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Original Article

Surveillance for surgical site infections developed during hospital stay & after discharge: A multicentric study

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***Background & objectives*: Surgical site infections (SSIs) are among the most prevalent healthcare-associated infections (HCAIs). They cause significant morbidity, leading to excess health expenditures and increased length of hospital stay. Despite a high population burden, data on post-discharge SSIs is lacking from low- and middle-income countries (LMICs). There is no existing surveillance system of SSIs in India that covers the post-discharge period. Therefore, we proposed a multicentric analysis to estimate the proportion and identify the risk factors associated with SSIs occurring during hospital stay and after discharge.**

***Methods*: SSI Surveillance was conducted in three hospitals in different parts of India according to the Centers for Disease Control and Prevention (CDC) guidelines (30 days-6 months). An indigenous database was developed for data entry and analysis. Logistic regression analysis was performed to test for an association between SSI and potential risk factors.**

***Results*: A total of 161 out of 3090 patients acquired SSI, resulting in a 5.2 per cent SSI incidence. Debridement surgery, which was carried out with either an amputation, open reduction internal fixation surgery (ORIF), or closed reduction internal fixation (CRIF) surgery, had the highest SSI rate (54.2%). Clean, polluted wound class and surgeries lasting longer than 120 minutes were substantially linked to an increased risk of SSI.**

***Interpretation & conclusions*: Post-discharge surveillance helped with the detection of 66 per cent of SSI cases. Combination surgeries were seen to increase the risk of SSIs in patients.**

Key words: Hospital stay - India - surgical site infections - surveillance network - post-discharge surveillance

One of the most prevalent healthcare-associated infections (HCAIs) is surgical site infection (SSI), which has severe psychological repercussions for patients and their families as well as significant

morbidity and mortality[1-5]. Approximately 2 per cent of surgeries in high-income nations result in SSIs. The burden and impact of SSIs in low- and middle-income countries (LMICs) is less known. According to the 2011 World Health Organization (WHO) report on the global burden of HAI from LMICs, with a pooled incidence of 11.8 SSI episodes per 100 surgical procedures in LMICs, SSIs are the most frequently reported kind of healthcare associated infection (HAI) in LMICs[6]. Since most hospitals stop monitoring for SSIs when a patient leaves the facility, the SSI burden is likely to be underestimated. Not counting SSIs during the post-discharge period can lead to a significant underestimation of the disease burden and related health effects. Most available SSI risk prediction techniques are based on in-hospital surveillance systems. These may be poor predictors of infections after discharge. Given that the average duration of stay in hospital after major surgical procedures continues to fall worldwide, robust post-discharge surveillance with trained and committed employees is becoming essential[1-5] to quantify the magnitude of the SSIs accurately.

In addition to the practice of IPC (Infection Prevention and Control) measures, Surveillance and feedback are highly cost-effective ways to lower HCAI rates in healthcare settings. There is currently no system in India for comprehensive post-discharge SSI surveillance. To fill this knowledge gap, we proposed a multicentric study to estimate the proportion and identify the risk factors associated with SSIs occurring during hospital stay and after discharge in three different hospitals in India with a diverse patient population. We also advocated developing an indigenous electronic surveillance system for SSIs, the first of its kind in the country.

Materials & Methods

This prospective multicentric cohort study was conducted at three hospitals. One was the Jai Prakash Narayan Apex Trauma Centre (JPNATC), a 285-bed, level 1 trauma centre of All India Institute of Medical Sciences (AIIMS), New Delhi. AIIMS is a 2,800-bed government, teaching, and referral hospital offering the highest tertiary care level in India[7]. The other participating hospital was the Kasturba Hospital (KMC) in Manipal, a 2,032-bed private facility in South India with advanced and sophisticated surgical capabilities, including coronary bypass, open-heart surgery, and kidney transplantation[8]. The third was the Tata Memorial Hospital (TMH), a university teaching hospital in Mumbai, a tertiary, referral, Government cancer center with 750 beds[9].

The study was conducted as part of a project and was approved by the Institutional Ethics Committee of all the three hospitals. Patient information was gathered and assembled for the research once it received approval from all hospitals' Ethics Committees. The monitoring adhered to the protocols established by the National Healthcare Safety Network (NHSN)[10]. SSIs that manifested within a 30-day window following a procedure without implants or within six months in other cases were identified based on the criteria outlined by the CDC. These incidents were documented and categorised as either superficial incisional, deep incisional, or organ/space SSIs per established definitions[10-12].

An electronic database was developed in the first six months, and the protocol was published[13]. The SSI Surveillance software programme was web-based (*http://ssi.haisindia.com*), as published earlier[13,14]. Subsequently, all three sites were trained on data collection and data entry into the software. A nurse was assigned for the post-discharge surveillance.

Inclusion criteria: Individuals who experienced SSIs per standard definitions were incorporated into the analysis. Instances where patients exhibited multiple SSIs, were treated as a single case for consideration.

Exclusion criteria: Individuals with immunodeficiency, a history of prior surgery at a different hospital, and those who passed away within 48h following surgery due to surgical complications, trauma, or other underlying reasons were excluded from the study.

SSI surveillance: Nineteen types of surgical procedures were included for this SSI surveillance, as follows: amputation, appendectomy, bipolar hemi arthroplasty, cholecystectomy, closed reduction internal fixation (CRIF), cyst excision, debridement, gastrojejunostomy, hip prosthesis, hernioplasty, laparotomy without bowel injury, open reduction internal fixation (ORIF), ORIF + CRIF, abdominal, head & neck, lower limb, spinal, thoracic, upper limb.

Over 26 months, consecutive patients who had undergone surgery were included in the surveillance for SSIs. A dedicated surveillance team routinely visited each patient post-surgery throughout their hospitalization to gather essential vital signs and clinical observations using a predefined form.

A structured approach was employed for post-discharge follow up. Questionnaires, delivered *via*

telephone and post, were utilized to gather data on the 30th day (initial assessment), the 60th day (subsequent assessment), and at the 6-month mark (final follow up, particularly for implant surgeries) post-operation. A dedicated form was completed and entered into the database to establish a denominator for each surgery. This encompassed various details, such as administrative particulars (admission/discharge/readmission dates), demographic information, measurements of height and weight, specifics of the surgical team (department, surgeon's name, and designation), type and duration of the surgery, whether it was an elective or emergent, degree of contamination, dressing used, prophylactic and therapeutic antibiotic administration, body temperature, American Society of Anesthesiologists (ASA) score, wound classification, comorbidities, smoking status, foreign body implantation, utilization of a tourniquet during surgery, duration of ICU stay, and history of blood transfusion.

Microbiological data was sourced from the laboratory registries, enabling the documentation of infection type (superficial or deep SSI). Information regarding antimicrobial usage was meticulously recorded based on available records. For every identified case of SSI, the surveillance team completed a dedicated case report form (CRF). The CRF and the denominator data were subsequently inputted into the SSI software system.

Post-discharge surveillance methodology: At discharge, all patients were given information on post-discharge care and a contact number to call if they experienced any SSI symptoms (explained in the local language). Supplementary material provides the questionnaire used to follow up with patients after discharge from the hospital.

Patient's outcome: The outcomes of SSIs were determined using the results generated. These outcomes encompassed various events such as mortality, revisits to the hospital, readmissions, and instances of reoperation on the same anatomical site. Additionally, antimicrobial use cases within 60 days to six months were considered. For analysis, on the final day of surveillance, the endpoints were categorized as superficial, deep, organ/space SSI, mortality, or the absence of an SSI in the database.

Microbiological techniques: The attending clinician submitted samples for diagnosing infections to the microbiological diagnostic unit, guided by their clinical judgment. The microbiological processing followed established protocols and methods[15]. Pathogens linked to HAIs that fulfilled the criteria set by the CDC were incorporated into the database. This encompassed excluding patients who were colonized with these pathogens.

Antimicrobial susceptibility testing: The antimicrobial susceptibility testing of isolates was conducted using automated systems or the disc diffusion method, following the guidelines provided by the Clinical and Laboratory Standards Institute (CLSI)[16]. Control strains included *Staphylococcus aureus* ATCC 25923, *Escherichia coli* ATCC 25922, and *Pseudomonas aeruginosa* ATCC 27853.

Statistical analysis: Continuous variables, such as age and duration of surgery, were recorded as categorical variables. Categorical variables such as gender, ward, wound class, surgeon's grade, and ASA scores were analyzed. The NHSN surgical risk index consists of three binary variables: ASA score (3, 4, or 5), wound classification (contaminated or dirty), and procedure duration exceeding the 75th percentile. Each risk factor carries a weight of 1 point, resulting in a potential range for the NHSN SSI risk index from 0 (indicating the lowest risk) to 3 (indicating the highest risk)[17]. Statistical relationships between SSI incidence and potential risk factors were explored using the Chi-square (χ^2) test. Univariate logistic regression was used to determine the independent predictive factors for SSI and the odds ratios (OR) with 95 per cent confidence interval (CI). Surgical procedures were transformed into binary variables, with '1' representing procedures that were performed and '0' representing procedures that were not performed. Multivariate stepwise logistic regression analysis was used for adjusted odds ratio with 95% CI, including all variables with $P< 0.2$. Statistical analyses were performed using STATA version 11.1 (Stata Corp., College Station, TX, USA). Statistical significance was set at $P< 0.05$.

Results

In the initial six months, we developed an indigenous surveillance system with a database for SSIs in patients during hospital stay and post-discharge.

From May 2018 to July 2020, a comprehensive SSI surveillance effort included 3,090 patients. Among them, 161 patients experienced SSIs, resulting in an SSI incidence rate of 5.2 per cent (95% CI: 4.5-6.1).

Incidence rates varied significantly between centres with SSI rate of 7 per cent (95% CI: 5.4-8.8) for 62 patients at AIIMS, New Delhi, 1.5% (95% CI: 1-2.2) for 25 patients at KMC, Manipal and 13.5 per cent (95% CI: 10.7-16.6) for 74 patients at TMH, Mumbai. One thousand and fifty-five (34%) patients enrolled were between the ages of 30-49 yr. Males comprised 2,004 (64.9%) of the total patients, while females accounted for 1,086 (35.1%). Most procedures were either clean 2,373 (77%) or clean contaminated 641 (21%). The median stay of patients in the hospital was seven days (IQR 5 to 10). The median length of stay for the 161 patients who developed SSI was 17 days (IQR: 9-26). There were no substantial differences in the median length of stay between hospitals. The median length of stay in the hospital for all patients and those with SSI was significantly different (P<0.01). Table I provides details of all the patients enrolled. Supplementary Tables I, II and III provide centre-specific details.

Post-discharge surveillance: Eighty-one (50.3%) of the 161 people diagnosed with SSIs were identified while patients were hospitalized. Post-discharge surveillance encompassed all patients who were discharged from the hospital. SSI was diagnosed in 80 patients (49.7%) during the post-discharge period and further classified into deep incisional primary, 45 (28%) and secondary, 14 (9%); superficial incisional primary, 76 (47%) and secondary, 26 (16%). Patients who had SSI events post-discharge had a median duration of 12 days, which is much less than those who did not have any SSI events post discharge with a median duration of 23 days in the hospital. Table I presents the particulars of the 161 patients who experienced SSIs and their corresponding risk categories.

SSI occurred in 12 of the 19 types of surgical operations performed. The maximum number of procedures and high SSI incidence was observed for ORIF 35/659 (5.3%). Debridement surgery 36/161 (22%) performed in conjunction with either amputation (56%), ORIF (33%), or CRIF (8%) had the highest SSI incidence of 54.2 per cent, followed by laparotomy without bowel injury (26.3%), head and neck (11.3%), lower limb (3.8%), and spinal surgery (1.8%). The SSIs were superficial in 102 (65.4%) patients, while 59 (36.6%) were profound. Antibiotics were given to each of the 161 individuals. Fifty (28.1%) patients had wound dehiscence; 28 (17.4%) patients underwent repeat surgery; and five patients died, resulting in an overall mortality of 3.1% (95% CI: 1.0-7.1). When SSIs were compared to non-SSIs, the risk ratio for mortality was 0.25 (95% CI: 0.01-0.8). Organ space SSIs were not reported in any of the patients.

Risk factors for surgical site infection: Table I shows the parameters statistically significantly associated with the SSI outcome. The univariate and multivariate logistic regression models identified duration of surgery, wound class, surgeons' grade, ASA class, risk index, and surveillance period as significant risk factors for SSI. Among the surgery procedures, debridement, head and neck, spinal, and laparotomy without bowel injury were all significantly associated with SSI development.

Microorganisms and antimicrobial susceptibility pattern: Microorganisms were grown from 155/161 (96.3%) patients' pus samples. The pus samples from the remaining six patients did not contain any microbe. A total of 229 organisms were obtained from the 161 cases of SSI. Fifty-six (34.8) out of 161 patients had polymicrobial infection from which 130 organisms were isolated. Table II shows the species distribution of microorganisms. *Klebsiella pneumoniae* 48 (21%) was the most common isolate. Table III shows the level of antimicrobial susceptibility in 229 organisms. High resistance to ceftazidime, ceftriaxone, ciprofloxacin, imipenem, and meropenem was found in 21/32 (65.6%), 15/17 (88.2%), 29/47 (61.7%), 16/24 (66.7%), and 17/24 (70.8%) of the 48 *Klebsiella pneumoniae* isolates, respectively.

Discussion

As part of our prospective multicentric cohort study, we developed a database for SSIs in patients during their hospital stay and post-discharge. It is the first effort in India to establish a system for SSI surveillance under the Indian Council of Medical Research (ICMR). The incidence of SSI was 5.2 per cent in our study. Earlier, a pilot study done in the Trauma Center had the SSI risk of 5.5 per cent (CI: 4.1%–7.3%)[18]. This pilot study had patients from a cohort of trauma victims at a tertiary care centre, which did not fully represent the actual burden of SSIs in India. In contrast, our study utilizing data from multiple sites, provides deeper insights into the risk factors, prevalence, and outcomes of SSIs across a broader and more diverse patient population in India. The independent risk factors for developing an SSI were duration of surgery, wound class, surgeons' grade, ASA class, risk index, and surveillance period, which are significant risk factors for SSI. Among the surgery

Table I. Univariate and multivariate analysis for patients' characteristics and risk factors for surgical site infections

	Total no. of patients (n=3090)	No. of patients with SSI (n=161)	Incidence of SSI (95% CI)	*Univariate analysis OR (95% CI)	Multivariate analysis OR (95% CI)
Gender					
Female	1,086	49	4.5 (3.4-5.9)	1	
Male	2,004	112	5.6 (4.6-6.7)	1.3 (0.9-1.8)	
Age groups (yr)					
10 – 29	915	38	4.2 (3.0-5.7)	1	
30 – 49	1055	57	5.4 (4.1-6.9)	1.3 (0.9-2.0)	
50 – 69	860	53	6.2 (4.7-8)	1.5 (1.0-2.3)	
≥ 70	260	13	5 (2.7-8.4)	1.2 (0.6-2.3)	
Duration of surgery (min)					
<60	666	15	2.3 (1.3-3.7)	1	
60–120	1135	30	2.6 (1.8-3.8)	1.2 (0.6-2.2)	
>120	1289	116	9.0 (7.5-10.7)	4.3 (2.5-7.4)	2.1 (1.3-3.6)
Ward					
Ortho ward	838	47	5.6 (4.1-7.4)	1	
Surgery ward	2252	114	5.1 (4.2-6.0)	0.9 (0.6-1.3)	
Wound class					
Clean	2,373	74	3.1 (2.5-3.9)	1	
Clean contaminated	641	81	12.6 (10.2-15.5)	4.5 (3.2-6.2)	2.8 (1.8-4.4)
Contaminated	76	6	7.9 (3-16.4)	2.7 (1.1-6.3)	2.1 (0.7-6.5)
Surgeons' grade					
Consultant	2,144	69	3.2 (2.5-4)	1	
Resident	804	88	10.8 (8.8-13.2)	3.7 (2.7-5.1)	
ASA class					
Class I	2,260	105	4.6 (3.8-5.6)	1	
Class II	692	47	6.8 (5-8.9)	1.5 (1-2.1)	
Class III, IV & V	138	9	6.5 (3-12)	1.4 (0.7-2.9)	0.4 (0.1-1.1)
SSI risk index					
0	2,196	63	2.9 (2.2-3.7)	1	
1	862	94	10.9 (8.9-13.2)	4.1 (3.0-5.8)	2.5 (1.5-4.1)
2 & 3	32	4	12.5 (3.5-29)	4.8 (1.6-14.2)	3.9 (0.7-20.4)
Surveillance period					
May 2018 – Jan 2019	875	30	3.4 (2.3-4.9)	1	
Feb 2019 – Oct 2019	1,500	94	6.3 (5.1-7.6)	1.9 (1.2-2.9)	1.3 (0.9-1.8)
Jan 2020 – July 2020	715	37	5.2 (3.7-7.1)	1.5(0.9-2.5)	
Surgical procedures					
Amputation	14	1	7.1 (0.2-33.9)	1.4 (0.2-10.8)	
Cholecystectomy	148	4	2.7 (0.7-6.8)	0.5 (0.2-1.3)	2.7 (0.8-8.7)
CRIF	306	10	3.3 (1.6-5.9)	0.6 (0.3-1.1)	3.9 (1.6-9.3)
Debridement	24	13	54.2 (32.8-74.4)	23.3 (10.3-52.9)	88.5 (30.1-260.2)
Gastrojejunostomy	8	1	12.5 (0.3-52.7)	2.6 (0.3-21.3)	

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	Total no. of patients (n=3090)	No. of patients with SSI (n=161)	Incidence of SSI (95% CI)	*Univariate analysis OR (95% CI)	Multivariate analysis OR (95% CI)
Laparotomy without bowel injury	19	5	26.3 (9.1-51.2)	6.7 (2.4-18.8)	26.2 (7.2-95.1)
ORIF	659	35	5.3 (3.7-7.3)	1 (0.7-1.5)	5.2 (2.6-10.4)
Abdominal	200	13	6.5 (3.5-10.9)	1.3 (0.7-2.3)	2.5 (1.1-5.8)
Head & neck	452	51	11.3 (8.5-14.6)	2.8 (2-4)	2.7 (1.3-5.6)
Lower limb	560	21	3.8 (2.3-5.7)	0.7 (0.4-1.1)	2.4 (1.2-5)
Spinal	325	6	1.8 (0.7-4)	0.3 (0.1-0.7)	
Upper limb	51	1	2.0 (0-10.4)	0.4 (0-2.6)	

*Univariate logistic regression. ASA Class, American Society of Anesthesiologists physical status classification; CRIF, closed reduction internal fixation; ORIF, open reduction internal fixation; OR (95% CI), odds ratio with 95% confidence interval

Table II: Organisms isolated from the SSI surveillance network in India from 2018 to 2020

Organism	n (%)
Klebsiella pneumoniae	48 (21)
Pseudomonas aeruginosa	43 (18.8)
Staphylococcus aureus	32 (14)
Escherichia coli	30 (13.1)
Acinetobacter baumannii	21 (9.2)
Enterobacter cloacae	17 (7.4)
Proteus mirabilis	6 (2.6)
Pseudomonas spp.	6 (2.6)
Citrobacter freundii	5 (2.2)
Enterobacter aerogenes	3 (1.3)
Streptococcus spp.	3 (1.3)
Morganella morganii	2 (0.9)
Streptococcus pyogenes	2 (0.9)
Enterobacter cloacae complex	1 (0.4)
Enterobacter spp.	1 (0.4)
Enterococcus faecalis	1 (0.4)
Enterococcus faecium	1 (0.4)
Klebsiella oxytoca	1 (0.4)
Klebsiella spp.	1 (0.4)
Serratia marcescens	1 (0.4)
Staphylococcus aureus MRSA	1 (0.4)
Staphylococcus epidermidis	1 (0.4)
Stenotrophomonas maltophilia	1 (0.4)
Streptococcus agalactiae	1 (0.4)
Total	229

procedures, debridement, head and neck, spinal, and laparotomy without bowel injury were all significantly associated with SSI development.

SSI rates vary across developed and developing countries, depending on the type of operation and the surveillance protocol implemented. HAIs can be reduced considerably in low-resource developing nations if surveillance and infection control techniques are used, according to studies from the International Nosocomial Infection Control Consortium (INICC)[19]. The SSI rate in our study was higher than in many high-income countries, where the SSI rate varies typically between 1.2 and 5.2 per cent[20]. The rate in our study was lower than that reported in Gujarat (8.95%)[21] and higher than the one from Dehradun (5%)[22] in India, as well as Iran (17.4%)[23], Egypt (17%)[24] and Pakistan (7.3%)[25].

Post-discharge surveillance assisted in diagnosing 50 per cent of SSI patients in our study, which is slightly less than reported in Egypt[26] and other studies in France[26], the United Kingdom, and Italy[27-29]. Considering the volume of surgeries conducted at these three hospitals and the relatively cleaner nature of the surgeries included in our study, the significance of this number becomes apparent. Given the demographics of Indian patients who frequently visit government-run hospitals, it's plausible that these occurrences might fade from memory once patients return to their remote villages. Establishing a systematic surveillance system for HAIs is imperative for India. In our previous endeavors, we initiated a surveillance system targeting Blood Stream Infections (BSIs), Urinary Tract Infections (UTIs), and Ventilator-associated Pneumonia (VAP). Remarkably, these efforts substantially reduced the infection rates associated with these conditions[30].

Several countries have adopted mandated SSI surveillance programs, increasing the completeness and representativeness of data collected[28,31,32]. SSI

Table III: Antimicrobial susceptibility pattern for organisms isolated from SSI surveillance network in India, from 2018 to 2020

Gram negative organisms, (n)	Amikacin	Ceftazidime	Ceftriaxone	Ciprofloxacin	Colistin	Imipenem	Meropenem	Tigecycline
Klebsiella pneumoniae, (n=48)	29/47 (61.7)	7/32 (21.9)	1/17 (5.9)	12/47 (25.5)	10/11 (90.9)	6/24 (25)	7/24 (29.2)	28/32 (87.5)
Pseudomonas aeruginosa, (n=43)	37/43 (86)	35/41 (85.4)	-	37/42 (88.1)	3/3 (100)	7/10 (70)	7/10 (70)	-
Escherichia coli, (n=30)	23/30 (76.7)	5/17 (29.4)	2/16 (12.5)	6/30 (20)	6/6 (100)	10/17 (58.8)	10/17 (58.8)	20/20 (100)
Acinetobacter baumannii, (n=21)	5/17 (29.4)	2/18 (11.1)	0/3 (0)	2/21 (9.5)	6/6 (100)	0/11 (0)	0/11 (0)	14/16 (87.5)
Enterobacter cloacae, (n=17)	14/16 (87.5)	6/9 (66.7)	1/7 (14.3)	9/16 (56.3)	6/6 (100)	6/9 (66.7)	6/8 (75)	11/11 (100.0)
Proteus mirabilis, (n=6)	6/6 (100)	6/6 (100)	-	6/6 (100)	-	0/1 (0)	-	-
Pseudomonas spp., (n=6)	5/6 (83.3)	5/6 (83.3)	-	4/6 (66.7)	-	1/1 (100)	-	1/1 (100)
Citrobacter freundii, (n=5)	2/4 (50)	3/4 (75)	2/3 (66.7)	3/5 (60)	3/3 (100.0)	2/4 (50)	1/3 (33.3)	4/4 (100)
Enterobacter aerogenes, (n=3)	3/3 (100)	3/3 (100)	-	3/3 (100)	-	-	-	1/1 (100)
Morganella morganii, (n=2)	2/2 (100)	2/2 (100)	-	2/2 (100)	-	-	-	-
Enterobacter cloacae complex, (n=1)	1/1 (100)	-	-	1/1 (100)	1/1 (100)	-	-	-
Enterobacter spp., (n=1)	1/1 (100)	1/1 (100)	-	1/1 (100)	-	-	-	1/1 (100)
Klebsiella oxytoca, (n=1)	0/1 (0)	1/1 (100)	-	1/1 (100)	-	-	-	1/1 (100)
Klebsiella spp., (n=1)	0/1 (0)	0/1 (0)	-	0/1 (0)	1/1 (100)	0/1 (0)	-	1/1 (100)
Serratia marcescens, (n=1)	1/1 (100.0)	1/1 (100)	-	1/1 (100)	-	-	-	1/1 (100)
Stenotrophomonas maltophilia, (n=1)	-	1/1 (100)	-	-	-	-	-	-
Gram positive organisms, (n)	Ciprofloxacin	Linezolid	Vancomycin	Oxacillin	-	-	-	-
Staphylococcus aureus, (n=32)	2/31 (6.5)	31/31 (100)	29/29 (100)	5/19 (26.3)	-	-	-	-
Streptococcus spp., (n=3)	-	3/3 (100)	3/3 (100)	-	-	-	-	-

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Gram negative organisms, (n)	Amikacin	Ceftazidime	Ceftriaxone	Ciprofloxacin	Colistin	Imipenem	Meropenem	Tigecycline
Streptococcus pyogenes, (n=2)	-	2/2 (100)	1/1 (100)	-	-	-	-	-
Enterococcus faecalis, (n=1)	1/1 (100)	1/1 (100)	1/1 (100)	-	-	-	-	-
Enterococcus faecium, (n=1)	0/1 (0)	1/1 (100)	1/1 (100)	-	-	-	-	-
Staphylococcus aureus MRSA, (n=1)	0/1 (0)	1/1 (100)	1/1 (100)	0/1 (0)	-	-	-	-
Staphylococcus epidermidis, (n=1)	0/1 (0)	-	1/1 (100)	0/1 (0)	-	-	-	-
Streptococcus agalactiae, (n=1)	-	1/1 (100)	1/1 (100)	-	-	-	-	-

Note: Data is presented as S/N (% of S) where S, number of susceptible isolates as numerator; n, number of isolates tested as denominator and proportion of isolates susceptible of the total isolates tested is mentioned as (% of S)

surveillance differs from device-associated infection surveillance such as VAP, CLABSI, and CAUTI, primarily focusing on hospital-based monitoring. SSI surveillance requires dedicated and trained personnel to meticulously monitor each patient for 5-6 months after hospital discharge. Collaborative studies across multiple centres would be invaluable in determining the ideal duration for post-discharge follow-ups in countries like India, allowing for the detection of the highest possible number of SSIs in a manner that is both cost-effective and sustainable.

We observed that 81.7 per cent of the isolates were Gram-negative, with a high rate of antimicrobial resistance. *Klebsiella pneumoniae* (21%) was the most common isolate. A similar profile was reported in other studies[24,33,34,35]. Increased utilization of higher-generation and extended courses of antimicrobials places additional economic strain on healthcare systems and patients. Furthermore, delayed recovery increases societal expenses, particularly in developing nations. Our study revealed that patients who developed SSIs experienced more extended hospital stays than those who did not.

Our multicentric study included a large sample size and various types of surgeries, which had a significant association with SSI. These factors support the research objective of identifying patient-related factors that could be included in general SSI surveillance. Middle-aged males were the predominant population at the trauma centre, a usual admissions trend, showing that most patients were in the economically productive age group. Compared to those under 29 yr, patients in the age group 50-69 yr were more likely to develop an SSI than those in the age groups 30-49 yr and more than 70 years (OR 1.5; *vs.* 1.3; *vs.* 1.2). Age above 45, female sex, diabetes, and procedures types such as gastrectomy, prostatectomy, hysterectomy, cholecystectomy, and appendectomy had all been reported as risk factors for SSIs[36].

Prolonged operative time longer than 2-3 h can increase the risk of SSI[23]. Cheng *et al*[37] observed in their study that the likelihood of SSI increased with increasing operative time. In our study, more than 2 h of surgery significantly increased the probability of SSI (OR 4.3). Surgical duration is frequently mentioned as an independent and potentially modifiable risk factor for SSI. The risk of SSI for clean contaminated wounds was more than four times higher compared to clean wounds. When a resident conducted the operation rather than a consultant, the risk of SSI was substantially higher. In comparison to class III or higher, ASA class II had a higher risk of SSI (OR 1.5 *vs.* 1.4). Our dataset's multivariate analysis showed that the risk of SSI increased as procedure duration increased (OR 2.1, 95% CI: 1.3-3.5; $P<0.001$). The wound classes of clean contaminated (OR 2.8, 95% CI: 1.8-4.5; $P<0.001$) and contaminated wounds (OR 2.6,

95% CI: 0.9-7.6; $P<0.001$) were linked to an increased risk of SSI. The risk of SSI was significantly related to increasing levels of risk index scores.

The initiation of surveillance initiatives for surgical site infections represents the initial stride toward preventing these infections[38]. Our study has been India's first multicentric systematic surveillance effort, in which patients were monitored for six months after undergoing various conventional surgical procedures. After piloting it at the Trauma center[7], the protocol was extended to two other Indian hospitals, one in Midwestern India[8] and the other in South India[9]. Under the aegis of the ICMR, this SSI Surveillance network could create the groundwork for the establishment of SSI surveillance in several other Indian hospitals. Our center is also leading multicentric surveillance on BSI and UTI under the technical support and coordination of ICMR and CDC, where 53 hospitals are enrolled[39], which aims to develop a systematic program on HAI surveillance (*https://www.haisindia.com/*).

Our study had some limitations. To begin with, it was not a nationally representative study on SSI -incidence in India. This study demonstrated the feasibility of establishing a surveillance system to reduce the occurrence of SSI in India. Second, some surgical procedures, such as appendectomy, bipolar hemi arthroplasty, cyst excision, hip prosthesis, hernioplasty, ORIF+CRIF, and thoracic surgeries, were in meager numbers, and hence SSIs were not recorded.

Overall, the incidence of SSI was 5.2 per cent in our study. The independent risk factors for developing an SSI were duration of surgery, wound class, surgeons' grade, ASA class, risk index, and surveillance period. Among the surgery procedures, debridement, head and neck, spinal, and laparotomy without bowel injury were all significantly associated with SSI development. Our results support the importance of systematic surveillance in identifying SSI incidence and patient-related risk factors.

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