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Comparison of surgical site infection rates among surgeons

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ABSTRACT

This paper presents a comparison of surgical site infection (SSI) rates among surgeons taking into account surgical procedures and risk factors. This methodological approach allows and facilitate such comparisons as it considers potential confounding factors that may be involved. A database of 5,023 surgical procedures classified according to the National Nosocomial Infection Surveillance System (NNIS) was used to obtain adjusted SSI rates considering the surgical site and three essential variables part of the NNIS surgical risk index: (i) the ASA (American Society of Anesthesiology) physical status score; (ii) the surgical wound classification and (iii) the duration of surgery. Surgical procedures were then categorized into four risk strata: low-risk, medium low risk; medium high risk and high risk. The comparison of these rates was done using indirect standardization. The SSI rate observed for each surgeon was compared to the expected rate for the same risk strata according to the hospital database, which was taken as the reference population. Finally, dividing the number of observed SSI by the expected SSI a standardized surgical site infection ratio (SSIR) was obtained for each surgeon by procedures. The SSIR may be considered a relative, indirect and adjusted rate by risk strata, which provides a feasible alternative to compare rates among surgical teams in the same institution. **Key-words:** hospital infections, surveillance, surgical site infection.

INTRODUCTION

Surgical site infections (SSI) are the third most common type of healthcare acquired infections (HAI) in hospitals.[3,4] Apart from representing substantial morbidity and mortality, SSI cause duplication of the hospital stay[5] and an estimated additional cost of 2,000 dollars per patient.[6] Different SSI surveillance methods have been developed and validated.[2, 6, 7] These methods include the classification of the main risk factors related to SSI occurrence depending on the patient or the surgical procedure itself.[7] Among these, the most frequently mentioned factors are: (i) the surgical wound classification; (ii) the operative technique (iii) events occurring during the surgery; (iv) the patient's intrinsic susceptibility to infection[2, 6, 7] and (v) aspects related to the patient surgical preparation.[8, 9] One of the roles of SSI surveillance is to enable adequate comparison within hospitals, services and surgical teams.[10] For an adequate comparison of the SSI rates, specific diagnostic criteria and adequate identification of the cases of patients with HAI are necessary and should accurately reflect the hospital population exposed to risk.

Since the widespread of the "wound contamination class" in the sixties,[2,7,11] several additional factors have been proposed in order to gather patient-related morbidity information, and thus enhance the comparability between the SSI rates.[7] Existing SSI surveillance systems that provide HAI information for surgical teams can reduce SSI rates by as much as 32%.[12] *The Study on the Efficacy of Nosocomial Infection Control* (SENIC) developed a multi-variable risk index for comparing the SSI which included four dichotomous factors: (i) surgeries lasting more than two hours; (ii) classification of the operative surgical wound in contaminated or infected; (iii) patients with three or more diagnostics on discharge and (iv) surgery involving the abdominal cavity.[7] At the end of the 1980´s, in the *National Nosocomial Infection Surveillance* (NNIS) study, the *Centers of Disease Control and Prevention* (CDC) further improved the SENIC proposed surgical risk index by incorporating the American Society of Anesthesiology (ASA) classification scale to measure the patient's intrinsic susceptibility to infection.[13] For the duration of surgery, the percentile 75, specific for each type of procedure, was substituted by a cut-off point for above or bellow two hours.

When the NNIS results were divulged it was found that the risk index of the study had a good capacity to distinguish between the majority of the surgical procedures even though it was very dependent on the number of procedures in each risk level.[14] This dependency prevented its use for the classification of hospital infections in small hospitals, and made it insuitable for detecting differences in databases containing a reduced number of surgeries. Therefore, an alternative method of classification for detecting small variations between the SSI risk categories was required. Furthermore, even if the relevance of the adoption of an index that permits better comparisons between the SSI risks is accepted, it is true that very few hospitals now use any form of infections grading.[15] This is mainly due to the difficulty in obtaining patient details that make up the index and the inadequacy of the patient details in computer records.[16,17] In this context, the CDC specialists suggested different approaches to permit comparison between the rates and surgeries over the last ten years. However, for minor surgical procedures, or in hospitals where a reduced number of interventions take place, no adequate system to estimate surgical performance and risks is available at present .

Gaynes[18] recommended that the SSI rates should incorporate some form of indirect standardization process.[19] The expected SSI value for samples is calculated to obtain the SSI referential rates for each level of risk. This number, multiplied by the number of procedures in the sample, is the SSI number expected for each risk level. The total of the SSI numbers expected in all risk categories is the SSI expected number for the sample. Finally the author[18] proposes the calculation of the standardized SSI ratio for use as an indicator between the rates. In this way, values lower than one would indicate intervention rates competitive with the average, while rates over one would signify that hospital infections over the average had occurred and required deeper investigation. Starting with the grading process described above, it would be possible to obtain a standardized surgical site infection ratio (SSIR) represented by an SSI coefficient adequately adjusted, that permit the confrontation of the expected SSI number with that obtained in the systematic SSI surveillance.18 The SSIR would offer a relatively simple and accessible alternative to compare SSI rates.[18,20]

The objective of this paper is to propose and evaluate a method for SSI comparison rates between the various surgical teams who operate in a teaching hospital in the Southern of Brazil.

PATIENTS AND METHODS

We included 5023 surgical procedures conducted in the Hospital de Clínicas de Porto Alegre (Porto Alegre Clinical Hospital) (HCPA), in Rio Grande Sul State, South of Brazil. All the procedures were classified according to CDC surgical procedures categories and further sub-divided by NNIS risk index levels, to reduce the considerable number of sub-categories obtained and enable standardization of the SSI.

Surgical procedures were grouped and distributed within a reduced number of risk corresponding to progressive levels of SSI risk occurrence. Accordingly, the entire database was concentrated into four pre-fixed strata defined as (i) low risk of SSI occurrence risk (< 2,0%), medium low-risk (2,0% |— 5,0%), medium high risk (5,0% |— 9,0%) and high risk (≥ 9,0%).[14]

Surgical teams who performed less than 20 surgical procedures were not included in the overall indirect standardization. In this process, the SSI reference rate was multiplied by the number of surgical procedures performed by each surgical team in that same strata. With this, the expected SSI number for each surgeon was obtained. The total of SSI numbers observed in the different risk grades for each surgeon divided by the corresponding total of the expected SSI risk (obtained by the above-mentioned method) generated the SSIR or surgical site infection ratio. The SSIR is equivalent to the standardized morbidity/mortality ratio or SMR generally used in the process of indirect standardization.[19] Therefore, the SSIR may be considered an indirect relative rate adjusted for the potential of risk of infection represented, in our study, by the four grades proposed.[14,18,20] In mathematical terms the SSIR may be expressed by the following equation: *SSIR= (SSI observed)/(SSI expected)*

For the interpretation of the SRSSI the following criteria were used:

SSIR = 0, the surgeon did not present cases of patients with SSI.

SSIR = <1, the surgeon presented a SSI rate lower than that expected for the distribution of his/her patients in the SSI risk grade.

SSIR = 1, the surgeon presented a SSI rate equal to that expected for the distribution of his/her patients in the SSI risk grade.

SSIR = >1, the surgeon presented a SSI rate greater than that expected for the distribution of his/her patients in the SSI risk grade.

To enable SSI rates comparison amongst surgeons considering potential risk factors, SSIR ratios were ranked from the surgeon with the lowest SSIR value (lowest rate of relative SSI) to the highest value (highest rate of relative SSI). For deciding between surgeons with the same SSIR result, the surgeon with the greatest number of performed surgical procedures was chosen.

Two trained research assistants revised all patients records[21,22] and gathered the following information: (i) surgical procedures (number of surgical procedures, type of surgery, surgical team, and ASA score), (ii) types and location site of HAI, if applicable, (iii) invasive procedures (e.g catheter and mechanical ventilation) performed; and (iv) preventive measures for HAI prevention. HAI data is processed using an informatized system developed at HCPA. HAI were classified using the diagnostic criteria of the CDC.

Statistical Analysis

The SSIR confidence interval was obtained using the Poisson distribution because of its similarity to the standardized ratio of morbidity/mortality (SMR) and in accordance with the method proposed by Kahn and Sempos.[19] A 5% significance level was used. The data were processed and analyzed using the following softwares: MS EXCEL® 14.0, Pepi® version 4.0 and SPSS® version 16.0.[26]

RESULTS

The original databank contained 5,023 surgical procedures of which all those presenting a frequency less than 20 were excluded The final number of patients considered was 4,627 .

The general SSI incidence rate observed was 7.78%. Approximately 160 subcategories of surgical procedures were performed and graded into four risk strata (0, 1, 2 and 3) with their respective SSI rates (Table 1). Some surgical procedures (e.g. neurosurgeries, nephrectomies, and transplants) were infrequent, and therefore, the related SSI rate was low or inexistent. The SSI in the column of risk level 1 of the NNIS, for example, present considerable internal variation which required grouping of the proportions or SSI rates to enable comparison. The reduced number of surgical procedures graded in NNIS level 3 corresponded to 1.87% (n = 94) of the sample studied. It was observed a linear increase in the SSI frequency as the level of the risks increased. This tendency was especially demonstrated in surgery involving the abdominal cavity, such as, cholecystectomies, appendectomies, geniturinaries, of the liver and pancreas, for example. The abdominal surgeries were the most representative in the sample, reaching a total of 965 (77.3%) of the surgical procedures submitted to the NNIS risk level classification.

Table 2 presents the surgical procedures (n = 4,627) and the respective SSI rates after grading into the four NNIS risk levels. The surgical procedures were grouped into SSI rates below 2% (low risk), from 2 to 5% (medium risk), from 5 to 9% (medium high risk) and over 9% (high risk). The expected SSI values in each of these grades were 1.43%, 3.31%, 6.62% and 18.47%, respectively. The SSI rate of the surgical procedures classified as of high risk (SSI rate above 9%) represented 56.25% (n = 207) of the studied sample. Table 3 demonstrates the surgeons, the number of surgical procedures and the respective SSI number distributed into the considered risk levels. A reasonable level of heterogeneity between expected and observed SSI rates amongst surgical teams can be observed. The discrepancies were more often within 3 and 4 surgical risk levels. Of note, some surgeons performed interventions belonging to only one of the risk levels, such as the surgeons codes 6, 7 and 33. On the other hand, surgeons 101,102 and 103 performed surgical interventions in 3 risk levels (2, 3, and 4).

To enable the comparison amongst surgeons, the SSIR general numbers were calculated for each surgeon by adding up all procedures registered in the databank for that surgeon and presented with their respective confidence intervals in Table 4. In this table, the surgeons were ranked in ascending SSIR order, listed from the first (surgeon code 401, SSIR 0.00) to the last (surgeon code 502, SSIR =1.85). It should be pointed out that only the one surgeon, (code 502, SSIR=1.85) who was classified in position 26th, presented a confidence interval statistically significant (CI 95% 1.25 –2.65). This finding may suggest the need for a more detailed monitoring of his/her performance prospectively to determine if the finding was an fortuity event or if that indicates a problem that requires intervention from the hospital infection control committee.

DISCUSSION

Using an existing databank of surgical procedures, it was possible to demonstrate the feasibility of a quite simple method for SSI standardized rates comparison amongst surgeons in a teaching hospital. The applicability of the proposed SSI adjustment method precludes the use of relatively more complex multivariable regression models,[27,28,29] and thus applicable for single hospitals. The results showed here demonstrate that it was possible to improve the understanding of the adjustment process of SSI rates thought a quite simple comparison method that can be used by any infection control committee as an easy and feasible method for surgical teams comparative performance analysis.[20, 21]

Of note, one of the limitations of the proposed methodology relies on the assumption of a necessary certain number of surgical procedures in each risk category. That means that the proposed method for SSI rates comparison may not be used in small or low surgical volume hospitals. In our study, considering the surgical procedures graded by the NNIS index as it was shown in Table 1, a pulverization of the number of surgical procedures was observed. The reduced number, or even the inexistence of surgeries in many of the NNIS risk levels, may preclude an accurate observation of any discrepant behaviour of SSI rates. Accordingly, only in surgeries with a constant and stable number in each NNIS category level it was possible to detect the increase in rates with addition of the risk factor, as in cholecystectomies, genitourinaries procedures, gastric and liver and pancreas surgeries, for example. However, in procedures with increase of the risk factors between levels 0 and 1, such as in cholecystectomies and genitourinaries procedures, even when an increase in the SSI rate was detected in levels 2 and 3, this did not adequately reflect the increasing risk due to the insufficient number of surgeries in these levels. In other surgical procedures, however, even with a sufficient number of stable cases in the first two risk levels (0 and 1) as in abdominal hysterectomies e appendectomies; in levels 3 and 4 the tendency was not confirmed. That is, in our databank, the inherent risk level per surgical procedure was not reflected adequately in the NNIS classification.[14] The predominance of surgeries involving the abdominal cavity, (which has a high infection risk, e.g. ≥ 9%) permits the observation of an increasing linear tendency of the frequency of SSI that could have been effectively confirmed with a larger number of surgical procedures. This limitation was originated after grouping categories that could more clearly reflect the inherently procedure-specific risk to enable SSI rates comparison.

More importantly than just simple grouping, the distribution of the procedure in risk grades (Table 2) permits the interpretation of the value of SSI rate, taking into account the risk inherent in the surgical procedure. To use this methodological approach in SSI epidemiological surveillance, the process of distribution of the surgical procedures in the risk grades should be dynamic, that is, it should change with each addition of a consistent number of surgeries, half-yearly or yearly, for example. The ratios of the standardized SSI (SSIR) vary considerably between professionals and categories, as it was shown in Table 4. The criteria for differentiating between two surgeons with equal scores was the number of procedures performed. Therefore a surgeon who operated more and thus exposed himself/herself to a greater risk ought to get a superior performance classification than another who had not performed so many interventions.

The HAI risk factors have been sufficiently studied in the last two decades and the complexity involving the SSI phenomenon also has been studied with multivariable regression models using extensive databanks in the SENIC and the NNIS studies.[31] Some authors have demonstrated that the variables used in the NNIS study (surgical procedure duration or ASA score) are not necessarily associated to SSI in certain specific surgical procedures.[29,30] Those studies recommend the development of a combination of specific risk factors for certain surgeries because they may be more predictive of SSI risk than the NNIS index alone.[25] Other studies recommend that infection control committees should focus on large, clean surgeries, such as the hip prostheses, due to the morbidity, mortality and economic impact of an SSI in these procedures.[17] As the classical risk factors have already been established,[14,20,] the challenge now facing the infection control comittee is to integrate this knowledge in the practical context of daily SSI surveillance.[31] The use of the SSIR, as suggested, permits the identification of local comparison references making it possible to detect more clearly changes of SSI risk behavior or to monitor trends between different surgeons or surgical procedures.

CONCLUSION

We believe that the proposed methodological approach to SSI standardized comparison rates enhances the possibility of adopting preventive measures27, 32,33 towards a relatively simple approach which precludes the utilization of multivariable analysis models.

Table 1. Operative procedure and SSI rates by NNIS risk index category, HCPA, (N=5023).

Operative procedure category		NNIS Risk Index							
		0		1		2		3	
Description	Code	Nº	SSI rate(%)	Nº	SSI rate(%)	Nº	SSI rate(%)	Nº	SSI rate(%)
Herniorraphy	HER	387	3.6	130	10.0	22	9.1	1	0.0
Cholecystectomy	CHOL	242	5.8	220	8.2	25	8.0	6	16.7
Open reduction of fracture	FX	166	1.2	115	3.5	23	0.0	-	-
Appendectomy	APPY	6	0.0	58	3.4	36	25.0	2	0.0
Colon	COLO	2	0.0	52	26.9	59	32.2	15	40.0
Coronary artery bypass graft	CABG	2	0.0	22	4.5	7	0.0	-	-
Mastectomy	MAST	132	3.8	64	7.8	2	0.0	-	-
Other genitourinary	OGU	311	5.1	291	6.5	50	26.0	2	100.0
Gastric	GAST	32	12.5	48	20.8	16	12.5	1	0.0
Other hem/lymph system	OBL	13	23.1	5	20.0	-	-	-	-
Other digestive	OGIT	3	0.0	105	1.9	37	27.0	8	12.5
Other endocrine system	OES	48	2.1	15	13.3	4	25.0	-	-
Other nervous system	ONS	3	0.0	2	0.0	2	0.0	-	-
Other integumentary system	OSKN	29	3.4	91	8.8	38	5.3	8	0.0
Prostatectomy	PRST	85	1.2	80	13.8	36	19.4	-	-
Laparotomy	XLAP	27	14.8	60	6.7	77	23.4	31	32.3
Skin graft	SKGR	28	7.1	19	0.0	4	0.0	-	-
Nephrectomy	NEPH	10	0.0	18	5.6	7	0.0	-	-
Vascular	VS	196	2.6	77	10.4	48	16.7	1	0.0
Cardiac	CARD	-	-	15	6.7	5	20.0	1	0.0
Abdominal hysterectomy	HYST	165	7.3	64	12.5	12	0.0	-	-
Other musculoeskeletal	OMS	273	1.8	159	6.3	18	5.6	2	0.0
Thoracic	THOR	7	0.0	34	23.5	11	27.3	-	-
Knee/Hip	PROS	69	2.9	46	0.0	13	0.0	-	-
Vaginal hysterectomy	VHYS	2	0.0	31	6.5	17	5.9	3	0.0
Other obstetric	OOB	-	-	1	0.0	-	-	-	-
Limb amputation	AMP	4	0.0	27	7.4	70	10.0	5	20.0
Head and neck	HN	2	50.0	-	-	1	100.0	-	-
Liver/pancreas	BILI	57	24.6	54	18.5	17	29.4	3	33.3
Splenectomy	SPLE	3	0.0	1	0.0	-	-	-	-
Organ transplant	TP	-	-	3	0.0	1	100.0	-	-
Other ENT (ear, nose, and throat).	OENT	11	9.1	3	33.3	2	0.0	-	-
Small bowel	SB	1	0.0	11	27.3	8	37.5	4	0.0
Ventricular shunt	VSHN	1	0.0	1	0.0	1	0.0	1	0.0
Cholecystectomy with laparoscope	CHL2	8	0.0	4	25.0	-	-	-	-
Herniorraphy with laparoscope	HER2	1	0.0	1	0.0	-	-	-	-
Laparotomy with laparoscope	XLP2	3	0.0	1	0.0	-	-	-	-
Other eye	OEYE	1	0.0	-	-	-	-	-	-
Other respiratory	ORES	-	-	-	-	1	0.0	-	-
Spinal fusion	FUS	-	-	1	0.0	-	-	-	-
Σ		2330	-	1929	-	670	-	94	-

N: number of operative procedures in each NNIS risk index category , SSI expressed per 100 operations.

Table 2. Operative procedures according to risk index category, occurrence of surgical site infection (SSI) and SSI rate (%), HCPA, 1996 (N=4627).

Risk Index category	N	SSI frequency	SSI Rate (%)
Low risk (< 2%)	698	10	1.43
Medium-low (≥ 2% a <5%)	1056	35	3.31
Medium-high (≥ 5% a <9%)	1752	116	6.62
High risk (≥ 9%)	1121	207	18.47
Σ	4627	368	-

SSI: surgical site infection; SSI rate (%): SSI expressed per 100 operations.

Table 3. Surgeon and operative procedure performed by risk index category, Observed SSI (OSSI), Observed SSI rate (OSSI rate, %). Expected SSI (ESSI) and Expected SSI rate (ESSI rate, %)

Surgeon (code)	Risk Index category	N	OSSI	OSSI rate (%)	ESSI	ESSI rate (%)
6	4	21	3	14.29	3.88	18.47
7	4	27	2	7.41	4.99	18.47
33	1	20	0	0.00	0.29	1.43
101	2	179	3	1.68	5.92	3.31
101	3	193	5	2.59	12.78	6.62
101	4	226	28	12.39	41.74	18.47
102	2	84	1	1.19	2.78	3.31
102	3	64	6	9.38	4.24	6.62
102	4	73	20	27.40	13.48	18.47
103	2	59	5	8.47	1.95	3.31
103	3	118	9	7.63	7.81	6.62
103	4	56	11	19.64	10.34	18.47
104	1	39	0	0.00	0.56	1.43
104	3	102	3	2.94	6.75	6.62
105	2	62	5	8.06	2.05	3.31
105	3	63	6	9.52	4.17	6.62
105	4	49	7	14.29	9.05	18.47
106	2	82	2	2.44	2.71	3.31
106	3	114	9	7.89	7.55	6.62
106	4	100	22	22.00	18.47	18.47
202	1	39	0	0.00	0.56	1.43
203	1	50	1	2.00	0.72	1.43
204	1	57	2	3.51	0.82	1.43
204	2	59	3	5.08	1.95	3.31
205	1	101	0	0.00	1.44	1.43
205	2	33	1	3.03	1.09	3.31
206	1	35	0	0.00	0.50	1.43
207	1	54	1	1.85	0.77	1.43
207	2	21	0	0.00	0.70	3.31
207	3	20	0	0.00	1.32	6.62
301	2	25	1	4.00	0.83	3.31
301	3	63	8	12.70	4.17	6.62
401	2	42	0	0.00	1.39	3.31
402	2	49	1	2.04	1.62	3.31
402	4	48	12	25.00	8.87	18.47
403	2	34	1	2.94	1.13	3.31
403	4	39	4	10.26	7.20	18.47
502	1	72	1	1.39	1.03	1.43
502	4	82	29	35.37	15.15	18.47
602	1	23	0	0.00	0.33	1.43

(CONTINUES)

Table 3. Surgeon and operative procedure performed by risk index category, Observed SSI (OSSI), Observed SSI rate (OSSI rate, %). Expected SSI (ESSI) and Expected SSI rate (ESSI rate, %)

Surgeon (code)	Risk Index category	N	OSSI	OSSI rate (%)	ESSI	ESSI rate (%)
602	3	99	7	7.07	6.55	6.62
602	4	57	14	24.56	10.53	18.47
603	1	20	1	5.00	0.29	1.43
603	3	100	6	6.00	6.62	6.62
603	4	48	10	20.83	8.87	18.47
701	2	27	1	3.70	0.89	3.31
701	3	58	4	6.90	3.84	6.62
702	2	25	0	0.00	0.83	3.31
702	3	64	8	12.50	4.24	6.62
705	3	166	9	5.42	10.99	6.62
705	4	21	1	4.76	3.88	18.47
707	3	50	4	8.00	3.31	6.62

N: number of operative procedures by risk index category; SSI: surgical site infection; SSI expressed per 100 operations.

Table 4. Surgeon's classification according to operational procedures and ratios of standardised surgical site infection (RSSSI). Details in the text.

Surgeon (code)	N	SSI observed	SSI expected	RSSSI*	95 CI%	Classification
401	42	0	1.39	0.00	0.00 – 2.65	1
202	39	0	0.56	0.00	0.00 – 6.59	2
206	35	0	0.50	0.00	0.00 – 7.38	3
33	20	0	0.29	0.00	0.00 – 12.72	4
207	95	1	2.79	0.36	0.01 – 2.00	5
205	134	1	2.53	0.40	0.01 – 2.20	6
7	27	2	4.99	0.40	0.05 – 1.45	7
104	141	3	7.31	0.41	0.08 – 1.20	8
101	598	36	60.44	0.60	0.42 – 0.82	9
403	73	5	8.33	0.60	0.19 – 1.40	10
705	187	10	14.87	0.67	0.32 – 1.24	11
6	21	3	3.88	0.77	0.16 – 2.26	12
701	85	5	4.73	1.06	0.34 – 2.47	13
603	168	17	15.78	1.08	0.63 – 1.72	14
106	296	33	28.73	1.15	0.79 – 1.61	15
105	174	18	15.27	1.18	0.70 – 1.86	16
602	179	21	17.41	1.21	0.75 – 1.84	17
707	50	4	3.31	1.21	0.33 – 3.09	18
402	97	13	10.49	1.24	0.66 – 2.12	19
103	233	25	20.10	1.24	0.80 – 1.84	20
102	221	27	20.50	1.32	0.87 – 1.92	21
203	50	1	0.72	1.39	0.04 – 7.74	22
702	89	8	5.07	1.58	0.68 – 3.11	23
301	88	9	5.00	1.80	0.82 – 3.42	24
204	116	5	2.77	1.81	0.58 – 4.21	25
502	154	30	16.18	1.85	1.25 – 2.65	26

N: nº of operative procedures in each strata; SSI: surgical site infection; expressed per 100 operations.

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