Original Article

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Bacterial Contaminants and their Antimicrobial Profile from Hospital Surfaces and Equipments of Various Areas in a Tertiary Care Hospital of Gujarat, India

Microbiology Section

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ABSTRACT

Introduction: Nosocomial infection is an important concern for healthcare professional in tertiary care centre as they have significant negative impact on patient's recovery as well as mortality and morbidity. These infections are mostly acquired through contaminated areas of hospitals.

Aim: To access the bacteriological profile of various hospital surfaces and equipments those are exposed to patient in routine clinical care.

Materials and Methods: This cross-sectional study was conducted in tertiary care centre in North Gujarat region, India over the duration of one month in October 2021. Swabs from surfaces were collected using aseptic precautions for aerobic culture. Microorganisms isolated from samples were subjected to identification and antibiotic sensitivity tests. Frequency and distribution of microorganisms were analysed according to different working areas in hospital.

Results: Out of 494 samples, total 171 samples (34.61%) showed bacterial growth, of which 186 different organisms were isolated. Highest number of isolates were *Bacillus* spp. (28.49%), *Staphylococcus aureus* (12.90%), *Pseudomonas aeruginosa* (9.14%), *Klebsiella* spp. (7.53%) and *Acinetobacter* spp. (7.53%).

Conclusion: Various surface areas in hospital always need a constant surveillance as they are found contaminated in various studies across the globe. So, intermittent microbiological surveillance is must in a tertiary care hospital in setting up infection control protocol.

Keywords: Antimicrobial susceptibility testing, Bacteriological contamination, Healthcare associated infections

INTRODUCTION

Hospital Acquired Infections (HAIs) are important concern in tertiary care centre now-a-days as they increase morbidity, mortality and duration of stay in hospital for patients. Such infection can be acquired by infected patients or it can originate from person's own microbial flora [1]. Also different studies across the globe represents that these pathogens in hospital environment were found in almost all the areas but majority of the studies, focus was mainly on intensive care and operation units only may be because of critical health conditions of patients and occurrence of multidrug resistant organisms in these areas [1-7]. Hospital acquired pathogens e.g. *S. aureus, Pseudomonas, E. coli, Klebsiella, Acinetobacter* are likely to be multidrug resistant organisms which are major concern for clinicians because they limit the therapeutic options for the patients [3,4]. Bacteria has the ability to remain viable even upto months on certain inanimate surfaces in the hospital due to lower temperature and humid environment [5]. Various hospital surfaces and medical equipments are often contaminated by the infected patients during the diagnostic and therapeutic procedures and these organisms can be transmitted to other patients or healthcare workers by direct or indirect contacts [6,7].

The present study was focused on a number of bacterial species, such as *E. coli,* methicillin-resistant *Staphylococcus aureus* (MRSA), glycopeptide-resistant Enterococci (GRE), *Acinetobacter baumannii, and Pseudomonas aeruginosa*. From the published research studies it was observed that the hands of healthcare workers who were directly exposed to infected patients were at high risk of harboring various pathogens, 30% of which were MRSA, 20% were GRE, and 15% were gram negative bacilli [8,9]. Knowledge regarding microbial profile in hospital environment is important aspect in hospital infection control program as it always vary in different Institutions. So, aim of the present study was to determine the distribution of bacterial pathogens which are prevalent on hospital surfaces and instruments of various departments in tertiary care centre and analysis of their antimicrobial susceptibility pattern.

MATERIALS AND METHODS

This cross-sectional study was conducted at Microbiology laboratory, Tertiary care centre in North Gujarat region over the duration of one month in October 2021. This is tertiary care teaching institute which is a major referral centre for other hospitals of North Gujarat, India. As the present study did not involve any procedure or data related to human subject, ethical permission was waived off from Institutional Ethical Committee (IEC).

Different Operation Theatres (OTs) (Emergency, Orthopaedics, Surgery, Ophthalmology, Ear, Nose and Throat (ENT) and Gynaecology), Intensive Care Unit (ICU) (Medical, Paediatric, Surgical) and patient care areas (wards, dialysis units, laboratory, and administrative areas) were examined in the present study. Convenient sampling method was used in the present study in which total of 494 surface swabs were collected from routinely touched medical equipment, floors, wall, and waiting areas, workstation (keyboards, computer, mouse), water tap and sinks.

No exact calculation was made to determine sample size but efforts were put to cover maximum areas of hospital which were routinely exposed to infected patients. Most critical and most representative locations were chosen as sampling sites after consultation with head of each respective department. All samples were collected in morning after the routine cleaning was completed and no prior information was given to staff before the sample collection. Moreover, samples in OTs and dialysis unit were collected before the start of procedures. Sample collection was done by using cotton swabs pre-moistened with sterile normal saline according to ISO/DIS 14698-1 [10].

Sample Processing

After the collection, samples were immediately sent to the Institutional microbiology laboratory for processing. After sample receiving in the lab, each swab was immersed in a liquid nutrient broth (BHI) and incubated at 37±1°C for 24 hrs under aerobic conditions. A loopful of turbid broth was subcultured on Nutrient agar (Himedia) and MacConkey agar (Himedia). After 24 hrs of incubation under aerobic condition at 37°C, pure colonies from Nutrient agar were used for Biochemical reactions for identifications of isolates. Gram negative bacteria were further identified by Gram stain and standard biochemical tests like Triple Sugar Iron Agar (TSI), Urea, Citrate, Sulfide Indole Motility (SIM) medium, growth in Lysine Iron Agar (LIA), Mannitol, Malonate, and Oxidase test. On the other hand, gram positive bacteria were further identified by Gram stain, optochin, bacitracin, CAMP (Christie-Atkins-Munch-Peterson) test, catalase, coagulase, bile esculin, and salt tolerance test [11].

Antibiotic Susceptibility Testing

Antimicrobial susceptibility testing of isolated organisms were done by disk diffusion methods by Kirby-Bauer [12]. An inoculum of each isolate approximately 1×10^8 colony forming unit (cfu)/mL were used by using the 0.5% McFarland Standard and aseptically flooded on the surface of sterile Mueller-Hinton Agar (Himedia). Antibiotics were selected in reference to Clinical Laboratory Standards Institute (CLSI) guidelines [13,14] and local availability. Different antibiotic disks (Himedia) were tested: penicillin (1 IU), gentamicin (10 µg), kanamycin (30 µg), erythromycin (15 µg), ampicillin (10 µg), amoxicillin-clavulanic acid (30 µg), cefoxitin (30 µg), ceftazidime (30 µg), ceftriaxone (30 µg), cefepime (30 µg), tetracycline (30 µg), levofloxacin (5 µg), imipenem (10 µg), piperacillin (100 µg), piperacillin/tazobactam (100/10 µg), ticarcillin (75/10 µg), sulfamethoxazole/trimethoprim (75/25 µg), ciprofloxacin (5 µg), chloramphenicol (30 µg), and fusidic acid (10 µg). They were aseptically placed on the seeded plates and then incubated at 37±1°C for 24 hrs. Zone diameters of the drugs were measured by antibiotic zone scale and interpreted by using CLSI criteria [14].

Extended-Spectrum beta-lactamase (ESBL) in Enterobacteriaceae isolates was performed in-vitro by double-disk synergy test in which combining amoxicillin-clavulanic acid along with third-generation cephalosporin was used. Appearances of a synergistic image between these antibiotics reflect a production of ESBL by the strain [13,14]. Resistance to methicillin among *S. aureus* strains was investigated using a cefoxitin disk under standard susceptibility testing. Strains with an inhibition diameter of less than 22 mm were considered MRSA [13,14]. Metalo-betalctamase (MBL) production among non fermenter was determined with ceftazidime (CAZ) disk by modified double disk synergic test and disk potentiation test using ethylenediaminetetraacetic acid (EDTA) and 2-mercaptopropionic acid (as chelating agents) to detect MBL production. Glycopeptide resistant Enterococci (GRE) was identified by detecting vancomycin resistance using Minimal Inhibitory Concentration (MIC) testing [13-15]. Quality control strains of *E. faecalis* American Type Culture Collection (ATCC) 29212, *S. aureus* ATCC® 25923, *E. coli* ATCC® 25922, *K. pneumoniae* ATCC®1705 and *Pseudomonas aeruginosa* ATCC® 27853 were used to confirm the result of antibiotics, media and to assess the quality of the general laboratory procedure.

STATISTICAL ANALYSIS

No statistical method was applied in analysis. The data was collected in Microsoft Excel sheet and results were presented as count and percentage.

RESULTS

Total of 494 samples were collected from different areas of hospital for culture and sensitivity. [Table/Fig-1] shows number of samples collected from different areas at glance. From each respective area samples collected from hospital equipments, floor, wall, bedside table, door/window handle, sinks and water tap, etc.

Area	Total N (%)
Operation theatre	170 (34.41)
NICU	34 (6.9)
MICU	34 (6.9)
Emergency area	22 (4.5)
Labour room	20 (4.1)
Wards (Medicine, Gynaecology, Surgery, Paediatric, Orthopaedic, Special room)	92 (18.6)
Radiology clinic	12 (2.4)
Reception area	10 (2.0)
General toilet (male female, handicap)	14 (2.8)
Dialysis ward	16 (3.2)
Central laboratory	24 (4.9)
Administrative offices	16 (3.2)
Pharmacy	10 (2.0)
Lifts and other area	20 (4.1)
Total	494 (100)

[Table/Fig-1]: Sample collection details from different areas.
*NICU: Neonatal intensive care unit; MICU: Medical intensive care unit
#other areas: surfaces of lobby, waiting areas, switch boards

Out of these 494 samples, total 171 samples (34.62%) showed bacterial growth, of which 186 different organisms were isolated in this study. Out of 186 isolates, 106 (56.99%) were gram positive organisms and 80 (43.01%) were gram negative organisms. Highest number of isolates were *Bacillus* spp. (28.49%) followed by *Staphylococcus aureus* (12.90%). Among gram negative bacteria *Pseudomonas aeruginosa* was most isolated (9.14%) followed by *Klebsiella* spp. (7.53%) and *Acinetobacter* spp. (7.53%). From a bacteriological point of view, the numbers of isolates were highest from toilet area (85.71%), labour room (75%, 15/20), emergency room (68.18, 15/22). ICUs (22.06%, 15/68) and OTs (18.24% 31/170) were having less bacterial threshold as compared to other areas. Distribution of organisms among different areas in hospital is shown in [Table/Fig-2].

Different antibiotic panel were selected for gram positive, gram negative and *Pseudomonas* isolates. In case of *Bacillus* spp. AST was not performed and they were considered as environmental contaminants. [Table/Fig-3] shows antibiotic susceptibility results of various gram positive isolates in the present study. *Staphylococcus aureus* was the highest in number (n=24) among all gram positive cocci which showed highest resistance to penicillin (62.5%) and erythromycin (54.17). It showed good susceptibility towards linezolid (100%), levofloxacin (79.17%) and cefoxitin (66.67%). Coagulase negative staphylococci (CoNS) also showed highest resistance to penicillin (73.68%). CoNS showed good sensitivity to linezolid (100%), levofloxacin (78.95%), gentamicin (78.95%) and cefoxitin (73.68%). Enterococci were highest resistant to penicillin (70%) and clindamycin (70%). Meanwhile it showed good susceptibility to linezolid (90%), Vancomycin (80%), levofloxacin (80%) and doxycycline (80%). [Table/Fig-4] shows antibiotic testing results for gram negative organism. In which *Pseudomonas* showed highest resistance to ampicillin (88.24%) followed by ampicillin/sulbactam (70.59%), aztreonam (70.59%) and ceftazidime (70.59%). *Acinetobacter spp*. was also showed highest resistant to ampicillin (85.72%) and cefotaxime (85.72%). *Klebsiella* spp. showed highest resistance to ceftriaxone (92.86%) followed by ampicillin (78.58%), ceftazidime (78.58%) and sulfamethoxazole+trimethoprim (78.58%). *E. coli* showed highest resistance to ampicillin (75%), aztreonam (75%) and sulfamethoxazole+trimethoprim (75%). *Proteus* spp. and Citrobacter spp. showed highest resistance to ampicillin (71.43%) and (83.34%) respectively. Meropenem showed 100% sensitivity

Organisms isolated	ICU	OT	Ward	Emergency	Labour room	Radiology	Reception area	General toilet	Dialysis unit	Central laboratory	Administrative department	Pharmacy	Other	Total
Bacillus spp.	5	7	9	4	4	1	2	5	1	4	3	3	5	53
Coagulase negative *Staphylococci* (CoNS)	2	5	2	2	1	0	2	0	0	2	2	0	1	19
Staphylococcus aureus	1	3	5	1	2	0	1	1	1	2	3	1	3	24
Enterococcus spp.	1	2	1	1	2	0	1	1	0	0	1	0	0	10
Pseudomonas aeruginosa	2	3	4	2	0	0	0	1	0	2	0	1	2	17
Acinetobacter spp.	1	2	3	2	1	1	1	0	1	0	1	0	1	14
Klebsiella spp.	1	2	2	0	1	2	1	2	1	0	0	0	2	14
Escherichia coli	0	0	4	1	0	0	0	1	0	1	1	0	0	8
Proteus spp.	1	1	2	1	1	0	1	0	0	0	0	0	0	7
Citrobacter spp.	0	1	2	0	1	0	0	1	0	0	0	0	1	6
Stenotrophomonas maltophilia	1	2	1	0	0	0	0	0	0	1	0	0	0	5
Burkholderia cepacia	0	1	1	0	1	0	0	0	1	0	0	0	0	4
Enterobacter spp.	0	2	0	0	1	0	0	0	0	0	0	0	0	3
Serratia spp.	0	0	1	1	0	0	0	0	0	0	0	0	0	2
Total	15	31	37	15	15	4	9	12	5	12	11	5	15	186

[Table/Fig-2a]: Distribution of bacterial isolates from different areas.
*Other areas: lifts, switchboards, waiting areas, lobby; ICU: Intensive care unit; OT: Operation theatre

Organisms isolated	Floor	Wall	Patient beds	Bedside table	Door/Window handle/ Elevator buttons	Sinks and water taps	Hospital equipments	Other items	Total
Bacillus spp.	14	11	7	5	7	4	2	3	53
Coagulase negative Staphylococci (CoNS)	1	2	5	3	4	1	1	2	19
Staphylococcus aureus	0	1	3	5	7	3	5	0	24
Enterococcus spp.	1	2	1	0	2	3	0	1	10
Pseudomonas aeruginosa	0	2	2	1	3	1	6	2	17
Acinetobacter spp.	2	3	1	0	1	1	4	2	14
Klebsiella spp.	0	2	1	0	2	3	4	2	14
Escherichia coli	0	0	1	1	1	3	2	0	8
Proteus spp.	0	1	0	0	3	1	1	1	7
Citrobacter spp.	0	0	0	1	2	0	1	2	6
Stenotrophomonas maltophilia	0	2	0	0	0	1	1	1	5
Burkholderia cepacia	0	0	1	0	1	0	1	1	4
Enterobacter spp.	0	0	0	0	1	2	0	0	3
Serratia spp.	0	1	1	0	0	0	0	0	2
Total organisms	18	27	23	16	34	23	28	17	186

[Table/Fig-2b]: Distribution of bacterial isolates in screened equipments and surfaces.
*other items: switchboards, chair and tables in waiting areas.

GPC		PG	AS	CF	GM	RC	QB	CH	SXT	VA	LZ	ERY	DA	DOX
Coagulase negative *Staphylococci* (CoNS) (n=19)	S	5 (26.32)	11 (57.89)	14 (73.68)	15 (78.95)	8 (42.11)	15 (78.95)	12 (63.16)	13 (68.42)	NT	19 (100)	10 (52.63)	12 (63.16)	9 (47.37)
	R	14 (73.68)	8 (42.11)	5 (26.32)	4 (21.05)	11 (57.89)	4 (21.05)	7 (36.84)	6 (31.58)	NT	0 (0)	9 (47.37)	7 (36.84)	10 (52.63)
Staphylococcus aureus (n=24)	S	9 (37.5)	11 (45.83)	16 (66.67)	16 (66.67)	15 (62.5)	19 (79.17)	13 (54.17)	14 (58.33)	NT	24 (100)	11 (45.83)	16 (66.67)	14 (58.33)
	R	15 (62.5)	13 (54.17)	8 (33.33)	8 (33.33)	9 (37.5)	5 (20.83)	11 (45.83)	10 (41.67)	NT	0 (0)	13 (54.17)	8 (33.33)	10 (41.67)
Enterococcus spp. (n=10)	S	3 (30)	6 (60)	NT	5 (50)	6 (60)	8 (80)	7 (70)	NT	8 (80)	9 (90)	5 (50)	3 (30)	8 (80)
	R	7 (70)	4 (40)	NT	5 (50)	4 (40)	2 (20)	3 (30)	NT	2 (20)	1 (10)	5 (50)	7 (70)	2 (20)

[Table/Fig-3]: Antibiotic susceptibility testing for gram positive organisms.
†S-Sensitive, R- Resistant.
††GPC- Gram Positive Cocci.
Penicillin PG, Ampicillin/Sulbactam AS, Cefoxitin CF, Gentamycin GM, Ciprofloxacin RC, Levofloxacin QB, Chloramphenicol CH, trimethoprim-sulfamethoxazole SXT, Vancomycin VA, Linezolid LZ, Erythromycin ERY, Clindamycin DA, Doxycycline DOX, NT-not tested.

to *Proteus* spp. and *Citrobacter* spp., Burkholderia cepacia complex and *Enterobacter* spp. It showed very good sensitivity to *Pseudomonas* (82.35%), *Acinetobacter* spp. (71.41%), *Klebsiella* spp. (85.72%) and *E. coli* (87.5%). Amikacin also showed good sensitivity to *Pseudomonas* (88.23%), *Enterobacter* spp. (100%), *Citrobacter* spp. (83.34%) and *Klebsiella* spp. (71.41%). Piperacillin-tazobactam was highest sensitive to *Citrobacter* spp. (83.34%). Cefepime also showed good sensitivity to *Proteus* spp. (85.71%).

GNB		Antibiotics															
		AMP	AS	AZT	CTX	CF	CTZ	CI	CH	MP	AK	GEN	CIP	TE	PC	PT	SXT
Pseudomonas aeruginosa (n=17)	S	2 (11.76)	5 (29.41)	5 (29.41)	6 (35.29)	7 (41.18)	5 (29.41)	10 (58.82)	NT	14 (82.35)	15 (88.23)	13 (76.47)	11 (64.71)	NT	7 (41.18)	12 (70.59)	8 (47.05)
	R	15 (88.24)	12 (70.59)	12 (70.59)	11 (64.71)	10 (58.22)	12 (70.59)	7 (41.18)	NT	3 (17.65)	2 (11.77)	4 (23.53)	6 (35.29)	NT	10 (58.22)	5 (29.41)	9 (52.95)
Acinetobacter spp.(n=14)	S	2 (14.28)	4 (28.57)	3 (21.42)	2 (14.28)	3 (21.42)	4 (28.57)	6 (42.86)	NT	10 (71.41)	8 (57.14)	7 (50)	6 (42.86)	3 (21.42)	4 (28.57)	9 (60.29)	4 (28.57)
	R	12 (85.72)	10 (71.41)	11 (78.58)	12 (85.72)	11 (78.58)	10 (71.41)	8 (57.14)	NT	4 (28.57)	6 (42.86)	7 (50)	8 (57.14)	11 (78.58)	10 (71.41)	5 (39.71)	10 (71.41)
Klebsiella spp. (n=14)	S	3 (21.42)	6 (42.86)	5 (39.71)	4 (28.57)	1 (7.14)	3 (21.42)	5 (39.71)	7 (50)	12 (85.72)	10 (71.41)	5 (39.71)	8 (57.14)	5 (39.71)	6 (42.86)	7 (50)	3 (21.42)
	R	11 (78.58)	8 (57.14)	9 (60.29)	10 (71.41)	13 (92.86)	11 (78.58)	9 (60.29)	7 (50)	2 (14.28)	4 (28.57)	9 (60.29)	6 (42.86)	9 (60.29)	8 (57.14)	7 (50)	11 (78.58)
E. coli (n=8)	S	2 (25)	4 (50)	2 (25)	3 (37.5)	3 (37.5)	2 (25)	4 (50)	6 (75)	7 (87.5)	6 (75)	3 (37.5)	5 (62.5)	4 (50)	5 (62.5)	4 (50)	2 (25)
	R	6 (75)	4 (50)	6 (75)	5 (62.5)	5 (62.5)	6 (75)	4 (50)	2 (25)	1 (12.5)	2 (25)	5 (62.5)	3 (37.5)	4 (50)	3 (37.5)	4 (50)	6 (75)
Proteus spp. (n=7)	S	2 (28.57)	4 (57.14)	3 (42.86)	3 (42.86)	3 (42.86)	3 (42.86)	6 (85.71)	4 (57.14)	7 (100)	4 (57.14)	5 (71.43)	6 (85.71)	4 (57.14)	5 (71.43)	5 (71.43)	3 (42.86)
	R	5 (71.43)	3 (42.86)	4 (57.14)	4 (57.14)	4 (57.14)	4 (57.14)	1 (14.29)	3 (42.86)	0 (0)	3 (42.86)	2 (28.57)	1 (14.29)	3 (42.86)	2 (28.57)	2 (28.57)	4 (57.14)
Citrobacter spp. (n=6)	S	1 (16.66)	3 (50)	4 (66.67)	5 (83.34)	5 (83.34)	5 (83.34)	6 (100)	3 (50)	6 (100)	5 (83.34)	5 (83.34)	4 (66.67)	4 (66.67)	3 (50)	5 (83.34)	2 (33.33)
	R	5 (83.34)	3 (50)	2 (33.33)	1 (16.66)	1 (16.66)	1 (16.66)	0 (00)	3 (50)	0 (00)	1 (16.66)	1 (16.66)	2 (33.33)	2 (33.33)	3 (50)	1 (16.66)	4 (66.67)
Stenotrop-homonas maltophilia (n=5)	S	2 (40)	4 (80)	2 (40)	2 (40)	2 (40)	2 (40)	4 (80)	3 (60)	4 (80)	3 (60)	3 (60)	3 (60)	2 (40)	2 (40)	4 (80)	4 (80)
	R	3 (60)	1 (20)	3 (60)	3 (60)	3 (60)	3 (60)	1 (20)	2 (40)	1 (20)	2 (40)	2 (40)	2 (40)	3 (60)	3 (60)	1 (20)	1 (20)
Burkholderia cepacia complex (n=4)	S	2 (50)	3 (75)	2 (50)	1 (25)	1 (25)	1 (25)	3 (75)	2 (50)	4 (100)	2 (50)	2 (50)	3 (75)	1 (25)	2 (50)	4 (100)	2 (50)
	R	2 (50)	1 (25)	2 (50)	3 (75)	3 (75)	3 (75)	1 (25)	2 (50)	0 (0)	2 (50)	2 (50)	1 (25)	3 (75)	2 (50)	0 (0)	2 (50)
Enterobacter spp. (n=3)	S	0 (0)	1 (33.33)	0 (0)	1 (33.33)	1 (33.33)	1 (33.33)	2 (66.67)	2 (66.67)	3 (100)	3 (100)	1 (33.33)	1 (33.33)	2 (66.67)	2 (66.67)	2 (66.67)	0 (0)
	R	3 (100)	2 (66.67)	3 (100)	2 (66.67)	2 (66.67)	2 (66.67)	1 (33.33)	1 (33.33)	0 (0)	0 (0)	2 (66.67)	2 (66.67)	1 (33.33)	1 (33.33)	1 (33.33)	3 (100)
Serratia spp. (n=2)	S	0 (0)	1 (50)	1 (50)	2 (100)	2 (100)	2 (100)	2 (100)	2 (100)	2 (100)	2 (100)	1 (50)	2 (100)	2 (100)	0 (0)	1 (50)	1 (50)
	R	2 (100)	1 (50)	1 (50)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (50)	0 (0)	0 (0)	2 (100)	1 (50)	1 (50)

[Table/Fig-4]: Antibiotic susceptibility testing for other organisms.
S-Sensitive, R- Resistant; GNB- Gram Negative Bacilli;
Ampicillin AMP, Ampicillin-Sulbactam AS, aztreonam AZT, cefotaxime CTX, ceftriaxone CF, ceftazidime CTZ, cefepime CI, chloramphenicol CH, meropenem MP; amikacin AK, gentamicin GEN, ciprofloxacin CIP, sulfamethoxazole + trimethoprim SXT, tetracycline TE, piperacillin PC, piperacillin-tazobactam PT, NT-not tested

Detection of MRSA, GRE, MBL and ESBL for *Staphylococcus aureus*, *Enterococcus*, *Pseudomonas aeruginosa* and *Acinetobacter* spp. *Klebsiella* and *E. coli* is shown in [Table/Fig-5].

Parameters		Values		
GPC	*Staphylococcus aureus*	Total	MRSA	%
		24	8	33.33
	Enterococcus spp.	Total	GRE	%
		10	2	20.00
Non lactose fermenter	Organisms	Total	MBL	%
	Pseudomonas aeruginosa	17	3	17.65
	Acinetobacter spp.	14	4	28.57
Lactose fermenter	Organisms	Total	ESBL	%
	Klebsiella spp.	14	7	50.00

[Table/Fig-5]: Detection of MRSA, GRE, MBL and ESBL from isolated organisms in this study.
*MRSA was detected among staphylococcus isolates, GRE was detected among enterococci isolates, MBL was detected among non fermenter and ESBL detection was done among lactose fermenter

DISCUSSION

In the present study, total samples were collected among which 238 were only from operation theatres and ICUs. Apart from these, rest of the samples were collected from emergency area, various wards, labour room, diagnostic laboratories, administrative offices, reception, pharmacy, etc. Out of total of 494 samples, 171 samples (34.62%) were positive for bacterial growth from which total 186 organisms were isolated. Various studies were conducted at different places which showed different positivity rate for bacterial growth. The study of Chaoui L et al., from Morocco showed highest positivity rate (88%) from various surfaces in hospital [15]. In study of Sebre S et al., from Ethiopia showed positivity rate of 86% [16]. Similarly study of Alphonce C et al., in Tanzania [17], Yadav M et al., in north east India [18], Najotra DK et al., in Kashmir [19], Ochie K and Ohagwu CC in Nigeria [20] showed positivity rate of 61.4%, 23.4%, 4.4% and 47.2% respectively. Significant differences in positivity rate are found across the globe. Various factors affect the results such as infection control practices, house keeping protocols, hand hygiene, target area for sampling, sampling methods, time of sampling, etc. [21].

In the present study total of 186 isolates were recovered from 171 samples from various sites in hospitals. Among these, *Bacillus* spp. was the most common organism found in hospital surfaces and equipments. Similar results were found in two previous studies of Sukesh K in Telangana [22] and Najotra DK et al., in Kashmir [19]. Among gram positive cocci, *Staphylococcus aureus* was most common isolate and among gram negative bacilli, *Pseudomonas, Acinetobacter* and *Klebseilla* spp. were common isolates. In the study of Chaoui L et al., [15], Enterobacteriaceae were common isolated organism followed by *Acinetobacter* spp. and *Pseudomonas* spp. while in study of Sebre S et al., non fermenters e.g. *Pseudomonas,*

Acinetobacter among gram negative and *Staphylococcus aureus* among gram positive isolates were common [16]. In study of Yadav M et al., in north east India [18], *Staphylococcus aureus, Acinetobacter* spp., *Pseudomonas* spp. were commonly isolated organisms. Similar result was found in study of Alphonce C et al., in Tanzania [17] also. In the present study in ICUs and OTs 46 (19.33%) out of 238 samples were culture positive. Various studies showed culture positivity rate like 23.4% in Yadav M et al., [18], 63.57% from medical instruments in Kandwal P et al., [23]. In present study most of the organisms (n=57) organisms were found from frequently touched objects like door/window handles, elevator buttons, sink and water taps, etc. These sites are frequently touched by both patients and healthcare workers and is one of the common reasons for cross-infection in hospital set-up. In each infection control protocol, prime focus is given to hand hygiene to prevent contamination of such objects, so, cross-infection in hospital can be reduced [24,25]. Bacteria frequently colonise the dialysis machine, thus, bacterial infection could be major risk for patients undergoing dialysis frequently. In the present study total of 16 samples were collected from dialysis centre, out of which 5 organism were isolated which shows 31.25% rate similar 30% in study of Gorke A [26].

Out of total 24 isolates of *Staphylococcus aureus*, 8 (33.33%) MRSA while among *Enterococcus* spp. (n=10), 2 were found to be GRE. Among gram negative isolates, 22.6% of total *Pseudomonas* and *Acinetobacter* were producing MBL. While among Enterobacteriaceae, 47.7% were producing ESBL. These results are similar to fond in earlier study of Chaoui L et al., [15]. Multidrug Resistant Organisms (MDRO) are major concern for clinicians as they found to be resistant for most of the available treatment. Also they led to increased stay, cost and morbidity and mortality among the hospitalised patients. The frequency and types are variable in different population and institutions. Failing to implement, follow the proper infections control policy and contact precautions has led to increase the frequency of MDRO in healthcare set-up [27,28].

Among gram positive isolates, in both *S. aureus* and CONs showed highest resistance to penicillin drug. Similar results were found in study of Sebre S et al., [16]. They showed highest sensitivity to linezolid and good sensitivity to cefoxitin, gentamicin and levofloxacin. While enterococci showed excellent sensitivity to linezolid, vancomycin, doxycyline and levofloxacin while they showed good amount of resistance to aminoglycoside. Among gram negative bacilli, *Pseudomonas* showed good sensitivity to meropenem, gentamicin and amikacin in the present study. While *Acinetobacter* had higher rate of resistance as compared to *Pseudomonas* which showed good sensitivity to meropenem. *Klebsiella* spp. and *E. coli* showed very good sensitivity to meropenem and levofloxacin, but showed resistance to aminoglycoside and cephalosporin. The results are quite similar to study of Kamini W et al., Tsering Y et al., and Roopashree S et al., in India [29-31]. Meropenem is the most sensitive drug for all other isolates e.g. *Proteus, Citrobacter, Stenotrophomonas, Burkholderia, Enterobacter* and *Serratia*. *Proteus* and *Citrobacter* showed good sensitivity to cefepime (85.71%) and (100%) apart from meropenem. *Stenotrophomonas* and *Burkholderia* were sensitive to piperacillin-tazobactam apart from cefepime and meropenem in the present study. Only two isolates were found for *Serratia* spp. and they were sensitive to most of the antibiotics in the panel except ampicillin and piperacillin. The frequency and distribution and multidrug resistance isolates varies from region to region as well as in different Institutions which depend the cleaning practices, antibiotic policies and adherence to protocol and Standard Operating Procedure (SOPs) made to prevent HAIs. Various studies across the India have been published in recent time which shows rising trends of antimicrobial resistance among different pathogens [22,27,29-31]. This can be very serious concern for microbiologists and clinicians working in tertiary care institutes. These MDRO can easily contaminate the different surfaces and equipments in the hospitals in routine use making control of hospital acquired infection difficult and also can lead to intermittent outbreak of infection in hospital.

Limitation(s)

The present study was cross-sectional and performed at single point of time in hospital working areas. Day to day and seasonal variations in bacteriological profile of hospital environment can be missed out in the present study.

CONCLUSION(S)

Many organisms were found in the study that may contaminate the hospital environment. Apart from *Bacillus* spp., *Staphylococcus*, *Pseudomonas*. *Acinetobacter* and *Klebsiella* were predominant organisms isolated in the present study. Similar organisms are also responsible for HAIs which could be major concern for infection control practices in tertiary care centre. All the healthcare professionals must be aware of this danger of transmission of pathogenic organisms from inanimate surfaces to patients, attendants and healthcare professionals. Also intermittent surveillance of different areas in hospital is warranted at regular interval to get an idea of bacteriological profile in respective Institution so one can modify/ implement infection control practices accordingly.

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