Review Article

Microbial Trends and their drug resistance responsible for Bloodstream Infections in a Superspeciality Transplant Hospital

Abstract:

Background & Objective**:** Bloodstream infections (BSIs) are critical healthcare-associated infections that lead to high morbidity and mortality, requiring rapid diagnosis and effective antimicrobial treatment. The increasing prevalence of multidrug-resistant organisms (MDROs) exacerbates this issue, particularly in developing countries. The purpose of this study is to assess the bacteriological profile and antimicrobial susceptibility trends of BSIs to establish an antibiogram for effective empirical treatment. Materials and Methods: This study was conducted retrospectively on 3,300 blood culture samples from a multispecialty hospital over 15 months. Cultures were performed using Bactec FX and identification and antibiotic susceptibility determined by Vitek2 and Kirby-Bauer methods following CLSI guidelines. Results: Overall, the positivity rate was (14.3%) with 473 isolates: (400 bacterial and 73 fungal). Gram-negative bacteria were predominant, led by *Klebsiella pneumoniae* (113 isolates) and *Escherichia coli* (100 isolates). Among the Gram-negative bacteria, antimicrobial susceptibility was found to be low for Cephalosporins (21%sensitivity) and Fluoroquinolones(19.3% sensitivity), with moderate susceptibility to Carbapenems(51.3%). Sensitivity was high for Colistin (98.9%), Amikacin(91.05%), Tigecycline (100%),Fosfomycin(100%) and Ceftazidime-avibactum Aztreonam (97.7%). Among Gram-positive bacteria*, Coagulase-negative Staphylococcal Species* (CONS) and *Staphylococcus aureus* were the most common. The overall sensitivity of Gram-positive bacteria to antibiotics tested was high compared to the Gram-negative bacteria. Sensitivity to antibiotics such as Linezolid was found to be 94.5% and Vancomycin was found to be 93.5%. Conclusion:The high incidence of MDROs especially among the Gram-negative bacteria highlights the need for continuous monitoring and antibiotic stewardship programs. Empirical therapy must consider local resistance patterns, and a multidisciplinary approach is essential to mitigate antimicrobial resistance

Keywords: Bloodstream infections (BSI), Antimicrobial Resistance (AMR), Healthcare-associated infections, Gram positive; Gram Negative, antibiotics.

Introduction:

Blood-stream infections are one of the most common healthcare associated infections.Bacteraemia is being described as simply the presence of viable bacteria in the blood, while septicaemia is caused by bacteria or their toxins in blood and brings about systemic manifestations being a significant cause of morbidity and mortality, which requires prompt assessment, diagnosis, and antibiotic treatment. It has devastating consequences including prolonged length of hospital stay, higher costs and high mortality [1, 2]. Bloodstream infections account for about 9-11% of hospital acquired infections in the developed countries while a higher prevalence of upto 19% has been recorded from the developing countries. Currently, multidrug-resistant bacteria are emerging which is of great concern as infections caused due to these organisms lead to fewer treatment options, use of expensive drugs, prolonged hospital stay, with increased morbidity and mortality. [2]

The risk factors for Blood stream infections include the use of healthcare devices such as peripheral and central venous catheters, extremes of age such as elderly patients and neonates and comorbid patients, such as those suffering from diabetes mellitus, malignancies, renal failure, burns, prior hospitalisation and transplant patients. [2].

Among the numerous organisms causing bloodstream infections, Gram-negative bacteria including *Escherichia coli* and *Klebsiella pneumoniae* which belong to the Enterobacterales are the most common followed by non- fermenting Gram-negative bacteria like *Pseudomonas aeruginosa* and *Acinetobacter baumannii* [1]. Among the Gram-positive organisms isolated, *Staphylococcus aureus*, *Coagulase Negative Staphylococcal* species (CONS) and *Enterococcus* species are the most common. [1] The pattern of organisms isolated also differ according to several factors such as type of catheters used, type of the healthcare facility, immune status of the patients, precautions taken and initial antimicrobial therapy [1]. Early diagnosis of bloodstream infections is important and prompt detection of these infections is an important function of Clinical Microbiology Laboratories [3]. Blood culture being the gold standard for bacteraemia detection is an essential tool in the diagnosis of these infections [2, 3]. The prevalence and susceptibility patterns of microorganisms vary according to the geography and also differ within the same hospital with time. Hence, regular monitoring of blood stream infections including all the possible range of organisms and their antibiotic susceptibility patterns is important in order to start effective emperical treatment and prevent inappropriate use of antibiotics, as well as to prevent emergence of antimicrobial drug resistance. Prompt detection would also greatly contribute to lowering the morbidity and mortality caused due to these infections [3]. Hence, the present study was undertaken to understand the pattern of organisms causing Blood stream infections and their antimicrobial susceptibility profiles.

Aim of Study:

This study aims to evaluate the bacteriological profile and calculate their antimicrobial trends in order to formulate an antibiogram for effective empirical treatment of blood-stream infections.

MATERIALS AND METHODS

The present study is a retrospective observational study conducted on 3300 patient samples received for blood culture test at the Microbiology Laboratory of a multispecialty hospital during the period from September'2021-December'2022. Blood culture samples were obtained after observing proper aseptic collection practices which included cleansing the venipuncture site with 70% Isopropyl alcohol and starting at the middle of the site, swabbing concentrically with 1 to 10% tincture-iodine solution or chlorhexidine-gluconate solution and allowing the site to air dry. The tops of each septum of the blood culture bottles were also disinfected using 70% Isopropanol or Ethanol. Two sets of bottles with a volume of 8-10 ml for adult patients and 1-3 ml for paediatric patients were obtained for culture. The samples were collected in blood culture bottles using closed connection devices and transported to the laboratory as soon as possible for processing, and were immediately loaded into the Bactec FX machine once received in the laboratory.

The blood culture bottles which flagged positive for growth were processed immediately. Gram stain was performed from the positive bottles using sterile aseptic precautions. The gram character of the bacteria were noted. The positive blood culture growth was further inoculated on solid media culture plates such as Blood agar, Chocolate agar and MacConkey's agar. After overnight incubation at 35-37◦C the colonies were identified either on automated blood culture systems such as Vitek2 Compact (biomerieux) and/or Vitek2 MS

(MALDI TOF). We carried out Antibiotic susceptibility testing using the Vitek2 Compact AST cards or Kirby-Bauer Disc diffusion methods. All the data were maintained in an Excel sheet and appropriate bio-statistical tools were utilized for data analysis. MIC and Disc diffusion results were reported according to CLSI guidelines M100 31st edition and 32nd edition. Quality Control strains were also run on a regular basis both for identification and antibiotic susceptibility.

Inclusion criteria: All blood cultures submitted to the Microbiology department over 15 months (from September'2021-December'2022) due to suspected infectious causes were included in the study.

Exclusion criteria: All non-infectious cases whose blood cultures were submitted to the Microbiology Department.

RESULTS

A total of 3300 blood culture samples were received in the Microbiology Laboratory during the period from September 2021 to December 2022.Out of the total samples received, 1712 samples were from the ICUs, 1448 from wards and 140 from OPDs. Positive growth was obtained from 473 samples and the positivity rate was 14.33%.

Out of the total positive samples, 275 were from ICUs, 145 from wards and 25 from OPD. Among the ICUs, majority were from the Liver ICU and Medical ICU followed by the Transplant ICU, Neurological ICU, Cardiac ICU and the Renal ICU. Highest blood culture positivity was found in the age-group of greater than 60 years followed by 46-60 years. Higher positivity (n=324) was observed among males as compared to females (n=149). The area-wise (ward, OPD/ICU) distribution overall blood culture specimens obtained and positive blood cultures are given in Fig 1 & Fig 2 respectively. Out of the total 473 isolates obtained, 400 were bacteria and 73 were fungal isolates. There was a total of 292 Gram-negative bacteria and 108 Gram-positive bacteria isolated.

Out of the total 400 bacterial isolates obtained, Enterobacterales particularly *Klebsiella pneumoniae* and *Escherichia coli* predominated the list with a total of 113 and 100 isolates respectively. Besides these two organisms, the second most commonly isolated Gram negative bacteria were *Acinetobacter baumannii* and *Burkholderia cepacia*. Apart from these, other enterobacterales such as *Proteus mirabilis* and *Salmonella typhi* were also obtained. Other non-fermenting gram-negative bacteria such as *Pseudomonas* spp, *Burkholderia cepacia* and *Stenotrophomonas maltophilia* were also isolated (Fig 1).

Gram-positive organisms were also isolated but were lesser in number compared to the Gram-negative bacteria. Among the Gram-positive bacteria that were isolated, *Coagulase negative Staphylococcal species* (CONS) predominated the list followed by *Staphylococcus aureus*. *Enterococcus* spp and *Streptococcus* spp were isolated but in lesser numbers (Fig 2). The trend of these organisms and their antimicrobial resistance patterns are given in the tables below. *Klebsiella pneumonia* which was the predominant organism found both in the Wards and ICUs had a low sensitivity to Amoxycillin-clavulanate (18.6%) both in the Wards and ICUs, the sensitivity of Piperacillin-tazobactum was 23.3% and 17.1% respectively in the wards and ICUs. It was found to have a low sensitivity to Cephalosporins such as Cefuroxime (16.3% and 14.3% respectively in the Wards and ICUs), Ceftriaxone (18.6% and 15.3% respectively in Wards and ICUs).The sensitivity to Cefepime was 35.9% and 18.6%

respectively in the Wards and ICUs. The sensitivity of *Klebsiella pneumonia* was also low for Carbapenems such as Ertapenem (37.2% and 21.4% in Wards and ICUs respectively), Imipenem (35.7% and 21.4% in Wards and ICUs respectively) and Meropenem (41.8% and 21.4% in Wards and ICUs respectively). Sensitivity to Fluoroquinolones was also low such as to Ciprofloxacin (18.6% and 20%) respectively in the Wards and ICUs. There was a high sensitivity to Colistin in the Wards (97.1%) and in the ICUs (98.5%). Sensitivity to Ceftazidime-avibactum Aztreonam combination was 100% and 90.9% respectively in the wards and ICUs and a sensitivity to Ceftazidime-avibactum alone was 50% and 70% respectively in the wards and ICUs. *Escherichia coli* was the second-most common isolated organism both in the Wards and ICUs. It was found to have a low sensitivity to Cephalosporins such as Cefuroxime (13% and 9% respectively in Wards and ICUs), Ceftriaxone (23.5% and 19% respectively in Wards and ICUs) and intermediate sensitivity to Cefoperazone-sulbactum (65.2% and 51.9% respectively in Wards and ICUs) and to Cefepime (55.8% and 39.0% respectively in Wards and ICUs).It was also found to have intermediate sensitivity to Piperacillin-tazobatum (60.8% and 51.9% respectively in Wards and ICUs) and Carbapenems such as Ertapenem (69.5% and 59.6%), Imipenem (76% and 55.8%) and Meropenem (78.2% and 59.6%) respectively in the wards and ICUs. It was found to have a high sensitivity to antibiotics such as Amikacin (95.6%, 86.5), Gentamicin (78.2%,63.5), Tigecycline (100%,100%), Colistin (100%,100%), Fosfomycin (100%,100%) and Ceftazidime-avibactum Aztreonam (100%,100%) respectively in the wards and ICUs.

Acinetobacter baumannii which was the most common non-fermenting Gram-negative bacilli isolated, had 100% sensitivity to Piperacillin-tazobactum in the wards and 0%sensitivity in the ICUs. Similar finding was seen with Carbapenems with 100% sensitivity in the Wards and 0% sensitivity in the ICUs. The sensitivity to Fluoroquinolones was 100% and 11.1% respectively in the Wards and ICUs. The sensitivity to Tigecycline was 100% and 66.7%, for Colistin it was 100% and 100% and for Minocycline it was 100% and 62.5% respectively in the Wards and ICUs. *Burkholderia cepacia* which was also one of the most common Gram-negative bacteria isolated had high sensitivity to Meropenem (100% and 100%), Levofloxacin (83.3% and 80%) and Trimethoprim-Sulfamethoxazole (100% and 100%) respectively in the Wards and ICUs. It was found to have 66.7% and 20% sensitivity to Ceftazidime, 33.3% and 80% for Minocycline and 100% and 0% to Chloramphenicol respectively for Wards and ICUs. *Coagulase Negative Staphylococcal Species* (CONS) which was found to be the commonest organism isolated among the Gram-positive bacteria had a 33.3% and 84.6% sensitivity to Fluoroquinolones and 53.3% and 91.3% sensitivity for Trimethoprim-Sulfamethoxazole respectively in the Wards and ICUs. Sensitivity to antibiotics such as Linezolid was found to be 100% and 86.9%, Teicoplanin 46.7% and 91.3%, Vancomycin 100% and 100% and to Tetracycline 100% and 91.3% respectively in the Wards and ICUs.

Staphylococcus aureus which was the second most common Gram-positive organism isolated had high sensitivity to Tetracycline (100% and 100%), Vancomycin (100% and 100%), Teicoplanin(100% and 100%) and Linezolid (100% and 100%) respectively in the Wards and ICUs. The sensitivity to Clindamycin was 25% and 50% and for Erythromycin it was found to be 12.5% and 25% respectively in the Wards and ICUs. The sensitivity to Trimethoprim-sulfamethoxazole was 87.5% both in the Wards and ICUs. *Enterococcus species* the third most common gram-positive organism isolated was found to have a low sensitivity to Erythromycin (0%) both in the Wards and ICUs and to Tetracycline (60% and 0% respectively in the Wards and ICUs).It was observed that the sensitivity of *Enterococcus faecium* to Teicoplanin and Vancomycin was 40% and 69.2%, Linezolid 60% and 76.9% respectively for Wards and ICUs. The sensitivity to Tigecycline was 100% both in the Wards and ICUs. The sensitivity of *Enterococcus faecalis* with Tigecycline was 100% and 83.3%

respectively in the Wards and ICUs and it was found to have 100% sensitivity for Linezolid, Teicoplanin and Vancomycin both in the Wards and ICUs.The *Streptococcus species* that were isolated included *Streptococcus pneumoniae*, *Streptococcus pyogenes*, *Streptococcus dysgalactiae*, *Streptococcus sanguinus*, *Streptococcus infantarius*, *Streptococcus gallolyticus* and *Streptococcus parasanguinus*.The sensitivity of *Streptococcus species* to almost all the antibiotics was found to be high both in the Wards and the ICUs.

The CRE rates for *Klebsiella pnemoniae* were 22.1% and 46.0% respectively in the Wards and ICUs. The CRE rate for *Escherichia coli* was found to be 8% and 20% respectively in the Wards and ICUs. Carbapenem-resistant *Acinetobacter baumannii* (CRAB) rate was 0% and 69.2% respectively in the Wards and ICUs.The rate of Methicillin Resistant *Staphylococcus aureus* (MRSA) was found to be 20% both in the Wards and ICUs.

Vancomycin-Resistant *Enterococci* (VRE) rate was found to be 11.1% and 14.8 % respectively in the Wards and ICUs.

DISCUSSION:

Blood stream infection if left untreated may be lethal, therefore prompt detection, identification and susceptibility testing of the pathogenic microorganisms is the vital responsibility of the Microbiology laboratory [3, 4, 5]. In the present study, the blood culture positivity was found to be 14.33%. This rate of positivity is similar to many studies in India and abroad [3,6,7]. A study done by Mehdinejad M et al in Iran showed a lower positivity rate of 5.6% [8]. Whereas a study by Sharma M et al on paediatric patients showed a higher overall positivity at 22.9 % [9]. The positivity rate observed by Pandey et al in their study in Nepal was similar to our study at 12.6% [10]. The variation in these numbers could be due to a variety of factors including number of blood culture bottles taken, volume of blood drawn, prior administration of antibiotics and various other factors such as geographical location, nature of the population and differences in the etiological agents [4,5]. The lower rate in our study could be due to the fact that us being a tertiary care centre, many patients would have already received antibiotics before they were admitted.

The gender-wise ratio was 2.17:1 (324:149) and was skewed in favour of males (Table 4). This is in accordance with the recent review of data in the National Hospital Discharge Survey (U.S) which states that the incidence of sepsis, severe sepsis, and septic shock is higher in men than in women [11]. Also, men are more likely to seek treatment earlier as they are the active and the main earning members of most families, so they may be more prompt to visit physician chambers for treatment. [4].

Our study found that the highest blood culture positivity was found in the age-group of greater than 60 years. This could be due to the fact that majority of the males were in this age-group and hence are predisposed to many diseases leading to a higher risk of BSIs.

In the present study, blood-stream infections due to Gram-negative bacteria outweighed the Gram-positive bacteria. Similar results were also seen in the studies by Palewar et al and Vanitha et al. [5,12] Among the Gram-negative bacteria, Enterobacterales predominated the list with majority of the isolates being *Klebsiella pneumonia* (28%) and *Escherichia coli* (25%) as found in other studies such as those carried out by Banik et al and Gupta et al [3,13].

Acinetobacter baumannii and *Burkholderia cepacia* group were the most common non-fermenting Gram-negative bacilli isolated (n=13 each). The total non-fermenting Gram-negative bacteria isolated were n=52 and contributed to 13% of the total bacteria isolated. This finding is important as most of these bacteria are nosocomial pathogens and also associated with a high degree of antimicrobial resistance. [14,15,6].

In this study, *Salmonella typhi* was isolated in 0.8% (4/473) cases. Similar findings were seen in studies by Jadhav et al (1.5%) [15]. However, there are studies which reported a higher prevalence of *Salmonella typhi* between 12-15% as seen in studies done by Vanitha et al and Chhina et al. [14,16].

Among the Gram positive organisms that were isolated, *Coagulase-negative Staphylococcal species* (CONS) (41/473) were the most common followed by *Staphylococcus aureus* (20/473). Over the past years, *Coagulase-negative Staphylococcal species* (CONS) once considered as skin commensals are now emerging as true pathogens in various settings. Improper blood collection practices and presence of long-standing intravascular catheters contribute to the spread of Blood Stream Infections due to these pathogens. There were similar studies done by Wattal et al and Karlowsky et al in which CONS was found to be the most commonly isolated [6,16].

Klebsiella pneumoniae *w*hich was the most common Enterobacterale isolated had a low susceptibility to Cephalosporins and Fluoroquinolones. This finding is similar to studies done by Mark et al. The study also suggests that resistance to Cephalosporins is a marker for the presence of Extended Spectrum Beta Lactamases (ESBLs) [17]. The high resistance of Cephalosporins and Fluoroquinolones is due to the fact that these antibiotics are one of the most commonly used both in inpatient and outpatient settings as stated in studies done by Banik et al and Palewar et al [3,5]. The isolates were found to have a moderate susceptibility to Carbapenems such as Meropenem and Imipenem. The decreasing susceptibility of Carbapenems is alarming and is due to irrational use of these drugs in inpatient settings. This finding is similar to the study conducted by Zhang et al [18]. Hence Carbapenems should be held back only for cases not responding to other combination therapies. It is also advised that Carbapenems should also be used in combination with other classes of antibiotics with a good profile to the isolated pathogen, to reduce the speed at which bacteria generate resistance to these drugs as mentioned in the study done by Watkins et al [19]

Susceptibility to drugs such as Amikacin, Gentamicin, Tigecycline, Colistin, Fosfomycin, Ceftazidime-avibactum was high. This is in accordance to similar studies done by Palewar et al, Sharma et al and Robilotti et al where these drugs were found susceptible to *Klebsiella pneumonia* isolates [5,20,21]. It was also found that sensitivity to the drug combination of Ceftazidime-avibactum with Aztreonam was high. This finding was seen in similar other studies including the studies done by Watkins et al [19] and Ojdana et al [22] where combination therapies were used for treatment.Hence we see that the treatment options for ESBL producing and CRE *Klebsiella pneumonia* is limited, therefore rational use of antibiotics is a must. Also, one should consider using combination therapies in case of multidrug resistant strains instead of using monotherapy for treatment.

Escherichia coli which was the second most common enterobacterale isolated in the present study had a moderate susceptibility to Cephalosporins, Piperacillin-tazobactum and Carbapenems. This was similar to the studies done by Dandamudi et al [23]. It was found to have a high susceptibility to drugs such as Amikacin, Gentamicin, Tigecycline, Colistin, Fosfomycin and Ceftazidime-avibactum Aztreonam which was similar to the studies done by Palewar et al and Sharma et al [5, 20].

There was a high resistance of *Acinetobacter baumannii* to Carbapenems and only few drugs like Fluroquinolones,Tigecycline,Colistin and Minocycline had a good susceptibility to this organism. This is similar to the study done by Viehman et al [24].

In the present study, *Coagulase-Negative Staphylococcal Species* (CONS) which was the most common Gram-positive organism isolated had good susceptibility to drugs such as Trimethoprim-Sulfamethoxazole, Linezolid, Teicoplanin, Tetracycline and Vancomycin. This finding was similar to the studies done by Palewar et al. [5]

Staphylococcus aureus, the second most common Gram-positive organism isolated in our study had high susceptibility to Teicoplanin, Linezolid, Tetracycline and Vancomycin. However, there was a low susceptibility for macrolides such as Clindamycin and Erythromycin. The Methicillin resistance (MRSA) rate was found to be (20%) both in the Wards and ICUs. This rate was found to be similar to the studies done by Sharma et al in the year 2015 [20]. However, higher rates of Methicillin Resistant *Staphylococcus aureus* (MRSA) were found in many other studies such as studies done by Banik et al and Palewar et al

[3, 5]. The susceptibility of *Enterococcus species* isolates to Linezolid, Vancomycin, Tigecycline, Teicoplanin was also high which was similar to the studies done by Palewar et al [5]. Vancomycin-Resistant *Enterococci* (VRE) rate was found to be 11.1% and 14.8 respectively in the Wards and ICUs. This finding was similar to studies done by Japoni et al [25]. There were however studies which demonstrated a higher rate of VRE as in the studies done by Palewar et al [5] and Vasudeva et al [4].

All the *Streptococcus species* isolated in the current study had a high susceptibility to all the antibiotics being tested. This finding was similar to the study done by Palewar et al [5]. Penicillin resistance was noted in 6.5% of the *Streptococcus species* being isolated. This finding was similar to the studies done by Chawla et al [26] who reported a 4% rate in resistance. A higher penicillin resistance of 16% was reported by Wattal et al [6]. Quinolone resistance was observed in 25% of *Streptococcus pneumoniae* isolates and 50% in other *Streptococcal species*. This is similar to the findings seen by Chawla et al in which a high resistance of Ciprofloxacin was seen (14%) which can be attributed to the high usage of quinolones nowadays [27]. There were however, earlier studies such as those done by Jones et al and Pletz et al which have mentioned an increasing trend in quinolone resistance [27,28]. All the isolates were susceptible to Ceftriaxone which is similar to the study done by Wattal et al [6].

CONCLUSION:

In the present study, Gram-negative bacteria were the predominant organisms isolated, with a low susceptibility to Fluoroquinolones and Cephalosporins, moderate susceptibility to Carbapenems and a high susceptibility to drugs such as Amikacin, Gentamicin, Tigecycline, Colistin, Fosfomycin, Ceftazidime-avibactum and Ceftazidime-avibactum Aztreonam combinations. The susceptibility of Gram-positive organisms to antibiotics such as Linezolid, Vancomycin, Tetracycline and Teicoplanin were still found to be high.

The treatment options for Gram-negative bacteria are limited, hence de-escalation of high-end antimicrobials is recommended once the sensitivity pattern of the isolate is known. In

addition, routine monitoring of etiology of blood stream infections and formulation of an antibiogram is a must for every healthcare setting. Also, an antibiotic restriction policy, use of combination therapies and antibiotic recycling may help in reducing the incidence of bloodstream infections and also prevent the emergence of antimicrobial resistance.

A vigorous infection control program along with formulation of an antimicrobial stewardship program is a must in this era.

COMPETING INTERESTS DISCLAIMER:

Authors have declared that they have no known competing financial interests OR non-financial interests OR personal relationships that could have appeared to influence the work reported in this paper.

HIGHLIGHTS OF THE STUDY:

- The overall blood culture positivity in this study was found to be 14.3%.
- Gram-negative bacteria were the predominant organisms with majority being *Klebsiella pneumonia* and *Escherichia coli.*
- Among the Gram-positive bacteria *Coagulase Negative Staphylococcal Species* (CONS) were most commony isolated.
- Antimicrobial resistance was found to be high among the Gram-negative bacteria with only few antibiotics having good sensitivity.
- The overall MRSA rate was found to be 20%.
- The overall VRE rate was found to be 12.9%.
- The CRE rates for *Klebsiella pnemoniae* was 34.1% and the CRE rate for *Escherichia coli* was found to be 14%.
- A vigorous infection control program along with formulation of an antimicrobial stewardship program is necessary.

LIMITATIONS OF THE STUDY:

The study was limited by small sample size which resulted from the short duration of data collection. A larger sample size spanning over several years would have been more robust for better statistical conclusions to be made.

Disclaimer (Artificial intelligence)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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Table 1: Overall distribution

	Frequency	Percentage
Age Group (in years)		
<1	38	1.15%
1 – 12	88	2.67%
13 – 18	59	1.79%
19 – 30	280	8.48%
31 – 45	631	19.12%
46 – 60	990	30.00%
>60	1214	36.79%
Gender		
Female	1028	31.15%
Male	2272	68.85%
Ward		
Ward	1268	38.42%
Liver ICU	615	18.64%
Medical ICU	559	16.94%
Transplant ICU	284	8.61%
Neuro ICU	199	6.03%
CT Post	142	4.30%
OPD	140	4.24%
Cardiac ICU	41	1.24%

BMT	28	0.85%
Renal ICU	14	0.42%
HDU	10	0.30%

ICU: Intensive Care Unit, OPD: Outpatient Distribution

Table 2: Overall growth distribution

Growth/No Growth	Frequency	Percentage
Growth	473	14.33%
No Growth	2827	85.67%

Table 3: Overall distribution of positive isolates

	Growth	
	Frequency	Percentage
Age Group (in years)		
<1	4	0.85%
1 – 12	2	0.42%
13-18	2	0.42%
19-30	42	8.88%
31-45	88	18.60%
46-60	158	33.40%
>60	177	37.42%
Gender		
Female	149	31.50%
Male	324	68.50%
Ward/ICU/OPD		
Ward	145	30.66%
Liver ICU	120	25.37%
Medical ICU	88	18.60%
Transplant ICU	30	6.34%
Neuro ICU	27	5.71%
CT Post	24	5.07%
OPD	25	5.29%
Cardiac ICU	7	1.48%
BMT	3	0.63%
Renal ICU	3	0.63%
HDU	1	0.21%

Table 4: Susceptibility of Gram-negative isolates in Wards and Intensive Care Units

Antibiotic	Klebsiella Pneumoniae		Escherichia Coli		Acinetobacter Baumannii		Burkholderia Cepacia	
	Ward	ICU	Ward	ICU	Ward	ICU	Ward	ICU
Ampicillin	0	0	2.3	5.8	NA	NA	NA	NA
Amoxicillin-Clavulanic Acid	18.6	18.6	46.5	36.5	NA	NA	NA	NA
Piperacillin/Tazobactam	23.3	17.1	60.8	51.9	100	0	NA	NA
Cefuroxime	16.3	14.3	13	9.6	NA	NA	NA	NA

Cefuroxime Axetil	16.3	14.3	13	9.6	NA	NA	NA	NA
Ceftriaxone	18.6	15.3	23.5	19.0	NA	NA	NA	NA
Cefoperazone/Sulbactum	37.2	22.9	65.2	51.9	100	22.2	NA	NA
Cefepime	35.9	18.6	55.8	39.0	100	0	NA	NA
Ertapenem	37.2	21.4	69.5	59.6	NA	NA	NA	NA
Imipenem	35.7	21.4	76	55.8	100	0	NA	NA
Meropenem	41.8	21.4	78.2	59.6	100	0	100	100
Doripenem	NA	NA	NA	NA	100	0	NA	NA
Amikacin	51.1	51.4	95.6	86.5	100	NA	NA	NA
Gentamycin	32.5	34.3	78.2	63.5	100	22.2	NA	NA
Ciprofloxacin	18.6	20	17.4	17.3	100	11.1	NA	NA
Levofloxacin	NA	20	14.2	0	100	11.1	83.3	80
Tigecycline	0	17.3	100	100	100	66.7	NA	NA
Colistin	27.8	98.5	100	100	NA	100	NA	NA
Trimethoprim/Sulfamethoxazole	28.6	33.3	41.3	38.5	100	11.1	100	100
Ticarcillin-Clavulanic Acid	NA	NA	NA	NA	100	0	0	0
Ceftazidime	NA	NA	NA	NA	100	0	66.7	20
Minocycline	NA	NA	NA	NA	100	62.5	33.3	80
Chloramphenicol	NA	NA	NA	NA	NA	NA	100	0
Fosfomycin	100	NA	100	100	NA	NA	NA	NA
Ceftazidime-Avibactum	50	70	33.3	0	NA	NA	NA	NA
Cefta-Avi+Aztreo	100	90.9	100	100	NA	NA	NA	NA

Table 4: Continue

Antibiotic	Stenotrophomonas Maltophilia		Enterobacter Cloacae		Pseudomonas Spp		Salmonella Typhi		Salmonella Spp	
	Ward	ICU	Ward	ICU	Ward	ICU	Ward	ICU	Ward	ICU
Ampicillin	NA	NA	NA	0	NA	NA	100	100	50	
Amoxicillin-Clavulanic Acid	NA	NA	0	0	NA	NA	100	100	100	
Piperacillin/Tazobactam	NA	NA	100	50	20	50	100	100	100	
Cefuroxime	NA	NA	0	0	NA	NA	0	NA	0	
Cefuroxime Axetil	NA	NA	0	0	NA	NA	0	NA	0	
Ceftriaxone	NA	NA	100	100	NA	NA	100	100	100	
Cefoperazone/ Sulbactum	NA	NA	100	50	20	50	100	100	50	
Cefepime	NA	NA	100	100	20	66.7	100	100	100	
Ertapenem	NA	NA	100	50	NA	NA	100	100	100	
Imipenem	NA	NA	100	50	20	66.7	100	100	100	
Meropenem	0	0	100	50	20	50	50	100	100	

Doripenem	NA	NA	NA	NA	33.3	50	NA	NA	NA	
Amikacin	NA	NA	50	50	100	66.7	0	NA	0	
Gentamycin	NA	NA	50	50	60	66.7	0	NA	0	
Ciprofloxacin	NA	NA	100	50	20	66.7	0	100	50	
Levofloxacin	0	100	100	NA	20	66.7	NA	NA	NA	
Tigecycline	NA	NA	100	100	NA	0	100	NA	100	
Colistin	NA	NA	100	100	100	100	100	100	100	
Trimethoprim/ Sulfamethoxazole	50	100	100	50	0	0	100	100	100	
Ticarcillin-Clavulanic Acid	0	80	NA	NA	0	0	NA	NA	NA	
Ceftazidime	0	40	NA	NA	60	60	NA	NA	NA	
Minocycline	100	100	NA	NA	100	66.7	NA	NA	NA	
Chloramphenicol	50	100	NA	NA	NA	NA	NA	NA	NA	
Fosfomycin	NA	NA	NA	NA	100	NA	NA	NA	NA	
Ceftazidime-Avibactum	NA	NA	NA	NA	100	NA	NA	NA	NA	
Cefta-Avi+Aztreo	NA	NA	NA	NA	100	NA	NA	NA	NA	

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514 **Table 4: Continue**

Antibiotic	Acinetobacter Spp		Proteus Mirabilis		Chryseobacterium Indologenes	Sphingomonas Paucimobilis	Elizabethkingia Meningoseptica	Serratia Marcesens	
	Ward	ICU	Ward	ICU	Ward	Ward	Ward	Ward	ICU
Ampicillin	NA	NA	0	0	NA	NA	NA	NA	NA
Amoxicillin-Clavulanic Acid	NA	NA	0	100	NA	NA	NA	0	0
Piperacillin/Tazobactam	NA	100	100	100	0	66.7	0	NA	NA
Cefuroxime	NA	NA	100	0	NA	NA	NA	0	0
Cefuroxime Axetil	NA	NA	100	0	NA	NA	NA	0	0
Ceftriaxone	NA	NA	100	0	NA	NA	NA	100	100
Cefoperazone/ Sulbactum	100	100	100	100	100	66.7	0	100	100
Cefepime	40	50	100	0	66.7	0	0	100	100
Ertapenem	NA	NA	0	100	NA	NA	NA	100	100
Imipenem	40	50	0	0	0	66.7	NA	NA	NA
Meropenem	40	50	100	100	0	100	NA	100	100
Doripenem	40	50	NA	NA	NA	NA	NA	NA	NA
Amikacin	100	100	100	0	0	66.7	NA	100	100
Gentamycin	80	50	100	0	66.7	66.7	NA	100	100

Ciprofloxacin	80	50	0	0	0	33.3	0	100	100
Levofloxacin	80	50	NA	NA	100	50	0	NA	NA
Tigecycline	100	100	0	0	0	100	100	100	100
Colistin	100	100	NA	NA	0	0	NA	NA	NA
Trimethoprim/ Sulfamethoxazole	80	50	0	0	100	66.7	100	100	100
Ticarcillin-Clavulanic Acid	60	100	NA	NA	0	66.7	NA	NA	NA
Ceftazidime	20	0	NA	NA	66.7	33.3	NA	NA	NA
Minocycline	100	100	NA	NA	100	100	100	NA	NA
Chloramphenicol	NA	NA	NA	NA	NA	NA	NA	NA	NA
Fosfomycin	NA	NA	NA	NA	NA	NA	NA	NA	NA
Ceftazidime-Avibactum	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cefta-Avi+Aztreo	NA	NA	NA	NA	NA	NA	NA	NA	NA

Table 5: Susceptibility of Gram-positive isolates in Wards and Intensive Care units

Antibiotics	Cons		Staphylococcus Aureus		Enterococcus Faecium		Enterococcus Faecalis	
	Ward	ICU	Ward	ICU	Ward	ICU	Ward	ICU
Ampicillin	NA	NA	NA	NA	NA	NA	NA	NA
Ceftriaxone	NA	NA	NA	NA	NA	NA	NA	NA
Gentamycin	66.7	60.8	75	100	NA	NA	NA	NA
Gentamycin High Level	NA	NA	NA	NA	20	30.7	0	50
Ciprofloxacin	33.3	84.6	12.5	12.5	20	0	0	33.3
Levofloxacin	33.3	84.6	12.5	37.5	20	0	0	33.3
Tigecycline	100	100	100	100	100	100	100	83.3
Trimethoprim/Sulfamethoxazole	53.3	91.3	87.5	87.5	NA	NA	NA	NA
Benzylpenicillin	6.6	65.2	0	12.5	20	0	100	100
Oxacillin	26.7	26	50	50	NA	NA	NA	NA
Erythromycin	6.6	33.3	12.5	25	0	0	0	0
Clindamycin	26.7	42.8	25	50	NA	NA	NA	NA
Linezolid	100	86.9	100	100	60	76.9	100	100
Daptomycin	NA	100	NA	100	100	0	NA	NA
Teicoplanin	46.7	91.3	100	100	40	69.2	100	100
Vancomycin	100	100	100	100	40	69.2	100	100
Tetracycline	100	91.3	100	100	60	0	0	0
Nitrofurantoin	NA	NA	NA	NA	NA	NA	NA	NA
Cefotaxime	NA	NA	NA	NA	NA	NA	NA	NA
Chloramphenicol	NA	NA	NA	NA	NA	NA	NA	NA
Moxifloxacin	NA	NA	NA	NA	NA	NA	NA	NA
Fosfomycin	NA	NA	NA	NA	100	100	NA	NA

521 **Table 5: Continue**

Antibiotics	Streptococcus Spp		Streptococcus Pneumoniae		Streptococcus Pyogenes		Enterococcus Spp	
	Ward	ICU	Ward	ICU	Ward	ICU	Ward	ICU
Ampicillin	80	80	NA	100	100		NA	
Ceftriaxone	100	100	100	100	100		NA	
Gentamycin	NA	NA	NA	NA	NA		NA	
Gentamycin High Level	NA	NA	NA	NA	NA		NA	
Ciprofloxacin	NA	NA	NA	NA	NA		0	
Levofloxacin	40	80	100	25	100		0	
Tigecycline	100	100	100	100	100		NA	
Trimethoprim/Sulfamethoxazole	100	NA	50	25	100		NA	
Benzylpenicillin	75	80	100	100	100		NA	
Oxacillin	NA	NA	NA	NA	NA		NA	
Erythromycin	0	75	0	25	100		0	
Clindamycin	60	100	50	100	100		100	
Linezolid	100	100	100	100	100		100	
Daptomycin	NA	NA	NA	NA	NA		NA	
Teicoplanin	NA	NA	NA	NA	NA		100	
Vancomycin	100	100	100	100	100		100	
Tetracycline	20	60	0	25	100		NA	
Nitrofurantoin	NA		NA	NA	NA		NA	
Cefotaxime	100	100	100	100	100		NA	
Chloramphenicol	100	100	100	100	100		NA	
Moxifloxacin	75	100	100	100	100		NA	
Fosfomycin	NA	NA	NA	NA	NA		NA	

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523 **Fig 1: Distribution of gram-negative isolates from positive blood cultures**

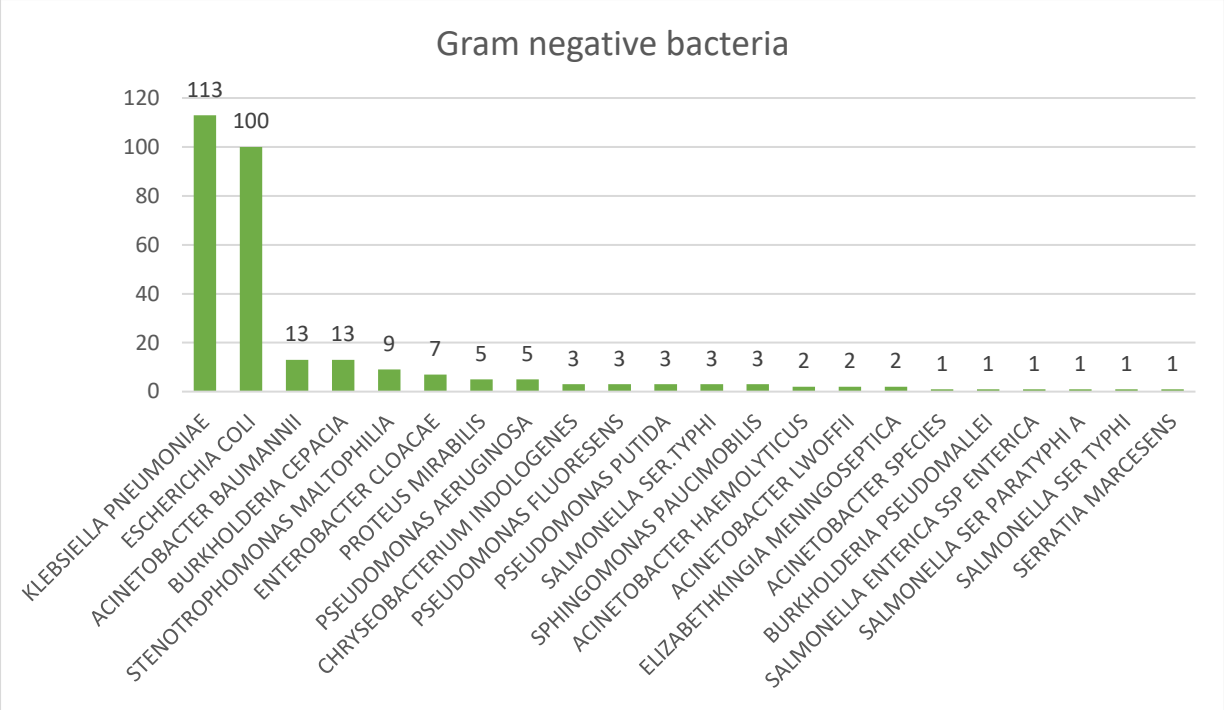


Fig 2: Distribution of Gram-positive isolates from positive blood cultures

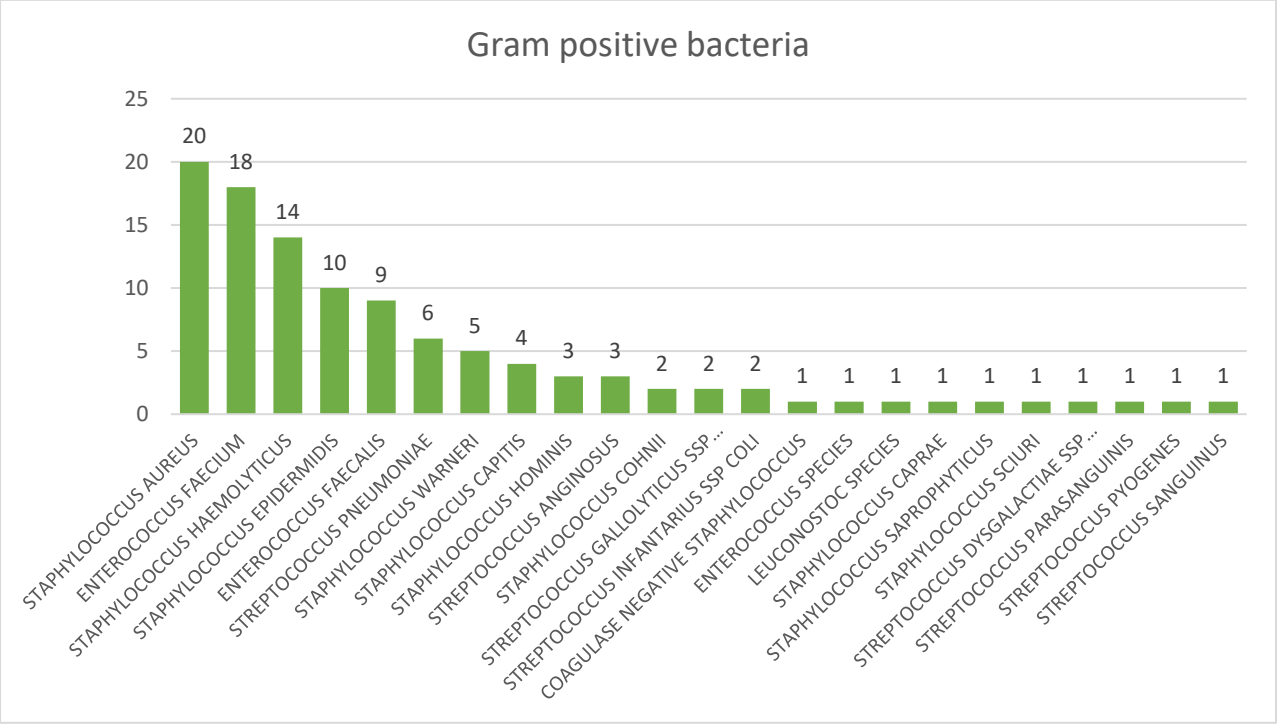
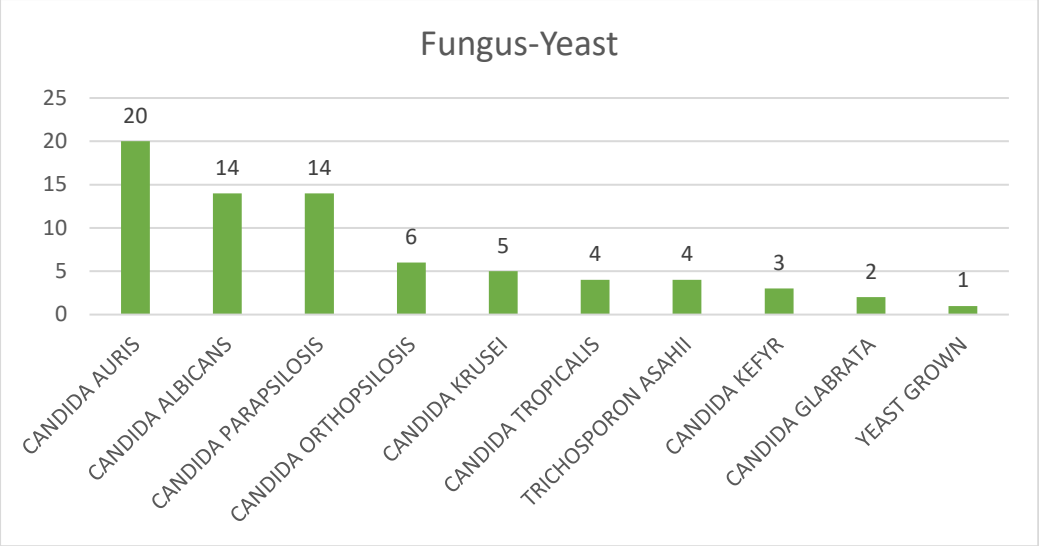


Fig 3: Distribution of Fungus-Yeast from positive blood cultures



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