidence was 5% (95% confidence interval, 3-7). However, the difference in incidence of SSI in the pre- and intervention periods was not statistically significant (1-way ANOVA, $F_{1,33} = 0.32$, $P = .5735$). Furthermore, the incidence of SSI per year was 6.1, 6.2, 6.5, and 5.3 in 2010, 2011, 2012, and 2013, respectively, and showed no statistical significant difference (1-way ANOVA, $F_{3,31} = 0.2$, $P = .8932$). The monthly incidence of SSI during the pre- and intervention periods is shown in Figure 1.

As shown in Figure 1, the monthly incidence increased during 2011 and 2012, followed by a decrease from January 2013 onward. During all 24 months (28,423 patient days), 101.3 L of ABHR were used. Therefore, an average of 3.56 L per 1,000 patient days of ABHR was used in the intervention period. The use of ABHR was between 1.14 and 4.95 L per 1,000 patient days per month from September 2011-March 2013. In April 2013, the use of ABHR increased to 7.17-20.98 L per 1,000 patient days per month, with a corresponding fall in SSIs in the last 5 months of the intervention period (Fig 2). An analysis of difference in incidence of SSI according to lag periods for the onset of effect of intervention did not reveal any significantly different results then that reported here.

Risk factors for SSI

Covariates that showed independent statistical significance were sex, renal disease, diabetes, history of smoking, duration of preoperative hospitalization, previous hospitalization, and duration of surgery (Table 1). Of the total cohort, 1.8% consisted of patients with diabetes; of those 28 individuals, 7 developed SSI (odds ratio [OR] = 4.43, *P* = .005). Among those who had a history of smoking (41.4% of the cohort), the odds of developing SSI were 2.14 compared with nonsmokers (*P* = .011). Of the cohort, 97% were administered antibiotics, but this was not associated with the risk of developing SSI (OR = 1.62, *P* = .507).

The mean duration of stay at the hospital before undergoing surgery was 4.3 days (mean ± SD, 4.3 ± 5.3), with a median of 2 days (range, 0-53 days). As the duration of preoperative stay increased, the risk of SSI increased (8-14 days: OR = 1.98, *P* = .046 and ≥15 days: OR = 3.22, *P* = .002 compared with 0-3 days preoperative stay). The duration of preoperative stay among the patients with SSI was 7.7 days compared with 4.1 days among those without SSI. Therefore, SSI contributed an average of 3.6 days longer to hospitalization. The duration of surgery was also found to be associated with SSI. As the duration of surgery increased to >60 minutes (n = 245), the odds of SSI increased by 2.31 times (*P* < .001) (Table 1).

DISCUSSION

This study, to our knowledge, is the first study to investigate and compare incidence of SSI and associated risk factors before and during the implementation of a bundle of hand hygiene interventions in a general surgical department in a rural hospital in India. No statistically significant difference of incidence could be determined. The comparison of risk factors associated with SSI was found to be different between the 2 periods (Table 1).[4]

The preoperative stay should be as short as possible to minimize the risk of SSI.[4] However, an increase in preoperative stay was seen in the intervention period compared with the preintervention period. A number of studies have reported preoperative hospital stay as an important risk factor for SSI.[17,18] A study from Serbia reports a difference in the duration of preoperative stay among those with and without SSI as 9.12 and 5.25 days, respectively.[19] In another study, it is suggested that preoperative stay correlates with comorbidity and severity of illness.[6] The focus should be to optimize the clinical status of the patients and treatment of underlying diseases, for example, a correlation of diabetes and SSI has been shown in previous studies and also in the present study.[17,18] High serum glucose levels after surgery influence the odds of contracting SSI; therefore, perioperative control of blood sugar should be achieved to prevent SSI.[20] Smoking was associated with SSI in our study and has previously been shown to correlate with SSI.[17,21] Interventions of smoking cessation have shown good results on lowering the risk of postoperative infections in high-income countries.[22] Duration of surgery was statistically significantly associated with SSI, both in the preintervention and intervention periods.[4] This finding is in line with previous studies from Vietnam and Tanzania, which reported odds of 2.1 times for SSI if the duration of surgery was ≥2 hours; the odds increased to 3.2 for duration of surgery >3 hours.[17,23,24] Our results of an overall no reduction of SSI after an ABHR intervention are contradictory to the results of a study conducted in Vietnam.[25] However, in a study from Mali, no difference in incidence of infection was observed despite an increase in compliance with ABHR use.[26] Also, a study conducted in India showed no difference in SSI rates after introduction of ABHR.[27] One important aspect for an apparent failure of ABHR intervention in our study could be the low amount of ABHR used during the initial phases of the intervention period. The mean amount of ABHR of 3.56 L per 1,000 patient days used in our study was low in comparison with the Mali study, which reported 3 times the use at 9.23 L per 1,000 patient days.[26] We observed an increase in ABHR use in the last 5 months of the intervention period, with a corresponding decrease in the SSI rate (Fig 2). However, no single factor that was measured in the present study could be attributed to having caused this increase in ABHR use. The intervention package of availability of ABHR and education of HCWs could have an inherent lag period. We did analyze the data with lag periods, but we did not get any significantly different

Table 1
Result of simple and multiple logistic regression of potential risk factors associated with SSIs of a cohort of 1,581 patients who have undergone surgery at the department of surgery, CRGH, Ujjain, India, September 2011-August 2013

			Simple logistic regression			Multiple logistic regression*		
Potential risk factors	SSI, n (%) (n = 103)	No SSI, n (%) (n = 1,478)	Odds ratio	*P* value	95% CI	Odds ratio	*P* value	95% CI
Age (y)				.43				
<18	9 (8.7)	231 (15.7)	Ref					
>18-35	26 (25.2)	346 (23.4)	1.93	.097	0.89-4.19			
>35-50	29 (28.2)	362 (24.5)	2.06	.065	0.96-4.42			
>50-65	28 (27.2)	373 (25.3)	1.93	.095	0.89-4.16			
>65	11 (10.7)	164 (11.1)	1.72	.239	0.7-4.25			
Female	27 (26.2)	311 (21.0)	1.33	.216	0.84-2.10	2.18	.017	1.15-4.13
Chronic disease	24 (23.3)	244 (16.5)	1.54	.076	0.95-2.48	0.51	.101	0.23-1.14
Tuberculosis	2 (1.9)	38 (2.6)	0.75	.694†	0.18-3.15			
Heart disease	2 (1.9)	58 (3.9)	0.48	.319†	0.12-2.01			
Renal disease	16 (15.5)	99 (6.7)	2.56	.001	1.45-4.53	3.61	.009	1.39-9.39
Hepatic disease	4 (3.9)	54 (3.7)	1.07	.904†	0.38-3.0			
Diabetes	7 (6.8)	21 (1.4)	5.06	.000	2.1-12.2	4.43	.005	1.57-12.44
Immunosuppression	4 (3.9)	83 (5.6)	0.68	.456†	0.24-1.89			
Smoking	54 (52.4)	601 (40.7)	1.61	.02	1.08-2.4	2.14	.011	1.19-3.85
ASA scores III, IV, and V‡	9 (9.9)	63 (4.9)	2.15	.041	1.03-4.47			
Previous hospitalization	13 (12.6)	49 (3.3)	4.21	.000	2.2-8.05	3.5	.001	1.66-7.4
Preoperative infection	70 (68.0)	889 (60.2)	1.41	.118	0.92-2.15			
Antibiotic administration	101 (98.1)	1,432 (96.9)	1.62	.507	0.39-6.78			
Emergency operation	9 (9.8)	61 (4.6)	2.26	.03	1.08-4.71			
Contaminated-dirty wound	0	9		§				
Duration of surgery >60 min	31 (34.1)	214 (16.5)	2.62	.000	1.66-4.14	2.31	.001	1.41-3.79
Drains inserted	34 (33.0)	253 (17.1)	2.39	.000	1.55-3.68			
Preoperative shower	90 (87.4)	1,316 (89.0)	0.85	.604	0.47-1.56			
Hair removal	92 (89.3)	1,331 (90.1)	0.92	.81	0.48-1.77			
Hair removal by shaving	91 (100.0)	1,318 (100.0)		§				
Hypoxia during surgery	1 (1.0)	29 (2.0)	0.49	.485†	0.07-3.63			
Oxygen during surgery	89 (86.4)	1,287 (87.1)	0.94	.845	0.53-1.69			
Duration preoperative stay (d)				.000				
0-3	37 (40.2)	775 (58.4)	Ref			Ref		
4-7	27 (29.4)	359 (27.1)	1.58	.082	0.94-2.63	1.36	.269	0.79-2.33
8-14	14 (15.2)	136 (10.3)	2.16	.019	1.14-4.09	1.98	.046	1.01-3.87
>15	14 (15.2)	57 (4.3)	5.14	.000	2.63-10.07	3.22	.002	1.52-6.78
Duration postoperative stay (d)				.000†				
0-3	1 (1.0)	427 (29.3)	Ref					
4-7	12 (12.1)	485 (33.3)	10.56	.024	1.37-81.59			
8-14	19 (19.2)	311 (21.3)	26.09	.002	3.47-195.9			
>15	67 (67.7)	235 (16.1)	121.74	.000	16.79-882.56			

ASA, American Society of Anesthesiologists.; *CI*, confidence interval; *CRGH*, Chandrikaben Rashmikant Gardi Hospital; *Ref*, reference; *SSI*, surgical site infection.
*Adjusted for age.
†Not included in further analyses because of counts <5 in at least 1 cell.
‡ASA classification: classes I-II (a normal healthy patient or a patient with mild systematic disease) and classes III-V (a patient with severe systematic disease, a patient with severe systematic disease that is a constant threat to life, or a moribund patient who is not expected to survive without the operation).[16]
§Not possible to calculate *P* value because of zero counts in at least 1 cell.

Table 2
Occurrence of SSI according to the type of surgery and proportion of emergency operations performed in each category of a cohort of 1,581 patients who have undergone a surgery at the department of surgery, CRGH, Ujjain, India, September 2011-August 2013

	Preintervention period				Intervention period			
Type of surgery	SSI	No SSI	Total	Emergency operation	SSI	No SSI	Total	Emergency operation
Upper and lower GI surgery	6 (2.1)	284 (97.9)	290 (40.7)	3 (1.0)	15 (2.5)	580 (97.5)	595 (38.3)	17 (3.0)
Genitourinary surgery	10 (7.4)	125 (92.6)	135 (18.9)	4 (3.0)	18 (6.6)	254 (93.4)	272 (17.5)	8 (3.3)
Skin surgery and minor procedures	3 (2.0)	146 (98.0)	149 (20.9)	1 (0.7)	19 (5.8)	310 (94.2)	329 (21.2)	4 (1.3)
Other surgeries*	5 (7.1)	65 (92.9)	70 (9.8)	3 (4.3)	26 (11.8)	195 (88.2)	221 (14.2)	3 (1.7)
Exploratory laparotomy	9 (20.9)	34 (79.1)	43 (6.0)	15 (34.9)	10 (12.2)	72 (87.8)	82 (5.3)	37 (49.3)
Multiple operation	2 (7.7)	24 (92.3)	26 (3.7)	1 (3.9)	6 (11.3)	47 (88.7)	53 (3.4)	1 (1.9)

NOTE. Values are n (%) or as otherwise indicated.
CRGH, Chandrikaben Rashmikant Gardi Hospital; *GI*, gastrointestinal; *SSI*, surgical site infection.
*Cardiovascular surgery, neurosurgery, and cancer surgery.

results then that reported here. Also, the intervention could have reached the critical threshold of trained HCWs in the last 5 months of the intervention period.

The number of ABHR dispensers available has been reported to be crucial for the compliance with ABHR.[26] Increasing the number of available ABHR dispensers could be a strategy to help increase compliance with ABHR during the My 5 Moments of Hand Hygiene as suggested by the WHO.[1] However, the number of dispensers for ABHR remained the same during the intervention period. The incidence of SSI was low during both study periods in comparison with other studies conducted in LMIC.[23] One reason could be lesser number of emergency operations (3.9% and 4.9%)

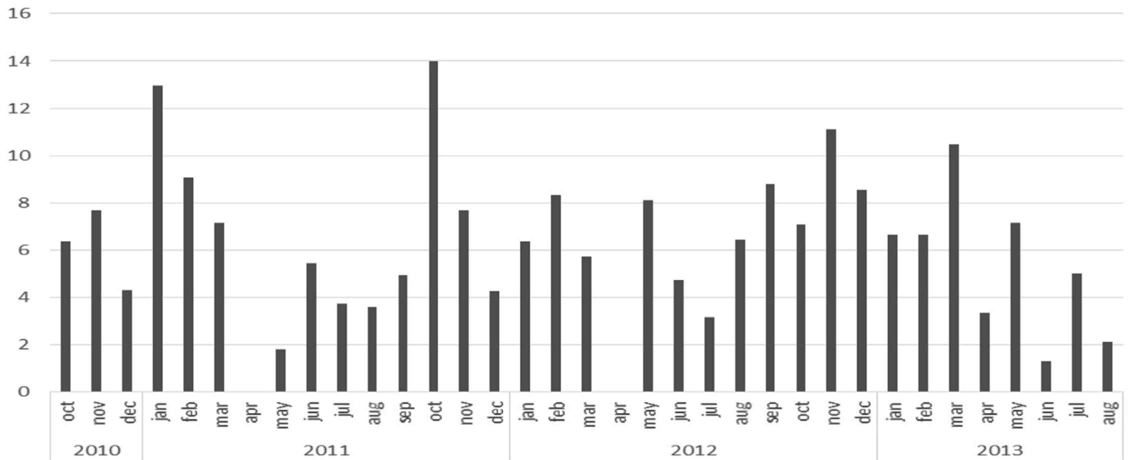

Fig 1. Monthly rate of surgical site infections (%) during the total study period.

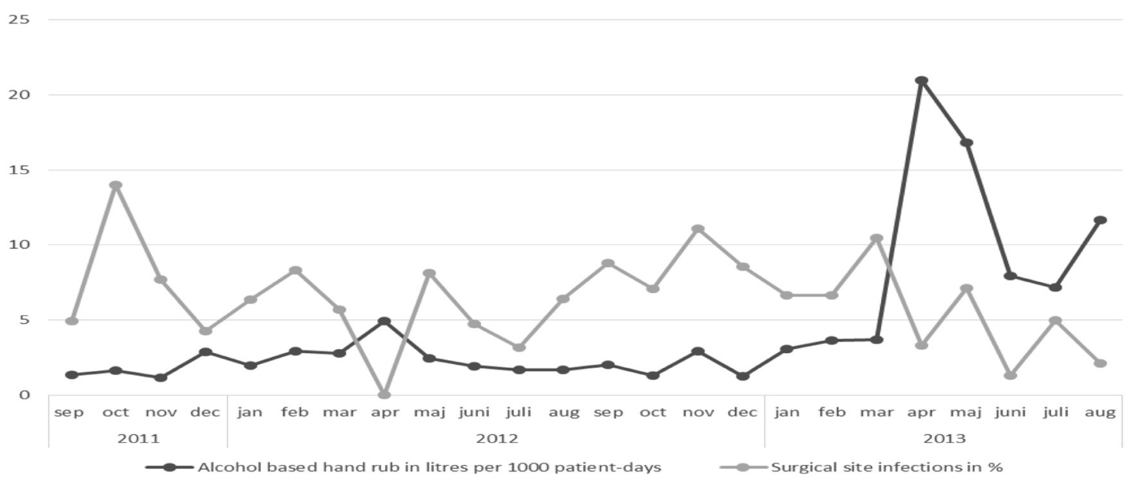

Fig 2. Monthly use of alcohol-based handrub (liters per 1,000 patient days) during the intervention period and rate of surgical site infection (%).

performed at the study site. During the intervention period, SSI was considerably higher (13%) among those undergoing an emergency surgery. This is comparable with a rate (12%) in a study from Vietnam, where 56% of the surgeries were emergency operations.[23]

The main strength of the study was the long follow-up time that is of great importance to eliminate bias caused by monthly fluctuations in SSI rates. Moreover, the definition of SSI used in this study was according to the definition of the CDC that is widely used and therefore enables comparison with other studies. Similarly, the program used for the intervention is a standardized approach. Our study has limitations. First, we did not measure the compliance of hand hygiene among the HCWs. Furthermore, other interventions occurring simultaneously with the present intervention could have influenced the rate of SSI. An antibiotic stewardship project is ongoing in the study setting, but we think that it did not have an effect on the current intervention. The same proportions of patients were administered antibiotics in the study periods (99% and 97%, respectively).[4]

The results of this study so far imply that the chain of contamination of microorganisms was not affected by the introduction of ABHR in the setting. One of the reasons may be the shorter time period of evaluation of intervention postimplementation. It is generally accepted that behavior change takes time. The WHO suggests a cycle of at least 4-5 years of implementation and adaptation for the hand hygiene intervention.[1] Similar results have previously been reported from India, and further translational research needs to be done to identify the process obstacles in ABHR interventions both through qualitative and quantitative studies. In addition, another possibility could be increased awareness among the staff for reporting HAIs, after the introduction of ABHR and training sessions were conducted, where the consequences of HAIs and importance of hand hygiene to reduce HAIs were presented. Therefore, there is a need for continuous interventions using the WHO and other customized tools to encourage the use of ABHR in our setting. Also, bundles of interventions need to be tested and tailored to LMIC. SSI surveillance and ABHR intervention are to be continued in the present setup. The follow-up results will be interesting.

Acknowledgments

We thank all participating HCWs and patients for their cooperation during data collection. We also thank Dr. J.K. Sharma (Dean, RDGMC) for providing administrative support to the project.

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