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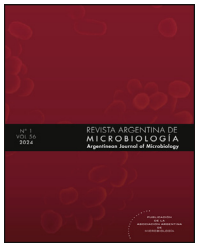

ORIGINAL ARTICLE

Bloodstream infections in immunocompromised adult patients

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Abstract Bloodstream infections (BSIs) are a major cause of morbidity and mortality in immunocompromised hosts, particularly those with malignancies, transplants, or autoimmune diseases. Epidemiologic surveillance is critical to optimize empirical antimicrobial therapy. Our aims were to describe the frequency, clinical and microbiological characteristics of BSIs in immunocompromised patients treated at two hospitals in Córdoba, Argentina. We conducted a retrospective study at two tertiary care centers in Córdoba, Argentina, including adult immunocompromised patients with microbiologically confirmed BSIs between January 2019 and December 2022. Underlying immunosuppression included malignancy, neutropenia, transplantation, or immunosuppressive therapy. Clinical data were analyzed over a 30-day period, and microbiological isolates were characterized. A total of 181 BSI episodes were included; 97 (53.6%) were hospital-acquired (HA-BSI) and 84 (46.4%) community-acquired (CA-BSI). Median age was 62 years (IQR 54.5–71.5), and 101 (55.8%) were male patients. Active malignancy was the most common immunosuppressive condition (n = 124, 68.5%). Primary bacteremia occurred in 51 cases (28.2%). Urinary (n = 34, 18.8%), intra-abdominal (n = 30, 16.6%), and catheter-related infections (n = 24, 13.3%) were the leading sources. Gram-negative bacilli

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(GNB) predominated (n = 150, 75.8%), with *Escherichia coli* (n = 71, 35.9%) and *Klebsiella pneumoniae* (n = 30, 15.2%) being the most frequent isolates. Multidrug-resistant organisms (MDRO) were identified in 67 (33.8%) episodes, more commonly in HA-BSI than CA-BSI (37 [46.3%] vs 15 [21.4%], $p = 0.001$). The overall 30-day mortality rate was 24.8% (n = 45). This study demonstrated that, in this cohort of immunocompromised adults, BSIs were slightly more often hospital-acquired and associated with substantial mortality. One-third of the isolates were multidrug-resistant organisms (MDROs).

PALABRAS CLAVE
Bacteriemia;
Infecciones;
Huésped Inmunocomprometido;
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Mortalidad hospitalaria

Infecciones del torrente sanguíneo en pacientes adultos inmunocomprometidos

Resumen Las infecciones del torrente sanguíneo (ITS) son causa importante de morbilidad y mortalidad en pacientes inmunocomprometidos, particularmente aquellos con neoplasias, trasplantes o enfermedades autoinmunitarias. Nuestros objetivos fueron describir la frecuencia y características clínicas y microbiológicas de las ITS en pacientes inmunocomprometidos atendidos en dos hospitales de Córdoba, Argentina. Llevamos a cabo un estudio retrospectivo en dos hospitales, incluyendo pacientes adultos inmunocomprometidos con ITS entre enero de 2019 y diciembre de 2022. Las causas de inmunosupresión incluyeron neoplasias malignas, neutropenia, trasplantes o tratamiento inmunosupresor. Se analizaron los datos clínicos durante un seguimiento de 30 días y se caracterizaron los aislamientos microbiológicos. Se incluyeron un total de 181 episodios de ITS; 97 (53,6%) fueron adquiridas en el hospital (ITS-IH) y 84 (46,4%) en la comunidad (ITS-AC). La mediana de edad fue de 62 años (RIC 54,5−71,5) y 101 (55,8%) correspondieron a pacientes de sexo masculino. La causa más frecuente de inmunosupresión fue la neoplasia activa (n = 124, 68,5%). La bacteriemia primaria se identificó en 51 (28,2%) casos, siendo los principales focos urinario (n = 34, 18,8%), intraabdominal (n = 30, 16,6%) e infección asociada a catéter (n = 24, 13.3%). Predominaron los bacilos Gram negativos (n = 150, 75,8%), destacándose *Escherichia coli* (n = 71, 35,9%) y *Klebsiella pneumoniae* (n = 30, 15,2%). Se identificaron microorganismos multirresistentes (MMR) en 67(33,8%) episodios, con mayor frecuencia en ITS-IH que en ITS-AC (37[46,3%] vs 15[21,4%], p = 0,001). La mortalidad global a 30 días fue del 24,8% (n = 45). En conclusión, las ITS en inmunosuprimidos fueron levemente más frecuentes en el ámbito hospitalario y se asociaron con una elevada mortalidad. Un tercio de los aislamientos correspondieron a MMR.

Introduction

Bloodstream infections (BSIs) represent a serious complication in immunocompromised patients and constitute a significant cause of morbidity and mortality in this vulnerable population[20,24]. This heterogeneous group includes patients with various underlying conditions, such as malignancies, organ transplants, or autoimmune diseases, who share a common feature: an altered immune response to infectious agents. This alteration increases both susceptibility to infections and the likelihood of severe progression[17,29]. It has been reported that BSIs account for between 25% and 30% of febrile episodes in patients with cancer and febrile neutropenia[6]. In transplant recipients, the incidence of these infections varies according to the transplanted organ, ranging between 8% and 20%[24]. Despite therapeutic advances and progress in critical care, the occurrence of BSIs is frequently associated with prolonged hospital stays, which increases the risk of nosocomial complications, raises healthcare costs, and may ultimately result in death[13,39]. Mortality associated with BSIs in immunosuppressed individuals is estimated to range from 18% to 42%[20,24,38,40].

This issue has gained increasing importance due to the sustained rise in diagnoses of autoimmune and neoplastic diseases, both hematologic and solid organ, as well as the continuing impact of the human immunodeficiency virus epidemic. Moreover, the development of a wide range of immunosuppressive agents in recent years, especially for the treatment of rheumatologic, onco-hematologic, and transplant-related conditions, has contributed not only to improved patient survival but also to increased infection rates, particularly those caused by opportunistic pathogens. Furthermore, the clinical manifestations and course of infections in immunocompromised patients often differ from those observed in the general population, complicating early diagnosis and timely therapeutic intervention[15,29].

A delayed or failed diagnosis of BSI generally leads to inadequate treatment in approximately 25% of cases, significantly increasing the risk of mortality, particularly in immunocompromised patients[2,37]. For this reason, knowledge of the local epidemiology of BSIs in this population is essential for selecting appropriate empirical regimens, with the goal of optimizing therapeutic success from the start of treatment[7,32]. The primary aim of the present study was to assess the frequency and clinical and microbiological characteristics of BSIs in immunocompromised patients at two tertiary care hospitals in Córdoba. The secondary objectives were to determine 30-day mortality among immunocompromised patients with BSIs, identify potential mortality-associated factors, and evaluate microbiological isolates and antimicrobial susceptibility profiles of BSI pathogens.

Materials and methods

A retrospective analytical study was conducted at two tertiary care hospitals in Córdoba: *Hospital Privado Universitario de Córdoba* and *Hospital Raúl Ángel Ferreyra*. Based on records from the Microbiology laboratories of both institutions, all patients over 18 years of age who developed at least one episode of bacteremia between January 2019 and December 2022 were identified. Medical records were reviewed, and patients were included if they met the following criteria: age $\geq$18 years, a clinically significant positive blood culture (excluding those considered contaminants), and an immunocompromised condition. The latter was defined as the presence of at least one of the following underlying conditions or previous clinical events: solid organ or bone marrow transplantation, neutropenia (absolute neutrophil count <1000 cells/μl), hypogammaglobulinemia, asplenia, human immunodeficiency virus (HIV) infection, active neoplastic disease with chemotherapy or radiotherapy treatment, chronic autoimmune or inflammatory diseases (including systemic lupus erythematosus, systemic sclerosis, rheumatoid arthritis, or other autoimmune disorders), or pharmacologic immunosuppressive therapy. Patients with contaminated blood cultures, those under 18 years of age, and pregnant women were excluded from the study.

For each included patient, general clinical characteristics, comorbidities, probable focus of infection, acquisition site (community or hospital), etiologic agent isolated, and antimicrobial susceptibility profile were recorded. Clinical follow-up was performed during the 30 days following the onset of the bloodstream infection episode to determine associated mortality.

Definitions

True positive blood culture: Growth of one or more microorganisms in at least one blood culture sample, excluding those considered potential skin contaminants (such as diphtheroids, *Propionibacterium* species, *Bacillus* species, coagulase-negative *Staphylococcus*, *Corynebacterium*, *Streptococcus viridans* group). In those cases, the following criteria had to be met: (A) Growth in two or more blood culture samples; (B) Isolation of the same microorganism from another site considered to be the source of the bloodstream infection; (C) Intravascular infection with a body temperature >38 °C or <36 °C, without another pathogen isolated, prompting the initiation of specific antimicrobial therapy[28].

Same episode of BSI: All blood cultures referring to the same isolate, exhibiting identical antimicrobial susceptibility and infectious focus, occurring in the same individual during the same period of time[28].

Polymicrobial blood cultures: Blood cultures in which two or more microbial species were isolated in one or more samples collected at the same time, consistent with the definition of true positive blood cultures[28].

Multidrug-resistant (MDR) bacteria: Defined by the Centers for Disease Control and Prevention (CDC) as bacteria belonging to the following groups: (a) Extended-spectrum beta-lactamase (ESBL)-producing *Enterobacteriaceae*; (b) Microorganisms with intrinsic resistance mechanisms, such as *Stenotrophomonas maltophilia*, *Burkholderia cepacia*, and *Ralstonia pickettii*; (c) Any Gram-negative bacillus (*Acinetobacter*, *Enterobacteriaceae*, *Pseudomonas*) resistant to three or more of the following drug classes: piperacillin/tazobactam, cephalosporins, carbapenems (imipenem, meropenem, ertapenem), monobactams (aztreonam), aminoglycosides (gentamicin, tobramycin, amikacin), and fluoroquinolones (ciprofloxacin, levofloxacin); (d) Among Gram-positive organisms, methicillin-resistant *Staphylococcus* and vancomycin-resistant *Enterococcus* are considered MDR pathogens[1,16,19,25].

Community-acquired BSI (CA-BSI): A blood culture obtained within the first 48 h of hospitalization, without any medical intervention during that period that could have induced it[9].

Hospital-acquired BSI (HA-BSI): Infection acquired after 48 hours of hospitalization in a patient admitted for a reason other than BSI, or occurring within 48–72 hours after discharge[9].

Classification of immunocompromised patients:

Neutropenic: Patients with absolute neutrophil count <1000 cells/ml[8].
Solid organ transplant recipients: Type of organ transplant was specified (kidney, pancreas, liver, heart, among others.). Corneal transplants were excluded.
Bone marrow transplant recipients.
HIV infection: Defined as the presence of anti-HIV antibodies, direct detection of the virus, or detection of one of its components.
Asplenia: Congenital or acquired absence of the spleen (structural or functional).
Active neoplastic disease (hematologic or solid organ): Active cancer was defined as cancer with ongoing treatment, treatment within the previous 6 months, or palliative treatment[31].
Autoimmune and inflammatory diseases: Systemic lupus erythematosus, systemic sclerosis, rheumatoid arthritis, and other autoimmune diseases.

Immunosuppressive drugs: A patient was considered to be receiving immunosuppressive therapy if they had received chemotherapy within the previous 6 months,

corticosteroids at doses equivalent to or greater than 20 mg/day of prednisone for at least 2 weeks in the previous 3 months, or other immunosuppressive agents such as tacrolimus, sirolimus, cyclosporine, mycophenolate, thymoglobulin, or biologic immunosuppressants.

Additional variables evaluated: Prior antimicrobial therapy for at least 72 hours in the previous month or previous 3 months; hospitalization in a general ward or intensive care unit for at least 48 hours in the previous 6 months; presence of urinary catheter, nephrostomy, central venous catheter, use of mechanical ventilation, or another invasive device in the month prior to the BSI episode; use of parenteral nutrition within the 72 hours prior to the onset of symptoms/diagnosis of BSI; microbiological isolation and its antimicrobial susceptibility spectrum.

Probable source of infection: Defined according to information and complementary studies recorded in the medical chart, as follows:

Primary bloodstream infection or bloodstream infection without focus: Isolation of microorganisms in blood cultures, fulfilling the definition of true positive blood culture, without identification of a probable infectious source[28].
Lower respiratory tract infection: (A) Tracheobronchitis: Chest X-ray without alveolar infiltrates and the presence of two of the following clinical manifestations: (1) Fever >38 °C; (2) Cough; (3) Purulent sputum and/or microorganism isolated from respiratory secretions; (4) Wheezing or rhonchi. (B) Pneumonia: Chest X-ray with alveolar infiltrate and one of the following: (1) Crackles or dullness; (2) Purulent sputum and/or microorganism isolated from respiratory secretions; (3) Positive blood culture.
Urinary tract infection (UTI): Meeting both of the following criteria: A) At least one of the following signs or symptoms: temperature ≥38 °C in patients <66 years, suprapubic pain (without another apparent cause), costovertebral angle tenderness (without another apparent cause), urgency, dysuria, or frequency; (B) Positive urine culture with no more than two microbial species, at least one with >100 000 CFU/ml[12].
Catheter-associated infection: (a) Catheter tip culture with >15 CFU (Maki technique) associated with blood culture isolating the same microorganism, plus one of the following signs or symptoms: (1) Fever >38 °C; (2) Regional pain; (3) Erythema; (4) Warmth; OR (b) Catheter blood culture positive 2 hours before peripheral blood culture, with the same microorganism isolated[22].
Surgical site infection: Infection occurring within 30 days after surgery (extended to 90 days for deep surgical procedures), associated with purulent drainage from the site or isolation of the same microorganism in blood culture and surgical site drainage fluid[12].
Cholecystitis/cholangitis: Fever or laboratory evidence of inflammatory response associated with elevated liver enzymes or biliary tract abnormality (dilatation, structural changes, choledocholithiasis, biliary stent, etc.) and/or gallbladder abnormality (wall thickening and/or inflammatory features on pathological examination)[14].
Gastrointestinal focus: Gastroenteritis (diarrhea, with or without vomiting, in the presence of fever >38 °C), enterocolitis.

Antimicrobial susceptibility testing: The Microbiology Laboratory routinely used the VITEK 2 Compact automated system (bioMérieux, France) and Phoenix M50 (Becton Dickinson, USA) to determine antimicrobial susceptibility, and MALDI-TOF Microflex mass spectrometry (Bruker, Germany) for species identification. The laboratory participates in the external quality control program for antimicrobial susceptibility testing and identification of the ANLIS Dr. Carlos Malbrán Institute of Health.

The present study was approved by the Research Committee of the Department of Teaching and Research of *Hospital Privado Universitario de Córdoba*.

Results

During the study period, 181 episodes of bloodstream infections (BSIs) were identified in immunosuppressed patients, representing 45% of the 402 BSI episodes recorded during that time in both hospitals. Of these, 84 (46.4%) corresponded to community-acquired BSI (CA-BSI) and 97 (54.6%) to hospital-acquired BSI (HA-BSI). Sixteen episodes involved polymicrobial blood cultures (8.8% of all BSI events), and 101 episodes (55.8%) occurred in male patients.

Regarding comorbidities, 124 patients (68.5%) had active malignancy, 73 of which (40.3%) were solid tumors and 51 (28.2%) hematologic malignancies. Additionally, 74 patients (40.9%) were smokers, 59 (32.6%) had diabetes mellitus, 54 (29.8%) had chronic kidney disease, 31 (17.1%) were kidney transplant recipients, and 37 (20.4%) presented with neutropenia at the time of the infectious episode. The remaining clinical characteristics are detailed in Table 1.

There were 51 (28.2%) episodes of primary bacteremia, 32 (33%) of which were HA-BSI and 19 (22.6%) CA-BSI. The most frequent infectious foci identified were urinary (n = 34, 18.8%), intra-abdominal (n = 30, 16.6%), and catheter-related bloodstream infection (n = 24, 13.3%). Urinary tract infections predominated among CA-BSI (25 [29.8%] vs. 9 [9.3%], $p = 0.005$), while catheter-related bacteremia was more common among HA-BSI (19 [19.6%] vs. 5 [6%], $p = 0.007$). Additional characteristics of infection sites are shown in Table 1.

With respect to isolated microorganisms, 150 Gram-negative bacilli (75.8%) were identified, with no significant differences between CA-BSI and HA-BSI (70 [76.1%] vs. 80 [75.5%], $p = 0.92$). *Escherichia coli* accounted for 71 (35.9%) of all isolates, with predominance in CA-BSI (49 [53.3%] vs. 22 [20.8%], $p < 0.001$). *Klebsiella pneumoniae* was responsible for 24 (22.6%) of all HA-BSI. Multidrug-resistant Gram-negative bacilli were more frequently associated with HA-BSI compared with CA-BSI (37 [46.3%] vs. 15 [21.4%], $p = 0.001$). Forty-eight Gram-positive cocci (24.2%) were isolated, with coagulase-negative *Staphylococcus* being the most frequent (n = 16, 8.1%). Additional microbiological isolates are shown in Table 2. Antimicrobial resistance profiles of Gram-positive cocci are detailed in Table 3.

Regarding antimicrobial susceptibility profiles of Gram-negative bacilli, 52 (34.7%) were multidrug-resistant (MDR), including 25 (16.7%) extended-spectrum β-lactamase (ESBL)-producers and 13 (8.7%) carbapenemase producers. Detailed susceptibility profiles of Gram-negative bacilli are detailed in Table 4.

Table 1 Clinical-epidemiological characteristics of BSIs in immunocompromised patients (community or hospital-acquired).

	Total BSIs n = 181 (100%)	CA-BSIs n = 84 (46.4%)	HA-BSIs n = 97 (53.6%)	*p*
Hospital Privado, n (%)	110 (60.8)	49 (53.8)	61 (62.9)	0.53
Hospital Ferreyra, n (%)	71 (39.2)	35 (41.7)	36 (37.1)	0.53
Age (years), m: IQR	62:54.5–71.5	66:56.25–73.75	61:50–69.5	0.009
Male, n (%)	101 (55.8)	46 (54.8)	55 (56.7)	0.79
Comorbidities				
Heart failure, n (%)	10 (5.5)	5 (6)	5 (5.2)	1
Coronary disease, n (%)	21 (11.6)	12 (14.3)	9 (9.3)	0.29
Chronic kidney disease, n (%)	54 (29.8)	28 (33.3)	26 (26.8)	0.33
Diabetes mellitus, n (%)	59 (32.6)	25 (29.8)	34 (35.1)	0.44
Tobacco use, n (%)	74 (40.9)	30 (35.7)	44 (45.4)	0.18
COPD, n (%)	16 (8.8)	4 (4.8)	12 (12.4)	0.07
Active cancer, n (%)	124 (68.5)	55 (65.5)	69 (71.1)	0.41
Solid tumor, n (%)	73 (40.3)	42 (50)	31 (32)	0.014
Hematologic malignancy, n (%)	51 (28.2)	13 (15.5)	38 (39.2)	<0.001
Autoimmune disease, n (%)	20 (11)	10 (11.9)	10 (10.3)	0.73
Alcoholism, n (%)	6 (3.3)	1 (1.2)	5 (5.2)	0.21
Bone marrow transplant, n (%)	18 (9.9)	6 (7.1)	12 (12.4)	0.24
Kidney transplant, n (%)	31 (17.1)	15 (17.9)	16 (16.5)	0.80
Neutropenia, n (%)	37 (20.4)	10 (11.9)	27 (27.8)	0.008
HIV infection, n (%)	2 (1.1)	1 (1.2)	1 (1)	1
Asplenia, n (%)	2 (1.1)	0 (0)	2 (2.1)	0.5
Corticoid use, n (%)	40 (22.1)	11 (13.1)	29 (29.9)	0.007
Immunosuppressive treatment, n (%)	64 (35.4)	29 (34.5)	35 (36.1)	0.82
Chemotherapy, n (%)	76 (42)	29 (34.5)	47 (48.5)	0.05
Radiotherapy, n (%)	6 (3.3)	4 (4.8)	2 (2.1)	0.41
BSI etiology				
Primary bacteremia, n (%)	51 (28.2)	19 (22.6)	32 (33)	0.12
Urinary tract infection, n (%)	34 (18.8)	25 (29.8)	9 (9.3)	<0.001
Intraabdominal, n (%)	30 (16.6)	17 (20.2)	13 (13.4)	0.21
Catheter-associated bacteremia, n (%)	24 (13.3)	5 (6)	19 (19.6)	0.007
Biliary/cholecystitis, n (%)	21 (11.6)	13 (15.5)	8 (8.2)	0.13
Skin and soft tissues, n (%)	8 (4.4)	1 (1.2)	7 (7.2)	0.07
Respiratory, n (%)	7 (3.9)	2 (2.4)	5 (5.2)	0.45
Prosthetic joint infection, n (%)	2 (1.1)	1 (1.2)	1 (1)	1
Endocarditis, n (%)	1 (0.6)	1 (1.2)	0 (0)	0.46
Peritonitis, n (%)	1 (0.6)	0 (0)	1 (1)	1
Intradialysis bacteremia, n (%)	1 (0.6)	0 (0)	1 (1)	1
Spondylodiscitis, n (%)	1 (0.6)	0 (0)	1 (1)	1

BSI: bloodstream infection; CA-BSI: community-acquired bloodstream infection; HA-BSI: hospital-acquired bloodstream infection; m: IQR median: interquartile range 25–75%; COPD: chronic obstructive pulmonary disease; HIV: human immunodeficiency virus.

Risk factors associated with MDR BSI included hospitalization longer than 48 hours (38 [56.7%] vs. 46 [35.1%], $p = 0.004$), antibiotic use in the previous 6 months (50 [74.6%] vs. 69 [52.7%], $p = 0.003$), recent surgical procedures (26 [38.8%] vs. 29 [22.1%], $p = 0.013$), urinary catheter placement (27 [40.3%] vs. 19 [14.5%], $p < 0.001$), and mechanical ventilation within the previous month (8 [11.9%] vs. 4 [3.1%], $p = 0.023$). Additional clinical characteristics and risk factors for MDR BSI are shown in Table 5.

Thirty-day mortality among patients with BSI episodes was more frequent in those with a history of COVID-19 infection within the previous month (7 [15.6%] vs. 4 [2.9%], $p = 0.006$) and in cases of polymicrobial bacteremia (8 [17.8%] vs. 8 [5.9%], $p = 0.029$). Additional BSI-related

Table 2 Main microbiological isolates in immunocompromised patients with BSIs (community or hospital acquired).

	Total BSIs n = 198 (100%)	CA-BSIs n = 92 (46.5%)	HA-BSIs n = 106 (53.5%)	*P*
Gram positive cocci n (%)	48 (24.2)	22 (23.9)	26 (24.5)	0.92
Coagulase negative staphylococcus, n (%)	16 (8.1)	5 (5.4)	11 (10.4)	0.20
Staphylococcus aureus, n (%)	6 (3)	2 (2.2)	4 (3.8)	0.68
Enterococcus faecalis, n (%)	4 (2)	2 (2.2)	2 (1.9)	1
Gram negative bacilli, n (%)	150 (75.8)	70 (76.1)	80 (75.5)	0.92
Escherichia coli, n (%)	71 (35.9)	49 (53.3)	22 (20.8)	<0.001
Klebsiella pneumoniae, n (%)	30 (15.2)	6 (6.5)	24 (22.6)	0.002
Pseudomonas aeruginosa, n (%)	18 (9.1)	6 (6.5)	12 (11.3)	0.241
Enterobacter cloacae, n (%)	8 (4)	3 (3.3)	5 (4.7)	0.72
Acinetobacter baumannii, n (%)	4 (2)	1 (1.1)	3 (2.8)	0.62
Serratia marcescens, n (%)	2 (1)	0 (0)	2 (1.9)	0.50

BSI: bloodstream infection: CA-BSI: community-acquired bloodstream infection; HA-BSI: hospital-acquired bloodstream infection.

Table 3 Description of Gram-positive cocci drug resistance in community and hospital-acquired BSIs in immunocompromised patients.

	Total n = 48 (100%)	CA-BSIs n = 22 (45.8%)	HA-BSIs n = 26 (54.2%)	*p*
MRM, n (%)	15 (31.3)	3 (13.6)	12 (46.2)	0.015
Staphylococcus aureus, n (%)	6 (3)	2 (2.2)	4 (3.8)	
Methicillin-resistant, n (%)	1 (16.7)	0 (0)	1 (25)	1
MRM, n (%)	1 (16.7)	0 (0)	1 (25)	1
Cephalothin, n (%)	1 (16.7)	0 (0)	1 (25)	1
Clindamycin, n (%)	4 (66.7)	1 (50)	3 (75)	1
Ciprofloxacin, n (%)	1 (16.7)	0 (0)	1 (25)	1
Gentamicin, n (%)	1 (16.7)	0 (0)	1 (25)	1
Negative coagulase Staphylococcus, n (%)	16 (8.1)	5 (5.4)	11 (10.4)	
Methicillin-resistant, n (%)	11 (68.8)	1 (20)	10 (90.9)	0.13
MRM, n (%)	11 (68.8)	1 (20)	10 (90.9)	0.13
Cephalothin, n (%)	11 (68.8)	1 (20)	10 (90.9)	0.13
Clindamycin, n (%)	10 (62.5)	3 (60)	7 (63.6)	1
Ciprofloxacin, n (%)	8 (50)	1 (20)	7 (63.6)	0.28
Gentamicin, n (%)	8 (50)	1 (20)	7 (63.6)	0.28
Oxacillin, n (%)	11 (68.8)	1 (20)	10 (90.9)	0.13
Rifampicin, n (%)	5 (31.3)	1 (20)	4 (36.4)	1
TMP/SMX, n (%)	5 (31.3)	1 (20)	4 (36.4)	1

BSI: bloodstream infections; CA: community-acquired; HA: hospital-acquired; TMP/SMX: trimethoprim/sulfamethoxazole; MRM: multiresistant microorganism.

characteristics associated with mortality are detailed in Table 6.

Discussion

In this cohort of immunocompromised patients, more than half of the BSI episodes were hospital-acquired, with a high proportion of Gram-negative bacilli (GNB) isolates and a high prevalence of multidrug-resistant organisms (MDROs), particularly in hospital-acquired cases. In line with reports from European and Latin American series, this pattern has been associated with prolonged hospitalization, use of invasive devices, and prior exposure to antibiotics in immunocompromised patients[21,23,27,35]. These findings reflect the vulnerability of this population to severe infections and underscore the need to optimize preventive strategies, diagnostic approaches, and appropriate empirical antimicrobial therapy. Several international studies concur that BSIs in immunocompromised patients represent

Table 4 Description of Gram-negative bacilli drug resistance in community and hospital-acquired BSIs in immunocompromised patients.

	Total n = 150 (100%)	CA-BSIs n = 70 (46.7%)	HA-BSI n = 80 (53.3%)	*p*
MRM, n (%)	52 (34.7)	15 (21.4)	37 (46.3)	0.001
Carbapenemase, n (%)	13 (8.7)	2 (2.9)	11 (13.8)	0.018
KPC, n (%)	12 (92.3)	2 (100)	10 (90.9)	1
Metalocarbapenemase, n (%)	0 (0)	0 (0)	0 (0)	1
Oxacarbapenemase, n (%)	1 (7.7)	0 (0)	1 (9.1)	1
ESBL, n (%)	25 (16.7)	8 (11.4)	17 (21.3)	0.107
Acinetobacter baumannii, n (%)	Total n = 4 (2)	CA-BSI n = 1 (1.1)	HA-BSI N = 3 (2.8)	*p*
MRM, n (%)	3 (75)	0 (0)	3 (100)	0.25
Amikacin, n (%)	2 (50)	0 (0)	2 (66.7)	1
Imipenem, n (%)	3 (75)	0 (0)	3 (100)	0.25
PTZ, n (%)	3 (75)	0 (0)	3 (100)	0.25
Escherichia coli, n (%)	Total n = 71 (35.9)	CA-BSI n = 49 (53.3)	HA-BSI n = 22 (20.8)	*p*
MRM, n (%)	16 (22.5)	9 (18.4)	7 (31.8)	0.23
Amikacin, n (%)	1 (1.4)	1 (2)	0 (0)	1
Ceftriaxone, n (%)	11 (15.5)	5 (10.2)	6 (27.3)	0.084
Ceftazidime, n (%)	11 (15.5)	5 (10.2)	6 (27.3)	0.084
Cefepime, n (%)	11 (15.5)	5 (10.2)	6 (27.3)	0.084
Ciprofloxacin, n (%)	37 (52.1)	23 (46.9)	14 (63.6)	0.19
Imipenem, n (%)	1 (1.4)	1 (2)	0 (0)	1
PTZ, n (%)	6 (8.5)	3 (6.1)	3 (13.6)	0.36
Carbapenemase, n (%)	1 (1.4)	1 (2)	0 (0)	1
KPC, n (%)	1 (1.4)	1 (2)	0 (0)	1
ESBL, n (%)	10 (14.1)	4 (8.2)	6 (27.3)	0.060
Klebsiella pneumoniae, n (%)	Total n = 30 (15.2)	CA-BSI n = 6 (6.5)	HA-BSI n = 24 (22.6)	*p*
MRM, n (%)	19 (63.3)	2 (33.3)	17 (70.8)	0.15
Amikacin, n (%)	5 (16.7)	1 (16.7)	4 (16.7)	1
Ampicillin, n (%)	29 (96.7)	6 (100)	23 (95.8)	1
Ampicillin sulbactam, n (%)	19 (63.3)	2 (33.3)	17 (70.8)	0.15
Ceftriaxone, n (%)	19 (63.3)	2 (33.3)	17 (70.8)	0.15
Cefepime, n (%)	19 (63.3)	2 (33.3)	17 (70.8)	0.15
Ciprofloxacin, n (%)	15 (50)	2 (33.3)	13 (54.2)	0.65
Imipenem, n (%)	8 (26.7)	1 (16.7)	7 (29.2)	1
PTZ, n (%)	18 (60)	2 (33.3)	16 (66.7)	0.18
TMP/SMX, n (%)	16 (53.3)	2 (33.3)	14 (58.3)	0.37
Colistin, n (%)	1 (9.1)	1 (100)	0 (0)	0.091
Fosfomycin, n (%)	2 (20)	1 (100)	1 (11.1)	0.20
Carbapenemase producer, n (%)	11 (36.7)	1 (16.7)	10 (41.7)	0.37
KPC, n (%)	10 (33.3)	1 (16.7)	9 (37.5)	0.63
Oxacarbapenemase, n (%)	1 (3.3)	0 (0)	1 (4.2)	1
ESBL, n (%)	10 (33.3)	1 (16.7)	9 (37.5)	0.63
Pseudomonas aeruginosa, n (%)	Total n = 18 (9.1)	CA-BSI n = 6 (6.5)	HA-BSI n = 12 (11.3)	*p*
MRM, n (%)	4 (22.2)	1 (16.7)	3 (25)	1
Amikacin, n (%)	3 (16.7)	0 (0)	3 (25)	0.51
Cefepime, n (%)	3 (16.7)	2 (33.3)	1 (8.3)	0.24
Ciprofloxacin, n (%)	4 (22.2)	1 (16.7)	3 (25)	1

Table 4 (*Continued*)

Pseudomonas aeruginosa, n (%)	Total n = 18 (9.1)	CA-BSI n = 6 (6.5)	HA-BSI n = 12 (11.3)	*p*
Gentamicin, n (%)	3 (16.7)	0 (0)	3 (25)	0.51
Imipenem, n (%)	4 (22.2)	2 (33.3)	2 (16.7)	0.56
Meropenem, n (%)	3 (16.7)	1 (16.7)	2 (16.7)	1
PTZ, n (%)	4 (22.2)	1 (16.7)	3 (25)	1

BSIs: bloodstream infections; CA: community-acquired; HA: hospital-acquired; TMP/SMX: trimethoprim/sulfamethoxazole; MRM: multiresistant microorganism; ESBL: extended-spectrum beta-lactamases; PTZ: piperacillin/tazobactam.

a significant burden on healthcare systems, both in terms of incidence and morbidity and mortality, with rates ranging between 30% and 50% in similar cohorts[23,26].

Regarding the main comorbidities of immunocompromised patients, active neoplasms, both solid and hematologic, were the most frequent, followed by smoking, diabetes mellitus, and chronic kidney disease. These findings are consistent with previous reports describing a significantly increased risk of bacteremia in patients with neoplasms, particularly hematologic, due to immune dysfunction associated with both the underlying disease and cytotoxic therapy[11,30]. Additionally, 20.4% of patients were identified as neutropenic, a well-documented risk factor in the literature, particularly linked to nosocomial infections and poor outcomes[7].

The predominant infectious focus was primary bacteremia (28.2%), followed by urinary tract infections (18.8%), intra-abdominal infections (16.6%), and catheter-associated bloodstream infections (13.3%). These results are consistent with international series that report a high frequency of bacteremia without an apparent focus in oncologic and immunocompromised patients. This difficulty in identifying a specific focus may be due to an attenuated immune response that limits the manifestation of symptoms, clinical signs, or radiological findings[11]. Notably, urinary tract BSIs were more frequent in CA-BSI (29.8% vs. 9.3%; $p < 0.001$), whereas catheter-associated BSI were significantly more frequent in HA-BSI (19.6% vs. 6%; $p = 0.007$). This pattern reflects the expected pathophysiology in each context, with a greater role of invasive devices in the hospital setting. The international literature has documented a similar prevalence, with urinary infections being the main portal of entry in ambulatory immunocompromised patients, and a high incidence of catheter-related bacteremia in hospitalized and intensive care unit patients[33,39].

Gram-negative bacilli were the predominant group of isolates (75.8%), with *Escherichia coli* (35.9%) in CA-BSI and *Klebsiella pneumoniae* (15.2%) in HA-BSI being the most frequent pathogens. Although GNB have historically predominated in BSIs in immunocompromised patients, various studies indicate that during the 1980s and 1990s, there was an increase in the proportion of Gram-positive cocci infections, attributed to the widespread use of intravascular catheters and antibiotic prophylaxis. However, since the 2000s, a resurgence of GNB BSI has been documented, particularly those caused by MDR strains, partly due to selective pressure exerted by intensive antimicrobial use and other healthcare-related factors[23,35]. In other series, *E. coli* has consistently been highlighted as the most frequent pathogen, though with slightly lower or higher proportions, possibly due to geographic or population influences[3,18,36]. Although less frequent (24.2%), Gram-positive cocci were clinically relevant, with coagulase-negative *Staphylococcus* being the most common finding in patients with invasive devices[10].

MDROs were detected in 33.8% of episodes, with a significant difference between hospital-acquired (46.3%) and community-acquired (21.4%; $p = 0.001$) cases. These data reflect the selective pressure exerted by hospital exposure and prior antibiotic use, factors widely documented in the literature as predictors of multidrug resistance, particularly in high-complexity institutions such as the hospitals where this study was conducted[26,34].

Among the risk factors significantly associated with MDRO BSIs in our cohort were prolonged hospitalization, recent antibiotic use (particularly carbapenems and vancomycin), prior surgery, urinary catheterization, and need for mechanical ventilation. These factors are widely recognized in the literature as predictors of colonization and subsequent infection with MDROs and are frequently incorporated into clinical scoring systems aimed at guiding the empirical initiation of broad-spectrum antimicrobial coverage[5,42].

The comparison with national data reported by the WHONET Argentina Network 2022–2023 revealed some noteworthy aspects regarding antimicrobial susceptibility[41]. Ceftriaxone resistance was 63.3% in *K. pneumoniae* and 15.5% in *E. coli*, slightly different from those reported in the same report (51.6% and 21.5%, respectively). Regarding carbapenemase-producing strains, in our study 36.7% of *K. pneumoniae* isolates were carbapenemase producers, exceeding the national average of 33.3%[41].

Thirty-day mortality was 24.8%, increasing significantly among patients with BSIs due to MDROs, recent or active COVID-19 infection, or polymicrobial blood cultures. These associations are important to consider given their high frequency in immunocompromised patients. Coinfection or sequential infection in patients who experienced severe viral illness, such as SARS-CoV-2, has been linked to persistent immune dysfunction, dysbiosis, and increased colonization by MDROs[4]. The higher mortality observed at *Hospital Ferreyra* compared with *Hospital Privado* (64.4% vs. 35.6%; $p < 0.05$) may be related to differences in patient complexity or initial therapeutic strategies, although this requires further analysis.

The strengths of this study include the number of patients included, the detailed characterization of infectious foci and resistance profiles, and the joint evaluation of clinical and microbiological variables. However, the study has

Table 5 Clinical characteristics of immunocompromised patients with BSIs, according to the isolate (MRM o not MRM).

	Total BSIs n = 198 (100%)	MRM n = 67 (33.8%)	Not MRM n = 131 (66.2%)	*p*
Demographic characteristics				
Hospital Privado, n (%)	119 (60.1)	35 (52.2)	84 (64.1)	0.106
Hospital Ferreyra, n (%)	79 (39.9)	32 (47.8)	47 (35.9)	
Male, n (%)	109 (55.1)	36 (53.7)	73 (55.7)	0.79
Community-acquired, n (%)	92 (46.5)	18 (26.9)	74 (56.5)	<0.001
Hospital-acquired, n (%)	106 (53.5)	49 (73.1)	57 (43.5)	
Associated factors				
Hospital stay >48 h, n (%)	84 (42.4)	38 (56.7)	46 (35.1)	0.004
Hospitalization in the previous 6 months, n (%)	134 (67.7)	55 (82.1)	79 (60.3)	0.002
ICU hospitalization in the previous 6 months, n (%)	46 (23.2)	24 (35.8)	22 (16.8)	0.003
Repeated UTI, n (%)	29 (14.6)	14 (20.9)	15 (11.5)	0.075
Steroid treatment, n (%)	43 (21.7)	20 (29.9)	23 (17.6)	0.047
Immunosuppressive treatment, n (%)	70 (35.4)	28 (41.8)	42 (32.1)	0.17
Chemotherapy, n (%)	85 (42.9)	30 (44.8)	55 (42)	0.70
Surgical procedure, n (%)	55 (27.8)	26 (38.8)	29 (22.1)	0.013
Parenteral nutrition, n (%)	13 (6.6)	5 (7.5)	8 (6.1)	0.76
Comorbidities				
Heart failure, n (%)	11 (5.6)	2 (3)	9 (6.9)	0.33
Coronary artery disease, n (%)	21 (10.6)	8 (11.9)	13 (9.9)	0.66
Chronic kidney disease, n (%)	58 (29.3)	20 (29.9)	38 (29)	0.90
Diabetes mellitus, n (%)	62 (31.3)	28 (41.8)	34 (26)	0.023
Tobacco use, n (%)	84 (42.4)	22 (32.8)	62 (47.3)	0.051
COPD, n (%)	17 (8.6)	8 (11.9)	9 (6.9)	0.22
Asthma, n (%)	3 (1.5)	0 (0)	3 (2.3)	0.55
Liver disease, n (%)	17 (8.6)	6 (9)	11 (8.4)	0.89
Malignancy, n (%)	137 (69.2)	45 (67.2)	92 (70.2)	0.65
Solid tumor, n (%)	84 (42.4)	25 (37.3)	59 (45)	0.57
Hematologic malignancy, n (%)	53 (26.8)	20 (29.9)	33 (25.2)	0.57
Neurologic disease, n (%)	18 (9.1)	7 (10.4)	11 (8.4)	0.63
Autoimmune disease, n (%)	20 (10.1)	8 (11.9)	12 (9.2)	0.53
Asplenia, n (%)	2 (1)	1 (1.5)	1 (0.8)	1
HIV/AIDS, n (%)	2 (1)	1 (1.5)	1 (0.8)	1
Bone marrow transplant, n (%)	21 (10.6)	7 (10.4)	14 (10.7)	0.95
Renal transplant, n (%)	33 (16.7)	16 (23.9)	17 (13)	0.051
Neutropenia, n (%)	43 (21.7)	11 (16.4)	32 (24.4)	0.19
Prolonged neutropenia, n (%)	28 (14.1)	8 (11.9)	20 (15.3)	0.52
COVID-19 in the previous month (%)	11 (5.6)	8 (11.9)	3 (2.3)	0.008
Current COVID-19, n (%)	9 (4.5)	7 (10.4)	2 (1.5)	0.008
Vesical catheter, n (%)	46 (23.2)	27 (40.3)	19 (14.5)	<0.001
Nephrostomy, n (%)	3 (1.5)	3 (4.5)	0 (0)	0.038
Central venous catheter, n (%)	77 (38.9)	32 (47.8)	45 (34.4)	0.067
Biliary tract prosthesis, n (%)	11 (5.6)	5 (7.5)	6 (4.6)	0.51
Mechanical ventilation, n (%)	12 (6.1)	8 (11.9)	4 (3.1)	0.023
Mortality in 30 days, n (%)	53 (26.8)	23 (34.3)	30 (22.9)	0.086
Antibiotic use in the previous 6 months, n (%)	119 (60.1)	50 (74.6)	69 (52.7)	0.003

Table 5 (*Continued*)

	Total BSIs n = 198 (100%)	MRM n = 67 (33.8%)	Not MRM n = 131 (66.2%)	*p*
Antibiotic use in the previous 3 months, n (%)	112 (56.6)	46 (68.7)	66 (50.4)	0.014
Antibiotic use in the previous month, n (%)	98 (49.5)	42 (62.7)	56 (42.7)	0.008
Type of antibiotics in the previous 6 months				
Carbapenems, n (%)	31 (15.7)	16 (23.9)	15 (11.5)	0.023
PTZ, n (%)	43 (21.7)	15 (22.4)	28 (21.4)	0.87
Beta-lactam (not PTZ), n (%)	31 (15.7)	13 (19.4)	18 (13.7)	0.30
Amikacin, n (%)	20 (10.1)	9 (13.4)	11 (8.4)	0.26
Vancomycin, n (%)	24 (12.1)	13 (19.4)	11 (8.4)	0.025
Colistin, n (%)	6 (3)	4 (6)	2 (1.5)	0.18
Macrolides, n (%)	10 (5.1)	6 (9)	4 (3.1)	0.091
Quinolones, n (%)	28 (14.1)	10 (14.9)	18 (13.7)	0.82
TMS/SMX, n (%)	17 (8.6)	9 (13.4)	8 (6.1)	0.082
Metronidazole, n (%)	15 (7.6)	6 (9)	9 (6.9)	0.60
Other, n (%)	31 (15.7)	13 (19.4)	18 (13.7)	0.30
Type of microorganism				
GPC, n%	48 (24.2)	15 (22.4)	33 (25.2)	0.66
GNB, n%	150 (75.8)	52 (77.6)	98 (74.8)	0.66

MRM: multiresistant microorganism; UTI: urinary tract infection; PTZ: piperacillin–tazobactam; COPD: chronic obstructive pulmonary disease; HIV: human immunodeficiency virus; TMP/SMX: trimethoprim/sulfamethoxazole; GPC: Gram-positive cocci; GNB: Gram-negative bacilli.

Table 6 Factors associated to 30-day mortality after BSI in immunocompromised patients.

	Survivors (30 days post BSI) n = 136	Dead (30 days post BSI) n = 45	*p*
Hospital Privado, n (%)	94 (69.1)	16 (35.6)	<0.005
Hospital Ferreyra, n (%)	42 (30.9)	29 (64.4)	<0.005
Male, n (%)	77 (56.6)	24 (53.3)	0.70
Community-acquired, n (%)	64 (47.1)	20 (44.4)	0.76
Hospital-acquired, n (%)	72 (52.9)	25 (55.6)	0.76
Comorbidities			
Heart failure, n (%)	6 (4.4)	4 (8.9)	0.26
Coronary artery disease, n (%)	21 (15.4)	0 (0)	0.005
Chronic kidney disease, n (%)	42 (30.9)	12 (26.7)	0.59
Diabetes mellitus, n (%)	46 (33.8)	13 (28.9)	0.54
Tobacco use, n (%)	54 (39.7)	20 (44.4)	0.57
COPD, n (%)	11 (8.1)	5 (11.1)	0.55
Malignancy, n (%)	86 (63.2)	38 (84.4)	0.008
Hematologic malignancy, n (%)	36 (26.5)	15 (33.3)	0.37
Non-hematologic malignancy, n (%)	50 (36.8)	23 (51.1)	0.089
Autoimmune disease, n (%)	14 (10.3)	6 (13.3)	0.58
HIV-AIDS, n (%)	1 (0.7)	1 (2.2)	0.43
Asplenia, n (%)	2 (1.5)	0 (0)	1
Alcoholism, n (%)	4 (2.9)	2 (4.4)	0.63
Bone marrow transplant, n (%)	12 (8.8)	6 (13.3)	0.39
Renal transplant, n (%)	29 (21.3)	2 (4.4)	0.009
Neutropenia	30 (22.1)	7 (15.6)	0.34
Risk factors			
COVID-19 in the previous month, n (%)	4 (2.9)	7 (15.6)	0.006
Current COVID-19, n (%)	3 (2.2)	6 (13.3)	0.008

Table 6 (*Continued*)

	Survivors (30 days post BSI) n = 136	Dead (30 days post BSI) n = 45	*p*
Hospitalization in the previous 48 h, n (%)	59 (43.4)	20 (44.4)	0.90
Hospitalization in the previous 6 months, n (%)	92 (67.6)	34 (75.6)	0.31
ICU hospitalization in the previous 6 months, n (%)	34 (25)	11 (24.4)	0.94
Repeated UTI, n (%)	23 (16.9)	3 (6.7)	0.089
Vesical catheter, n (%)	30 (22.1)	16 (35.6)	0.071
Nephrostomy, n (%)	3 (2.2)	0 (0)	0.57
Central venous catheter, n (%)	52 (38.2)	18 (40)	0.83
Parenteral nutrition, n (%)	8 (5.9)	3 (6.7)	1
Biliary tract prothesis, n (%)	5 (3.7)	4 (8.9)	0.22
Mechanic ventilation, n (%)	6 (4.4)	6 (13.3)	0.076
Steroid treatment, n (%)	32 (23.5)	8 (17.8)	0.42
Immunosuppressive treatment, n (%)	53 (39)	11 (24.4)	0.077
Chemotherapy, n (%)	57 (41.9)	19 (42.2)	0.97
Radiotherapy, n (%)	5 (3.7)	1 (2.2)	1
Infection in the previous 6 months, n (%)	75 (55.1)	25 (55.6)	0.96
Infection in the previous 3 months, n (%)	70 (51.5)	24 (53.3)	0.82
Surgery, n (%)	36 (26.5)	17 (37.8)	0.14
Microbiologic characteristics			
Polymicrobial hemoculture, n (%)	8 (5.9)	8 (17.8)	0.029
Gram-negative, n (%)	104 (76.5)	36 (80)	0.62
Gram-positive, n (%)	32 (23.5)	9 (20)	0.62
ESBL, n (%)	19 (14)	6 (13.3)	0.91
VR, n (%)	0 (0)	1 (2.2)	0.24
Methicillin-resistant, n (%)	9 (6.6)	3 (6.7)	1
Carbapenemase producer, n (%)	4 (2.9)	9 (20)	0.001
MRM, n (%)	43 (31.6)	23 (51.1)	0.019
Type of infection			
Primary bacteremia, n (%)	36 (26.5)	15 (33.3)	0.37
UTI, n (%)	29 (21.3)	5 (11.1)	0.128
Intraabdominal infection, n (%)	26 (19.1)	4 (8.9)	0.11
Catheter-associated infection, n (%)	20 (14.7)	4 (8.9)	0.31
Biliary tract infection, n (%)	10 (7.4)	11 (24.4)	0.002
Respiratory infection, n (%)	4 (2.9)	3 (6.7)	0.36

COPD: chronic obstructive pulmonary disease; HIV: human immunodeficiency virus; ESBL: extended-spectrum beta-lactamase; VR: vancomycin-resistant; MRM: multi-resistant microorganism; UTI: urinary tract infection.

limitations that are inherent to its retrospective design, such as reliance on the quality of clinical records and the inability to establish causality. Additionally, pharmacokinetic variables and adherence to antimicrobial treatment were not assessed.

The findings of this study highlight the importance of local epidemiological surveillance and antimicrobial stewardship programs for empirical treatment optimization in immunocompromised patients. Furthermore, they underscore the need for prospective studies evaluating interventions aimed at reducing the incidence of MDRO BSIs and improving clinical outcomes in this high-risk population.

Conclusions

In conclusion, this study showed that BSIs in immunocompromised patients were predominantly hospital-acquired and associated with a high frequency of Gram-negative bacteremia, mainly due to *E. coli* and *K. pneumoniae*. A high proportion of MDROs was observed, particularly in hospital-acquired BSI, which were associated with increased mortality. The most relevant clinical factors linked to multidrug resistance included prolonged hospitalization, recent antibiotic use, and recent SARS-CoV-2 infection.

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Conflicts of interest

None declared.

References

1. Averbuch D, Orasch C, Cordonnier C, Livermore DM, Mikulska M, Viscoli C, Gyssens IC, Kern WV, Klyasova G, Marchetti O, Engelhard D, Akova M. ECIL4, a joint venture of EBMT, EORTC ICHS, ESGICH/ESCMID and ELN. European guidelines for empirical antibacterial therapy for febrile neutropenic patients in the era of growing resistance: summary of the 2011 4th European Conference on Infections in Leukemia. Haematologica. 2013;98:1826–35, http://dx.doi.org/10.3324/haematol.2013.091025.
2. Carrigan SD, Scott G, Tabrizian M. Toward resolving the challenges of sepsis diagnosis. Clin Chem. 2004;50:1301–14, http://dx.doi.org/10.1373/clinchem.2004.032144.
3. Cermák P, Kolár M, Látal T. Frequency of Gram-negative bacterial pathogens in bloodstream infections and their resistance to antibiotics in the Czech Republic. Int J Antimicrob Agents. 2004;23:401–4, http://dx.doi.org/10.1016/j.ijantimicag.2003.07.021.
4. Contou D, Claudinon A, Pajot O, Micaëlo M, Longuet Flandre P, Dubert M, Cally R, Logre E, Fraissé M, Mentec H, Plantefève G. Bacterial and viral co-infections in patients with severe SARS-CoV-2 pneumonia admitted to a French ICU. Ann Intensive Care. 2020;10:119, http://dx.doi.org/10.1186/s13613-020-00736-x.
5. Ding L, Shen S, Chen J, Tian Z, Shi Q, Han R, Guo Y, Hu F. *Klebsiella pneumoniae* carbapenemase variants: the new threat to global public health. Clin Microbiol Rev. 2023;36, http://dx.doi.org/10.1128/cmr.00008-23, e0000823.
6. Feld R. Bloodstream infections in cancer patients with febrile neutropenia. Int J Antimicrob Agents. 2008;32 Suppl. 1:S30–3, http://dx.doi.org/10.1016/j.ijantimicag.2008.06.017.
7. Finello M, Suasnabar DF, García MJ, Díaz MV, Richetta L, Toranzo A, Hernández D, Cometto MA, Vázquez SM, Caeiro JP, Sierra J, Saad EJ. Características clínicas y microbiológicas de infecciones del torrente sanguíneo en pacientes adultos neutropénicos. Rev Argent Microbiol. 2021;53:183–93.
8. Flowers CR, Seidenfeld J, Bow EJ, Karten C, Gleason C, Hawley DK, Kuderer NM, Langston AA, Marr KA, Rolston KV, Ramsey SD. Antimicrobial prophylaxis and outpatient management of fever and neutropenia in adults treated for malignancy: American Society of Clinical Oncology clinical practice guideline. J Clin Oncol. 2013;31:794–810, http://dx.doi.org/10.1200/JCO.2012.45.8661.
9. Gambra M, Flores J, Ramírez K, Palma S, Zitko P, Valenzuela MT, Beltrán C. Incidencia y mortalidad de bacteriemia en un hospital clínico docente en Santiago de Chile. Rev Med Chil. 2012;140:859–66, http://dx.doi.org/10.4067/S0034-98872012000700005 [in Spanish].
10. Grafia I, Chumbita M, Seguí E, Cardozo C, Laguna JC, García de Herreros M, Garcia-Pouton N, Villaescusa A, Pitart C, Rico-Caballero V, Marco-Hernández J, Zamora C, Viladot M, Padrosa J, Tuca A, Mayor-Vázquez E, Marco F, Martínez JA, Mensa J, Garcia-Vidal C, Soriano A, Puerta-Alcalde P. Epidemiology and risk factors for recurrence in biliary source bloodstream infection episodes in oncological patients. Microbiol Spectr. 2023;11, http://dx.doi.org/10.1128/spectrum.02142-23, e0214223.
11. Gudiol C, Aguado JM, Carratalà J. Bloodstream infections in patients with solid tumors. Virulence. 2016;7:298–308, http://dx.doi.org/10.1080/21505594.2016.1141161.
12. Horan TC, Andrus M, Dudeck MA. CDC/NHSN surveillance definition of health care-associated infection and criteria for specific types of infections in the acute care setting. Am J Infect Control. 2008;36:309–32, http://dx.doi.org/10.1016/j.ajic.2008.03.002.
13. Karchmer AW. Nosocomial bloodstream infections: organisms, risk factors, and implications. Clin Infect Dis. 2000;31 Suppl. 4:S139–43, http://dx.doi.org/10.1086/314078.
14. Kiriyama S, Takada T, Strasberg SM, Solomkin JS, Mayumi T, Pitt HA, Gouma DJ, Garden OJ, Büchler MW, Yokoe M, Kimura Y, Tsuyuguchi T, Itoi T, Yoshida M, Miura F, Yamashita Y, Okamoto K, Gabata T, Hata J, Higuchi R, Windsor JA, Bornman PC, Fan ST, Singh H, de Santibanes E, Gomi H, Kusachi S, Murata A, Chen XP, Jagannath P, Lee S, Padbury R, Chen MF, Tokyo Guidelines Revision Committee. New diagnostic criteria and severity assessment of acute cholangitis in revised Tokyo Guidelines. J Hepatobiliary Pancreat Sci. 2012;19:548–56, http://dx.doi.org/10.1007/s00534-012-0537-3.
15. Kritikos A, Manuel O. Bloodstream infections after solid-organ transplantation. Virulence. 2016;7:329–40, http://dx.doi.org/10.1080/21505594.2016.1139279.
16. Leclercq R. Epidemiological and resistance issues in multidrug-resistant staphylococci and enterococci. Clin Microbiol Infect. 2009;15:224–31, http://dx.doi.org/10.1111/j.1469-0691.2009.02739.x.
17. Low CY, Rotstein C. Emerging fungal infections in immunocompromised patients. F1000 Med Rep. 2011;3:14, http://dx.doi.org/10.3410/M3-14.
18. Luzzaro F, Ortisi G, Larosa M, Drago M, Brigante G, Gesu G. Prevalence and epidemiology of microbial pathogens causing bloodstream infections: results of the OASIS multicenter study. Diagn Microbiol Infect Dis. 2011;69:363–9, http://dx.doi.org/10.1016/j.diagmicrobio.2010.10.016.
19. Magiorakos AP, Srinivasan A, Carey RB, Carmeli Y, Falagas ME, Giske CG, Harbarth S, Hindler JF, Kahlmeter G, Olsson-Liljequist B, Paterson DL, Rice LB, Stelling J, Struelens MJ, Vatopoulos A, Weber JT, Monnet DL. Multidrug-resistant, extensively drug-resistant and pandrug-resistant bacteria: an international expert proposal for interim standard definitions for acquired resistance. Clin Microbiol Infect. 2012;18:268–81, http://dx.doi.org/10.1111/j.1469-0691.2011.03570.x.
20. Maschmeyer G, Haas A. The epidemiology and treatment of infections in cancer patients. Int J Antimicrob Agents. 2008;31:193–7, http://dx.doi.org/10.1016/j.ijantimicag.2007.06.014.
21. McCreery RJ, Florescu DF, Kalil AC. Sepsis in immunocompromised patients without human immunodeficiency virus. J Infect Dis. 2020;222 Suppl. 2:S156–65, http://dx.doi.org/10.1093/infdis/jiaa320.
22. Mermel LA, Allon M, Bouza E, Craven DE, Flynn P, O'Grady NP, Raad II, Rijnders BJ, Sherertz RJ, Warren DK. Clinical practice guidelines for the diagnosis and management of intravascular catheter-related infection: 2009 Update by the Infectious Diseases Society of America. Clin Infect Dis. 2009;49:1–45, http://dx.doi.org/10.1086/599376.
23. Montassier E, Batard E, Gastinne T, Potel G, de La Cochetière MF. Recent changes in bacteremia in patients with cancer: a systematic review of epidemiology and antibiotic resistance. Eur J Clin Microbiol Infect Dis. 2013;32:841–50, http://dx.doi.org/10.1007/s10096-013-1819-7.
24. Moreno A, Cervera C, Gavaldá J, Rovira M, de la Cámara R, Jarque I, Montejo M, de la Torre-Cisneros J, Miguel Cisneros J, Fortún J, López-Medrano F, Gurguí M, Muñoz P, Ramos A, Carratalá J. Bloodstream infections among transplant recipients: results of a nationwide surveillance in

Spain. Am J Transplant. 2007;7:2579–86, http://dx.doi.org/10.1111/j.1600-6143.2007.01964.x.
25. Patolia S, Abate G, Patel N, Patolia S, Frey S. Risk factors and outcomes for multidrug-resistant Gram-negative bacilli bacteremia. Ther Adv Infect Dis. 2018;5:11–8, http://dx.doi.org/10.1177/2049936117727497.
26. Rodríguez-Baño J, Gutiérrez-Gutiérrez B, Machuca I, Pascual A. Treatment of infections caused by extended-spectrum-beta-lactamase- AmpC-, and carbapenemase-producing Enterobacteriaceae. Clin Microbiol Rev. 2018;31, http://dx.doi.org/10.1128/CMR.00079-17, e00079-17.
27. Rosenthal VD, Yin R, Nercelles P, Rivera-Molina SE, Jyoti S, Dongol R, Aguilar-De-Moros D, Tumu N, Alarcon-Rua J, Stagnaro JP, Alkhawaja S, Jimenez-Alvarez LF, Cano-Medina YA, Valderrama-Beltran SL, Henao-Rodas CM, Zuniga-Chavarria MA, El-Kholy A, Agha HM, Sahu S, Anusandhan SO, Bhattacharyya M, Kharbanda M, Poojary A, Nair PK, Myatra SN, Chawla R, Sandhu K, Mehta Y, Rajhans P, Zand F, Abdellatif-Daboor M, Tai CW, Gan CS, Mat Nor MB, Aguirre-Avalos G, Hernandez-Chena BE, Sassoe-Gonzalez A, Villegas-Mota I, Aleman-Bocanegra MC, Bat-Erdene I, Carreazo NY, Castaneda-Sabogal A, Janc J, Belskiy V, Hlinkova S, Yildizdas D, Havan M, Koker A, Sungurtekin H, Dinleyici EC, Guclu E, Tao L, Memish ZA, Jin Z. International Nosocomial Infection Control Consortium (INICC) report of health care associated infections, data summary of 45 countries for 2015 to 2020, adult and pediatric units, device-associated module. Am J Infect Control. 2024;52:1002–11, http://dx.doi.org/10.1016/j.ajic.2023.12.019.
28. Saad EJ, Baenas DF, Boisseau CS, García MJ, Nuñez SA, Balderramo DC, Hernandez D, Caeiro JP. Características de las infecciones del torrente sanguíneo en pacientes adultos de dos centros de tercer nivel de Córdoba Argentina. Rev Fac Cien Med Univ Nac Cordoba. 2018;75:156–67, http://dx.doi.org/10.31053/1853.0605.v75.n3.19455 [in Spanish].
29. Saad EJ, Fernández P, Cardozo Azua AE, Ellena V, Diz C, Giordano G, Borgogno P, Nuñez S, Sarmantano D, Guzman A, Schwarz F, Naser S, Flores MF, Alaye ML, Caeiro JP, De la Fuente J. Infections in the first year after renal transplant. Medicina (B Aires). 2020;80:611–21.
30. Satlin MJ, Cohen N, Ma KC, Gedrimaite Z, Soave R, Askin G, Chen L, Kreiswirth BN, Walsh TJ, Seo SK. Bacteremia due to carbapenem-resistant Enterobacteriaceae in neutropenic patients with hematologic malignancies. J Infect. 2016;73:336–45, http://dx.doi.org/10.1016/j.jinf.2016.07.002.
31. Scarvelis D, Wells PS. Diagnosis and treatment of deep-vein thrombosis. CMAJ. 2006;175:1087–92, http://dx.doi.org/10.1503/cmaj.060366.
32. Sierra J, Díaz MV, de Jesús García M, Finello M, Suasnabar DF, Richetta L, Toranzo A, Hernández D, Cometto MA, Vázquez SM, Caeiro JP, Saad EJ. Infecciones del torrente sanguíneo en pacientes oncológicos. Medicina (B Aires). 2020;80:329–38.
33. Suárez Fernández ML, Ridao Cano N, Álvarez Santamarta L, Gago Fraile M, Blake O, Díaz Corte C. A current review of the etiology clinical features, and diagnosis of urinary tract infection in renal transplant patients. Diagnostics (Basel). 2021;11, http://dx.doi.org/10.3390/diagnostics11081456, 1456.
34. Tamma PD, Aitken SL, Bonomo RA, Mathers AJ, van Duin D, Clancy CJ. Infectious Diseases Society of America 2023 Guidance on the treatment of antimicrobial resistant gram-negative infections. Clin Infect Dis. 2023, http://dx.doi.org/10.1093/cid/ciad428, ciad428.
35. Trecarichi EM, Giuliano G, Cattaneo C, Ballanti S, Criscuolo M, Candoni A, Marchesi F, Laurino M, Dargenio M, Fanci R, Cefalo M, Delia M, Spolzino A, Maracci L, Nadali G, Busca A, Del Principe MI, Daffini R, Simonetti E, Dragonetti G, Zannier ME, Pagano L, Tumbarello M, Haematologic Malignancies Associated Bloodstream Infections Surveillance (HEMABIS) registry–Sorveglianza Epidemiologica Infezioni Fungine in Emopatie Maligne (SEIFEM) Group Italy. Bloodstream infections caused by *Escherichia coli* in onco-haematological patients: Risk factors and mortality in an Italian prospective survey. PLoS One. 2019;14, http://dx.doi.org/10.1371/journal.pone.0224465, e0224465.
36. Ülkü Tüzemen N, Payaslioğlu M, Özakin C, Ener B, Akalin H. Trends of bloodstream infections in a university hospital during 12 years. Pol J Microbiol. 2022;71:443–52, http://dx.doi.org/10.33073/pjm-2022-039.
37. Varani S, Stanzani M, Paolucci M, Melchionda F, Castellani G, Nardi L, Landini MP, Baccarani M, Pession A, Sambri V. Diagnosis of bloodstream infections in immunocompromised patients by real-time PCR. J Infect. 2009;58:346–51, http://dx.doi.org/10.1016/j.jinf.2009.03.001.
38. Viasus D, Gudiol C, Fernández-Sabé N, Cabello I, Garcia-Vidal C, Cisnal M, Duarte R, Antonio M, Carratalà J. Effect of statins on outcomes in immunosuppressed patients with bloodstream infection. Eur J Clin Microbiol Infect Dis. 2011;30:77–82, http://dx.doi.org/10.1007/s10096-010-1056-2.
39. 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. Clin Infect Dis. 2004;39:309–17, http://dx.doi.org/10.1086/421946.
40. Wisplinghoff H, Seifert H, Wenzel RP, Edmond MB. Current trends in the epidemiology of nosocomial bloodstream infections in patients with hematological malignancies and solid neoplasms in hospitals in the United States. Clin Infect Dis. 2003;36:1103–10, http://dx.doi.org/10.1086/374339.
41. Red WHONET Argentina. Mapas de Resistencia Antimicrobiana Red WHONET Argentina 2023 [Internet]. Buenos Aires: ANLIS-Malbrán; 2023. Available from: https://antimicrobianos.com.ar/wp-content/uploads/2024/12/Mapas-deResistencia-Antimicrobiana-Red-WHONET-Argentina-2023.pdf. [Accessed 7 Septembee 2025].
42. Zhang F, Wang H, Liu L, Su T, Ji B. Machine learning model for the prediction of gram-positive and gram-negative bacterial bloodstream infection based on routine laboratory parameters. BMC Infect Dis. 2023;23:675, http://dx.doi.org/10.1186/s12879-023-08602-4.