Determining the Frequency, Factors and Bacteriological Profile of Surgical Site Infection in a Tertiary Care Teaching Hospital of Western Uttar Pradesh

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Abstract

Background: Surgical site infections (SSIs) account for nearly 20% to 25% of all Health care associated infections (HCAIs) worldwide. SSI rates are reported to range from 2.5% to 41.9% resulting in high morbidity and mortality. **Settings and Design:** A prospective study was carried out in a tertiary care teaching hospital of Western Uttar Pradesh to determine the frequency, factors and bacteriological profile of Surgical site Infections. **Materials and Method:** Patients, of all age group, gender and diagnosed as a case of SSI as per CDC clinical criteria were included. The demographic detail, diagnostic criteria, associated risk factors were noted. Culture and antimicrobial susceptibility pattern was determined. Laboratory and clinical data were analysed. **Observations & Results:** Significant determinants of SSIs were; male population, young and middle age group, hot and humid climate, type II diabetes, prolonged duration of surgery and certain surgical procedures such as lower segment caesarean section, cholecystectomy, laparotomy etc.The rate of SSI was 2.78% and culture positivity rate was (55.04 %). There was predominance of Gram negative bacteria (76.73%). Coagulase Negative Staphylococci (72.22%) and *Pseudomonas aeruginosa* (35.48 %) were the predominant bacteria isolated. The clinical isolates showed high level of resistance to various antimicrobial agents.

Conclusions: Knowledge about the factors responsible and the bacteriological profile of SSI will guide the clinicians in choosing the appropriate treatment options which will ultimately reduce the morbidity, cost and lead to better clinical outcome.

Key-words: *Surgical site infection, bacteriological spectrum, risk factors, susceptibility pattern*

Introduction

Surgical site infection (SSI) is defined as an infection that occurs within 30 days after the operation and involves the skin and subcutaneous tissue of the incision (superficial incisional) and/or the deep soft tissue (for example, fascia, muscle) of the incision (deep incisional) and/or any part of the anatomy (for example, organs and spaces) other than the incision that was opened or manipulated during an operation (organ/space) as per WHO.[1] Infections are usually caused by exogenous or endogenous microorganisms that enter the operative wound during the course of the surgery .[2] The risk factors of SSI are multifactorial and associated with an extended length of hospital stay, pain, discomfort and sometimes prolonged or permanent disability. The prevalence of SSI varies from region to region and hospital to hospital. Paucity of data from this geographical area prompted us to carry out this study to determine the frequency, risk factors; bacteriological profile and the antibiotic susceptibility pattern of SSI in a tertiary care hospital so that efficient empirical treatment can be initiated for better clinical outcome.

Materials and Methods

A prospective study was carried out for a period of ten months by the hospital infection control unit of a tertiary care teaching hospital.The approval from the Institutional Ethical and Research Committee was obtained before conducting the study. The clinical diagnosis of SSI was made by a consultant surgeon or an infection control nurse during their daily round.Informed consent wastaken from all the patients before collection of clinical samples. Patients of all age groups and either gender admitted in various surgical units and diagnosed as a case of post-operative SSI as per clinical criteria laid down by CDC[3] were included in the study.Samples from stitch abscess, episiotomy, new-born circumcision site and infected burn wound were excluded.

Methodology: The age & sex of the patient, symptoms and its duration, clinical presentation, type of surgery, clinical diagnosis and associated comorbidities was recorded for each patient.The rate of SSI in percentage was calculated using the formula: number of surgical site infections in a month divided by number of surgeries performed in a month multiplied by hundred.

Pus and /or pus discharge collected from the surgical site was immediately transported to the laboratory under aseptic precaution for isolation and identification of bacterial pathogens as per the standard bacteriological technique. [4]Antibiotic susceptibility testing was carried out by Kirby-Bauer disk diffusion method on Mueller Hinton agar plates as per CLSI recommendations,[5] using commercially available antibiotic discs (Hi Media, Mumbai, India).

Pathogens, expressing various resistant phenotypes such as Methicillin resistance in *Staphylococcus* spp. and Exended spectrum betalactamase (ESBL) production by phenotypic confirmatory test (PCT) as per CLSI guidelines [5]and Metallobetalactamase (MBL) production as per the method used by Yong *et al*. [6], were identified using various phenotypic methods.

P.aeruginosa ATCC 27853, *S.aureus* ATCC 25923, *E.coli* ATCC 25922 and *K.pneumoniae* ATCC 700603 (ESBL positive) was used for quality control.

Statistical Analysis

Statistical analysis was carried out using **Chi square** test

Results

Out of total 13180 surgeries performed during the study period 367 patients developed SSI. The cumulative infection rate was 2.78%. Out of total 367 cases with SSI, 68.40% were males and 31.60% were female patients. Male to female sex ratio was 2.16:1 with male pre-ponderance. Majority of cases were in the second (26.70%) and third (27.52%) decade of life [Fig.1]. The number of cases was reported comparatively more in the month of August (3.39%) and July (2.95%) showing that the hot and humid climate may be one of the predisposing factors [Fig.2] (χ2- value=1.03; p-Value=0.999).

Association with co-morbid condition

Type II Diabetes Mellitus was the most common co-morbid condition (predisposing factor) identified (13.35 %) followed by malignancy (2.73%), heart disease and hypertension (0.27%). However, in 83.65% patients who developed SSIs no pre-existing co-morbid conditions were identified.

Relationship with duration of surgery & wound class

The incidence of SSI increased (53.68%) with prolonged duration of surgery that is surgery taking ≥2 hours as compared to surgery taking < 2 hours (46.32%). (χ2 - value= 267.62, P Value < 0.001, Statistically Significant) [Table 1]. As per CDC criteria of classification the percentage of SSI was maximum in cases of dirty wounds (11.85%) as compared to contaminated wounds (6.5%), clean contaminated wounds (4.78%) and clean class of wounds (1.84 %) [Table 2].(χ2-value= 149.03, p value < 0.00001, Statistically Significant)

Relationship with type of operation

The incidence of SSI was found to be high following general surgery operations (59.67%) followed by obstetrics & gynaecology surgeries (31.60%) and orthopedic surgeries (8.71%). Distribution of various operations and their number is shown in Table 3.

Microbiological profile and distribution of organisms isolated from cases of SSI

Out of the total 367 cases, 202 (55.04 %) cases of

SSI were culture positive. Among the culture positive cases majority, 191(94.55 %) cases had mono-microbial (Mm) etiology as compared to 11 (5.44 %) which had poly-microbial (Pm). There was predominance of Gram negative bacilli (GNB)(76.73%) both as in Mm and Pm groups. [Table 4]

P. aeruginosa (30.05 %) was the predominant GNB and CONS (13.14%) was the predominant Gram positive cocci (GPC) isolated from cases of SSI. These 13.14% of CONS were only the clinically significant isolates of CONS. *E.coli* (21.13%), *Acinetobacter* species (14.08%), *Klebsiella* species (11.74%) and *S.aureus* (3.29 %) were the other pathogen isolated. [Table 5]

Susceptibility pattern

The susceptibility pattern of bacterial pathogen isolated from cases of SSI is shown in Table 6. The clinical isolates of *P. aeruginosa* showed resistance to multiple antimicrobial agents including meropenem and imipenem (35% each). Members of Enterobactericeae; *Klebsiella* spp., *E.coli* and *Proteus* spp. were also multi drug resistant (MDR). However, the isolates of *P. aeruginosa* and members of Enteriobactericeae were 100% susceptible to colistin and polymixin B. A total of 76.56% *P. aeruginosa* and 83.33% *Acinetobacter species* were MBL producers. Among the members of Enteriobactericeae, ESBL production was seen in 45.68% and both ESBL & CRE (Carbapenemase producing Enterobactericeae) co-producer was seen in 44.44 %. Moreover, (64.28%) of these clinically significant isolates of CONS from cases of SSI were methicillin resistant (MR) which indeed is a very high number and was to be reported as they are significant therapeutic problem.A total of 42.85% *Staphylococcus aureus* were MRSA. However, all our isolates of Staphylococcus species were sensitive to linezolid and vancomycin.

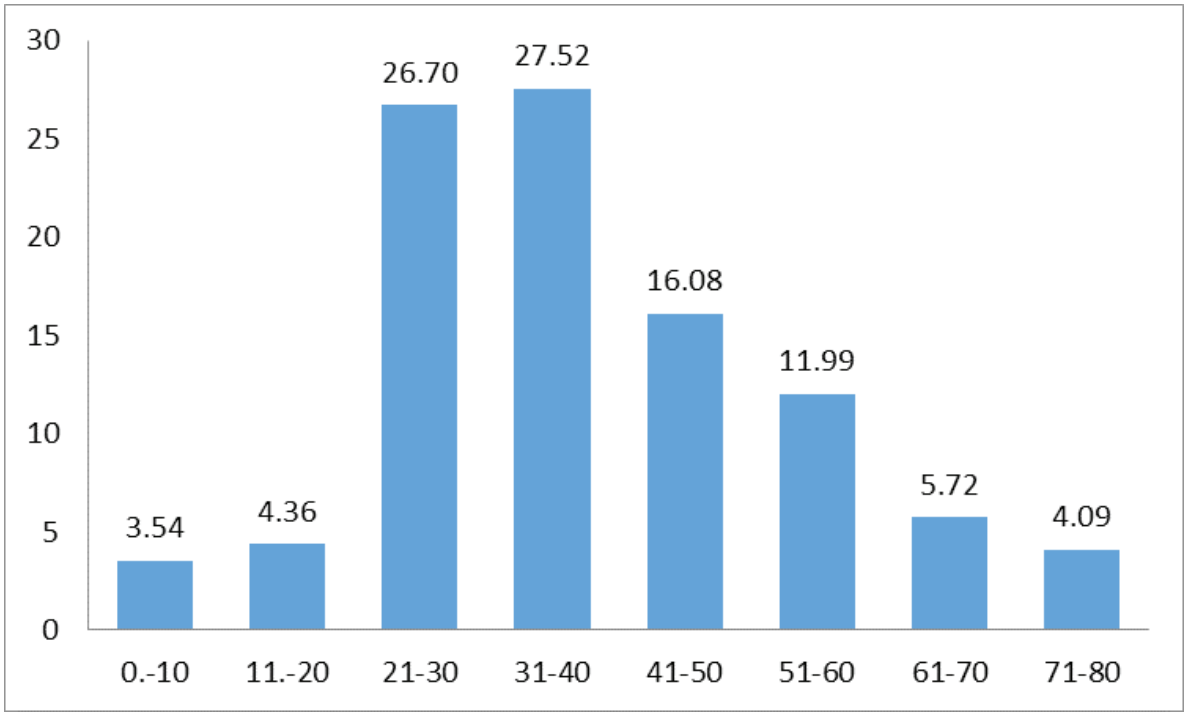

Fig. 1: Age wise distribution of cases of SSI (n= 367)

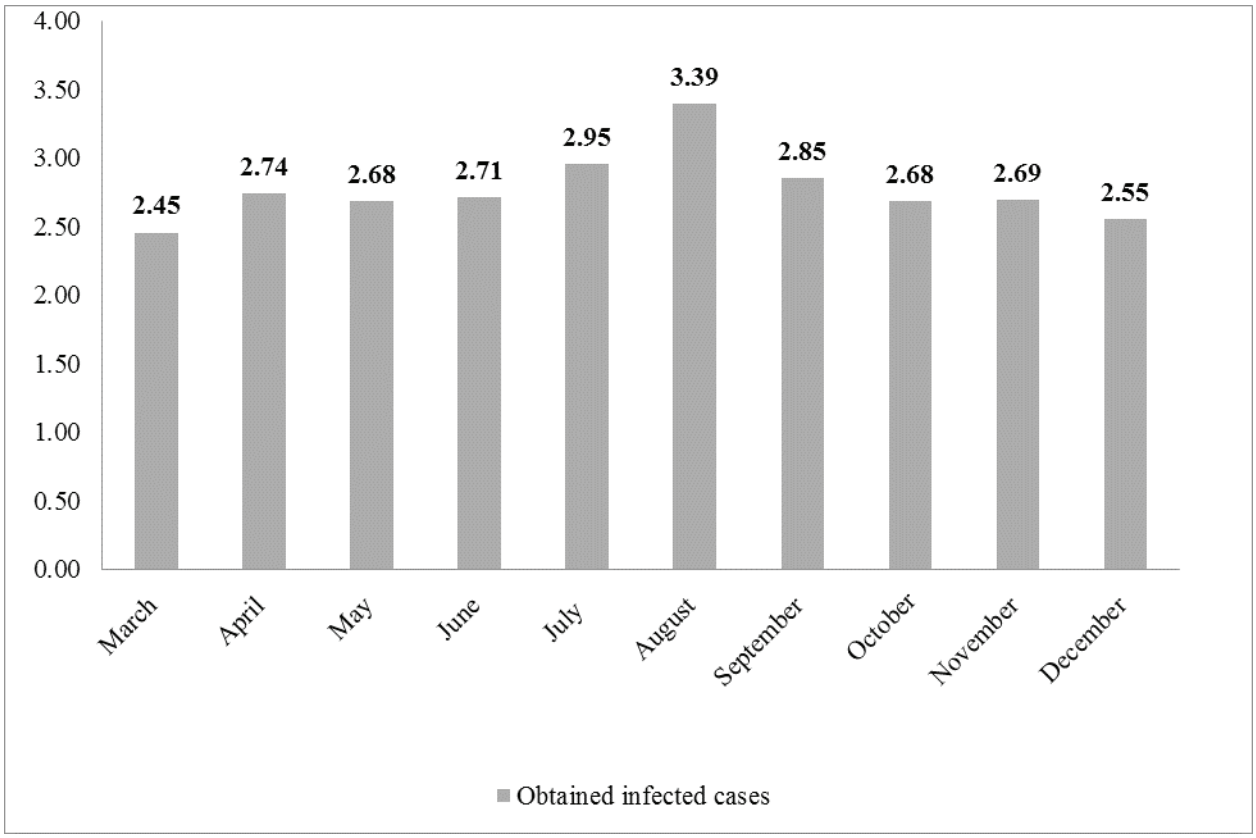

Fig. 2: Month wise distribution of frequency of cases of SSI

Table 1: Correlation between duration of surgery and postoperative wound infections (n = 13180)

S. No.	Duration of Surgery (in hours)	No. of cases with SSI	No. of cases without SSI	Total No. of surgeries	Percentage of infected cases %
1	<2	170	10374	10544	46.32
2	≥2	197	2439	2636	53.68
	TOTAL	367	12813	13180	100
χ2-value= 267.62, P Value < 0.001(Statistically Significant)					

Table 2: Distribution of SSI cases as per the CDC Criteria of Classification of Surgical Wounds (n= 367)

Type of Surgical Wounds	Total No. of surgeries performed	No. of cases with SSI	% of cases with SSI	No. of cases without SSI	% of cases without SSI
Clean	9753	180	1.84	9573	98.16
Clean contaminated	2510	120	4.78	2390	95.22
Contaminated	790	52	6.5	738	93.5
Dirty	127	15	11.8	112	88.2
(χ2-value= 149.03, p value < 0.00001, Statistically Significant)					

Table 3: Department wise distribution of various types of operations in cases of SSI (n=367)

Department	No. of SSI	%
Obstetrics &Gynaecology *	116	31.60
# Surgery **	219	59.68
Orthopaedic Surgery ***	32	8.72
*Lower segment caesarean section -91 , Total abdominal hysterectomy bilateral and salpingoopherectomy – 25		
** Cholecystectomy – 55 (Open – 19, Lap – 36), Laprotomy-74,Herniorraphy – 30, Appendix – 27, Incision and drainage – 22, Skin grafting, Flap coverage, Debridement – 11		
***Open reduction internal fixation nailing, plating – 23, Arthotomy – 06, Amputation – 03		

includes all surgical branches

Table 4: Mono-microbial (Mm) and poly-microbial (Pm) distribution of microorganisms isolated (n=202)

	Microorganism isolated	No of samples	Total	Percentage %
Mm etiology	GNB	155	191	94.55%
	GPC	36		
Pm etiology	GNB + GNB	9	11	5.45%
	GNB+GPC	2		
			202	100%

Table 5: Distribution of organisms isolated from cases of SSI (n=213)

Isolates	Mm SSI isolates Number	Pm SSI isolates Number	Total Isolates Number	%
P.aeruginosa.	55	9	64	30.05
Acinetobacter spp.	30	0	30	14.08
E . coli	39	6	45	21.13
Klebsiella spp.	24	1	25	11.74
Proteus spp.	7	4	11	5.16
CONS	26	2	28	13.14
S .aureus	7	0	07	3.29
Enterococcus spp.	3	0	03	1.41
Total	191	22	213	100

Table 6: Antibiotic susceptibility pattern of bacteria isolated from SSI

Etiological agent (No.of isolates)	Antibiotic Resistant pattern (%)																		
GNB	AMP	AMC	A/S	PI	PIT	TE	COT	CIP	CAZ	CTR	AT	CPM	AK	GEN	TOB	C	IPM	ETP	MRP
P.aeruginosa (n=64)	-	-	-	70	29	-	-	82	76	-	75	82	57	57	57	-	35	-	35
Acinetobacter spp. (n=30)	-	-	76	86	40	13	13	13	86	86	-	50	80	80	80		66	-	66
E.coli (n=45)	86	69	69	86	69	55	65	41	86	86	86	69	37	37	37	16	48	48	48
Klebsiella spp. (n=25)	76	48	48	76	48	28	28	36	76	76	76	46	24	32	24	20	40	40	40
Proteus spp. (n=11)	63	54	54	63	54	36	36	36	63	63	63	63	54	54	54	27	45	45	45
GPC	P	AMP	CX	E	CD	COT	TE	DO	CIP	MO	GEN	C	LZ	VA	HLG		HLS	TEI	
CONS (n=28)	88	88	81	81	74	22	22	22	59	59	18	18	00	00	-		-	-	
S. aureus (n=7)	71	71	28	86	86	28	43	43	57	57	28	28	00	00	-		-	-	
Enterococcus spp. (n=3)	100	100	-	67	-	-	100	67	-	-	-	-	00	00	67		67	00	

PI-Piperacillin, PIT- Piperacillin- Tazobactam ,CIP- Ciprofloxacin, CAZ- Ceftazidime, CPM- Cefepime, AZ-Aztreonam, GEN-Gentamicin, AK- Amikacin, TOB- Tobramycin,IMP- Imipenem, A/S- Ampicillin–sulbactum, TE-Tetracycline, COT- Cotrimoxazole,CTR- Ceftriaxone, MRP- Meropenem, IMP- Imipenem, ETP- Ertapenem,CL- Colistin, PB- Polymyxin B, AMP- Ampicillin, CX- Cefoxitin, GHL- Gentamycin high level, SHL- Streptomycin High level,E- Erythromycin, CD- Clindamycin, COT- Cotrimoxazole, TE- Tetracycline, DO- Doxycycline,CIP- Ciprofloxacin, MO- Moxifloxacin,GEN- Gentamicin, C- Chloramphenicol,TEI- Teicoplanin, LZ- Linezolid, VA- Vancomycin

Discussion

SSI is the most common cause of HCAIs worldwide.[7] The incidence of infected surgical wounds may be influenced by various factors such as pre-operative care, the theatre environment, post-operative care and the type of surgery. The rate of SSI in our hospital was 2.78% which is comparable with SSI rate ranging from 2.8% to a high as 55.6 % reported from India.[8]We reported more SSI in the month of August (3.39 %) and July (2.95%) showing that the hot and humid climate was one of the predisposing factors. Similar finding was reported earlier.[9]

Our finding of male predominance (68.40%) was consistent with other studies. [10, 11]We observed SSI more in the second and third decade of life.[Fig.2] However, there are two schools of thoughts ; an Iranian study found, age to be significantly associated with risk of SSIs, [9] while another study observed that it was not a significant predictor.[12]Diabetes mellitus was the main co-morbid condition associated in our study, this finding was consistent with many other studies across the world, which have pointed out that the diabetics are more prone for infection. [13] However, in significant number of cases (83.65%) no associated risk factors were identified. Similar observation wasnoted by Shah *et al*.2015 [14]

It has been observed that surgeries that take ≥ 2 hours are associated with higher infection rates. [15]Longer exposure of tissues to theatre environment, hypothermia and requirement of blood transfusion, all of them are potential risk factors for SSI. [16, 17] Majority of our cases (53.68%) occurred when the duration of operation was ≥ 2 hours [Table 1] (χ2-value= 267.62, p value < 0.001 statistically significant). Similarly, studies from Lahore & Islamabad too reported doubling infection rate in surgeries that took ≥2 hours, showing direct relation to duration of surgical procedure.[15,18]This may be because, a longer exposure time will increase the level of contamination of the wound and subsequently the degree of damage to the tissues and greater fatigue among the members of surgical team may also lead to breaks in sterile technique. [19]

As per the CDC criteria of classification of surgical wounds, an increasing frequency of infection rate was seen from clean to dirty class of wound respectively in the present study [Table2](χ2-value= 200.46, p value < 0.001(Statistically significant), as also reported by others.[14, 20] However, another study from Punjab reported no significant difference between infection rate and wound class.[21]Maximum cases of SSI was seen after general surgery operations (59.67%) followed by obstetrics &gynecology surgeries (31.60%) and orthopedic surgeries (8.71%). [Table 3] The general surgery operations included cholecystectomy; open and laparoscopic, herniorraphy, appendectomy, incision & drainage, skin grafting, flap coverage and debridement. Wounds and other open lesions are liable to contamination with organisms from body surfaces and environment. Infection occurs when the contaminants evades the host's defences, replicates in large numbers, and attacks and harms the host tissues.

Looking at the microbiological profile; a comparatively higher percentage of culture negative (45%) cases were reported in our study. Similar findings of high culture negativity has been reported by other workers in the past, [22] which may be due to following reasons; the infection may have been due to certain fastidious bacteria which had especial growth requirements or maybe due to the usage of broad spectrum antibiotics empirically which might have led to sterile cultures in clinically suspected cases. Among the culture positive cases Mm etiology was predominant (94.55 %) [Table 4]. Similar findings have been reported in the past. [23] However, Giacometti *et al*.,2000[24] reported single etiological agent in 44.1% and mixed growth in 53.9%; which was not concordant with our finding.

Pseudomonas species and CONS were the predominant bacteria isolated, followed by *E.coli ,Acinetobacter* species , *Klebsiella* species , *Proteus* species , *S.aureus* and *Enterococcus* species. [Table 5] Studies documented that *Pseudomonas* species can multiply on common objects in hospital environment such as dressing materials; buckets used for soaking plaster of Paris etc. and may be the reason for isolation in higher number from hospital associated infections. [25] A study by Laxminarayan *et al*.,2000[26] showed predominance of *S.aureus* followed by *E.coli* and *P.aeruginosa* . [26] In a nutshell the rate of isolation differs in different geographical area. In our set up the GNBs dominated the GPCs. This trend was also observed in Pune.[27]

The clinical isolates of *P. aeruginosa* showed resistance to multiple commonly prescribed anti pseudomonal agents. [Table 6] However, there is paucity of data on the prevalence of carbapenem resistance in the Indian literature. [28]Out of these isolates 40.09% were MBL producers. Similar finding was reported by Kaur *et.al* in 2017. [29] and Anil *et al.,* in 2011.[30]Such high level of resistance to drugs like meropenem and imipenem is an alarm for the judicious use of carbapenems. Resistance to carbapenems is due to decreased outer membrane permeability, increased efflux systems, alteration of penicillin binding proteins and carbapenem hydrolysing enzymes –carbapenemases. They may be chromosomally or plasmid mediated and therefore poses a threat of spread of resistance by gene transfer among gram negative bacteria. The appearance of MBL genes and their spread among bacterial pathogens is a matter of concern. [28] However, all our isolates were sensitive to polymyxin-B, colistin and tigecycline last few drug we are left with, in this era of desperation.

E.coli, showed high level of resistance towards beta lactum group of antibiotics, aminoglycosides and floroquinolones. ESBL and CRE co- producers were very high 44.44% & 64% in *E.coli &Klebsiella* speciesrespectively. A total of 72.72 % of *Proteus* species were ESBL producers. Resistance in patients with SSI is an emerging problem worldwide, [28]and the misuse of third generation cephalosporin and fluroquinolones appears to promote the prevalence of ESBL.

In our set up overall MR was high in CONS (64.28%) as compared to *S.aureus* (42.85%)(p=0.301) which is a matter of therapeutic concern as MRs are resistant to beta lactams, cephalosporins and betalactamase inhibitors leaving very few treatment options. Kakati *et al* 2013, [20] reported MRSA in 28.57% strain isolated from the wounds of admitted patients. As per the recent report of a multicentre study carried out by the Indian Council of Medical Research Antimicrobial Resistance Surveillance Network in 2017, the overall prevalence of MRSA distribution varied from as low as 21% at AIIMS to as high as 45% at CMC, 43% at PGIMER and 35% at JIPMER and moreover the prevalence of MR was higher in CONS than *S.aureus*. [31]

Conclusion

High level of resistance to various antimicrobial agents was observed and the emergence of antibiotic resistant strains might lead to treatment failure. Knowledge regarding various associated risk factors, bacteriological profile and its susceptibility will guide the clinician in choosing the appropriate treatment of SSI which would help reduce the morbidity and reduction in treatment costs and indirectly reduce the burden of HCAI in the hospitals.Moreover, as there are no previous reported data of SSI from this geographical area this study will act as a baseline and help initiateefficient empirical treatment while waiting for sensitivity reports.

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