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Original Article

Prevalence, microbiological patterns, and risk factors of hospital-acquired infections in a Tunisian university hospital

Salma Balhi[1,2], Sameh Boughattas[3,4], Asma Ben Cheikh[1,2], Nihel Haddad[1,2], Héla Ghali[1,2], Sana Bhiri[1,2], AbdelhalimTrabelsi[3,4], HouyemSaid[1,2]

[1] *Department of Preventive and Community Medicine, Sahloul University Hospital, 4011, Sousse, Tunisia*
[2] *University of Sousse, Faculty of Medicine of Sousse, 4002, Sousse, Tunisia*
[3] *Microbiology Department, Sahloul University Hospital, 4011, Sousse, Tunisia*
[4] *Faculty of Pharmacy of Monastir, University of Monastir, 5000, Monastir, Tunisia*

Abstract

Background: This study aimed to determine the prevalence of hospital-acquired infections (HAIs), identify associated risk factors, and describe the microbiological profile of HAIs in a university hospital (UH) in central Tunisia during 2025.

Methods: A prevalence study was conducted at a UH in Sousse, central Tunisia. Following the Centers for Disease Control and Prevention definitions, all infections occurring more than 48 hours after hospital admission were classified as HAIs and included in the study. Data collection included a one-day survey per department and a six-day prevalence assessment. Baseline characteristics, clinical features, isolated pathogens, and antimicrobial resistance profiles were recorded.

Results: Among 255 eligible patients, 29 had at least one HAI, yielding a prevalence of 11.4%. Bloodstream infections and pneumonia were the most frequent HAIs (32.4% each). Gram-negative bacteria represented 67.4% of all isolates, with *Klebsiella pneumonia* and *Acinetobacter baumannii* being the most common (15.2% each). More than half of the isolates (59.4%) were multidrug resistant, including 53.8% of non-fermentative Gram-negative bacilli resistant to carbapenems and 73.3% of *Enterobacterales* resistant to third-generation cephalosporins. Multivariate analysis showed that prolonged hospital stay (> 10 days) was identified as an independent risk factor for HAIs (AOR = 8.08, 95% CI: 2.54-25.67, $p< 0.001$).

Conclusions: Our findings indicate a high prevalence of HAIs and MDR pathogens. Strict adherence to infection control measures, combined with the implementation of an antibiotic stewardship program at the regional and national levels, is crucial to reducing infections and limiting the emergence of resistant strains.

Key words: hospital-acquired infection; prevalence; antimicrobial resistance; Tunisia.

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Introduction

Hospital-acquired infections (HAIs), also known as healthcare-associated or nosocomial infections, are among the main challenges to patient safety and significantly affect the quality of healthcare delivery [1,2]. They are associated with prolonged length of hospital stays, poorer clinical outcomes, increased healthcare costs, and higher mortality rates [1,3].

HAIs affect both developing and developed countries [4], with higher prevalence in low-resource settings. According to the World Health Organization (WHO) [4], at any given time, approximately 10% of patients in developing countries and 7% in developed countries acquire at least one HAI [4]. A recent meta-analysis performed in 2022 estimated that the pooled point-prevalence of HAIs in Africa was 12.76% [5], nearly twice the rate reported in developed countries [5]. In Tunisia, a national point prevalence survey (PPS) conducted in 2012 reported an overall prevalence rate of 7.7% [6].

Risk factors for the development of HAIs include being part of high-risk populations, such as immunocompromised patients, prolonged stays in intensive care units (ICU) or neonatal units, the use of invasive medical devices, and the overall intensity of treatment, including the administration of broad-spectrum antibiotics [2].

The burden of HAI is exacerbated by the rise of antimicrobial resistance (AMR), particularly due to multidrug-resistant (MDR) pathogens [2,4,7]. Managing patients with HAIs often requires the use of broad-spectrum antibiotic regimens, which in turn contribute to the selection and dissemination of resistant strains [7]. AMR infections are among the leading causes of death worldwide [7]. In 2019, bacterial AMR was directly responsible for an estimated 1.27 million deaths worldwide, with the highest mortality rates observed in Sub-Saharan Africa

[7].

In Tunisia, the emergence of MDR bacteria represents a growing public health concern [8,9]. Nevertheless, only a few studies have focused on microbiological resistance patterns among patients with HAI. A recent Tunisian study investigating MDR epidemiology over five years reported a resistance rate of 26.4%, with a predominance of hospital-acquired isolates [8].

This study, therefore, aimed to determine the prevalence of HAIs, identify their associated risk factors, and describe the microbiological profile of HAIs in a university hospital (UH) in central Tunisia, during 2025.

Methods

Study design and setting

A prevalence survey (PS) was performed at Sahloul UH, Sousse, Tunisia. Patients in each ward were assessed in a single day, and all data were collected between April 14 and April 19, 2025. Sahloul UH is a teaching and referral facility with a surgical focus, located in central Tunisia. In 2024, the hospital recorded 25,969 inpatient admissions.

Study population

All patients admitted for more than 48 hours at the time of the survey were included. Patients admitted to short-stay units (such as the endoscopy unit, emergency department, or hemodialysis unit) and ambulatory patients were not included. Departments included in the analysis were distributed as follows:

- Intensive care units: surgical resuscitation, medical resuscitation, post-operative general surgery, post-operative cardiovascular and thoracic surgery, pediatric resuscitation, and transplant unit
- Surgical services: surgery, orthopedics, maxillofacial surgery, pre-cardiovascular and thoracic surgery, neurosurgery, urology, and burns service.
- Medical services: gastroenterology, internal medicine, cardiology, pediatrics, neurology, nephrology, and rehabilitation.

Variables definitions

Hospital-acquired infection: Infections that occur at least 48 hours after hospital admission, or within 30 days following a surgical procedure, and up to one year after the insertion of a prosthetic device or implant [10]. All types of HAIs that occurred during the study period were documented and classified using Centers for Disease Prevention and Control (CDC) criteria: bloodstream infection (BSI), pneumonia, urinary tract infection (UTI), surgical site infection (SSI), and skin infection [10]. Infections occurring in more than one site in the same patient were recorded as separate events, except when the same microorganism was isolated at the same time.

Immunosuppression [10]:

- Treatment reducing resistance to infection: immunosuppressive therapy, chemotherapy, radiotherapy, corticosteroid therapy ≥ 30 days, or recent high-dose corticosteroid therapy (> 5mg/kg of prednisolone for more than 5 days).
- Advanced disease: hematologic malignancy, metastatic cancer, or HIV infection with CD4 count < 500/mm^3

Multi-drug resistantpathogens: acquired non-susceptibility to at least one agent in three or more antimicrobial categories [11].

The surveillance of MDR bacteria at Sahloul UH was guided by the WHO Priority Pathogens list recommendations, including [12]:

- *Acinetobacter baumannii* resistant to imipenem.
- Enterobacterales resistant to third-generation cephalosporins and/or carbapenems.
- *Pseudomonas aeruginosa* resistant to third-generation cephalosporins (ceftazidime) or resistant to both ceftazidime and imipenem
- Methicillin-resistant *Staphylococcus aureus* (MRSA).
- *Enterococcus faecium resistant to vancomycin* (VRE).

Data collection

Prevalence survey

The data collection form was adapted from the national survey 'Noso-Tun 12' [13]. The survey was conducted by the Department of Preventive Medicine and Community Medicine, consisting of several senior hygiene technicians, physicians, and nurses. The team is responsible for personnel training, survey operations, and data collection. Due to the limited number of investigators, data collection was performed over six consecutive days, with each ward surveyed on a single day, and each bed was surveyed only once.

For all eligible patients included in the PS, the following information was recorded: baseline demographic characteristics (including date of hospital and ward admission, age, gender), comorbidities (diabetes, immunosuppression, obesity, and malnutrition) and extrinsic risk factors for HAIs,

including antibiotic therapy within the previous six months, use of invasive medical devices (urinary catheters, peripheral or central vascular catheters—arterial or venous, intubation/tracheostomy, parenteral nutrition), surgical intervention within the past 30 days and presence of infection at the time of admission.

Only active HAIs present on the survey date were recorded. An infection was considered active if clinical signs or symptoms were observed on the day of the survey or had been previously documented, and the patient remained under treatment at the time of assessment. For patients with an active HAI on the survey day, additional data were collected, including the infection site, type of specimen obtained, identified microorganisms, and their antimicrobial susceptibility profiles.The diagnosis of HAIs was initially classified as definite (microbiologically confirmed) or deferred (microbiological documentation was not available at the time of the survey). The data collection form allowed for the documentation of up to three coexisting infections per patient present on the day of the survey. Patient data were anonymized by assigning a unique study ID.

Microbiological methods and antibiotic susceptibility

Microbiological diagnosis and antibiograms were performed in the microbiology laboratory of Sahloul University Hospital, Sousse, Tunisia. The specimens included blood, urine, bronchoalveolar lavage, sputum, catheters, and pus. Bacterial and fungal strains were identified using conventional microbiological methods, including culture on selective and differential media (such as blood agar, MacConkey agar, and chocolate agar), Gram staining, and a panel of biochemical tests (catalase, coagulase, oxidase, and carbohydrate fermentation tests). In addition, strain identification and antimicrobial susceptibility testing were conducted using the VITEK 2 automated system (VITEK-2, Biomérieux, France) following the 2023 CA-SFM/EUCAST (European Committee on Antimicrobial Susceptibility Testing) recommendations [14]. Pathogens were classified as MDR or non-MDR based on their susceptibility profiles.

Statistical Analysis

Statistical analysis was performed by the SPSS statistical package (version 26.0, SPSS Inc, Chicago, IL, USA). The prevalence of HAIs was calculated as the total number of HAIs divided by the total number of eligible patients present on the survey day. The prevalence of MDR infections was determined as the number of MDR infections divided by the total number of targeted bacteria isolates included in thesurveillance system. Length of stay (LOS) (days) was defined as the time from hospital admission to the survey day. Patients were classified as having a short/median stay (≤ 10 days) or a long stay (> 10 days). Variables are expressed as frequencies and percentages or medians and interquartile ranges (IQR). Comparisons were made between patients with and without HAIs. For categorical variables, comparisons were performed using the χ^2 test or Fisher's exact test, as appropriate. For continuous variables, the t-test or Wilcoxon rank-sum test was used, based on data distribution.

A binary logistic regression analysis was performed to identify independent predictors associated with HAIs. Variables with a $p \leq 0.20$ in the univariate analysis were included in the multivariable regression model. Results were reported as odds ratio (OR) with 95% confidence intervals (95% CI). A $p< 0.05$ was considered statistically significant for all tests.

Results

Socio-demographic and clinical characteristics of the study population

A total of 255 patients were enrolled in the study, including 152 males (59.6%) and 103 females (40.4%),

Table 1. Socio-demographic and clinical characteristics of study participants (N = 255).

Variables (N = 255)	n	%
Socio-demographic characteristics		
Gender		
Male	152	59.6
Female	103	40.4
Age, years (median:IQR)	50.0 (30.5-65.0)	
Hospitalization site		
Wards of admission		
Medical	96	37.6
Surgical	123	48.2
ICU	36	14.1
LOS (median) days		
Short / median (≤ 10 days)	154	60.4
Long (> 10 days)	101	39.6
Intrinsic factors		
Diabetes	62	24.3
Obesity	21	8.2
Malnutrition	17	6.7
Immunosuppression	22	8.6
Extrinsic factors		
Invasive procedures		
Urinary catheter	55	21.6
CVC	30	11.8
PVC	173	67.8
Parenteral nutrition	12	4.7
Intubation/mechanical ventilation	23	9
Surgical intervention within the past 30 days	90	35.3
Antibiotic received in the previous 06 months	54	21.2
Infection at hospital admission	55	21.6

HAI: hospital-acquired infection; ICU: intensive care unit; LOS: Length of stay; CVC: central venous catheter; PVC: peripheral venous catheter; IQR: Interquartile range.

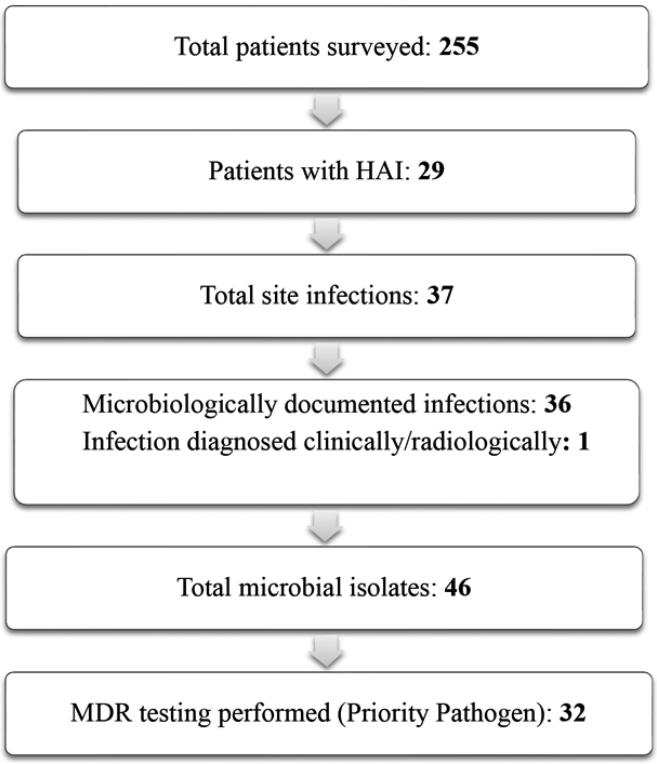
with a sex ratio (M/F) of 1.47. The median age of patients was 50.0 years (IQR = 30.5-65.0). The majority of patients were hospitalized in the surgical and medical ward 48.2% and 37.6%, respectively.

Overall, 24.3% of participants had diabetes, and 8.6% were immunocompromised. Infections present on admission were recorded in 21.6% of cases, while 24.6% reported prior antibiotic use within the past six months, and 39 .6% patients (101) were hospitalized for more than 10 days. Additional patient characteristics are summarized in Table 1. Among the surveyed patients, 34.9% (n = 166) had at least one intrinsic factor, while 81.6% (n = 208) had at least one extrinsic factor.

Hospital-acquired infections prevalence

Among the 255 inpatients surveyed, 37 infections were identified in 29 patients, with a mean of 1.27 episodes per infected patient. The prevalence of infected patients was 11.4%, while the overall infectionrate was 14.5%. Figure 1 illustrates the flow chart summarizing HAIs observed in this study. The distribution of HAIs was as follows: 32.4% BSIs, 32.4% pneumonia, 16.2% SSIs, 16.2% UTIs, and 2.7% skin and soft tissue infections (Figure 2).

Figure 1. Flow chart of patient infections, microbial, and MDR testing in this study.



Microbiological patterns

Microbiological cultures were performed in 97.3% (36/37) of cases. A single microorganism was identified in 75% (n = 27) of cases, two microorganisms in 22.3% (n = 8), and three microorganisms in 2.7% (n = 1). A total of 46 isolates were recovered. Gram-negative bacteria were predominant, accounting for 67.4% of all isolates. The most frequently identified pathogens were *Klebsiella pneumoniae* (n = 7, 15.2%), *Acinetobacter baumannii* (n = 7, 15.2%), *Pseudomonas aeruginosa* (n = 6, 13%), and coagulase-negative staphylococci (n = 6, 13.0%) (Table 2).

Figure 2. Distribution of hospital-acquired infections by site.

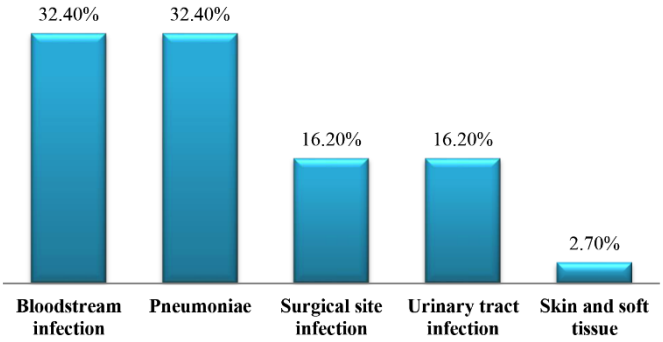


Table 2. etiology of hospital-acquired infections by microbial family isolates.

Family / Isolates	n	%
Gram-positive cocci		
Staphylococcus		
Coagulase-negative staphylococci	6	13
Staphylococcus aureus	3	6.5
Enterococcus		
Enterococcus faecalis	2	4.3
Enterococcus faecium	1	2.1
Gram-positive bacilli		
Corynebacterium spp.	2	4.3
Total Gram-positive bacteria	**14**	**30.4**
Gram-negative bacilli		
Enterobacterales		
Klebsiella pneumoniae	7	15.2
Enterobacter cloacae	4	8.6
Escherichia coli	3	6.5
Proteus mirabilis	1	2.1
Non-fermenting Gram-negative Bacilli		
Acinetobacter baumanii	7	15.2
Pseudomonas aeruginosa	6	13
Stenotrophomonas maltophilia	2	4.3
Haemophilus spp	1	2.1
Total Gram-negative bacteria	***31***	***67.4***
Yeasts		
Candida glabrata	**1**	**2.2**
Total	**46**	**100**

Table 3. Multidrug resistance among isolates.

Bacterial isolates	N = 32 (% total isolates)	Non-MDR, n (% of species)	MDR, n (% of species)
Gram-positive cocci			
Staphylococcus aureus	3 (9.3%)	2 (66.7%)	1 (33.3%)
Enterococcus faecium	1 (3.1%)	0	1 (100.0%)
Total Gram-positive bacteria	**4 (12.5%)**	**2 (50.0%)**	**2 (50.0%)**
Gram-negative bacilli			
Enterobacterales			
Klebsiella pneumoniae	7 (21.8%)	1 (14.3%)	6 (85.7%)
Enterobacter cloacae	4 (12.5%)	1 (25.0%)	3 (75.0%)
Escherichia coli	3 (9.3%)	2 (66.7%)	1 (33.3%)
Proteus mirabilis	1 (3.1%)	1 (100.0%)	0
Total Enterobacterales	**15 (46.9%)**	**5 (33.4%)**	**10 (66.6%)**
Non fermenting Gram-negative bacilli			
Acinetobacter baumannii	7 (21.8%)	1 (14.3%)	6 (85.7%)
Pseudomonas aeruginosa	6 (18.7%)	5 (83.3%)	1 (16.7%)
Total Non-fermenting Gram-negative bacilli	**13 (40.6%)**	**6 (46.2%)**	**7 (53.8%)**
Total Gram-negative bacilli	**28 (87.5%)**	**11 (39.3%)**	**17 (60.7%)**
Total bacteria	**32 (100%)**	**13 (40.6%)**	**19 (59.4%)**

MDR: multi-drug resistant.

Multidrug-resistant patterns of the isolates

Among the isolates collected through the microbiological surveillance, 19 (59.4%) were classified as MDR. *Acinetobacter baumannii* and *Klebsiella pneumoniae* were the most frequently identified pathogens (n = 7/32, 21.8% each) and accounted for the highest proportion of MDR strains (n = 6/19, 31.5% each) among all recoveredisolates (Table 3).

Antimicrobial susceptibility of isolates

Resistance to carbapenems among non-fermentative Gram-negative bacilli was 53.8%. Enterobacterales showed a resistance rate of 26.6% to carbapenems and 73.3% to third-generation cephalosporins.

Factors associated with hospital-acquired infections

In univariate analysis, several factors were associated with HAI including hospitalization in the ICU (OR = 14.56, 95% CI: 4.77-44.39), prolonged LOS (OR = 12.36, 95% CI: 4.14-37.72), medical devices use (OR = 4.2, 95% CI:1.89-9.32), surgical intervention within the past 30 days (OR = 4.14, 95% CI: 1.83-9.37) and antibiotic use in the previous six months (OR = 2.60, 95% CI: 1.14-5.90). In the multivariate regression model, prolonged LOS (> 10 days) remained an independent predictor of HAI (AOR = 8.08, 95% CI:

Table 4. Factors associated with hospital-acquired infections among study participants.

Variables (N = 255)	HAI		COR (CI)	*p*	AOR (CI)	*p*
	Yes (n = 29)	No (n = 226)				
Gender						
Male	55.2 (16)	60.2 (136)	Ref			
Female	44.8 (13)	39.8 (90)	1.22 (0.56-2.67)	0.6		
Age (years) Median (IQR)	50.0 (32.0-65.2)	49.5(16.5-65.0)	0.99 (0.97-1.00)	0.26		
Wards of admission						
Medical	17.2 (5)	40.3 (91)	Ref			
Surgical	27.6 (8)	50.9 (115)	1.26 (0.41-4.00)	0.688	0.56 (0.14-2.26)	0.42
ICU	55.2 (16)	8.8 (20)	14.56 (4.77-44.39)	< 0.001*	3.49 (0.65-18.63)	0.14
LOS (Median: IQR) days						
Short /medium (≤ 10days)	13.8 (4)	66.4 (150)	Ref			
Long (> 10 days)	86.2 (25)	33.6 (76)	12.36 (4.14-37.72)	< 0.001*	8.08 (2.54-25.67)	< 0.001*
Comorbidities						
Diabetes	34.5 (10)	23.0 (52)	1.76 (0.77-4.02)	0.17		
Obesity	10.3 (03)	8.0 (18)	1.33 (0.36-4.83)	0.66		
Malnutrition	10.3 (03)	6.2 (14)	1.74 (0.47-6.48)	0.39		
Immunosuppression	6.9 (02)	8.8 (20)	0.76 (0.169-3.44)	0.72		
Medical devices use						
Yes	17 (58.6)	57 (25.2)	4.2 (1.89-9.32)			
No	12 (41.4)	169 (74.8)	Ref	< 0.001*	5.06 (0.38-66.8)	0.21
Surgical intervention within the past 30 days	65.5 (19)	31.4 (71)	4.14 (1.83-9.37)	< 0.001*	0.45 (0.15-1.38)	0.168
Antibiotic received in the previous 6 months	37.9 (11)	19.0 (43)	2.60 (1.14-5.90)	0.01*	0.50 (0.17-1.43)	0.2
Infection at hospital admission	31.0 (9)	20.4 (46)	1.76 (0.75-4.12)	0.18		

*Statistically significant at $p < 0.05$; For categorical variables: test de Khi2 and for continuous variables: test U de Mann Whitney; COR: crude odds ratio; AOR: adjusted odds ratio; CI: confidence interval; HAI: hospital-acquired infection; ICU: intensive care unit; LOS: Length of stay; CVC: central venous catheter; PVC: peripheral venous catheter.

2.54-25.67, $p< 0.001$) (Table 4).

Discussion

HAIs remain a major public health issue, contributing to increased morbidity, mortality, and healthcare costs [5]. A recent meta-analysis from Sub-Saharan Africa revealed a high overall burden of HAI, with a pooled in-hospital mortality rate of 22% [15]. Due to excessive use of antibiotics, almost 20% of all reported bacteria are MDR, representing one of the major challenges associated with HAIs [16].

In our study, 11.4% of patients presented at least one HAI. This rate was higher than that reported in other Tunisian studies, including the second national PPS (6.7%) [6], and a study from southern Tunisia (9.02%) [17], but lower than that observed in central Tunisia, where the prevalence reached17.7% [18]. The higher prevalence observed in our study compared with the national survey may be explained by differences in hospital structure. Indeed, the national PPS included both private and public hospitals, whereas our study was conducted in a university hospital with a predominantly surgical focus. It is well established that the prevalence of HAI varies according to the type of hospital activity, with higher rates generally reported in surgical settings. At the continental level, a recent meta-analysisincluding 81,968 patients from 92 studies across 20 African countries reported aprevalence of HAIs ranging from 1.6% to 90.2% with a median of 15% [19]. By comparison, the most recent European PPS, including 20,869 patients, reported a prevalence of 7.1% [20]. Evidence demonstrates that interventions such as hand hygiene, active surveillance, environmental cleaning, and multimodal strategies are effective in reducing the burdenof HAIs [19].

BSIs and pneumonia were the most frequent HAIs (32.4% each). BSIs are associated with severe complications, including life-threatening sepsis [21], and significantlyincrease ICU mortality, with rates ranging from 35% to 50% [22]. Both BSIs and pneumonia are strongly linked to medical deviceuse and are largely preventable through strict adherence to infection prevention and control measures [21]. International comparisons highlight differences in HAI profiles. In Sub-Saharan Africa, SSIs are the most common [15], whereas in Europe, pneumonia (29.3%) and UTIs (19.2%) predominate [20]. Such variability may be explained by differences in clinical activities, case definitions, and diagnosis methods.

In the present study, 97.3% of patients had microbiological documentation. This proportion was higher than that reported in other Tunisian studies, which found documentation in only 34.6% [6] and 11.4% [18] of cases. The lack of microbiological confirmation and antimicrobial susceptibility data may compromise appropriate therapeutic choices and contribute to the spread of MDR pathogens [6].

Klebsiella pneumoniae and *Acinetobacter baumannii* were the most frequently isolated pathogens, each accounting for 15.2% of cases. These results are consistent with the second national PPS [6], in which *Klebsiella pneumonia* predominated. Conversely, our pathogen distribution differed significantly from that reported in most international studies, where *Escherichia coli* is usually the leading pathogen [15]. The variation in the microbiological profile could be explained by differences in infection sites, geographic location, and patient age group (children versus adults).

In the current study, 59.4% of identified pathogens were classified as MDR, reflecting a global trend in which an estimated 136 million hospital-associateddrug-resistant infections occur annually [23], with middle-income countries demonstrating the highest burden [23]. The spread of resistance is largely driven by factors such as inappropriate prescribing practices, overuse of broad-spectrum antibiotics, and uncontrolled access to antimicrobial agents, which contribute significantly to the spread of resistance [23]. The WHO published a list of antibiotic-resistant "priority pathogens", including 12 bacterial families considered the greatest threats to human health [12]. The most critical group comprises MDR bacteria, notably *Acinetobacter*, *Pseudomonas,*and various *Enterobacteriaceae*. These organisms are associated with severe and often fatal infections such as BSIs and pneumonia [12].

Regarding the antibiotic sensitivity pattern of HAIs, isolates showed that carbapenem resistance among non-fermentative Gram-negative bacilli reached 53.8%. This rate was higher than that reported in Sierra leone 13.4% [24], but lower than that observed in the fourth national PPS in Serbia, where 80.5% of isolates were resistant to carbapenem [25]. Similarly, resistance rates among *Enterobacterales* were 26.6% for carbapenems and 73.3% for third-generation cephalosporins. These findings align with a recent African meta-analysis reporting a 70.3% resistance rate to third-generation cephalosporins among *Enterobacterales* [19], but remain higher than European rates (34.7%) [20]. Such data suggest that these antibiotics can no longer be considered reliable for empirical HAI treatment, underscoring the urgent need for alternative strategies.

Regarding risk factors, HAIs were more frequent in patients with prolonged hospital stays (> 10 days).

Similar findings have been reported in Tunisian [17,18,26] and international studies [15]. The increased risk is largely attributed to greater exposure to invasive procedures and prolonged use of medical devices, particularly among patients with multiple comorbidities [27].

Strengths and limitations

This study has several strengths. First, to our knowledge, it is the first study in Tunisia to comprehensively investigate the microbiological profile and AMR patterns of HAIs across all hospital wards, with a microbiological documentation rate of 97.3%. In contrast, previous Tunisian studies were either national surveys providing only limited microbiological data (34.6%) [6], or monocentric investigations restricted to specific units, such as ICUs [28], or focused on particular pathogens [29] or infection sites [30]. Second, standardized CDC HAI definitions and the validated CDC methodology were applied. Third, both theoretical and practical training sessions were organized for all data collectors, many of whom had already participated in previous surveys.

The main limitations of this study are its cross-sectional design, which is common to all prevalence surveys. In addition, the relatively small sample size may have reduced the statistical power to detect significant associations between risk factors and the occurrence of HAIs, thus limiting the generalizability of the results. Further incidence-based and multicenter studies are warranted to support and extend these findings.

Conclusions

Our findings indicate a high prevalence of HAIs and MDR pathogens. Strict adherence to infection control measures, combined with the implementation of an antibioticstewardship program at regional and national levels, is crucial to reduce infections and limit the emergence of resistant strains.

Acknowledgements

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Ethical Statement

This study was approved by the Ethics Committee of Sahloul UHand in accordance with the Helsinki Declaration. It did not interfere with patient management, and all data were analyzed anonymously.

Authors Contributions

All authors made significant contributions to this work. Conceptualization: SB, HG, NH. Methodology: SB, ABC, SB, HS, Formal analysis: SB, SBo, AT, TM, ABR, Data curation: SBo, AT, HS, Writing-original draft preparation: SB, Writing-review and editing: SB, TM, ABR, Supervision: HS, AT. All authors have read and agreed to the published version of the manuscript.

Corresponding author

Dr. Salma Balhi
Department of Preventive Medicine and CommunityMedicine,
Sahloul University, Sousse, Faculty of Medicine of Sousse, University of Sousse, Sousse, Tunisia.
Tel: +21650 921 287
E-mail: salmabalhi@yahoo.fr

Conflict of interest

No conflict of interest is declared.

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