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ORIGINAL RESEARCH

Improving surveillance system and surgical site infection rates through a network: A pilot study from Thailand

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Background: Surveillance of surgical site infections (SSI) provides data upon which interventions to improve patient safety can be based. In Thailand, however, SSI surveillance has not yet been standardized.

Objectives: To develop a standardized SSI surveillance system and to monitor SSI rates after introduction of such a system.

Methods: We conducted a prospective study among 17,752 patients who underwent surgery in ten hospitals in Thailand from April 2004 to May 2005. The SSI rates were computed and benchmarked with the US rates, reported in terms of standardized infection ratio (SIR). We estimated the incidence rate ratio of surgical site infections by comparing the incidence in the last study period with the incidence in the first study period.

Results: The study included 17,869 operations and identified 248 SSIs, yielding an SSI rate of 1.4 infections/100 operations and a corresponding SIR of 0.6 (95% confidence interval [CI] = 0.5–0.7). During the study period the overall SSI rate decreased from 1.8 infections/100 operations to 1.2 infections/100 operations, yielding an incidence rate ratio of 0.65 (95% CI = 0.47–0.89).

Conclusion: Our study highlighted that a standardized SSI surveillance in a developing country can be initiated through a network and may be followed by a decrease in SSI rates.

Keywords: surgical site infection, surveillance, network, Thailand

Introduction

Surgical site infections (SSIs) are costly and constitute a heavy and potentially preventable burden on both patients and health care providers.[1–7] In recent years, several countries have established surveillance systems for nosocomial infections on a national basis.[8–19] Participation in such systems has shown to be associated with a reduction in surgical site infections.[20,21] In addition, the data can be used for benchmarking, education, policy, and decision making in participating hospitals; [9–17,19] and for improving the quality of care.[9–17,19] Therefore, several developed countries[9–17,19] established a national surveillance network.

In Thailand, a national surveillance network has not yet been established. The SSI surveillance is conducted in different ways in the different hospitals with regards to surveillance method and criteria, data analysis, and feedback. A national database on SSI and interhospital benchmarking of SSI rates in Thailand has thus not been available. We therefore conducted this study to develop a standardized SSI surveillance system, to benchmark and monitor SSI rates, and to improve SSI rates in Thailand.

Methods

Setting

Our study was conducted in 13 hospitals in southern Thailand (87% of all hospitals in southern Thailand) including one university hospital, four tertiary care hospitals affiliated with medical schools, and eight general hospitals. All participating hospitals had a computer in the infection control unit, a hospital computer database, and adequate clinical and laboratory information for diagnosis of SSI. Participation was voluntary and the hospitals were assured of confidentiality of their data. However, two general hospitals dropped out from the study due to insufficient infection control personnel and one general hospital was excluded due to inadequate data quality. Only ten hospitals, approximately 10% of the hospitals for the whole country and 67% of the hospitals in southern Thailand, were included in the final analysis.

Network strategies

We developed a standard form and manual for SSI surveillance and a website. We further developed a software called NISA (Nosocomial Infection Surveillance Application)[22] which was used for data entry, data analysis, and data interpretation in all participating hospitals. Additionally, we organized four quarterly meetings for the participating hospitals for training and discussion of methodological points, data management, and exchange of participants' experience such as SSI definition, data collection, data analysis, data distribution, and data utilization in infection control practices. The first meeting was conducted before start of data collection. In addition, the researchers visited each study hospital every two to three months in order to facilitate the work, advise, and supervise as they needed, and the participating hospitals could consult the researchers at any time via telephone and email. During the study periods, the participating hospitals could use the NISA software to compute their own SSI rates, standardized infection ratio (SIR), and surgeon-specific rates and SIRs. In addition, the hospitals received pooled data of all participating hospitals stratified by infection and SIR quarterly so they could compare their own data with the network data.

Data collection

A prospective study was conducted from April 2004 to May 2005. Each participating hospital monitored at least two procedures of interest. The hospital selected procedures to surveillance based on high cost (hospital A, B, and C), high volume (hospital D, E, and F), and both high volume and high incidence (hospital G, H, I, and J). One hospital selected 90% of the suggested procedures, five hospitals monitored 80% of the procedures, one hospital monitored 60% of procedures, and two hospitals monitored 40% of the procedures. All data were collected by experts in infection control and epidemiology. After one day of training in data collection and diagnosis criteria, infection control nurses (ICNs) in each hospital prospectively collected the pertinent data and recorded the data on the preprinted data collection forms. The collected data included patients' demographic data, diagnosis, operation, antibiotics administered, clinical signs and symptoms of infection, laboratory results including microbiology and serology results, and imaging results.

The patients' medical records, operative notes, anesthetic records, diagnostic imaging reports, microbiology investigation data, and other laboratory results were reviewed. Information on variables related to operative procedure (ie, duration of operation, type of operation, degree of wound contamination, surgeon, and antibiotic prophylaxis) was also reviewed. The American Society of Anesthesiologists (ASA) score on the patients' physical status was identified from anesthetic records. Medical records of the discharged patients in the outpatient department and medical records of the readmitted patients were also reviewed for evidence of infection developing after hospital discharge. In addition, telephoning by health care personnel and mailing to all patients were used as a part of post discharge surveillance in this study. Postoperative follow-up was 30 days after the operative procedure in patients without any implants and one year if an implant was in place.[23,24]

The data from NISA software were checked with the preprinted data collection forms by ICNs in each participating hospitals. Then, both data from NISA software and data collection forms were sent to the research center for rechecking, editing, processing, and analysis. In case of inconsistencies between NISA data and the data collection forms or incomplete information, the data collection forms were sent back to the hospital for rechecking and correction.

Definition

The US Centers for Disease Control and Prevention (CDC) NNIS System criteria were employed for diagnosing SSI and classifying the cases as superficial incisional, deep incisional, or organ/space SSI.[23,24] The ASA score was used to measure patient physical status.[25] The operative procedures were classified according to degree of contamination into one of four classes (clean, clean-contaminated, contaminated, or dirty/infected). The patients' final diagnoses and operations were coded according to the International Classification of Disease 10th Revision (ICD-10) and the International Classification of Disease 9th Revision, Clinical Modification (ICD-9 CM), respectively. The operative procedures were also classified and assigned risk index categories according to the NNIS.[26] In the NNIS risk index the duration of the surgical procedure is defined in terms of the number of minutes that an operation lasts; the 75th percentile for the duration of a given procedure (as determined on the basis of data from the CDC) is rounded up to the nearest hour to produce T, the time point that distinguishes procedures of long and short duration.

Statistical analysis

Demographic data and antibiotic prophylaxis were expressed as percentages. Thai T-values including percentiles and 95% confidence interval (CI) were computed. The Thai T-values were stratified by operative procedures, and compared with the NNIS T-values.[10] Incidence of SSI was calculated, using the NNIS operative procedure categories.

The SIR was computed as the ratio between the observed number of infections and the expected number of events. We computed expected numbers of SIRS as the sum of expected numbers for all risk index categories of specific procedures by applying NNIS rates specific for degree of wound contamination, ASA score, and duration of operation on the study population.[27–29] We estimated the 95% CI of SIR assuming a Poisson distribution.[27–29] The SSI rates were stratified by wound class, ASA score, NNIS risk index, urgency of operation, hospitals, calendar periods (two-month or four-month categories from April 2004 to May, 2005 to increase the statistical precision), and operative procedures.

To compare incidence ratios between the first and the last period of the study we estimated the incidence rate ratio as the ratio of SSI rate in the last period to SSI rate in the first period of the study.

All data analyses were performed using the statistical software STATA version 9 (Stata Corp, College Station, TX).

Results

Patient characteristics

The study included ten hospitals with 17,752 patients who underwent 17,869 operations. Women accounted for 77.1% of the studied patients. The median patient age (interquartile range) was 30 (23 to 38) years and the overall mortality rate was 0.5%. The median lengths (interquartile range) of preoperative, postoperative, and total hospital stay were 0 (0 to 1), 4 (3 to 5), and 4 (3 to 6) days, respectively.

The use of antibiotic prophylaxis

Eighty-eight percent of the patients received antibiotic prophylaxis. The three most common antibiotics used for prophylaxis were ampicillin (35.6%), cefazolin (12.4%), and amoxicillin (12.1%). Antibiotic prophylaxis was administered for more than 24 hours after the operation in 62% of the cases.

Operation characteristics

Among 17,869 operations, 46.2% were classified as emergency. The median duration of operation (interquartile range) was 45 (30 to 65) minutes. The proportion of operations in which the Thai T-values exceeded the 75th percentile NNIS T-values varied among the different operative procedures, ranging from 0% in laparotomy to 70.2% in knee prosthesis operations. Colon surgery, hip prosthesis, knee prosthesis, and laminectomy had substantially longer duration of operation than the NNIS, but the durations of mastectomy, cholecystectomy, and hysterectomy were similar to the NNIS. Thus overall, only 16.7% of procedures in Thailand exceeded the 75th percentile NNIS T-values (Table 1).

Incidence of SSI and SIR

In total, 248 SSIs were identified in 17,869 operations, accounting for an overall crude SSI rate of 1.4 infections/100 operations and a corresponding SIR of 0.6 (95% CI = 0.5–0.7). Most SSIs were classified as superficial SSI (69.8%), followed by deep incisional SSI (19.7%) and organ/space SSI (10.5%). Thirty-one percent of the deep incisional SSIs occurred after cesarean section, followed by 27% after appendectomy and open reduction fracture procedures, respectively. Organ/space SSIs occurred mostly after craniotomy (31%), followed by hysterectomy (19%), and open reduction fracture procedures (15%), respectively.

Of the 248 SSIs, 107 SSIs (43.1%) were detected after hospital discharge. The majority of the post discharge SSIs occurred in cesarean section, appendectomy, and open reduction fracture procedures. Among the SSIs detected after discharge, 45% were identified through follow-up in the out patient clinic, 31% from telephoning by health care personnel, and 24% from mailing. The incidences of SSIs and the SIR (95% CI) stratified by characteristics are shown in Table 2. All ten participating hospitals seemed to reduce their SSI rates during the study period (Table 3–4), although the statistical precision was low. Overall, however, the SSI rate decreased from 1.8 infections/100 operations to 1.2 infections/100 operations, yielding an incidence rate ratio of 0.65 (95% CI = 0.47–0.89) within 14 months.

Table 1 75th percentile of duration of operation (T value) stratified by operative procedures

Operative procedures	Hospitals No.	Operations No.	75th percentile NNIS T value	75th percentile Thai T value			Exceeded 75th percentile NNIS T value (%)
			Hours	Hours	Minutes	95% CI	
Appendectomy	9	3,358	1	0.75	45	45–45	11.52
Cholecystectomy	4	295	2	1.92	115	100–120	21.36
Colon surgery	2	176	3	3.75	225	210–245	48.30
Craniotomy	4	651	4	4.33	260	245–280	36.25
Herniorrhaphy	7	951	2	1.08	65	60–70	8.10
Mastectomy	2	145	3	2.75	165	154–185	23.45
Small bowel	1	18	3	1.94	116	85–229	11.11
Laparotomy	1	10	2	0.92	55	36–65	0.00
Open reduction of fracture	7	1,171	2	1.42	85	80–90	8.63
Knee prosthesis	2	84	2	2.50	150	142–155	70.24
Hip prosthesis	2	35	2	2.75	165	150–183	51.43
Laminectomy	3	87	2	3.42	205	180–225	66.67
Spinal fusion	1	16	4	3.98	239	154–331	12.50
Other musculoskeletal	1	19	3	1.17	70	59–117	5.26
Cesarean section	9	9,851	1	0.92	55	55–55	16.78
Hysterectomy	7	972	2	1.92	115	110–120	20.99
Other genitourinary	1	30	2	1.00	60	50–85	3.33
Total			–	–	–	–	**16.68**

Abbreviation: NNIS, National Nosocomial Infection Surveillance system.

Table 2 Surgical site infection rates (infections/100 operations) and standardized infection ratios (SIR) stratified by characteristics

Characteristics	Operations No.	Infections No.	Rate of infections/100 operations	SIR	95% CI
Wound class					
Clean	2,894	36	1.2	1.0	0.7–1.4
Clean-contaminated	14,031	158	1.1	0.5	0.4–0.5
Contaminated	675	29	4.3	1.2	0.8–1.8
Dirty/infected	269	25	9.3	3.2	1.3–6.3
ASA classification					
I	12,552	140	1.1	0.5	0.4–0.5
II	4,704	94	2.0	0.9	0.8–1.1
III	539	11	2.0	0.7	0.4–1.1
IV	67	3	4.5	2.0	0.1–9.1
V	7	0	0.0	0.0	–
NNIS risk index category					
0	13,689	132	1.0	0.5	0.4–0.5
1	3,844	98	2.5	0.8	0.7–0.9
2	314	18	5.7	1.2	0.7–1.9
3	22	0	0.0	0.0	–
Type of operation					
Elective	9,610	142	1.5	0.7	0.6–0.8
Emergency	8,259	106	1.3	0.5	0.5–0.6
Total	**17,869**	**248**	**1.4**	**0.6**	**0.5–0.7**

Abbreviations: ASA, American Society of Anesthesiologists; NNIS, National Nosocomial Infection Surveillance system; NNIS risk index, the National Nosocomial Infection Surveillance system risk index consists of duration of operation, wound class, and ASA score.

Table 3 Surgical site infection rates (infections/100 operations) and standardized infection ratios (SIR) stratified by study periods

Period	Operations No.	Infections No.	Rate of infections/100 operations	SIR	95% CI
April 2004–May 2004	1,749	31	1.8	0.8	0.6–1.1
June 2004–July 2004	2,910	53	1.8	0.8	0.6–1.0
August 2004–September 2004	2,624	35	1.3	0.6	0.4–0.7
October 2004–November 2004	2,648	38	1.4	0.6	0.5–0.8
December 2004–January 2005	2,608	29	1.1	0.5	0.4–0.6
February 2005–March 2005	2,700	30	1.1	0.5	0.4–0.6
April 2005–May 2005	2,630	32	1.2	0.5	0.4–0.6
Total	**17,869**	**248**	**1.4**	**0.6**	**0.5–0.7**

For the procedures with at least 50 operations, the SSI rates were stratified by procedure and NNIS risk index. No infections occurred in the NNIS risk index categories 2 and 3, (data not shown) (Table 5).

Discussion

Our study showed that we were able to develop a SSI surveillance network in Thailand which seemed to fulfill the requirements for an effective surveillance system. Implementation of the system may be followed by a reduction in SSI rates in all participating hospitals.

The possibility of developing a network in a limited resource country such as Thailand is consistent with previous reports from developed countries.[9–17,19] The NISA software allowed adequate and timely feedback of SSI rates in Thailand[30] because of easy access for the participating hospitals to compute their own infection rates and to create a timely report. In developing countries where the internet may not be easy to access in all parts of the country, the stand alone software could be more appropriate than web-based software used in the developed countries.[9–17,19]

In our study, the participating hospitals could benchmark their rates with pooled data provided by the research center, and had the opportunity to share their experience with other network members and experts every three months. This may explain the overall decrease we found in infection rates due to improved quality of surgical care.[31,32] The findings were similarly to reports from the developed countries.[9–17,19] These strategies may thus apply to other developing countries. We found a decrease of SSI rates over the study period in all 10 hospitals. Our statistical precision is, however, low and this may be a chance finding. Prolonged surveillance would increase the sample size and thereby improve the precision[33] of the reduction in SSI rate in each participating hospital.

Table 4 Comparing surgical site infection (SSI) rates (infections/100 operations) and rate ratios between the first period and the last period stratified by hospitals

Hospital	First period (April–July 2004)			Last period (February–May 2005)			Rate ratio[a]	95% CI
	Operations No.	Infections No.	Rate of infections/100 operations	Operations No.	Infections No.	Rate of infections/100 operations		
A	579	8	1.38	534	6	1.12	0.81	0.28–2.33
B	843	12	1.42	1063	6	0.56	0.40	0.15–1.05
C	396	6	1.52	472	4	0.85	0.56	0.16–1.96
D	434	8	1.84	624	6	0.96	0.52	0.18–1.49
E	594	11	1.85	556	8	1.44	0.78	0.31–1.92
F	376	7	1.86	498	4	0.80	0.43	0.13–1.46
G	623	12	1.93	681	11	1.62	0.84	0.37–1.89
H	328	7	2.13	340	6	1.76	0.83	0.28–2.43
I	132	3	2.27	126	2	1.59	0.70	0.12–4.11
J	354	10	2.82	436	9	2.06	0.73	0.30–1.78
Total	**4,659**	**84**	**1.80**	**5,330**	**62**	**1.16**	**0.65**	**0.47–0.89**

Note: [a]Rate ratio, ratio of SSI rate in the last period to SSI rate in the first period; 95% CI, 95% confidence intervals of rate ratio.

Table 5 Surgical site infection rates (infections/100 operations) stratified by operative procedures and NNIS risk index

Operative procedures	NNIS risk index[a]	No. of operations	No. of infections	Rate of infections/100 operations
Appendectomy	0	2,673	32	1.20
	1	599	25	4.17
	2	84	8	9.52
Cholecystectomy	0	193	7	3.63
	1	89	4	4.49
Colon surgery	0	37	2	5.41
	1	80	9	11.25
	2	51	2	3.92
Craniotomy	0	167	1	0.60
	1	397	7	1.76
	2	81	3	3.70
Herniorrhaphy	0	825	7	0.85
	1	121	2	1.65
Mastectomy	0	107	0	0.00
	1	38	59	2.63
Open reduction of fracture	0	828	9	1.09
	1	316	12	3.80
	2	26	4	15.38
Knee prosthesis	0	23	0	0.00
	1	58	1	1.72
Cesarean section	0	7,981	59	0.74
	1	1,835	34	1.85
Hysterectomy	0	745	14	1.88
	1	214	3	1.40

Note: [a]NNIS risk index, The National Nosocomial Infection Surveillance system risk index consists of duration of operation, wound class, and ASA score.
Abbreviations: ASA, American Society of Anesthesiologists; NNIS, National Nosocomial Infection Surveillance system.

The overall SSI rate in our study was lower than the rate reported recently from the CDC.[10] This may be because of incomplete post discharge surveillance,[28,30] prolonged used of antibiotic prophylaxis beyond the current guideline,[34,35] or because of less severity ill among surgical patients in Thailand than those in the US. After we stratified the SSI rates by procedures and the NNIS risk index, most SSI rates were comparable to the current studies from the EU.[9,12]

After two years of follow-up, all ten study hospitals were able to maintain the developed SSI surveillance system and to continue their participation in the network. Hopefully, the positive outcomes from this study may inspire the other Thai hospitals to enter the network because they would gain some benefit free of charge.

The study has also shown that applying previous knowledge[28,30] and continuing seeking for appropriate strategy to fulfill the gap may lead to achieve the setting goal to reduce the SSI rates such as in Thailand.

The strengths of this study were that we could use standard definitions and methods,[23,24] and benchmarking data with the NNIS system.[10] In addition, the data were collected and analyzed by trained personnel and rechecked by the researchers, and all SSIs were confirmed by the experts in infection control for ensuring valid data. Each participating hospital selected its own procedures of interest to surveillance. Although this was a strength for the individual hospital since the system this way could help problem solving in each hospital, it may have introduced a selection bias if procedures left out of the study had a higher or lower SSI rate than expected. Other countries have chosen to monitor the surgical procedures which are commonly performed in all hospitals.[9,11–17,19] Following that strategy Thai national surveillance on SSI could initially concentrate on colon surgery, appendectomy, open reduction fracture, craniotomy, and cholecystectomy which are commonly performed in most general hospitals, tertiary care hospitals, and university hospitals in Thailand. In addition, the incidence of SSI in these procedures is quite high.[28]

Our study has other limitations. For several procedures we had small sample sizes which lowered our statistical precision. This limitation is also seen in previous studies.[27,28,30] However, selecting common procedures for surveillance and increasing the number of participating hospitals should increase the precision. This inadequacy impelled us to use the 75th percentile NNIS T-values as a cut-point of time for applying to calculate the SIRs in this study which may be inappropriate because only 16.7% of procedures exceeded the 75th percentile NNIS T-values for the overall procedures. This may affect to the accuracy of the SIRs in our study. The difference in T-values between the NNIS and Thai may be due to differences in surgeon expertise.

The SSI risk differ by surgical procedure.[7,36,37] To take into account, we consider it a strength that we were able to standardized the SSI rate using the NNIS risk index which has been shown to correlate linearly with adjusted SSI rates and it has been widely used as a national and international benchmarking tool.[34]

We included all operations that met the NNIS operative criteria and were selected by a hospital to be monitored. However, selection bias may have occurred if the hospitals selected the procedures in which they had a lower than average incidence of SSI. This will make us underestimate the SSI rates. Conversely, if the hospitals selected the procedures with a higher than average incidence of SSI, it would result in overestimation of the SSI rates. We find the latter scenario most likely because the hospitals aimed to improve their SSI rates. Three hospitals had dropped out from the study after they were included in the study. This may lead to selection bias due to loss to follow up.

Lastly, incomplete post-discharge surveillance in Thailand may have led us to underestimated SSI rates. Although all participating hospitals intended to follow all patients included in the study after hospital discharge, only 72%–85% of these could be pursued. We do not, however, expect the post-discharge surveillance to be less complete in the last part of our study period and incomplete post-discharge surveillance therefore cannot explain the decreasing SSI rates we found after implementation of the surveillance system. If a hospital had a smaller or a higher inclusion of post-discharge surveillance than the average, the hospital should, however, interpret their benchmarked data with caution. Improving post-discharge surveillance in Thailand would lead to more accurate SSI rates.

In conclusion, a standardized SSI surveillance, relevant preliminary benchmarked data, and a reduction in the overall SSI rate in a developing country could be achieved through a SSI network.

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Disclosure

The authors have no conflicts of interest in this work.

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