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Development of a Surgical Site Infection (SSI) Surveillance System, Calculation of SSI Rates and Specification of Important Factors Affecting SSI in a Digestive Organ Surgical Department

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ABSTRACT

We have developed an original system to conduct surgical site infection (SSI) surveillance. This system accumulates SSI surveillance information based on the National Nosocomial Infections Surveillance (NNIS) System and the Japanese Nosocomial Infections Surveillance (JNIS) System. The features of this system are as follows: easy input of data, high generality, data accuracy, SSI rate by operative procedure and risk index category (RIC) can be promptly calculated and compared with the current NNIS SSI rate, and the SSI rates and accumulated data can be exported electronically. Using this system, we monitored 798 patients in 24 operative procedure categories in the Digestive Organs Surgery Department of Mazda Hospital, Mazda Motor Corporation, from January 2004 through December 2005. The total number and rate of SSI were 47 and 5.89%, respectively. The SSI rates of 777 patients were calculated based on 15 operative procedure categories and Risk Index Categories (RIC). The highest SSI rate was observed in the rectum surgery of RIC 1 (30%), followed by the colon surgery of RIC3 (28.57%). About 30% of the isolated infecting bacteria were Enterococcus faecalis, Staphylococcus aureus, Klebsiella pneumoniae, Pseudomonas aeruginosa, and Escherichia coli. Using quantification theory type 2, the American Society of Anesthesiology score (4.531), volume of hemorrhage under operation (3.075), wound classification (1.76), operation time (1.352), and history of diabetes (0.989) increased to higher ranks as factors for SSI. Therefore, we evaluated this system as a useful tool in safety control for operative procedures.

Key words: *Surveillance, Surgical Site Infection, Nosocomial Infection*

Nosocomial infection surveillance is a continuous activity to epidemiologically monitor the standard infection rates, evaluate the effectiveness of infection-control measures, and quickly detect outbreaks of nosocomial infection due to various factors. It is also a method of infection prevention to minimize the nosocomial infection rate[19]. Furthermore, as nosocomial infection surveillance itself reduces the nosocomial infection rate, it is very important for hospital security management[2,8,9,23].

In the United States, in January 1970, the National Nosocomial Infections Surveillance (NNIS) System developed by the Centers for Disease Control and Prevention (CDC) commenced operations. Presently, more than 300 facilities in the United States are providing the NNIS system with surveillance data. The gathered surveillance data are compiled and disclosed in the NNIS System Annual Report, and guidelines for infection control are prepared by the CDC on the basis of the data obtained.

In Japan, the Japanese Nosocomial Infections Surveillance (JNIS) Committee of the Japanese Society of Environmental Infections led the development of the JNIS System, which resembles the NNIS System, in 1999, and surveillance of the rate of surgical site infection (SSI) was begun[14]. This SSI surveillance was promoted to a national project under the management of the Ministry of Health, Labor and Welfare in July 2002, and is expected to spread further. However, only just over 50 facilities are participating in this project and it has only surveyed slightly more than 30,000 cases, which is far lower than the 2.02 million cases surveyed in the United States.

While the importance of nosocomial infection surveillance as part of nosocomial infection management activities at each medical facility is recognized, it is implemented only in some of the hospitals, and surveillance skills have not been established.

Under these circumstances, electronization of SSI surveillance data is essential for the efficient and rapid implementation of SSI surveillance as a hospital operation[25]. In addition, system compatibility to overcome differences in data properties among participating facilities and to guarantee data accuracy through the incorporation of functions to check entry defects concerning essential items and their consistency, as well as simplicity of the input operation are requirements for software used for electronic data capture[24]. Moreover, the software must be able to adjust and categorize not only the SSI rate in each operative procedure at each facility, but also risk factors in each patient, and to analyze them in a manner that permits a comparison with the SSI rate in the United States reported in the latest NNIS System Annual Report[18]. In addition, to use the accumulated SSI surveillance data for purposes such as the identification of factors important for the occurrence of SSI, a function to export the accumulated information is necessary. In this report, we present our original SSI surveillance system, which fulfils these requirements. The SSI rate and results of estimation of factors important in the occurrence of SSI obtained using this system are also reported.

MATERIALS AND METHODS

1. Development of an SSI surveillance system

In developing the system, we prepared a data flow diagram (DFD)[31] to clarify the treatment processes of the data obtained by SSI surveillance. On the basis of the prepared DFD, a system was developed using the relational type database software Microsoft Access®. The system was designed to collect a total of 43 items consisting of the presence or absence of a history of diabetes or malignant tumor, preoperative serum albumin level, and intraoperative volume of hemorrhage[29], which are reported to be risk factors for the occurrence of SSI, as well as the patient number, date of surgery, age at surgery, gender, operative procedure, operation time (hours), operation time (minutes), operation time, wound classification, American Society of Anesthesiologist (ASA) grade, whether general anesthesia was performed, whether emergency surgery was performed, whether there was trauma, whether endoscopic surgery was performed, whether there were implants, whether multiple procedures were performed, whether an artificial anus was created, whether day surgery was performed, whether SSI occurred, date of infection, depth of infection site, infection site, periods defined as SSI, culture specimen, pathogens 1, pathogens 2, pathogens 3, pathogens 4, whether there was a subcutaneous abscess, whether there was a ruptured suture, whether there was a residual tumor, whether there was secondary blood stream infection, outcome, cause of death, hospital code, patient's name, date of admission, surgeon, and date of discharge, which are data items captured by the JNIS system.

2. Calculation of the SSI rate and estimation of factors important for the occurrence of SSI

Using the developed SSI surveillance system, the SSI rate was calculated at the Department of Gastrointestinal Surgery, Mazda Hospital, Mazda Motor Corporation. The subjects were patients who underwent surgery during the two years from January 2004 to December 2005. Using the statistical analysis function incorporated into this system, individual patients were classified into risk index categories (RIC) similar to those in the JNIS system3,7,17), and the SSI rate was calculated for each operative procedure. Pathogens isolated from the SSI foci were also statistically evaluated.

In addition, important factors involved in the occurrence of SSI in these patients were extracted. Using the SSI surveillance data export function incorporated into this system, the SSI surveillance data accumulated in the system was exported as CSV files, and multivariate analysis (quantification method of the second type) was performed according to whether SSI occurred as the dependent variable, and age at surgery, gender, operation time, wound classification, ASA class, whether general anesthesia was performed, whether emergency surgery was performed, whether there was trauma, whether there was an implant, whether endoscopic surgery was performed, whether multiple procedures were performed, whether an artificial anus was constructed, whether day surgery was performed, whether the patient had a history of diabetes, whether the patient had a history of malignant tumor, preoperative serum albumin level, and volume of intraoperative hemorrhage as independent variables. In this analysis, age at surgery was classified into four categories (0-14, 15-64, 65-74, and 75- years) according to the method for population categorization by age of the Ministry of Health, Labor and Welfare, operation time into five categories (0-60, 61-120, 121-180, 181-240, and 241- min)[5], preoperative serum albumin level into three categories (0-2.4, 2.5-3.9, and 4-)[1], and volume of intraoperative hemorrhage into three categories (0-600, 601-1,500, and 1,501- ml)[30].

RESULTS

1. Development of the SSI surveillance system

1) Preparation of DFD

Fig. 1 shows the DFD that we prepared. The DFD made it possible to determine the operations necessary for SSI surveillance as a whole. This DFD was composed of: (1) processes in which information obtained from patients by SSI surveillance activities is classified into surgical information, infection information, and outcome information, input step-wise into the system, and accumulated (Processes 1-3); (2) processes in which the SSI rate and cut-off value of the operation time observed in the NNIS System Annual Report (NNIS SSI rate and NNIS T time, respectively) are input into the system to update it (Processes 4 and 5); (3) processes in which the RIC of accumulated patients is calculated (Process 6), the SSI rates are calculated according to the RIC, RIC stratified by the surgeon, and RIC stratified by patient age (Processes 7-9) for each operative procedure, and the calculated SSI rates are compared with the NNIS SSI rate (Processes 10-12); (4) and processes in which the accumulated SSI surveillance data are electronically exported (Process 13).

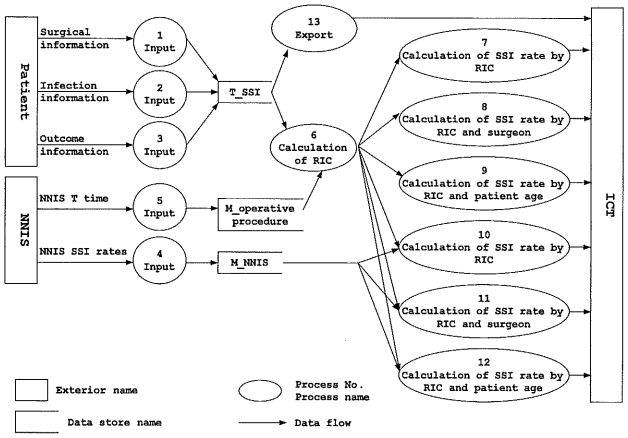


Fig. 1. Data flow diagram

2) Preparation of tables for the accumulation of surveillance data and master tables and construction of their relationships

Tables for the accumulation of collected SSI surveillance data were prepared as T_SSI consisting of 38 items (Fig. 2). The master tables consisted of a total of 25 tables. The master tables and T_SSI were linked by relationships constructed between them (Fig. 2).

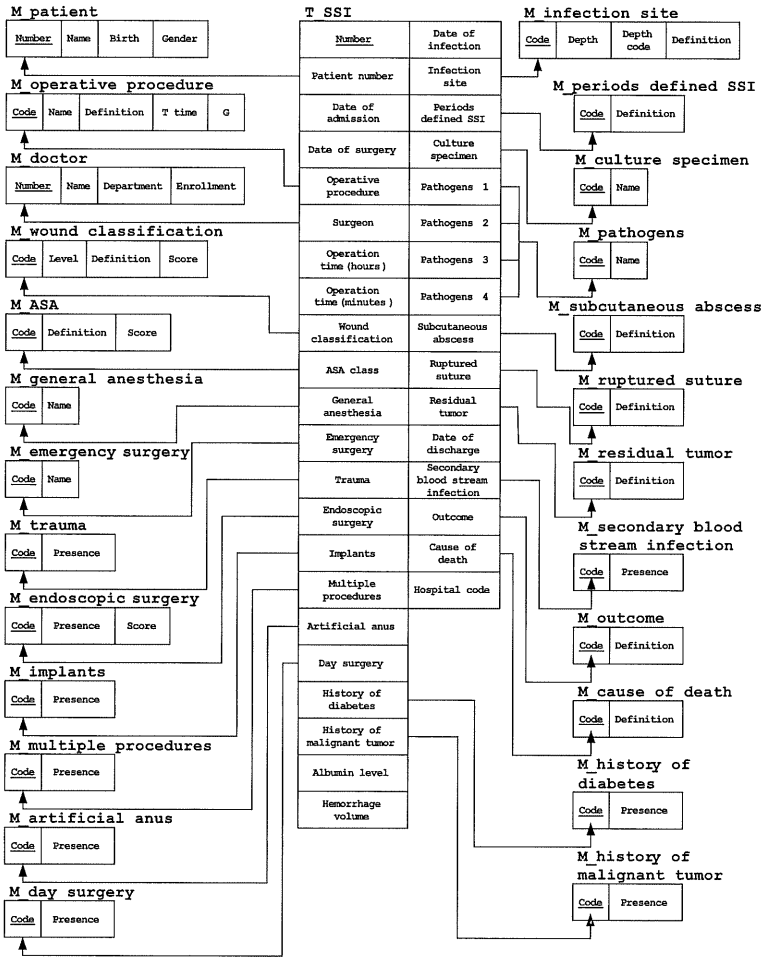


Fig. 2. Entity relationship diagram

3) Preparation of a system menu screen

A system menu screen was prepared and it is displayed when the system is switched on. On this screen, the surveillance data entry and search function, NNIS data updating function, statistical function, or surveillance data export function is selected.

4) Preparation of the SSI surveillance data entry and search screen

An SSI surveillance data entry and search screen was prepared. Entry of new SSI surveillance data can be started by clicking the new entry button. Also, by clicking the patient number search or unentered outcome information search button, editing of previously entered data such as adding, changing, and deleting can be performed.

Figs. 3-5 show SSI surveillance data entry screens. All entry items (43 items) were classified into surgical information to be entered in Process 1 on the DFD (28 items), infection information to be entered in Process 2 (11 items), and outcome information to be entered in Process 3 (4 items). Then, of the surgical information, basic patient data (8 items) are shown at the top of the input screen, while other surgical information, infection information and outcome information are shown in the lower halves of different pages, which can be switched using the tab-control key. Of all entry items, 28 were entered by selecting the right statement from a list derived from the master tables using combo boxes, and 10 were entered as numbers using 10 keys.

At the end of the entry processes, the state of entry of each essential item is checked separately in Processes 1-3. If an error is detected, a message indicating its content is shown, and the preservation process of the entered data is cancelled. In addition, the consistency of entries among items, e.g., between the sample and causative agent and between discharge due to death and cause of death, is checked, and, if an error is detected, the process is similarly cancelled. The diagnostic criteria of SSI can be referred to during data entry by clicking on the SSI diagnostic criteria display button.

5) Preparation of the NNIS System Annual Report data entry screen

Fig. 6 shows the NNIS System Annual Report data entry screen. (1) The SSI rate by the RIC, (2) cut-off value of the operation time (T time), and (3) state of RIC integration for each operative procedure observed in the NNIS System Annual Report are input into this system as Processes 4-5 of the DFD. (1) was prepared to handle annual updates of the NNIS SSI rate, (2) to handle changes in the cut-off time used for the calculation of the SSI rate, and (3) to handle part of the SSI rate integrated into the RIC in the NNIS System Annual Report.

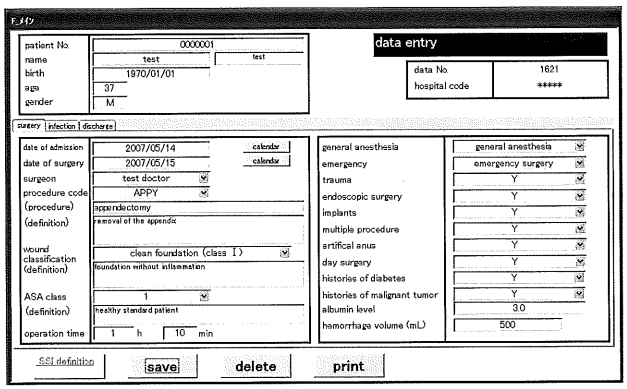


Fig. 3. Operation data entry screen (sample)

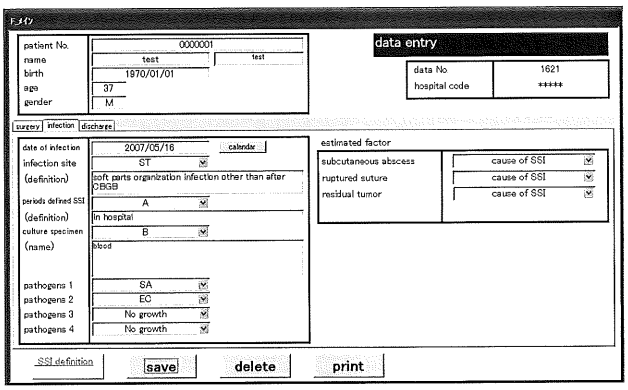


Fig. 4. Infection data entry screen (sample)

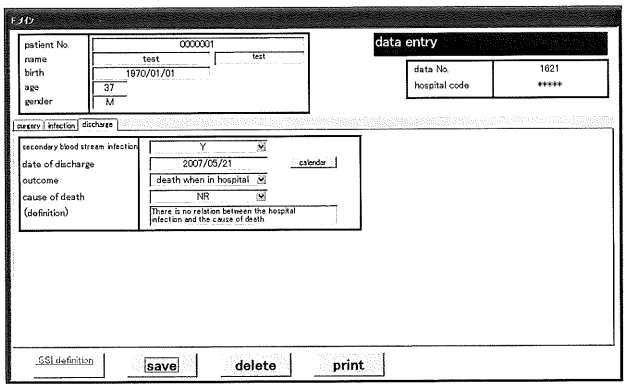
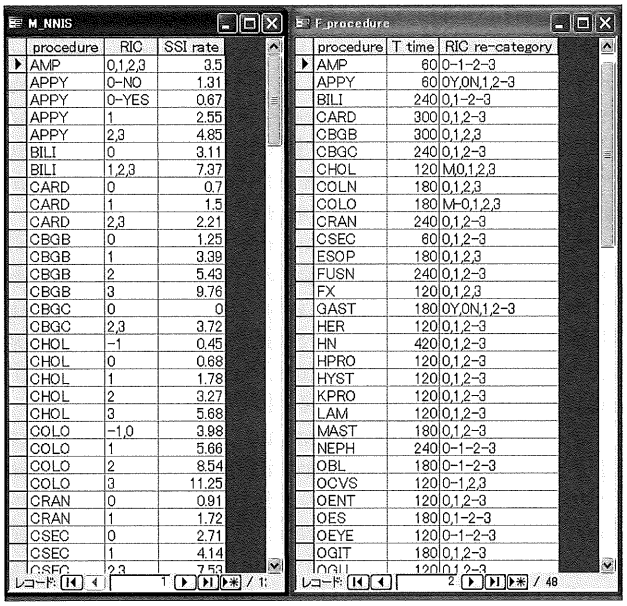


Fig. 5. Discharge data entry screen (sample)



M_NNIS

procedure	RIC	SSI rate
AMP	0,1,2,3	3.5
APPY	0-NO	1.31
APPY	0-YES	0.67
APPY	1	2.55
APPY	2,3	4.85
BILI	0	3.11
BILI	1,2,3	7.37
CARD	0	0.7
CARD	1	1.5
CARD	2,3	2.21
CBGB	0	1.25
CBGB	1	3.39
CBGB	2	5.43
CBGB	3	9.76
CBGC	0	0
CBGC	2,3	3.72
CHOL	-1	0.45
CHOL	0	0.68
CHOL	1	1.78
CHOL	2	3.27
CHOL	3	5.68
COLO	-1,0	3.98
COLO	1	5.66
COLO	2	8.54
COLO	3	11.25
CRAN	0	0.91
CRAN	1	1.72
CSEC	0	2.71
CSEC	1	4.14
CSEC	2,3	7.53

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F_procedure

procedure	T time	RIC re-category
AMP	60	0-1-2-3
APPY	60	0Y,0N,1,2-3
BILI	240	0,1-2-3
CARD	300	0,1,2-3
CBGB	300	0,1,2,3
CBGC	240	0,1,2-3
CHOL	120	M0,1,2,3
COLN	180	0,1,2,3
COLO	180	M-0,1,2,3
CRAN	240	0,1,2-3
CSEC	60	0,1,2-3
ESOP	180	0,1,2,3
FUSN	240	0,1,2-3
FX	120	0,1,2,3
GAST	180	0Y,0N,1,2-3
HER	120	0,1,2-3
HN	420	0,1,2-3
HPRO	120	0,1,2-3
HYST	120	0,1,2-3
KPRO	120	0,1,2-3
LAM	120	0,1,2-3
MAST	180	0,1,2-3
NEPH	240	0-1-2-3
OBL	180	0-1-2-3
OCVS	120	0-1,2,3
OENT	120	0,1,2-3
OES	180	0,1-2-3
OEYE	120	0-1-2-3
OGIT	180	0,1,2-3
OGU	120	0,1,2-3

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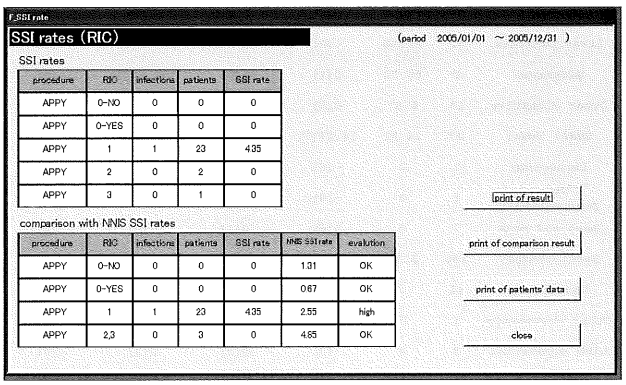
Fig. 6. NNIS annual report data entry screen

6) Calculation of the SSI rate

The SSI rate can be calculated by entering the intended period of analysis (first and last days of the intended period) and selecting the operative procedure and processing method on the statistical analysis choice screen. The intended period of analysis can be set freely, and the operative procedure can be selected from among the 46 items included in the JNIS system. The SSI rate can be analyzed in three modes: by the RIC, by the RIC stratified by the surgeon, and by the RIC stratified by the patient's age.

The SSI rate was calculated as in the model shown in Fig. 7. The SSI rate using the RIC was calculated by the Q_SSISTA obtained through Processes 6 and 7 in the figure. Similarly, the SSI rate using the RIC stratified by the surgeon was calculated from the Q_SSIDOC obtained through Processes 6 and 8, and the SSI rate using the RIC stratified by the patient's age was calculated from the Q_SSIAGE obtained through Processes 6 and 9.

Fig. 8 shows an analysis result screen of the SSI rate using the RIC developed by this system through the above processes. This screen also displays a table comparing the SSI rate with the NNIS SSI rate to facilitate reference to the SSI rates in the United States reported by the NNIS in its Annual Report and a comparison with the surveillance data accumulated in this system. The SSI rates using the RIC that can be compared with the NNIS SSI rate are displayed in Q_SSISTA2 obtained through Processes 6, 10-1, and 10-2 in Fig. 7. Similarly, the SSI rates using the RIC stratified by the surgeon that can be compared with the NNIS SSI rates are displayed in Q_SSIDOC2 obtained by Processes 6, 11-1, and 11-2, and the SSI rates using the RIC stratified by the patient's age that can be compared with the NNIS SSI rates are displayed in Q-SSIAGE2 obtained through Processes 6, 12-1, and 12-2. The results of analysis and data on patients of interest can be exported easily by selecting a button on the screen.



F_SSI rate

SSI rates (RIC) (period 2005/01/01 ~ 2005/12/31)

SSI rates

procedure	RIC	infections	patients	SSI rate
APPY	0-NO	0	0	0
APPY	0-YES	0	0	0
APPY	1	1	23	435
APPY	2	0	2	0
APPY	3	0	1	0

print of result

comparison with NNIS SSI rates

procedure	RIC	infections	patients	SSI rate	NNIS SSIrate	evalution
APPY	0-NO	0	0	0	1.31	OK
APPY	0-YES	0	0	0	0.67	OK
APPY	1	1	23	435	2.55	high
APPY	2,3	0	3	0	4.85	OK

print of comparison result

print of patients' data

close

Fig. 8. Analysis result screen (sample)

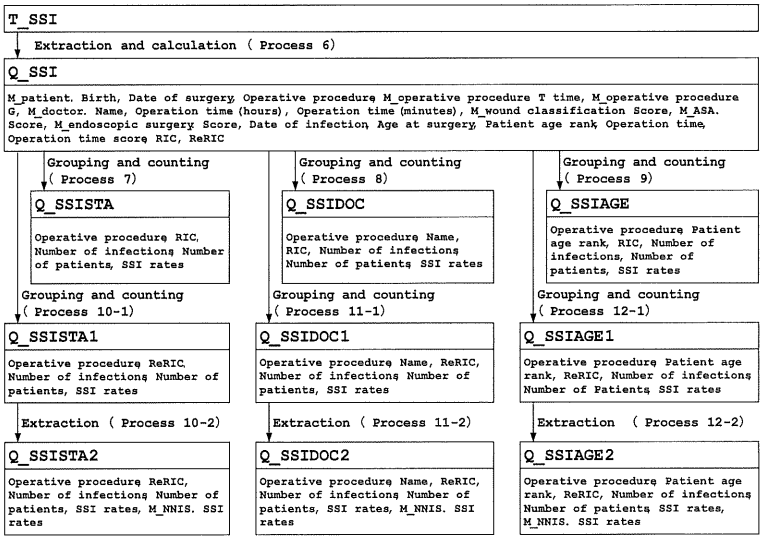


Fig. 7. SSI rate calculation model

7) SSI surveillance data export function

SSI surveillance data accumulated in this system can be exported as a CSV file by selecting either a specified period (date of surgery) or no condition (all accumulated data) in Process 14 of the DFD.

2. Calculation of the infection rate, identification of the pathogen, and estimation of factors important in the occurrence of SSI

Tables 1 and 2 show the results of SSI rate calculations using the SSI surveillance system developed in this study. Of the 798 patients surveyed, who underwent 24 operative procedures, SSI was observed in 47, and the rate was 5.89%. When analysis was performed by the RIC in 777 patients who underwent 15 operative procedures performed in 10 or more patients, the SSI rate was particularly high for other digestive surgery (25.00% in RIC2) among the procedures performed in two or more patients in Table 1, and rectum surgery (30.00% in RIC1 and 20.00% in RIC2) and colon surgery (28.57% in RIC3) in Table 2. These values could be calculated immediately by the statistical function of this system.

Fig. 9 shows the pathogens isolated from SSI lesions. Fifty-one strains were clinically isolated from the 47 patients who developed SSI, and Enterococcus faecalis, Staphylococcus aureus, Klebsiella pneumoniae, and Pseudomonas aeruginosa accounted for 27.45% of these strains.

To extract factors important for the occurrence of SSI from the SSI surveillance data collected from 798 patients, multivariate analysis (quantification method of the second type) was performed by selecting whether SSI occurred as the dependent variable. Fig. 10 shows the results. The top 5 factors that affected the occurrence of SSI and their range scores were the ASA class (4.531), volume of intraoperative hemorrhage (3.075), wound classification (1.76), operation time (1.352), and whether there was a history of diabetes (0.989).

Table 1. SSI rates, by operative procedure and risk index category

Operative procedure category	N	SSI rate	Risk Index Category 0 rate (N)	1 rate (N)	2 rate (N)	3 rate (N)
Other cardiovascular	26	0	0(14)	0(12)	-(0)	-(0)
Other respiratory	13	0	-(0)	0(11)	0(2)	-(0)
Thoracic	17	0	0(6)	0(10)	0(1)	-(0)
Liver/pancreas	42	11.90	-(0)	11.11(27)	13.33(15)	-(0)
Esophagus	2	50.00	0(1)	-(0)	100.00(1)	-(0)
Other digestive	15	6.67	0(5)	0(6)	25.00(4)	-(0)
Small bowel	27	14.81	14.29(7)	9.09(11)	12.50(8)	100.00(1)
Laparotomy	1	0	-(0)	-(0)	-(0)	0(1)
Other genitourinary	1	0	-(0)	0(1)	-(0)	-(0)
Head and neck	7	0	0(6)	0(1)	-(0)	-(0)
Herniorrhaphy	180	3.33	1.98(101)	6.15(65)	0(14)	-(0)
Mastectomy	61	0	0(32)	0(28)	0(1)	-(0)
Other obstetrics	1	0	-(0)	0(1)	-(0)	-(0)
Limb amputation	3	0	-(0)	0(2)	0(1)	-(0)
Other musculoskeletal	1	0	-(0)	-(0)	0(1)	-(0)
Other hem/lymph system	40	2.50	3.57(28)	0(12)	-(0)	-(0)
Other endocrine system	2	0	0(1)	0(1)	-(0)	-(0)
Other integumentary system	11	0	0(9)	0(1)	0(1)	-(0)
Splenectomy	3	0	0(1)	0(1)	0(1)	-(0)

Table 2. SSI rates, by selected operative procedure and modified risk index category incorporating endoscope use

Operative procedure category	N	SSI rate	Risk Index Category 0-NO rate (N)	0-YES rate (N)	1 rate (N)	2 rate (N)	3 rate (N)
Appendectomy	59	5.08	-(0)	-(0)	2.86(35)	10.00(20)	0(4)
Gastric	89	7.87	0(3)	-(0)	7.35(68)	5.88(17)	100.00(1)

Operative procedure category	N	SSI rate	Risk Index Category M rate (N)	0 rate (N)	1 rate (N)	2 rate (N)	3 rate (N)
Cholecystectomy	85	2.35	0(2)	3.17(63)	0(15)	0(3)	0(2)
Colon	80	10.00	-(0)	0(8)	8.11(37)	10.71(28)	28.57(7)
Rectum	32	28.13	-(0)	0(1)	30.00(20)	20.00(10)	100.00(1)

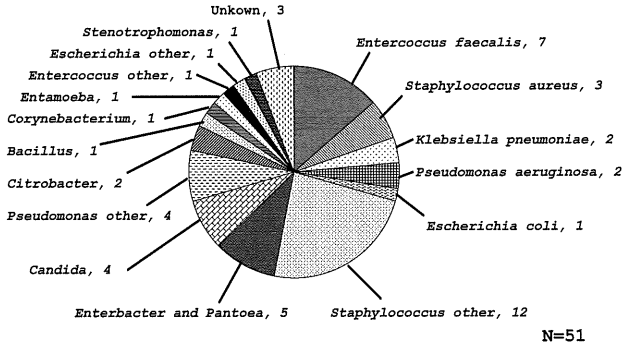


Fig. 9. SSI rates, by operative procedure and risk index category

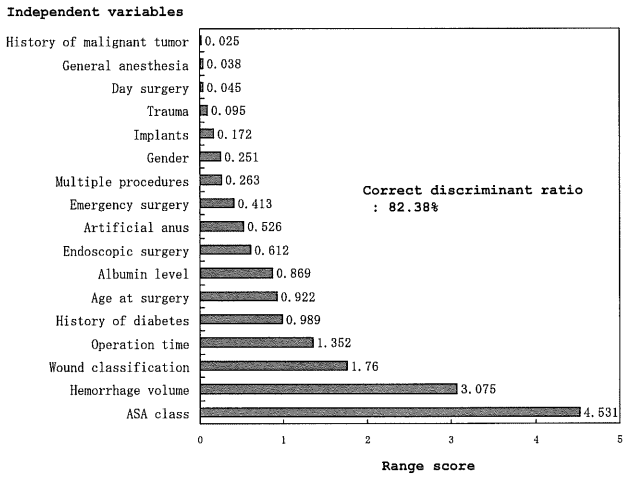


Fig. 10. Range score calculated by multivariate analysis (quantification theory type 2)

Table 3 shows the category scores of these 5 items. According to Table 3, SSI clearly occurred at a higher frequency when the ASA class was 4 or 5, when the intraoperative volume of hemorrhage exceeded 1501 ml, when the wound classification was class 3 or 4, when the operation time was 241 minutes or longer, and when there was a history of diabetes. The judgments by this analysis were correct in 82.38% of cases, leading to satisfactory accuracy.

Table 3. Category scores of major risk factors calculated by multivariate analysis (quantification theory type 2)

Independent variables	Range score	Category	Category score
History of diabetes	0.989	absence	0.110
		presence	-0.880
Operation time	1.352	0-60 min	0.587
		61-120 min	0.151
		121-180 min	0.338
		181-240 min	0.106
		241- min	-0.765
Wound classification	1.760	1	0.336
		2	-0.006
		3	-1.424
		4	-1.292
Hemorrhage volume	3.075	0-600 ml	-0.021
		601-1500 ml	0.780
		1501- ml	-2.295
ASA class	4.531	1	0.026
		2	-0.057
		3	0.203
		4	-4.328
		5	-2.002

DISCUSSION

The implementation of surgical site infection surveillance is considered to be a necessary activity of medical organizations to ensure the safety of surgery and to improve the quality of safety measures. Indeed, in the United States, it has been reported that the occurrence of SSI was associated with an average 7-day prolongation of hospitalization and additional charges of about 3,000 dollars[4], having considerable effects on patient satisfaction and cost.

Under these circumstances, a nationwide use of hospital SSI surveillance is desirable. Actually, "Ministerial Ordinance of Partial Revision of the Rules for the Enforcement of Medical Laws" issued in February, 2005 by the Ministry of Health, Labor and Welfare recommends implementation of this surveillance[26], and systematic efforts to implement it were adopted as an item of "Hospital Function Assessment" performed by the Japan Council for Quality Health Care[22]. However, in the implementation of SSI surveillance, technical understanding by medical staff regarding its methods or their application in the hospital remains inadequate. Moreover, as staff members in charge of measures against nosocomial infections are difficult to recruit, few organizations are performing this surveillance as a routine task. Up to the present, storage, sorting, and assessment of collected surveillance data and their use to improve the situation have been done only on paper, and the development of an electronic system has been desired to improve the efficiency and accuracy of these procedures[10]. To meet this need, we developed an original electronic system using the commercial database software Microsoft AccessR to perform SSI surveillance easily and accurately. The concepts of the development were: (1) to accumulate SSI surveillance data in a mode compatible with the NNIS and JNIS systems; (2) to realize a simple and comfortable entry environment by the extensive use of 10 keys and combo boxes; (3) to achieve a high level of flexibility in handling different coding systems for patient properties, including the number of digits in the patient ID numbers; (4) to ensure the accuracy of entries by checking functions of entry defects of essential items and consistency among items; (5) to be able to statistically process the accumulated data by operative procedure, to immediately sort the data by the RIC, and to compare them with the latest NNIS SSI rates; (6) and to allow printing or electronic exporting of the accumulated data and surveillance results. The system that we developed realized these concepts. Furthermore, as promptness and accuracy are the most important factors for nosocomial infection surveillance, and as efficient operation is also required, it is thought this system will contribute to not only the implementation of SSI surveillance, but also the domestic spread of SSI surveillance, because, to our knowledge, no software has been developed specifically for this purpose.

When SSI surveillance was performed using this system in the Department of Gastrointestinal Surgery, Mazda Hospital, Mazda Motor Corporation, the surveillance results concerning 24 operative procedures could be immediately printed out according to the RIC. Moreover, the analytical results according to the RIC could be displayed with stratification by the surgeon or by patient's age, achieving a high degree of freedom in statistical analyses. In addition, as stratification by these two items is considered to provide information useful for the prompt implementation of measures to control SSI in hospitals, this function is considered to be directly pertinent to improvements in anti-nosocomial infection measures.

The SSI rate was particularly high for rectum surgery (30.00% in RIC1 and 20.00% in RIC2) and colon surgery (28.57% in RIC3) among operative

procedures. According to the SSI Surveillance Summary of the JNIS Committee of the Japanese Society of Environmental Infections (issued in March, 2005)[13], the SSI rate was 22.65% for RIC1 rectum surgery, 33.15% for RIC2 rectum surgery, and 21.05% for RIC3 colon surgery, in accord with our results at 39 domestic facilities. In these two operative procedures, the risk of SSI is considered to increase as opening of the gastrointestinal tract increases the chances of contamination by intestinal bacteria, and because these procedures, which are semi-unclean surgery, further increase the degree of microbial contamination due to intraoperative efflux of intestinal contents, etc. While the further accumulation of cases must be awaited, and a conclusion at this point should be avoided, the occurrence of SSI tended to increase with rises in the RIC value.

Of the pathogens isolated from the SSI lesions, Enterococcus faecalis, Staphylococcus aureus, Klebsiella pneumoniae, Pseudomonas aeruginosa, and Escherichia coli accounted for about 30% of all isolates. The above SSI Surveillance Summary of the JNIS Committee also reported that Enterococcus faecalis, Staphylococcus aureus, Pseudomonas aeruginosa, and Escherichia coli were major pathogens among a total of 960 strains isolated, and the frequency of their isolation was similar to ours. Since these bacteria are present at high concentrations in the lower gastrointestinal tract, they are considered to directly affect the infection rates in operative procedures such as REC and COLN.

As a result of statistical analysis of the surveillance data collected in this study, (1) the ASA class of the patient, (2) volume of intraoperative hemorrhage, (3) wound classification, (4) operation time, and (5) history of diabetes were selected as important factors for SSI, exerting greater effects than other factors. Presently, in Japan, the SSI rate is generally calculated and presented according to the RIC level using three factors, i.e., the ASA class, wound classification, and operation time, for risk adjustment according to the NNIS method. Although problems have been suggested regarding the risk adjustment methods of the NNIS, e.g., the occurrence of SSI was reported not to have correlated with the operation time or ASA class in Japanese patients undergoing gastrointestinal surgery[20,21], the ASA class of the patient, wound classification, and operation time all ranked high among risk factors by multivariate analysis in our study, supporting the NNIS risk adjustment method. In addition, the volume of intraoperative hemorrhage and history of diabetes were suggested to be high risk factors for the occurrence of SSI, in agreement with some reports[11,12,15,28].

It has been suggested that the rate of SSI can be reduced if medical staff take various measures to improve or intervene in factors extracted as important in the occurrence of SSI[6,16,27]. Thus, evidence-based activities are necessary for future anti-nosocomial infection measures, and the core operation is considered to be infection surveillance. The SSI surveillance system that we have developed, which allows accurate and easy implementation of surveillance in each facility, is offered as a useful tool for surgical safety management.

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