



NOSOCOMIAL INFECTIONS

Monitoring Surgical Site Infections: Insights from an Italian Teaching Hospital

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Keywords

Healthcare-Associated Infections • Infection Control • Surgical Site Infection • Surveillance • Patient Safety

Summary

Background. Surgical Site Infections (SSIs) are among one of the most frequent and costly healthcare-associated infections (HAIs), leading to increased patient morbidity, prolonged hospital stays, and higher healthcare costs. Surveillance programs are essential for detecting, monitoring, and preventing SSIs. However, the implementation and effectiveness of these programs varies across healthcare facilities. This study aims to provide effective data gathered from SSI trend assessment at Ferrara Teaching Hospital to improve surveillance systems.

Materials and methods. A retrospective study was conducted on data collected between 2020 to 2023 from the SICHER surveillance system and Hospital Discharge Cards at Ferrara Teaching Hospital. The analysis examined infection rates across various surgical procedures, applying two primary indicators: SSI Percentage by Category and Incidence Density of Hospital-Onset SSIs. Statistical analyses were performed using STATA software.

Results. An average of 5,158 surgical procedures were executed annually between 2020 to 2023, and SICHER-monitored procedures steadily increased during this period, reaching 80.7% coverage in 2023. The highest infection rates were recorded in colon surgery, while cardiac surgery consistently recorded no infections. The overall incidence density of hospital-onset SSIs was 0.18 per 1,000 follow-up days, with significant variations across surgical categories. The accuracy of HDCs in documenting SSIs improved over time, achieving a 97.2% match in 2023.

Conclusion. The study highlights an increasing trend in SSI surveillance coverage and accuracy, demonstrating the effectiveness of the SICHER system in monitoring infections. However, variations in infection rates among different procedures suggest the need for targeted strategies, particularly for high-risk surgeries such as colorectal and orthopaedic procedures.

Introduction

Healthcare-associated infections (HAIs) caused by bacteria, viruses, or other pathogens represent one of the most common adverse events associated with medical care. They can occur across all healthcare settings, including inpatient facilities, outpatient clinics, and long-term residential care facilities. HAI transmission can result from both endogenous mechanisms and exogenous events, the latter being the most frequent. In hospital settings, it is estimated that approximately 5-15% of hospitalized patients develop at least one HAI during their stay [1]. Therefore, HAIs represent a significant public health issue as they generate heightened costs, reduce quality of life, and increase the risk of morbidity and mortality [2, 3].

According to the Centers for Disease Control and Prevention (CDC), HAIs are classified into several categories, including central line-associated bloodstream infections, catheter-associated urinary tract infections, surgical site infections (SSIs), ventilator-associated pneumonias, non-ventilator-associated nosocomial pneumonias, gastrointestinal infections, other primary bloodstream infections not associated with central

lines, and urinary tract infections not associated with catheters [4]. Among these groups, SSIs are the most frequent and the most costly. An estimated 0.5%-3% of patients undergoing surgery develop such infections, leading to extended hospital stays of approximately 7-11 additional days, increased emergency department visits, and a higher risk of hospital readmission [5-7].

However, the actual frequency of SSIs is likely underestimated since roughly 50% occur after patient discharge [8]. Currently there is no international scientific standard for post-discharge SSI surveillance [9]. Common methods for identifying surgical wound infections after hospital discharge include direct observation by healthcare personnel, telephone follow-up interviews, patient-reported questionnaires, and outpatient follow-up visits [10]. Due to the lack of standardized post-discharge surveillance, SSIs are often overlooked [11, 12].

With the growing demand for healthcare services, early diagnosis of SSIs has become critical to enabling timely and effective treatment, accelerating patient recovery [10, 13]. Evidence suggests that SSI surveillance in hospital settings can reduce infection rates by increasing awareness and attention among

healthcare professionals and promoting best practices - although this focus is not universally shared among all practitioners today [14, 15]. Surveillance is widely considered a key component of infection prevention and control programs [16, 17]. To date, there is no single, “correct”, or universally accepted methodology for designing or implementing surveillance systems [16, 18]. However, some minimum criteria have been identified to ensure quality surveillance, such as a written plan clearly indicating objectives, targets and elements of the surveillance process, consistent application of surveillance methods, coherent surveillance elements, adequate human resources and information technology services, and evaluation strategies. Furthermore, for a successful surveillance program, there should be a robust data validation process to ensure that the data is accurate and reliable [16, 18, 19].

In this context, the development of surveillance and monitoring systems capable of providing comprehensive, timely, and accurate information regarding SSIs is essential to effectively address this important issue. These systems can be considered an integral part of programs aimed at promoting the quality of healthcare [20].

This study aims to monitor SSI trends at the Ferrara Teaching Hospital, with the objective of providing useful data to improve surveillance systems and contribute to reducing the incidence of this phenomenon.

Material and methods

STUDY DESIGN, DATA COLLECTION AND SETTING

A retrospective study was conducted on data from 2020 to 2023, collected from both surgical site infection surveillance of the Emilia-Romagna Region, called “SICHER”, and the Hospital Discharge Cards (HDCs) of the Ferrara Teaching Hospital. The SICHER system aims to collect information on every surgical procedure and calculates infection rates taking into account: the volume of activity within each specific operational unit, each patient’s intrinsic risk factors, and the risk associated with the type of surgical procedure [21].

Ferrara Teaching Hospital is the primary hospital serving the city of Ferrara, acting as a high-specialty referral hub for provincial healthcare and acute care management. Healthcare services are distributed across 41 Units and grouped into 9 clinical departments. The hospital is equipped with 660 regular inpatient beds, 21 Day Hospital beds, 30 Day Surgery beds, and extensive diagnostic facilities. The hospital includes 139 outpatient clinics and houses 23 operating rooms, 4 Day Surgery rooms, and a delivery suite. Each year, the Ferrara Teaching Hospital performs an average of 2.2 million outpatient procedures, 27,010 inpatient admissions (excluding healthy newborns), and 6,717 Day Hospital/Day Surgery admissions [22].

ANALYSIS

From the “SICHER” surgical site infection (SSI) surveillance data, the total number of procedures

performed, the number of SSIs, and the number of follow-up days (postoperative inpatient days with a documented discharge date) were extracted. The surgical procedures were classified according to the US National Healthcare Safety Network (NHSN) classification system [17, 23]. The procedures included in the surveillance were only those necessary to obtain sufficient data to reach statistically valid conclusions (Tab. I), as outlined in the Technical Document from the Italian National Institute of Health titled *National Surveillance of Surgical Site Infections (SNICH2) and Prevention Indicators in Hospitals* [24]. Coronary artery bypass grafting procedures (CABG, CBGB, and CBGC) were not included as they are not procedures performed at the hospital under study.

From this data, the following two indicators were calculated [24, 25]:

- **SSIs Percentage by Category:** This indicator provides a picture of the proportion of infections related to a specific surgical procedure, but this is heavily influenced by the intensity of post-discharge surveillance, which considerably varies among hospitals and countries.

The formula is:

Infections in category X/Procedures in category X*100

- **Incidence Density of Hospital-Onset SSIs:** This indicator considers only infections detected within the hospital setting. Although it does not provide a complete epidemiological picture, such as for procedures with a short postoperative hospital stay, it is independent of post-discharge surveillance practices and adjusts for variations in postoperative inpatient stay duration. As such, this indicator may be the most reliable for inter-hospital or network-wide comparisons.

The formula is:

Infections in category X/Follow-up days in category X *1000

For both indicators, “X” denotes a specific NHSN category. The descriptive data analysis and calculation of indicators were performed using the STATA software.

Results

Table II presents the number of SICHER procedures performed, coverage of monitored procedures, and the total, partial and no match concordance with the Hospital Discharge Cards (HDCs) between the years 2020–2023. The average number of SICHER procedures performed at the Ferrara Teaching Hospital over the period of study was $5,751.3 \pm 261.2$, with the highest value (6,087) in 2023 and the lowest (5,375) in 2020. The coverage of monitored procedures was at least 75% each year, reaching a maximum of 80.7% in 2023.

SICHER concordance with the HDCs showed a continuous improvement trend that reached 97.2% in 2023, while the partial and no match percentages decreased accordingly over the period studied.

An improving trend in SICHER coverage was observed

Tab. I. Type of Surgical Procedure under Surveillance by the Italian National Institute of Health.

NHSN	Description	ICD-9-CM codes included in the category
COLO	Colon Surgery (Incision, resection, or anastomosis of the large intestine; includes large-small and small-large intestinal anastomoses, Laparoscopic removal of the large intestine, Enterotomy and Intestinal anastomosis)	45.00-45.03, 45.15, 45.26, 45.31-45.34, 45.4, 45.41, 45.49, 45.50-45.52, 45.4, 45.41, 45.49, 45.50-45.52, 45.61-45.63, 45.7-45.95, 46.0, 46.03, 46.04, 46.1-46.14, 46.20-46.24, 46.31, 46.39, 46.4, 46.41, 46.43, 45.5, 46.51, 46.52, 46.7-46.76, 46.9-46.94
REC	Rectal surgery	48.25, 48.35, 48.40, 48.42, 48.43, 48.49, 48.5-48.59, 48.6-48.69, 48.74
CHOL	Cholecystectomy (includes laparoscopic procedures)	51.0, 51.03, 51.04, 51.13, 51.2-51.24
HPRO	Hip arthroplasty	00.70-00.73, 00.85-00.87, 81.51-81.53
KPRO	Knee arthroplasty	00.80-00.84, 81.54-81.55
LAM	Laminectomy (Exploration or decompression of the spinal cord through removal or incision of vertebral structures)	03.0-03.09, 80.50, 80.51, 80.59, 84.60-84.69
CSEC	Cesarean Section	74.0-74.2, 74.4, 74.9-74.99
CARD	Cardiac surgery	35.00-35.04, 35.06, 35.08, 35.10-35.14, 35.20-35.28, 35.31-35.35, 35.39, 35.42, 35.50, 35.51, 35.53, 35.54, 35.60-35.63, 35.70-35.73, 35.81-35.84, 35.91-35.95, 35.98-35.99, 37.10-37.12, 37.31-37.33, 37.35-37.37, 37.41, 37.49, 37.60
CABG	Coronary Bypass, Unspecified	36.1-36.2
CBGB	Coronary Bypass with Thoracic and Donor Site Incision (thoracic procedure for revascularization of the heart; includes the procedure to obtain a suitable vein from a donor site for the bypass)	36.10-36.14, 36.19
CBGC	Coronary Bypass with Thoracic Incision Only (thoracic procedure for direct heart revascularization using, for example, the internal mammary artery)	36.15-36.17, 36.2

Tab. II. SICHeR procedures performed, their match in HDCs and their coverage, Ferrara Teaching Hospital years from 2020 to 2023.

	Year			
	2020	2021	2022	2023
SICHeR procedures performed	5.375	5.866	5.677	6.087
Match in HDCs	95,60%	96,60%	96,70%	97,20%
Partial Match in HDCs	1,20%	1,40%	0,90%	0,50%
Not in HDCs	3,20%	2,60%	2,40%	2,30%
Total SICHeR coverage	75,30%	79,80%	78,10%	80,70%
CARD	50,00%	100,00%	18,20%	31,80%
CHOL	83,40%	92,20%	94,70%	88,30%
COLO	71,10%	80,90%	82,90%	84,70%
CSEC	96,70%	98,80%	98,80%	90,00%
HPRO	95,30%	98,50%	90,20%	90,40%
KPRO	100,00%	100,00%	91,70%	93,80%
LAM	84,10%	93,20%	84,70%	90,40%
REC	83,10%	90,00%	84,70%	75,60%

for COLO procedures over the study period, while higher coverage was observed only in the last year, in 2023, for LAM and CHOL procedures. Nonetheless, the coverage of these three procedures stayed consistently above the hospital's average, except for COLO in 2020. Despite a downward trend, CSEC, HPRO, and KPRO procedures consistently stayed above the hospital's average. REC coverage showed initial improvement but worsened in the final two years, falling below the hospital average

in 2023. CARD procedures showed a fluctuating trend, peaking at (100%) in 2021 and dropping to a minimum of (18.2%) in 2022.

Table III presents the number of surgeries performed, the number of SSIs and the follow-up days in the Ferrara Teaching Hospital from 2020 to 2023. Over the study period, the average number of surgeries was $5,158.75 \pm 247.40$, while those monitored were $1,560.25 \pm 63.09$. The majority were CSEC, followed by CHOL, COLO, HPRO, LAM, REC, KPRO, and CARD. Unlike the total volume of surgeries, the ones monitored increased over the first three years of the study before stabilizing in the final year, while the proportion demonstrated a fluctuating trend.

The average number of SSIs was 57.75 ± 18.08 , however, this dropped to 15.5 ± 5.07 for monitored procedures. The ratio of SSIs in monitored procedures ranged from approximately 20% (2020) to 33% (2022). The most commonly occurring SSIs were observed in COLO, CSEC, and HPRO procedures, while sporadic cases were detected in some study years for CHOL, KPRO, LAM, and REC procedures. No SSIs were reported for the CARD subgroup for the entire period.

The average number of follow-up days were $98,385.5 \pm 4,410.19$, of which $31,891 \pm 2,756.40$ were attributable to monitored procedures with a maximum value of 34,114 days in 2022. The overall trend increased for all surgeries performed in the hospital during the first three years and declined in the final year. The highest number of follow-up days was recorded for HPRO, followed by CHOL, COLO, LAM, CSEC, REC, KPRO, and CARD.

Tab. III. Number of surgeries performed, of SSIs and of follow-up days, Ferrara Teaching Hospital years from 2020 to 2023.

Procedure	Year											
	Surgeries				SSIs				Follow-up days			
	2020	2021	2022	2023	2020	2021	2022	2023	2020	2021	2022	2023
CARD	1	1	2	4	0	0	0	0	31	11	45	96
CHOL	254	317	410	422	0	3	0	0	4.162	4.607	6.738	6.481
COLO	257	266	266	278	4	8	3	10	4.419	4.412	5.115	4.803
CSEC	443	428	415	362	2	5	4	3	6.258	2.271	2.579	1.974
HPRO	255	251	236	202	3	2	4	1	12.367	11.738	12.700	12.755
KPRO	16	11	11	14	0	0	1	0	1.042	756	795	856
LAM	203	192	222	252	0	0	2	3	3.051	3.023	4.902	5.129
REC	59	62	61	68	0	2	0	2	945	1.095	1.240	1.168
Total studied	1.488	1.528	1.623	1.602	9	20	14	19	32.275	27.913	34.114	33.262
Total	4.852	5.258	5.092	5.433	43	78	42	68	92.588	97.429	102.475	101.050
Ratio	30,67%	29,06%	31,87%	29,49%	20,93%	25,64%	33,33%	27,94%	34,86%	28,65%	33,29%	32,92%

Table IV presents the SSIs Percentage by Category and Incidence Density of Hospital-Onset SSIs recorded at the Ferrara Teaching Hospital. The average infection rate was $0.31 \pm 0.27\%$, with a maximum value of 1.48% in 2021 and a minimum of 0.82% in 2022. Among the surgical categories, above hospital average values were observed only for COLO procedures, while CHOL procedures remained below the average value. CARD procedures consistently showed zero infection rates. SSI rates that were above the hospital average were observed in the following procedures/years: CSEC in 2022, HPRO in 2020 and 2022, KPRO and LAM in 2022, and REC in 2021 and 2023.

The average density of SSIs was 0.18 ± 0.10 . COLO procedures always showed higher than the hospital average, while HPRO and CHOL remained consistently below it. CARD procedures showed zero. Values above the hospital average were observed in 2021 for CSEC and REC, in 2022 for CSEC and KPRO, and in 2023 for CSEC and REC.

Discussion

Surveillance of surgical site infections (SSIs) plays a key role in reducing infection rates, facilitates infection trend identification, informs prevention strategies, and supports the evaluation the intervention effectiveness [26]. Therefore, all Italian regions should continuously improve the surveillance strategies aimed at predicting, preventing and controlling nosocomial infections in all healthcare institutions [26-29]. In fact, the purpose of this study aimed at monitoring surgical site infection (SSIs) trends is to provide useful data so that surveillance systems for these types of infections can be improved.

Data analysis was conducted based on reports collected through the SICHeR surveillance system of surgical site infections in the Region of Emilia-Romagna. The results show a steadily increasing coverage of procedures during the study period, reaching just over 80% in the final year, exceeding the overall regional average [30].

However, this positive trend is not confirmed across all procedures included in the study. In particular, an opposite trend is observed in hip arthroplasty procedures, and in caesarean sections [31], which show a significant decrease in coverage (-6.7%). SSIs in these cases unfortunately represent one of the leading adverse events for these procedures [31, 32]. Furthermore, given the low volume of cardiac procedures minor fluctuations in surveillance coverage can produce disproportionately large percentage variations, reflecting the statistical instability associated with small sample sizes.

The SICHeR system was applied to almost all of the Hospital Discharge Records (HDCs) over the period of this study. Although there is room for improvement, this result should be positively regarded since proper HDC compilation ensures alignment between clinical, processing, and administrative data. HDCs represent the most comprehensive source of information regarding a patient's hospital stay, and serve as a tool for "evaluation, monitoring, and strengthening" of care, particularly for "complex" patients - such as those treated for conditions related to an infection [33].

In recent years, an increase in surgical activity has been observed, both overall and for certain procedures included in the study, such as cholecystectomy and spinal surgeries. For the former, no notable increase in SSIs was observed ("only" 3 cases in 2021); while for the latter an increasing trend in the development of SSIs over the last two years is shown. Despite an increase in cholecystectomy procedures, there is not a rise in surgical site infections. This could be attributed to the reorganization of operating room practices, which not only increased the volume of procedures but also reduced their duration. It is well-known that the longer the cholecystectomy procedure is, the higher the risk factor is for developing infection [34].

In colon surgery two indicators exceeded the hospital average. This could be due to a higher prevalence of laparotomic compared to laparoscopic techniques, since latter is associated with significantly lower infection incidence compared to open surgery [35]. Prevention

Tab. IV. SSIs Percentage by Category and Incidence Density of Hospital-Onset SSIs, Ferrara Teaching Hospital years from 2020 to 2023.

Procedure	Year							
	SSIs Percentage by Category				Incidence Density of Hospital-Onset SSIs			
	2020	2021	2022	2023	2020	2021	2022	2023
CARD	0	0	0	0	0	0	0	0
CHOL	0	0,95	0	0	0	0,65	0	0
COLO	1,56	3,01	1,13	3,6	0,91	1,81	0,59	2,08
CSEC	0,45	1,17	0,96	0,83	0,32	2,2	1,55	1,52
HPRO	1,18	0,8	1,69	0,5	0,24	0,17	0,31	0,08
KPRO	0	0	9,09	0	0	0	1,26	0
LAM	0	0	0,9	1,19	0	0	0,41	0,58
REC	0	3,23	0	2,94	0	1,83	0	1,71
Total studied	0,6	1,31	0,86	1,19	0,28	0,72	0,41	0,57
Total	0,89	1,48	0,82	1,25	0,46	0,8	0,41	0,67

of SSIs in this context should be addressed through comprehensive perioperative improvement bundles, complemented by continuous monitoring and evaluation process [36]. In recent years, SSIs following hip replacement surgery have significantly increased [37], unlike the findings of our study, which do not identify an upward trend for this type of procedure. The multifactorial nature of SSIs [38–42] highlights the need for effective interventions across multiple stages of surgical care. These efforts must involve all stakeholders and, when necessary, patients as well. Interactive quality improvement tools such as Clinical Audits are particularly effective in identifying shortcomings and guiding quality improvement initiatives [43].

LIMITATIONS

Despite providing valuable insights into the surveillance of surgical site infections, this study presents certain limitations. First, it analyses only local data without the ability to compare similar settings, which limits how generalized the findings are in all contexts. Second, the data is not stratified by patient type, making it impossible to identify patients at higher risk of developing SSIs. Finally, since the data is categorized by type of procedure rather than by Operational Unit (OU), it is not possible to identify specific OUs at higher risk of SSI prevalence.

Conclusion

This study aimed to monitor the trends of SSIs at the Ferrara Teaching Hospital, with the goal of improving surveillance systems and contributing to the reduction of this phenomenon. The results demonstrate steady progress in the coverage of SICHER-monitored procedures, reaching over 80% in 2023, surpassing the regional average. However, this trend was not consistent across all procedures. While infections related to colon surgery remained above the hospital average, the absence of significant increases in SSIs for cholecystectomy procedures highlights the potential impact of improved operating room practices, such as reduced procedure times. In addition, the results emphasize the importance

of accurate Hospital Discharge Record (HDC) documentation, which ensures strong correlations between clinical, administrative, and surveillance data. This makes HDCs a fundamental tool for monitoring and improving patient care.

Ultimately, these findings provide valuable insights for improving SSIs monitoring and emphasize the importance of evidence-based, coordinated interventions to address this healthcare challenge.

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None.

Conflict of Interest statement

The Authors declare that there is no conflict of interest.

Authors' contribution

Conceptualization: GG, PA; Methodology: GG, GF, PA; formal analysis: GG; Data Curation: PA; Writing, original draft preparation: GG, MT, PA; Writing, review and editing: GG, GF, NB, CR, LL, PA; Visualization: GG; Supervision: GF, LL, PA; Project administration: PA. All authors approved the final version of the manuscript.

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