

RESEARCH ARTICLE



OPEN ACCESS

Received: 19-04-2020

Accepted: 01-05-2020

Published: 18-06-2020

Editor: Dr Natarajan Gajendran

Citation: Diaz-Cornejo N, Ruiz-Garcés L, Ortiz-Girón J, Ramirez-Barbera N (2020) **Antimicrobial resistance profiles of bacterial pathogens isolated from the bloodstream in patients of a hospital institution in Montería — Córdoba.** Indian Journal of Science and Technology 13(19): 1908-1916. <https://doi.org/10.17485/IJST/13i19.349>

*Corresponding author.

Luis Ruiz-Garcés

Faculty of Health Science, University of Sinu, Medicine Program, Montería, Colombia
luiscarlosrg03@gmail.com

Funding: None

Competing Interests: None

Copyright: © 2020 Diaz-Cornejo, Ruiz-Garcés, Ortiz-Girón, Ramirez-Barbera. This is an open access article distributed under the terms of the [Creative Commons Attribution License](https://creativecommons.org/licenses/by/4.0/), which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

Published By Indian Society for Education and Environment (iSee)

Antimicrobial resistance profiles of bacterial pathogens isolated from the bloodstream in patients of a hospital institution in Montería — Córdoba

Nohra Diaz-Cornejo¹, Luis Ruiz-Garcés^{1*}, José Ortiz-Girón¹, Nathalie Ramirez-Barbera¹

¹ Faculty of Health Science, University of Sinu, Medicine Program, Montería, Colombia

Abstract

Objectives: To determine the most frequent bacterial pathogens in the bloodstream and their resistance profiles in a hospital institution in Montería - Córdoba. **Methods:** An observational study was conducted, during the months of January to December 2018, 113 blood samples from patients with sepsis were evaluated. The identification and susceptibility of the bacteria were determined through the VITEK system, using the GNI + cards for Gram-negative bacilli and GPI for Gram-positive cocci and the GNS 113 and GPS 102 cards for Gram-negative bacilli and Gram-positive cocci respectively. **Findings:** Among the Gram-negative bacteria, the ones that were most frequently isolated were *Pseudomonas aeruginosa*, *Klebsiella pneumonia* and *Acinetobacter baumannii*; while among the Gram-positive bacteria *Staphylococcus epidermidis* was the pathogen that was most frequently isolated. Gram-negative *Pseudomonas aeruginosa* isolates showed high resistance to doripenem, imipenem and meropenem. *Acinetobacter baumannii* showed high resistance to most antibiotics. *Serratia marcescens*, *Escherichia coli*, *Enterobacter cloacae* had a low resistance rate. Gram-positive *Staphylococcus epidermidis*, *Staphylococcus haemolyticus*, *Staphylococcus hominis* ss. *hominis*, *Enterococcus faecalis* and *Staphylococcus aureus* ss. *aureus* showed high resistance to erythromycin. **Novelty:** A high prevalence of antimicrobial resistance was observed in the present investigation.

Keywords: Blood culture; bacteremia; antimicrobial resistance; sepsis

1 Introduction

The presence of live microorganisms in a patient's blood is usually indicative of a serious invasive infection that requires urgent antimicrobial treatment^(1,2). Approximately 200,000 cases of bacteraemia occur annually worldwide with mortality rates ranging from 20% to 50%, which is why they require rapid and adequate empirical therapy before the blood culture results are ready; blood cultures are essential in the diagnosis and treatment of etiologic agents⁽³⁻⁵⁾.

The lethality of sepsis in terms of mortality rate has decreased over the past two decades, however, the increase in cases of sepsis, particularly in developing countries, remains a major health problem that creates a major challenge for clinicians in the selection of suitable antimicrobial agents, since it is further complicated by the increasing development of resistance of bacteria to antimicrobial agents, which is the pillar of sepsis treatment⁽⁶⁾. Both Gram-positive and Gram-negative bacteria have been isolated from the bloodstream and the predominance of one type over another varies from place to place⁽⁶⁾.

Various epidemiological studies of bloodstream infections (ITOS) have been carried out in Europe and the United States of America (USA), with patients registered in national databases; It is estimated that in Europe there are 1,213,460 to 1,381,590 episodes with 157,000 deaths per year and in the United States of America 575,462 and 677,389 with 79,000 to 94,000 deaths per year^(7,8). In the countries like South Africa and Ethiopia, the rate of Sepsis mortality is almost 53%, which is considered a major health problem in developing countries⁽⁹⁾. Being the most prevalent bacteria *Staphylococcus aureus*, *Staphylococcus* negative coagulase, *Enterococcus* spp., Enterobacteriaceae, *Pseudomonas aeruginosa*, *Acinetobacter baumannii* y *Escherichia coli*^(10,11). In Latin America, although the same volume of information does not exist, epidemiological studies of bacteraemia have been carried out in national surveillance programs in Brazil (SCOPE) or from the international antimicrobial resistance surveillance program SENTRY⁽¹²⁾.

In Colombia there have been few epidemiological studies of sepsis, however there are studies published by Vásquez et al., 2018, who characterized pediatric patients with positive blood cultures from the pediatric intensive care service of the San José Bogotá Hospital, April 2012 to 2017, reporting the most frequent non-contaminating isolated germs such as *Staphylococcus aureus* (30%), followed by *Klebsiella pneumoniae* (17.5%) and *Streptococcus pneumoniae* (17.5%). The most frequent contaminating germ was *Staphylococcus epidermidis* (47.5%), also Cortes et al., 2013 determined the frequency of isolated microorganisms in patients with bacteraemia in intensive care units in Colombia and their resistance profiles, the microorganisms most frequently were *Staphylococcus aureus* 12.5%, *Klebsiella pneumoniae* 8.2%, *Escherichia coli* 5.7%, *Acinetobacter baumannii* y 4.0% and *Pseudomonas aeruginosa* 3.8%. Negative coagulase *Staphylococcus* recorded an oxacillin resistance rate greater than 70%. There was a trend towards a lower resistance rate among the isolates of *E. coli* y *K. pneumoniae* during the study period, while the carbapenem resistance rate of *A. baumannii* exceeded 50%.

In Montería (Córdoba), the first epidemiological study of sepsis and its resistance profiles has not been carried out, with the present investigation it is sought to provide updated information on the main bacteria isolated from the bloodstream and the tendency of antibiotic resistance profiles, serving as an aid to doctors in our region when choosing the most appropriate therapy. Because the resistance may be different according to the region and according to geographical and epidemiological characteristics.

2 Materials and Method

2.1 Study design

An observational prospective study was carried out in a clinic in the city of Montería - Córdoba, during the months of January to December 2018.

2.2 Sampling

During the study period, 113 blood samples from patients with sepsis were evaluated. Informed consent was obtained from patients or close relatives of patients before being included in the study. All patients of both sexes, all age groups with suspected or proven infection were admitted⁽⁶⁾.

Blood samples were collected by trained laboratory personnel at the doctor's request. Two blood samples were collected before patients were treated with antibiotics. Samples were collected after a thorough cleaning of the venous site with 70% alcohol and 2% iodine tincture. Under aseptic conditions, 10 ml of blood was drawn by venous puncture and about 5 ml of blood was inoculated into each of the 50 ml of tryptone soy broth and incubated at 37 ° C^(13,14). Turbidity (growth sign bacterial) was checked daily until day 14 to report that there was no bacterial growth. The turbid broth cultures were subcultured in MacConkey agar, blood agar, chocolate agar and salted mannitol agar, to be subsequently incubated at 37 ° C for 24 to 48 hours^(15,16). Subsequently, pure colonies were grown in agar nutritive and blood agar for identification through the VITEK system, using the GNI + cards for Gram-negative bacilli and GPI for Gram-positive coconuts. Prior to the inoculation of the cards, Gram staining and oxidase, catalase and / or coagulase reaction according to the microorganism were carried out in all cases⁽¹⁷⁾.

2.3 Susceptibility testing

The susceptibility of the bacterial isolates to different antimicrobials was determined through the VITEK system, for which 3 ml of sterile saline was transferred to a test tube, subsequently an isolated colony was selected, mixed and the density was determined through the McFarland scale which should have been between 0.5-0.63⁽¹⁷⁾. In the sensitivity studies, the GNS 113 and GPS 102 cards were used for Gram-negative bacilli and Gram-positive cocci, respectively⁽¹⁷⁾. The antimicrobials used are: Amicacin, Ampicillin / Sulbactam, Cephalothin, Cefepime, Cefepime, Cefotaxime, Ceftazidime, Ceftriaxone, Ciprofloxacin, Ciprofloxacin, Clindamycin, Colistin, Doripenem, Erythromycin, Ertapenem, Gentamicin, Mipenoxine, Mipenexin, Mipenexin, Mimophenoxyacin, Nitroxamine, Nitroxamine, Nitroxamine, Nitroxamine, Nitroxamine, Nitroxamine, Nitroxamine, Nitroxamine, Nitroxamine, Nitroxamine, Nitroxamine, Nitroxamine Piperacillin / Tazobactam, Quinipristin / Dalfopristin, Rifampin, Teicoplanin, Tetracillin, Tigecycline, Trimethoprim / Sulfamethoxazole, Vancomycin.

3 Results

3.1 Distribution of positive samples

During the period, January to December 2018, a total of 113 patients were confirmed with sepsis, of which it was found that the frequency of isolation of Gram-negative bacteria (n = 82, 72.6%) was greater than that of Gram-positive bacteria (n = 31, 27.4%) ([Figure 1](#)).

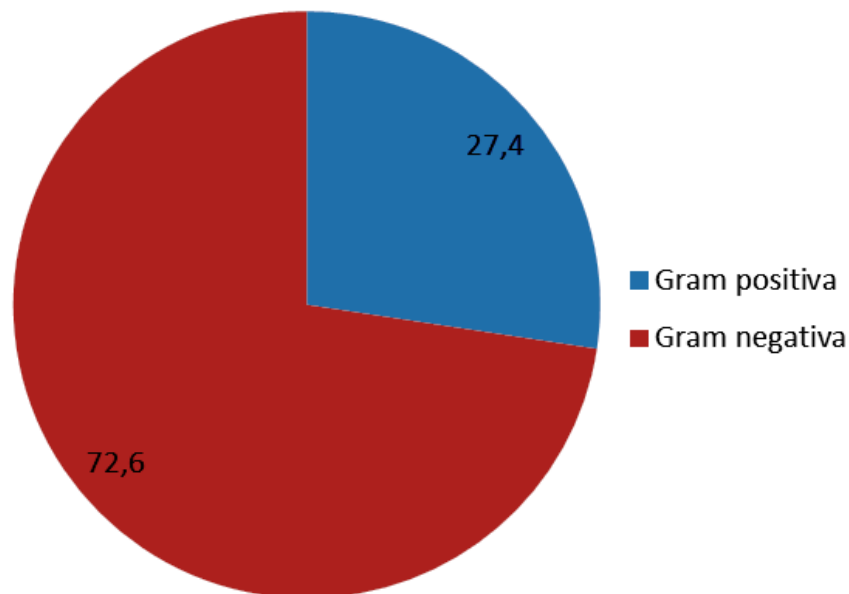


Fig 1. Distribution of positive culture samples from patients with suspected sepsis.

3.2 Frequency of occurrence of microorganisms causing sepsis

The Gram-negative bacteria identified were *Pseudomonas aeruginosa* 18 (21.9%), *Klebsiella pneumoniae* 18 (21.9%), *Acinetobacter baumannii* 18 (21.9%), *Serratia marcescens* 12 (14.6%), *Escherichia coli* 10 (12.3%) y *Enterobacter cloacae* 6 (7.4%) (Figure 2).

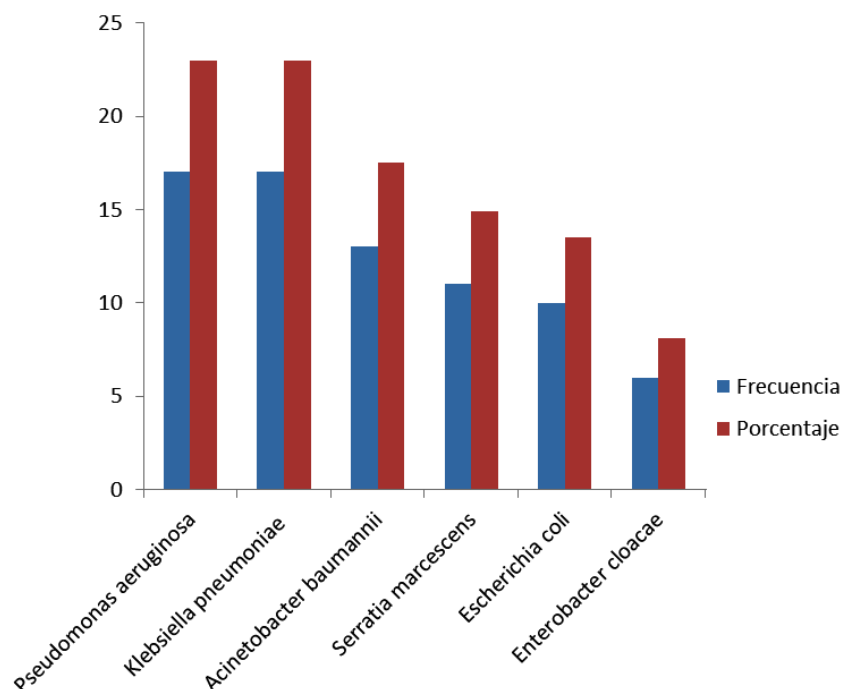


Fig 2. Frequency of occurrence of Gram - negative microbial strains responsible for sepsis.

The most frequently identified Gram-positive bacteria were the *Staphylococcus epidermidis* 9 (29.2%), *Staphylococcus haemolyticus* 6 (19.3%), *Staphylococcus hominis* ss. *Hominis* 6 (19.3%), *Enterococcus faecalis* 5 (16.1%) and *Staphylococcus aureus* ss. *Aureus* 5 (16.1) (Figure 3).

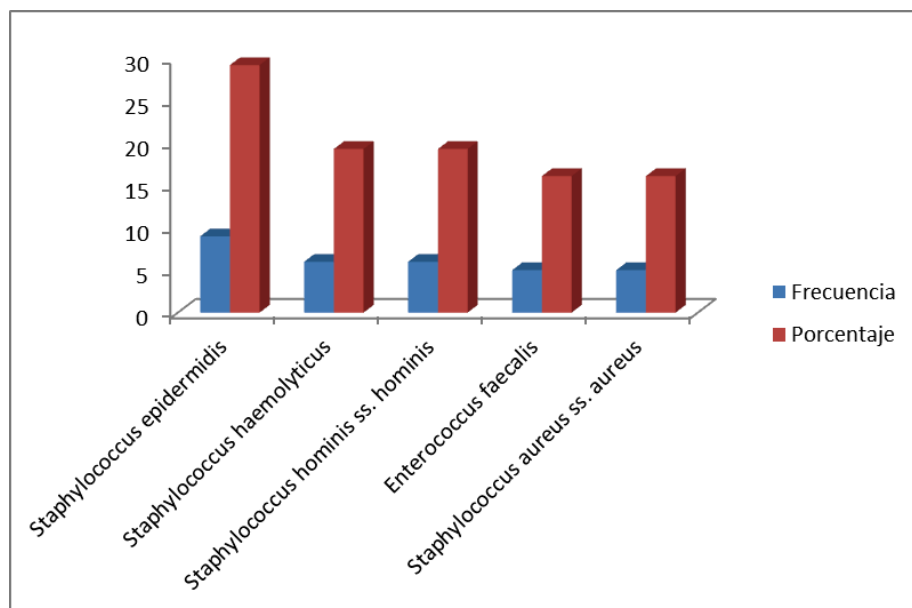


Fig 3. Frequency of occurrence of Gram - positive microbial strains responsible for sepsis

3.3 Resistance of microorganisms Gram — negative to antimicrobial agents

The sensitivity and resistance of the Gram-negative bacteria are shown in Table 1. The antimicrobials used were piperacillin-tazobactam, ceftazidime, cefepime, doripenem, imipenem, meropenem, amikacin, gentamicin, ciprofloxacin and Colistin. *Pseudomonas aeruginosa* has a greater resistance to doripenem (50%) and imipenem (56.2%); *Klebsiella pneumoniae* showed resistance to ceftazidime (25%) and cefepime (25%); *Acinetobacter baumannii* showed resistance to most drugs such as piperacillin-tazobactam (61.9), ceftazidime (61.9), cefepime (61.9), doripenem (61.9), imipenem (61.9), meropenem (61.9) and ciprofloxacin (61.9); *Serratia marcescens* presented a low resistance to ceftazidime (11,1); *Escherichia coli* showed resistance to ceftazidime (52.4) and cefepime (52.4); *Enterobacter cloacae* presented a low percentage of resistance to most of the antimicrobials used piperacillin-tazobactam (8.4%), ceftazidime (8.4%), cefepime (8.4%), doripenem (8.4%), imipenem (8.4%), meropenem (8.4%), ciprofloxacin (8.4%) and colistin (8.4%).

Table 1. Antibiotic susceptibility pattern of Gram-negative bacteria isolated from blood cultures

Isolation		PIP-TZ N/ (%)	CAZ N/ (%)	FEP N/ (%)	DPM N/ (%)	IPM N/ (%)	MEM N/ (%)	AMK N/ (%)	G N/ (%)	CIP N/ (%)	COL N/ (%)
<i>Pseudomonas aeruginosa</i> (18)	S	9 (50)	10 (56,2)	10 (56,2)	9 (50)	8 (43,8)	9 (50)	12 (68,8)	15 (81,2)	10 (56,2)	100
	I	2 (12,5)	2 (12,5)	2 (12,5)	0 (0)	0 (0)	1 (6,2)	2 (12,5)	0 (0)	0 (0)	0 (0)
	R	7 (37,5)	6 (31,2)	6 (31,2)	9 (50)	10 (56,2)	8 (43,8)	4 (18,8)	3 (18,8)	8 (43,8)	0 (0)
<i>Klebsiella pneumoniae</i> (18)	S	15 (81,2)	14 (75)	14 (75)	17 (93,8)	17 (93,8)	17 (93,8)	17 (93,8)	17 (93,8)	14 (75)	
	I	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0	1 (6,2)	1 (6,2)	
	R	3 (18,8)	4 (25)	4 (25)	1 (6,2)	1 (6,2)	1 (6,2)	1 (6,2)	0 (0)	3 (18,8)	
<i>Acinetobacter baumannii</i> (18)	S	7 (38,1)	4 (23,8)	7 (38,1)	7 (38,1)	7 (38,1)	7 (38,1)		7 (38,1)	7 (38,1)	15 (85,7)
	I	0 (0)	3 (14,3)	0 (0)	0 (0)	0 (0)	0 (0)		6 (33,3)	0 (0)	0 (0)
	R	11 (61,9)	11 (61,9)	11 (61,9)	11 (61,9)	11 (61,9)	11 (61,9)		5 (28,6)	11 (61,9)	3 (14,3)
<i>Serratia marcescens</i> (12)	S		9 (70,4)	12 (100)	12 (100)		12 (100)	12 (100)	12 (100)	12 (100)	
	I		2 (18,5)	0 (0)	0 (0)		0 (0)	0 (0)	0 (0)	0 (0)	
	R		1 (11,1)	0 (0)	0 (0)		0 (0)	0 (0)	0 (0)	0 (0)	
<i>Escherichia coli</i> (10)	S	8 (84,2)	4 (47,6)	4 (47,6)	8 (84,2)	8 (84,2)	8 (85)	10 (100)	10 (100)	3 (33)	8 (84,2)
	I	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	2 (15,8)
	R	2 (15,8)	6 (52,4)	6 (52,4)	2 (15,8)	2 (15,8)	2 (15)	0 (0)	0 (0)	7 (66,7)	0 (0)
<i>Enterobacter cloacae</i> (6)	S	4 (83,3)	3 (66,6)	5 (91,7)	5 (91,7)	5 (91,7)	5 (91,7)	6 (100)	5 (91,7)	3 (66,7)	3 (66,7)
	I	1 (8,3)	2 (25)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (8,3)	2 (25)	2 (25)
	R	1 (8,4)	1 (8,4)	1 (8,3)	1 (8,3)	1 (8,3)	1 (8,3)	0 (0)	0 (0)	1 (8,3)	1 (8,3)

N:number of sensitive isolates

Piperacillin-Tazobactam (PIP-TZ); ceftazidime (CAZ); Cefepime(FEP); Doripenem (DPM); Imipenem (IPM); Meropenem (MEM); Amikacin (AMK);Gentamicin (G); Ciprofloxacin (CIP); Colistin (COL)

3.4 Resistance of Gram-positive microorganisms to antimicrobial agents

The sensitivity and resistance of Gram-positive bacteria are shown in Table 2. The antimicrobials used were trimethoprim/sulfamethoxazole, erythromycin, nitrofurantoin, ciprofloxacin, levofloxacin, vancomycin, gentamicin, teicoplanin, minocycline, rifampin and tetracycline. Of the antimicrobials used *Staphylococcus epidermidis* showed resistance to erythromycin (13%) and ciprofloxacin (18.2%); *Staphylococcus haemolyticus* showed no resistance to any of the antibiotics used; *Staphylococcus hominis* ss. *hominis* presented resistance to erythromycin (40%) and nitrofurantoin (40%); *Enterococcus faecalis* and *Staphylococcus aureus* ss. *aureus* showed resistance to erythromycin (40%).

Table 2. Antibiotic susceptibility pattern of Gram-positive bacteria isolated from blood cultures.

		TMP/SMX	E	NIT	CIP	LEFX	VAN	GEN	TEC	MINO	RIF	TET
<i>Staphylococcus epidermidis</i> (9)	S	8 (85,7)	1 (6,7)	7 (81,8)	6 (72,7)	7 (85,7)	9 (100)	9 (100)	9 (100)	9 (100)	9 (100)	9 (100)
	I	0 (0)	2 (13,3)	1 (9,1)	2 (18,2)	1 (7,1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
	R	1 (14,3)	6 (80)	1 (9,1)	1 (9,1)	1 (7,1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
<i>Staphylococcus haemolyticus</i> (6)	S	6 (100)	6 (100)	6 (100)	5 (83)	5 (83)	6 (100)	6 (100)	6 (100)	6 (100)	6 (100)	6 (100)
	I	0 (0)	0 (0)	0 (0)	1 (17)	1 (17)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
	R	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
<i>Staphylococcus hominis</i> ss. <i>Hominis</i> (6)	S	5 (83)	3 (60)	3 (60)	(6) 100	(6) 100	(6) 100	(6) 100	(6) 100	(6) 100	(6) 100	(6) 100
	I	1 (17)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
	R	0 (0)	2 (40)	2 (40)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
<i>Enterococcus faecalis</i> (5)	S	5 (100)	3 (60)	5 (100)	5 (100)	5 (100)	5 (100)	5 (100)	5 (100)	5 (100)	5 (100)	5 (100)
	I	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
	R	0 (0)	2 (40)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
<i>Staphylococcus aureus</i> (5)	S	5 (100)	3 (60)	5 (100)	5 (100)	5 (100)	5 (100)	5 (100)	5 (100)	5 (100)	5 (100)	5 (100)
	I	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
	R	0 (0)	2 (40)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)

N: number of sensitive isolates

Trimethoprim / Sulfamethoxazole (TMP / SMX); Erythromycin (E); Nitrofurantoin (NIT); Ciprofloxacin (CIP); Levofloxacin (Lfx); Vancomycin (VAN); Gentamicin (GEN); Teicoplanin (TEC); Minocycline (MINO); Rifampicin (RIF); Tetracycline

4 Discussion

Given the increasing resistance of bacteria to antimicrobials, surveillance programs have become important in defining the distribution of species and the resistance patterns of pathogens that cause bloodstream infections, therefore, they are the basis for adequate empirical therapy⁽¹⁸⁾. Bacterial infection of the bloodstream is one of the main agents that cause morbidity and mortality throughout the world, which requires urgent and effective treatment to control infections⁽⁴⁾; because mortality rates double from 30% to 60%, when inadequate empirical treatment was administered to patients in the Intensive Care Unit (ICU) with bloodstream infections⁽¹⁹⁾. In this prospective study, information is provided on the distribution of bacterial isolates that cause infections in the bloodstream along with their antibiotic susceptibility pattern, crucial information in the effective management of septicemic cases.

According to Biedenbach et al., 2004, the frequency of occurrence of bacterial species that cause bloodstream infections in different parts of the world was quite variable; demonstrating that Gram-positive species were causative agents in 57% of infections in the Medical Centers of North America compared to a minority of cases in Latin America and Europe (51%). However, Orsini et al., 2012 and Wisplinghoff et al., 2004 reported that in the United States of America there is a tendency towards an increase in the incidence of Gram-negative organisms that cause infections in the bloodstream. This variation of the etiologic agents from one country to another could be due to geographical locations, epidemiological differences in the

etiological agents, other factors may also be due to the nature of the patient population, the limited sample size and the study period. In the present investigation, Gram-negative bacteria ($n = 82$, 72.6%) were the most frequent cause of bloodstream infections (Figure 1); Similar results were reported studies conducted by Droz et al., 2019, in the Netherlands on pathogenic bacteria in the bloodstream in pediatrics also reported a greater number of isolated Gram-negative bacteria (63.9%), compared to Gram-positive (35.8%) in Colombia by De la Rosa et al., 2016, which conducted a prospective multicenter study, conducted in ten hospitals in four cities between September 2007 and February 2008, similar results have been reported in Mexico by Sánchez et al., 2010; in Argentina by Saad et al., 2018, in Iran by Rabirad et al., 2014 and in Nepal by Prakash et al., 2016. The majority of cases of Gram-negative bacteraemia that occurred in hospitalized patients were associated with healthcare as is patient management and hand washing^(20–24).

Among the Gram-negative bacteria, the ones that were most frequently isolated were *Pseudomonas aeruginosa*, *Klebsiella pneumoniae* and *Acinetobacter baumannii* (Figure 2), the reason for the high isolation rates of these Gram-negative bacteria may be due to the acquisition of an infection during the hospital stay, since they are recognized opportunistic pathogens, which mainly affects hospitalized patients and also remains on inanimate surfaces for long periods, this fact facilitates its dissemination in the hospital environment and the hands of health personnel constitute a fundamental vehicle of transmission in the frequent occurrence of outbreaks, the incidence of infections has continuously increased in the last two decades^(25,26). Our results are consistent with another study with *Pseudomonas* spp. It was the most common bacterial organism that caused bloodstream infections.

Gram-positive bacteria also represent a serious threat because their morbidity in bloodstream infections is constantly increasing worldwide^(27,28). Among Gram-positive bacteria, *S. epidermidis* was the pathogen that was most frequently isolated in the present study, followed by *S. haemolyticus* (figure 3). These two species have been reported in national and international studies as the most frequent among nosocomial infections⁽²⁹⁾. De la Rosas et al., 2016 also reports *S. epidermidis* as the Gram-positive bacterium most frequently in isolation of bloodstream infections, it was also reported by Cortes et al., 2017 and Mamishi et al., 2005. *S. epidermidis* it was recognized as low incidence pollutants until the 1970s; however, several studies have reported an increase in the incidence of infection with this bacterium⁽³⁰⁾, which are of growing concern, due to the high distribution of methicillin resistance among the isolates and their durability in the devices, which it often results in the replacement of the device, which causes more trauma and cost⁽²⁶⁾. From the epidemiological point of view, he has developed strategies to conquer the hospital environment, such as his ability to colonize the inert surface of invasive medical devices and forming biofilms. The formation of biofilms in *S. haemolyticus* has not yet been fully clarified⁽²⁹⁾.

As published by the World Health Organization in the United States, antimicrobial resistant microorganisms (AMR) cause more than 2 million infections and are associated with approximately 23,000 deaths each year and the European Center for the Prevention and Control of Diseases (ECDC) reported that AMR is associated with approximately 25,000 deaths per year^(31,32). In the present study, the antimicrobial resistance profile of Gram-negative bacteria showed a higher resistance rate compared to Gram-positive bacteria, such as it has also been demonstrated in other studies^(33,34). *Pseudomonas aeruginosa* showed high sensitivity to most of the drugs used, however it showed high resistance to doripenem (50), imipenem (56.2) and meropenem (43.8). Comparing the results obtained with another study conducted in Latin America (Argentina, Brazil, Chile, Costa Rica, Ecuador, Guatemala, Mexico, Panama, Peru and Venezuela, Colombia), it was possible to observe a similarity in the results with a resistance to imipenem (44.9%), meropenem (38.4%) and doripenem (49%)^(35–37). This may be due to empirical and inappropriate use as a first-line treatment. This is an alarming sign for clinicians because it leaves a very limited choice of medications such as colistin and tigecycline, which have serious side effects and toxicity⁽³³⁾. While *Klebsiella pneumoniae* showed high sensitivity to all antibiotics used in ranges between 75% - 93.8%, similar results were reported by Alam et al., 2011.

Acinetobacter baumannii isolates showed high resistance to most antibiotics with a percentage of 61.9%, with the exception of colistin which presented a resistance of 14.3%. According to Cortes et al., 2013 in Colombia, a five-fold increase in resistance was reported between 2001 and 2008. Globally, this bacterium has also exhibited high resistance to most antibiotics⁽³⁵⁾. There are multiple studies that explore the treatment alternatives for *A. baumannii* infection, antibiotic therapies that have been ruled out because of high toxicity rates, such as colistin, have been resumed, these antibiotics have shown efficacy in the treatment of multidrug-resistant strains of this microorganism⁽¹⁴⁾. While the rates of resistance to multiple drugs in isolates of *Serratia marcescens*, *Escherichia coli*, *Enterobacter cloacae* were low; similar studies have been reported as those conducted by⁽⁹⁾.

S. epidermidis y *S. haemolyticus* they are frequent natural colonizers of the wet surfaces of the body, such as the armpits, the inguinal area and the perineal area; they have adapted to become nosocomial pathogens because they exhibit resistance to antibiotics and antiseptics, as well as their ability to produce biofilms. In the present work *S. epidermidis*, *Staphylococcus haemolyticus*, *Staphylococcus hominis* ss. *hominis*, *Enterococcus faecalis* y *Staphylococcus aureus* ss. *Aureus* showed high resistance to erythromycin (Table 2). Similar results were published by⁽³⁸⁾ where they reported a high resistance of these bacteria to erythromycin (62% of isolates), oxacillin (51%), gentamicin (61%), lincomycin (60%), ofloxacin (60%) and rifampicin (51%).

Bora et al., 2018 also reported resistance to several non- β -lactam antimicrobial types such as ciprofloxacin (58% –72%), gentamicin (26% –72%) and cotrimoxazole (46% –47%).

5 Conclusion

A high prevalence of antimicrobial resistance was observed in the present investigation, particularly in Gram-negative bacteria. This high prevalence of antimicrobial resistance rates in the region may be due to excessive drug use due to its easy availability.

References

- Opintan JA, Newman MJ. Prevalence of antimicrobial resistant pathogens from blood cultures: results from a laboratory based nationwide surveillance in Ghana. Springer Science and Business Media LLC. 2017. Available from: <https://dx.doi.org/10.1186/s13756-017-0221-0>. doi:10.1186/s13756-017-0221-0.
- Orsinia J, Mainardia C, Muzyloa E, Karkia N, Cohenb N, Sakoulasc G. Microbiological Profile of Organisms Causing Bloodstream Infection in Critically Ill Patients. *J Clin Med Res*. 2012;4(6):371–377.
- Hattori H, Maeda M, Nagatomo Y, Takuma T, Niki Y, Naito Y, et al. Epidemiology and risk factors for mortality in bloodstream infections: A single-center retrospective study in Japan. *American Journal of Infection Control*. 2018;46(12):e75–e79. Available from: <https://dx.doi.org/10.1016/j.ajic.2018.06.019>. doi:10.1016/j.ajic.2018.06.019.
- Prakash B, Raj S, Lamichhane S, Subedi S, Thapa U. Bacteriological Profile and Antibiotic Susceptibility Pattern of Blood Culture Isolates from Patients Visiting Tertiary Care Hospital in Kathmandu, Nepal. *Global Journal of Medical Research: C Microbiology and Pathology*. 2016;16(1):24–31.
- Cleven BEE, Palka-Santini M, Gielen J, Meembor S, Kronke M, Krut O. Identification and Characterization of Bacterial Pathogens Causing Bloodstream Infections by DNA Microarray. *Journal of Clinical Microbiology*. 2006;44(7):2389–2397. Available from: <https://dx.doi.org/10.1128/jcm.02291-05>. doi:10.1128/jcm.02291-05.
- Alam MS, Kapur P, Pillai PK, Pillai KK. Resistant patterns of bacteria isolated from bloodstream infections at a university hospital in Delhi. *Journal of Pharmacy and Bioallied Sciences*. 2011;3(4):525–525. Available from: <https://dx.doi.org/10.4103/0975-7406.90106>. doi:10.4103/0975-7406.90106.
- Khurana S, Bhardwaj N, Kumari M, Malhotra R, Mathur P. Prevalence, etiology, and antibiotic resistance profiles of bacterial bloodstream infections in a tertiary care hospital in Northern India: A 4-year study. *Journal of Laboratory Physicians*. 2018;10(04):426–431. Available from: https://dx.doi.org/10.4103/jlp.jlp_78_18. doi:10.4103/jlp.jlp_78_18.
- Robineau O, Robert J, Rabaud C, Bedos JP, Varon E, Péan Y, et al. Management and outcome of bloodstream infections: a prospective survey in 121 French hospitals (SPA-BACT survey). *Infection and Drug Resistance*. 2018;Volume 11:1359–1368. Available from: <https://dx.doi.org/10.2147/idr.s165877>. doi:10.2147/idr.s165877.
- Hasani A, Faezi NA, Rezaee MA, Sheykhsharan E, Darabi N, Leylabadlo HE. Determination of Antimicrobial Resistance Patterns in Bloodstream Infections-Isolated Bacteria From a University Tertiary Hospital Patients. *International Journal of Enteric Pathogens*. 2019;7(2):49–54. Available from: <https://dx.doi.org/10.15171/ijep.2019.12>. doi:10.15171/ijep.2019.12.
- Mahmoudia S, Mahzarib M, Banara M, Pourakbaria B, Haghi M, Mohammadib M. Antimicrobial resistance patterns of Gram-negative bacteria isolated from bloodstream infections in an Iranian referral paediatric hospital: A 5.5-year study. *Journal of Global Antimicrobial Resistance*. 2017;11:17–22.
- Arabestani MR, Fazzeli H, Esfahani BN. Identification of the most common pathogenic bacteria in patients with suspected sepsis by multiplex PCR. *The Journal of Infection in Developing Countries*. 2014;8(04):461–468. Available from: <https://dx.doi.org/10.3855/jidc.3856>. doi:10.3855/jidc.3856.
- Rosa GDL, León AL, Jaimes F. Epidemiología y pronóstico de pacientes con infección del torrente sanguíneo en 10 hospitales de Colombia. *Revista chilena de infectología*. 2016;33(2):141–149. Available from: <https://dx.doi.org/10.4067/s0716-10182016000200003>. doi:10.4067/s0716-10182016000200003.
- Serrano MRG, Escartín NL, Arriaza MM, Díaz JCR. Microbiological diagnosis of bacteraemia and fungaemia: Blood cultures and molecular methods. *Enfermedades infecciosas y microbiología clínica (English ed)*. 2019;37(5):335–340. Available from: <https://dx.doi.org/10.1016/j.eimce.2018.03.018>. doi:10.1016/j.eimce.2018.03.018.
- Terfa K, Taddese B, Hailu T, Sori L, Geleto S, Mengistu G, et al. Assessment of Bacterial Profile and Antimicrobial Resistance Pattern of Bacterial Isolates from Blood Culture in Addis Ababa Regional Laboratory, Addis Ababa, Ethiopia. *Clinical Microbiology*. 2018;7(2):1–7. Available from: <C:/Users/Luis%20Carlos/Downloads/assessment-of-bacterial-profile-and-antimicrobial-resistance-pattern-ofbacterial-isolates-from-blood-culture-in-addis-ababa-region-2327-5073-1000312.pdf>.
- Shiferaw AAA, Tesera H, Belachew T, Mihiretie GD. The bacterial profile and antibiotic susceptibility pattern among patients with suspected bloodstream infections, Gondar, north-west Ethiopia. *Pathology and Laboratory Medicine International*. 2018;Volume 10(2):1–7. Available from: <https://dx.doi.org/10.2147/plmi.s153444>. doi:10.2147/plmi.s153444.
- Biedenbach D, Moet G, Jones R. Occurrence and antimicrobial resistance pattern comparisons among bloodstream infection isolates from the SEN-TRY Antimicrobial Surveillance Program (1997–2002). *Diagnostic Microbiology and Infectious Disease*. 2004;50:59–69. Available from: <https://www.sciencedirect.com/science/article/pii/S0732889304001026?via%3Dihub>.
- Jordá L, Vila A, Lanza A, Bonvehí P, Nazar J, Mikietuk A. Utilidad del sistema VITEK en la identificación bacteriana y estudios de sensibilidad antimicrobiana. *ActaBioquímica Clínica Latinoamericana*. 2005;39(1):19–25.
- Wisplinghoff H, Bischoff T, Tallent SM, Seifert H, Wenzel RP, Edmond MB. Nosocomial Bloodstream Infections in US Hospitals: Analysis of 24,179 Cases from a Prospective Nationwide Surveillance Study. *Clinical Infectious Diseases*. 2004;39(3):309–317. Available from: <https://dx.doi.org/10.1086/421946>. doi:10.1086/421946.
- Ibrahim EH, Sherman G, Ward S, Fraser VJ, Kollef MH. The Influence of Inadequate Antimicrobial Treatment of Bloodstream Infections on Patient Outcomes in the ICU Setting. *Chest*. 2000;118(1):146–155. Available from: <https://dx.doi.org/10.1378/chest.118.1.146>. doi:10.1378/chest.118.1.146.
- Vásquez P, Soto F, Pinzón D, González D, Peña C. Caracterización de pacientes pediátricos con hemocultivos positivos del servicio de cuidado intensivo pediátrico del Hospital. *REVISTA INFECTIO*. 2017;23(2):183–188.
- Sánchez R, Becerra G, Grajales L, Canseco L. Frecuencia de microorganismos aislados de hemocultivos en un hospital de tercer nivel en el estado de Chiapas. *Enfermedades Infecciosas y Microbiología*. 2010;30(2):53–58. Available from: <https://www.medigraphic.com/pdfs/micro/ei-2010/ei102d.pdf>.
- Rabirad N, Mohammadpoor M, Shojaie LA, Bayat A, Alebouyeh R, M. Antimicrobial susceptibility patterns of the gram-negative bacteria isolated from septicemia in Children's. *Journal of Preventive Medicine and Hygiene*. 2014;55:23–26.

- 23) KP P, Arora V, PP G. Bloodstream Bacterial Pathogens and their Antibiotic Resistance Pattern in Dhahira Region, Oman. *Oman Medical journal*. 2011;26(4):240–247. Available from: <https://dx.doi.org/10.5001/omj.2011.59>. doi:10.5001/omj.2011.59.
- 24) Marschall J, Fraser VJ, Doherty J, Warren DK. Between Community and Hospital: Healthcare-Associated Gram-Negative Bacteremia among Hospitalized Patients. Cambridge University Press (CUP). 2009. Available from: <https://dx.doi.org/10.1086/606165>. doi:10.1086/606165.
- 25) Mehrad B, Clark NM, Zhanel GG, Lynch JP. Antimicrobial Resistance in Hospital-Acquired Gram-Negative Bacterial Infections. *Chest*. 2015;147(5):1413–1421. Available from: <https://dx.doi.org/10.1378/chest.14-2171>. doi:10.1378/chest.14-2171.
- 26) Sobhani A, Mallaei M, Kazemi S. Bloodstream Bacterial Pathogens and Their Antibiotic Resistance Patterns in Rasht, Iran. *J Med Bacteriol*. 2016;5(6):13–20.
- 27) Ahmed D, Nahid A, Bashar A, Halim F, Akter N, Sadique. Bacterial etiology of bloodstream infections and antimicrobial resistance in. *Antimicrobial Resistance and Infection Control*. 2005;6(2):1–11.
- 28) Zhang F, Li Y, Lv Y, Zheng B, Xue F. Bacterial susceptibility in bloodstream infections: Results from China Antimicrobial Resistance Surveillance Trial (CARST) Program, 2015–2016. *Journal of Global Antimicrobial Resistance*. 2019;17:276–282. Available from: <https://dx.doi.org/10.1016/j.jgar.2018.12.016>. doi:10.1016/j.jgar.2018.12.016.
- 29) Rigatti F, Tizotti MK, Hörner R, Domingues VO, Martini R, Mayer LE, et al. Bacteremias por Staphylococcus coagulase negativos oxacilina resistentes em um hospital escola na cidade de Santa Maria, Estado do Rio Grande do Sul. *Revista da Sociedade Brasileira de Medicina Tropical*. 2010;43(6):686–690. Available from: <https://dx.doi.org/10.1590/s0037-86822010000600017>. doi:10.1590/s0037-86822010000600017.
- 30) Cortes JA, Leal AL, Montañez AM, Buitrago G, Castillo JS, Guzman L. Frequency of microorganisms isolated in patients with bacteremia in intensive care units in Colombia and their resistance profiles. Elsevier BV. 2013. Available from: <https://dx.doi.org/10.1016/j.bjid.2012.10.022>. doi:10.1016/j.bjid.2012.10.022.
- 31) Marston HD, Dixon DM, Knisely JM, Palmore TN, Fauci AS. Antimicrobial Resistance. *JAMA*. 2016;316(11):1193–1193. Available from: <https://dx.doi.org/10.1001/jama.2016.11764>. doi:10.1001/jama.2016.11764.
- 32) Rios A, Moutinhob C, Pintoc F, Fiol FD, Jozalaa A, Chauda M, et al. Alternatives to overcoming bacterial resistances: State-of-the-art. *Microbiological Research*. 2016;191:51–80.
- 33) Nazir A, Sana I, Peerzada BY, Farooq T. Study of prevalence and antimicrobial susceptibility pattern of blood culture isolates from a tertiary care hospital of North India. *International Journal of Research in Medical Sciences*. 2018;6(12):4046–4046. Available from: <https://dx.doi.org/10.18203/2320-6012.ijrms20184905>. doi:10.18203/2320-6012.ijrms20184905.
- 34) Khosravi AD, Mehdienejad M, Morvaridi A. Study of Prevalence and Antimicrobial Susceptibility Pattern of Bacteria Isolated from Blood Cultures. *Journal of Biological Sciences*. 2009;9(3):249–253. Available from: <https://dx.doi.org/10.3923/jbs.2009.249.253>. doi:10.3923/jbs.2009.249.253.
- 35) Padgett D, Luque M, Rivera D, Galindo C, Zepeda L, Hernandez A. Resistencia Antimicrobiana en bacterias Aisladas en el Instituto Hondureño de Seguridad Social. *Rev med hondur*. 2011;79(3):117–121.
- 36) Bouchami O, Achour W, Hassen AB. Prevalence and mechanisms of macrolide resistance among Staphylococcus epidermidis isolates from neutropenic patients in Tunisia. *Clinical Microbiology and Infection*. 2007;13(1):103–106. Available from: <https://dx.doi.org/10.1111/j.1469-0691.2006.01567.x>. doi:10.1111/j.1469-0691.2006.01567.x.
- 37) Bora P, Datta P, Gupta V, Singhal L, Chander J. Characterization and antimicrobial susceptibility of coagulase-negative staphylococci isolated from clinical samples. *Journal of Laboratory Physicians*. 2018;10(04):414–419. Available from: https://dx.doi.org/10.4103/jlp.jlp_55_18. doi:10.4103/jlp.jlp_55_18.
- 38) Droz N, Hsia Y, Ellis S, Dramowski A, Sharland M, Basmaci R. Bacterial pathogens and resistance causing community acquired paediatric bloodstream infections in low- and middle-income countries: a systematic review and meta-analysis. Springer Science and Business Media LLC. 2019. Available from: <https://dx.doi.org/10.1186/s13756-019-0673-5>. doi:10.1186/s13756-019-0673-5.